

# OREDA

## Offshore Reliability Data Handbook

4th Edition

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<sup>1</sup> The companies listed below are those being members of OREDA in 2002.

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The existence of this document does not imply that there are no other ways to present the offshore reliability data compiled in this book. Furthermore, the viewpoint or technical perspective expressed in this publication is subject to changes brought about by technological developments and comments received from users of the former OREDA Reliability Handbooks (-84, -92, -97).

Requests for interpretation may arise regarding the meaning of parts of the handbook as they relate to specific applications. Those requests should be directed to SINTEF Industrial Management at the addresses given. As publications issued by the OREDA project represent a consensus of all participating companies, it is important to ensure that any interpretation has also received the joint agreement of those companies. For this reason, it may in some cases be necessary to consult the OREDA Steering Committee. In these cases it will not be possible to provide an instant response to interpretation requests, except in those cases where the matter has previously received formal consideration.

## PREFACE

The reliability, availability, maintenance and safety (RAMS) of offshore exploration and production (E & P) facilities are of considerable concern to employees, companies and authorities. RAMS analyses are carried out to provide a basis for decisions in offshore engineering, fabrication and operations. In order to allow these analyses to be conducted, a source of reliability data is required.

The OREDA participating companies have responded to this need by publishing four reliability data handbooks. The previous editions of the OREDA handbook were published in 1984, 1992 and 1997 respectively.

The current 2002 edition has not been changed significantly compared to the former -97 edition. However, it should be noted that *drivers are no longer included within the boundary of the driven unit* but defined as separate entities. As the 2002 edition contains a lot more subsea data than previously, these data are presented in a fashion more adapted to subsea application. The handbook is divided into two parts. Part I describe the OREDA project, different data collection phases and the estimation procedures used to generate the handbook. In Part II the reliability data tables are presented for both topside and subsea equipment. In order to interpret and apply the data given in Part II in the most correct manner, it is recommended to read Part I before using data shown in Part II.

While each new edition of the handbook is considered to be a step forward, it is realised that the quality and the quantity of the data presented in the handbook may be inadequate for certain applications. The OREDA Steering Committee's intention is therefore to keep the handbook up to date according to the state of technology by publishing new editions.

The current handbook covers phase IV and V of OREDA data collection. This represent broadly the time period of 1993 – 00. It may, however, be seen that some data collected may be beyond this time period.

Data collected are in general not covering the whole lifetime of equipment, but typically a time windows of 2 – 4 years of operation. Infant mortality failures are as a rule not collected for topside equipment, hence, the data collected are from the normal steady-state operating time period as illustrated in Figure 5. For subsea equipment failures are in general collected on a whole lifetime basis, i.e. including the infant mortality period.

The source data for this book are stored in a computer database except for phase I. The database and the associated software are available only to the oil companies participating in the OREDA project. The data presented in this handbook are extracted and compiled from this database and presented as generic data tables. *The database does, however, contain additional information -and information on a more detailed level- than what is covered in this handbook.* For those who want to exploit this possibility, one of the participating oil companies needs to be contacted. A list with contact names for each participating company can be found in the OREDA Homepage: <http://OREDA.com>

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# PART I

## INTRODUCTION

### THE OREDA PROJECT

The Offshore Reliability Data (OREDA) project was established in 1981 in co-operation with the Norwegian Petroleum Directorate. The initial objective of OREDA was to collect reliability data for safety equipment. The current organisation, as a co-operating group of several oil companies, was established in 1983, and at the same time the scope of OREDA was extended to cover reliability data from a wide range of equipment used in oil and gas exploration and production. Offshore topside and subsea equipment are primarily covered, but some onshore E & P equipment is also included.

The main objective of the OREDA project is to contribute to an improved safety and cost-effectiveness in design and operation of oil and gas exploration and production facilities; through collection and analysis of maintenance and operational data, establishment of a high quality reliability database, and exchange of reliability, availability, maintenance and safety (RAMS) technology among the participating companies.

### PROJECT PHASES

#### Phase I (1983 - 1985)

The purpose of phase I was to collect and compile data from offshore drilling and production operations. The data were published in the OREDA-84 handbook. An objective of the handbook was to demonstrate the ability of the eight participating oil companies to co-operate on this issue and create a forum for a common co-operative process in this field. Data was collected on a wide area of equipment (large population) but not with as much detailed information as in later phases.

#### Phase II (1987 - 1990)

The scope was adjusted to only collect data on production critical equipment, to improve the quality of the data, and to store the data in a PC database format. A tailor-made PC program (called the OREDA software) was developed to aid the collection and analysis of the data. The data were published in the OREDA-92 handbook. This Handbook also contains the data collected in phase I.

#### Phase III (1990 - 1992)

The number of equipment categories was increased, and more data on maintenance programs were collected. The data quality was improved by means of the comprehensive "Guidelines for Data Collection" and through quality control. The OREDA software was modified into a more general-purpose data collection tool, and its user interface was improved. The data collected in this phase are contained in the OREDA-97 handbook.

#### Phase IV (1993 - 1996)

A new general software was developed for data collection and analysis, plus specific software and procedures for automatic data import and conversion. Data were collected mainly for the



same equipment as in phase III, and the data collection was - to a greater extent - carried out by the companies themselves. Data on planned maintenance are included.

### Phase V (1997 – 2000)

Some new equipment classes were included and more focus was given on collecting subsea data. As a parallel activity, the ISO standard 14 224: “*Petroleum and natural gas industries - Collection and exchange of reliability and maintenance data for equipment*” was developed and issued in July 1999. A revised version including downstream equipment is currently being developed by ISO TC67 Workgroup 4 with the secretariate at NTS in Oslo. (See: <http://www.nts.no/>)

Phase VI were completed in 2001 and phase VII is planned to last 2002 - 2003.

Up-to-date information on the OREDA project is available on the Internet address:

<http://www.oreda.com>

## PARTICIPANTS

During phase IV and V several changes have been experienced in company participation in OREDA as to new companies joining and leaving OREDA as well as companies being merged/sold. The following summarise the companies that have contributed with data in these phases:

Companies	Phase IV	Phase V	Comments
AGIP	√	√	
BP	√	√	
Chevron	√	√	Merged with Texaco
ELF	√	√	Merged with TOTAL
Esso/Exxon	√	√	(Merged with Mobil)
Norsk Hydro	√	√	
Phillips Petroleum Company Norway	√		
Statoil	√	√	
Saga Petroleum	√		Sold to Norsk Hydro
Shell	√	√	
Texaco		√	Merged with Chevron
TOTAL	√		Merged with Elf

## ORGANISATION

OREDA is managed by a Steering Committee with one member and one deputy member from each of the participating oil companies. The Steering Committee elects one of its members as chairman and appoints a Project Manager. The Project Manager co-ordinates the activities approved by the Steering Committee, including data quality assurance. Det Norske Veritas served as Project Manager during phases I and II; SINTEF during phases III - V, and act as current project manager in Phase VII.

**EQUIPMENT CATEGORIES COVERED IN THE DIFFERENT PHASES**

Table 1 shows the equipment categories that have been included in the four OREDA handbooks (including this one). Most of the equipment derives from offshore installations, but a few equipment units from onshore E&P have also been included. In phase V more emphasis has been placed on collection of subsea data.

**Table 1 Equipment classes covered by the four OREDA Handbooks**

System	Equipment class	Phase I (-84 edition) (1983 – 85)	Phase II (-92 edition) <sup>2</sup> (1987 – 90)	Phase III (-97 edition) (1990 – 92)	Phase IV (2002 edition) (1993 – 96)		Phase V (1997 – 00)	SUM
		No. of units	No. of units	No. of units	No. of units	No. of units	No. of units	No. of units
<b>Rotating machinery</b>	- Gas Turbines		109	54	56	28	247	
	- Compressors	17	50	45	75	56	243	
	- Combustion engines				39	64	103	
	- Pumps	478	271	103	294	152	1298	
	- Turboexpanders				7	8	15	
	- Electric generators	76		49	87	8	220	
	- Electric motors				56	122	178	
<b>Static equipment</b>	- Vessels	359	329	54	148	51	941	
	- Heaters and boilers				8	1	9	
	- Heat exchangers	519	170	75	51	17	832	
<b>Other topside</b>	- Valves	658	645	899	821	349	3372	
	- F&G detection equipment	3683		5828	79	779	10369	
	- Process sensors/control	3740		487	140	69	4436	
Misc. equipment phase I only	- Misc. el. systems	1321					1321	
	- Misc. safety systems	1703					1703	
	- Misc. utility systems	1035					1035	
	- Drilling systems	880					880	
<b>Subsea equipment</b>	- Control systems			14		17	31	
	- Wellhead & X-mas tree			21		83	104	
	- Pipelines					144	144	
	- Template					4	4	
	- Manifold					29	29	
	- Risers					42	42	
	- Running tools					6	6	
- Misc. equipment (phase II)		15				15		
<b>Total</b>		<b>14469</b>	<b>1589</b>	<b>7629</b>	<b>1841</b>	<b>2037</b>	<b>27565</b>	

<sup>2</sup> The -92 edition do also contain the data issued in the -84 version.

## SCOPE OF THE OREDA HANDBOOK

The OREDA handbook presents high quality reliability data for offshore equipment collected during phase IV and V of the OREDA project. The intention of the handbook is to provide both quantitative and qualitative information as a basis for RAMS analyses.

For each *topside* equipment unit, the following information is presented:

- A drawing illustrating the boundary of the equipment unit, i.e., a specification of subunits and so-called maintainable items that are part of the equipment unit.
- A listing of all failure modes, classified as *critical*, *degraded* or *incipient*, respectively.
- The observed number of failures for each failure mode.
- The aggregated observed time in service for the equipment unit, classified as calendar time, operational time, and number of demands.
- An estimate of the failure rate for each failure mode with associated uncertainty limits.
- A repair time estimate, i.e., the number of man-hours required to repair the failure and restore the function.
- A repair time estimate, i.e., the elapsed time in number of hours required repairing the failure and restoring the function. This time is the *active* repair time, i.e. the time when actual repair work was being done.
- Supportive information, e.g., number of items and installations.
- A cross-tabulation of maintainable item versus failure mode, and of failure descriptor/-cause versus failure mode.

For each *subsea* equipment unit, the following information is presented:

- A drawing illustrating the boundary of the equipment unit, i.e., a specification of subunits and components that are part of the equipment unit.
- A listing of all components.
- The observed number of failures for each component.
- The aggregated observed time in service for the equipment unit, classified as calendar time.
- An estimate of the failure rate for each component with associated uncertainty limits.
- A repair time estimate, i.e., the elapsed time in number of hours required repairing the failure and restoring the function. This time is the *active* repair time, i.e. the time when actual repair work was done.
- Supportive information, e.g., number of items and installations.
- A cross-tabulation of component versus failure mode, of subunit versus failure mode, of equipment unit versus failure mode and of failure descriptor/-cause versus failure mode.

**LIMITATIONS**

Information released from each participating company has been kept confidential by rendering it anonymous. Only generic data are published. The single event information, which is the basis for the estimates, is (in most cases) gathered from two or more installations, and consequently the figures in the handbook reflect a weighted average of the experience.

The OREDA project is so far restricted to failure data collected on hardware components and systems; information about human errors is not included. Nevertheless, component failures may have been caused by human errors and, therefore, implicitly, human errors are included in the failure rate estimates.

Details and limitations of the methods used are described in the section "ESTIMATION PROCEDURES" on page 23.

## THE OREDA TOPSIDE DATA STRUCTURE

### GENERAL

In order to collect data and analyse them in a consistent manner, a taxonomy description has been developed in the OREDA project. The following gives a summary of that taxonomy to better understand the platform on which these data have been collected and stored. Note that some of the parameters given in this description are not included in the generic data presented in this handbook, but contained in the source database.

### MAIN DATA CATEGORIES

For each equipment category the database is split into three separate database files: an *Inventory* part, a *Maintenance* part, and a *Failure* part.

The **Inventory** part contains a description of each *equipment unit* for which data have been collected, e.g., pump. This description contains technical data (e.g., capacity, size) as well as some operating and environmental data (e.g., operating mode, vibrations). The inventory description for each equipment unit is stored in an *Inventory record* in the database.

The **Failure** part contains the failure events being experienced for an equipment unit (inventory) during the period of surveillance; one record for each failure event. The failure events are always related to one equipment unit (inventory).

The **Maintenance** part contains information about the corrective and the scheduled preventive maintenance program for each equipment unit (e.g., maintenance action, interval, man-hours). Data on corrective maintenance is related to its preceding failure, while data on preventive maintenance is related to the equipment unit.

### SYSTEM HIERARCHY

The various items are classified into equipment categories termed *Equipment classes* e.g. pumps, compressors, valves etc. Each individual item within a class is termed an *Equipment Unit* (e.g. one pump). Each equipment class is further classified according to its design characteristics and type of service (system). Table 2 gives an example for the two equipment classes *Pumps* and *Fire & Gas detectors*.

Equipment within an equipment class is subdivided in two lower indenture levels, called *subunits* and *maintainable items (MI)*. This subdivision is purely hierarchic and has the following interpretation:

**Level 1 – Equipment Unit:** The highest level used in OREDA and typically includes an equipment unit with one main function, e.g. pump, compressor.

**Level 2 – Subunit:** An equipment unit is subdivided in several subunits, each with one function required for the *equipment unit* to perform its main function. Typical subunits are e.g., cooling, lubrication. The subunits may be redundant, e.g., two independent start units.

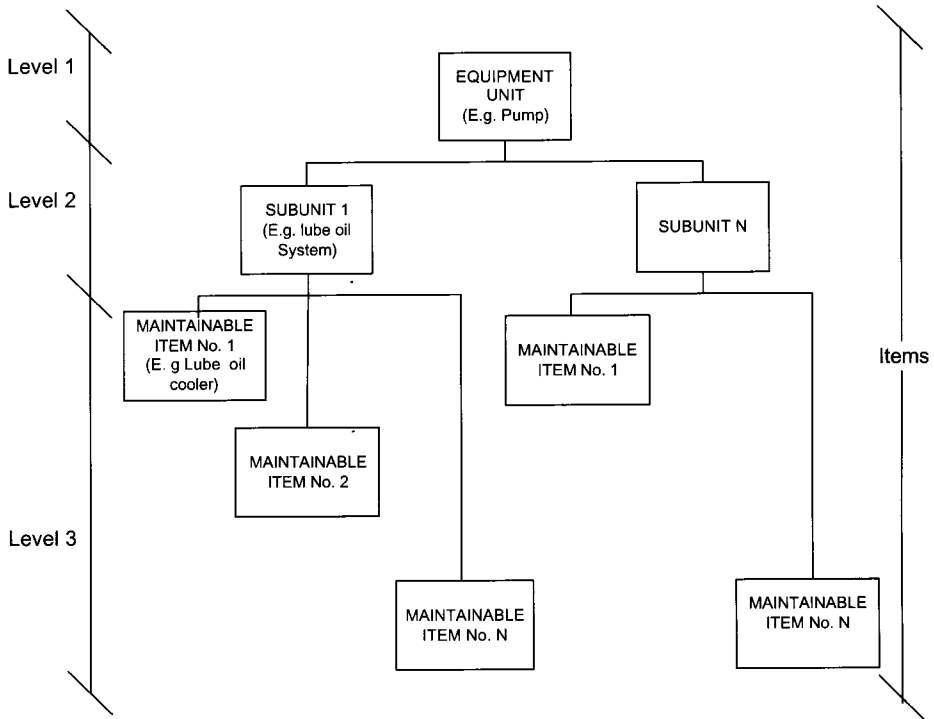
**Level 3 - Maintainable Item (MI):** These are subsets of each subunit and will typically consist of the lowest level units that are due for preventive maintenance.

The hierarchy is illustrated in Figure 1.

**Table 2 System Classification (Example)**

EQUIPMENT CLASS		DESIGN CLASS		SYSTEM	
Description	Code	Description	Code	Description	Code
Pumps	PU	Centrifugal	CE	Water fire fighting	FF
		Reciprocating	RE	Sea water injection	WI
		Rotary	RO	Oil handling	OH
				Gas utilities	GU
				Gas processing	GP
				.....	....
Fire & Gas detectors	FG	Smoke/combustion	BS	Fire detection	FD
		Heat	BH		
		Flame	BF		
		Hydrocarbon gas	AB	Gas detection	GD
		H2S gas	AS		

(Example: PU-RO-OH indicate a rotary pump used in oil handling)



**Figure 1 System Hierarchy**

Several subunits may be relevant for several equipment categories (e.g., lubrication system, starting system). In these cases the subunits are given the same name and the same set of MIs. This is done in order to standardise the subunits/MIs as much as possible, although some of the MIs in these subunits may not apply for all equipment categories.

**EQUIPMENT BOUNDARIES**

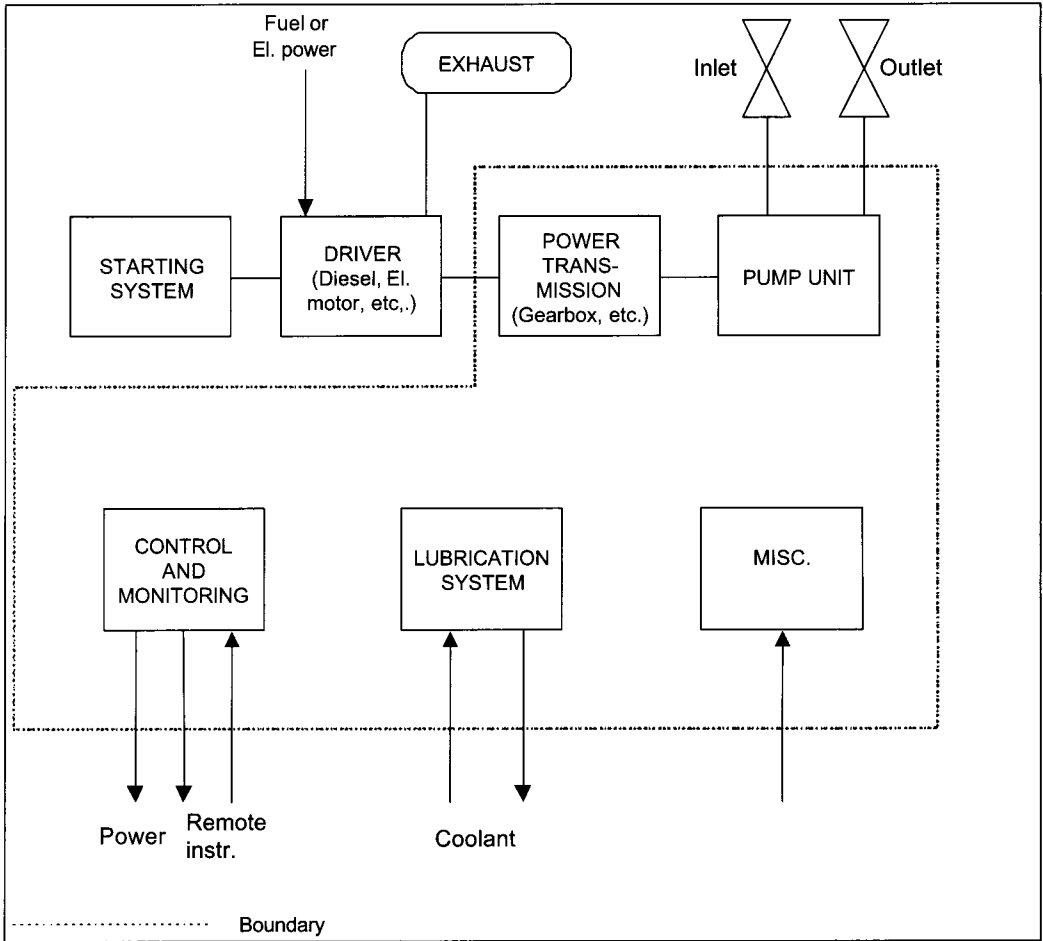
To compare failure events from different equipment categories, installations, or sources, it is important to have a common definition of which components or parts that are to be included in an inventory. The *boundary* defines parts associated with the generic item that are considered to be essential for its function or that are sold by the manufacturer as part of the item. For example, the power transmission (e.g. gear) is included within the boundary for a pump, while the driver (e.g. el.motor) is not. The boundary is normally sufficiently determined by a boundary diagram as illustrated in Figure 2. Further, a tabular description as shown in Table 3 lists those subunits and MIs that are included within the boundary.

The boundaries are established to confine the same items as the corresponding tag numbers or sub-tag numbers used by the participating oil companies. The equipment units correspond to the companies' main tag level, while the subunits correspond to the sub-tag level.

When establishing the equipment boundaries, the following principles have been applied:

- The connected units are excluded from the equipment unit boundary unless specifically included by the boundary specification. *Failures that occur in a connection (e.g. leak) are included* unless it is known specifically that it has occurred on the connected item outside the boundary.
- When a driver and the driven unit use common subunits (e.g., lubrication), failures of this subunit is as a common rule related to the *driven* unit.
- Failures on drivers (e.g. gas turbine) and driven units (e.g. compressors) are presented for each of those equipment classes *separately*. When e.g. a failure rate for a combination of driver and driven units is needed (e.g. compressors driven by gas turbines) the combined values from those two equipment classes should be used.
- Instrumentation is included only where this equipment has specific control and/or monitoring function for the equipment unit and/or is locally mounted (sensors). Instrumentation of a more general use, such as supervisory system (SCADA) is, as a rule, not included.





**Figure 2 Boundary Definition, Pumps**

**INVENTORY DATA**

For each equipment unit there is an inventory description divided into two parts:

1. One part common to all equipment categories (e.g., manufacturer, model, function, operating time).
2. One part containing equipment category specific data (e.g., capacity, size, power consumption).

**Table 3 Subdivision in Maintainable Items, Pumps**

EQUIPMENT CLASS	PUMPS				
SUBUNITS	Power transmission	Pump unit	Control and Monitoring	Lubrication system	Miscellaneous
<b>MAINTAINABLE ITEMS</b>	<ul style="list-style-type: none"> <li>• Gearbox</li> <li>• Bearing</li> <li>• Seals</li> <li>• Lubrication</li> <li>• Coupling to driver</li> <li>• Coupling to driven unit</li> </ul>	<ul style="list-style-type: none"> <li>• Support</li> <li>• Casing</li> <li>• Impeller</li> <li>• Shaft</li> <li>• Radial bearing</li> <li>• Thrust bearing</li> <li>• Seals</li> <li>• Valves</li> <li>• Piping</li> <li>• Cylinder liner<sup>1</sup></li> <li>• Piston<sup>1</sup></li> <li>• Diaphragm<sup>2</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Control unit</li> <li>• Actuating device</li> <li>• Monitoring unit</li> <li>• Internal pwr supply</li> <li>• Valves</li> </ul>	<ul style="list-style-type: none"> <li>• Reservoir</li> <li>• Pump w/ motor</li> <li>• Filters</li> <li>• Cooler</li> <li>• Valves</li> <li>• Piping</li> <li>• Oil</li> </ul>	<ul style="list-style-type: none"> <li>• Purge air</li> <li>• Cooling/heating system</li> <li>• Filter, cyclone</li> <li>• Pulsation damper</li> <li>• Others</li> </ul>

**FAILURE DATA**

In OREDA a failure event is defined as a *physical* failure of equipment. This implies that all events where a work order is issued, and some maintenance action carried out, would be considered as failure in OREDA (see the definitions on page 40).

For each failure a description (record) of the failure is given in the database together with the corrective action(s) carried out to restore the item to normal operating condition. The information is partly based on numeric data, partly on codes selected from a predefined menu, and partly on free text.

## THE OREDA SUBSEA DATA STRUCTURE

### MAIN DATA CATEGORIES

The OREDA subsea database consists of three main parts: An *Inventory* part, a *Failure* part, and a *Maintenance* part.

The **Inventory part** contains a description of each Equipment Unit (e.g. an X-mas tree). It contains technical and operational data on all three indenture levels applied: (1) Equipment Unit, (2) Subunit and (3) Component level.

The **Failure part** contains the failure events experienced for one Equipment Unit during the period of surveillance; one failure record for each failure event. If no failures are experienced for a specific equipment unit, the corresponding failure database will be empty. Subsea failures are linked to the lowest level in the equipment hierarchy, the component level.

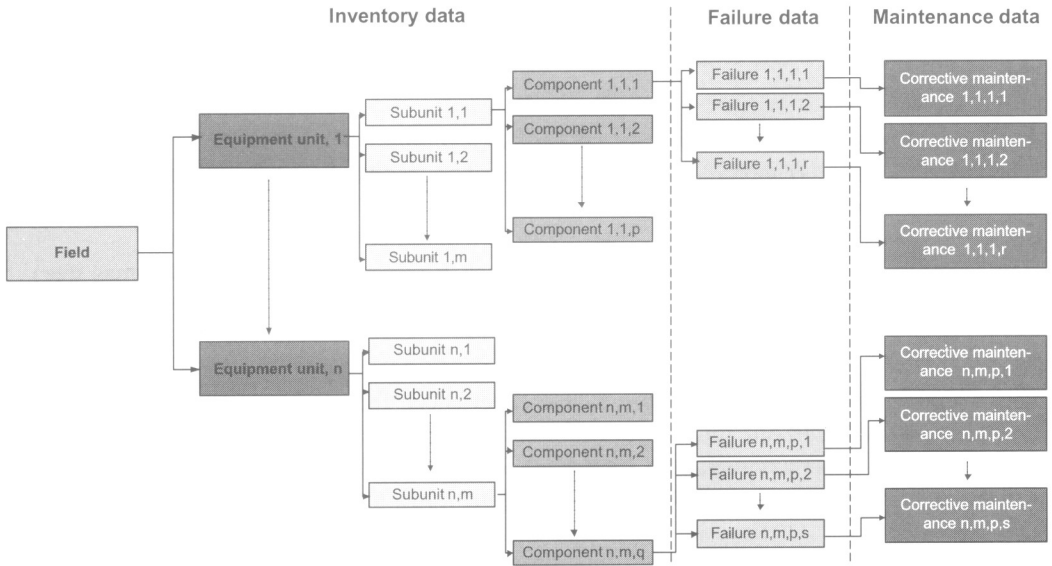
The **Maintenance part** contains information about the corrective maintenance/ intervention being carried out (e.g. maintenance action, downtime, resources) and is related to a failure event record.

### SYSTEM HIERARCHY

The *system hierarchy* in OREDA, subsea part, is broken down into four levels starting on top viz.:

- **Field/Installation:** This is an identifier for the subsea field and its installation(s). For each field several installations may be included.
- **Equipment unit:** An equipment unit on the highest equipment level used in OREDA which typically includes a unit with one main function, e.g. X-mas tree, control system, etc.
- **Subunit:** An equipment unit is subdivided in several subunits, each with function(s) required for the *equipment unit* to perform its main function. Typical subunits are e.g. umbilical, HPU etc. The subunits may be redundant, e.g. two independent HPUs.
- **Component:** These are subsets of each subunit and will typically consist of the lowest level items that are being repaired or replaced as a whole (e.g. valve, sensor etc)

The hierarchy is illustrated in Figure 3.

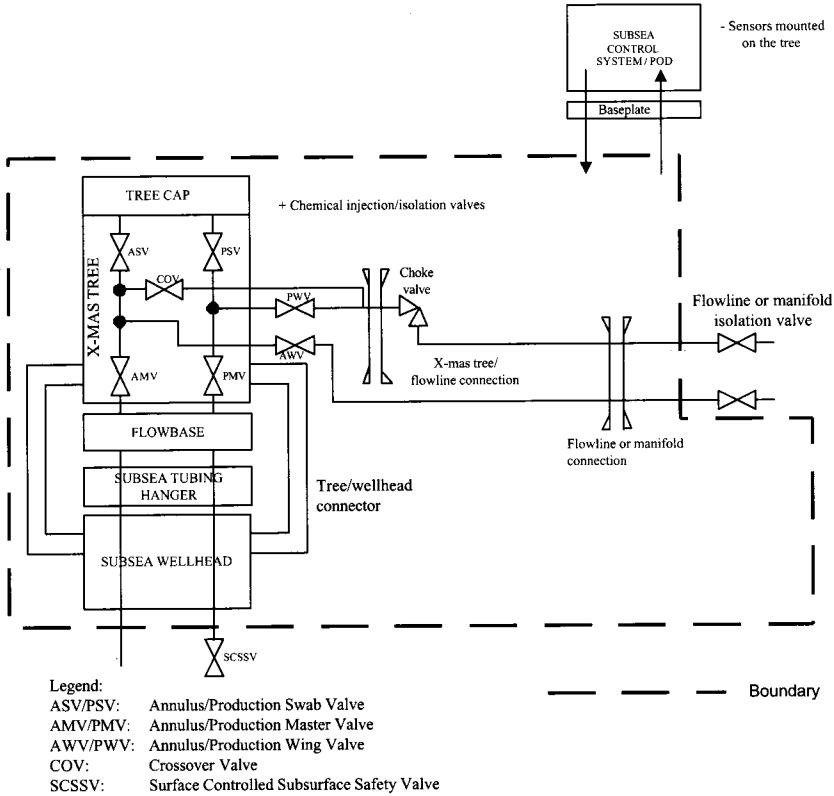


**Figure 3 - System hierarchy**

The failures and corrective maintenance actions are as shown in Figure 3 linked to the component where they occurred.

**EQUIPMENT BOUNDARIES**

The boundaries of what constitutes a subsea system and the various levels in the inventory need to be clearly defined to ensure that in-service times and failures are allocated correctly. A typical equipment level boundary used in OREDA is illustrated in Figure 4. Boundary details for the each equipment class are given in each equipment class chapter respectively.



**Figure 4 - Boundary definition, X-mas tree**

**INVENTORY DATA**

The inventory data are used to describe an equipment unit and its associated subunits and components, to be able to compare equal with equal and retrieve relevant data from the database. Furthermore, the inventory data may represent explanatory variables affecting the observed reliability.

These data are mainly of static character; i.e. they do not change in course of time. They are also recorded once for each item. Some are, however, of a more dynamic nature and may change during the surveillance period (e.g. no. of demands).

## FAILURE EVENT AND MAINTENANCE DATA

For each failure a description of the failure is given together with the maintenance/intervention (corrective action) carried out to restore the item to normal operating conditions. This information is divided in two event records:

- *Failure*; i.e. description of the failure event
- *Maintenance/intervention*; i.e. description of the maintenance action

These records contain a set of attributes describing the failure and maintenance action respectively. The attributes are based on numeric data, codes selected from a predefined menu, and free text description.

## ESTIMATION PROCEDURES

The main purpose of the OREDA-2002 handbook is to present average failure rate estimates together with repair time estimates. This section presents a brief description of the statistical methods that are used.

### FAILURE RATE

The *failure rate* function tells us how likely it is that an item that has survived up to time  $t$ , will fail during the next unit of time. If the item is deteriorating, this likelihood will increase with the age  $t$ . A man who has reached the age of 95 years will obviously have a higher probability of dying during the next year than a 20 years old man. The failure rate function will therefore usually be a function of the time - or, the age of the item.

To give a mathematical definition of the failure rate function, we start with the time to failure,  $T$ , of the item, i.e., the time from the item is put into operation until the first failure occurs. It is generally impossible to predict the exact value of the time to failure, and  $T$  will therefore be a random variable with some distribution. The failure rate function,  $\lambda(t)$ , may now be defined mathematically as:

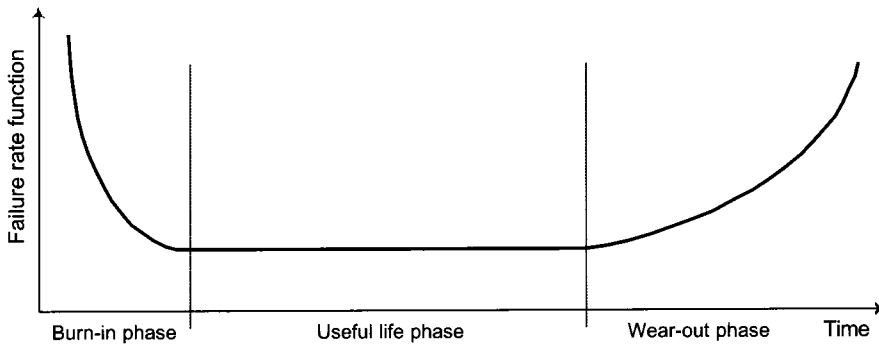
$$\lambda(t) \cdot \Delta t \approx \Pr(t < T \leq t + \Delta t \mid T > t)$$

The right hand side of this equation denotes “the probability that the item will fail in the time interval  $(t, t + \Delta t)$ , when the item is still functioning at time  $t$ ” or with other words: “the probability that an item that has reached the age  $t$  will fail in the next interval  $(t, t + \Delta t)$ .” The approximation is sufficiently accurate when  $\Delta t$  is the length of a very “short” time interval.

The failure rate function is sometimes also called ‘hazard rate’ or ‘force of mortality’.

The life of a technical item may generally be split into three different phases: the *burn-in* (or infant mortality) phase, the *useful life* phase, and the *wear-out* phase. The failure rate function will usually have different shapes in the three phases. As illustrated in Figure 5, the failure rate function may be decreasing in the burn-in phase, close to constant in the useful life phase, and increasing in the wear-out phase. The curve in Figure 5 is called a “bath-tub” curve because of its characteristic shape, and is often claimed to be a realistic model for mechanical equipment.

If we assume that the failure rate function is constant during the useful life phase, this means that the item is not deteriorating during this phase. The deterioration will start when, or if, the item enters the wear-out phase.



**Figure 5 Bath-Tub Shape of the Failure Rate**

So-called burn-in problems may be caused by inherent quality problems in the item, or by installation problems. Inherent quality problems may sometimes be removed by careful quality testing prior to installation. Installation problems have been disregarded in the OREDA data collection, notably for most *topside equipment*. The burn-in phase is therefore not included in the OREDA database, and we may assume that the data collection is started with the useful life phase. For subsea equipment data is collected on a whole lifetime basis, i.e. data collection starts when the equipment is installed and ready for its intended service. This means that the equipment may no necessarily have been

Many of the items covered in OREDA are subject to some maintenance or replacement policy. The items will thereby often be replaced or refurbished before they reach the wear-out phase.

The main part of the failure events in the OREDA database will therefore come from the useful life phase, where the failure rate is close to constant.

All the failure rate estimates presented in this handbook are therefore based on the assumption that the failure rate function is *constant* and independent of time, in which case  $\lambda(t) = \lambda$ .

#### Note

- No statistical tests have been performed to verify the assumption of a constant failure rate.
- Since data are assumed to come from “bottom” of the bath-tub curve, the failure rate estimates presented therefore represent some kind of minimum over the entire life cycle of the equipment.

An important implication of the constant failure rate assumption is that an item is considered to be “as good as new” as long as it is functioning. All failures are purely chance failures and independent of the age of the item.

The mean time to failure, MTTF, may be calculated as



$$MTTF = \frac{1}{\lambda}$$

These and related concepts are thoroughly discussed in e.g., Høyland and Rausand (1994).

**ESTIMATORS AND UNCERTAINTY LIMITS FOR A HOMOGENEOUS SAMPLE**

When we have failure data from identical items that have been operating under the same operational and environmental conditions, we have a so-called *homogeneous sample*. The only data we need to estimate the failure rate  $\lambda$  in this case, are the observed number of failures,  $n$ , and the aggregated time in service,  $\tau$ .

The estimator of  $\lambda$  is given by:

$$\hat{\lambda} = \frac{\text{Number of failures}}{\text{Aggregated time in service}} = \frac{n}{\tau}$$

See e.g. Høyland and Rausand (1994) for further details.

The aggregated time in service,  $\tau$ , may be measured either as calendar time or operating time, and both these are presented in the data tables in Part II.

Note that this approach is valid only in the following situations:

- Failure times for a specified number of items, with the *same* failure rate  $\lambda$ , are available.
- Data (several failures) is available for *one* item for a period of time, and the failure rate  $\lambda$  is constant during this period.
- A combination of the two above situations, i.e., there are several items where each item might have several failures. This is the typical situation for the OREDA data.

In the data tables in Part II of the handbook, estimates are given for each failure mode.

**Uncertainty intervals for the failure rate**

The uncertainty of the estimate  $\hat{\lambda}$  may be presented as a 90% confidence interval. This is an interval  $(\lambda_L, \lambda_U)$ , such that the “true value” of  $\lambda$  fulfils:

$$\Pr(\lambda_L \leq \lambda < \lambda_U) = 90\%$$

With  $n$  failures during an aggregated time in service  $\tau$ , this 90% confidence interval is given by:

$$\left( \frac{1}{2\tau} Z_{0.95,2n}, \frac{1}{2\tau} Z_{0.05,2(n+1)} \right)$$

where  $z_{0.95, v}$  and  $z_{0.05, v}$  denote the upper 95% and 5% percentiles, respectively, of the  $\chi^2$ -distribution with  $v$  degrees of freedom, see Table 4, page 31.

**Example**

Assume that  $n = 6$  failures have been observed during an aggregated time in service  $\tau = 10000$  hours.

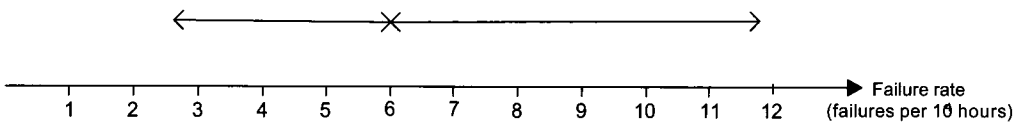
The failure rate estimate is then given by:

$$\hat{\lambda} = n / \tau = 6 \cdot 10^{-4} \text{ failures per hour}$$

and a 90% confidence interval is given by:

$$\left( \frac{1}{2\tau} z_{0.95, 2n}, \frac{1}{2\tau} z_{0.05, 2(n+1)} \right) = \left( \frac{1}{20000} z_{0.95, 12}, \frac{1}{20000} z_{0.05, 14} \right) = (2.6 \cdot 10^{-4}, 11.8 \cdot 10^{-4})$$

The estimate and the confidence interval are illustrated in Figure 6.



**Figure 6 Estimate and 90% Confidence Interval for the Example.**

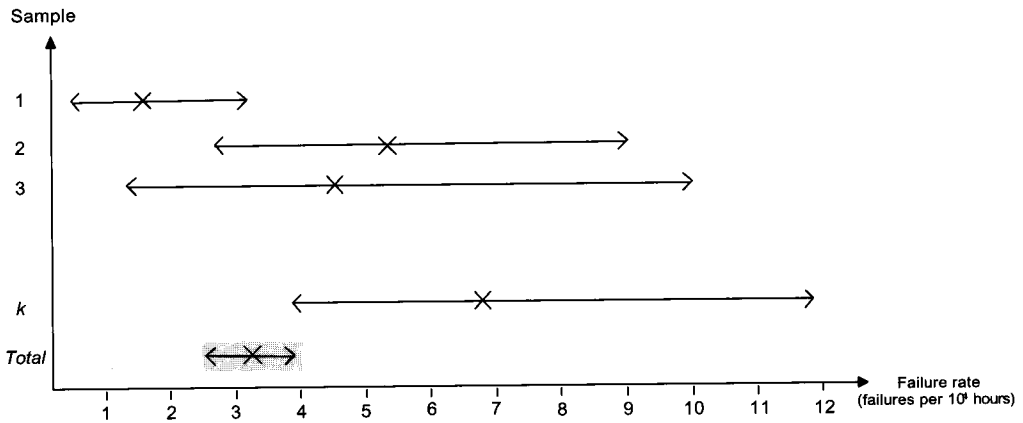
**Note**

The given interval is a confidence interval for the failure rate for the items we have data for. There is no guarantee that items installed in the future will have a failure rate within this interval.

**MULTI-SAMPLE PROBLEMS**

In many cases we do not have a homogeneous sample of data. The aggregated data for an item may come from different installations with different operational and environmental conditions, or we may wish to present an “average” failure rate estimate for slightly different items. In these situations we may decide to merge several more or less homogeneous samples, into what we call a multi-sample.

The various samples may have different failure rates, and different amounts of data - and thereby different confidence intervals. This is illustrated in Figure 7.



**Figure 7 Multi-Sample Problem**

To merge all the samples, and estimate the “average” failure rate as the total number of failures divided by the aggregated time in service will not always give an adequate result. The 'confidence' interval will especially be unrealistically short, as illustrated in Figure 7. We therefore need a more advanced estimation procedure to take care of the multi-sample problem.

Below, the so-called OREDA-estimator of the “average” failure rate in a multi-sample situation is presented together with a 90% uncertainty interval. Spjøtvoll (1985) gives a rationale for the estimation procedure.

The OREDA-estimator is based on the following assumptions:

- We have  $k$  different samples. A sample may e.g., correspond to a platform, and we may have data from similar items used on  $k$  different platforms.
- In sample no.  $i$  we have observed  $n_i$  failures during a total time in service  $\tau_i$ , for  $i = 1, 2, \dots, k$ .
- Sample no.  $i$  has a constant failure rate  $\lambda_i$ , for  $i = 1, 2, \dots, k$ .
- Due to different operational and environmental conditions, the failure rate  $\lambda_i$  may vary between the samples.

The variation of the failure rate between samples may be modelled by assuming that the failure rate is a random variable with some distribution given by a probability density function  $\pi(\lambda)$ .

The mean, or “average” failure rate is then:  $\theta = \int_0^{\infty} \lambda \cdot \pi(\lambda) d\lambda$ .

and the variance is:  $\sigma^2 = \int_0^{\infty} (\lambda - \theta)^2 \cdot \pi(\lambda) d\lambda$ .

To calculate the multi-sample OREDA-estimator, the following procedure is used:

1. Calculate an initial estimate  $\hat{\theta}_1$  of the mean (“average”) failure rate  $\theta$ , by pooling the data:

$$\hat{\theta}_1 = \frac{\text{Total no. of failures}}{\text{Total time in service}} = \frac{\sum_{i=1}^k n_i}{\sum_{i=1}^k \tau_i}$$

2. Calculate:

$$S_1 = \sum_{i=1}^k \tau_i$$

$$S_2 = \sum_{i=1}^k \tau_i^2$$

$$V = \sum_{i=1}^k \frac{(n_i - \hat{\theta}_1 \tau_i)^2}{\tau_i} = \sum_{i=1}^k \frac{n_i^2}{\tau_i} - \hat{\theta}_1^2 S_1$$

3. Calculate an estimate for  $\sigma^2$ , a measure of the variation between samples, by:

$$\hat{\sigma}^2 = \frac{V - (k-1)\hat{\theta}_1^2}{S_1^2 - S_2} \times S_1 \quad \text{when greater than 0, else 0.}$$

4. Calculate the final estimate  $\theta^*$  of the mean (“average”) failure rate  $\theta$  by:

$$\theta^* = \frac{1}{\sum_{i=1}^k \frac{1}{\frac{\hat{\theta}_1}{\tau_i} + \hat{\sigma}^2}} \times \sum_{i=1}^k \left( \frac{1}{\frac{\hat{\theta}_1}{\tau_i} + \hat{\sigma}^2} \times \frac{n_i}{\tau_i} \right)$$

5. Let  $SD = \hat{\sigma}$

In the data tables in Part II of the handbook  $\theta^*$  corresponds to the mean (column 4), and  $SD$  corresponds to the standard deviation (column 6).

The *lower* and *upper* “uncertainty” values are given by:

$$\int_{\text{Lower}}^{\text{Upper}} \pi(\lambda) \, d\lambda = 90\%$$

Since the distribution  $\pi(\lambda)$  is not known in advance, the following pragmatic approach is used:

6.  $\pi(\lambda)$  is assumed to be the probability density function of a *Gamma* distribution with parameters  $\alpha$  and  $\beta$ .
7. The parameters  $\alpha$  and  $\beta$  are estimated by:

$$\hat{\beta} = \frac{\theta^*}{\hat{\sigma}^2}$$

$$\hat{\alpha} = \hat{\beta} \cdot \theta^*$$

8. The following formulas are now applied:

$$Lower = \frac{1}{2\hat{\beta}} z_{0.95, 2\hat{\alpha}}$$

$$Upper = \frac{1}{2\hat{\beta}} z_{0.05, 2\hat{\alpha}}$$

where  $z_{0.95, v}$  and  $z_{0.05, v}$  denote the *upper* 95% and 5% percentiles, respectively, of the  $\chi^2$ -distribution with  $v$  degrees of freedom, see Table 4, page 31. In situations where  $v$  is not an integer, an interpolation in the  $\chi^2$ -distribution is performed.

#### Note 1

More detailed analysis of the OREDA data (see Vatn 1993) has indicated that there may be a large variation between installations. The multi-sample OREDA estimator should therefore as a rule be used instead of the  $n/\tau$  estimator which is based on a homogeneous sample. The variation between the samples (installations) is measured by the standard deviation SD.

#### Note 2

In the OREDA-84 and OREDA-92 handbooks, a slightly different approach was taken. The mean value was estimated with the same procedure as in this handbook, but the *lower* and *upper* values were given a slightly different interpretation.

#### Note 3

In the case of  $k = 1$ , the procedure cannot be used. In this case the  $n/\tau$  estimate is given for the mean, and the *lower* and *upper* values should be interpreted as a traditional 90% confidence interval.

#### Note 4

If no failures are observed for an item, the following approach is used to obtain lower, mean and upper values for "All failure modes":

1. Let  $\hat{\lambda}_p$  denote the failure rate estimate ("mean") one level up in the taxonomy hierarchy.

2. Let  $\tau$  denote the total time in service (operational or calendar) for the item of interest
3. Let

$$\alpha = 1/2$$

$$\beta = \frac{1}{2\hat{\lambda}_p} + \tau$$

4. An estimate for the failure rate is now

$$\hat{\lambda} = \frac{\alpha}{\beta}$$

5. The standard deviation is given by

$$SD = \sqrt{\frac{\alpha}{\beta^2}}$$

6. A 90% uncertainty interval is given by

$$\left( \frac{1}{2\beta} z_{0.95,2\alpha}, \frac{1}{2\beta} z_{0.05,2\alpha} \right) = \left( \frac{0.002}{\beta}, \frac{1.9}{\beta} \right)$$

**ESTIMATION OF DEMAND PROBABILITIES**

If information about “number of demands” is given (see Section “Data table, Reliability Data”, page 32) it is possible to estimate the demand probability. The demand probability is always related to one specific failure mode, for example a critical fail to start. The demand failure probability is estimated by:

$$\hat{p} = \frac{n}{d}$$

where  $n$  is the number of failures with the appropriate failure mode, and  $d$  is the number of demands. Note that in the data table presentations the demand probabilities may apparently look different. The reason for this is that in some cases there are registered “demand failures”, but the number of demands is not recorded for one or more inventories. For these inventories, the demand failures are not added to the total number of demand failures for that data table.

**PERCENTAGE POINTS OF THE CHI-SQUARE DISTRIBUTION**

**Table 4 Percentage Points of the Chi-square ( $\chi^2$ ) Distribution**

$\Pr(Z > z_{\alpha, \nu}) = \alpha$

$\nu/\alpha$	0.995	0.990	0.975	0.950	0.05	0.025	0.010	0.005
1	0.00	0.00	0.00	0.00	3.84	5.02	6.63	7.88
2	0.01	0.02	0.05	0.10	5.99	7.38	9.21	10.60
3	0.07	0.11	0.22	0.35	7.81	9.35	11.34	12.84
4	0.21	0.30	0.48	0.71	9.49	11.14	13.28	14.86
5	0.41	0.55	0.83	1.15	11.07	12.38	15.09	16.75
6	0.68	0.87	1.24	1.64	12.59	14.45	16.81	18.55
7	0.99	1.24	1.69	2.17	14.07	16.01	18.48	20.28
8	1.34	1.65	2.18	2.73	15.51	17.53	20.09	21.96
9	1.73	2.09	2.70	3.33	16.92	19.02	21.67	23.59
10	2.16	2.56	3.25	3.94	18.31	20.48	23.21	25.19
11	2.60	3.05	3.82	4.57	19.68	21.92	24.72	26.76
12	3.07	3.57	4.40	5.23	21.03	23.34	26.22	28.30
13	3.57	4.11	5.01	5.89	22.36	24.74	27.69	29.82
14	4.07	4.66	5.63	6.57	23.68	26.12	29.14	31.32
15	4.60	5.23	6.27	7.26	25.00	27.49	30.58	32.80
16	5.14	5.81	6.91	7.96	26.30	28.85	32.00	34.27
17	5.70	6.41	7.56	8.67	27.59	30.19	33.41	35.72
18	6.26	7.01	8.23	9.39	28.87	31.53	34.81	37.16
19	6.84	7.63	8.91	10.12	30.14	32.85	36.19	38.58
20	7.43	8.26	9.59	10.85	31.41	34.17	37.57	40.00
25	10.52	11.52	13.12	14.61	37.65	40.65	44.31	46.93
26	11.16	12.20	13.84	15.38	38.89	41.92	45.64	48.29
27	11.81	12.88	14.57	16.15	40.11	43.19	46.96	49.64
28	12.46	13.56	15.31	16.93	41.34	44.46	48.28	50.99
29	13.12	14.26	16.05	17.71	42.56	45.72	49.59	52.34
30	13.79	14.95	16.79	18.49	43.77	46.98	50.89	53.67
40	20.71	22.16	24.43	26.51	55.76	59.34	63.69	66.77
50	27.99	29.71	32.36	34.76	67.50	71.42	76.15	79.49
60	35.53	37.48	40.48	43.19	79.08	83.30	88.38	91.95
70	43.28	45.44	48.76	51.74	90.53	95.02	100.42	104.22
80	51.17	53.54	57.15	60.39	101.88	106.63	112.33	116.32
90	59.20	61.75	65.65	69.13	113.14	118.14	124.12	128.30
100	67.33	70.06	74.22	77.93	124.34	129.56	135.81	140.17

## TOPSIDE DATA TABLE FORMATS

### DATA TABLE, RELIABILITY DATA

Each data table contains an identification of the item and the estimated reliability parameters. The figures provided should be interpreted on the basis of the assumptions specified in the boundary definition for each equipment category and the estimation method applied. The format of the data table is shown in Figure 8.

Taxonomy no		Item												
Population	Installations	Aggregated time in service (10 <sup>6</sup> hours)					No of demands							
		Calendar time *			Operational time †									
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)						
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max				
Comments														

**Figure 8 Format of the Reliability Data Tables**

The various entries of the data table are explained in the following:

***Taxonomy number and Item***

The taxonomy number is a numerical identification of the item. The description of the item is given in a hierarchical structure. Only data from items of this generic category of components/equipment are input to the estimates presented in the quantitative part of the data table.

***Population***

Total number of items forming the basis for the estimates.

***Installations***

Total number of installations (platforms) covered by the data surveillance for the item in question.



***Aggregated time in service***

Two types of time scales are presented as the basis for the failure rate estimates; calendar time and operational time. The aggregated time in service for the total population is given for both time scales. Note that while the calendar time is given with high certainty, the operational time has in many cases to be based on estimates (by the data collector).

***Number of demands***

The accumulated number of demands/cycles for the total population is given when available. In several cases these numbers are based on estimates and not accurate measurements.

***Failure mode***

This column contains a brief description of the manner in which the failure occurred, when such information is available.

***Number of failures***

The total number of failure events is presented for each failure mode. The accumulated number of failures is presented as "All modes".

***Failure rate***

The failure rate columns present estimates of the failure rate for each failure mode. Results are given both under the "multi-sample" assumption, and under the assumption of homogeneous data sets. In the multi-sample situation the failure rate is assumed to vary between installations (platforms), and each platform represents one sample. The following entries are included:

<i>Mean</i>	An estimate of the "average" failure rate with respect to the specified failure mode, obtained by using the OREDA estimator.
<i>(Lower, Upper)</i>	A 90% uncertainty interval for the failure rate.
<i>SD</i>	A standard deviation indicating the variation between the multiple samples.
<i>n/τ</i>	The total number of failures divided by the total time in service, i.e., the estimate of the failure rate we would use for a homogeneous sample.

All the entries are measured per  $10^6$  hours and refer either to calendar time (marked \*) or operational time (marked †).

**Active repair time (hours)**

This column contains the average calendar time (hours) required to repair and return the item to a state where it is ready to resume its functions. Active repair time is the time when actual repair work is being done. It does not include time to shut down the unit, issue work order, wait for spare parts, start-up after repair etc. The active repair time is therefore normally shorter than the *downtime* where some of the activities indicated above may be included.

**Note:**

During the data collection exercises it has been very difficult to obtain data regarding active repair times. In the OREDA database there is a good coverage of “restoration man-hours” data, whereas the data for “active repair time” is rather sparse. It should also be noted that active repair hours are highly influenced by how maintenance is organised on the platform. The figures for active repair times should therefore only be used as an indication of what the actual active repair times would be. It is highly recommended to use some kind of expert judgement in addition to the values given in the handbook.

**Repair (manhours)**

The repair columns present three values of the repair time (man-hours). The *mean* value is the average number of man-hours recorded to repair the failure and restore the function. The *min* and *max* values are the lowest and highest number of man-hours recorded for the repair of the item.

**Comments**

When available the on on-demand failure probability is given in the Comment field.

**DATA TABLE, MAINTAINABLE ITEM VERSUS FAILURE MODE**

The reliability data presented in the data table in Figure 8 (page 32) does not give information on which part of the equipment has failed. In the *Maintainable Item versus Failure Mode* listing the relative contribution from each maintainable item to the total failure rate may be obtained. The figures in the table represent *percentages of occurrence* for each combination of failure mode and maintainable item. The row sum represents the total percentage of failures that are related to the actual maintainable item. Note that several maintainable items might be assigned to each failure record. In such situations, the “score” for the actual maintainable item/failure mode combination is set to  $1/n$ , where  $n$  is the number of maintainable items listed for that failure record. The column sum represents the contribution for each failure mode in percentages.

This information is valuable input to an FMEA/FMECA analysis. The FMEA/FMECA analysis is further a major part of a reliability centred maintenance (RCM) analysis. As the RCM methodology focuses on failure causes, it is also important to have information regarding failure causes as discussed in the next section. Note that several maintainable items might be assigned to each failure record.

**DATA TABLE, FAILURE DESCRIPTOR VERSUS FAILURE MODE**

In the *Failure Descriptor versus Failure Mode* listing the relative contribution from each failure descriptor (cause) to the total failure rate may be obtained. The figures in the table represent percentages of occurrence for each combination of failure descriptor and failure mode. The row sum represents the total percentage of failures that are related to the actual failure descriptor. The column sum represents the contribution for each failure mode in percentages.

As mentioned above, the information about failure causes is essential in an RCM analysis. For example scheduled replacement of units is only applicable if one or more failure causes may be related to ageing, wear, corrosion etc.

## SUBSEA DATA TABLE FORMATS

### DATA TABLE, RELIABILITY DATA

Each data table contains an identification of the item and the estimated reliability parameters. The figures provided should be interpreted on the basis of the assumptions specified in the boundary definition for each equipment category and the estimation method applied. The format of the data table is shown in Figure 8.

Taxonomy no		Item											
Population	Installations						Aggregated time in service (10 <sup>6</sup> hours)						
		Failure data					Calendar time						
Component	No of units	#	Severity class				Failure rate (per 10 <sup>6</sup> hours).					Active repair time (hours)	
			C	D	I	U	Lower	Mean	Upper	SD	n/τ	Mean	
<b>Subunit no. 1</b> Component no. 1 Component no..2													
<b>Subunit no. 2</b> Component no....													
<b>Equipment level</b>													
<b>Comments</b> For components with no failures, n is set to 0.5 based on a non-informative prior. * Mean failure for the common component is used in the estimator.													

**Figure 9 Format of the Reliability Data Tables**

The various entries of the data table are explained in the following:

#### *Taxonomy number and Item*

The taxonomy number is a numerical identification of the item. The description of the item is given in a hierarchical structure. Only data from items of this generic category of components/equipment are input to the estimates presented in the quantitative part of the data table.

#### *Population*

Total number of items forming the basis for the estimates.

#### *Installations*

Total number of installations (platforms) covered by the data surveillance for the item in question.

**Aggregated time in service**

The aggregated time in service for the total population is given for calendar time scale for the equipment unit level. A subunit and its related component(s) may have different calendar time recorded as the latter is recorded individually for each subunit and component in the database.

**Component**

This column contains the list of subunits and component for which the failure data is presented. The subunits are in bold letters. The equipment unit level data are presented in the last row. The number of items on each level is listed in the table.

**Number of failures**

The total number of failure events (#) is presented for each subunit and component. The criticality distribution is given for each item i.e. critical (C), degraded (D), incipient (I) and unknown (U).

**Failure rate**

The failure rate columns present estimates of the failure rate for each subunit and component. Results are given both under the “multi-sample” assumption, and under the assumption of homogeneous data sets. In the multi-sample situation the failure rate is assumed to vary between installations (platforms), and each platform represents one sample. The following entries are included:

<i>Mean</i>	An estimate of the “average” failure rate with respect to the specified failure mode, obtained by using the OREDA estimator.
<i>(Lower, Upper)</i>	A 90% uncertainty interval for the failure rate.
<i>SD</i>	A standard deviation indicating the variation between the multiple samples.
<i>n/τ</i>	The total number of failures divided by the total time in service, i.e., the estimate of the failure rate we would use for a homogeneous sample.

All the entries are measured per  $10^6$  hours and refer to calendar time.

**Active repair time (hours)**

This column contains the elapsed calendar time (hours) required to repair and return the item to a state where it is ready to resume its functions. This is the part of the total repair time used on-site. The *mean* value is the average number of hours recorded to repair the failure and restore the function. Active repair time should not be mixed with *downtime* which may additionally include time periods such as shutdown, repair vessel mobilisation, start-up after repair etc.

**Comments**

The comment field presents comments to the calculation of failure rates.

For components with no failures,  $n$  is set to 0.5 based on a non-informative prior.  
\* Mean failure for the common component is used in the estimator.

### **DATA TABLE, COMPONENT VERSUS FAILURE MODE**

The reliability data presented in the data table in Figure 8 (page 32) give information on which part of the equipment has failed. The *Component versus Failure Mode* lists the number failure modes for each component. The figures in the table represent number of occurrence for each combination of failure mode and component. The row sum represents the total number of failures that are related to the actual component. The column sum represents the total number of each failure mode.

This information is valuable input to an FMEA/FMECA analysis (see e.g. IEC 812). The FMEA/FMECA analysis is further a major part of a reliability centred maintenance (RCM) analysis (see e.g. Rausand and Vatn 1997). As the RCM methodology focuses on failure causes, it is also important to have information regarding failure causes as discussed in the next section.

### **DATA TABLE, SUBUNIT VERSUS FAILURE MODE**

The *Subunit versus Failure Mode* lists the number of failure modes for each subunit. The figures in the table represent number of occurrence for each combination of failure mode and subunit. The row sum represents the number of failures that are related to the actual subunit. The column sum represents the number of each failure mode.

### **DATA TABLE, EQUIPMENT UNIT VERSUS FAILURE MODE**

The *Equipment unit versus Failure Mode* table lists the number of failure modes at the equipment unit level.

### **DATA TABLE, FAILURE DESCRIPTOR VERSUS FAILURE MODE**

In the *Failure Descriptor versus Failure Mode* listing the relative contribution from each failure descriptor (cause) to the total failure rate may be obtained. The figures in the table represent percentages of occurrence for each combination of failure descriptor and failure mode. The descriptor is presented for each component. The row sum represents the total percentage of failures that are related to the actual failure descriptor for each component. The column sum represents the contribution for each failure mode in percentages.

## MISCELLANEOUS ESTIMATION PROCEDURES

### NO FAILURES ARE OBSERVED FOR A SPECIFIC FAILURE MODE

In the data tables failure rate estimates are only presented for those failure modes for which failures have been recorded. The standard failure rate estimate in this situation is  $\hat{\lambda} = 0$ . An alternative procedure for estimating the failure rate in this situation is given under Note 4 on page 29. To use the procedure, the term “*All failure modes*” should be replaced with the failure mode of interest. Further information may be obtained from the Internet address:

<http://www.sintef.no/oreda/analysis/>

### WEIGHTING OREDA-2002 DATA WITH OTHER DATA SOURCES

In many RAMS analyses, data may also be available from other sources than this handbook. For offshore RAMS analyses, the most obvious data source in addition to this book, is the previous handbooks. A method for weighting data from OREDA-97 and OREDA-2002 is given below. The method is based on an approach suggested in the OREDA Data Analysis Guidelines (Vatn 1993).

The calculations are repeated for all failure modes of interest. Let  $\lambda_{III}$  denote the mean failure rate for Phase IV and V data (column 4) in the OREDA-2002 handbook. Further, let  $SD_{III}$  denote the standard deviation in column 6.  $\lambda_{II}$  is the corresponding mean in the OREDA-97 handbook. A weighted failure rate estimate is given by:

$$\hat{\lambda} = \frac{\lambda_{II}^2 + \lambda_{III}^2 \left( \frac{\lambda_{II}}{\lambda_{III}} + \frac{|\lambda_{II} - \lambda_{III}|}{SD_{III}} \right)^2}{\lambda_{II} + \lambda_{III} \left( \frac{\lambda_{II}}{\lambda_{III}} + \frac{|\lambda_{II} - \lambda_{III}|}{SD_{III}} \right)^2}$$

where  $|x|$  denotes the absolute value of  $x$ .

If in addition, standard deviation and uncertainty limits are required, please consult the Internet address:

<http://www.sintef.no/oreda/analysis/>

where also a rationale for the above procedure is given.

## DEFINITIONS<sup>3</sup>

The main terminology used in the OREDA-97 handbook is defined in this section. The specific definitions of the terminology and parameters used in the statistical estimation procedures are included in the section “Estimation Procedures”.

Terms marked with (C) are categorised in pre-defined codes.

### *Active Repair Time*

Active repair time is the total (calendar) time required to repair and return the item to a state where it is ready to resume its functions.

This excludes the time to detect the failure, time to isolate the equipment from the process before repair, delay and waiting for spare parts or tools, and any time after the repair has been completed if the item is not put into service immediately. Time for testing is included when such testing is an integrated part of the repair activity.

### *Boundary*

The interface between an item and its surroundings.

### *Calendar Time*

The interval of time between the start and end of data surveillance for a particular item.

### *Component (C) – Subsea*

These are subsets of each subunit (subsea inventory) and will typically consist of the lowest level items that are repaired/replaced as a whole (e.g. valve, sensor etc.).

### *Equipment unit*

The highest indenture level including subunits and smaller entities belonging to that equipment unit. Equipment unit corresponds in most cases to tag number for topside equipment.

### *Failure*

The termination or the degradation of the ability of an item to perform its required function(s). It includes:

- Complete failure of the item
- Failure of part of the item that causes unavailability of the item for corrective action
- Failure discovered during inspection, testing, or preventive maintenance that requires repair
- Failure on safety devices or control/monitoring devices that necessitates shutdown, or reduction of the items capability below specified limits.

The following outages are not considered as failures:

- Unavailability due to preventive or planned maintenance

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<sup>3</sup> Useful definitions related to this Handbook will also be found in the standards ISO 14224 and NORSOK Z016.



- Shutdown of the item due to external conditions, or where no physical failure condition of the item is revealed. A shutdown is not to be considered a failure unless there is *some recorded maintenance activity*.

A required function is defined as any function necessary to maintain the item's capability of providing its output at specified capacity and quality. Note that a failure could be either complete loss of function or function degradation below an acceptable limit.

*A failure will normally require a work order and involvement by maintenance personnel.*

### **Failure Descriptor (C)**

An attribute of the failure event that can be easily deduced technically. The failure descriptor is the *apparent, immediate cause* of the failure and is related to *subunit level*.

### **Failure Mode (C)**

The effect by which a failure is observed on the failed unit. The failure modes describe the loss of required system function(s) that result from failures, or an undesired change in state or condition. The failure mode is related to the equipment unit level. The failure mode is a description of the various abnormal states/conditions of an equipment unit, and the possible transition from correct to incorrect state.

The failure mode can be subdivided in two major classes:

1. Demanded change of state is not achieved
2. Undesired change in conditions (state)

The first class typically comprises events like fail-to-start/stop and fail-to-open/close, i.e. directly related to a failure of the *function* of the unit. The latter category can either be related to *function* and *condition* as follows:

- a) Undesired change in *manner of operation* (e.g. spurious stop, high output)
- b) Undesired *change of condition* (e.g. vibration, leakage). This category does not affect the function immediately, but may do so if not attended to within a reasonable time.

(See e.g., Rausand and Øien (1996) for a thorough discussion of failures and failure modes).

### **Item**

A common term used to denote any level of hardware assembly; i.e. equipment unit, subunit, maintainable items and parts.

### **Maintainable Item (C)**

An item that constitutes an assembly of parts that are normally the lowest indenture level during maintenance.

***Number of Demands***

The total number of times an item is required to perform its specified function(s) during the calendar time.

***Operational Time***

The period of time during which a particular item performs its required function(s), between the start and end of data surveillance.

***Population***

The total number of items of one particular type in service during the period of the event data surveillance.

***Sample***

The group of items of one particular type in service - described by its taxonomy code - on one installation during the period of the event data surveillance.

***Severity Class Types (C)***

**CRITICAL FAILURE:** A failure which causes immediate and complete loss of a system's capability of providing its output.

**DEGRADED FAILURE:** A failure which is not critical, but which prevents the system from providing its output within specifications. Such a failure would usually, but not necessarily, be gradual or partial, and may develop into a critical failure in time.

**INCIPIENT FAILURE:** A failure which does not immediately cause loss of a system's capability of providing its output, but which, if not attended to, could result in a critical or degraded failure in the near future.

**UNKNOWN:** Failure severity was not recorded or could not be deduced.

The severity class is used to describe effect on operational status and the severity of loss of output from the system. Each failure has been associated with only one severity class, either critical, degraded or incipient, *independently of the failure mode and failure cause*. The severity classification is confined to the location and use of the *equipment unit* that has failed.

***Subunit (C) - Topside***

An assembly of items that provides a specific function that is required for the equipment unit to achieve its intended performance. Corresponds frequently with sub-tag number(s).

***Subunit (C) - Subsea***

A subsea equipment unit is subdivided in several subunits, each with function(s) required for the *equipment unit* to perform its main function. Typical subunits are e.g. umbilical, HPU etc. The subunits may be redundant, e.g. two independent HPUs.

***Taxonomy (C)***

A systematic classification of items into generic groups based on factors possibly common to several of the items, e.g. functional type, medium handled.

## REFERENCES

- A. Høyland and M. Rausand. *Reliability Theory; Models and Statistical Methods*. John Wiley & Sons, New York, 1994.
- IEC 812. *Analysis Techniques for System Reliability - Procedures for Failure Modes and Effects Analysis (FMEA)*. International Electrotechnical Commission, Geneva, 1985.
- ISO 14224. *Petroleum and natural gas industries - Collection and exchange of reliability and maintenance data for equipment*. International Standards Organisation.
- NORSOK Z016. *Regularity Management & Reliability Technology*. NORSOK standard issued 2000 by NTS (norsok@nts.no)
- OREDA-84. *Offshore Reliability Data*. DNV-Technica, P.O.Box 300, 1322 Høvik, Norway, 1<sup>st</sup> edition, 1984.
- OREDA-92. *Offshore Reliability Data*. Det Norske Veritas (DNV), P.O.Box 300, 1322 Høvik, Norway, 2 edition, 1992.
- OREDA-97. *Offshore Reliability Data*. Prepared by SINTEF and marketed by DNV. 3<sup>rd</sup> edition, 1997.
- M. Rausand and K. Øien. *The basic concepts of failure analysis*. Reliability Engineering and System Safety, 53:73-83, 1996.
- M. Rausand and J. Vatn. *Reliability Centered Maintenance*. In C. G. Soares, editor, Risk and Reliability in Marine Technology. Balkema, Holland, 1997.
- E. Spjøtvoll. *Estimation of failure rate from reliability data bases*. In 'Society of Reliability Engineers' Symposium (1985: Trondheim).
- J. Vatn. *OREDA Data Analysis Guidelines*. Technical Report STF75 A93024, SINTEF Industrial Management, N-7465 Trondheim, Norway, 1993.
- H. Sandtorv. *Experience with the collection, quality control and application of an offshore R&M database*. Workshop on QRA databases. London 1993.
- H. Sandtorv et al.: *Practical experience with a data collection project - The OREDA project*. Reliability Engineering and System Safety. 1995
- K. Haugen et al: *The analysis of failure data in presence of critical and degraded failures*. EsRel Conference in Bournemouth 1995.
- K. Haugen et al.: *Analysis of OREDA data for maintenance optimisation*. Conference on Safety and Reliability in Industrial management. Trondheim May 1996.
- P. Hokstad et al.: *Estimation of average rate of occurrence of failures*. EsRel '96.
- H. Sandtorv: *Quality of reliability databanks*. EsReDa conference on quality of reliability data. Stockholm 1998.
- H. Sandtorv: *Problems and solution with the collection of reliability data from different data sources*. EsRel'99 Munich.
- H. Sandtorv: *Evolution of operation experience data collection methods*. EsReDa Conference 2000 in Lyon.
- R. Østebø et al.: *Subsea reliability performance - oil & gas industry*. Deep Offshore Technology Conference. 2000 in New Orleans.

## **PART II**

# **Reliability Data Presentation**

# RELIABILITY DATA PRESENTATION

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**PREFACE**

Part II of the Handbook present numeric failure and maintenance data for the various equipment classes as described in Part I. Part II is organised as follows:

The equipment classes are categorised in 5 major categories, as shown in the following table:

<b>System</b>	<b>Equipment class</b>
<i><b>Machinery</b></i>	- Compressors - Gas Turbines - Pumps - Combustion engines - Turboexpanders
<i><b>Electric equipment</b></i>	- Electric generators - Electric motors
<i><b>Mechanical equipment</b></i>	- Heat exchangers - Vessels - Heaters and boilers
<i><b>Control and safety equipment</b></i>	- Fire & Gas detectors - Process sensors - Valves
<i><b>Subsea equipment</b></i>	- Common components - Control systems - Manifold - Flowline - Subsea Isolation System - Risers - Running tool - Wellhead & X-mas tree

1. For each equipment class (e.g. compressors) there is an Inventory description at the start of the respective chapter that contains:

- Descriptive part
- Boundary diagram
- Subdivision in 'Subunits' and 'Maintainable Items'
- List of failure modes

2. Then the data tables described in Part I with failure and maintenance data are given for the whole equipment class population (i.e. all compressors). Similarly the cross-tabulation of failure modes and failure descriptors/maintainable items is also given for the whole equipment class.
3. Next, the equipment class is split in more narrow taxonomy classes (e.g. centrifugal compressors) and the same tables as indicated above are presented for each of those taxonomy classes. Note that the split into various taxonomy classes may be between equipment classes. The guiding rule has been to retain a population of similar design, size, performance and any other characteristics that has been deemed appropriate and at the same time keeping the size of the book within a manageable level.

MACHINERY

Compressors

Inventory description

The compressor driver along with auxiliary systems such as lubrication, cooling and start systems for driver are not included within the compressor boundary as shown in Figure 10. Driver units are recorded as separate OREDA inventories (Electric Motor, Gas Turbine or Combustion Engine) and the failures on the driver, if recorded, are recorded separately for each of those driver categories.

A compressor train is considered as one inventory in OREDA. (Each compressor train may consist of up to four compressor stages either as separate units (casings) or integrated in one compressor unit).

For compressors with a common lub.oil- and seal oil system, failures are as a general rule assigned to the subunit that is assumed to be the one most affected. Otherwise the failures are assigned to the lub.oil system. Inlet and outlet valves are not within the boundary. The boundary definition is shown in Figure 10, and the subdivision in Subunits and Maintainable Items are shown in Table 5.

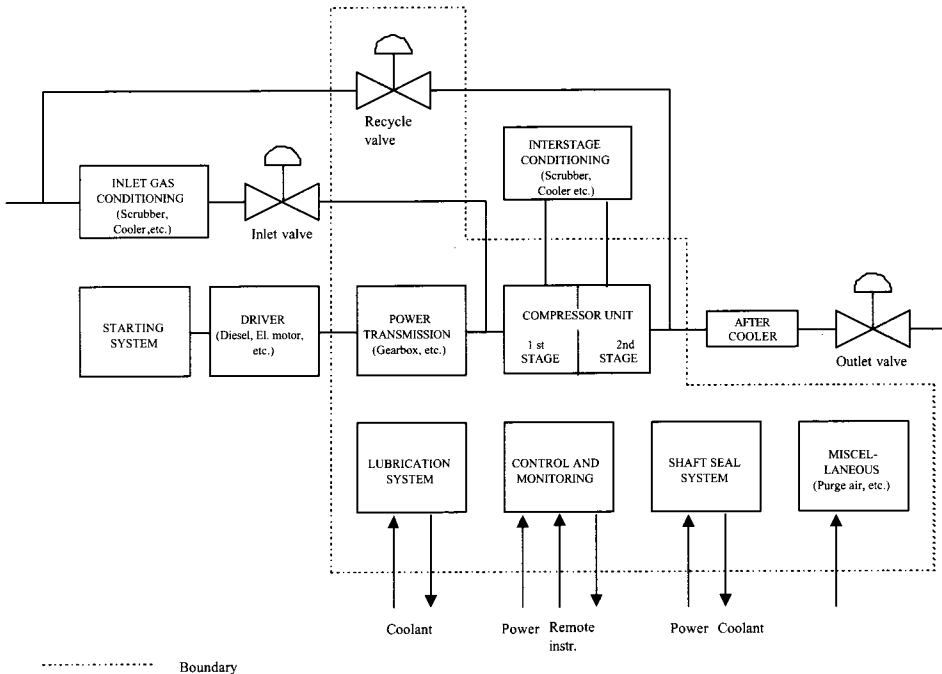


Figure 10 Compressors, Boundary Definition

**Table 5 Compressors, Subdivision in Maintainable Items**

COMPRESSOR					
Power transmission	Compressor unit	Control and Monitoring	Lubrication system	Shaft seal system	Miscellaneous
<ul style="list-style-type: none"> <li>• Gearbox</li> <li>• Bearing</li> <li>• Seals</li> <li>• Lubrication</li> <li>• Couplings</li> <li>• Instruments</li> </ul>	<ul style="list-style-type: none"> <li>• Antisurge system</li> <li>• Casing</li> <li>• Cylinder liner</li> <li>• Instruments</li> <li>• Shaft seals</li> <li>• Radial bearing</li> <li>• Thrust bearing</li> <li>• Interstage seals</li> <li>• Valves &amp; piping</li> <li>• Piston<sup>4</sup></li> <li>• Packing</li> <li>• Rotor w/impellers</li> </ul>	<ul style="list-style-type: none"> <li>• Instruments</li> <li>• Cabling, junction box etc.</li> <li>• Control unit</li> <li>• Actuating device</li> <li>• Monitoring</li> <li>• Internal power supply</li> <li>• Valves</li> </ul>	<ul style="list-style-type: none"> <li>• Reservoir w/heating system</li> <li>• Pump w/motor</li> <li>• Filter</li> <li>• Cooler</li> <li>• Valves &amp; piping</li> <li>• Oil</li> <li>• Instruments</li> <li>• Seals</li> </ul>	<ul style="list-style-type: none"> <li>• Buffer gas system</li> <li>• Dry gas seal</li> <li>• Instruments</li> <li>• Overhead tank</li> <li>• Reservoir</li> <li>• Scrubber</li> <li>• Pump w/motor/gear</li> <li>• Filter</li> <li>• Valves</li> <li>• Seal gas</li> <li>• Seal oil</li> </ul>	<ul style="list-style-type: none"> <li>• Base frame</li> <li>• Cooler</li> <li>• Valves</li> <li>• Magnetic bearing control system</li> <li>• Piping</li> <li>• Purge air</li> <li>• Silencers</li> </ul>

(For all subunits the MIs "Unknown" and "Subunit" are included.)

<sup>4</sup> Reciprocating compressor only



**List of failure modes**

AIR	Abnormal instrument reading
BRD	Breakdown
ERO	Erratic output
ELP	External leakage - Process medium
ELU	External leakage - Utility medium
FTS	Fail to start on demand
STP	Fail to stop on demand
HIO	High output
INL	Internal leakage
LOO	Low output
SER	Minor in-service problems
NOI	Noise
OTH	Other
OHE	Overheating
PDE	Parameter deviation
UST	Spurious stop
STD	Structural deficiency
UNK	Unknown
VIB	Vibration

Taxonomy no 1.1		Item Machinery Compressors								
Population 131	Installations 38	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 82472			
		Calendar time * 3.8235			Operational time † 2.4253					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>595*</b> <b>595†</b>	<b>0.00</b>	<b>166.07</b>	<b>839.82</b>	<b>361.26</b>	<b>155.62</b>	<b>17.8</b>	<b>0.5</b>	<b>29.3</b>	<b>1818.0</b>
Abnormal instrument reading	3*	0.00	1.11	4.88	1.91	0.78	7.0	16.0	16.5	17.0
	3†	0.00	6.03	29.41	12.28	1.24				
Breakdown	5*	0.01	1.28	4.17	1.51	1.31	61.5	25.5	367.0	1481.0
	5†	0.00	6.20	34.23	17.26	2.06				
Erratic output	12*	0.00	6.00	29.41	12.36	3.14	32.2	3.0	56.8	580.0
	12†	0.00	9.41	43.25	17.34	4.95				
External leakage - Process medium	44*	0.00	10.26	50.98	46.43	11.51	8.3	0.5	12.0	197.0
	44†	0.00	12.45	51.89	58.15	18.14				
External leakage - Utility medium	31*	0.00	11.80	58.78	25.04	8.11	12.6	1.0	23.6	123.5
	31†	0.01	24.22	105.90	41.33	12.78				
Fail to start on demand	72*	0.21	22.45	74.13	27.10	18.83	26.3	1.0	37.3	704.0
	72†	0.59	40.25	127.61	45.88	29.69				
Fail to stop on demand	3*	0.00	1.44	7.87	3.69	0.78	3.5	3.5	10.8	18.0
	3†	0.00	2.80	15.40	7.43	1.24				
High output	1*	0.00	0.27	1.52	0.90	0.26	7.0	14.0	14.0	14.0
	1†	0.00	0.45	2.42	1.56	0.41				
Internal leakage	5*	0.00	1.38	7.61	3.74	1.31	113.4	2.0	171.4	304.0
	5†	0.00	2.68	14.47	9.25	2.06				
Low output	153*	0.00	39.10	202.86	148.47	40.02	15.0	0.5	22.3	964.0
	153†	0.00	44.11	230.34	187.13	63.08				
Noise	3*	0.00	0.99	5.68	3.07	0.78	51.0	4.0	37.7	76.0
	3†	0.00	1.86	9.91	6.54	1.24				
Other	4*	0.00	1.71	8.62	3.69	1.05	7.0	1.0	22.3	59.0
	4†	0.00	3.07	16.14	7.30	1.65				
Overheating	69*	0.00	17.03	88.21	65.54	18.05	7.9	0.5	15.2	447.0
	69†	0.00	20.16	104.43	81.99	28.45				
Parameter deviation	50*	0.00	12.26	63.60	50.49	13.08	15.5	0.5	20.5	250.0
	50†	0.00	14.91	77.84	63.18	20.62				
Spurious stop	124*	0.02	37.34	158.37	60.97	32.43	23.7	1.0	32.0	1818.0
	124†	0.27	60.30	224.30	82.81	51.13				
Structural deficiency	6*	0.00	2.29	12.24	5.64	1.57	13.4	2.0	19.6	43.0
	6†	0.00	3.02	14.75	6.17	2.47				
Vibration	10*	0.00	3.14	13.47	5.21	2.62	5.5	1.0	29.7	100.0
	10†	0.10	4.54	14.03	4.95	4.12				
<b>Degraded</b>	<b>544*</b> <b>544†</b>	<b>0.20</b>	<b>177.75</b>	<b>733.92</b>	<b>278.74</b>	<b>142.28</b>	<b>10.4</b>	<b>0.3</b>	<b>15.9</b>	<b>410.0</b>
Abnormal instrument reading	15*	0.00	4.37	18.89	7.33	3.92	5.0	2.0	15.4	29.0
	15†	0.00	7.42	32.03	12.42	6.18				
Erratic output	18*	0.01	9.82	40.18	15.21	4.71	17.2	2.0	20.7	96.0
	18†	0.05	16.69	64.82	24.00	7.42				
<b>Comments</b>										

(cont.)

Taxonomy no 1.1		Item Machinery Compressors								
Population 131	Installations 38	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 82472			
		Calendar time * 3.8235			Operational time † 2.4253					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Process medium	49*	0.00	14.41	69.84	28.92	12.82	2.5	0.5	8.7	98.0
	49†	0.01	20.89	92.26	36.25	20.20				
External leakage - Utility medium	95*	0.00	33.69	164.70	68.96	24.85	13.5	0.3	20.6	218.0
	95†	0.00	46.25	222.39	91.67	39.17				
Fail to start on demand	1*	0.00	0.32	1.65	1.35	0.26	1.0	1.0	1.0	1.0
	1†	0.00	0.44	2.45	1.43	0.41				
Fail to stop on demand	5*	0.44	1.35	2.67	0.70	1.31	3.3	0.5	4.5	7.0
	5†	0.00	2.19	11.90	5.55	2.06				
High output	4*	0.00	0.99	4.12	1.57	1.05	4.7	3.0	4.4	7.0
	4†	0.01	1.49	4.93	1.80	1.65				
Internal leakage	13*	0.00	3.48	15.81	6.29	3.40	44.5	1.0	55.4	216.0
	13†	0.00	5.52	25.75	10.45	5.36				
Low output	109*	0.00	31.61	173.39	81.21	28.51	10.6	0.5	11.9	128.0
	109†	0.00	64.65	344.53	158.14	44.94				
Minor in-service problems	2*	0.00	0.48	1.81	0.67	0.52	2.0	2.0	2.0	2.0
	2†	0.03	0.76	2.27	0.77	0.82				
Noise	4*	0.00	0.92	3.58	1.33	1.05	17.4	5.0	26.0	64.0
	4†	0.01	1.49	5.20	1.92	1.65				
Other	68*	0.05	23.23	93.09	34.90	17.78	23.3	1.0	27.7	410.0
	68†	0.11	35.69	138.95	51.50	28.04				
Overheating	28*	0.00	8.34	43.22	19.06	7.32	8.3	1.0	12.0	48.0
	28†	0.00	11.36	54.56	22.48	11.54				
Parameter deviation	107*	0.00	41.05	233.42	124.90	27.99	3.9	0.3	6.7	101.0
	107†	0.00	48.02	265.16	159.89	44.12				
Structural deficiency	7*	0.00	2.71	14.91	7.02	1.83	4.4	0.5	7.4	17.0
	7†	0.00	3.56	18.44	8.09	2.89				
Unknown	6*	0.00	3.00	16.47	7.71	1.57	33.0	4.0	33.5	64.0
	6†	0.00	7.70	40.20	17.99	2.47				
Vibration	13*	0.26	4.06	11.84	3.92	3.40	9.9	1.0	22.3	96.0
	13†	0.09	6.49	20.70	7.46	5.36				
<b>Incipient</b>	<b>1064*</b>	<b>0.20</b>	<b>292.46</b>	<b>1237.63</b>	<b>476.01</b>	<b>278.28</b>	<b>7.4</b>	<b>0.3</b>	<b>12.0</b>	<b>961.0</b>
	<b>1064†</b>	<b>9.20</b>	<b>725.38</b>	<b>2326.94</b>	<b>841.71</b>	<b>438.70</b>				
Abnormal instrument reading	374*	0.02	106.24	471.62	185.84	97.82	4.8	0.3	7.1	176.0
	374†	0.11	148.98	626.54	240.20	154.21				
Erratic output	7*	0.00	2.56	12.69	5.38	1.83	20.4	1.0	30.7	137.0
	7†	0.00	4.16	20.64	8.76	2.89				
External leakage - Process medium	23*	0.00	8.11	40.04	16.93	6.02	11.4	1.0	12.9	115.0
	23†	0.00	11.71	53.28	21.23	9.48				
External leakage - Utility medium	113*	0.19	30.35	106.30	39.24	29.55	12.3	0.3	21.9	370.0
	113†	0.89	128.20	440.61	162.36	46.59				
Fail to start on demand	1*	0.00	0.34	1.87	0.88	0.26	4.0	4.0	4.0	4.0
	1†	0.00	3.12	17.19	8.66	0.41				

Comments

(cont.)

Taxonomy no 1.1		Item Machinery Compressors								
Population 131	Installations 38	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 82472			
		Calendar time * 3.8235			Operational time † 2.4253					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Internal leakage	48*	0.00	16.23	36.94	87.10	12.55	1.9	1.0	3.0	15.5
	48†	0.01	226.49	1050.49	424.42	19.79				
Low output	1*	0.00	0.25	1.35	0.62	0.26	-	2.0	2.0	2.0
	1†	0.00	0.40	2.23	1.07	0.41				
Minor in-service problems	326*	0.00	86.43	483.73	253.23	85.26	2.3	0.3	4.0	78.0
	326†	0.00	115.11	635.07	319.64	134.41				
Noise	8*	0.00	1.89	7.70	2.91	2.09	13.7	4.0	12.9	33.0
	8†	0.04	3.07	9.83	3.55	3.30				
Other	64*	0.01	19.15	82.97	32.21	16.74	57.1	1.0	63.2	961.0
	64†	0.05	35.52	144.98	54.83	26.39				
Overheating	10*	0.00	3.50	15.32	5.98	2.62	12.2	2.0	22.4	98.0
	10†	0.00	6.52	30.85	12.62	4.12				
Parameter deviation	38*	0.00	11.22	52.54	21.37	9.94	5.8	1.0	10.3	92.0
	38†	0.01	16.21	69.26	26.76	15.67				
Structural deficiency	13*	0.01	4.13	16.78	6.33	3.40	6.6	0.5	15.8	64.0
	13†	0.06	6.08	20.16	7.38	5.36				
Unknown	19*	0.00	6.66	28.47	30.96	4.97	14.5	2.0	13.3	32.0
	19†	0.00	20.44	108.37	72.52	7.83				
Vibration	19*	0.04	5.25	17.66	6.48	4.97	2.2	1.0	11.4	119.0
	19†	0.04	7.83	27.88	10.30	7.83				
<b>Unknown</b>	<b>63*</b>	<b>0.03</b>	<b>26.37</b>	<b>109.84</b>	<b>41.87</b>	<b>16.48</b>	<b>15.6</b>	<b>0.8</b>	<b>23.5</b>	<b>249.0</b>
	<b>63†</b>	<b>0.04</b>	<b>43.36</b>	<b>180.25</b>	<b>68.62</b>	<b>25.98</b>				
Abnormal instrument reading	21*	0.00	7.98	44.10	22.32	5.49	3.0	1.0	8.1	16.0
	21†	0.00	14.80	81.34	39.27	8.66				
External leakage - Utility medium	5*	0.00	1.53	8.77	4.73	1.31	7.0	7.0	85.5	164.0
	5†	0.00	2.91	16.61	8.92	2.06				
Low output	1*	0.00	0.74	3.83	2.81	0.26	-	12.0	12.0	12.0
	1†	0.00	0.88	4.67	3.15	0.41				
Noise	1*	0.00	0.37	2.08	1.10	0.26	14.0	-	-	-
	1†	0.00	0.71	3.94	2.39	0.41				
Other	15*	0.00	7.53	33.06	12.94	3.92	16.0	2.0	21.0	105.0
	15†	0.01	12.79	54.67	21.12	6.18				
Overheating	1*	0.00	0.25	1.35	0.62	0.26	-	3.0	3.0	3.0
	1†	0.00	0.40	2.23	1.07	0.41				
Unknown	18*	0.00	6.75	31.73	12.93	4.71	19.9	0.8	34.5	249.0
	18†	0.00	9.18	39.92	15.52	7.42				
Vibration	1*	0.00	0.60	3.09	2.29	0.26	-	9.0	9.0	9.0
	1†	0.00	0.92	4.87	3.30	0.41				
<b>All modes</b>	<b>2266*</b>	<b>0.39</b>	<b>656.86</b>	<b>2795.97</b>	<b>1078.30</b>	<b>592.66</b>	<b>11.3</b>	<b>0.3</b>	<b>17.9</b>	<b>1818.0</b>
	<b>2266†</b>	<b>16.32</b>	<b>1300.52</b>	<b>4175.73</b>	<b>1511.11</b>	<b>934.30</b>				

**Comments**

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 6.5 · 10<sup>-4</sup>

**Maintainable item versus failure mode, to be continued**

Item: Compressors

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.04	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Antisurge system	0.22	0.00	0.04	0.13	0.35	0.18	0.04	0.18	0.00	0.00
Base frame	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bearing	0.00	0.00	0.00	0.18	0.00	0.04	0.00	0.00	0.00	0.00
Buffer gas system	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.22	0.00	0.00	0.04	0.00	0.09	0.00	0.00	0.00	0.00
Casing	0.00	0.02	0.04	0.18	0.00	0.00	0.00	0.00	0.00	0.00
Check valves	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	0.84	0.00	0.00	0.04	0.22	0.53	0.00	0.00	0.00	0.00
Control-, isolating & check valves	0.04	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00
Cooler(s)	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driven unit	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driver	0.00	0.00	0.00	0.11	0.18	0.00	0.00	0.00	0.00	0.00
Cylinder liner	0.13	0.00	1.94	0.62	0.00	0.04	0.00	0.04	5.78	0.00
Dry gas seal	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.04	0.00	0.00
Filter(s)	0.02	0.00	0.04	0.18	0.00	0.00	0.09	0.04	0.31	0.00
Gearbox/var.drive	0.09	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.09
Instrument, flow	0.57	0.00	0.00	0.09	0.00	0.04	0.00	0.00	0.00	0.00
Instrument, general	0.84	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.04	0.00
Instrument, level	2.07	0.00	0.00	0.22	0.00	0.04	0.00	0.04	0.00	0.00
Instrument, pressure	4.07	0.00	0.00	0.31	0.09	0.31	0.04	0.00	0.04	0.00
Instrument, speed	0.26	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00
Instrument, temperature	4.65	0.00	0.04	0.11	0.09	0.13	0.00	0.00	0.04	0.00
Instrument, vibration	1.08	0.00	0.00	0.11	0.04	0.00	0.00	0.00	0.00	0.00
Internal piping	0.02	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.22	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00
Interstage seals	0.00	0.00	0.09	0.11	0.00	0.00	0.00	0.04	0.04	0.00

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

**Item:** Compressors

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Lube oil	0.07	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.09	0.00
Lubrication	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.26	0.00	0.00	0.00	1.24	0.00	0.00
Oil tank w/heating system	0.02	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.18	0.00	0.31	0.44	0.04	0.00	0.00	0.00	0.22	0.04
Overhead tank	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Packing	0.00	0.00	0.22	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	0.04	0.90	0.00	0.00	0.00	0.00	0.00	0.00
Piping, pipe support + bellows	0.00	0.00	0.18	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Piston(s)	0.00	0.02	0.09	0.00	0.09	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.18	0.49	0.00	0.13	0.00	0.00	1.32	0.00
Pump w/motor/gear	0.00	0.00	0.00	0.40	0.00	0.09	0.00	0.00	0.13	0.18
Purge air	0.00	0.00	0.00	0.09	0.00	0.04	0.00	0.00	0.00	0.00
Radial bearing	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reservoir w/heating system	0.04	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Rotor w/ impellers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04
Seal gas	0.00	0.00	0.13	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Seal oil	0.04	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.04	0.00
Seals	0.00	0.00	0.09	0.35	0.00	0.00	0.00	0.00	0.04	0.00
Shaft seals	0.00	0.00	0.09	0.53	0.00	0.09	0.04	0.22	0.01	0.00
Silencers	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Subunit	0.18	0.04	0.09	0.44	0.09	0.31	0.00	0.04	0.68	0.13
Thrust bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.66	0.09	0.13	1.24	0.00	0.57	0.00	0.88	0.62	0.09
Valves	0.66	0.00	1.24	1.21	0.44	0.26	0.00	0.13	2.21	0.09
Total	18.23	0.22	5.12	10.77	1.63	3.27	0.22	2.91	11.65	0.71

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

Item: Compressors

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.09	0.00	0.00	0.00	0.04	0.00	0.04	0.00	0.26
Antisurge system	0.00	0.42	0.11	0.18	0.13	0.00	0.00	0.04	0.00	2.03
Base frame	0.00	0.00	0.00	0.88	0.13	0.00	0.00	0.00	0.04	1.06
Bearing	0.00	0.04	0.00	0.04	0.04	0.00	0.00	0.04	0.00	0.40
Buffer gas system	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Cabling & junction boxes	0.00	0.09	0.04	0.09	0.04	0.00	0.04	0.04	0.00	0.71
Casing	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.38
Check valves	0.00	0.00	0.22	0.04	0.00	0.00	0.00	0.04	0.00	0.31
Control unit	0.00	0.31	0.40	0.09	0.04	0.18	0.04	0.53	0.13	3.35
Control-, isolating & check valves	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.22
Cooler(s)	0.09	0.04	0.04	0.04	0.00	0.00	0.00	0.06	0.04	0.61
Coupling to driven unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.38
Coupling to driver	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.33
Cylinder liner	3.40	0.04	0.57	0.31	0.22	0.00	0.26	0.13	0.18	13.68
Dry gas seal	0.00	0.04	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.22
Filter(s)	0.00	0.31	0.44	7.33	0.00	0.00	0.04	0.15	0.00	8.95
Gearbox/var.drive	0.04	0.09	0.00	0.04	0.00	0.00	0.00	0.00	0.04	0.55
Instrument, flow	0.00	0.09	0.44	0.04	0.00	0.00	0.00	0.00	0.00	1.27
Instrument, general	0.00	0.04	0.26	0.18	0.00	0.00	0.00	0.09	0.00	1.50
Instrument, level	0.00	0.24	0.44	0.22	0.00	0.00	0.04	0.29	0.00	3.62
Instrument, pressure	0.00	0.18	0.75	0.29	0.00	0.00	0.04	0.44	0.00	6.57
Instrument, speed	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.04	0.00	0.49
Instrument, temperature	0.09	0.22	0.71	0.29	0.00	0.00	0.00	0.57	0.09	7.03
Instrument, vibration	0.00	0.09	0.71	0.00	0.00	0.00	0.00	0.49	0.40	2.91
Internal piping	0.09	0.04	0.00	0.26	0.00	0.00	0.00	0.00	0.04	0.55
Internal power supply	0.00	0.18	0.04	0.00	0.00	0.00	0.00	0.18	0.00	0.75
Interstage seals	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.38

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

Item: Compressors

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Lube oil	0.00	0.13	0.00	0.04	0.00	0.00	0.00	0.04	0.00	0.46
Lubrication	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Monitoring	0.00	0.22	0.35	0.18	0.00	0.00	0.00	0.09	0.00	1.81
Oil	0.00	0.09	0.00	0.09	0.00	0.00	0.09	0.09	0.00	1.85
Oil tank w/heating system	0.00	0.22	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.38
Other	0.00	0.40	0.09	0.49	0.09	0.00	0.57	0.04	0.09	3.00
Overhead tank	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Packing	0.01	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.37
Piping	0.00	0.00	0.00	0.20	0.09	0.00	0.00	0.10	0.00	1.34
Piping, pipe support + bellows	0.07	0.09	0.00	0.22	0.04	0.00	0.00	0.00	0.04	0.86
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.24
Pump w/motor	0.11	0.09	0.35	0.22	0.00	0.04	0.13	0.09	0.04	3.20
Pump w/motor/gear	0.00	0.44	0.00	0.09	0.00	0.04	0.00	0.04	0.09	1.50
Purge air	0.00	0.00	0.26	0.13	0.00	0.00	0.00	0.00	0.00	0.53
Radial bearing	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.10
Reservoir w/heating system	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.13
Rotor w/ impellers	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.17
Seal gas	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
Seal oil	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.57
Seals	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.57
Shaft seals	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.06	0.00	1.13
Silencers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Subunit	0.13	0.53	0.09	0.22	0.00	0.00	0.09	0.32	0.09	3.47
Thrust bearing	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.09
Unknown	0.44	0.26	0.26	0.71	0.22	0.00	0.13	0.93	0.26	7.50
Valves	0.22	1.37	1.92	1.13	0.04	0.04	0.35	0.29	0.04	11.65
Total	4.77	6.66	8.61	14.47	1.15	0.35	1.90	5.47	1.90	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.



**Failure descriptor versus failure mode, to be continued**

Item: Compressors

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	0.13	0.00	0.00	0.09	0.04	0.00	0.00	0.00	0.31	0.00
Breakage	0.26	0.04	0.09	0.09	0.00	0.04	0.00	0.00	0.00	0.00
Burst	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cavitation	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.13	0.00	0.04	0.26	0.00	0.00	0.00	0.00	0.00	0.00
Combined causes	0.04	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.04
Contamination	0.09	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.40	0.00	0.00	0.09	0.18	0.49	0.00	0.04	0.04	0.00
Corrosion	0.09	0.00	0.00	0.04	0.00	0.04	0.00	0.04	0.00	0.00
Deformation	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04
Earth/isolation fault	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	0.04	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00
Erosion	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fatigue	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	3.40	0.00	0.00	0.00	0.18	0.18	0.00	0.00	0.00	0.00
Instrument failure - general	6.27	0.00	0.09	0.35	0.35	0.75	0.09	0.04	0.62	0.00
Leakage	0.04	0.00	1.06	4.15	0.00	0.04	0.00	0.09	0.00	0.00
Looseness	0.18	0.00	0.09	0.44	0.09	0.13	0.00	0.00	0.00	0.04
Material failure - general	0.13	0.00	0.13	0.49	0.00	0.00	0.09	0.00	0.00	0.04
Mechanical Failure - general	0.44	0.09	3.18	2.56	0.13	0.35	0.04	0.13	9.14	0.13
Misc. external influences	0.18	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.26	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
No cause found	0.26	0.00	0.00	0.04	0.00	0.04	0.00	0.00	0.00	0.04
No power/ voltage	0.04	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.71	0.00	0.00	0.04	0.00	0.13	0.00	0.00	0.00	0.00
Open circuit	0.40	0.00	0.04	0.04	0.00	0.09	0.00	0.00	0.00	0.00
Other	0.00	0.04	0.04	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Out of adjustment	3.27	0.00	0.00	0.00	0.26	0.22	0.00	0.04	0.09	0.00
Overheating	0.00	0.00	0.13	0.04	0.04	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Software failure	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.18	0.04	0.00	0.00	0.04	0.09	0.00	0.13	0.00	0.00
Unknown	0.53	0.00	0.04	0.13	0.00	0.26	0.00	0.00	0.71	0.09
Vibration	0.31	0.00	0.04	0.18	0.00	0.00	0.00	0.00	0.04	0.13
Wear	0.18	0.00	0.09	1.50	0.26	0.00	0.00	2.38	0.40	0.13
Total	18.23	0.22	5.12	10.77	1.63	3.27	0.22	2.91	11.65	0.71

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

Item: Compressors

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.04	0.09	0.31	0.22	0.00	0.00	0.09	0.22	0.00	1.54
Breakage	0.00	0.22	0.04	0.35	0.04	0.00	0.09	0.00	0.04	1.32
Burst	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Cavitation	0.00	0.04	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.18
Clearance/ alignment failure	0.00	0.09	0.00	0.04	0.00	0.00	0.00	0.00	0.09	0.66
Combined causes	0.00	0.04	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.22
Contamination	0.04	0.22	0.09	0.66	0.00	0.00	0.09	0.00	0.00	1.24
Control failure	0.13	0.35	0.40	0.09	0.04	0.00	0.00	0.44	0.00	2.69
Corrosion	0.00	0.13	0.04	0.35	0.00	0.00	0.00	0.04	0.00	0.79
Deformation	0.00	0.00	0.04	0.09	0.00	0.00	0.00	0.04	0.00	0.35
Earth/isolation fault	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.18
Electrical failure - general	0.04	0.40	0.04	0.09	0.00	0.04	0.04	0.13	0.00	1.06
Erosion	0.00	0.04	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.18
External influence - general	0.00	0.22	0.13	0.00	0.00	0.00	0.00	0.04	0.00	0.44
Fatigue	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Faulty power/voltage	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
Faulty signal/indication/alarm	0.04	0.04	0.00	0.04	0.00	0.00	0.00	0.44	0.13	4.46
Instrument failure - general	0.26	0.44	4.19	1.10	0.04	0.13	0.00	1.28	0.04	16.06
Leakage	0.04	0.62	0.13	0.18	0.00	0.00	0.00	0.09	0.00	6.44
Looseness	0.00	0.04	0.00	0.22	0.00	0.00	0.00	0.00	0.09	1.32
Material failure - general	0.00	0.04	0.00	0.26	0.18	0.00	0.13	0.13	0.00	1.63
Mechanical Failure - general	3.57	0.97	1.54	9.31	0.71	0.00	0.44	0.71	0.53	33.98
Misc. external influences	0.04	0.04	0.13	0.13	0.00	0.00	0.04	0.09	0.09	1.10
Miscellaneous - general	0.00	0.22	0.00	0.04	0.00	0.00	0.04	0.00	0.00	0.35
No cause found	0.00	0.13	0.04	0.00	0.00	0.00	0.00	0.18	0.04	0.79
No power/ voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.18
No signal/indication/alarm	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.02
Open circuit	0.00	0.00	0.40	0.18	0.00	0.04	0.09	0.13	0.00	1.41
Other	0.04	0.44	0.04	0.53	0.00	0.00	0.13	0.09	0.00	1.41
Out of adjustment	0.09	0.40	0.35	0.00	0.00	0.00	0.00	0.26	0.13	5.12
Overheating	0.18	0.09	0.13	0.00	0.00	0.00	0.04	0.26	0.00	0.93
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.22
Software failure	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.44
Sticking	0.00	0.31	0.00	0.18	0.00	0.04	0.00	0.00	0.00	1.02
Unknown	0.18	0.31	0.09	0.09	0.04	0.04	0.57	0.26	0.00	3.35
Vibration	0.00	0.00	0.13	0.18	0.04	0.00	0.00	0.31	0.44	1.81
Wear	0.00	0.44	0.00	0.09	0.00	0.00	0.00	0.09	0.26	5.83
Total	4.77	6.66	8.61	14.47	1.15	0.35	1.90	5.47	1.90	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 1.1.1		Item Machinery Compressors Centrifugal								
Population 65	Installations 18	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 7120			
		Calendar time * 1.9867		Operational time † 1.3303						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/r		Min	Mean	Max
<b>Critical</b>	<b>149*</b> <b>149†</b>	<b>5.49</b>	<b>73.31</b>	<b>208.81</b>	<b>68.58</b>	<b>75.00</b>	<b>52.5</b>	<b>1.0</b>	<b>79.8</b>	<b>1818.0</b>
Abnormal instrument reading	2*	0.00	1.21	4.91	1.85	1.01	2.5	17.0	17.0	17.0
	2†	0.05	12.03	45.57	16.80	1.50				
Breakdown	3*	0.00	1.67	8.49	3.66	1.51	6.5	25.5	518.0	1481.0
	3†	0.00	13.85	61.25	24.09	2.26				
Erratic output	6*	0.00	3.40	17.29	7.46	3.02	51.3	3.0	102.5	580.0
	6†	0.00	5.18	25.44	10.70	4.51				
External leakage - Process medium	2*	0.00	1.24	6.90	3.56	1.01	86.0	2.0	99.5	197.0
	2†	0.00	1.59	8.15	3.53	1.50				
External leakage - Utility medium	8*	0.04	4.92	16.83	6.20	4.03	35.2	1.0	46.4	123.5
	8†	0.21	30.08	103.62	38.19	6.01				
Fail to start on demand	49*	0.61	25.87	79.50	27.87	24.66	28.9	1.0	44.0	704.0
	49†	1.51	41.89	126.56	43.22	36.83				
Fail to stop on demand	1*	0.00	0.66	3.61	1.69	0.50	-	-	-	-
	1†	0.00	1.25	6.91	3.52	0.75				
High output	1*	0.00	0.47	2.62	1.31	0.50	7.0	14.0	14.0	14.0
	1†	0.00	0.76	4.27	2.26	0.75				
Internal leakage	5*	0.00	3.21	17.65	8.32	2.52	113.4	2.0	171.4	304.0
	5†	0.00	6.45	33.73	15.13	3.76				
Low output	2*	0.00	1.24	6.90	3.56	1.01	621.0	619.0	791.5	964.0
	2†	0.00	1.59	8.15	3.53	1.50				
Other	2*	0.00	1.30	5.77	2.27	1.01	-	59.0	59.0	59.0
	2†	0.00	2.06	9.32	3.71	1.50				
Overheating	1*	0.00	0.47	2.62	1.31	0.50	223.0	447.0	447.0	447.0
	1†	0.00	0.76	4.27	2.26	0.75				
Parameter deviation	2*	0.00	0.91	3.80	1.45	1.01	4.0	4.0	6.0	8.0
	2†	0.00	1.39	5.73	2.18	1.50				
Spurious stop	60*	0.10	23.38	88.28	32.56	30.20	39.8	1.0	47.4	1818.0
	60†	0.19	44.02	164.94	60.87	45.10				
Vibration	5*	0.01	2.84	10.53	3.89	2.52	13.0	21.0	57.3	100.0
	5†	0.16	4.11	12.40	4.22	3.76				
<b>Degraded</b>	<b>209*</b> <b>209†</b>	<b>10.58</b>	<b>114.20</b>	<b>313.45</b>	<b>101.31</b>	<b>105.20</b>	<b>19.4</b>	<b>0.5</b>	<b>23.7</b>	<b>410.0</b>
Abnormal instrument reading	14*	0.04	7.26	26.24	9.70	7.05	5.0	2.0	16.4	29.0
	14†	0.06	12.25	45.27	16.72	10.52				
Erratic output	5*	0.00	2.10	10.59	4.54	2.52	11.1	4.0	18.6	35.0
	5†	0.00	3.45	17.98	8.00	3.76				
External leakage - Process medium	20*	0.03	9.88	38.25	14.14	10.07	3.7	0.5	13.6	98.0
	20†	0.06	15.11	57.67	21.25	15.03				
<b>Comments</b>										

(cont.)

Taxonomy no 1.1.1		Item Machinery Compressors Centrifugal								
Population 65	Installations 18	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 7120			
		Calendar time * 1.9867		Operational time † 1.3303						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/r		Min	Mean	Max
External leakage - Utility medium	59*	0.46	32.04	101.63	36.55	29.70	21.4	2.0	24.1	218.0
	59†	0.63	48.64	155.65	56.23	44.35				
Fail to stop on demand	3*	0.00	1.56	8.14	3.66	1.51	3.5	7.0	7.0	7.0
	3†	0.00	2.48	13.72	6.99	2.26				
High output	4*	0.00	1.85	8.58	3.46	2.01	4.7	3.0	4.4	7.0
	4†	0.01	2.68	10.00	3.69	3.01				
Internal leakage	10*	0.00	4.71	21.89	8.86	5.03	54.6	2.0	69.1	216.0
	10†	0.00	7.77	36.94	15.15	7.52				
Low output	11*	0.26	6.77	20.41	6.93	5.54	8.0	2.0	14.1	50.0
	11†	0.08	10.75	36.54	13.44	8.27				
Minor in-service problems	2*	0.00	0.94	4.23	1.68	1.01	2.0	2.0	2.0	2.0
	2†	0.00	1.36	5.33	1.98	1.50				
Noise	3*	0.01	1.36	4.92	1.82	1.51	18.2	5.0	29.7	64.0
	3†	0.01	2.08	7.78	2.87	2.26				
Other	58*	0.32	34.29	113.48	41.52	29.19	28.5	1.0	27.3	410.0
	58†	0.45	50.08	166.62	61.04	43.60				
Overheating	2*	0.19	1.03	2.40	0.71	1.01	13.0	26.0	26.0	26.0
	2†	0.00	1.76	7.36	2.81	1.50				
Parameter deviation	9*	0.00	4.74	19.87	7.60	4.53	3.8	2.0	8.2	28.0
	9†	0.04	6.78	24.31	8.98	6.77				
Vibration	9*	0.13	5.42	16.66	5.84	4.53	18.7	6.0	30.3	96.0
	9†	0.07	8.66	29.42	10.82	6.77				
<b>Incipient</b>	<b>498*</b>	<b>6.87</b>	<b>241.98</b>	<b>737.40</b>	<b>255.64</b>	<b>250.66</b>	<b>9.8</b>	<b>0.3</b>	<b>15.3</b>	<b>531.0</b>
	<b>498†</b>	<b>107.97</b>	<b>1028.64</b>	<b>2748.61</b>	<b>875.96</b>	<b>374.35</b>				
Abnormal instrument reading	211*	1.09	92.14	297.51	107.93	106.21	5.3	1.0	7.8	73.0
	211†	3.50	143.25	439.58	153.79	158.61				
Erratic output	5*	0.00	2.94	14.84	6.38	2.52	22.9	1.0	40.4	137.0
	5†	0.00	3.69	16.76	6.67	3.76				
External leakage - Process medium	2*	0.00	1.79	9.85	4.87	1.01	5.5	2.0	5.5	9.0
	2†	0.00	2.18	11.70	5.40	1.50				
External leakage - Utility medium	86*	0.52	41.94	134.90	48.86	43.29	13.9	0.3	25.5	370.0
	86†	21.01	242.21	673.13	218.83	64.65				
Fail to start on demand	1*	0.00	0.61	3.18	1.41	0.50	4.0	4.0	4.0	4.0
	1†	0.00	6.03	28.91	11.91	0.75				
Internal leakage	48*	0.00	33.59	177.09	120.69	24.16	1.9	1.0	3.0	15.5
	48†	4.31	476.62	1583.00	579.67	36.08				
Low output	1*	0.00	0.45	2.17	0.90	0.50	-	2.0	2.0	2.0
	1†	0.00	0.69	3.56	1.56	0.75				
Minor in-service problems	59*	0.03	29.67	122.39	46.47	29.70	5.6	1.0	9.0	78.0
	59†	0.26	57.98	216.15	79.79	44.35				
<b>Comments</b>										

(cont.)

Taxonomy no 1.1.1		Item Machinery Compressors Centrifugal								
Population 65	Installations 18	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 7120			
		Calendar time * 1.9867		Operational time † 1.3303						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Noise	4*	0.07	1.85	5.58	1.90	2.01	7.7	4.0	7.7	11.0
	4†	0.73	2.90	6.24	1.75	3.01				
Other	51*	0.00	22.58	100.52	39.67	25.67	40.5	1.0	39.4	531.0
	51†	0.02	39.09	168.09	65.09	38.34				
Overheating	2*	0.00	1.42	6.75	2.77	1.01	6.5	2.0	50.0	98.0
	2†	0.00	5.83	28.75	12.15	1.50				
Parameter deviation	12*	0.00	6.42	30.56	12.54	6.04	7.1	2.0	19.7	92.0
	12†	0.00	10.06	48.10	19.78	9.02				
Structural deficiency	5*	0.00	2.64	11.66	4.58	2.52	13.3	4.0	30.0	64.0
	5†	0.00	3.98	16.42	6.23	3.76				
Unknown	2*	0.02	1.09	3.43	1.23	1.01	-	4.0	5.0	6.0
	2†	0.30	1.55	3.61	1.06	1.50				
Vibration	9*	0.12	5.24	16.12	5.66	4.53	2.7	1.0	20.1	119.0
	9†	0.02	9.33	36.69	13.66	6.77				
<b>Unknown</b>	<b>45*</b>	<b>0.22</b>	<b>43.16</b>	<b>155.79</b>	<b>57.57</b>	<b>22.65</b>	<b>23.1</b>	<b>1.0</b>	<b>28.0</b>	<b>249.0</b>
	<b>45†</b>	<b>0.28</b>	<b>63.76</b>	<b>238.49</b>	<b>88.02</b>	<b>33.83</b>				
Abnormal instrument reading	21*	0.00	18.20	82.30	32.71	10.57	3.0	1.0	8.1	16.0
	21†	0.00	30.26	136.30	54.09	15.79				
External leakage - Utility medium	5*	0.00	2.91	15.13	6.71	2.52	7.0	7.0	85.5	164.0
	5†	0.00	5.35	27.90	12.45	3.76				
Low output	1*	0.00	1.36	7.63	4.00	0.50	-	12.0	12.0	12.0
	1†	0.00	1.55	8.66	4.50	0.75				
Noise	1*	0.00	0.66	3.61	1.69	0.50	14.0	-	-	-
	1†	0.00	1.25	6.91	3.52	0.75				
Other	13*	0.03	12.51	49.89	18.65	6.54	16.0	2.0	23.2	105.0
	13†	0.07	16.72	62.33	23.01	9.77				
Overheating	1*	0.00	0.45	2.17	0.90	0.50	-	3.0	3.0	3.0
	1†	0.00	0.69	3.56	1.56	0.75				
Unknown	2*	0.00	1.14	4.97	1.94	1.01	63.0	3.0	126.0	249.0
	2†	0.07	1.60	4.81	1.63	1.50				
Vibration	1*	0.00	1.92	10.57	5.14	0.50	-	9.0	9.0	9.0
	1†	0.00	2.15	11.88	6.00	0.75				
<b>All modes</b>	<b>901*</b>	<b>71.73</b>	<b>474.00</b>	<b>1171.64</b>	<b>358.40</b>	<b>453.51</b>	<b>19.5</b>	<b>0.3</b>	<b>28.1</b>	<b>1818.0</b>
	<b>901†</b>	<b>269.12</b>	<b>1465.59</b>	<b>3449.98</b>	<b>1024.16</b>	<b>677.29</b>				

**Comments**

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 5.6 · 10<sup>-3</sup>

**Maintainable item versus failure mode, to be continued**

**Item: Compressors - Centrifugal**

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.11	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00
Antisurge system	0.55	0.00	0.11	0.33	0.89	0.44	0.11	0.44	0.00	0.00
Bearing	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00
Buffer gas system	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.11	0.00	0.00	0.11	0.00	0.22	0.00	0.00	0.00	0.00
Casing	0.00	0.00	0.11	0.44	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	1.11	0.00	0.00	0.11	0.22	1.00	0.00	0.00	0.00	0.00
Control-, isolating & check valves	0.11	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00
Cooler(s)	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driven unit	0.00	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driver	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00
Cylinder liner	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00
Dry gas seal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00
Filter(s)	0.00	0.00	0.00	0.11	0.00	0.00	0.22	0.11	0.33	0.00
Gearbox/var.drive	0.22	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00	0.22
Instrument, flow	0.87	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, level	4.66	0.00	0.00	0.44	0.00	0.00	0.00	0.11	0.00	0.00
Instrument, pressure	5.70	0.00	0.00	0.33	0.22	0.78	0.11	0.00	0.11	0.00
Instrument, speed	0.44	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00
Instrument, temperature	6.31	0.00	0.00	0.28	0.22	0.00	0.00	0.00	0.00	0.00
Instrument, vibration	1.66	0.00	0.00	0.28	0.11	0.00	0.00	0.00	0.00	0.00
Internal piping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.44	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00
Interstage seals	0.00	0.00	0.22	0.11	0.00	0.00	0.00	0.11	0.09	0.00

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

**Item: Compressors - Centrifugal**

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Lube oil	0.17	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Lubrication	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	1.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.55	0.00	0.00	0.00	3.11	0.00	0.00
Oil tank w/heating system	0.06	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.33	0.00	0.11	0.67	0.00	0.00	0.00	0.00	0.22	0.11
Overhead tank	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Packing	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00
Piping, pipe support + bellows	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.00	0.89	0.00	0.22	0.00	0.00	0.00	0.00
Pump w/motor/gear	0.00	0.00	0.00	1.00	0.00	0.22	0.00	0.00	0.00	0.44
Purge air	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Radial bearing	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reservoir w/heating system	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Rotor w/ impellers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Seal gas	0.00	0.00	0.33	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Seal oil	0.11	0.00	0.00	0.89	0.00	0.00	0.00	0.00	0.11	0.00
Seals	0.00	0.00	0.11	0.78	0.00	0.00	0.00	0.00	0.00	0.00
Shaft seals	0.00	0.00	0.11	0.22	0.00	0.22	0.11	0.55	0.04	0.00
Subunit	0.22	0.00	0.00	0.78	0.00	0.33	0.00	0.00	0.04	0.00
Thrust bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	1.44	0.22	0.00	2.77	0.00	1.00	0.00	2.22	0.44	0.00
Valves	0.55	0.00	1.22	2.33	0.11	0.22	0.00	0.22	0.22	0.11
Total	27.52	0.33	2.66	17.54	1.78	5.55	0.55	6.99	1.66	0.89

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

Item: Compressors - Centrifugal

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.55
Antisurge system	0.00	1.05	0.28	0.44	0.33	0.00	0.00	0.11	0.00	5.11
Bearing	0.00	0.11	0.00	0.11	0.00	0.00	0.00	0.11	0.00	0.44
Buffer gas system	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.22
Cabling & junction boxes	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.55
Casing	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.67
Control unit	0.00	0.67	0.00	0.22	0.00	0.22	0.11	0.78	0.22	4.66
Control-, isolating & check valves	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.55
Cooler(s)	0.11	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.44
Coupling to driven unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.94
Coupling to driver	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Cylinder liner	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Dry gas seal	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
Filter(s)	0.00	0.67	0.44	1.22	0.00	0.00	0.11	0.22	0.00	3.44
Gearbox/var.drive	0.11	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.11	1.17
Instrument, flow	0.00	0.22	0.11	0.11	0.00	0.00	0.00	0.00	0.00	1.54
Instrument, general	0.00	0.11	0.00	0.11	0.00	0.00	0.00	0.11	0.00	0.89
Instrument, level	0.00	0.61	0.78	0.22	0.00	0.00	0.11	0.61	0.00	7.55
Instrument, pressure	0.00	0.44	0.00	0.17	0.00	0.00	0.11	0.33	0.00	8.31
Instrument, speed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.89
Instrument, temperature	0.00	0.44	0.22	0.61	0.00	0.00	0.00	0.33	0.11	8.53
Instrument, vibration	0.00	0.11	0.11	0.00	0.00	0.00	0.00	1.11	0.78	4.16
Internal piping	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Internal power supply	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.33	0.00	1.44
Interstage seals	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.68

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.



**Maintainable item versus failure mode, continued**

Item: Compressors - Centrifugal

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Lube oil	0.00	0.33	0.00	0.11	0.00	0.00	0.00	0.11	0.00	0.94
Lubrication	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28
Monitoring	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.22	0.00	2.44
Oil	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.77
Oil tank w/heating system	0.00	0.55	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.94
Other	0.00	0.22	0.00	0.11	0.00	0.00	0.00	0.11	0.11	2.00
Overhead tank	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Packing	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
Piping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55
Piping, pipe support + bellows	0.00	0.22	0.00	0.11	0.00	0.00	0.00	0.00	0.00	1.00
Pump w/motor	0.00	0.11	0.00	0.11	0.00	0.00	0.00	0.11	0.11	1.55
Pump w/motor/gear	0.00	1.11	0.00	0.22	0.00	0.11	0.00	0.11	0.22	3.44
Purge air	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Radial bearing	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
Reservoir w/heating system	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.22
Rotor w/ impellers	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Seal gas	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55
Seal oil	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.11	1.44
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.89
Shaft seals	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.04	0.00	1.52
Subunit	0.00	1.00	0.00	0.11	0.00	0.00	0.00	0.15	0.11	2.74
Thrust bearing	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.22
Unknown	0.22	0.33	0.00	0.78	0.22	0.00	0.00	1.11	0.33	11.10
Valves	0.00	3.22	0.50	1.22	0.00	0.11	0.00	0.39	0.00	10.43
Total	0.67	13.76	2.55	6.77	0.55	0.44	0.44	6.66	2.66	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Compressors - Centrifugal

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	0.22	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.67	0.00
Breakage	0.44	0.11	0.00	0.22	0.00	0.11	0.00	0.00	0.00	0.00
Burst	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.22	0.00	0.11	0.33	0.00	0.00	0.00	0.00	0.00	0.00
Combined causes	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	0.22	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	1.00	0.00	0.00	0.22	0.33	0.55	0.00	0.11	0.00	0.00
Corrosion	0.11	0.00	0.00	0.11	0.00	0.11	0.00	0.11	0.00	0.00
Deformation	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00
Erosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fatigue	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	8.10	0.00	0.00	0.00	0.44	0.44	0.00	0.00	0.00	0.00
Instrument failure - general	4.11	0.00	0.00	0.22	0.33	1.11	0.22	0.00	0.00	0.00
Leakage	0.11	0.00	1.89	8.99	0.00	0.00	0.00	0.22	0.00	0.00
Looseness	0.44	0.00	0.11	0.89	0.00	0.33	0.00	0.00	0.00	0.11
Material failure - general	0.33	0.00	0.22	0.78	0.00	0.00	0.22	0.00	0.00	0.00
Mechanical Failure - general	0.22	0.11	0.00	1.44	0.00	0.78	0.11	0.22	0.33	0.33
Misc. external influences	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.11	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00
No cause found	0.67	0.00	0.00	0.11	0.00	0.11	0.00	0.00	0.00	0.00
No power/ voltage	0.11	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00
No signal/indication/alarm	1.44	0.00	0.00	0.11	0.00	0.33	0.00	0.00	0.00	0.00
Open circuit	0.44	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.11	0.00	0.00	0.11	0.00	0.00	0.00	0.00
Out of adjustment	6.88	0.00	0.00	0.00	0.55	0.33	0.00	0.11	0.22	0.00
Overheating	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.44	0.11	0.00	0.00	0.11	0.22	0.00	0.33	0.00	0.00
Unknown	0.78	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Vibration	0.33	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.33
Wear	0.44	0.00	0.11	3.11	0.00	0.00	0.00	5.88	0.22	0.11
Total	27.52	0.33	2.66	17.54	1.78	5.55	0.55	6.99	1.66	0.89

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

**Item: Compressors - Centrifugal**

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.11	0.22	0.44	0.00	0.00	0.00	0.33	0.00	2.11
Breakage	0.00	0.55	0.11	0.44	0.11	0.00	0.11	0.00	0.00	2.22
Burst	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Clearance/ alignment failure	0.00	0.22	0.00	0.11	0.00	0.00	0.00	0.00	0.22	1.22
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Contamination	0.11	0.44	0.11	1.22	0.00	0.00	0.00	0.00	0.00	2.22
Control failure	0.22	0.89	0.67	0.00	0.00	0.00	0.00	0.67	0.00	4.66
Corrosion	0.00	0.33	0.00	0.55	0.00	0.00	0.00	0.00	0.00	1.33
Deformation	0.00	0.00	0.11	0.22	0.00	0.00	0.00	0.00	0.00	0.67
Earth/isolation fault	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.22
Electrical failure - general	0.11	0.78	0.00	0.11	0.00	0.11	0.00	0.22	0.00	1.78
Erosion	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Fatigue	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
Faulty power/voltage	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33
Faulty signal/indication/alarm	0.11	0.11	0.00	0.11	0.00	0.00	0.00	1.00	0.33	10.65
Instrument failure - general	0.00	0.89	0.22	0.67	0.00	0.00	0.00	1.55	0.00	9.32
Leakage	0.00	1.55	0.22	0.11	0.00	0.00	0.00	0.11	0.00	13.21
Looseness	0.00	0.11	0.00	0.44	0.00	0.00	0.00	0.00	0.22	2.66
Material failure - general	0.00	0.00	0.00	0.55	0.33	0.00	0.00	0.33	0.00	2.77
Mechanical Failure - general	0.00	1.78	0.11	0.67	0.11	0.00	0.00	0.22	0.22	6.66
Misc. external influences	0.00	0.11	0.00	0.11	0.00	0.00	0.00	0.11	0.00	0.55
Miscellaneous - general	0.00	0.11	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.33
No cause found	0.00	0.33	0.11	0.00	0.00	0.00	0.00	0.44	0.11	1.89
No power/ voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.44
No signal/indication/alarm	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.22
Open circuit	0.00	0.00	0.00	0.22	0.00	0.11	0.11	0.22	0.00	1.33
Other	0.11	1.00	0.11	0.11	0.00	0.00	0.11	0.11	0.00	1.78
Out of adjustment	0.00	1.00	0.44	0.00	0.00	0.00	0.00	0.33	0.33	10.21
Overheating	0.00	0.11	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.33
Sticking	0.00	0.78	0.00	0.33	0.00	0.11	0.00	0.00	0.00	2.44
Unknown	0.00	0.78	0.00	0.00	0.00	0.11	0.11	0.33	0.00	2.33
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.78	2.00
Wear	0.00	1.00	0.00	0.22	0.00	0.00	0.00	0.00	0.44	11.54
Total	0.67	13.76	2.55	6.77	0.55	0.44	0.44	6.66	2.66	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 1.1.1.1		Item Machinery Compressors Centrifugal Electric driven									
Population 34	Installations 9	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 3751				
		Calendar time * 1.1503		Operational time † 0.8560							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	<b>89*</b> <b>89†</b>	<b>0.65</b>	<b>80.37</b>	<b>270.60</b>	<b>99.39</b>	<b>77.37</b>	<b>66.9</b>	<b>1.0</b>	<b>89.3</b>	<b>1818.0</b>	
Erratic output	4*	0.00	3.94	21.13	9.74	3.48	74.8	3.0	149.5	580.0	
	4†	0.00	6.25	33.05	15.03	4.67					
External leakage - Process medium	2*	0.00	2.30	11.71	5.06	1.74	86.0	2.0	99.5	197.0	
	2†	0.00	2.66	12.83	5.30	2.34					
External leakage - Utility medium	1*	0.00	0.81	4.01	1.69	0.87	123.5	123.5	123.5	123.5	
	1†	0.00	1.10	5.41	2.28	1.17					
Fail to start on demand	30*	0.11	25.66	96.28	35.53	26.08	34.7	1.0	43.0	704.0	
	30†	0.16	35.03	130.39	48.14	35.05					
High output	1*	0.06	0.91	2.63	0.87	0.87	7.0	14.0	14.0	14.0	
	1†	0.00	1.35	5.54	2.10	1.17					
Internal leakage	4*	0.00	4.71	25.03	11.45	3.48	141.5	91.0	213.8	304.0	
	4†	0.00	5.27	27.98	12.81	4.67					
Low output	2*	0.00	2.30	11.71	5.06	1.74	621.0	619.0	791.5	964.0	
	2†	0.00	2.66	12.83	5.30	2.34					
Other	1*	0.00	1.24	6.11	2.58	0.87	-	59.0	59.0	59.0	
	1†	0.00	1.53	7.17	2.92	1.17					
Overheating	1*	0.06	0.91	2.63	0.87	0.87	223.0	447.0	447.0	447.0	
	1†	0.00	1.35	5.54	2.10	1.17					
Parameter deviation	1*	0.00	0.81	4.01	1.69	0.87	4.0	4.0	4.0	4.0	
	1†	0.00	1.10	5.41	2.28	1.17					
Spurious stop	41*	0.25	36.99	127.49	46.99	35.64	45.9	1.0	61.1	1818.0	
	41†	0.41	55.38	188.85	69.51	47.90					
Vibration	1*	0.00	1.02	4.34	1.67	0.87	13.0	21.0	21.0	21.0	
	1†	0.08	1.22	3.53	1.17	1.17					
<b>Degraded</b>	<b>102*</b> <b>102†</b>	<b>31.03</b>	<b>115.39</b>	<b>243.48</b>	<b>67.29</b>	<b>88.67</b>	<b>17.5</b>	<b>0.5</b>	<b>25.8</b>	<b>410.0</b>	
		<b>48.04</b>	<b>151.33</b>	<b>301.60</b>	<b>79.67</b>	<b>119.15</b>					
Abnormal instrument reading	2*	0.00	2.60	13.39	5.83	1.74	-	14.0	14.0	14.0	
	2†	0.00	5.31	26.32	11.17	2.34					
Erratic output	4*	0.00	3.94	21.13	9.74	3.48	11.1	10.0	22.3	35.0	
	4†	0.00	6.25	33.05	15.03	4.67					
External leakage - Process medium	7*	1.11	6.40	15.27	4.57	6.09	3.7	0.5	6.1	12.0	
	7†	0.38	8.91	26.78	9.05	8.18					
External leakage - Utility medium	26*	3.12	29.44	78.46	24.97	22.60	10.9	2.0	20.4	218.0	
	26†	5.69	34.98	84.96	25.72	30.37					
Fail to stop on demand	2*	0.00	1.79	7.90	3.11	1.74	3.5	7.0	7.0	7.0	
	2†	0.00	2.35	11.35	4.69	2.34					
High output	3*	0.54	2.66	6.10	1.79	2.61	4.7	3.0	4.7	7.0	
	3†	0.01	3.19	12.71	4.75	3.50					
<b>Comments</b>											

(cont.)

Taxonomy no 1.1.1.1		Item Machinery Compressors Centrifugal Electric driven									
Population 34	Installations 9	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 3751				
		Calendar time * 1.1503		Operational time † 0.8560							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Internal leakage	8*	0.00	7.25	35.34	14.75	6.95	54.6	2.0	69.1	216.0	
	8†	0.00	10.77	53.17	22.48	9.35					
Low output	6*	0.04	5.61	19.03	7.00	5.22	5.6	2.0	5.6	15.0	
	6†	0.46	7.01	20.35	6.73	7.01					
Minor in-service problems	2*	0.01	1.65	6.21	2.29	1.74	2.0	2.0	2.0	2.0	
	2†	0.02	2.15	7.35	2.71	2.34					
Noise	3*	0.02	2.43	8.31	3.06	2.61	18.2	5.0	29.7	64.0	
	3†	0.01	3.42	13.15	4.85	3.50					
Other	25*	2.22	34.86	101.62	33.65	21.73	30.3	4.0	36.3	410.0	
	25†	3.46	45.26	128.52	42.16	29.20					
Parameter deviation	8*	0.05	8.01	28.34	10.47	6.95	2.8	2.0	6.9	28.0	
	8†	0.08	10.19	34.29	12.60	9.35					
Vibration	6*	0.10	7.88	25.30	9.16	5.22	18.7	6.0	34.3	96.0	
	6†	0.06	11.71	41.82	15.45	7.01					
<b>Incipient</b>	<b>269*</b>	<b>14.94</b>	<b>266.41</b>	<b>788.37</b>	<b>262.32</b>	<b>233.86</b>	<b>10.5</b>	<b>0.3</b>	<b>13.6</b>	<b>531.0</b>	
	<b>269†</b>	<b>14.30</b>	<b>366.15</b>	<b>1103.28</b>	<b>374.72</b>	<b>314.24</b>					
Abnormal instrument reading	149*	7.60	141.51	420.76	140.20	129.53	5.6	1.0	7.4	73.0	
	149†	11.50	192.98	567.07	188.29	174.06					
Erratic output	3*	0.00	2.34	10.94	4.44	2.61	9.0	1.0	9.0	16.0	
	3†	0.03	3.03	9.86	3.59	3.50					
External leakage - Process medium	1*	0.00	0.81	4.01	1.69	0.87	2.0	2.0	2.0	2.0	
	1†	0.00	1.10	5.41	2.28	1.17					
External leakage - Utility medium	25*	0.47	23.96	74.42	26.35	21.73	6.6	0.3	9.3	40.0	
	25†	0.64	31.89	98.89	34.98	29.20					
Internal leakage	1*	0.06	0.91	2.63	0.87	0.87	2.0	4.0	4.0	4.0	
	1†	0.00	1.35	5.54	2.10	1.17					
Minor in-service problems	37*	0.30	38.74	131.48	48.36	32.17	4.8	1.0	7.3	72.0	
	37†	0.24	52.47	194.97	71.99	43.22					
Noise	4*	0.34	3.21	8.55	2.72	3.48	7.7	4.0	7.7	11.0	
	4†	0.41	4.37	11.97	3.87	4.67					
Other	34*	0.11	38.98	153.01	56.91	29.56	45.3	1.0	49.5	531.0	
	34†	0.19	59.26	230.24	85.26	39.72					
Parameter deviation	3*	0.00	4.83	20.66	7.99	2.61	-	2.0	35.7	92.0	
	3†	0.00	5.44	22.70	8.67	3.50					
Structural deficiency	4*	0.00	3.74	16.27	6.33	3.48	13.3	4.0	21.5	50.0	
	4†	0.00	5.40	24.91	10.02	4.67					
Unknown	1*	0.00	1.24	6.11	2.58	0.87	-	4.0	4.0	4.0	
	1†	0.00	1.53	7.17	2.92	1.17					
Vibration	7*	0.18	7.22	22.11	7.72	6.09	2.7	1.0	19.3	119.0	
	7†	0.30	9.14	27.70	9.51	8.18					
<b>Comments</b>											

(cont.)

Taxonomy no 1.1.1.1		Item Machinery Compressors Centrifugal Electric driven								
Population 34	Installations 9	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 3751			
		Calendar time * 1.1503			Operational time † 0.8560					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Unknown	7*	0.01	7.92	32.62	12.38	6.09	12.8	3.0	41.2	164.0
	7†	0.02	14.92	61.45	23.32	8.18				
Abnormal instrument reading	2*	0.00	2.60	13.39	5.83	1.74	-	3.0	6.5	10.0
	2†	0.00	5.31	26.32	11.17	2.34				
External leakage - Utility medium	2*	0.35	1.79	4.17	1.23	1.74	7.0	7.0	85.5	164.0
	2†	0.01	2.79	10.91	4.05	2.34				
Other	2*	0.12	1.95	5.75	1.91	1.74	30.0	60.0	60.0	60.0
	2†	0.01	3.41	13.60	5.09	2.34				
Unknown	1*	0.06	0.91	2.63	0.87	0.87	1.5	3.0	3.0	3.0
	1†	0.00	1.35	5.54	2.10	1.17				
<b>All modes</b>	<b>467*</b>	<b>49.33</b>	<b>471.49</b>	<b>1260.79</b>	<b>401.97</b>	<b>405.99</b>	<b>24.0</b>	<b>0.3</b>	<b>30.6</b>	<b>1818.0</b>
	<b>467†</b>	<b>61.94</b>	<b>650.36</b>	<b>1774.99</b>	<b>572.11</b>	<b>545.54</b>				

**Comments**  
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 6.7 · 10<sup>-3</sup>

Taxonomy no 1.1.1.1.1		Item Machinery Compressors Centrifugal Electric driven (100-1000) kW								
Population 5	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 1299			
		Calendar time * 0.1705		Operational time † 0.1258						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	27*	<b>21.19</b>	<b>151.76</b>	<b>381.84</b>	<b>117.91</b>	<b>158.38</b>	25.7	1.0	49.2	580.0
	27†	<b>10.11</b>	<b>256.43</b>	<b>772.46</b>	<b>262.19</b>	<b>214.67</b>				
Erratic output	2*	0.15	11.47	36.68	13.24	11.73	146.8	7.0	293.5	580.0
	2†	0.05	21.40	84.78	31.63	15.90				
Fail to start on demand	12*	39.95	69.68	106.12	20.32	70.39	7.0	1.0	11.0	60.0
	12†	20.54	103.00	237.56	69.73	95.41				
High output	1*	0.00	5.73	24.83	9.64	5.87	7.0	14.0	14.0	14.0
	1†	0.06	9.57	33.16	12.23	7.95				
Overheating	1*	0.00	5.73	24.83	9.64	5.87	223.0	447.0	447.0	447.0
	1†	0.06	9.57	33.16	12.23	7.95				
Spurious stop	11*	9.89	62.11	151.68	46.07	64.53	6.1	1.0	10.0	26.0
	11†	3.56	101.57	307.09	105.05	87.46				
<b>Degraded</b>	13*	<b>33.28</b>	<b>74.98</b>	<b>130.28</b>	<b>30.06</b>	<b>76.26</b>	31.4	1.0	33.6	148.0
	13†	<b>15.97</b>	<b>115.01</b>	<b>289.72</b>	<b>89.52</b>	<b>103.36</b>				
Erratic output	3*	0.08	17.05	63.54	23.46	17.60	9.5	10.0	19.0	35.0
	3†	0.06	33.26	134.26	50.52	23.85				
External leakage - Process medium	3*	1.15	17.08	49.40	16.32	17.60	4.0	1.0	6.0	12.0
	3†	2.42	23.18	62.04	19.79	23.85				
External leakage - Utility medium	2*	1.02	11.94	33.27	10.83	11.73	2.0	2.0	3.0	4.0
	2†	0.79	18.42	55.36	18.68	15.90				
Fail to stop on demand	1*	0.00	5.67	24.34	9.42	5.87	-	-	-	-
	1†	0.04	7.10	25.51	9.43	7.95				
Internal leakage	2*	1.30	11.52	30.23	9.53	11.73	149.0	136.0	142.0	148.0
	2†	0.35	16.38	50.64	17.87	15.90				
Noise	1*	0.00	5.73	24.83	9.64	5.87	2.5	5.0	5.0	5.0
	1†	0.06	9.57	33.16	12.23	7.95				
Other	1*	0.00	5.67	24.34	9.42	5.87	-	-	-	-
	1†	0.04	7.10	25.51	9.43	7.95				
<b>Incipient</b>	61*	<b>10.12</b>	<b>344.86</b>	<b>1049.53</b>	<b>363.13</b>	<b>357.83</b>	5.3	0.3	9.2	72.0
	61†	<b>6.35</b>	<b>643.71</b>	<b>2116.99</b>	<b>773.08</b>	<b>485.00</b>				
Abnormal instrument reading	24*	18.72	136.28	344.07	106.43	140.79	4.9	1.0	7.6	59.0
	24†	7.40	237.17	720.04	248.17	190.82				
Erratic output	1*	0.00	5.67	24.34	9.42	5.87	16.0	16.0	16.0	16.0
	1†	0.04	7.10	25.51	9.43	7.95				
External leakage - Utility medium	6*	14.48	34.98	62.68	14.97	35.20	3.2	0.3	5.7	20.0
	6†	21.68	49.60	86.81	20.19	47.71				
Minor in-service problems	17*	0.17	96.13	387.31	145.62	99.72	4.6	1.0	8.7	72.0
	17†	0.51	196.74	775.32	288.75	135.17				
Noise	1*	0.39	6.08	17.71	5.87	5.87	-	-	-	-
	1†	0.59	8.39	24.12	7.95	7.95				
<b>Comments</b>										

(cont.)

Taxonomy no 1.1.1.1.1		Item Machinery Compressors Centrifugal Electric driven (100-1000) kW									
Population 5	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 1299				
		Calendar time * 0.1705		Operational time † 0.1258							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Other	10*	0.03	56.01	239.18	92.37	58.66	6.0	3.0	12.0	50.0	
	10†	0.14	116.50	479.28	181.80	79.51					
Structural deficiency	2*	1.30	11.52	30.23	9.53	11.73	14.5	4.0	27.0	50.0	
	2†	0.35	16.38	50.64	17.87	15.90					
<b>Unknown</b>	2*	<b>0.15</b>	<b>11.47</b>	<b>36.68</b>	<b>13.24</b>	<b>11.73</b>	<b>15.8</b>	<b>3.0</b>	<b>31.5</b>	<b>60.0</b>	
	2†	<b>0.05</b>	<b>21.40</b>	<b>84.78</b>	<b>31.63</b>	<b>15.90</b>					
Other	1*	0.00	5.73	24.83	9.64	5.87	30.0	60.0	60.0	60.0	
	1†	0.06	9.57	33.16	12.23	7.95					
Unknown	1*	0.00	5.73	24.83	9.64	5.87	1.5	3.0	3.0	3.0	
	1†	0.06	9.57	33.16	12.23	7.95					
<b>All modes</b>	<b>103*</b>	<b>42.72</b>	<b>579.49</b>	<b>1654.84</b>	<b>544.05</b>	<b>604.20</b>	<b>13.8</b>	<b>0.3</b>	<b>22.9</b>	<b>580.0</b>	
	<b>103†</b>	<b>17.00</b>	<b>1047.22</b>	<b>3293.44</b>	<b>1177.95</b>	<b>818.94</b>					
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 8.5 10 <sup>-3</sup>											



Taxonomy no 1.1.1.1.2		Item Machinery Compressors Centrifugal Electric driven (1000-3000)kW								
Population 6	Installations 5	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 815			
		Calendar time * 0.2012		Operational time † 0.1677						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	37*	<b>6.74</b>	<b>179.76</b>	<b>542.30</b>	<b>184.69</b>	<b>183.93</b>	<b>13.0</b>	<b>1.0</b>	<b>17.8</b>	<b>197.0</b>
	37†	<b>9.60</b>	<b>205.57</b>	<b>616.59</b>	<b>206.86</b>	<b>220.58</b>				
Erratic output	2*	1.42	9.32	23.00	7.03	9.94	2.8	3.0	5.5	8.0
	2†	0.37	11.01	33.32	11.43	11.92				
External leakage - Process medium	1*	0.01	5.92	24.21	9.17	4.97	170.0	197.0	197.0	197.0
	1†	0.04	6.44	22.59	8.34	5.96				
Fail to start on demand	12*	0.52	59.18	197.29	72.31	59.65	13.7	1.0	15.9	128.0
	12†	0.77	67.25	217.74	79.08	71.54				
Other	1*	0.33	5.15	15.01	4.97	4.97	-	59.0	59.0	59.0
	1†	0.36	6.10	17.95	5.96	5.96				
Parameter deviation	1*	0.00	4.67	22.15	9.08	4.97	4.0	4.0	4.0	4.0
	1†	0.00	5.79	28.78	12.25	5.96				
Spurious stop	20*	1.29	96.59	308.46	111.33	99.42	4.6	2.0	7.6	25.0
	20†	1.89	110.62	346.70	123.70	119.23				
<b>Degraded</b>	32*	<b>107.07</b>	<b>157.62</b>	<b>216.14</b>	<b>33.34</b>	<b>159.07</b>	<b>14.9</b>	<b>0.5</b>	<b>28.4</b>	<b>410.0</b>
	32†	<b>105.55</b>	<b>187.43</b>	<b>288.32</b>	<b>56.17</b>	<b>190.78</b>				
Erratic output	1*	0.00	4.40	19.18	7.47	4.97	16.0	32.0	32.0	32.0
	1†	0.00	5.36	24.72	9.94	5.96				
External leakage - Process medium	2*	0.03	10.34	40.67	15.14	9.94	3.3	0.5	3.3	6.0
	2†	0.05	12.05	44.83	16.55	11.92				
External leakage - Utility medium	8*	5.21	41.11	105.47	32.87	39.77	7.0	2.0	6.9	24.0
	8†	6.40	48.30	122.84	38.13	47.69				
Fail to stop on demand	1*	0.00	4.40	19.18	7.47	4.97	3.5	7.0	7.0	7.0
	1†	0.00	5.36	24.72	9.94	5.96				
High output	1*	0.03	5.44	19.06	7.04	4.97	4.0	4.0	4.0	4.0
	1†	0.35	6.08	17.94	5.96	5.96				
Internal leakage	5*	0.00	19.15	87.79	35.11	24.85	26.6	2.0	52.6	216.0
	5†	0.00	24.19	113.93	46.50	29.81				
Low output	3*	4.11	14.96	31.33	8.61	14.91	2.0	2.0	2.0	2.0
	3†	4.11	17.90	39.63	11.32	17.89				
Other	6*	6.26	30.66	70.28	20.55	29.83	42.0	5.0	74.8	410.0
	6†	7.36	36.00	82.49	24.12	35.77				
Parameter deviation	5*	0.21	23.52	78.37	28.72	24.85	2.9	2.0	7.9	28.0
	5†	0.15	29.23	105.88	39.12	29.81				
<b>Incipient</b>	130*	<b>54.56</b>	<b>661.08</b>	<b>1853.59</b>	<b>604.93</b>	<b>646.23</b>	<b>6.7</b>	<b>1.0</b>	<b>8.7</b>	<b>172.0</b>
	130†	<b>71.85</b>	<b>744.21</b>	<b>2025.40</b>	<b>651.89</b>	<b>775.03</b>				
Abnormal instrument reading	84*	6.34	443.06	1406.82	506.19	417.56	4.2	1.0	5.8	44.0
	84†	9.69	488.18	1515.06	536.28	500.79				
Erratic output	2*	0.00	12.01	53.70	21.24	9.94	5.5	1.0	5.5	10.0
	2†	0.01	12.65	54.44	21.09	11.92				
<b>Comments</b>										

(cont.)

Taxonomy no 1.1.1.1.2		Item Machinery Compressors Centrifugal Electric driven (1000-3000)kW									
Population 6	Installations 5	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 815				
		Calendar time * 0.2012		Operational time † 0.1677							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
External leakage - Process medium	1*	0.00	4.67	22.15	9.08	4.97	2.0	2.0	2.0	2.0	
	1†	0.00	5.79	28.78	12.25	5.96					
External leakage - Utility medium	10*	8.14	47.52	113.86	34.17	49.71	11.1	2.0	13.1	40.0	
	10†	31.44	58.63	92.68	18.85	59.62					
Internal leakage	1*	0.00	4.40	19.18	7.47	4.97	2.0	4.0	4.0	4.0	
	1†	0.00	5.36	24.72	9.94	5.96					
Minor in-service problems	13*	21.09	67.37	134.96	35.80	64.62	4.8	1.0	5.5	20.0	
	13†	36.29	78.07	132.64	29.81	77.50					
Other	16*	4.16	70.95	208.91	69.41	79.54	20.8	1.0	25.3	172.0	
	16†	1.90	85.84	264.75	93.15	95.39					
Structural deficiency	2*	1.42	9.32	23.00	7.03	9.94	12.0	8.0	16.0	24.0	
	2†	0.37	11.01	33.32	11.43	11.92					
Vibration	1*	0.03	5.44	19.06	7.04	4.97	3.0	3.0	3.0	3.0	
	1†	0.35	6.08	17.94	5.96	5.96					
All modes	199*	111.37	991.89	2607.76	823.08	989.22	9.1	0.5	13.4	410.0	
	199†	150.01	1128.97	2869.65	890.57	1186.39					
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.5 · 10 <sup>2</sup>											

Taxonomy no 1.1.1.1.3		Item Machinery Compressors Centrifugal Electric driven (3000-10000)kW								
Population 20	Installations 7	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 1637			
		Calendar time * 0.7261			Operational time † 0.5100					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	25*	0.21	47.73	178.54	65.90	34.43	219.3	2.0	228.3	1818.0
	25†	0.43	63.81	220.36	81.24	49.02				
External leakage - Process medium	1*	0.00	1.82	7.78	3.00	1.38	2.0	2.0	2.0	2.0
	1†	0.16	2.10	5.98	1.96	1.96				
External leakage - Utility medium	1*	0.12	1.49	4.21	1.38	1.38	123.5	123.5	123.5	123.5
	1†	0.00	2.22	11.60	5.18	1.96				
Fail to start on demand	6*	0.17	11.09	34.99	12.54	8.26	168.5	2.0	172.8	704.0
	6†	1.10	13.85	39.09	12.80	11.77				
Internal leakage	4*	0.00	8.30	41.96	18.04	5.51	141.5	91.0	213.8	304.0
	4†	0.00	9.29	47.16	20.33	7.84				
Low output	2*	0.00	4.05	19.64	8.14	2.75	621.0	619.0	791.5	964.0
	2†	0.00	4.70	21.49	8.58	3.92				
Spurious stop	10*	0.27	18.56	58.89	21.18	13.77	265.5	2.0	203.1	1818.0
	10†	0.20	29.40	101.55	37.44	19.61				
Vibration	1*	0.00	1.82	7.78	3.00	1.38	13.0	21.0	21.0	21.0
	1†	0.16	2.10	5.98	1.96	1.96				
<b>Degraded</b>	44*	12.11	101.55	263.37	82.47	60.60	13.6	2.0	25.1	218.0
	44†	20.75	136.75	337.82	103.30	86.28				
Abnormal instrument reading	2*	0.00	3.67	17.49	7.18	2.75	-	14.0	14.0	14.0
	2†	0.00	7.29	34.95	14.39	3.92				
External leakage - Process medium	2*	0.00	3.67	17.49	7.18	2.75	-	8.0	9.0	10.0
	2†	0.00	7.29	34.95	14.39	3.92				
External leakage - Utility medium	11*	0.29	27.48	89.68	32.67	15.15	16.7	3.0	32.7	218.0
	11†	0.35	31.97	104.14	37.91	21.57				
High output	2*	0.50	3.11	7.59	2.30	2.75	5.0	3.0	5.0	7.0
	2†	0.01	4.26	17.03	6.37	3.92				
Internal leakage	1*	0.12	1.49	4.21	1.38	1.38	6.0	6.0	6.0	6.0
	1†	0.00	1.97	9.51	3.93	1.96				
Low output	3*	0.00	6.19	30.79	13.11	4.13	8.0	4.0	8.0	15.0
	3†	0.00	7.03	34.49	14.49	5.88				
Minor in-service problems	2*	0.00	3.25	13.25	5.01	2.75	2.0	2.0	2.0	2.0
	2†	0.01	4.17	16.12	5.95	3.92				
Noise	2*	0.00	2.51	10.15	3.82	2.75	26.0	20.0	42.0	64.0
	2†	0.01	3.61	14.08	5.22	3.92				
Other	13*	0.32	35.48	117.88	43.17	17.90	14.7	4.0	26.3	109.0
	13†	0.56	48.80	158.08	57.42	25.49				
Parameter deviation	1*	0.12	1.49	4.21	1.38	1.38	2.5	2.0	2.0	2.0
	1†	0.00	2.22	11.60	5.18	1.96				
Vibration	5*	0.26	10.80	33.15	11.60	6.89	18.7	6.0	38.4	96.0
	5†	0.14	16.37	54.75	20.08	9.80				

Comments

(cont.)

Taxonomy no 1.1.1.1.3		Item Machinery Compressors Centrifugal Electric driven (3000-10000)kW										
Population 20	Installations 7	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 1637					
		Calendar time *			Operational time †							
		0.7261					0.5100					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)				
		Lower	Mean	Upper	SD	n/r		Min	Mean	Max		
<b>Incipient</b>	66*	<b>19.08</b>	<b>151.80</b>	<b>389.98</b>	<b>121.62</b>	<b>90.90</b>	31.2	1.0	27.3	531.0		
	66†	<b>30.65</b>	<b>204.81</b>	<b>507.54</b>	<b>155.48</b>	<b>129.42</b>						
Abnormal instrument reading	35*	8.49	75.24	197.58	62.31	48.20	12.6	1.0	11.7	73.0		
	35†	11.10	105.90	283.08	90.23	68.63						
External leakage - Utility medium	9*	0.15	21.47	73.81	27.20	12.40	4.2	2.0	7.9	32.0		
	9†	0.19	25.77	88.12	32.45	17.65						
Minor in-service problems	3*	0.03	5.53	20.46	7.56	4.13	6.7	4.0	6.7	11.0		
	3†	0.16	6.81	20.91	7.33	5.88						
Noise	3*	0.45	4.15	10.97	3.48	4.13	7.7	4.0	7.7	11.0		
	3†	1.00	5.87	14.07	4.22	5.88						
Other	8*	0.90	20.66	62.07	20.93	11.02	401.5	3.0	155.0	531.0		
	8†	1.94	29.27	84.84	28.04	15.69						
Parameter deviation	1*	0.00	2.94	14.22	5.88	1.38	-	2.0	2.0	2.0		
	1†	0.00	3.57	17.11	7.04	1.96						
Unknown	1*	0.00	2.94	14.22	5.88	1.38	-	4.0	4.0	4.0		
	1†	0.00	3.57	17.11	7.04	1.96						
Vibration	6*	0.20	12.12	38.05	13.60	8.26	2.6	1.0	22.0	119.0		
	6†	0.49	15.71	47.68	16.43	11.77						
<b>Unknown</b>	5*	<b>0.00</b>	<b>8.95</b>	<b>39.87</b>	<b>15.74</b>	<b>6.89</b>	7.0	3.0	46.0	164.0		
	5†	<b>0.00</b>	<b>17.33</b>	<b>76.62</b>	<b>30.12</b>	<b>9.80</b>						
Abnormal instrument reading	2*	0.00	3.67	17.49	7.18	2.75	-	3.0	6.5	10.0		
	2†	0.00	7.29	34.95	14.39	3.92						
External leakage - Utility medium	2*	0.66	3.01	6.75	1.95	2.75	7.0	7.0	85.5	164.0		
	2†	0.12	4.84	14.85	5.19	3.92						
Other	1*	0.01	1.66	6.27	2.31	1.38	-	-	-	-		
	1†	0.00	3.17	14.90	6.08	1.96						
<b>All modes</b>	140*	<b>37.91</b>	<b>313.94</b>	<b>812.41</b>	<b>254.16</b>	<b>192.82</b>	69.6	1.0	63.5	1818.0		
	140†	<b>60.61</b>	<b>429.18</b>	<b>1077.31</b>	<b>332.28</b>	<b>274.53</b>						
<b>Comments</b>												
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.2 10 <sup>-3</sup>												

Taxonomy no 1.1.1.1.4		Item Machinery Compressors Centrifugal Electric driven (20000-30000)kW								
Population 3	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0526		Operational time † 0.0526						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Degraded</b>	13*	146.27	247.34	393.19	247.34	247.34	-	6.0	15.6	40.0
	13†	146.27	247.34	393.19	247.34	247.34				
External leakage - Utility medium	5*	37.48	95.13	200.06	95.13	95.13	-	6.0	19.0	35.0
	5†	37.48	95.13	200.06	95.13	95.13				
Other	5*	37.48	95.13	200.06	95.13	95.13	-	7.0	16.0	40.0
	5†	37.48	95.13	200.06	95.13	95.13				
Parameter deviation	2*	6.75	38.05	119.77	38.05	38.05	-	6.0	7.0	8.0
	2†	6.75	38.05	119.77	38.05	38.05				
Vibration	1*	0.95	19.03	90.28	19.03	19.03	-	14.0	14.0	14.0
	1†	0.95	19.03	90.28	19.03	19.03				
<b>Incipient</b>	12*	131.75	228.31	369.86	228.31	228.31	-	2.0	14.3	92.0
	12†	131.75	228.31	369.86	228.31	228.31				
Abnormal instrument reading	6*	49.75	114.16	225.27	114.16	114.16	-	2.0	5.8	19.0
	6†	49.75	114.16	225.27	114.16	114.16				
Minor in-service problems	4*	25.97	76.10	174.18	76.10	76.10	-	3.0	7.8	12.0
	4†	25.97	76.10	174.18	76.10	76.10				
Parameter deviation	2*	6.75	38.05	119.77	38.05	38.05	-	13.0	52.5	92.0
	2†	6.75	38.05	119.77	38.05	38.05				
<b>All modes</b>	25*	330.69	475.65	664.29	475.65	475.65	-	2.0	15.0	92.0
	25†	330.69	475.65	664.29	475.65	475.65				
<b>Comments</b>										

Taxonomy no 1.1.1.2		Item Machinery Compressors Centrifugal Turbine driven								
Population 22	Installations 8	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 2469			
		Calendar time * 0.5999		Operational time † 0.4095						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>44*</b> <b>44†</b>	<b>41.52</b>	<b>73.49</b>	<b>112.84</b>	<b>21.92</b>	<b>73.34</b>	<b>5.6</b>	<b>1.0</b>	<b>75.3</b>	<b>1481.0</b>
Breakdown	1* 1†	0.01 0.01	1.46 2.12	5.26 8.25	1.94 3.06	1.67 2.44	-	1481.0	1481.0	1481.0
Erratic output	2* 2†	0.00 0.00	4.87 5.69	24.17 27.64	10.26 11.48	3.33 4.88	4.3	3.0	8.5	14.0
External leakage - Utility medium	3* 3†	0.01 0.01	5.27 7.59	21.25 30.75	8.00 11.59	5.00 7.33	0.5	1.0	28.0	55.0
Fail to start on demand	15* 15†	3.26 7.81	31.57 41.97	84.69 98.46	27.05 29.18	25.00 36.63	3.0	2.0	54.5	203.0
Fail to stop on demand	1* 1†	0.12 0.00	1.76 2.97	5.06 13.11	1.67 5.15	1.67 2.44	-	-	-	-
Other	1* 1†	0.12 0.00	1.76 2.97	5.06 13.11	1.67 5.15	1.67 2.44	-	-	-	-
Parameter deviation	1* 1†	0.01 0.01	1.46 2.12	5.26 8.25	1.94 3.06	1.67 2.44	-	8.0	8.0	8.0
Spurious stop	16* 16†	15.79 9.69	25.69 35.70	37.54 75.08	6.67 20.70	26.67 39.07	10.0	2.0	16.2	80.0
Vibration	4* 4†	2.22 0.01	6.60 9.18	12.87 38.21	3.33 14.56	6.67 9.77	-	40.0	69.3	100.0
<b>Degraded</b>	<b>104*</b> <b>104†</b>	<b>12.78</b>	<b>149.69</b>	<b>417.19</b>	<b>135.80</b>	<b>173.35</b>	<b>33.2</b>	<b>1.0</b>	<b>21.0</b>	<b>180.0</b>
Abnormal instrument reading	12* 12†	1.62 13.64	19.24 29.29	53.74 49.74	17.51 11.17	20.00 29.31	5.0	2.0	16.7	29.0
Erratic output	1* 1†	0.01 0.01	1.46 2.12	5.26 8.25	1.94 3.06	1.67 2.44	-	4.0	4.0	4.0
External leakage - Process medium	13* 13†	0.83 0.63	19.78 28.14	59.48 86.74	20.11 30.49	21.67 31.75	-	1.0	17.7	98.0
External leakage - Utility medium	33* 33†	0.61 0.52	43.20 69.45	137.31 236.40	49.43 87.00	55.01 80.59	100.0	2.0	28.4	88.0
Fail to stop on demand	1* 1†	0.12 0.00	1.76 2.97	5.06 13.11	1.67 5.15	1.67 2.44	-	-	-	-
High output	1* 1†	0.01 0.01	1.46 2.12	5.26 8.25	1.94 3.06	1.67 2.44	-	3.5	3.5	3.5
Internal leakage	2* 2†	0.00 0.00	3.87 6.70	18.21 33.59	7.43 14.37	3.33 4.88	-	-	-	-
Low output	2* 2†	0.02 0.07	5.27 5.88	20.55 19.05	7.62 6.92	3.33 4.88	3.0	6.0	19.0	32.0
Other	33* 33†	0.89 0.75	47.68 72.08	148.57 235.68	52.77 85.91	55.01 80.59	25.4	1.0	19.8	180.0
<b>Comments</b>										

(cont.)

Taxonomy no 1.1.1.2		Item Machinery Compressors Centrifugal Turbine driven									
Population 22	Installations 8	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 2469				
		Calendar time * 0.5999		Operational time † 0.4095							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
Overheating	2*	0.73	3.54	8.08	2.36	3.33	13.0	26.0	26.0	26.0	
	2†	0.07	5.98	19.29	6.99	4.88					
Parameter deviation	1*	0.01	1.90	7.10	2.62	1.67	9.0	18.0	18.0	18.0	
	1†	0.00	3.19	14.93	6.07	2.44					
Vibration	3*	0.07	4.64	14.76	5.32	5.00	-	10.0	18.0	26.0	
	3†	0.02	6.89	27.39	10.23	7.33					
<b>Incipient</b>	<b>147*</b>	<b>20.07</b>	<b>236.67</b>	<b>660.45</b>	<b>215.10</b>	<b>245.03</b>	<b>17.0</b>	<b>1.0</b>	<b>23.7</b>	<b>370.0</b>	
	<b>147†</b>	<b>15.25</b>	<b>391.87</b>	<b>1180.91</b>	<b>401.18</b>	<b>359.00</b>					
Abnormal instrument reading	59*	28.71	92.07	184.69	49.04	98.35	2.9	2.0	9.0	46.0	
	59†	21.66	142.62	352.24	107.70	144.09					
Erratic output	2*	0.00	4.87	24.17	10.26	3.33	43.8	38.0	87.5	137.0	
	2†	0.00	5.69	27.64	11.48	4.88					
External leakage - Process medium	1*	0.00	4.68	22.76	9.45	1.67	9.0	9.0	9.0	9.0	
	1†	0.00	4.85	24.47	10.51	2.44					
External leakage - Utility medium	37*	0.32	54.46	192.19	70.98	61.67	40.8	1.0	46.5	370.0	
	37†	0.40	90.52	338.56	124.96	90.36					
Low output	1*	0.01	1.46	5.26	1.94	1.67	-	2.0	2.0	2.0	
	1†	0.01	2.12	8.25	3.06	2.44					
Minor in-service problems	18*	0.05	37.86	154.48	58.42	30.00	6.5	2.0	14.0	78.0	
	18†	0.10	66.50	270.30	102.05	43.96					
Other	16*	6.71	24.23	50.63	13.89	26.67	23.0	1.0	21.3	64.0	
	16†	3.70	34.92	93.13	29.65	39.07					
Overheating	1*	0.00	2.14	9.59	3.80	1.67	1.0	2.0	2.0	2.0	
	1†	0.06	2.59	7.96	2.79	2.44					
Parameter deviation	9*	0.00	19.00	96.34	41.50	15.00	7.1	4.0	13.8	50.0	
	9†	0.00	34.87	170.38	71.31	21.98					
Structural deficiency	1*	0.00	3.36	16.71	7.11	1.67	-	64.0	64.0	64.0	
	1†	0.00	3.58	17.57	7.38	2.44					
Unknown	1*	0.00	1.53	6.81	2.69	1.67	-	6.0	6.0	6.0	
	1†	0.00	2.23	10.53	4.30	2.44					
Vibration	1*	0.12	1.76	5.06	1.67	1.67	-	-	-	-	
	1†	0.00	2.97	13.11	5.15	2.44					
<b>Unknown</b>	<b>38*</b>	<b>6.81</b>	<b>100.35</b>	<b>290.03</b>	<b>95.77</b>	<b>63.34</b>	<b>29.3</b>	<b>1.0</b>	<b>24.4</b>	<b>249.0</b>	
	<b>38†</b>	<b>5.39</b>	<b>141.72</b>	<b>427.38</b>	<b>145.42</b>	<b>92.80</b>					
Abnormal instrument reading	19*	0.31	44.43	152.77	56.30	31.67	3.0	1.0	8.5	16.0	
	19†	0.36	70.19	254.24	93.94	46.40					
External leakage - Utility medium	3*	0.00	5.79	29.37	12.65	5.00	-	-	-	-	
	3†	0.00	10.34	53.35	23.25	7.33					
Low output	1*	0.00	3.36	16.71	7.11	1.67	-	12.0	12.0	12.0	
	1†	0.00	3.58	17.57	7.38	2.44					
<b>Comments</b>											

(cont.)

Taxonomy no 1.1.1.2		Item Machinery Compressors Centrifugal Turbine driven								
Population 22	Installations 8	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 2469			
		Calendar time * 0.5999		Operational time † 0.4095						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Noise	1*	0.12	1.76	5.06	1.67	1.67	14.0	-	-	-
	1†	0.00	2.97	13.11	5.15	2.44				
Other	11*	0.96	30.24	91.76	31.59	18.34	2.0	2.0	19.5	105.0
	11†	2.32	37.08	108.29	35.88	26.86				
Overheating	1*	0.01	1.46	5.26	1.94	1.67	-	3.0	3.0	3.0
	1†	0.01	2.12	8.25	3.06	2.44				
Unknown	1*	0.00	2.14	9.59	3.80	1.67	124.5	249.0	249.0	249.0
	1†	0.06	2.59	7.96	2.79	2.44				
Vibration	1*	0.00	4.68	22.76	9.45	1.67	-	9.0	9.0	9.0
	1†	0.00	4.85	24.47	10.51	2.44				
All modes	333*	171.84	564.28	1141.65	305.35	555.07	18.7	1.0	29.7	1481.0
	333†	160.16	878.17	2070.53	615.17	813.25				
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 4.5 · 10 <sup>-3</sup>										



Taxonomy no 1.1.1.2.1		Item Machinery Compressors Centrifugal Turbine driven (3000-10000)kW									
Population 10	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 563				
		Calendar time * 0.1601		Operational time † 0.1246							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	9*	5.28	71.74	204.89	67.36	56.23	-	8.0	78.6	203.0	
	9†	8.93	88.85	239.78	76.83	72.23					
Fail to start on demand	7*	4.51	56.68	159.93	52.33	43.73	-	8.0	87.5	203.0	
	7†	8.07	68.38	177.69	55.68	56.18					
Spurious stop	1*	0.00	5.91	24.82	9.50	6.25	-	36.0	36.0	36.0	
	1†	0.14	8.92	28.14	10.08	8.03					
Vibration	1*	0.03	7.77	29.39	10.84	6.25	-	68.0	68.0	68.0	
	1†	0.55	8.60	25.07	8.30	8.03					
<b>Degraded</b>	14*	13.63	96.66	242.71	74.87	87.47	-	1.0	19.4	40.0	
	14†	4.93	145.64	440.85	151.15	112.35					
Abnormal instrument reading	3*	5.44	19.14	39.68	10.82	18.74	-	2.0	13.3	20.0	
	3†	2.21	27.84	78.59	25.72	24.08					
External leakage - Process medium	2*	0.82	17.08	51.18	17.13	12.50	-	40.0	40.0	40.0	
	2†	3.03	18.07	43.57	13.13	16.05					
External leakage - Utility medium	5*	0.01	26.82	115.99	45.01	31.24	-	5.0	19.4	40.0	
	5†	0.01	50.41	227.09	90.11	40.13					
Low output	1*	0.03	7.77	29.39	10.84	6.25	-	32.0	32.0	32.0	
	1†	0.55	8.60	25.07	8.30	8.03					
Other	3*	3.79	19.81	46.15	13.63	18.74	-	1.0	7.3	16.0	
	3†	1.65	30.06	89.19	29.70	24.08					
<b>Incipient</b>	11*	11.58	77.70	192.72	59.07	68.73	9.0	2.0	14.9	64.0	
	11†	8.66	110.37	312.08	102.21	88.28					
Abnormal instrument reading	4*	4.74	25.29	59.22	17.53	24.99	-	3.0	5.3	8.0	
	4†	0.43	38.75	125.98	45.82	32.10					
External leakage - Process medium	1*	0.01	10.42	44.14	16.99	6.25	9.0	9.0	9.0	9.0	
	1†	0.01	10.98	44.93	17.01	8.03					
External leakage - Utility medium	1*	0.03	7.77	29.39	10.84	6.25	-	15.0	15.0	15.0	
	1†	0.55	8.60	25.07	8.30	8.03					
Minor in-service problems	1*	0.03	7.77	29.39	10.84	6.25	-	39.0	39.0	39.0	
	1†	0.55	8.60	25.07	8.30	8.03					
Other	2*	0.98	12.02	33.79	11.04	12.50	-	2.0	5.0	8.0	
	2†	0.02	19.52	81.42	31.06	16.05					
Structural deficiency	1*	0.03	7.77	29.39	10.84	6.25	-	64.0	64.0	64.0	
	1†	0.55	8.60	25.07	8.30	8.03					
Unknown	1*	0.00	5.91	24.82	9.50	6.25	-	6.0	6.0	6.0	
	1†	0.14	8.92	28.14	10.08	8.03					
<b>Unknown</b>	13*	6.19	133.52	400.55	134.46	81.22	-	1.0	16.6	105.0	
	13†	9.63	151.18	440.64	145.92	104.33					
Abnormal instrument reading	6*	0.93	50.43	157.26	55.89	37.49	-	1.0	9.3	16.0	
	6†	1.73	67.49	206.59	72.06	48.15					
<b>Comments</b>											

(cont.)

Taxonomy no 1.1.1.2.1		Item Machinery Compressors Centrifugal Turbine driven (3000-10000)kW									
Population 10	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 563				
		Calendar time * 0.1601		Operational time † 0.1246							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
Low output	1*	0.03	7.77	29.39	10.84	6.25		12.0	12.0	12.0	
	1†	0.55	8.60	25.07	8.30	8.03					
Other	5*	0.91	54.57	171.25	61.16	31.24		2.0	27.8	105.0	
	5†	0.91	56.19	176.73	63.21	40.13					
Vibration	1*	0.01	10.42	44.14	16.99	6.25		9.0	9.0	9.0	
	1†	0.01	10.98	44.93	17.01	8.03					
All modes	47*	62.65	388.92	946.95	287.11	293.65	9.0	1.0	27.8	203.0	
	47†	60.52	507.13	1315.06	411.78	377.18					
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.2 · 10 <sup>-2</sup>											

Taxonomy no 1.1.1.2.2		Item Machinery Compressors Centrifugal Turbine driven (10000-20000)kW									
Population 12	Installations 5	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 1906				
		Calendar time * 0.4399		Operational time † 0.2849							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	35*	58.51	79.26	102.60	13.45	79.57	5.6	1.0	74.2	1481.0	
	35†	62.66	123.44	200.83	42.59	122.87					
Breakdown	1*	0.02	1.97	6.69	2.46	2.27	-	1481.0	1481.0	1481.0	
	1†	0.02	3.05	10.49	3.86	3.51					
Erratic output	2*	0.00	7.15	32.44	12.91	4.55	4.3	3.0	8.5	14.0	
	2†	0.00	8.57	37.81	14.85	7.02					
External leakage - Utility medium	3*	0.06	7.38	24.65	9.04	6.82	0.5	1.0	28.0	55.0	
	3†	0.14	11.23	35.97	13.00	10.53					
Fail to start on demand	8*	1.45	17.36	48.58	15.84	18.19	3.0	2.0	5.1	8.0	
	8†	9.45	28.28	55.27	14.36	28.08					
Fail to stop on demand	1*	0.03	2.52	8.19	2.98	2.27	-	-	-	-	
	1†	0.00	4.53	18.90	7.21	3.51					
Other	1*	0.03	2.52	8.19	2.98	2.27	-	-	-	-	
	1†	0.00	4.53	18.90	7.21	3.51					
Parameter deviation	1*	0.02	1.97	6.69	2.46	2.27	-	8.0	8.0	8.0	
	1†	0.02	3.05	10.49	3.86	3.51					
Spurious stop	15*	5.88	32.29	76.16	22.63	34.10	10.0	2.0	14.8	80.0	
	15†	31.87	52.04	76.23	13.60	52.66					
Vibration	3*	1.05	6.79	16.70	5.09	6.82	-	40.0	70.0	100.0	
	3†	2.77	10.38	21.96	6.08	10.53					
<b>Degraded</b>	90*	23.42	216.01	572.79	181.73	204.60	33.2	1.0	21.4	180.0	
	90†	44.20	341.86	873.59	271.78	315.94					
Abnormal instrument reading	9*	3.20	20.75	51.05	15.57	20.46	5.0	10.0	18.3	29.0	
	9†	16.65	32.27	52.05	10.91	31.59					
Erratic output	1*	0.02	1.97	6.69	2.46	2.27	-	4.0	4.0	4.0	
	1†	0.02	3.05	10.49	3.86	3.51					
External leakage - Process medium	11*	0.02	24.23	101.14	38.60	25.01	-	1.0	13.6	98.0	
	11†	0.05	34.75	141.65	53.54	38.62					
External leakage - Utility medium	28*	7.08	65.38	173.43	55.04	63.65	100.0	2.0	31.0	88.0	
	28†	11.65	105.18	277.49	87.77	98.29					
Fail to stop on demand	1*	0.03	2.52	8.19	2.98	2.27	-	-	-	-	
	1†	0.00	4.53	18.90	7.21	3.51					
High output	1*	0.02	1.97	6.69	2.46	2.27	-	3.5	3.5	3.5	
	1†	0.02	3.05	10.49	3.86	3.51					
Internal leakage	2*	0.00	5.51	24.33	9.56	4.55	-	-	-	-	
	2†	0.00	10.26	46.44	18.46	7.02					
Low output	1*	0.00	3.13	13.55	5.26	2.27	3.0	6.0	6.0	6.0	
	1†	0.04	3.91	12.82	4.68	3.51					
Other	30*	1.63	76.32	235.85	83.14	68.20	25.4	2.0	21.2	180.0	
	30†	4.82	114.07	342.97	115.86	105.31					
<b>Comments</b>											

(cont.)

Taxonomy no 1.1.1.2.2		Item Machinery Compressors Centrifugal Turbine driven (10000-20000)kW									
Population 12	Installations 5	Aggregated time in service (10 <sup>6</sup> hours)						No of demands 1906			
		Calendar time * 0.4399			Operational time † 0.2849						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t	Min		Mean	Max	
Overheating	2*	0.99	4.96	11.44	3.36	4.55	13.0	26.0	26.0	26.0	
	2†	0.32	9.03	27.31	9.35	7.02					
Parameter deviation	1*	0.01	2.75	10.86	4.04	2.27	9.0	18.0	18.0	18.0	
	1†	0.00	4.90	21.30	8.28	3.51					
Vibration	3*	0.37	6.84	20.34	6.78	6.82	-	10.0	18.0	26.0	
	3†	0.17	10.78	34.01	12.19	10.53					
<b>Incipient</b>	<b>136*</b>	<b>71.37</b>	<b>337.52</b>	<b>766.15</b>	<b>222.68</b>	<b>309.18</b>	<b>17.2</b>	<b>1.0</b>	<b>24.6</b>	<b>370.0</b>	
	<b>136†</b>	<b>88.26</b>	<b>583.11</b>	<b>1441.26</b>	<b>440.86</b>	<b>477.43</b>					
Abnormal instrument reading	55*	69.37	132.98	213.29	44.33	125.04	2.9	2.0	9.4	46.0	
	55†	85.02	215.98	395.63	96.67	193.08					
Erratic output	2*	0.00	7.15	32.44	12.91	4.55	43.8	38.0	87.5	137.0	
	2†	0.00	8.57	37.81	14.85	7.02					
External leakage - Utility medium	36*	4.54	77.77	229.10	76.12	81.84	40.8	1.0	47.5	370.0	
	36†	4.68	136.19	412.03	141.13	126.38					
Low output	1*	0.02	1.97	6.69	2.46	2.27	-	2.0	2.0	2.0	
	1†	0.02	3.05	10.49	3.86	3.51					
Minor in-service problems	17*	0.25	51.33	187.95	69.43	38.65	6.5	2.0	11.7	78.0	
	17†	0.61	97.65	340.96	125.84	59.68					
Other	14*	9.74	30.04	59.40	15.59	31.83	23.0	1.0	23.6	64.0	
	14†	8.89	46.81	109.31	32.31	49.15					
Overheating	1*	0.00	3.13	13.55	5.26	2.27	1.0	2.0	2.0	2.0	
	1†	0.04	3.91	12.82	4.68	3.51					
Parameter deviation	9*	0.01	28.98	127.65	50.07	20.46	7.1	4.0	13.8	50.0	
	9†	0.04	54.90	231.47	88.86	31.59					
Vibration	1*	0.03	2.52	8.19	2.98	2.27	-	-	-	-	
	1†	0.00	4.53	18.90	7.21	3.51					
<b>Unknown</b>	<b>25*</b>	<b>0.65</b>	<b>70.55</b>	<b>233.66</b>	<b>85.50</b>	<b>56.83</b>	<b>29.3</b>	<b>2.0</b>	<b>35.6</b>	<b>249.0</b>	
	<b>25†</b>	<b>1.01</b>	<b>128.15</b>	<b>433.21</b>	<b>159.24</b>	<b>87.76</b>					
Abnormal instrument reading	13*	0.02	37.81	162.52	62.93	29.55	3.0	4.0	6.0	8.0	
	13†	0.09	73.80	303.75	115.24	45.64					
External leakage - Utility medium	3*	0.00	8.41	38.96	15.73	6.82	-	-	-	-	
	3†	0.00	15.97	73.42	29.44	10.53					
Noise	1*	0.03	2.52	8.19	2.98	2.27	14.0	-	-	-	
	1†	0.00	4.53	18.90	7.21	3.51					
Other	6*	0.39	16.08	49.37	17.28	13.64	2.0	2.0	11.2	36.0	
	6†	1.35	24.77	73.54	24.49	21.06					
Overheating	1*	0.02	1.97	6.69	2.46	2.27	-	3.0	3.0	3.0	
	1†	0.02	3.05	10.49	3.86	3.51					
Unknown	1*	0.00	3.13	13.55	5.26	2.27	124.5	249.0	249.0	249.0	
	1†	0.04	3.91	12.82	4.68	3.51					

Comments

(cont.)

<b>Taxonomy no</b> 1.1.1.2.2		<b>Item</b> Machinery Compressors Centrifugal Turbine driven (10000-20000)kW								
<b>Population</b> 12	<b>Installations</b> 5	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b> 1906			
		<b>Calendar time *</b> 0.4399			<b>Operational time †</b> 0.2849					
<b>Failure mode</b>	<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours)</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
		<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/τ</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>	286* 286†	292.23 371.45	701.91 1179.56	1254.69 2357.72	298.76 624.28	650.19 1004.00	18.9	1.0	30.2	1481.0
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 2.1 · 10 <sup>-3</sup>										

Taxonomy no 1.1.1.3		Item Machinery Compressors Centrifugal Unknown								
Population 9	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 900			
		Calendar time * 0.2365		Operational time † 0.0648						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>16*</b> <b>16†</b>	<b>7.87</b> <b>9.71</b>	<b>67.65</b> <b>865.69</b>	<b>176.21</b> <b>2808.94</b>	<b>55.29</b> <b>1021.04</b>	<b>67.65</b> <b>246.91</b>	<b>8.5</b>	<b>1.0</b>	<b>23.2</b>	<b>84.5</b>
Abnormal instrument reading	2*	0.85	8.46	22.84	7.32	8.46	2.5	17.0	17.0	17.0
Breakdown	2†	3.56	109.67	332.46	114.30	30.86	6.5	25.5	36.5	47.5
	2†	0.07	8.46	28.24	10.36	8.46				
External leakage - Utility medium	4*	2.62	16.91	41.59	12.68	16.91	21.8	18.5	36.4	84.5
	4†	2.60	236.71	769.63	279.97	61.73				
Fail to start on demand	4*	5.77	16.91	32.79	8.46	16.91	4.3	1.0	5.8	10.5
	4†	0.99	123.74	417.36	153.35	61.73				
Internal leakage	1*	0.21	4.23	12.66	4.23	4.23	1.0	2.0	2.0	2.0
	1†	0.08	55.50	226.62	85.72	15.43				
Spurious stop	3*	0.05	12.68	48.72	17.94	12.68	4.3	6.0	6.0	6.0
	3†	0.26	179.18	729.42	275.56	46.30				
<b>Degraded</b>	<b>3*</b> <b>3†</b>	<b>3.47</b> <b>9.91</b>	<b>12.68</b> <b>54.63</b>	<b>26.62</b> <b>128.96</b>	<b>7.32</b> <b>38.34</b>	<b>12.68</b> <b>46.30</b>	<b>13.7</b>	<b>11.0</b>	<b>30.5</b>	<b>50.0</b>
Low output	3*	3.47	12.68	26.62	7.32	12.68	13.7	11.0	30.5	50.0
	3†	9.91	54.63	128.96	38.34	46.30				
<b>Incipient</b>	<b>82*</b> <b>82†</b>	<b>3.40</b> <b>37.88</b>	<b>346.69</b> <b>4941.54</b>	<b>1140.75</b> <b>16757.28</b>	<b>416.64</b> <b>6162.92</b>	<b>346.69</b> <b>1265.43</b>	<b>3.4</b>	<b>1.0</b>	<b>6.9</b>	<b>98.0</b>
Abnormal instrument reading	3*	3.47	12.68	26.62	7.32	12.68	4.0	6.0	6.0	6.0
	3†	0.51	120.52	452.91	167.11	46.30				
External leakage - Utility medium	24*	9.83	101.47	275.96	88.79	101.47	4.9	1.0	9.2	53.0
	24†	35.85	1469.37	4509.04	1577.57	370.37				
Fail to start on demand	1*	0.21	4.23	12.66	4.23	4.23	4.0	4.0	4.0	4.0
	1†	0.08	55.50	226.62	85.72	15.43				
Internal leakage	47*	0.06	198.71	870.90	340.50	198.71	1.9	1.0	3.0	15.5
	47†	4.29	2895.34	11773.26	4445.64	725.31				
Minor in-service problems	4*	5.77	16.91	32.79	8.46	16.91	8.5	2.0	9.5	15.5
	4†	8.77	174.40	522.05	174.28	61.73				
Other	1*	0.21	4.23	12.66	4.23	4.23	6.0	3.0	3.0	3.0
	1†	0.08	55.50	226.62	85.72	15.43				
Overheating	1*	0.21	4.23	12.66	4.23	4.23	12.0	98.0	98.0	98.0
	1†	0.08	55.50	226.62	85.72	15.43				
Vibration	1*	0.21	4.23	12.66	4.23	4.23	3.0	25.5	25.5	25.5
	1†	0.08	55.50	226.62	85.72	15.43				
<b>All modes</b>	<b>101*</b> <b>101†</b>	<b>34.37</b> <b>94.73</b>	<b>427.03</b> <b>5889.87</b>	<b>1202.45</b> <b>18535.59</b>	<b>393.13</b> <b>6632.54</b>	<b>427.03</b> <b>1558.64</b>	<b>4.5</b>	<b>1.0</b>	<b>9.6</b>	<b>98.0</b>
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 4.4 10 <sup>-3</sup>										

Taxonomy no 1.1.1.3.1		Item Machinery Compressors Centrifugal Unknown Unknown								
Population 9	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 900			
		Calendar time * 0.2365		Operational time † 0.0648						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>16*</b> <b>16†</b>	<b>7.87</b> <b>9.71</b>	<b>67.65</b> <b>865.69</b>	<b>176.21</b> <b>2808.94</b>	<b>55.29</b> <b>1021.04</b>	<b>67.65</b> <b>246.91</b>	<b>8.5</b>	<b>1.0</b>	<b>23.2</b>	<b>84.5</b>
Abnormal instrument reading	2* 2†	0.85 3.56	8.46 109.67	22.84 332.46	7.32 114.30	8.46 30.86	2.5	17.0	17.0	17.0
Breakdown	2* 2†	0.07 0.17	8.46 117.40	28.24 478.24	10.36 180.72	8.46 30.86	6.5	25.5	36.5	47.5
External leakage - Utility medium	4* 4†	2.62 2.60	16.91 236.71	41.59 769.63	12.68 279.97	16.91 61.73	21.8	18.5	36.4	84.5
Fail to start on demand	4* 4†	5.77 0.99	16.91 123.74	32.79 417.36	8.46 153.35	16.91 61.73	4.3	1.0	5.8	10.5
Internal leakage	1* 1†	0.21 0.08	4.23 55.50	12.66 226.62	4.23 85.72	4.23 15.43	1.0	2.0	2.0	2.0
Spurious stop	3* 3†	0.05 0.26	12.68 179.18	48.72 729.42	17.94 275.56	12.68 46.30	4.3	6.0	6.0	6.0
<b>Degraded</b>	<b>3*</b> <b>3†</b>	<b>3.47</b> <b>9.91</b>	<b>12.68</b> <b>54.63</b>	<b>26.62</b> <b>128.96</b>	<b>7.32</b> <b>38.34</b>	<b>12.68</b> <b>46.30</b>	<b>13.7</b>	<b>11.0</b>	<b>30.5</b>	<b>50.0</b>
Low output	3* 3†	3.47 9.91	12.68 54.63	26.62 128.96	7.32 38.34	12.68 46.30	13.7	11.0	30.5	50.0
<b>Incipient</b>	<b>82*</b> <b>82†</b>	<b>3.40</b> <b>37.88</b>	<b>346.69</b> <b>4941.54</b>	<b>1140.75</b> <b>16757.28</b>	<b>416.64</b> <b>6162.92</b>	<b>346.69</b> <b>1265.43</b>	<b>3.4</b>	<b>1.0</b>	<b>6.9</b>	<b>98.0</b>
Abnormal instrument reading	3* 3†	3.47 0.51	12.68 120.52	26.62 452.91	7.32 167.11	12.68 46.30	4.0	6.0	6.0	6.0
External leakage - Utility medium	24* 24†	9.83 35.85	101.47 1469.37	275.96 4509.04	88.79 1577.57	101.47 370.37	4.9	1.0	9.2	53.0
Fail to start on demand	1* 1†	0.21 0.08	4.23 55.50	12.66 226.62	4.23 85.72	4.23 15.43	4.0	4.0	4.0	4.0
Internal leakage	47* 47†	0.06 4.29	198.71 2895.34	870.90 11773.26	340.50 4445.64	198.71 725.31	1.9	1.0	3.0	15.5
Minor in-service problems	4* 4†	5.77 8.77	16.91 174.40	32.79 522.05	8.46 174.28	16.91 61.73	8.5	2.0	9.5	15.5
Other	1* 1†	0.21 0.08	4.23 55.50	12.66 226.62	4.23 85.72	4.23 15.43	6.0	3.0	3.0	3.0
Overheating	1* 1†	0.21 0.08	4.23 55.50	12.66 226.62	4.23 85.72	4.23 15.43	12.0	98.0	98.0	98.0
Vibration	1* 1†	0.21 0.08	4.23 55.50	12.66 226.62	4.23 85.72	4.23 15.43	3.0	25.5	25.5	25.5
<b>All modes</b>	<b>101*</b> <b>101†</b>	<b>34.37</b> <b>94.73</b>	<b>427.03</b> <b>5889.87</b>	<b>1202.45</b> <b>18535.59</b>	<b>393.13</b> <b>6632.54</b>	<b>427.03</b> <b>1558.64</b>	<b>4.5</b>	<b>1.0</b>	<b>9.6</b>	<b>98.0</b>
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 4.4 · 10 <sup>3</sup>										

Taxonomy no 1.1.2		Item Machinery Compressors Reciprocating								
Population 32	Installations 10	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 36658			
		Calendar time * 0.7323		Operational time † 0.5046						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>367*</b> <b>367†</b>	<b>0.01</b>	<b>347.08</b>	<b>1678.18</b>	<b>693.22</b>	<b>501.19</b>	<b>8.9</b>	<b>0.5</b>	<b>13.0</b>	<b>250.0</b>
Abnormal instrument reading	1* 1†	0.00 0.19	1.86 2.19	7.90 6.09	3.05 1.98	1.37 1.98	16.0	16.0	16.0	16.0
Breakdown	2* 2†	0.09 0.07	2.27 3.41	6.84 10.62	2.32 3.77	2.73 3.96	116.5	74.0	140.5	207.0
Erratic output	2* 2†	0.00 0.05	5.04 13.26	21.49 50.59	8.30 18.64	2.73 3.96	20.0	8.0	14.0	20.0
External leakage - Process medium	40* 40†	0.00 0.00	36.68 45.55	201.99 246.92	100.72 114.85	54.63 79.26	3.8	0.5	6.7	81.0
External leakage - Utility medium	16* 16†	0.00 0.06	17.39 24.15	82.87 95.41	34.03 35.56	21.85 31.71	3.4	1.0	6.9	50.0
Fail to start on demand	11* 11†	0.01 0.01	15.40 37.42	65.18 166.98	25.07 65.98	15.02 21.80	39.4	4.0	42.0	204.0
Fail to stop on demand	2* 2†	0.00 0.00	4.52 9.20	19.93 40.96	7.83 16.16	2.73 3.96	3.5	3.5	10.8	18.0
Low output	140* 140†	0.00 0.00	122.03 140.44	663.02 752.91	308.86 347.39	191.19 277.42	6.2	0.5	10.9	168.0
Noise	2* 2†	0.00 0.00	3.81 8.72	17.89 39.92	7.30 15.93	2.73 3.96	29.0	4.0	18.5	33.0
Other	1* 1†	0.00 0.00	4.19 10.07	20.60 44.20	8.68 17.30	1.37 1.98	-	1.0	1.0	1.0
Overheating	64* 64†	0.00 0.00	58.83 72.66	305.92 356.65	135.89 149.99	87.40 126.82	3.8	0.5	8.2	36.0
Parameter deviation	46* 46†	0.00 0.00	42.79 53.10	231.70 275.04	107.70 121.17	62.82 91.15	15.9	0.5	21.1	250.0
Spurious stop	30* 30†	7.43 31.64	43.47 63.24	104.22 103.64	31.29 22.20	40.97 59.45	12.0	1.0	13.9	48.0
Structural deficiency	5* 5†	0.03 1.56	7.26 10.08	26.79 24.79	9.89 7.56	6.83 9.91	11.4	2.0	13.8	36.0
Vibration	5* 5†	0.03 2.93	6.68 9.77	24.11 19.90	8.91 5.35	6.83 9.91	4.0	1.0	7.6	28.0
<b>Degraded</b>	<b>241*</b> <b>241†</b>	<b>0.80</b>	<b>269.46</b>	<b>1051.97</b>	<b>390.37</b>	<b>329.12</b>	<b>7.3</b>	<b>0.3</b>	<b>8.5</b>	<b>128.0</b>
Erratic output	8* 8†	1.34 4.82	24.58 50.60	72.95 138.09	24.29 44.51	10.93 15.85	36.0	8.0	29.4	96.0
External leakage - Process medium	24* 24†	0.00 0.00	24.42 34.68	126.96 157.98	56.38 62.96	32.78 47.56	2.2	0.5	3.9	24.0
External leakage - Utility medium	8* 8†	0.12 1.51	9.58 14.10	30.71 37.49	11.10 11.91	10.93 15.85	4.9	0.3	7.3	22.0
<b>Comments</b>										

(cont.)



Taxonomy no 1.1.2		Item Machinery Compressors Reciprocating								
Population 32	Installations 10	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 36658			
		Calendar time * 0.7323		Operational time † 0.5046						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/r		Min	Mean	Max
Fail to start on demand	1*	0.00	1.40	6.51	2.63	1.37	1.0	1.0	1.0	1.0
	1†	0.01	1.94	7.53	2.79	1.98				
Fail to stop on demand	2*	0.31	2.83	7.47	2.36	2.73	3.3	0.5	3.3	6.0
	2†	0.01	3.74	14.92	5.58	3.96				
Internal leakage	2*	0.31	2.83	7.47	2.36	2.73	2.3	1.0	4.0	7.0
	2†	0.01	3.74	14.92	5.58	3.96				
Low output	92*	0.27	107.04	422.57	157.47	125.64	11.3	0.5	12.1	128.0
	92†	0.26	214.65	883.00	334.94	182.31				
Other	1*	0.00	4.19	20.60	8.68	1.37	-	30.0	30.0	30.0
	1†	0.00	10.07	44.20	17.30	1.98				
Overheating	23*	0.24	28.56	95.52	35.04	31.41	7.8	1.0	10.3	48.0
	23†	6.99	41.71	100.53	30.29	45.58				
Parameter deviation	65*	0.00	57.31	304.91	201.91	88.77	1.8	0.3	2.1	10.0
	65†	0.00	68.55	366.56	239.26	128.80				
Structural deficiency	5*	0.03	6.68	24.11	8.91	6.83	3.7	0.5	5.4	10.0
	5†	2.93	9.77	19.90	5.35	9.91				
Unknown	6*	0.06	12.24	44.50	16.44	8.19	33.0	4.0	33.5	64.0
	6†	0.17	31.03	111.15	41.07	11.89				
Vibration	4*	0.11	5.80	17.99	6.37	5.46	1.2	1.0	1.2	1.5
	4†	0.01	8.86	36.49	13.85	7.93				
<b>Incipient</b>	<b>454*</b>	<b>0.03</b>	<b>427.59</b>	<b>1970.30</b>	<b>791.74</b>	<b>619.99</b>	<b>3.6</b>	<b>0.3</b>	<b>4.5</b>	<b>116.0</b>
	<b>454†</b>	<b>1.91</b>	<b>615.73</b>	<b>2397.46</b>	<b>888.66</b>	<b>899.65</b>				
Abnormal instrument reading	98*	0.00	90.60	433.07	178.08	133.83	3.1	0.3	3.4	24.0
	98†	0.22	127.28	513.02	192.92	194.20				
Erratic output	2*	0.00	5.04	21.49	8.30	2.73	8.0	5.0	6.5	8.0
	2†	0.05	13.26	50.59	18.64	3.96				
External leakage - Process medium	20*	0.65	28.02	86.20	30.24	27.31	13.0	1.0	14.8	115.0
	20†	7.08	42.08	101.31	30.50	39.63				
External leakage - Utility medium	22*	13.36	31.27	55.28	13.01	30.04	9.7	0.3	10.7	116.0
	22†	8.35	49.40	118.81	35.74	43.60				
Minor in-service problems	236*	0.00	200.63	1099.31	514.60	322.29	1.6	0.3	2.7	29.0
	236†	0.00	231.74	1249.76	579.27	467.66				
Noise	4*	0.37	6.24	18.33	6.09	5.46	19.7	5.0	16.8	33.0
	4†	1.06	9.64	25.49	8.07	7.93				
Other	9*	0.18	21.82	73.45	26.97	12.29	1.7	1.0	6.9	20.0
	9†	0.60	46.30	148.35	53.63	17.83				
Overheating	8*	2.69	11.66	25.80	7.37	10.93	13.9	2.0	13.3	51.0
	8†	2.18	17.48	45.00	14.05	15.85				
Parameter deviation	22*	0.02	23.21	97.82	37.55	30.04	5.5	1.0	5.6	24.0
	22†	0.99	34.14	103.93	35.98	43.60				
<b>Comments</b>										

(cont.)

Taxonomy no 1.1.2		Item Machinery Compressors Reciprocating									
Population 32	Installations 10	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 36658				
		Calendar time * 0.7323		Operational time † 0.5046							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Structural deficiency	6*	0.22	8.18	24.96	8.68	8.19	1.4	0.5	2.7	8.0	
	6†	0.21	10.83	33.62	11.90	11.89					
Unknown	17*	0.00	23.23	134.17	72.82	23.22	14.5	2.0	14.5	32.0	
	17†	0.00	74.82	387.69	170.92	33.69					
Vibration	10*	3.21	13.18	28.69	8.11	13.66	1.8	1.0	2.7	8.0	
	10†	1.61	17.28	47.36	15.30	19.82					
Unknown	12*	<b>0.04</b>	<b>14.45</b>	<b>56.56</b>	<b>21.01</b>	<b>16.39</b>	<b>5.7</b>	<b>0.8</b>	<b>10.2</b>	<b>24.0</b>	
	12†	<b>2.02</b>	<b>21.18</b>	<b>57.77</b>	<b>18.61</b>	<b>23.78</b>					
Unknown	12*	0.04	14.45	56.56	21.01	16.39	5.7	0.8	10.2	24.0	
	12†	2.02	21.18	57.77	18.61	23.78					
All modes	1074*	<b>0.16</b>	<b>1038.22</b>	<b>4671.32</b>	<b>1852.75</b>	<b>1466.68</b>	<b>6.3</b>	<b>0.3</b>	<b>8.5</b>	<b>250.0</b>	
	1074†	<b>6.30</b>	<b>1501.47</b>	<b>5666.15</b>	<b>2089.96</b>	<b>2128.25</b>					
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.9 10 <sup>-4</sup>											

**Maintainable item versus failure mode, to be continued**

**Item: Compressors - Reciprocating**

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Base frame	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Casing	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Check valves	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	0.84	0.00	0.00	0.00	0.09	0.19	0.00	0.00	0.00	0.00
Cooler(s)	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driver	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00
Cylinder liner	0.28	0.00	4.10	1.30	0.00	0.00	0.00	0.09	12.20	0.00
Filter(s)	0.00	0.00	0.09	0.09	0.00	0.00	0.00	0.00	0.19	0.00
Gearbox/var. drive	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, flow	0.37	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00
Instrument, general	0.84	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.09	0.00
Instrument, level	0.28	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	2.05	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, speed	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	2.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.09	0.00
Instrument, vibration	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal piping	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Interstage seals	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.09	0.00	0.47	0.28	0.09	0.00	0.00	0.00	0.19	0.00
Packing	0.00	0.00	0.47	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	0.09	0.56	0.00	0.00	0.00	0.00	0.00	0.00
Piping, pipe support + bellows	0.00	0.00	0.09	0.19	0.00	0.00	0.00	0.00	0.00	0.00
Piston(s)	0.00	0.05	0.19	0.00	0.19	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.37	0.28	0.00	0.09	0.00	0.00	2.79	0.00
Pump w/motor/gear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.00
Seals	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.09	0.00
Silencers	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Subunit	0.00	0.09	0.09	0.09	0.19	0.37	0.00	0.00	1.12	0.19
Unknown	0.19	0.00	0.19	0.09	0.00	0.19	0.00	0.00	0.93	0.19
Valves	0.74	0.00	1.30	0.42	0.19	0.09	0.00	0.09	3.63	0.09
Total	9.22	0.19	7.82	4.28	1.12	1.12	0.00	0.19	21.60	0.56

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

Item: Compressors - Reciprocating

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.09
Base frame	0.00	0.00	0.00	1.86	0.19	0.00	0.00	0.00	0.09	2.14
Cabling & junction boxes	0.00	0.00	0.09	0.09	0.09	0.00	0.09	0.09	0.00	0.74
Casing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Check valves	0.00	0.00	0.47	0.09	0.00	0.00	0.00	0.09	0.00	0.65
Control unit	0.00	0.00	0.74	0.00	0.09	0.19	0.00	0.28	0.09	2.51
Cooler(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.28
Coupling to driver	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.47
Cylinder liner	7.17	0.09	1.21	0.65	0.47	0.00	0.56	0.28	0.37	28.77
Filter(s)	0.00	0.00	0.09	14.25	0.00	0.00	0.00	0.09	0.00	14.80
Gearbox/var.drive	0.00	0.09	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.19
Instrument, flow	0.00	0.00	0.84	0.00	0.00	0.00	0.00	0.00	0.00	1.30
Instrument, general	0.00	0.00	0.56	0.19	0.00	0.00	0.00	0.09	0.00	1.86
Instrument, level	0.00	0.00	0.28	0.09	0.00	0.00	0.00	0.09	0.00	0.84
Instrument, pressure	0.00	0.00	1.30	0.28	0.00	0.00	0.00	0.19	0.00	4.19
Instrument, speed	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.19
Instrument, temperature	0.19	0.09	1.12	0.00	0.00	0.00	0.00	0.28	0.09	3.96
Instrument, vibration	0.00	0.09	1.30	0.00	0.00	0.00	0.00	0.09	0.19	2.47
Internal piping	0.09	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.09	0.74
Internal power supply	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Interstage seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14
Monitoring	0.00	0.00	0.74	0.28	0.00	0.00	0.00	0.00	0.00	1.40
Oil	0.00	0.00	0.00	0.09	0.00	0.00	0.19	0.19	0.00	0.56
Other	0.00	0.47	0.19	0.56	0.09	0.00	1.02	0.00	0.09	3.54
Packing	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.65
Piping	0.00	0.00	0.00	0.28	0.19	0.00	0.00	0.19	0.00	1.30
Piping, pipe support + bellows	0.09	0.00	0.00	0.37	0.09	0.00	0.00	0.00	0.09	0.93
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.51
Pump w/motor	0.00	0.09	0.28	0.28	0.00	0.09	0.19	0.09	0.00	4.56
Pump w/motor/gear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28
Seals	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.37
Silencers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19
Subunit	0.19	0.00	0.19	0.28	0.00	0.00	0.19	0.19	0.09	3.26
Unknown	0.74	0.00	0.47	0.84	0.28	0.00	0.19	0.47	0.28	5.03
Valves	0.37	0.09	2.33	0.65	0.00	0.00	0.74	0.09	0.09	10.94
Total	8.85	1.02	12.38	21.97	1.49	0.37	3.26	2.79	1.77	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Compressors - Reciprocating

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Breakage	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00
Combined causes	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.09
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.00	0.00	0.00	0.00	0.09	0.28	0.00	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Erosion	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	6.52	0.00	0.19	0.47	0.00	0.28	0.00	0.09	1.02	0.00
Leakage	0.00	0.00	0.28	0.28	0.00	0.00	0.00	0.00	0.00	0.00
Looseness	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.09	0.37	0.00	0.00	0.00	0.00	0.00	0.09
Mechanical Failure - general	0.56	0.09	6.70	2.33	0.09	0.09	0.00	0.09	18.62	0.00
Misc. external influences	0.19	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.37	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Open circuit	0.37	0.00	0.09	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Overheating	0.00	0.00	0.09	0.09	0.09	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Software failure	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.47	0.00	0.09	0.09	0.00	0.47	0.00	0.00	1.40	0.19
Vibration	0.19	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.09	0.00
Wear	0.00	0.00	0.09	0.09	0.56	0.00	0.00	0.00	0.09	0.00
Total	9.22	0.19	7.82	4.28	1.12	1.12	0.00	0.19	21.60	0.56

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

**Item: Compressors - Reciprocating**

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.00	0.00	0.09	0.00	0.00	0.19	0.00	0.00	0.28
Breakage	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.09	0.28
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28
Combined causes	0.00	0.09	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.37
Contamination	0.00	0.00	0.09	0.28	0.00	0.00	0.19	0.00	0.00	0.56
Control failure	0.09	0.00	0.09	0.09	0.09	0.00	0.00	0.37	0.00	1.12
Corrosion	0.00	0.00	0.09	0.28	0.00	0.00	0.00	0.09	0.00	0.47
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.09
Erosion	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.28
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Instrument failure - general	0.56	0.19	7.64	1.02	0.09	0.28	0.00	0.37	0.09	18.81
Leakage	0.09	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.93
Looseness	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.28
Material failure - general	0.00	0.00	0.00	0.09	0.00	0.00	0.28	0.00	0.00	0.93
Mechanical Failure - general	7.36	0.37	2.33	17.97	1.12	0.00	0.93	0.65	0.93	60.24
Misc. external influences	0.00	0.00	0.09	0.00	0.00	0.00	0.09	0.00	0.19	1.02
Miscellaneous - general	0.00	0.37	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.47
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Open circuit	0.00	0.00	0.74	0.19	0.00	0.00	0.09	0.09	0.00	1.68
Other	0.00	0.00	0.00	1.02	0.00	0.00	0.00	0.09	0.00	1.21
Out of adjustment	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.09	0.00	0.56
Overheating	0.37	0.00	0.19	0.00	0.00	0.00	0.09	0.56	0.00	1.49
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.37
Software failure	0.00	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.84
Unknown	0.37	0.00	0.09	0.19	0.09	0.00	0.93	0.00	0.00	4.38
Vibration	0.00	0.00	0.19	0.37	0.09	0.00	0.00	0.37	0.28	1.68
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	1.02
Total	8.85	1.02	12.38	21.97	1.49	0.37	3.26	2.79	1.77	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 1.1.2.1		Item Machinery Compressors Reciprocating Electric driven									
Population 32	Installations 10	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 36658				
		Calendar time * 0.7323		Operational time † 0.5046							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
<b>Critical</b>	<b>367*</b> <b>367†</b>	<b>0.01</b>	<b>347.08</b>	<b>1678.18</b>	<b>693.22</b>	<b>501.19</b>	<b>8.9</b>	<b>0.5</b>	<b>13.0</b>	<b>250.0</b>	
Abnormal instrument reading	1* 1†	0.00 0.19	1.86 2.19	7.90 6.09	3.05 1.98	1.37 1.98	16.0	16.0	16.0	16.0	
Breakdown	2* 2†	0.09 0.07	2.27 3.41	6.84 10.62	2.32 3.77	2.73 3.96	116.5	74.0	140.5	207.0	
Erratic output	2* 2†	0.00 0.05	5.04 13.26	21.49 50.59	8.30 18.64	2.73 3.96	20.0	8.0	14.0	20.0	
External leakage - Process medium	40* 40†	0.00 0.00	36.68 45.55	201.99 246.92	100.72 114.85	54.63 79.26	3.8	0.5	6.7	81.0	
External leakage - Utility medium	16* 16†	0.00 0.06	17.39 24.15	82.87 95.41	34.03 35.56	21.85 31.71	3.4	1.0	6.9	50.0	
Fail to start on demand	11* 11†	0.01 0.01	15.40 37.42	65.18 166.98	25.07 65.98	15.02 21.80	39.4	4.0	42.0	204.0	
Fail to stop on demand	2* 2†	0.00 0.00	4.52 9.20	19.93 40.96	7.83 16.16	2.73 3.96	3.5	3.5	10.8	18.0	
Low output	140* 140†	0.00 0.00	122.03 140.44	663.02 752.91	308.86 347.39	191.19 277.42	6.2	0.5	10.9	168.0	
Noise	2* 2†	0.00 0.00	3.81 8.72	17.89 39.92	7.30 15.93	2.73 3.96	29.0	4.0	18.5	33.0	
Other	1* 1†	0.00 0.00	4.19 10.07	20.60 44.20	8.68 17.30	1.37 1.98	-	1.0	1.0	1.0	
Overheating	64* 64†	0.00 0.00	58.83 72.66	305.92 356.65	135.89 149.99	87.40 126.82	3.8	0.5	8.2	36.0	
Parameter deviation	46* 46†	0.00 0.00	42.79 53.10	231.70 275.04	107.70 121.17	62.82 91.15	15.9	0.5	21.1	250.0	
Spurious stop	30* 30†	7.43 31.64	43.47 63.24	104.22 103.64	31.29 22.20	40.97 59.45	12.0	1.0	13.9	48.0	
Structural deficiency	5* 5†	0.03 1.56	7.26 10.08	26.79 24.79	9.89 7.56	6.83 9.91	11.4	2.0	13.8	36.0	
Vibration	5* 5†	0.03 2.93	6.68 9.77	24.11 19.90	8.91 5.35	6.83 9.91	4.0	1.0	7.6	28.0	
<b>Degraded</b>	<b>241*</b> <b>241†</b>	<b>0.80</b>	<b>269.46</b>	<b>1051.97</b>	<b>390.37</b>	<b>329.12</b>	<b>7.3</b>	<b>0.3</b>	<b>8.5</b>	<b>128.0</b>	
Erratic output	8* 8†	1.34 4.82	24.58 50.60	72.95 138.09	24.29 44.51	10.93 15.85	36.0	8.0	29.4	96.0	
External leakage - Process medium	24* 24†	0.00 0.00	24.42 34.68	126.96 157.98	56.38 62.96	32.78 47.56	2.2	0.5	3.9	24.0	
External leakage - Utility medium	8* 8†	0.12 1.51	9.58 14.10	30.71 37.49	11.10 11.91	10.93 15.85	4.9	0.3	7.3	22.0	
<b>Comments</b>											

(cont.)

Taxonomy no 1.1.2.1		Item Machinery Compressors Reciprocating Electric driven									
Population 32	Installations 10	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 36658				
		Calendar time * 0.7323		Operational time † 0.5046							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Fail to start on demand	1*	0.00	1.40	6.51	2.63	1.37	1.0	1.0	1.0	1.0	
	1†	0.01	1.94	7.53	2.79	1.98					
Fail to stop on demand	2*	0.31	2.83	7.47	2.36	2.73	3.3	0.5	3.3	6.0	
	2†	0.01	3.74	14.92	5.58	3.96					
Internal leakage	2*	0.31	2.83	7.47	2.36	2.73	2.3	1.0	4.0	7.0	
	2†	0.01	3.74	14.92	5.58	3.96					
Low output	92*	0.27	107.04	422.57	157.47	125.64	11.3	0.5	12.1	128.0	
	92†	0.26	214.65	883.00	334.94	182.31					
Other	1*	0.00	4.19	20.60	8.68	1.37	-	30.0	30.0	30.0	
	1†	0.00	10.07	44.20	17.30	1.98					
Overheating	23*	0.24	28.56	95.52	35.04	31.41	7.8	1.0	10.3	48.0	
	23†	6.99	41.71	100.53	30.29	45.58					
Parameter deviation	65*	0.00	57.31	304.91	201.91	88.77	1.8	0.3	2.1	10.0	
	65†	0.00	68.55	366.56	239.26	128.80					
Structural deficiency	5*	0.03	6.68	24.11	8.91	6.83	3.7	0.5	5.4	10.0	
	5†	2.93	9.77	19.90	5.35	9.91					
Unknown	6*	0.06	12.24	44.50	16.44	8.19	33.0	4.0	33.5	64.0	
	6†	0.17	31.03	111.15	41.07	11.89					
Vibration	4*	0.11	5.80	17.99	6.37	5.46	1.2	1.0	1.2	1.5	
	4†	0.01	8.86	36.49	13.85	7.93					
<b>Incipient</b>	<b>454*</b>	<b>0.03</b>	<b>427.59</b>	<b>1970.30</b>	<b>791.74</b>	<b>619.99</b>	<b>3.6</b>	<b>0.3</b>	<b>4.5</b>	<b>116.0</b>	
	<b>454†</b>	<b>1.91</b>	<b>615.73</b>	<b>2397.46</b>	<b>888.66</b>	<b>899.65</b>					
Abnormal instrument reading	98*	0.00	90.60	433.07	178.08	133.83	3.1	0.3	3.4	24.0	
	98†	0.22	127.28	513.02	192.92	194.20					
Erratic output	2*	0.00	5.04	21.49	8.30	2.73	8.0	5.0	6.5	8.0	
	2†	0.05	13.26	50.59	18.64	3.96					
External leakage - Process medium	20*	0.65	28.02	86.20	30.24	27.31	13.0	1.0	14.8	115.0	
	20†	7.08	42.08	101.31	30.50	39.63					
External leakage - Utility medium	22*	13.36	31.27	55.28	13.01	30.04	9.7	0.3	10.7	116.0	
	22†	8.35	49.40	118.81	35.74	43.60					
Minor in-service problems	236*	0.00	200.63	1099.31	514.60	322.29	1.6	0.3	2.7	29.0	
	236†	0.00	231.74	1249.76	579.27	467.66					
Noise	4*	0.37	6.24	18.33	6.09	5.46	19.7	5.0	16.8	33.0	
	4†	1.06	9.64	25.49	8.07	7.93					
Other	9*	0.18	21.82	73.45	26.97	12.29	1.7	1.0	6.9	20.0	
	9†	0.60	46.30	148.35	53.63	17.83					
Overheating	8*	2.69	11.66	25.80	7.37	10.93	13.9	2.0	13.3	51.0	
	8†	2.18	17.48	45.00	14.05	15.85					
Parameter deviation	22*	0.02	23.21	97.82	37.55	30.04	5.5	1.0	5.6	24.0	
	22†	0.99	34.14	103.93	35.98	43.60					
<b>Comments</b>											

(cont.)



Taxonomy no 1.1.2.1		Item Machinery Compressors Reciprocating Electric driven									
Population 32	Installations 10	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 36658				
		Calendar time * 0.7323		Operational time † 0.5046							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Structural deficiency	6* 6†	0.22 0.21	8.18 10.83	24.96 33.62	8.68 11.90	8.19 11.89	1.4	0.5	2.7	8.0	
Unknown	17*	0.00	23.23	134.17	72.82	23.22	14.5	2.0	14.5	32.0	
	17†	0.00	74.82	387.69	170.92	33.69					
Vibration	10*	3.21	13.18	28.69	8.11	13.66	1.8	1.0	2.7	8.0	
	10†	1.61	17.28	47.36	15.30	19.82					
Unknown	12*	<b>0.04</b>	<b>14.45</b>	<b>56.56</b>	<b>21.01</b>	<b>16.39</b>	<b>5.7</b>	<b>0.8</b>	<b>10.2</b>	<b>24.0</b>	
	12†	<b>2.02</b>	<b>21.18</b>	<b>57.77</b>	<b>18.61</b>	<b>23.78</b>					
Unknown	12*	0.04	14.45	56.56	21.01	16.39	5.7	0.8	10.2	24.0	
	12†	2.02	21.18	57.77	18.61	23.78					
All modes	1074*	<b>0.16</b>	<b>1038.22</b>	<b>4671.32</b>	<b>1852.75</b>	<b>1466.68</b>	<b>6.3</b>	<b>0.3</b>	<b>8.5</b>	<b>250.0</b>	
	1074†	<b>6.30</b>	<b>1501.47</b>	<b>5666.15</b>	<b>2089.96</b>	<b>2128.25</b>					
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.9·10 <sup>-4</sup>											

Taxonomy no 1.1.2.1.1		Item Machinery Compressors Reciprocating Electric driven (100-1000) kW									
Population 18	Installations 8	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 36658				
		Calendar time * 0.3669		Operational time † 0.2195							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	28*	12.57	82.29	202.98	62.02	76.31	30.7	1.0	28.0	204.0	
	28†	18.43	170.90	453.76	144.08	127.56					
Abnormal instrument reading	1*	0.00	3.09	15.62	6.72	2.73	16.0	16.0	16.0	16.0	
	1†	0.01	4.80	18.97	7.07	4.56					
Erratic output	2*	0.05	6.84	23.40	8.62	5.45	20.0	8.0	14.0	20.0	
	2†	0.08	18.37	69.19	25.52	9.11					
Fail to start on demand	8*	0.00	17.77	82.71	33.51	21.80	52.3	8.0	55.6	204.0	
	8†	0.00	45.19	233.41	102.06	36.45					
Fail to stop on demand	1*	0.00	5.55	27.02	11.25	2.73	-	18.0	18.0	18.0	
	1†	0.00	13.68	63.85	25.91	4.56					
Noise	1*	0.00	5.55	27.02	11.25	2.73	-	4.0	4.0	4.0	
	1†	0.00	13.68	63.85	25.91	4.56					
Other	1*	0.00	5.55	27.02	11.25	2.73	-	1.0	1.0	1.0	
	1†	0.00	13.68	63.85	25.91	4.56					
Spurious stop	13*	0.77	34.55	106.55	37.48	35.43	18.1	1.0	17.4	38.0	
	13†	17.70	62.23	128.92	35.15	59.23					
Structural deficiency	1*	0.00	3.09	15.62	6.72	2.73	36.0	36.0	36.0	36.0	
	1†	0.01	4.80	18.97	7.07	4.56					
<b>Degraded</b>	63*	0.21	147.48	600.92	227.11	171.69	28.3	2.0	27.9	128.0	
	63†	0.10	367.60	1618.72	634.87	287.02					
Erratic output	8*	3.56	32.07	84.56	26.73	21.80	36.0	8.0	29.4	96.0	
	8†	6.99	67.41	180.63	57.66	36.45					
External leakage - Process medium	1*	0.00	2.68	11.56	4.48	2.73	-	-	-	-	
	1†	0.10	5.76	17.99	6.40	4.56					
External leakage - Utility medium	1*	0.03	2.38	7.56	2.73	2.73	6.0	6.0	6.0	6.0	
	1†	0.05	3.92	12.59	4.56	4.56					
Low output	40*	0.00	73.02	401.36	191.40	109.01	28.9	2.0	28.8	128.0	
	40†	0.00	202.49	1113.74	525.67	182.23					
Other	1*	0.00	5.55	27.02	11.25	2.73	-	30.0	30.0	30.0	
	1†	0.00	13.68	63.85	25.91	4.56					
Overheating	4*	0.06	10.85	39.02	14.42	10.90	23.5	2.5	23.5	48.0	
	4†	0.11	16.54	56.97	21.00	18.22					
Parameter deviation	1*	0.00	2.68	11.56	4.48	2.73	1.0	10.0	10.0	10.0	
	1†	0.10	5.76	17.99	6.40	4.56					
Unknown	6*	1.70	17.60	47.91	15.42	16.35	33.0	4.0	33.5	64.0	
	6†	0.22	42.56	153.69	56.79	27.34					
Vibration	1*	0.00	2.68	11.56	4.48	2.73	-	-	-	-	
	1†	0.10	5.76	17.99	6.40	4.56					
<b>Incipient</b>	59*	0.70	130.36	467.91	172.89	160.79	16.4	1.0	15.8	116.0	
	59†	0.21	315.28	1334.85	513.53	268.80					
<b>Comments</b>											

(cont.)

Taxonomy no 1.1.2.1.1		Item Machinery Compressors Reciprocating Electric driven (100-1000) kW									
Population 18	Installations 8	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 36658				
		Calendar time * 0.3669		Operational time † 0.2195							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Abnormal instrument reading	8*	6.25	20.78	42.23	11.34	21.80	4.8	2.0	4.8	9.0	
	8†	0.05	39.87	163.47	61.93	36.45					
Erratic output	2*	0.05	6.84	23.40	8.62	5.45	8.0	5.0	6.5	8.0	
	2†	0.08	18.37	69.19	25.52	9.11					
External leakage - Process medium	6*	0.08	16.64	61.16	22.59	16.35	30.2	6.0	30.2	115.0	
	6†	1.90	30.93	90.53	30.02	27.34					
External leakage - Utility medium	9*	2.86	23.66	61.21	19.15	24.53	19.1	1.0	20.1	116.0	
	9†	0.20	45.66	171.19	63.17	41.00					
Minor in-service problems	5*	0.79	11.25	32.32	10.65	13.63	9.4	2.0	9.4	20.0	
	5†	0.05	20.52	81.20	30.28	22.78					
Noise	3*	2.33	8.60	18.11	4.99	8.18	19.7	5.0	19.7	33.0	
	3†	0.13	15.60	52.15	19.13	13.67					
Other	4*	0.03	25.86	106.13	40.22	10.90	-	4.0	12.8	20.0	
	4†	0.25	62.60	239.91	88.37	18.22					
Overheating	2*	0.99	5.49	12.96	3.85	5.45	41.5	51.0	51.0	51.0	
	2†	0.00	13.35	60.91	24.29	9.11					
Parameter deviation	2*	0.12	4.48	13.72	4.78	5.45	3.5	2.0	3.5	5.0	
	2†	0.89	7.83	20.51	6.46	9.11					
Unknown	17*	0.00	30.22	175.28	95.66	46.33	14.5	2.0	14.5	32.0	
	17†	0.00	95.16	524.98	264.13	77.45					
Vibration	1*	0.03	2.38	7.56	2.73	2.73	-	-	-	-	
	1†	0.05	3.92	12.59	4.56	4.56					
<b>All modes</b>	150*	1.91	349.46	1249.08	461.50	408.79	23.7	1.0	22.7	204.0	
	150†	1.22	843.29	3433.54	1297.25	683.38					
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.9 10 <sup>-4</sup>											

Taxonomy no 1.1.2.1.2		Item Machinery Compressors Reciprocating Electric driven (1000-3000)kW									
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)						No of demands			
		Calendar time * 0.1248			Operational time † 0.0583						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	7*	26.31	56.07	105.33	56.07	56.07	43.3	4.0	51.0	207.0	
	7†	56.30	119.98	225.39	119.98	119.98					
Breakdown	2*	2.84	16.02	50.42	16.02	16.02	116.5	74.0	140.5	207.0	
	2†	6.08	34.28	107.89	34.28	34.28					
External leakage - Process medium	1*	0.40	8.01	38.01	8.01	8.01	8.0	8.0	8.0	8.0	
	1†	0.86	17.14	81.33	17.14	17.14					
Fail to start on demand	2*	2.84	16.02	50.42	16.02	16.02	5.5	4.0	6.5	9.0	
	2†	6.08	34.28	107.89	34.28	34.28					
Noise	1*	0.40	8.01	38.01	8.01	8.01	29.0	33.0	33.0	33.0	
	1†	0.86	17.14	81.33	17.14	17.14					
Spurious stop	1*	0.40	8.01	38.01	8.01	8.01	22.0	22.0	22.0	22.0	
	1†	0.86	17.14	81.33	17.14	17.14					
<b>Degraded</b>	1*	0.40	8.01	38.01	8.01	8.01	9.0	22.0	22.0	22.0	
	1†	0.86	17.14	81.33	17.14	17.14					
External leakage - Utility medium	1*	0.40	8.01	38.01	8.01	8.01	9.0	22.0	22.0	22.0	
	1†	0.86	17.14	81.33	17.14	17.14					
<b>Incipient</b>	10*	43.45	80.10	135.85	80.10	80.10	4.4	2.0	4.8	8.0	
	10†	92.98	171.40	290.69	171.40	171.40					
Abnormal instrument reading	2*	2.84	16.02	50.42	16.02	16.02	5.0	2.0	5.0	8.0	
	2†	6.08	34.28	107.89	34.28	34.28					
External leakage - Utility medium	3*	6.57	24.03	62.12	24.03	24.03	3.0	2.0	3.0	4.0	
	3†	14.05	51.42	132.92	51.42	51.42					
Minor in-service problems	2*	2.84	16.02	50.42	16.02	16.02	5.5	3.0	5.5	8.0	
	2†	6.08	34.28	107.89	34.28	34.28					
Noise	1*	0.40	8.01	38.01	8.01	8.01	-	8.0	8.0	8.0	
	1†	0.86	17.14	81.33	17.14	17.14					
Other	1*	0.40	8.01	38.01	8.01	8.01	4.0	4.0	4.0	4.0	
	1†	0.86	17.14	81.33	17.14	17.14					
Vibration	1*	0.40	8.01	38.01	8.01	8.01	6.0	6.0	6.0	6.0	
	1†	0.86	17.14	81.33	17.14	17.14					
<b>All modes</b>	18*	93.18	144.18	213.78	144.18	144.18	20.7	2.0	23.7	207.0	
	18†	199.39	308.52	457.46	308.52	308.52					
<b>Comments</b>											

Taxonomy no 1.1.2.1.3		Item Machinery Compressors Reciprocating Electric driven (3000-10000)kW					Population 12		Installations 2		Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
Failure mode		No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)										
			Calendar time *	Operational time †			Min		Mean	Max									
			0.2405	0.2268															
			Lower	Mean	Upper	SD	n/τ												
<b>Critical</b>		<b>332*</b>	<b>1181.54</b>	<b>1380.57</b>	<b>1592.47</b>	<b>125.03</b>	<b>1380.57</b>	<b>6.6</b>	<b>0.5</b>	<b>11.0</b>	<b>250.0</b>								
		<b>332†</b>	<b>1252.81</b>	<b>1463.84</b>	<b>1688.52</b>	<b>132.57</b>	<b>1463.84</b>												
External leakage - Process medium		39*	20.24	162.18	417.18	130.18	162.18	3.7	0.5	6.6	81.0								
		39†	21.46	171.96	442.34	138.03	171.96												
External leakage - Utility medium		16*	29.93	66.53	114.84	26.30	66.53	3.4	1.0	6.9	50.0								
		16†	31.74	70.55	121.77	27.89	70.55												
Fail to start on demand		1*	0.21	4.16	12.45	4.16	4.16	4.0	4.0	4.0	4.0								
		1†	0.22	4.41	13.21	4.41	4.41												
Fail to stop on demand		1*	0.21	4.16	12.45	4.16	4.16	3.5	3.5	3.5	3.5								
		1†	0.22	4.41	13.21	4.41	4.41												
Low output		140*	415.09	582.17	772.40	109.07	582.17	6.2	0.5	10.9	168.0								
		140†	440.12	617.28	818.99	115.65	617.28												
Overheating		64*	213.88	266.13	323.11	33.27	266.13	3.8	0.5	8.2	36.0								
		64†	226.78	282.19	342.60	35.27	282.19												
Parameter deviation		46*	63.14	191.28	375.72	98.05	191.28	15.9	0.5	21.1	250.0								
		46†	66.95	202.82	398.38	103.97	202.82												
Spurious stop		16*	41.73	66.53	96.04	16.63	66.53	6.8	1.0	10.8	48.0								
		16†	44.24	70.55	101.83	17.64	70.55												
Structural deficiency		4*	0.14	16.63	55.56	20.37	16.63	3.2	2.0	6.3	12.0								
		4†	0.15	17.64	58.91	21.60	17.64												
Vibration		5*	5.90	20.79	43.11	11.76	20.79	4.0	1.0	7.6	28.0								
		5†	6.25	22.05	45.71	12.47	22.05												
<b>Degraded</b>		<b>177*</b>	<b>293.37</b>	<b>736.03</b>	<b>1341.07</b>	<b>325.95</b>	<b>736.03</b>	<b>2.4</b>	<b>0.3</b>	<b>3.8</b>	<b>41.0</b>								
		<b>177†</b>	<b>311.07</b>	<b>780.42</b>	<b>1421.96</b>	<b>345.61</b>	<b>780.42</b>												
External leakage - Process medium		23*	15.16	95.64	233.80	71.06	95.64	2.2	0.5	3.9	24.0								
		23†	16.08	101.41	247.90	75.34	101.41												
External leakage - Utility medium		6*	9.23	24.95	46.91	11.76	24.95	3.9	0.3	4.7	8.0								
		6†	9.79	26.46	49.74	12.47	26.46												
Fail to start on demand		1*	0.21	4.16	12.45	4.16	4.16	1.0	1.0	1.0	1.0								
		1†	0.22	4.41	13.21	4.41	4.41												
Fail to stop on demand		2*	0.42	8.32	24.91	8.32	8.32	3.3	0.5	3.3	6.0								
		2†	0.44	8.82	26.41	8.82	8.82												
Internal leakage		2*	0.42	8.32	24.91	8.32	8.32	2.3	1.0	4.0	7.0								
		2†	0.44	8.82	26.41	8.82	8.82												
Low output		52*	153.85	216.23	287.32	40.74	216.23	2.5	0.5	4.8	40.0								
		52†	163.13	229.28	304.65	43.20	229.28												
Overheating		19*	51.73	79.01	110.99	18.13	79.01	4.6	1.0	7.7	41.0								
		19†	54.85	83.77	117.68	19.22	83.77												
Parameter deviation		64*	2.30	266.13	888.91	325.95	266.13	1.8	0.3	1.9	6.0								
		64†	2.43	282.19	942.53	345.61	282.19												
<b>Comments</b>																			

(cont.)

Taxonomy no 1.1.2.1.3		Item Machinery Compressors Reciprocating Electric driven (3000-10000)kW										
Population 12	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands					
		Calendar time *			Operational time †							
		0.2405					0.2268					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)				
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max		
Structural deficiency	5*	5.90	20.79	43.11	11.76	20.79	3.7	0.5	5.4	10.0		
	5†	6.25	22.05	45.71	12.47	22.05						
Vibration	3*	3.41	12.48	26.18	7.20	12.48	1.2	1.0	1.2	1.5		
	3†	3.62	13.23	27.76	7.64	13.23						
<b>Incipient</b>	<b>385*</b>	<b>1138.37</b>	<b>1600.96</b>	<b>2128.16</b>	<b>302.16</b>	<b>1600.96</b>	<b>2.0</b>	<b>0.3</b>	<b>3.0</b>	<b>37.5</b>		
	<b>385†</b>	<b>1207.03</b>	<b>1697.53</b>	<b>2256.53</b>	<b>320.39</b>	<b>1697.53</b>						
Abnormal instrument reading	88*	304.22	365.93	432.38	39.01	365.93	2.9	0.3	3.3	24.0		
	88†	322.57	388.01	458.46	41.36	388.01						
External leakage - Process medium	14*	21.40	58.22	109.73	27.58	58.22	3.4	1.0	6.2	37.5		
	14†	22.69	61.73	116.35	29.25	61.73						
External leakage - Utility medium	10*	21.04	41.58	67.76	14.40	41.58	1.7	0.3	3.0	14.0		
	10†	22.31	44.09	71.85	15.27	44.09						
Minor in-service problems	229*	489.85	952.26	1538.61	323.18	952.26	1.4	0.3	2.5	29.0		
	229†	519.40	1009.70	1631.41	342.67	1009.70						
Other	4*	5.68	16.63	32.25	8.32	16.63	1.1	1.0	1.8	3.0		
	4†	6.02	17.64	34.19	8.82	17.64						
Overheating	6*	9.23	24.95	46.91	11.76	24.95	2.8	2.0	5.7	12.0		
	6†	9.79	26.46	49.74	12.47	26.46						
Parameter deviation	20*	48.60	83.17	125.24	23.52	83.17	5.7	1.0	5.9	24.0		
	20†	51.53	88.18	132.79	24.94	88.18						
Structural deficiency	6*	9.23	24.95	46.91	11.76	24.95	1.4	0.5	2.7	8.0		
	6†	9.79	26.46	49.74	12.47	26.46						
Vibration	8*	16.55	33.27	54.68	11.76	33.27	1.2	1.0	2.2	8.0		
	8†	17.55	35.27	57.98	12.47	35.27						
<b>Unknown</b>	<b>12*</b>	<b>28.80</b>	<b>49.90</b>	<b>75.72</b>	<b>14.40</b>	<b>49.90</b>	<b>5.7</b>	<b>0.8</b>	<b>10.2</b>	<b>24.0</b>		
	<b>12†</b>	<b>30.53</b>	<b>52.91</b>	<b>80.29</b>	<b>15.27</b>	<b>52.91</b>						
Unknown	12*	28.80	49.90	75.72	14.40	49.90	5.7	0.8	10.2	24.0		
	12†	30.53	52.91	80.29	15.27	52.91						
<b>All modes</b>	<b>906*</b>	<b>3042.26</b>	<b>3767.47</b>	<b>4556.77</b>	<b>461.18</b>	<b>3767.47</b>	<b>3.9</b>	<b>0.3</b>	<b>6.3</b>	<b>250.0</b>		
	<b>906†</b>	<b>3225.76</b>	<b>3994.71</b>	<b>4831.63</b>	<b>489.00</b>	<b>3994.71</b>						
Comments												

Taxonomy no 1.1.3		Item Machinery Compressors Screw								
Population 34	Installations 16	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 38694			
		Calendar time * 1.1045		Operational time † 0.5904						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>79*</b> <b>79†</b>	<b>0.00</b>	<b>116.04</b>	<b>609.99</b>	<b>275.74</b>	<b>71.53</b>	<b>14.7</b>	<b>1.0</b>	<b>23.2</b>	<b>163.0</b>
Erratic output	4*	0.00	7.41	40.83	20.46	3.62	6.8	7.0	9.8	15.0
	4†	0.00	9.79	53.89	26.82	6.78				
External leakage - Process medium	2*	0.00	2.28	10.91	4.49	1.81	17.5	12.0	29.0	46.0
	2†	0.00	3.54	15.62	6.14	3.39				
External leakage - Utility medium	7*	0.00	12.88	71.55	36.87	6.34	14.1	13.0	38.9	96.0
	7†	0.00	16.30	92.68	49.60	11.86				
Fail to start on demand	12*	0.00	18.90	83.77	32.98	10.86	5.9	1.0	8.7	32.0
	12†	0.03	27.27	112.54	42.74	20.33				
Low output	11*	0.00	18.29	100.56	47.65	9.96	16.2	2.0	26.7	163.0
	11†	0.00	22.94	126.59	63.76	18.63				
Noise	1*	0.00	1.12	6.21	3.17	0.91	73.0	76.0	76.0	76.0
	1†	0.00	1.64	7.89	3.25	1.69				
Other	1*	0.00	1.12	6.21	3.17	0.91	7.0	7.0	7.0	7.0
	1†	0.00	1.64	7.89	3.25	1.69				
Overheating	4*	0.00	5.63	25.58	10.18	3.62	20.1	2.0	20.5	70.0
	4†	0.05	7.60	26.26	9.68	6.78				
Parameter deviation	2*	0.01	2.51	9.48	3.50	1.81	10.8	11.0	21.5	32.0
	2†	0.00	4.39	21.73	9.22	3.39				
Spurious stop	34*	0.00	47.83	248.15	109.74	30.78	15.8	2.0	23.6	148.0
	34†	0.00	60.01	319.53	146.54	57.59				
Structural deficiency	1*	0.00	1.62	8.57	3.89	0.91	21.5	43.0	43.0	43.0
	1†	0.01	1.96	7.66	2.85	1.69				
<b>Degraded</b>	<b>94*</b> <b>94†</b>	<b>0.00</b>	<b>145.59</b>	<b>799.98</b>	<b>386.44</b>	<b>85.11</b>	<b>9.7</b>	<b>1.0</b>	<b>16.4</b>	<b>123.0</b>
Abnormal instrument reading	1*	0.00	1.12	6.21	3.17	0.91	5.0	5.0	5.0	5.0
	1†	0.00	1.64	7.89	3.25	1.69				
Erratic output	5*	0.00	8.35	44.28	20.22	4.53	6.9	2.0	10.6	35.0
	5†	0.00	11.16	58.03	25.80	8.47				
External leakage - Process medium	5*	0.00	8.41	44.47	20.24	4.53	2.5	1.0	4.6	15.0
	5†	0.00	11.79	60.36	26.12	8.47				
External leakage - Utility medium	28*	0.00	45.78	251.84	124.36	25.35	10.7	1.0	18.0	111.0
	28†	0.00	53.70	311.26	169.39	47.43				
Internal leakage	1*	0.00	1.12	6.21	3.17	0.91	48.0	48.0	48.0	48.0
	1†	0.00	1.64	7.89	3.25	1.69				
Low output	6*	0.00	5.88	32.94	19.24	5.43	6.5	2.0	6.5	12.0
	6†	0.00	8.04	44.34	22.21	10.16				
Noise	1*	0.00	1.12	6.21	3.17	0.91	15.0	15.0	15.0	15.0
	1†	0.00	1.64	7.89	3.25	1.69				
<b>Comments</b>										

(cont.)

Taxonomy no 1.1.3		Item Machinery Compressors Screw									
Population 34	Installations 16	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 38694				
		Calendar time * 1.1045		Operational time † 0.5904							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Other	9*	0.00	13.26	66.10	28.18	8.15	16.1	1.0	30.4	123.0	
	9†	0.00	19.67	93.62	38.43	15.24					
Overheating	3*	0.00	3.12	16.57	7.58	2.72	11.0	16.0	20.0	24.0	
	3†	0.00	5.15	21.86	8.42	5.08					
Parameter deviation	33*	0.00	58.51	328.77	173.25	29.88	8.4	2.0	15.7	101.0	
	33†	0.00	67.77	360.86	238.35	55.90					
Structural deficiency	2*	0.00	3.64	20.01	9.49	1.81	6.3	8.0	12.5	17.0	
	2†	0.00	4.93	25.67	11.43	3.39					
<b>Incipient</b>	<b>112*</b>	<b>0.00</b>	<b>179.70</b>	<b>987.42</b>	<b>477.83</b>	<b>101.41</b>	<b>15.0</b>	<b>1.0</b>	<b>28.2</b>	<b>961.0</b>	
	<b>112†</b>	<b>0.00</b>	<b>212.34</b>	<b>1217.73</b>	<b>657.06</b>	<b>189.71</b>					
Abnormal instrument reading	65*	0.00	107.89	596.67	303.32	58.85	6.3	1.0	10.5	176.0	
	65†	0.00	123.75	677.24	416.91	110.10					
External leakage - Process medium	1*	0.00	1.62	8.57	3.89	0.91	1.0	2.0	2.0	2.0	
	1†	0.01	1.96	7.66	2.85	1.69					
External leakage - Utility medium	5*	0.01	5.97	24.61	9.34	4.53	5.5	1.0	10.4	38.0	
	5†	0.32	9.68	29.33	10.08	8.47					
Minor in-service problems	31*	0.00	52.11	287.82	145.62	28.07	3.5	1.0	6.2	23.0	
	31†	0.00	61.03	342.85	199.27	52.51					
Other	4*	0.00	5.75	26.89	10.93	3.62	321.2	1.0	482.0	961.0	
	4†	0.00	10.80	49.56	19.84	6.78					
Parameter deviation	4*	0.00	5.74	26.06	10.37	3.62	4.3	2.0	5.7	8.0	
	4†	0.03	8.75	34.18	12.69	6.78					
Structural deficiency	2*	0.00	2.32	11.72	5.05	1.81	6.5	10.0	13.0	16.0	
	2†	0.00	3.97	18.51	7.51	3.39					
<b>Unknown</b>	<b>6*</b>	<b>0.06</b>	<b>15.65</b>	<b>60.26</b>	<b>22.21</b>	<b>5.43</b>	<b>5.0</b>	<b>8.0</b>	<b>11.7</b>	<b>16.0</b>	
	<b>6†</b>	<b>0.15</b>	<b>32.53</b>	<b>119.50</b>	<b>44.14</b>	<b>10.16</b>					
Other	2*	0.00	6.20	32.48	14.61	1.81	-	8.0	9.0	10.0	
	2†	0.00	14.83	73.00	30.79	3.39					
Unknown	4*	0.00	9.57	43.26	17.19	3.62	5.0	8.0	13.0	16.0	
	4†	0.00	18.10	81.69	32.45	6.78					
<b>All modes</b>	<b>291*</b>	<b>0.00</b>	<b>456.85</b>	<b>2473.49</b>	<b>1149.61</b>	<b>263.47</b>	<b>13.1</b>	<b>1.0</b>	<b>22.6</b>	<b>961.0</b>	
	<b>291†</b>	<b>0.00</b>	<b>544.54</b>	<b>3034.94</b>	<b>1575.81</b>	<b>492.90</b>					

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.8 · 10<sup>-4</sup>



**Maintainable item versus failure mode, to be continued**

**Item: Compressors - Screw**

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Base frame	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bearing	0.00	0.00	0.00	1.37	0.00	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Casing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	0.00	0.00	0.00	0.00	0.69	0.34	0.00	0.00	0.00	0.00
Cooler(s)	0.00	0.00	0.00	0.86	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driver	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00
Dry gas seal	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00
Filter(s)	0.17	0.00	0.00	0.69	0.00	0.00	0.00	0.00	0.69	0.00
Instrument, flow	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	1.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, level	0.69	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00
Instrument, pressure	6.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, speed	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	9.28	0.00	0.00	0.00	0.00	1.03	0.00	0.00	0.00	0.00
Instrument, vibration	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal piping	0.17	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.34	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00
Interstage seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lube oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00
Monitoring	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.34	0.34	0.00	0.00	0.00	0.00	0.34	0.00
Piping	0.00	0.00	0.00	3.26	0.00	0.00	0.00	0.00	0.00	0.00
Piping, pipe support + bellows	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Purge air	0.00	0.00	0.00	0.34	0.00	0.34	0.00	0.00	0.00	0.00
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reservoir w/heating system	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rotor w/ impellers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Seals	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00
Shaft seals	0.00	0.00	0.34	3.44	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	0.69	0.00	0.34	0.69	0.00	0.00	0.00	0.34	1.03	0.34
Unknown	0.00	0.00	0.34	0.69	0.00	0.69	0.00	0.00	0.00	0.00
Valves	0.69	0.00	1.03	0.69	2.41	1.03	0.00	0.00	3.09	0.00
Total	22.68	0.00	2.75	13.75	3.09	4.12	0.00	0.34	5.84	0.69

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

Item: Compressors - Screw

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Base frame	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.34
Bearing	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	1.72
Cabling & junction boxes	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03
Casing	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.69
Control unit	0.00	0.34	0.34	0.00	0.00	0.00	0.00	0.69	0.00	2.41
Cooler(s)	0.34	0.34	0.34	0.00	0.00	0.00	0.00	0.46	0.00	2.35
Coupling to driver	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Dry gas seal	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	1.03
Filter(s)	0.00	0.34	1.72	0.69	0.00	0.00	0.00	0.11	0.00	4.41
Instrument, flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Instrument, general	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	2.06
Instrument, level	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.00	0.00	1.72
Instrument, pressure	0.00	0.00	1.03	0.69	0.00	0.00	0.00	1.72	0.00	9.97
Instrument, speed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Instrument, temperature	0.00	0.00	0.69	0.34	0.00	0.00	0.00	2.41	0.00	13.75
Instrument, vibration	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.69
Internal piping	0.34	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	1.20
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	1.03
Interstage seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.34
Lube oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69
Monitoring	0.00	0.34	0.00	0.34	0.00	0.00	0.00	0.00	0.00	1.37
Oil	0.00	0.34	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.69
Other	0.00	0.69	0.00	1.37	0.34	0.00	0.69	0.00	0.00	4.12
Piping	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.11	0.00	3.89
Piping, pipe support + bellows	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Pump w/motor	0.86	0.00	1.72	0.34	0.00	0.00	0.34	0.00	0.00	3.26
Purge air	0.00	0.00	2.06	1.03	0.00	0.00	0.00	0.00	0.00	3.78
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.34
Reservoir w/heating system	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Rotor w/ impellers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00	1.03
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Shaft seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	4.12
Subunit	0.34	1.03	0.00	0.34	0.00	0.00	0.00	1.37	0.00	6.53
Unknown	0.00	1.03	0.34	0.00	0.00	0.00	0.34	2.06	0.00	5.50
Valves	0.34	0.34	4.81	2.58	0.34	0.00	0.00	0.69	0.00	18.04
Total	2.41	5.50	13.40	10.65	1.72	0.00	1.37	11.68	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Compressors - Screw

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	0.34	0.00	0.00	0.34	0.34	0.00	0.00	0.00	0.34	0.00
Breakage	0.69	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cavitation	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.00	0.00	0.00	0.00	0.00	1.03	0.00	0.00	0.34	0.00
Corrosion	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	0.34	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	12.03	0.00	0.00	0.34	1.72	1.37	0.00	0.00	1.03	0.00
Leakage	0.00	0.00	1.37	3.44	0.00	0.34	0.00	0.00	0.00	0.00
Looseness	0.00	0.00	0.34	0.69	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.69	0.00	0.00	6.87	0.69	0.00	0.00	0.00	1.37	0.00
Misc. external influences	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00
No signal/indication/alarm	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open circuit	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	3.09	0.00	0.00	0.00	0.34	0.69	0.00	0.00	0.00	0.00
Overheating	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Software failure	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.34	0.00
Vibration	0.69	0.00	0.34	0.34	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	0.00	1.72	0.00	0.00	0.00	0.34	2.06	0.69
Total	22.68	0.00	2.75	13.75	3.09	4.12	0.00	0.34	5.84	0.69

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

**Item: Compressors - Screw**

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.34	0.34	1.72	0.00	0.00	0.00	0.00	0.69	0.00	4.47
Breakage	0.00	0.00	0.00	1.37	0.00	0.00	0.00	0.00	0.00	2.41
Cavitation	0.00	0.34	0.00	0.34	0.34	0.00	0.00	0.00	0.00	1.37
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Contamination	0.00	0.34	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.69
Control failure	0.00	0.00	0.69	0.34	0.00	0.00	0.00	0.00	0.00	2.41
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.34
Earth/isolation fault	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69
Electrical failure - general	0.00	0.69	0.34	0.34	0.00	0.00	0.00	0.34	0.00	2.41
External influence - general	0.00	1.72	1.03	0.00	0.00	0.00	0.00	0.34	0.00	3.09
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	1.37
Instrument failure - general	0.00	0.00	3.78	2.75	0.00	0.00	0.00	3.78	0.00	26.80
Leakage	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.34	0.00	5.84
Looseness	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03
Material failure - general	0.00	0.34	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.69
Mechanical Failure - general	0.69	0.69	3.09	4.12	1.03	0.00	0.00	2.41	0.00	21.65
Misc. external influences	0.34	0.00	0.69	0.69	0.00	0.00	0.00	0.34	0.00	3.09
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03
Open circuit	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.69
Other	0.00	0.34	0.00	0.00	0.00	0.00	0.69	0.00	0.00	1.03
Out of adjustment	0.69	0.00	0.69	0.00	0.00	0.00	0.00	0.69	0.00	6.19
Overheating	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.34
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Sticking	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.34
Unknown	0.00	0.00	0.34	0.00	0.00	0.00	0.69	1.03	0.00	2.75
Vibration	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	1.72
Wear	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.69	0.00	5.84
Total	2.41	5.50	13.40	10.65	1.72	0.00	1.37	11.68	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 1.1.3.1		Item Machinery Compressors Screw Diesel driven									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0245		Operational time † 0.0010							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max	
<b>Degraded</b>	2*	14.47	81.54	256.65	81.54	81.54	34.5	15.0	69.0	123.0	
	2†	355.00	2000.00	6295.00	2000.00	2000.00					
Other	2*	14.47	81.54	256.65	81.54	81.54	34.5	15.0	69.0	123.0	
	2†	355.00	2000.00	6295.00	2000.00	2000.00					
<b>Incipient</b>	5*	80.32	203.85	428.69	203.85	203.85	103.3	5.0	206.6	961.0	
	5†	1970.00	5000.00	10515.00	5000.00	5000.00					
Abnormal instrument reading	1*	2.04	40.77	193.45	40.77	40.77	14.0	28.0	28.0	28.0	
	1†	50.00	1000.00	4745.00	1000.00	1000.00					
Minor in-service problems	1*	2.04	40.77	193.45	40.77	40.77	11.5	23.0	23.0	23.0	
	1†	50.00	1000.00	4745.00	1000.00	1000.00					
Other	2*	14.47	81.54	256.65	81.54	81.54	241.5	5.0	483.0	961.0	
	2†	355.00	2000.00	6295.00	2000.00	2000.00					
Structural deficiency	1*	2.04	40.77	193.45	40.77	40.77	8.0	16.0	16.0	16.0	
	1†	50.00	1000.00	4745.00	1000.00	1000.00					
<b>All modes</b>	7*	133.93	285.39	536.12	285.39	285.39	83.6	5.0	167.3	961.0	
	7†	3285.00	7000.00	13150.00	7000.00	7000.00					
<b>Comments</b>											

Taxonomy no 1.1.3.1.1		Item Machinery Compressors Screw Diesel driven (100-1000) kW								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0245		Operational time † 0.0010						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Degraded</b>	2*	14.47	81.54	256.65	81.54	81.54	34.5	15.0	69.0	123.0
	2†	355.00	2000.00	6295.00	2000.00	2000.00				
Other	2*	14.47	81.54	256.65	81.54	81.54	34.5	15.0	69.0	123.0
	2†	355.00	2000.00	6295.00	2000.00	2000.00				
<b>Incipient</b>	5*	80.32	203.85	428.69	203.85	203.85	103.3	5.0	206.6	961.0
	5†	1970.00	5000.00	10515.00	5000.00	5000.00				
Abnormal instrument reading	1*	2.04	40.77	193.45	40.77	40.77	14.0	28.0	28.0	28.0
	1†	50.00	1000.00	4745.00	1000.00	1000.00				
Minor in-service problems	1*	2.04	40.77	193.45	40.77	40.77	11.5	23.0	23.0	23.0
	1†	50.00	1000.00	4745.00	1000.00	1000.00				
Other	2*	14.47	81.54	256.65	81.54	81.54	241.5	5.0	483.0	961.0
	2†	355.00	2000.00	6295.00	2000.00	2000.00				
Structural deficiency	1*	2.04	40.77	193.45	40.77	40.77	8.0	16.0	16.0	16.0
	1†	50.00	1000.00	4745.00	1000.00	1000.00				
<b>All modes</b>	7*	133.93	285.39	536.12	285.39	285.39	83.6	5.0	167.3	961.0
	7†	3285.00	7000.00	13150.00	7000.00	7000.00				
Comments										

Taxonomy no 1.1.3.2		Item Machinery Compressors Screw Electric driven								
Population 33	Installations 16	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 38694			
		Calendar time * 1.0800		Operational time † 0.5894						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>79*</b>	<b>0.00</b>	<b>119.07</b>	<b>623.23</b>	<b>280.02</b>	<b>73.15</b>	<b>14.7</b>	<b>1.0</b>	<b>23.2</b>	<b>163.0</b>
	<b>79†</b>	<b>0.00</b>	<b>140.31</b>	<b>771.01</b>	<b>373.65</b>	<b>134.04</b>				
Erratic output	4*	0.00	7.43	41.04	20.71	3.70	6.8	7.0	9.8	15.0
	4†	0.00	9.79	53.91	26.83	6.79				
External leakage - Process medium	2*	0.43	2.02	4.58	1.33	1.85	17.5	12.0	29.0	46.0
	2†	0.00	3.55	15.81	6.24	3.39				
External leakage - Utility medium	7*	0.00	12.91	71.93	37.34	6.48	14.1	13.0	38.9	96.0
	7†	0.00	16.30	92.72	49.64	11.88				
Fail to start on demand	12*	0.01	19.39	85.34	33.45	11.11	5.9	1.0	8.7	32.0
	12†	0.03	27.31	112.65	42.77	20.36				
Low output	11*	0.00	18.32	100.68	48.26	10.19	16.2	2.0	26.7	163.0
	11†	0.00	22.95	126.63	63.80	18.66				
Noise	1*	0.00	1.14	6.30	3.17	0.93	73.0	76.0	76.0	76.0
	1†	0.00	1.64	7.89	3.25	1.70				
Other	1*	0.00	1.14	6.30	3.17	0.93	7.0	7.0	7.0	7.0
	1†	0.00	1.64	7.89	3.25	1.70				
Overheating	4*	0.00	5.69	25.77	10.24	3.70	20.1	2.0	20.5	70.0
	4†	0.05	7.60	26.23	9.67	6.79				
Parameter deviation	2*	0.01	2.90	11.70	4.40	1.85	10.8	11.0	21.5	32.0
	2†	0.00	4.42	21.89	9.28	3.39				
Spurious stop	34*	0.00	49.58	255.89	111.67	31.48	15.8	2.0	23.6	148.0
	34†	0.00	60.15	320.06	146.70	57.69				
Structural deficiency	1*	0.00	1.64	8.64	3.90	0.93	21.5	43.0	43.0	43.0
	1†	0.01	1.96	7.64	2.83	1.70				
<b>Degraded</b>	<b>92*</b>	<b>0.00</b>	<b>145.57</b>	<b>800.25</b>	<b>391.94</b>	<b>85.19</b>	<b>9.2</b>	<b>1.0</b>	<b>15.2</b>	<b>111.0</b>
	<b>92†</b>	<b>0.00</b>	<b>163.88</b>	<b>929.89</b>	<b>529.52</b>	<b>156.10</b>				
Abnormal instrument reading	1*	0.00	1.14	6.30	3.17	0.93	5.0	5.0	5.0	5.0
	1†	0.00	1.64	7.89	3.25	1.70				
Erratic output	5*	0.00	8.39	44.63	20.45	4.63	6.9	2.0	10.6	35.0
	5†	0.00	11.16	58.06	25.82	8.48				
External leakage - Process medium	5*	0.00	8.86	46.23	20.66	4.63	2.5	1.0	4.6	15.0
	5†	0.00	11.83	60.47	26.16	8.48				
External leakage - Utility medium	28*	0.00	45.81	252.37	126.02	25.93	10.7	1.0	18.0	111.0
	28†	0.00	53.70	311.42	169.53	47.51				
Internal leakage	1*	0.00	1.14	6.30	3.17	0.93	48.0	48.0	48.0	48.0
	1†	0.00	1.64	7.89	3.25	1.70				
Low output	6*	0.00	5.91	33.01	19.44	5.56	6.5	2.0	6.5	12.0
	6†	0.00	8.05	44.37	22.22	10.18				
Noise	1*	0.00	1.14	6.30	3.17	0.93	15.0	15.0	15.0	15.0
	1†	0.00	1.64	7.89	3.25	1.70				
<b>Comments</b>										

(cont.)

Taxonomy no 1.1.3.2		Item Machinery Compressors Screw Electric driven									
Population 33	Installations 16	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 38694				
		Calendar time * 1.0800		Operational time † 0.5894							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
Other	7* 7†	0.00	12.12	62.14	26.92	6.48	10.0	1.0	17.5	46.0	
Overheating	3*	0.00	16.03	80.33	34.37	11.88	11.0	16.0	20.0	24.0	
	3†	0.00	5.15	21.87	8.42	5.09					
Parameter deviation	33*	0.00	58.96	332.10	175.64	30.56	8.4	2.0	15.7	101.0	
	33†	0.00	67.80	360.97	238.56	55.99					
Structural deficiency	2*	0.00	3.67	20.15	9.58	1.85	6.3	8.0	12.5	17.0	
	2†	0.00	4.93	25.68	11.43	3.39					
<b>Incipient</b>	<b>107*</b> <b>107†</b>	<b>0.00</b>	<b>179.22</b>	<b>985.45</b>	<b>484.37</b>	<b>99.08</b>	<b>10.3</b>	<b>1.0</b>	<b>18.8</b>	<b>961.0</b>	
Abnormal instrument reading	64*	0.00	108.32	600.47	307.63	59.26	6.2	1.0	10.2	176.0	
	64†	0.00	122.36	663.52	417.49	108.59					
External leakage - Process medium	1*	0.00	1.64	8.64	3.90	0.93	1.0	2.0	2.0	2.0	
	1†	0.01	1.96	7.64	2.83	1.70					
External leakage - Utility medium	5*	0.01	6.74	28.31	10.85	4.63	5.5	1.0	10.4	38.0	
	5†	0.29	9.74	29.63	10.25	8.48					
Minor in-service problems	30*	0.00	51.24	285.27	147.80	27.78	3.1	1.0	5.5	23.0	
	30†	0.00	59.42	325.43	199.95	50.90					
Other	2*	0.00	3.80	17.66	7.15	1.85	480.5	1.0	481.0	961.0	
	2†	0.00	6.96	33.79	14.02	3.39					
Parameter deviation	4*	0.00	6.55	29.66	11.80	3.70	4.3	2.0	5.7	8.0	
	4†	0.02	8.82	34.52	12.83	6.79					
Structural deficiency	1*	0.00	1.30	6.11	2.49	0.93	5.0	10.0	10.0	10.0	
	1†	0.00	2.01	11.08	5.54	1.70					
<b>Unknown</b>	<b>6*</b>	<b>0.06</b>	<b>15.73</b>	<b>60.80</b>	<b>22.46</b>	<b>5.56</b>	<b>5.0</b>	<b>8.0</b>	<b>11.7</b>	<b>16.0</b>	
	<b>6†</b>	<b>0.15</b>	<b>32.54</b>	<b>119.59</b>	<b>44.18</b>	<b>10.18</b>					
Other	2*	0.00	6.23	32.72	14.79	1.85	-	8.0	9.0	10.0	
	2†	0.00	14.83	73.04	30.82	3.39					
Unknown	4*	0.00	9.62	43.68	17.39	3.70	5.0	8.0	13.0	16.0	
	4†	0.00	18.10	81.74	32.47	6.79					
<b>All modes</b>	<b>284*</b> <b>284†</b>	<b>0.00</b>	<b>459.38</b>	<b>2500.47</b>	<b>1166.09</b>	<b>262.97</b>	<b>11.2</b>	<b>1.0</b>	<b>18.8</b>	<b>961.0</b>	
<b>Comments</b>											
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.8 10 <sup>-4</sup>											



Taxonomy no 1.1.3.2.1		Item Machinery Compressors Screw Electric driven (100-1000) kW									
Population 30	Installations 14	Aggregated time in service (10 <sup>6</sup> hours)						No of demands 37994			
		Calendar time * 1.0025			Operational time † 0.5511						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / c	Min		Mean	Max	
<b>Critical</b>	29*	<b>0.00</b>	<b>35.24</b>	<b>180.04</b>	<b>77.85</b>	<b>28.93</b>	<b>22.8</b>	<b>2.0</b>	<b>27.7</b>	<b>108.0</b>	
	29†	<b>0.00</b>	<b>47.42</b>	<b>228.74</b>	<b>94.40</b>	<b>52.63</b>					
External leakage - Process medium	2*	0.26	2.35	6.22	1.97	2.00	17.5	12.0	29.0	46.0	
	2†	0.00	3.90	17.02	6.64	3.63					
Fail to start on demand	6*	0.02	9.43	38.08	14.33	5.99	6.9	3.0	9.2	19.0	
	6†	0.05	13.06	49.92	18.39	10.89					
Low output	2*	0.00	2.58	12.33	5.06	2.00	29.0	10.0	29.0	48.0	
	2†	0.00	3.45	16.75	6.96	3.63					
Noise	1*	0.00	1.29	7.10	3.39	1.00	73.0	76.0	76.0	76.0	
	1†	0.00	1.78	8.47	3.48	1.81					
Other	1*	0.00	1.29	7.10	3.39	1.00	7.0	7.0	7.0	7.0	
	1†	0.00	1.78	8.47	3.48	1.81					
Overheating	2*	0.00	2.58	12.33	5.06	2.00	38.5	7.0	38.5	70.0	
	2†	0.00	3.45	16.75	6.96	3.63					
Parameter deviation	1*	0.00	1.50	6.96	2.81	1.00	5.5	11.0	11.0	11.0	
	1†	0.00	2.23	12.24	5.93	1.81					
Spurious stop	14*	0.00	16.83	82.60	34.74	13.97	24.9	2.0	31.6	108.0	
	14†	0.01	23.13	100.89	39.30	25.41					
<b>Degraded</b>	21*	<b>0.00</b>	<b>23.09</b>	<b>126.78</b>	<b>59.41</b>	<b>20.95</b>	<b>11.8</b>	<b>2.0</b>	<b>14.1</b>	<b>48.0</b>	
	21†	<b>0.00</b>	<b>29.80</b>	<b>156.95</b>	<b>71.13</b>	<b>38.11</b>					
Abnormal instrument reading	1*	0.00	1.29	7.10	3.39	1.00	5.0	5.0	5.0	5.0	
	1†	0.00	1.78	8.47	3.48	1.81					
Erratic output	1*	0.00	1.29	7.10	3.39	1.00	4.0	4.0	4.0	4.0	
	1†	0.00	1.78	8.47	3.48	1.81					
External leakage - Process medium	1*	0.00	1.50	6.96	2.81	1.00	7.5	15.0	15.0	15.0	
	1†	0.00	2.23	12.24	5.93	1.81					
External leakage - Utility medium	5*	0.00	5.81	32.35	16.74	4.99	17.0	2.0	17.0	39.0	
	5†	0.00	7.81	40.97	18.48	9.07					
Internal leakage	1*	0.00	1.29	7.10	3.39	1.00	48.0	48.0	48.0	48.0	
	1†	0.00	1.78	8.47	3.48	1.81					
Low output	6*	0.00	6.79	38.53	20.56	5.99	6.5	2.0	6.5	12.0	
	6†	0.00	8.99	49.44	23.48	10.89					
Noise	1*	0.00	1.29	7.10	3.39	1.00	15.0	15.0	15.0	15.0	
	1†	0.00	1.78	8.47	3.48	1.81					
Other	2*	0.00	3.38	17.72	7.98	2.00	11.0	2.0	22.0	42.0	
	2†	0.00	4.46	20.89	8.50	3.63					
Overheating	2*	0.00	1.86	8.53	3.42	2.00	11.0	16.0	20.0	24.0	
	2†	0.03	3.44	11.50	4.22	3.63					
Parameter deviation	1*	0.00	1.50	6.96	2.81	1.00	1.0	2.0	2.0	2.0	
	1†	0.00	2.23	12.24	5.93	1.81					
<b>Comments</b>											

(cont.)

Taxonomy no 1.1.3.2.1		Item Machinery Compressors Screw Electric driven (100-1000) kW								
Population 30	Installations 14	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 37994			
		Calendar time * 1.0025			Operational time † 0.5511					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/r		Min	Mean	Max
<b>Incipient</b>	19*	0.01	26.90	118.17	46.27	18.95	34.5	1.0	62.8	961.0
	19†	0.08	37.66	149.90	56.01	34.48				
Abnormal instrument reading	8*	0.02	11.05	44.68	16.83	7.98	7.3	2.0	11.1	29.0
External leakage - Utility medium	8†	0.52	14.95	45.23	15.49	14.52	8.3	2.0	16.0	38.0
	3*	0.00	3.69	16.82	6.71	2.99				
Minor in-service problems	3†	0.56	5.68	15.39	4.94	5.44	4.7	3.0	4.7	7.0
	3*	0.00	3.75	19.84	9.04	2.99				
Other	3†	0.01	5.21	21.11	7.96	5.44	480.5	1.0	481.0	961.0
	2*	0.00	4.41	19.48	7.65	2.00				
Parameter deviation	2†	0.00	7.94	36.79	14.85	3.63	4.0	8.0	8.0	8.0
	2*	0.00	3.38	17.72	7.98	2.00				
Structural deficiency	2†	0.00	4.46	20.89	8.50	3.63	5.0	10.0	10.0	10.0
	1*	0.00	1.50	6.96	2.81	1.00				
<b>Unknown</b>	1†	0.00	2.23	12.24	5.93	1.81	-	8.0	12.5	16.0
	4*	0.02	14.38	58.13	21.89	3.99				
Other	4†	0.18	33.90	122.50	45.26	7.26	-	8.0	9.0	10.0
	2*	0.00	7.21	36.39	15.64	2.00				
Unknown	2†	0.00	16.99	79.38	32.24	3.63	-	16.0	16.0	16.0
	2*	0.00	7.21	36.39	15.64	2.00				
<b>All modes</b>	2†	0.00	16.99	79.38	32.24	3.63	22.3	1.0	31.7	961.0
	73*	0.01	96.86	446.69	179.62	72.82				
		73†	0.14	140.26	584.42	222.81	132.47			

**Comments**

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 2.6 10<sup>-5</sup>

Taxonomy no 1.1.3.2.2		Item Machinery Compressors Screw Electric driven (1000-3000)kW									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 700				
		Calendar time * 0.0351			Operational time † 0.0320						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	50*	<b>1111.22</b>	<b>1425.96</b>	<b>1804.90</b>	<b>1425.96</b>	<b>1425.96</b>	<b>10.1</b>	<b>1.0</b>	<b>20.7</b>	<b>163.0</b>	
	50†	<b>1219.15</b>	<b>1564.46</b>	<b>1980.19</b>	<b>1564.46</b>	<b>1564.46</b>					
Erratic output	4*	38.93	114.08	261.09	114.08	114.08	6.8	7.0	9.8	15.0	
	4†	42.71	125.16	286.45	125.16	125.16					
External leakage - Utility medium	7*	93.69	199.63	375.03	199.63	199.63	14.1	13.0	38.9	96.0	
	7†	102.78	219.02	411.45	219.02	219.02					
Fail to start on demand	6*	74.58	171.12	337.67	171.12	171.12	5.0	1.0	8.3	32.0	
	6†	81.82	187.73	370.46	187.73	187.73					
Low output	9*	133.90	256.67	447.90	256.67	256.67	13.3	2.0	26.2	163.0	
	9†	146.90	281.60	491.40	281.60	281.60					
Overheating	2*	10.12	57.04	179.53	57.04	57.04	1.8	2.0	2.5	3.0	
	2†	11.11	62.58	196.96	62.58	62.58					
Parameter deviation	1*	1.43	28.52	135.32	28.52	28.52	16.0	32.0	32.0	32.0	
	1†	1.56	31.29	148.47	31.29	31.29					
Spurious stop	20*	377.98	570.39	828.78	570.39	570.39	9.5	2.0	17.9	148.0	
	20†	414.69	625.78	909.27	625.78	625.78					
Structural deficiency	1*	1.43	28.52	135.32	28.52	28.52	21.5	43.0	43.0	43.0	
	1†	1.56	31.29	148.47	31.29	31.29					
<b>Degraded</b>	71*	<b>1646.44</b>	<b>2024.87</b>	<b>2466.99</b>	<b>2024.87</b>	<b>2024.87</b>	<b>8.3</b>	<b>1.0</b>	<b>15.5</b>	<b>111.0</b>	
	71†	<b>1806.34</b>	<b>2221.53</b>	<b>2706.58</b>	<b>2221.53</b>	<b>2221.53</b>					
Erratic output	4*	38.93	114.08	261.09	114.08	114.08	7.6	2.0	12.3	35.0	
	4†	42.71	125.16	286.45	125.16	125.16					
External leakage - Process medium	4*	38.93	114.08	261.09	114.08	114.08	1.3	1.0	2.0	3.0	
	4†	42.71	125.16	286.45	125.16	125.16					
External leakage - Utility medium	23*	448.28	655.94	929.27	655.94	655.94	9.2	1.0	18.2	111.0	
	23†	491.82	719.65	1019.53	719.65	719.65					
Other	5*	56.18	142.60	299.88	142.60	142.60	9.5	1.0	15.3	46.0	
	5†	61.64	156.45	329.01	156.45	156.45					
Overheating	1*	1.43	28.52	135.32	28.52	28.52	-	-	-	-	
	1†	1.56	31.29	148.47	31.29	31.29					
Parameter deviation	32*	664.40	912.62	1225.81	912.62	912.62	8.7	2.0	16.2	101.0	
	32†	728.93	1001.25	1344.86	1001.25	1001.25					
Structural deficiency	2*	10.12	57.04	179.53	57.04	57.04	6.3	8.0	12.5	17.0	
	2†	11.11	62.58	196.96	62.58	62.58					
<b>Incipient</b>	88*	<b>2086.41</b>	<b>2509.70</b>	<b>2996.39</b>	<b>2509.70</b>	<b>2509.70</b>	<b>5.0</b>	<b>1.0</b>	<b>8.5</b>	<b>176.0</b>	
	88†	<b>2289.05</b>	<b>2753.44</b>	<b>3287.41</b>	<b>2753.44</b>	<b>2753.44</b>					
Abnormal instrument reading	56*	1262.96	1597.08	1995.22	1597.08	1597.08	6.0	1.0	10.1	176.0	
	56†	1385.62	1752.19	2189.00	1752.19	1752.19					
External leakage - Process medium	1*	1.43	28.52	135.32	28.52	28.52	1.0	2.0	2.0	2.0	
	1†	1.56	31.29	148.47	31.29	31.29					
<b>Comments</b>											

(cont.)

Taxonomy no 1.1.3.2.2		Item Machinery Compressors Screw Electric driven (1000-3000)kW									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 700				
		Calendar time * 0.0351		Operational time † 0.0320							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max	
External leakage - Utility medium	2*	10.12	57.04	179.53	57.04	57.04	1.3	1.0	2.0	3.0	
	2†	11.11	62.58	196.96	62.58	62.58					
Minor in-service problems	27*	543.50	770.02	1061.86	770.02	770.02	2.9	1.0	5.6	23.0	
	27†	596.28	844.81	1164.99	844.81	844.81					
Parameter deviation	2*	10.12	57.04	179.53	57.04	57.04	4.5	2.0	4.5	7.0	
	2†	11.11	62.58	196.96	62.58	62.58					
Unknown	2*	<b>10.12</b>	<b>57.04</b>	<b>179.53</b>	<b>57.04</b>	<b>57.04</b>	<b>5.0</b>	<b>8.0</b>	<b>10.0</b>	<b>12.0</b>	
	2†	<b>11.11</b>	<b>62.58</b>	<b>196.96</b>	<b>62.58</b>	<b>62.58</b>					
Unknown	2*	10.12	57.04	179.53	57.04	57.04	5.0	8.0	10.0	12.0	
	2†	11.11	62.58	196.96	62.58	62.58					
All modes	211*	<b>5352.71</b>	<b>6017.57</b>	<b>6744.98</b>	<b>6017.57</b>	<b>6017.57</b>	<b>7.4</b>	<b>1.0</b>	<b>14.0</b>	<b>176.0</b>	
	211†	<b>5872.57</b>	<b>6602.00</b>	<b>7400.06</b>	<b>6602.00</b>	<b>6602.00</b>					

**Comments**

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 8.6 · 10<sup>-3</sup>

<b>Taxonomy no</b> 1.1.3.2.3		<b>Item</b> Machinery Compressors Screw Electric driven Unknown									
<b>Population</b> 2	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>				
		<b>Calendar time *</b> 0.0424			<b>Operational time †</b> 0.0064						
<b>Failure mode</b>		<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours)</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
			<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/t</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>		0* 0†	0.04 0.27	11.49 68.55	44.12 263.23	16.25 96.94	0.00 0.00	-	-	-	-
<b>Comments</b>											

### Gas Turbines

#### Inventory description

The boundary shown in Figure 11 applies to gas turbines that are driving compressors, generators, and pumps. The corresponding subdivision in Subunits and Maintainable Items is shown in Table 6.

Gas turbines are generally installed in acoustic hoods. These hoods have their own dedicated ventilation system. Failure of the ventilation system of the hood may cause shutdown of the turbine. The hood is included within the boundary of the turbine system. External fuel supply (main supply) is not included, but local fuel supply equipment should be included. If there are subunits, which are common to the driver (i.e. the gas turbine), and the *driven unit* (e.g. a compressor), these are to be regarded as a part of the *driven unit*.

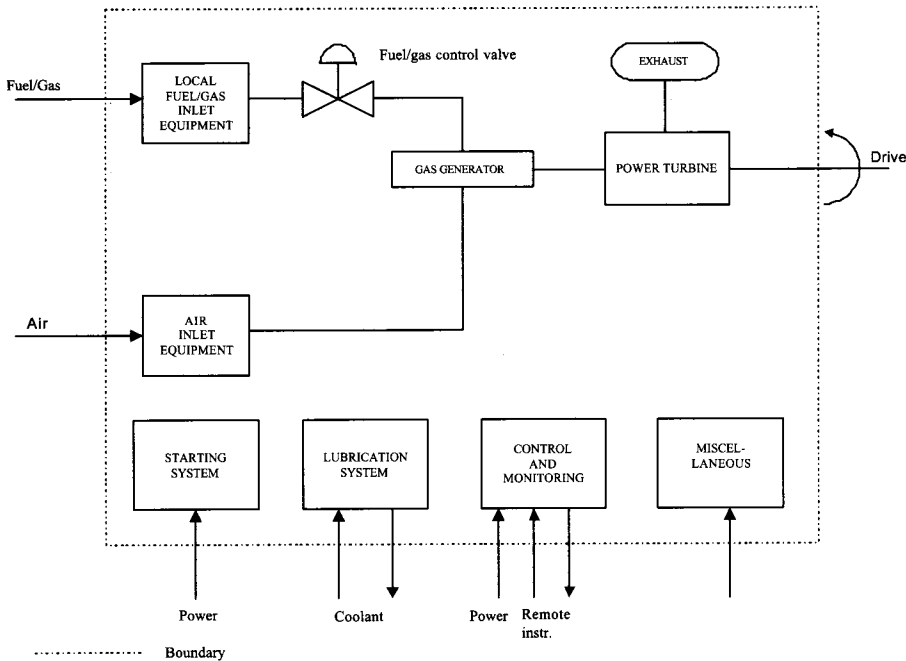


Figure 11 Gas Turbines, Boundary Definition

**Table 6 Gas Turbines, Subdivision in Maintainable Items**

GAS TURBINE					
Starting system	Gas generator	Power turbine	Control and Monitoring	Lubrication system	Miscellaneous
<ul style="list-style-type: none"> <li>• Instruments</li> <li>• Start energy (battery, air)</li> <li>• Starting unit</li> <li>• Start control</li> </ul>	<ul style="list-style-type: none"> <li>• Air inlet</li> <li>• Compr. rotor</li> <li>• Compr. stator</li> <li>• Combustion chambers</li> <li>• Burners/Fuel nozzles</li> <li>• Fuel control</li> <li>• Fuel filter</li> <li>• Fuel pump</li> <li>• Fuel scrubber/coalescer</li> <li>• HP turbine</li> <li>• Instruments</li> <li>• Casing</li> <li>• Thrust bearing</li> <li>• Radial bearing</li> <li>• Seals</li> <li>• Valves &amp; piping</li> </ul>	<ul style="list-style-type: none"> <li>• Rotor</li> <li>• Stator</li> <li>• Casing</li> <li>• Instruments</li> <li>• Radial bearing</li> <li>• Thrust bearing</li> <li>• Seals</li> <li>• Exhaust</li> <li>• Valves &amp; piping</li> </ul>	<ul style="list-style-type: none"> <li>• Instruments</li> <li>• Cabling &amp; junction boxes</li> <li>• Control unit</li> <li>• Actuating device</li> <li>• Monitoring</li> <li>• Internal power supply</li> <li>• Valves</li> </ul>	<ul style="list-style-type: none"> <li>• Reservoir w/heating system</li> <li>• Pump w/motor</li> <li>• Filter</li> <li>• Cooler</li> <li>• Valves &amp; piping</li> <li>• Oil</li> <li>• Seals</li> </ul>	<ul style="list-style-type: none"> <li>• Hood</li> <li>• Purge air</li> </ul>

(For all subunits the MIs "Unknown" and "Subunit" are included.)

### List of failure modes

AIR	Abnormal instrument reading
BRD	Breakdown
ERO	Erratic output
ELF	External leakage - Fuel
ELU	External leakage - Utility medium
FTS	Fail to start on demand
STP	Fail to stop on demand
HIO	High output
INL	Internal leakage
LOO	Low output
SER	Minor in-service problems
NOI	Noise
OTH	Other
OHE	Overheating
PDE	Parameter deviation
UST	Spurious stop
STD	Structural deficiency
UNK	Unknown
VIB	Vibration



Taxonomy no 1.2		Item Machinery Gas Turbines								
Population 84	Installations 23	Aggregated time in service (106 hours)					No of demands 11096			
		Calendar time * 2.5723		Operational time † 1.7836						
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>941*</b>	<b>33.48</b>	<b>354.75</b>	<b>969.98</b>	<b>312.92</b>	<b>365.81</b>	<b>27.0</b>	<b>0.1</b>	<b>39.4</b>	<b>3001.0</b>
	<b>941†</b>	<b>17.72</b>	<b>553.77</b>	<b>1679.62</b>	<b>577.96</b>	<b>527.59</b>				
Abnormal instrument reading	4*	0.00	2.66	13.56	5.86	1.56	33.7	4.0	62.8	163.0
	4†	0.00	3.49	17.11	7.19	2.24				
Breakdown	26*	2.04	9.17	20.51	5.90	10.11	66.9	2.0	79.4	301.0
	26†	2.59	13.25	30.69	9.03	14.58				
Erratic output	21*	0.04	10.06	37.46	13.83	8.16	35.2	1.0	47.0	284.0
	21†	0.13	13.46	44.51	16.28	11.77				
External leakage - Fuel	40*	0.04	19.09	76.34	28.58	15.55	19.0	0.3	46.4	1113.0
	40†	0.06	28.70	114.45	42.78	22.43				
External leakage - Utility medium	15*	0.03	7.72	29.04	10.71	5.83	21.3	1.0	28.9	100.0
	15†	0.07	9.66	32.85	12.09	8.41				
Fail to start on demand	299*	16.57	110.77	274.55	84.11	116.24	27.8	1.0	33.3	511.0
	299†	13.14	174.06	495.20	162.57	167.64				
Fail to stop on demand	8*	1.24	3.02	5.43	1.30	3.11	5.6	2.0	6.3	12.0
	8†	0.00	4.60	19.20	7.32	4.49				
High output	5*	0.03	1.68	5.31	1.90	1.94	11.9	5.0	24.0	52.0
	5†	0.00	2.47	13.61	6.87	2.80				
Internal leakage	6*	0.00	2.00	9.57	3.94	2.33	39.4	6.0	68.0	343.0
	6†	0.06	3.38	10.56	3.76	3.36				
Low output	27*	0.00	12.03	57.28	23.51	10.50	29.1	2.0	42.4	604.0
	27†	0.00	16.55	77.40	31.45	15.14				
Other	12*	0.09	5.00	15.63	5.57	4.67	34.8	2.0	42.5	115.0
	12†	0.11	7.58	24.13	8.69	6.73				
Overheating	54*	0.00	16.36	87.40	57.21	20.99	18.6	0.1	31.8	243.0
	54†	0.00	25.48	137.01	88.07	30.28				
Parameter deviation	31*	0.05	14.48	56.09	20.74	12.05	22.3	1.0	34.5	249.0
	31†	0.10	20.27	73.93	27.31	17.38				
Spurious stop	370*	0.62	126.98	463.12	171.11	143.84	20.7	1.0	29.4	1024.0
	370†	0.44	200.23	797.43	297.98	207.45				
Structural deficiency	5*	0.00	2.28	10.29	4.08	1.94	346.5	12.0	693.2	3001.0
	5†	0.01	2.98	11.34	4.18	2.80				
Unknown	3*	0.01	1.17	4.28	1.58	1.17	68.0	68.0	68.0	68.0
	3†	0.00	1.46	7.93	3.70	1.68				
Vibration	15*	0.00	5.28	23.17	9.07	5.83	41.8	3.0	87.8	326.0
	15†	1.42	8.57	20.72	6.26	8.41				
<b>Degraded</b>	<b>704*</b>	<b>46.77</b>	<b>266.17</b>	<b>633.28</b>	<b>189.13</b>	<b>273.68</b>	<b>18.9</b>	<b>1.0</b>	<b>29.6</b>	<b>939.0</b>
	<b>704†</b>	<b>57.76</b>	<b>369.56</b>	<b>906.51</b>	<b>276.08</b>	<b>394.71</b>				
Abnormal instrument reading	34*	0.07	11.84	41.85	15.46	13.22	9.0	1.0	14.1	70.0
	34†	0.12	17.50	59.93	22.07	19.06				
Erratic output	58*	5.47	22.08	47.87	13.49	22.55	14.0	1.0	21.0	150.0
	58†	12.70	31.50	57.13	13.82	32.52				
<b>Comments</b>										

(cont.)

Taxonomy no 1.2		Item Machinery Gas Turbines								
Population 84	Installations 23	Aggregated time in service (106 hours)					No of demands 11096			
		Calendar time * 2.5723		Operational time † 1.7836						
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Fuel	55*	0.11	17.09	59.10	21.79	21.38	11.6	2.0	16.3	84.0
	55†	0.00	25.88	118.40	47.25	30.84				
External leakage - Utility medium	112*	9.74	41.91	92.52	26.38	43.54	27.8	1.0	43.3	939.0
	112†	11.22	60.72	142.74	42.34	62.79				
Fail to start on demand	1*	0.00	0.34	1.71	0.73	0.39	6.0	10.0	10.0	10.0
	1†	0.00	0.56	2.97	1.95	0.56				
High output	4*	0.00	1.36	7.04	3.07	1.56	4.0	2.0	4.0	8.0
	4†	0.76	2.24	4.35	1.12	2.24				
Internal leakage	12*	0.04	4.67	18.78	7.05	4.67	24.5	2.0	25.0	109.0
	12†	0.02	7.23	28.09	10.40	6.73				
Low output	76*	0.55	32.57	102.18	36.49	29.55	19.5	1.0	29.8	520.0
	76†	1.20	44.19	134.90	46.89	42.61				
Minor in-service problems	12*	0.00	6.64	29.97	11.90	4.67	4.0	1.0	11.8	36.0
	12†	0.00	9.23	40.46	15.82	6.73				
Noise	4*	0.00	1.40	6.88	2.90	1.56	55.0	10.0	91.3	312.0
	4†	0.00	2.11	9.94	4.06	2.24				
Other	119*	6.58	50.37	128.43	39.92	46.26	24.5	1.0	34.8	354.0
	119†	11.71	70.04	168.92	50.91	66.72				
Overheating	92*	0.00	28.92	162.17	85.17	35.77	11.8	1.0	22.6	110.0
	92†	0.00	41.24	237.87	128.97	51.58				
Parameter deviation	69*	0.00	29.83	147.60	62.53	26.82	7.0	1.0	11.4	76.0
	69†	0.00	39.07	188.66	77.90	38.69				
Structural deficiency	30*	0.00	12.94	57.28	22.54	11.66	31.8	2.0	63.7	490.0
	30†	0.02	17.01	70.93	27.06	16.82				
Unknown	14*	0.00	4.57	25.40	13.10	5.44	41.3	2.0	41.3	116.0
	14†	0.00	5.83	32.05	15.54	7.85				
Vibration	12*	0.09	4.51	13.97	4.94	4.67	75.8	3.0	81.5	560.0
	12†	0.15	6.51	20.05	7.04	6.73				
<b>Incipient</b>	<b>1593*</b>	<b>131.55</b>	<b>569.36</b>	<b>1258.95</b>	<b>359.36</b>	<b>619.28</b>	<b>12.0</b>	<b>0.5</b>	<b>18.9</b>	<b>1519.0</b>
	<b>1593†</b>	<b>262.37</b>	<b>1359.67</b>	<b>3162.33</b>	<b>932.68</b>	<b>893.14</b>				
Abnormal instrument reading	538*	31.35	187.83	453.16	136.61	209.15	8.1	0.5	11.4	184.0
	538†	50.01	483.37	1295.86	413.75	301.64				
Erratic output	14*	0.03	5.79	21.13	7.81	5.44	8.2	1.0	12.2	28.0
	14†	0.24	7.51	22.76	7.83	7.85				
External leakage - Fuel	30*	0.00	9.96	49.69	21.20	11.66	11.1	2.0	11.2	32.0
	30†	0.00	14.15	67.98	28.01	16.82				
External leakage - Utility medium	164*	0.91	48.68	151.65	53.85	63.76	10.6	1.0	17.4	235.0
	164†	0.74	124.79	440.19	162.56	91.95				
Fail to start on demand	2*	0.00	0.84	3.12	1.15	0.78	2.5	1.0	4.5	8.0
	2†	0.21	1.13	2.67	0.79	1.12				
Internal leakage	13*	0.00	3.68	18.44	7.90	5.05	10.0	2.0	12.4	48.0
	13†	0.00	6.87	37.75	18.48	7.29				
<b>Comments</b>										

(cont.)

Taxonomy no 1.2		Item Machinery Gas Turbines								
Population 84	Installations 23	Aggregated time in service (106 hours)					No of demands 11096			
		Calendar time * 2.5723		Operational time † 1.7836						
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max
Low output	5*	0.00	1.72	9.12	4.17	1.94	10.0	8.0	14.5	28.0
	5†	0.00	3.30	18.12	8.49	2.80				
Minor in-service problems	407*	4.04	156.96	480.42	167.54	158.22	10.2	1.0	15.4	963.0
	407†	10.86	286.87	865.22	294.48	228.19				
Noise	11*	0.89	4.01	8.97	2.58	4.28	36.1	6.0	82.4	294.0
	11†	0.08	5.82	18.64	6.74	6.17				
Other	238*	1.74	92.23	287.15	101.92	92.52	21.4	1.0	37.2	1519.0
	238†	3.28	152.79	472.03	166.36	133.44				
Overheating	20*	0.53	7.33	20.99	6.91	7.78	18.9	1.0	31.5	165.0
	20†	2.95	10.60	22.13	6.06	11.21				
Parameter deviation	64*	0.00	26.25	129.40	54.65	24.88	10.6	1.0	14.2	215.0
	64†	0.00	33.27	163.49	68.83	35.88				
Structural deficiency	39*	0.17	16.68	54.60	19.91	15.16	23.2	1.0	43.1	175.0
	39†	0.26	25.29	82.77	30.18	21.87				
Unknown	35*	0.00	10.77	56.46	39.25	13.61	25.3	5.0	24.4	222.0
	35†	0.00	12.61	65.31	48.33	19.62				
Vibration	13*	0.00	5.45	23.07	8.88	5.05	13.8	3.0	20.9	57.0
	13†	0.00	11.19	53.17	21.80	7.29				
<b>Unknown</b>	<b>25*</b>	<b>1.33</b>	<b>11.46</b>	<b>29.85</b>	<b>9.37</b>	<b>9.72</b>	<b>6.9</b>	<b>1.0</b>	<b>24.1</b>	<b>212.0</b>
	<b>25†</b>	<b>2.82</b>	<b>16.37</b>	<b>39.18</b>	<b>11.75</b>	<b>14.02</b>				
Abnormal instrument reading	5*	0.00	2.59	11.91	4.78	1.94	2.3	1.0	3.3	7.0
	5†	0.00	3.31	13.89	5.32	2.80				
External leakage - Fuel	1*	0.00	0.43	2.23	1.75	0.39	4.0	8.5	8.5	8.5
	1†	0.00	0.62	2.94	1.21	0.56				
Other	7*	0.53	2.76	6.42	1.89	2.72	8.3	8.0	24.2	78.0
	7†	0.86	4.15	9.48	2.77	3.92				
Unknown	11*	0.03	5.23	18.23	6.73	4.28	8.0	2.0	31.8	212.0
	11†	0.07	7.34	24.15	8.82	6.17				
Vibration	1*	0.00	0.40	2.08	1.49	0.39				
	1†	0.00	0.56	2.97	1.98	0.56				
<b>All modes</b>	<b>3263*</b>	<b>241.71</b>	<b>1199.23</b>	<b>2758.09</b>	<b>808.20</b>	<b>1268.49</b>	<b>17.7</b>	<b>0.1</b>	<b>27.1</b>	<b>3001.0</b>
	<b>3263†</b>	<b>460.22</b>	<b>2398.21</b>	<b>5585.47</b>	<b>1648.61</b>	<b>1829.46</b>				
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.7. 10-2										

Maintainable item versus failure mode, to be continued

Item: Gas Turbines

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.09	0.00	0.00	0.00	0.03	0.32	0.00	0.00	0.00	0.00
Air inlet	0.25	0.00	0.03	0.15	0.03	0.08	0.00	0.03	0.31	0.00
Burners/fuel nozzles	0.00	0.00	0.20	0.03	0.04	0.21	0.00	0.03	0.09	0.00
Cabling & junction boxes	0.54	0.00	0.00	0.03	0.06	0.14	0.00	0.00	0.00	0.00
Casing	0.00	0.03	0.06	0.17	0.00	0.00	0.00	0.00	0.00	0.00
Combustion chambers	0.00	0.03	0.12	0.03	0.03	0.09	0.00	0.00	0.03	0.00
Compressor rotor	0.00	0.03	0.00	0.00	0.00	0.03	0.00	0.00	0.03	0.00
Compressor stator	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00
Control unit	1.53	0.03	0.00	0.03	0.18	0.87	0.06	0.00	0.12	0.00
Cooler(s)	0.00	0.00	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00
Exhaust	0.03	0.03	0.03	0.37	0.03	0.00	0.00	0.03	0.00	0.18
Filter(s)	0.11	0.00	0.00	0.35	0.03	0.06	0.00	0.03	0.17	0.00
Fuel control	0.09	0.00	0.17	0.00	0.43	0.78	0.00	0.03	0.12	0.00
Fuel filter	0.03	0.00	0.03	0.00	0.03	0.06	0.00	0.00	0.21	0.00
Fuel pump	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.05	0.00
Fuel scrubber/coalescer	0.03	0.00	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Hood	0.03	0.00	0.00	0.03	0.00	0.12	0.00	0.00	0.00	0.03
HP turbine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Instrument, flame	0.40	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00
Instrument, flow	0.35	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00
Instrument, general	0.95	0.00	0.00	0.00	0.03	0.05	0.00	0.00	0.03	0.03
Instrument, level	0.43	0.00	0.00	0.03	0.06	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	2.63	0.00	0.11	0.08	0.06	0.26	0.00	0.03	0.06	0.00
Instrument, speed	0.87	0.00	0.00	0.03	0.09	0.34	0.12	0.00	0.03	0.00
Instrument, temperature	3.69	0.00	0.03	0.00	0.10	0.03	0.00	0.00	0.00	0.00
Instrument, vibration	1.27	0.00	0.00	0.03	0.03	0.08	0.00	0.00	0.03	0.00
Internal power supply	0.28	0.00	0.00	0.06	0.00	0.06	0.00	0.00	0.03	0.00
Monitoring	1.81	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.06	0.00	0.05	0.00	0.00	0.02	0.00
Other	0.31	0.06	0.15	0.83	0.15	0.43	0.00	0.09	0.09	0.00
Piping	0.00	0.03	0.54	1.47	0.00	0.03	0.00	0.03	0.02	0.03
Pump w/motor	0.06	0.03	0.00	0.72	0.05	0.06	0.03	0.06	0.06	0.09
Purge air	0.06	0.03	0.00	0.00	0.00	0.03	0.00	0.00	0.06	0.03
Radial bearing	0.00	0.06	0.00	0.06	0.00	0.03	0.00	0.00	0.00	0.00
Reservoir w/heating system	0.00	0.00	0.00	0.06	0.00	0.03	0.00	0.03	0.00	0.00
Rotor	0.00	0.12	0.00	0.00	0.03	0.00	0.00	0.00	0.03	0.00
Seals	0.00	0.00	0.41	1.12	0.01	0.02	0.00	0.06	0.00	0.00
Start control	0.03	0.00	0.00	0.00	0.01	0.15	0.00	0.00	0.00	0.00
Start energy (battery, air)	0.00	0.00	0.00	0.03	0.06	0.18	0.00	0.00	0.00	0.00
Starting unit	0.00	0.00	0.06	0.34	0.06	1.04	0.00	0.00	0.03	0.00
Stator	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.03	0.00
Subunit	0.12	0.06	0.06	0.18	0.09	0.95	0.00	0.03	0.77	0.00
Thrust bearing	0.03	0.03	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.00
Unknown	1.44	0.12	0.37	0.67	0.12	1.26	0.06	0.12	0.15	0.03
Valves	0.35	0.09	1.12	1.30	0.93	1.16	0.00	0.34	0.67	0.03
Total	17.81	0.80	3.86	8.92	2.85	9.26	0.28	0.95	3.31	0.46

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Maintainable item versus failure mode, continued

Item: Gas Turbines

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.25	0.00	0.09	0.00	0.00	0.00	0.09	0.00	0.87
Air inlet	0.25	0.89	0.90	1.00	0.03	0.00	0.25	0.26	0.03	4.47
Burners/fuel nozzles	2.91	0.15	0.16	0.12	0.08	0.00	0.00	0.08	0.00	4.11
Cabling & junction boxes	0.09	0.34	0.03	0.37	0.00	0.00	0.03	0.29	0.00	1.92
Casing	0.03	0.09	0.03	0.09	0.06	0.00	0.06	0.00	0.03	0.66
Combustion chambers	0.02	0.09	0.00	0.00	0.03	0.00	0.00	0.03	0.03	0.54
Compressor rotor	0.02	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.12	0.26
Compressor stator	0.05	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.02	0.18
Control unit	0.03	0.60	0.31	0.28	0.03	0.00	0.12	1.30	0.03	5.53
Cooler(s)	0.12	0.11	0.06	0.12	0.09	0.00	0.00	0.12	0.02	1.23
Exhaust	0.06	0.49	0.03	0.31	0.58	0.00	0.03	0.17	0.06	2.44
Filter(s)	0.03	0.25	0.49	0.74	0.00	0.00	0.00	0.21	0.00	2.47
Fuel control	0.01	0.21	0.21	0.21	0.00	0.03	0.00	0.74	0.00	3.04
Fuel filter	0.00	0.12	0.18	1.15	0.03	0.00	0.06	0.12	0.00	2.04
Fuel pump	0.00	0.12	0.00	0.03	0.00	0.00	0.00	0.09	0.00	0.60
Fuel scrubber/coalescer	0.00	0.00	0.03	0.06	0.00	0.00	0.06	0.03	0.00	0.31
Hood	0.15	0.55	0.00	0.52	0.09	0.00	0.00	0.12	0.03	1.69
HP turbine	0.00	0.03	0.03	0.00	0.02	0.00	0.00	0.06	0.00	0.20
Instrument, flame	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.09	0.00	0.58
Instrument, flow	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.03	0.00	0.51
Instrument, general	0.00	0.41	0.03	0.09	0.00	0.03	0.03	0.28	0.00	1.96
Instrument, level	0.00	0.00	0.12	0.06	0.00	0.00	0.00	0.00	0.00	0.70
Instrument, pressure	0.15	0.11	0.17	0.21	0.03	0.03	0.00	0.34	0.00	4.27
Instrument, speed	0.00	0.09	0.09	0.06	0.00	0.06	0.00	0.67	0.00	2.46
Instrument, temperature	0.15	0.40	0.18	0.18	0.00	0.00	0.03	0.60	0.00	5.40
Instrument, vibration	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.58	0.23	2.28
Internal power supply	0.00	0.18	0.00	0.12	0.00	0.00	0.03	0.40	0.00	1.16
Monitoring	0.00	0.09	0.09	0.15	0.00	0.00	0.03	0.06	0.00	2.27
Oil	0.03	0.22	0.12	0.15	0.03	0.00	0.00	0.14	0.00	0.82
Other	0.15	0.70	0.41	1.99	0.34	0.00	0.31	0.26	0.09	6.37
Piping	0.02	0.32	0.01	0.37	0.11	0.00	0.03	0.05	0.08	3.12
Pump w/motor	0.06	0.62	0.14	0.15	0.00	0.00	0.12	0.35	0.02	2.63
Purge air	0.06	0.25	0.03	0.86	0.03	0.00	0.00	0.09	0.00	1.53
Radial bearing	0.00	0.09	0.00	0.00	0.03	0.00	0.06	0.09	0.09	0.52
Reservoir w/heating system	0.00	0.06	0.03	0.12	0.00	0.00	0.00	0.00	0.00	0.34
Rotor	0.00	0.00	0.00	0.06	0.03	0.00	0.00	0.00	0.03	0.31
Seals	0.03	0.06	0.01	0.03	0.00	0.00	0.03	0.02	0.00	1.80
Start control	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.32
Start energy (battery, air)	0.00	0.12	0.09	0.12	0.03	0.00	0.00	0.00	0.00	0.64
Starting unit	0.00	0.25	0.00	0.09	0.00	0.00	0.06	0.03	0.00	1.96
Stator	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.09
Subunit	0.06	0.66	0.18	0.49	0.03	0.00	0.03	0.40	0.15	4.28
Thrust bearing	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.25
Unknown	0.31	1.16	0.34	1.72	0.37	0.00	0.18	1.62	0.18	10.24
Valves	0.27	1.32	0.49	0.55	0.14	0.09	0.37	1.39	0.02	10.64
Total	5.09	11.52	5.03	12.84	2.27	0.25	1.93	11.34	1.26	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptor versus failure mode, to be continued

Item: Gas Turbines

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	0.31	0.00	0.00	0.06	0.06	0.18	0.00	0.00	0.64	0.00
Breakage	0.70	0.09	0.12	0.21	0.06	0.12	0.00	0.00	0.00	0.03
Burst	0.00	0.00	0.12	0.12	0.00	0.00	0.00	0.03	0.00	0.00
Cavitation	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.03
Clearance/ alignment failure	0.00	0.00	0.09	0.06	0.00	0.09	0.00	0.03	0.03	0.00
Combined causes	0.00	0.00	0.03	0.00	0.03	0.12	0.00	0.00	0.03	0.00
Common mode failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
Contamination	0.12	0.00	0.00	0.03	0.03	0.03	0.00	0.00	0.28	0.00
Control failure	0.31	0.00	0.00	0.09	0.34	0.70	0.06	0.00	0.21	0.00
Corrosion	0.28	0.00	0.12	0.40	0.12	0.09	0.00	0.03	0.00	0.00
Deformation	0.03	0.12	0.21	0.83	0.03	0.09	0.03	0.03	0.00	0.09
Earth/isolation fault	0.06	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00
Electrical failure - general	0.86	0.00	0.00	0.00	0.34	0.67	0.00	0.00	0.09	0.00
Erosion	0.03	0.00	0.15	0.18	0.00	0.03	0.00	0.00	0.00	0.00
External influence - general	0.12	0.00	0.00	0.03	0.03	0.06	0.00	0.00	0.18	0.00
Fatigue	0.03	0.00	0.00	0.06	0.00	0.03	0.00	0.03	0.03	0.03
Faulty power/voltage	0.03	0.00	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	5.03	0.00	0.00	0.06	0.18	0.46	0.00	0.00	0.03	0.00
Instrument failure - general	3.86	0.09	0.09	0.03	0.25	1.04	0.12	0.03	0.12	0.00
Leakage	0.09	0.03	0.46	2.15	0.03	0.25	0.00	0.18	0.15	0.00
Looseness	0.21	0.00	0.28	0.58	0.00	0.12	0.00	0.03	0.03	0.03
Material failure - general	0.09	0.00	0.67	1.35	0.06	0.03	0.00	0.03	0.03	0.00
Mechanical Failure - general	0.21	0.37	0.92	1.35	0.61	2.42	0.00	0.25	0.49	0.09
Misc. external influences	0.21	0.00	0.03	0.06	0.12	0.06	0.00	0.03	0.06	0.00
Miscellaneous - general	0.03	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
No cause found	0.15	0.00	0.06	0.06	0.00	0.09	0.03	0.03	0.03	0.03
No power/ voltage	0.12	0.00	0.00	0.00	0.03	0.06	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.70	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00
Open circuit	0.28	0.00	0.00	0.00	0.03	0.21	0.00	0.00	0.00	0.00
Other	0.09	0.00	0.03	0.03	0.06	0.31	0.00	0.00	0.06	0.03
Out of adjustment	2.39	0.00	0.00	0.03	0.00	0.49	0.03	0.06	0.15	0.00
Overheating	0.06	0.00	0.00	0.03	0.00	0.09	0.00	0.00	0.00	0.00
Short circuiting	0.09	0.00	0.00	0.00	0.03	0.06	0.00	0.00	0.03	0.00
Software failure	0.18	0.00	0.00	0.00	0.03	0.15	0.00	0.00	0.00	0.00
Sticking	0.12	0.03	0.00	0.00	0.12	0.28	0.00	0.06	0.06	0.00
Unknown	0.18	0.03	0.06	0.12	0.06	0.43	0.00	0.00	0.18	0.00
Vibration	0.25	0.00	0.03	0.03	0.06	0.09	0.00	0.00	0.00	0.00
Wear	0.55	0.03	0.37	0.74	0.12	0.06	0.00	0.09	0.34	0.09
Total	17.81	0.80	3.86	8.92	2.85	9.26	0.28	0.95	3.31	0.46

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

**Item:** Gas Turbines

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.15	0.49	1.04	1.93	0.06	0.00	0.00	0.43	0.00	5.36
Breakage	0.12	0.40	0.06	0.52	0.52	0.00	0.03	0.21	0.03	3.25
Burst	0.00	0.25	0.00	0.03	0.21	0.00	0.00	0.03	0.00	0.80
Cavitation	0.00	0.03	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.31
Clearance/ alignment failure	0.03	0.12	0.09	0.06	0.00	0.00	0.00	0.03	0.09	0.74
Combined causes	2.30	0.03	0.00	0.03	0.00	0.00	0.00	0.12	0.03	2.73
Common mode failure	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.06
Contamination	0.70	0.43	0.80	0.86	0.00	0.00	0.28	0.21	0.09	3.86
Control failure	0.03	0.28	0.25	0.09	0.03	0.00	0.18	1.13	0.03	3.74
Corrosion	0.03	0.28	0.00	0.74	0.15	0.00	0.15	0.00	0.00	2.39
Deformation	0.06	0.09	0.00	0.25	0.06	0.06	0.00	0.09	0.00	2.08
Earth/isolation fault	0.03	0.28	0.06	0.09	0.00	0.00	0.00	0.03	0.00	0.61
Electrical failure - general	0.12	0.77	0.12	1.16	0.00	0.00	0.09	0.80	0.06	5.09
Erosion	0.03	0.00	0.00	0.09	0.03	0.00	0.03	0.03	0.03	0.64
External influence - general	0.06	0.40	0.15	0.46	0.00	0.00	0.00	0.12	0.00	1.62
Fatigue	0.03	0.03	0.00	0.15	0.12	0.00	0.00	0.00	0.03	0.58
Faulty power/voltage	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.21	0.00	0.37
Faulty signal/indication/alarm	0.18	0.43	0.18	0.12	0.00	0.00	0.00	1.29	0.09	8.06
Instrument failure - general	0.03	0.83	0.43	0.58	0.00	0.06	0.03	1.26	0.03	8.89
Leakage	0.06	0.49	0.15	0.21	0.18	0.00	0.06	0.18	0.03	4.72
Looseness	0.00	0.18	0.00	0.55	0.03	0.00	0.00	0.21	0.03	2.30
Material failure - general	0.03	0.21	0.03	0.25	0.12	0.00	0.12	0.12	0.03	3.19
Mechanical Failure - general	0.46	1.62	0.52	1.20	0.37	0.09	0.49	1.32	0.18	12.96
Misc. external influences	0.18	0.43	0.09	0.28	0.00	0.00	0.00	0.43	0.09	2.08
Miscellaneous - general	0.00	0.06	0.03	0.34	0.00	0.00	0.03	0.03	0.00	0.67
No cause found	0.03	0.06	0.00	0.00	0.00	0.03	0.00	0.18	0.06	0.86
No power/ voltage	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.34
No signal/indication/alarm	0.00	0.15	0.06	0.09	0.00	0.00	0.00	0.12	0.00	1.20
Open circuit	0.03	0.09	0.00	0.09	0.00	0.00	0.03	0.28	0.00	1.04
Other	0.09	1.07	0.03	0.15	0.03	0.00	0.00	0.25	0.00	2.24
Out of adjustment	0.06	0.34	0.37	0.40	0.03	0.00	0.00	0.64	0.00	5.00
Overheating	0.09	0.06	0.09	0.06	0.00	0.00	0.00	0.21	0.00	0.70
Short circuiting	0.00	0.15	0.03	0.03	0.00	0.00	0.00	0.15	0.00	0.58
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37
Sticking	0.00	0.43	0.03	0.52	0.00	0.00	0.00	0.12	0.00	1.78
Unknown	0.06	0.43	0.34	0.15	0.00	0.00	0.28	0.31	0.06	2.70
Vibration	0.00	0.09	0.03	0.28	0.03	0.00	0.00	0.58	0.15	1.62
Wear	0.06	0.46	0.03	0.98	0.25	0.00	0.12	0.09	0.09	4.47
Total	5.09	11.52	5.03	12.84	2.27	0.25	1.93	11.34	1.26	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 1.2.1		Item Machinery Gas Turbines Aeroderivative								
Population 39	Installations 12	Aggregated time in service (106 hours)					No of demands 6864			
		Calendar time * 1.3917			Operational time † 0.8828					
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>604*</b>	<b>13.44</b>	<b>363.52</b>	<b>1097.15</b>	<b>373.99</b>	<b>434.01</b>	<b>21.5</b>	<b>0.1</b>	<b>28.3</b>	<b>604.0</b>
	<b>604†</b>	<b>3.54</b>	<b>590.62</b>	<b>2078.09</b>	<b>767.34</b>	<b>684.18</b>				
Abnormal instrument reading	2*	0.00	2.06	10.36	4.44	1.44	4.0	4.0	28.5	53.0
	2†	0.00	3.08	14.70	6.04	2.27				
Breakdown	15*	2.87	9.92	20.43	5.54	10.78	60.9	2.0	74.1	301.0
	15†	1.01	15.11	43.76	14.46	16.99				
Erratic output	8*	0.12	6.01	18.67	6.61	5.75	84.4	3.0	75.1	284.0
	8†	0.23	9.73	29.93	10.50	9.06				
External leakage - Fuel	30*	0.06	21.70	85.03	31.60	21.56	10.9	0.3	17.7	80.0
	30†	0.07	34.45	137.39	51.36	33.98				
External leakage - Utility medium	5*	0.66	3.58	8.43	2.50	3.59	42.7	1.0	33.8	100.0
	5†	1.39	5.50	11.83	3.32	5.66				
Fail to start on demand	181*	13.74	121.47	318.77	100.50	130.06	23.7	1.0	25.7	324.0
	181†	4.84	183.84	562.12	195.78	205.03				
Fail to stop on demand	7*	0.98	4.67	10.63	3.09	5.03	5.6	2.0	6.3	12.0
	7†	0.01	7.62	30.79	11.60	7.93				
High output	5*	0.01	3.17	12.62	4.72	3.59	11.9	5.0	24.0	52.0
	5†	0.00	5.28	26.96	11.66	5.66				
Internal leakage	4*	0.00	2.66	12.24	4.91	2.87	13.3	6.0	13.3	28.0
	4†	1.13	4.53	9.80	2.76	4.53				
Low output	18*	0.00	14.55	73.91	31.87	12.93	38.4	5.0	53.7	604.0
	18†	0.00	20.16	102.35	44.12	20.39				
Other	7*	0.52	5.58	15.27	4.93	5.03	42.8	4.0	45.2	114.0
	7†	0.56	8.96	26.16	8.67	7.93				
Overheating	50*	0.00	23.87	136.31	76.64	35.93	19.0	0.1	33.0	243.0
	50†	0.00	39.52	226.30	121.94	56.64				
Parameter deviation	14*	0.00	6.92	30.16	11.74	10.06	21.8	3.0	23.4	96.0
	14†	0.00	12.21	60.09	25.34	15.86				
Spurious stop	247*	0.40	137.65	537.83	199.65	177.49	17.5	1.0	23.0	565.0
	247†	0.09	236.68	1028.66	399.78	279.79				
Unknown	1*	0.00	1.17	6.30	2.91	0.72	-	-	-	-
	1†	0.00	1.37	6.88	2.95	1.13				
Vibration	10*	1.55	6.94	15.49	4.45	7.19	25.1	3.0	65.4	326.0
	10†	0.63	11.18	33.11	11.02	11.33				
<b>Degraded</b>	<b>374*</b>	<b>26.42</b>	<b>236.55</b>	<b>622.71</b>	<b>196.70</b>	<b>268.74</b>	<b>17.3</b>	<b>1.0</b>	<b>27.3</b>	<b>768.0</b>
	<b>374†</b>	<b>22.95</b>	<b>364.69</b>	<b>1064.56</b>	<b>352.71</b>	<b>423.65</b>				
Abnormal instrument reading	21*	0.09	14.57	51.40	18.98	15.09	10.4	2.0	15.5	70.0
	21†	0.13	22.23	78.18	28.87	23.79				
Erratic output	25*	8.81	18.13	30.15	6.59	17.96	19.3	4.0	28.8	150.0
	25†	10.53	27.92	52.09	12.97	28.32				
<b>Comments</b>										

(cont.)



Taxonomy no 1.2.1		Item Machinery Gas Turbines Aeroderivative									
Population 39	Installations 12	Aggregated time in service (106 hours)					No of demands 6864				
		Calendar time * 1.3917		Operational time † 0.8828							
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
External leakage - Fuel	28*	0.00	15.89	71.48	28.35	20.12	9.9	2.0	16.4	84.0	
	28†	0.00	28.66	142.91	60.92	31.72					
External leakage - Utility medium	60*	7.33	37.05	85.62	25.16	43.11	19.2	1.0	32.5	768.0	
	60†	3.10	56.70	168.26	56.03	67.97					
Fail to start on demand	1*	0.00	0.65	3.24	1.38	0.72	6.0	10.0	10.0	10.0	
	1†	0.00	1.14	6.43	3.42	1.13					
High output	3*	0.59	2.15	4.52	1.24	2.16	2.0	2.0	2.0	2.0	
	3†	0.02	3.55	12.28	4.53	3.40					
Internal leakage	10*	0.03	7.11	26.30	9.71	7.19	24.7	2.0	25.3	109.0	
	10†	0.07	11.39	39.72	14.66	11.33					
Low output	42*	3.16	37.70	105.45	34.38	30.18	14.4	1.0	31.1	520.0	
	42†	3.85	54.86	157.79	52.01	47.58					
Minor in-service problems	10*	0.05	7.69	26.82	9.90	7.19	4.0	1.0	12.5	36.0	
	10†	0.06	11.31	40.58	15.00	11.33					
Noise	3*	0.00	2.03	9.45	3.82	2.16	55.0	10.0	114.0	312.0	
	3†	0.00	3.27	14.40	5.64	3.40					
Other	59*	7.89	42.37	99.41	29.46	42.40	17.5	2.0	23.2	200.0	
	59†	15.82	61.90	132.81	37.17	66.83					
Overheating	63*	0.00	30.60	158.86	115.63	45.27	9.5	1.0	17.4	82.0	
	63†	0.00	47.97	248.75	182.59	71.36					
Parameter deviation	29*	2.06	17.89	46.71	14.68	20.84	6.9	1.5	9.2	39.0	
	29†	0.32	28.33	91.97	33.44	32.85					
Structural deficiency	13*	0.78	9.04	25.13	8.17	9.34	58.6	2.0	107.9	490.0	
	13†	1.03	13.90	39.67	13.04	14.73					
Unknown	1*	0.00	0.65	3.24	1.38	0.72	14.0	14.0	14.0	14.0	
	1†	0.00	1.14	6.43	3.42	1.13					
Vibration	6*	0.03	4.18	14.15	5.20	4.31	115.0	3.0	101.8	560.0	
	6†	0.03	6.45	23.71	8.76	6.80					
<b>Incipient</b>	<b>926*</b>	<b>75.63</b>	<b>575.67</b>	<b>1466.54</b>	<b>455.61</b>	<b>665.39</b>	<b>9.2</b>	<b>0.5</b>	<b>14.1</b>	<b>358.0</b>	
	<b>926†</b>	<b>32.84</b>	<b>936.50</b>	<b>2831.34</b>	<b>968.51</b>	<b>1048.93</b>					
Abnormal instrument reading	332*	15.60	200.62	568.15	186.18	238.56	8.3	0.5	10.6	184.0	
	332†	3.94	327.32	1055.10	382.49	376.07					
Erratic output	2*	0.00	2.85	13.16	5.30	1.44	1.0	1.0	8.5	16.0	
	2†	0.00	3.60	16.83	6.83	2.27					
External leakage - Fuel	14*	0.14	10.27	32.71	11.79	10.06	9.1	2.0	9.9	25.0	
	14†	0.08	16.71	61.66	22.77	15.86					
External leakage - Utility medium	109*	0.58	60.40	199.12	72.77	78.32	9.1	1.0	16.1	235.0	
	109†	0.27	109.00	431.16	160.78	123.47					
Fail to start on demand	1*	0.00	1.00	5.17	2.29	0.72	1.0	1.0	1.0	1.0	
	1†	0.00	1.35	6.69	2.84	1.13					
<b>Comments</b>											

(cont.)

Taxonomy no 1.2.1		Item Machinery Gas Turbines Aeroderivative								
Population 39	Installations 12	Aggregated time in service (106 hours)					No of demands 6864			
		Calendar time * 1.3917		Operational time † 0.8828						
Failure mode	No of failures	Failure rate (per 106 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Internal leakage	11*	0.03	6.78	24.77	9.15	7.90	11.1	2.0	13.9	48.0
	11†	0.00	12.01	54.69	21.79	12.46				
Low output	5*	0.00	3.66	16.93	6.82	3.59	10.0	8.0	14.5	28.0
	5†	0.00	6.75	32.75	13.57	5.66				
Minor in-service problems	256*	1.31	137.85	455.21	166.43	183.95	7.7	1.0	9.1	187.0
	256†	1.01	228.06	850.54	313.97	289.98				
Noise	8*	0.50	5.08	13.77	4.43	5.75	34.0	6.0	83.7	294.0
	8†	0.16	7.94	24.67	8.74	9.06				
Other	121*	2.33	82.10	250.20	86.74	86.95	13.8	1.0	23.0	358.0
	121†	2.17	130.24	408.87	146.06	137.06				
Overheating	5*	0.52	3.53	8.80	2.70	3.59	5.5	1.0	13.4	30.0
	5†	0.61	5.72	15.23	4.85	5.66				
Parameter deviation	21*	0.00	22.88	102.71	40.70	15.09	5.3	1.5	5.4	22.0
	21†	0.00	30.27	140.12	56.52	23.79				
Structural deficiency	26*	0.22	22.77	75.04	27.42	18.68	23.7	1.0	46.4	175.0
	26†	0.34	36.15	119.61	43.76	29.45				
Unknown	8*	0.00	12.29	65.46	30.03	5.75	28.8	14.0	22.8	35.0
	8†	0.00	13.43	74.34	37.94	9.06				
Vibration	7*	0.00	5.30	25.89	10.84	5.03	10.3	3.0	14.8	38.0
	7†	0.00	8.16	34.77	13.42	7.93				
<b>Unknown</b>	<b>17*</b>	<b>2.10</b>	<b>14.46</b>	<b>36.10</b>	<b>11.10</b>	<b>12.22</b>	<b>7.3</b>	<b>1.0</b>	<b>29.4</b>	<b>212.0</b>
	<b>17†</b>	<b>5.14</b>	<b>20.66</b>	<b>44.71</b>	<b>12.59</b>	<b>19.26</b>				
Abnormal instrument reading	1*	0.00	1.00	5.17	2.29	0.72	1.0	1.0	1.0	1.0
	1†	0.00	1.35	6.69	2.84	1.13				
Other	6*	1.31	4.39	8.95	2.41	4.31	9.0	8.0	26.2	78.0
	6†	0.00	8.01	35.98	14.26	6.80				
Unknown	10*	0.51	8.53	25.04	8.31	7.19	7.8	2.0	34.3	212.0
	10†	1.32	12.02	31.80	10.08	11.33				
<b>All modes</b>	<b>1921*</b>	<b>133.07</b>	<b>1186.51</b>	<b>3120.38</b>	<b>985.06</b>	<b>1380.36</b>	<b>14.6</b>	<b>0.1</b>	<b>21.2</b>	<b>768.0</b>
	<b>1921†</b>	<b>48.95</b>	<b>1909.61</b>	<b>5846.09</b>	<b>2039.40</b>	<b>2176.01</b>				
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.6. 10-2										

Maintainable item versus failure mode, to be continued

Item: Gas Turbines - Aeroderivative

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.10	0.00	0.00	0.00	0.05	0.39	0.00	0.00	0.00	0.00
Air inlet	0.16	0.00	0.00	0.16	0.05	0.05	0.00	0.05	0.31	0.00
Burners/fuel nozzles	0.00	0.00	0.21	0.05	0.02	0.16	0.00	0.05	0.10	0.00
Cabling & junction boxes	0.60	0.00	0.00	0.05	0.00	0.10	0.00	0.00	0.00	0.00
Casing	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Combustion chambers	0.00	0.05	0.10	0.05	0.05	0.16	0.00	0.00	0.05	0.00
Compressor rotor	0.00	0.05	0.00	0.00	0.00	0.05	0.00	0.00	0.05	0.00
Compressor stator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	1.67	0.05	0.00	0.05	0.00	0.96	0.05	0.00	0.10	0.00
Cooler(s)	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00
Exhaust	0.05	0.00	0.05	0.16	0.00	0.00	0.00	0.05	0.00	0.26
Filter(s)	0.18	0.00	0.00	0.44	0.05	0.10	0.00	0.05	0.29	0.00
Fuel control	0.10	0.00	0.18	0.00	0.31	1.04	0.00	0.00	0.21	0.00
Fuel filter	0.05	0.00	0.00	0.00	0.05	0.05	0.00	0.00	0.05	0.00
Fuel pump	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.08	0.00
Fuel scrubber/coalescer	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hood	0.00	0.00	0.00	0.05	0.00	0.21	0.00	0.00	0.00	0.00
HP turbine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00
Instrument, flame	0.31	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
Instrument, flow	0.49	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.52	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.05	0.00
Instrument, level	0.21	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	3.22	0.00	0.18	0.13	0.05	0.39	0.00	0.05	0.10	0.00
Instrument, speed	1.12	0.00	0.00	0.05	0.08	0.57	0.21	0.00	0.05	0.00
Instrument, temperature	4.10	0.00	0.05	0.00	0.10	0.05	0.00	0.00	0.00	0.00
Instrument, vibration	1.76	0.00	0.00	0.05	0.00	0.13	0.00	0.00	0.05	0.00
Internal power supply	0.26	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.05	0.00
Monitoring	2.03	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.05	0.00	0.08	0.00	0.00	0.03	0.00
Other	0.16	0.05	0.16	1.09	0.10	0.62	0.00	0.10	0.10	0.00
Piping	0.00	0.05	0.23	1.43	0.00	0.05	0.00	0.05	0.03	0.05
Pump w/motor	0.10	0.05	0.00	0.91	0.03	0.05	0.05	0.10	0.10	0.10
Purge air	0.05	0.05	0.00	0.00	0.00	0.05	0.00	0.00	0.10	0.05
Radial bearing	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reservoir w/heating system	0.00	0.00	0.00	0.05	0.00	0.05	0.00	0.05	0.00	0.00
Rotor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
Seals	0.00	0.00	0.55	0.75	0.02	0.03	0.00	0.10	0.00	0.00
Start control	0.05	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Start energy (battery, air)	0.00	0.00	0.00	0.05	0.05	0.10	0.00	0.00	0.00	0.00
Starting unit	0.00	0.00	0.10	0.47	0.05	0.88	0.00	0.00	0.00	0.00
Stator	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.05	0.00
Subunit	0.16	0.05	0.10	0.21	0.16	0.94	0.00	0.05	0.31	0.00
Thrust bearing	0.05	0.05	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
Unknown	0.68	0.10	0.26	0.47	0.10	0.42	0.10	0.16	0.05	0.05
Valves	0.29	0.16	0.99	1.48	0.33	1.51	0.00	0.42	0.88	0.05
Total	18.53	0.78	3.75	9.06	1.82	9.53	0.42	1.30	3.38	0.57

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Maintainable item versus failure mode, continued

Item: Gas Turbines - Aero-derivative

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.21	0.00	0.16	0.00	0.00	0.00	0.16	0.00	1.07
Air inlet	0.00	0.52	0.36	0.96	0.00	0.00	0.10	0.10	0.00	2.84
Burners/fuel nozzles	4.88	0.21	0.23	0.10	0.03	0.00	0.00	0.08	0.00	6.12
Cabling & junction boxes	0.00	0.26	0.00	0.42	0.00	0.00	0.00	0.44	0.00	1.87
Casing	0.00	0.05	0.00	0.05	0.05	0.00	0.10	0.00	0.00	0.36
Combustion chambers	0.03	0.10	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.65
Compressor rotor	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.16	0.36
Compressor stator	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.03	0.08
Control unit	0.05	0.36	0.05	0.21	0.00	0.00	0.10	1.74	0.05	5.47
Cooler(s)	0.00	0.07	0.00	0.10	0.16	0.00	0.00	0.10	0.00	1.11
Exhaust	0.10	0.57	0.00	0.21	0.36	0.00	0.00	0.05	0.10	1.98
Filter(s)	0.05	0.27	0.42	1.25	0.00	0.00	0.00	0.36	0.00	3.47
Fuel control	0.02	0.26	0.16	0.21	0.00	0.05	0.00	0.73	0.00	3.27
Fuel filter	0.00	0.16	0.00	1.64	0.05	0.00	0.00	0.00	0.00	2.06
Fuel pump	0.00	0.21	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.86
Fuel scrubber/coalescer	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.05	0.00	0.21
Hood	0.21	0.31	0.00	0.73	0.10	0.00	0.00	0.10	0.05	1.77
HP turbine	0.00	0.05	0.05	0.00	0.03	0.00	0.00	0.05	0.00	0.29
Instrument, flame	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.42
Instrument, flow	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.05	0.00	0.70
Instrument, general	0.00	0.00	0.05	0.10	0.00	0.05	0.05	0.16	0.00	1.04
Instrument, level	0.00	0.00	0.05	0.10	0.00	0.00	0.00	0.00	0.00	0.42
Instrument, pressure	0.00	0.13	0.08	0.26	0.00	0.00	0.00	0.34	0.00	4.94
Instrument, speed	0.00	0.16	0.00	0.10	0.00	0.10	0.00	0.94	0.00	3.38
Instrument, temperature	0.10	0.47	0.10	0.26	0.00	0.00	0.05	0.83	0.00	6.13
Instrument, vibration	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.88	0.23	3.17
Internal power supply	0.00	0.16	0.00	0.16	0.00	0.00	0.05	0.62	0.00	1.41
Monitoring	0.00	0.16	0.10	0.00	0.00	0.00	0.05	0.10	0.00	2.50
Oil	0.05	0.17	0.00	0.10	0.00	0.00	0.00	0.23	0.00	0.72
Other	0.05	0.78	0.49	2.39	0.36	0.00	0.10	0.34	0.00	6.92
Piping	0.03	0.23	0.02	0.31	0.08	0.00	0.00	0.00	0.13	2.70
Pump w/motor	0.10	0.61	0.10	0.00	0.00	0.00	0.05	0.49	0.00	2.88
Purge air	0.10	0.36	0.05	0.94	0.05	0.00	0.00	0.16	0.00	1.98
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.10	0.21
Reservoir w/heating system	0.00	0.00	0.05	0.10	0.00	0.00	0.00	0.00	0.00	0.31
Rotor	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.05	0.16
Seals	0.05	0.10	0.02	0.05	0.00	0.00	0.00	0.03	0.00	1.70
Start control	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.36
Start energy (battery, air)	0.00	0.10	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.47
Starting unit	0.00	0.21	0.00	0.05	0.00	0.00	0.00	0.05	0.00	1.82
Stator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Subunit	0.00	0.55	0.10	0.36	0.05	0.00	0.05	0.47	0.10	3.67
Thrust bearing	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.26
Unknown	0.10	0.78	0.26	1.51	0.47	0.00	0.10	0.94	0.16	6.72
Valves	0.20	1.30	0.57	0.42	0.13	0.16	0.16	2.03	0.03	11.10
Total	6.14	10.05	3.33	13.85	2.03	0.36	1.04	12.86	1.20	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptor versus failure mode, to be continued

Item: Gas Turbines - Aero derivative

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	0.31	0.00	0.00	0.00	0.05	0.21	0.00	0.00	0.73	0.00
Breakage	0.78	0.05	0.10	0.31	0.10	0.05	0.00	0.00	0.00	0.05
Burst	0.00	0.00	0.16	0.21	0.00	0.00	0.00	0.05	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Clearance/ alignment failure	0.00	0.00	0.16	0.10	0.00	0.16	0.00	0.05	0.05	0.00
Combined causes	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.05	0.00
Common mode failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
Contamination	0.16	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.10	0.00
Control failure	0.31	0.00	0.00	0.10	0.21	0.73	0.05	0.00	0.16	0.00
Corrosion	0.16	0.00	0.00	0.57	0.05	0.16	0.00	0.00	0.00	0.00
Deformation	0.05	0.21	0.26	1.04	0.00	0.10	0.05	0.05	0.00	0.10
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	0.73	0.00	0.00	0.00	0.05	0.52	0.00	0.00	0.05	0.00
Erosion	0.00	0.00	0.16	0.10	0.00	0.05	0.00	0.00	0.00	0.00
External influence - general	0.16	0.00	0.00	0.05	0.05	0.10	0.00	0.00	0.00	0.00
Fatigue	0.05	0.00	0.00	0.10	0.00	0.05	0.00	0.05	0.05	0.05
Faulty power/voltage	0.00	0.00	0.00	0.05	0.00	0.05	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	5.36	0.00	0.00	0.00	0.10	0.36	0.00	0.00	0.05	0.00
Instrument failure - general	3.90	0.10	0.16	0.05	0.21	1.25	0.21	0.00	0.21	0.00
Leakage	0.10	0.05	0.52	1.67	0.00	0.16	0.00	0.21	0.26	0.00
Looseness	0.31	0.00	0.31	0.83	0.00	0.21	0.00	0.05	0.05	0.05
Material failure - general	0.05	0.00	0.57	1.41	0.05	0.00	0.00	0.05	0.05	0.00
Mechanical Failure - general	0.26	0.21	0.68	1.30	0.42	2.50	0.00	0.36	0.47	0.10
Misc. external influences	0.05	0.00	0.00	0.00	0.00	0.05	0.00	0.05	0.00	0.00
Miscellaneous - general	0.05	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00
No cause found	0.10	0.00	0.10	0.10	0.00	0.16	0.05	0.05	0.05	0.05
No power/ voltage	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.94	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
Open circuit	0.31	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00
Other	0.05	0.00	0.00	0.05	0.10	0.36	0.00	0.00	0.05	0.00
Out of adjustment	2.55	0.00	0.00	0.05	0.00	0.68	0.05	0.10	0.26	0.00
Overheating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.05	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Software failure	0.31	0.00	0.00	0.00	0.05	0.16	0.00	0.00	0.00	0.00
Sticking	0.16	0.05	0.00	0.00	0.10	0.36	0.00	0.05	0.10	0.00
Unknown	0.10	0.05	0.00	0.16	0.00	0.10	0.00	0.00	0.10	0.00
Vibration	0.42	0.00	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00
Wear	0.68	0.05	0.52	0.68	0.16	0.05	0.00	0.16	0.47	0.10
Total	18.53	0.78	3.75	9.06	1.82	9.53	0.42	1.30	3.38	0.57

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Failure descriptor versus failure mode, continued

Item: Gas Turbines - Aero derivative

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.16	0.52	0.83	2.81	0.00	0.00	0.00	0.31	0.00	5.93
Breakage	0.10	0.31	0.10	0.47	0.47	0.00	0.00	0.21	0.00	3.12
Burst	0.00	0.42	0.00	0.05	0.21	0.00	0.00	0.05	0.00	1.15
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Clearance/ alignment failure	0.00	0.16	0.16	0.10	0.00	0.00	0.00	0.05	0.05	1.04
Combined causes	3.90	0.05	0.00	0.05	0.00	0.00	0.00	0.05	0.05	4.37
Common mode failure	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.10
Contamination	0.94	0.52	0.26	1.30	0.00	0.00	0.16	0.26	0.16	3.96
Control failure	0.00	0.36	0.10	0.05	0.00	0.00	0.05	1.30	0.05	3.49
Corrosion	0.05	0.21	0.00	0.94	0.21	0.00	0.00	0.00	0.00	2.34
Deformation	0.05	0.10	0.00	0.42	0.10	0.10	0.00	0.16	0.00	2.81
Earth/isolation fault	0.00	0.16	0.00	0.10	0.00	0.00	0.00	0.05	0.00	0.31
Electrical failure - general	0.10	0.62	0.16	0.83	0.00	0.00	0.05	0.99	0.10	4.22
Erosion	0.00	0.00	0.00	0.10	0.05	0.00	0.00	0.00	0.05	0.52
External influence - general	0.00	0.05	0.00	0.10	0.00	0.00	0.00	0.16	0.00	0.68
Fatigue	0.05	0.05	0.00	0.21	0.10	0.00	0.00	0.00	0.00	0.78
Faulty power/voltage	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.31	0.00	0.47
Faulty signal/indication/alarm	0.00	0.00	0.21	0.16	0.00	0.00	0.00	1.82	0.05	8.12
Instrument failure - general	0.00	0.73	0.26	0.47	0.00	0.10	0.05	1.61	0.05	9.37
Leakage	0.05	0.68	0.16	0.05	0.31	0.00	0.00	0.26	0.05	4.53
Looseness	0.00	0.16	0.00	0.83	0.05	0.00	0.00	0.31	0.00	3.18
Material failure - general	0.00	0.16	0.00	0.26	0.05	0.00	0.10	0.16	0.00	2.92
Mechanical Failure - general	0.21	1.30	0.52	0.57	0.21	0.16	0.21	1.46	0.16	11.09
Misc. external influences	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.26	0.10	0.62
Miscellaneous - general	0.00	0.05	0.05	0.42	0.00	0.00	0.05	0.05	0.00	0.88
No cause found	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.83
No power/ voltage	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.26
No signal/indication/alarm	0.00	0.21	0.00	0.05	0.00	0.00	0.00	0.21	0.00	1.46
Open circuit	0.05	0.05	0.00	0.16	0.00	0.00	0.05	0.36	0.00	1.30
Other	0.10	0.99	0.00	0.10	0.05	0.00	0.00	0.36	0.00	2.24
Out of adjustment	0.05	0.26	0.16	0.52	0.00	0.00	0.00	0.57	0.00	5.26
Overheating	0.05	0.05	0.00	0.10	0.00	0.00	0.00	0.10	0.00	0.31
Short circuiting	0.00	0.10	0.05	0.05	0.00	0.00	0.00	0.26	0.00	0.62
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52
Sticking	0.00	0.68	0.05	0.73	0.00	0.00	0.00	0.16	0.00	2.45
Unknown	0.10	0.26	0.21	0.10	0.00	0.00	0.21	0.26	0.00	1.67
Vibration	0.00	0.10	0.00	0.36	0.00	0.00	0.00	0.42	0.26	1.77
Wear	0.10	0.57	0.05	1.25	0.21	0.00	0.10	0.05	0.05	5.26
Total	6.14	10.05	3.33	13.85	2.03	0.36	1.04	12.86	1.20	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 1.2.1.1		Item Machinery Gas Turbines Aeroderivative (-1000) kW									
Population 7	Installations 2	Aggregated time in service (106 hours)					No of demands				
		Calendar time * 0.1556		Operational time † 0.1555							
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	<b>57*</b>	<b>288.09</b>	<b>364.05</b>	<b>447.34</b>	<b>48.51</b>	<b>366.23</b>	-	<b>1.0</b>	<b>20.0</b>	<b>120.0</b>	
Breakdown	57†	288.37	364.41	447.79	48.56	366.63	-	2.0	37.0	72.0	
External leakage - Utility medium	2*	0.34	11.17	33.96	11.73	12.85	-	1.0	1.0	1.0	
Fail to start on demand	2†	0.34	11.19	34.00	11.74	12.86	-	4.0	17.6	109.0	
High output	1*	0.11	5.84	18.13	6.43	6.43	-	36.0	36.0	36.0	
Spurious stop	1†	0.11	5.84	18.15	6.43	6.43	-	4.0	25.1	120.0	
<b>Degraded</b>	<b>25*</b>	<b>12.06</b>	<b>123.31</b>	<b>334.69</b>	<b>107.57</b>	<b>160.63</b>	-	<b>2.0</b>	<b>28.1</b>	<b>156.0</b>	
Erratic output	25†	12.04	123.44	335.22	107.77	160.80	-	8.0	10.7	12.0	
External leakage - Fuel	4*	8.99	25.96	50.06	12.85	25.70	-	20.0	20.0	20.0	
External leakage - Utility medium	4†	9.00	25.99	50.11	12.86	25.73	-	2.0	42.0	156.0	
Other	7*	4.79	36.87	94.10	29.26	44.98	-	2.0	28.9	130.0	
Parameter deviation	7†	4.78	36.90	94.26	29.32	45.02	-	6.0	6.0	6.0	
Structural deficiency	10*	3.18	49.30	143.46	47.48	64.25	-	4.0	4.0	4.0	
Vibration	10†	3.17	49.35	143.69	47.57	64.32	-	30.0	30.0	30.0	
<b>Incipient</b>	<b>21*</b>	<b>51.30</b>	<b>120.91</b>	<b>214.40</b>	<b>50.62</b>	<b>134.93</b>	-	<b>1.0</b>	<b>8.1</b>	<b>78.0</b>	
Abnormal instrument reading	21†	51.17	120.99	214.85	50.80	135.07	-	1.0	3.4	6.0	
Minor in-service problems	10*	16.84	58.26	120.04	32.59	64.25	-	1.0	3.5	6.0	
Other	10†	16.82	58.31	120.24	32.66	64.32	-	12.0	12.0	12.0	
Structural deficiency	7*	19.75	43.47	74.66	17.00	44.98	-	4.0	41.0	78.0	
	7†	19.77	43.51	74.74	17.02	45.02	-	4.0	41.0	78.0	
	1*	0.11	5.84	18.13	6.43	6.43	-	1.0	19.7	156.0	
	1†	0.11	5.84	18.15	6.43	6.43	-	1.0	19.7	156.0	
	3*	0.33	16.09	49.81	17.59	19.28	-	1.0	19.7	156.0	
	3†	0.33	16.11	49.87	17.61	19.30	-	1.0	19.7	156.0	
<b>All modes</b>	<b>103*</b>	<b>335.61</b>	<b>601.10</b>	<b>929.17</b>	<b>182.47</b>	<b>661.78</b>	-	<b>1.0</b>	<b>19.7</b>	<b>156.0</b>	
	103†	335.02	601.54	931.15	183.26	662.50	-	1.0	19.7	156.0	
<b>Comments</b>											

Taxonomy no 1.2.1.2		Item Machinery Gas Turbines Aeroderivative (3000-10000)kW									
Population 5	Installations 2	Aggregated time in service (106 hours)					No of demands 108				
		Calendar time * 0.0927		Operational time † 0.0717							
Failure mode	No of failures	Failure rate (per 106 hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	<b>20*</b>	<b>107.87</b>	<b>202.53</b>	<b>321.28</b>	<b>65.71</b>	<b>215.72</b>	<b>9.3</b>	<b>1.0</b>	<b>27.8</b>	<b>326.0</b>	
	<b>20†</b>	<b>113.95</b>	<b>257.67</b>	<b>448.45</b>	<b>103.68</b>	<b>279.08</b>					
Abnormal instrument reading	1*	0.08	15.77	56.61	20.92	10.79	-	53.0	53.0	53.0	
	1†	0.12	19.22	67.11	24.77	13.95					
External leakage - Fuel	2*	0.27	18.69	59.23	21.29	21.57	4.5	4.0	4.5	5.0	
	2†	0.30	24.23	77.93	28.22	27.91					
Fail to start on demand	4*	7.74	38.35	88.16	25.83	43.14	18.0	1.0	18.0	68.0	
	4†	7.79	49.16	120.17	36.52	55.82					
Internal leakage	1*	0.20	9.84	30.51	10.79	10.79	10.0	10.0	10.0	10.0	
	1†	0.24	12.76	39.74	14.11	13.95					
Other	1*	0.08	15.77	56.61	20.92	10.79	-	4.0	4.0	4.0	
	1†	0.12	19.22	67.11	24.77	13.95					
Spurious stop	10*	1.61	83.50	259.57	92.01	107.86	6.7	1.0	8.2	29.0	
	10†	1.66	109.02	344.53	123.62	139.54					
Vibration	1*	0.08	15.77	56.61	20.92	10.79	-	326.0	326.0	326.0	
	1†	0.12	19.22	67.11	24.77	13.95					
<b>Degraded</b>	<b>13*</b>	<b>83.92</b>	<b>141.27</b>	<b>210.69</b>	<b>38.89</b>	<b>140.22</b>	<b>5.9</b>	<b>2.0</b>	<b>55.0</b>	<b>520.0</b>	
	<b>13†</b>	<b>107.61</b>	<b>181.76</b>	<b>271.60</b>	<b>50.31</b>	<b>181.40</b>					
Erratic output	2*	0.27	18.69	59.23	21.29	21.57	8.5	8.0	8.5	9.0	
	2†	0.30	24.23	77.93	28.22	27.91					
External leakage - Utility medium	1*	0.20	9.84	30.51	10.79	10.79	4.0	12.0	12.0	12.0	
	1†	0.24	12.76	39.74	14.11	13.95					
Low output	7*	18.26	90.57	208.29	61.03	75.50	6.3	5.0	103.0	520.0	
	7†	28.15	112.46	242.89	68.29	97.68					
Minor in-service problems	1*	0.20	9.84	30.51	10.79	10.79	2.0	2.0	2.0	2.0	
	1†	0.24	12.76	39.74	14.11	13.95					
Parameter deviation	2*	0.27	18.69	59.23	21.29	21.57	5.5	5.0	5.5	6.0	
	2†	0.30	24.23	77.93	28.22	27.91					
<b>Incipient</b>	<b>54*</b>	<b>375.89</b>	<b>563.46</b>	<b>782.00</b>	<b>124.17</b>	<b>582.45</b>	<b>3.2</b>	<b>1.0</b>	<b>12.1</b>	<b>121.0</b>	
	<b>54†</b>	<b>546.22</b>	<b>732.87</b>	<b>942.07</b>	<b>120.72</b>	<b>753.52</b>					
Abnormal instrument reading	11*	1.44	91.03	286.89	102.75	118.65	2.0	1.0	2.2	8.0	
	11†	1.53	119.00	381.28	137.84	153.49					
Erratic output	2*	4.18	23.15	54.68	16.26	21.57	1.0	1.0	8.5	16.0	
	2†	6.03	29.47	67.51	19.73	27.91					
External leakage - Utility medium	7*	3.59	60.93	179.29	59.55	75.50	5.8	1.0	8.5	34.0	
	7†	3.18	79.09	238.12	80.72	97.68					
Fail to start on demand	1*	0.20	9.84	30.51	10.79	10.79	1.0	1.0	1.0	1.0	
	1†	0.24	12.76	39.74	14.11	13.95					
Internal leakage	1*	0.20	9.84	30.51	10.79	10.79	4.0	4.0	4.0	4.0	
	1†	0.24	12.76	39.74	14.11	13.95					
<b>Comments</b>											

(cont.)



Taxonomy no 1.2.1.2		Item Machinery Gas Turbines Aeroderivative (3000-10000)kW								
Population 5	Installations 2	Aggregated time in service (106 hours)					No of demands 108			
		Calendar time * 0.0927		Operational time † 0.0717						
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Low output	1*	0.08	15.77	56.61	20.92	10.79	-	28.0	28.0	28.0
	1†	0.12	19.22	67.11	24.77	13.95				
Minor in-service problems	6*	26.13	62.39	111.25	26.42	64.72	3.5	1.0	4.4	10.0
	6†	29.67	80.12	150.57	37.74	83.72				
Other	5*	22.91	55.87	100.54	24.12	53.93	2.7	1.0	14.0	47.0
	5†	29.16	71.71	129.54	31.20	69.77				
Overheating	1*	0.08	15.77	56.61	20.92	10.79	-	30.0	30.0	30.0
	1†	0.12	19.22	67.11	24.77	13.95				
Parameter deviation	12*	1.33	98.56	314.53	113.48	129.43	3.3	1.5	3.3	8.0
	12†	1.45	128.98	418.33	152.04	167.45				
Structural deficiency	6*	1.06	98.41	320.67	116.75	64.72	1.0	1.0	55.0	121.0
	6†	1.51	120.76	387.83	140.37	83.72				
Vibration	1*	0.08	15.77	56.61	20.92	10.79	-	14.0	14.0	14.0
	1†	0.12	19.22	67.11	24.77	13.95				
<b>Unknown</b>	<b>3*</b>	<b>4.93</b>	<b>39.48</b>	<b>101.56</b>	<b>31.69</b>	<b>32.36</b>	<b>1.0</b>	<b>1.0</b>	<b>9.0</b>	<b>18.0</b>
	<b>3†</b>	<b>8.10</b>	<b>48.78</b>	<b>117.84</b>	<b>35.56</b>	<b>41.86</b>				
Abnormal instrument reading	1*	0.20	9.84	30.51	10.79	10.79	1.0	1.0	1.0	1.0
	1†	0.24	12.76	39.74	14.11	13.95				
Other	1*	0.08	15.77	56.61	20.92	10.79	-	8.0	8.0	8.0
	1†	0.12	19.22	67.11	24.77	13.95				
Unknown	1*	0.08	15.77	56.61	20.92	10.79	-	18.0	18.0	18.0
	1†	0.12	19.22	67.11	24.77	13.95				
<b>All modes</b>	<b>90*</b>	<b>793.89</b>	<b>955.76</b>	<b>1130.07</b>	<b>102.33</b>	<b>970.75</b>	<b>5.1</b>	<b>1.0</b>	<b>21.4</b>	<b>520.0</b>
	<b>90†</b>	<b>909.99</b>	<b>1216.90</b>	<b>1560.49</b>	<b>198.36</b>	<b>1255.86</b>				

**Comments**

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0, 100

Taxonomy no 1.2.1.3		Item Machinery Gas Turbines Aeroderivative (10000-20000)kW								
Population 7	Installations 2	Aggregated time in service (106 hours)					No of demands 2647			
		Calendar time * 0.2353		Operational time † 0.1630						
Failure mode	No of failures	Failure rate (per 106 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max
<b>Critical</b>	<b>176*</b>	<b>110.78</b>	<b>591.75</b>	<b>1386.60</b>	<b>410.62</b>	<b>748.07</b>	<b>15.9</b>	<b>0.1</b>	<b>29.4</b>	<b>390.0</b>
	<b>176†</b>	<b>78.83</b>	<b>864.59</b>	<b>2380.32</b>	<b>770.48</b>	<b>1079.79</b>				
External leakage - Fuel	6*	4.03	21.68	50.87	15.08	25.50	13.7	6.0	27.4	80.0
	6†	2.04	30.38	87.95	29.06	36.81				
External leakage - Utility medium	3*	0.23	10.65	32.92	11.61	12.75	42.7	17.0	52.0	100.0
	3†	3.90	16.85	37.24	10.63	18.41				
Fail to start on demand	33*	102.01	139.60	182.04	24.42	140.26	14.5	1.0	26.5	135.0
	33†	143.27	197.45	258.77	35.24	202.46				
Low output	2*	0.23	7.39	22.46	7.74	8.50	5.0	9.0	9.5	10.0
	2†	0.13	10.65	34.23	12.39	12.27				
Other	1*	0.03	7.99	30.76	11.34	4.25	-	-	-	-
	1†	0.05	8.48	29.63	10.94	6.14				
Overheating	41*	0.73	117.48	411.35	151.85	174.27	14.8	0.1	28.8	213.0
	41†	0.92	183.74	667.72	246.72	251.54				
Spurious stop	86*	40.36	283.64	710.82	219.05	365.53	15.3	1.0	28.9	390.0
	86†	27.85	417.24	1208.57	399.39	527.62				
Unknown	1*	0.03	7.99	30.76	11.34	4.25	-	-	-	-
	1†	0.05	8.48	29.63	10.94	6.14				
Vibration	3*	0.23	10.65	32.92	11.61	12.75	58.8	20.0	96.0	172.0
	3†	3.90	16.85	37.24	10.63	18.41				
<b>Degraded</b>	<b>117*</b>	<b>19.08</b>	<b>360.59</b>	<b>1073.79</b>	<b>357.95</b>	<b>497.30</b>	<b>18.4</b>	<b>3.0</b>	<b>40.4</b>	<b>768.0</b>
	<b>117†</b>	<b>9.08</b>	<b>546.66</b>	<b>1716.37</b>	<b>613.19</b>	<b>717.81</b>				
Abnormal instrument reading	9*	2.48	29.89	83.71	27.30	38.25	10.7	8.0	23.4	70.0
	9†	0.84	43.53	135.35	47.99	55.22				
Erratic output	7*	13.08	28.77	49.40	11.25	29.75	18.7	6.0	35.8	75.0
	7†	11.30	40.05	83.16	22.71	42.95				
External leakage - Fuel	5*	5.38	18.94	39.24	10.70	21.25	12.8	16.0	26.2	48.0
	5†	2.56	26.00	70.45	22.62	30.68				
External leakage - Utility medium	8*	2.79	27.15	72.91	23.30	34.00	52.0	3.0	140.3	768.0
	8†	1.02	39.15	119.73	41.72	49.08				
Low output	5*	2.52	30.87	86.68	28.31	21.25	29.8	4.0	48.8	121.0
	5†	7.94	35.36	78.87	22.65	30.68				
Other	12*	1.42	38.10	114.96	39.16	51.00	23.8	4.0	47.5	200.0
	12†	0.64	56.67	183.67	66.73	73.62				
Overheating	60*	0.89	169.49	610.12	225.44	255.02	8.5	5.5	16.6	79.5
	60†	1.23	266.99	986.94	364.48	368.11				
Parameter deviation	4*	5.96	17.19	33.13	8.50	17.00	7.5	8.0	16.0	20.0
	4†	8.10	24.20	47.26	12.27	24.54				
Structural deficiency	5*	5.38	18.94	39.24	10.70	21.25	101.8	130.0	241.8	490.0
	5†	2.56	26.00	70.45	22.62	30.68				
<b>Comments</b>										

(cont.)

Taxonomy no 1.2.1.3		Item Machinery Gas Turbines Aeroderivative (10000-20000)kW								
Population 7	Installations 2	Aggregated time in service (106 hours)					No of demands 2647			
		Calendar time * 0.2353		Operational time † 0.1630						
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Vibration	2* 2†	0.23 0.13	7.39 10.65	22.46 34.23	7.74 12.39	8.50 12.27	4.0	4.0	7.0	10.0
<b>Incipient</b>	<b>234*</b> <b>234†</b>	<b>256.21</b> <b>175.77</b>	<b>826.91</b> <b>1183.82</b>	<b>1662.39</b> <b>2938.99</b>	<b>442.16</b> <b>901.19</b>	<b>994.59</b> <b>1435.63</b>	<b>7.6</b>	<b>1.0</b>	<b>13.4</b>	<b>192.0</b>
Abnormal instrument reading	87* 87†	39.70 27.35	286.34 421.60	721.55 1225.85	222.98 405.62	369.78 533.76	4.8	1.0	9.2	68.0
External leakage - Fuel	3* 3†	0.84 3.53	19.09 21.49	57.35 52.09	19.32 15.75	12.75 18.41	10.3	3.0	11.0	19.0
External leakage - Utility medium	26* 26†	56.03 32.41	102.33 138.12	159.88 304.08	31.94 86.57	110.51 159.51	8.4	1.0	16.6	72.0
Internal leakage	2* 2†	0.23 0.13	7.39 10.65	22.46 34.23	7.74 12.39	8.50 12.27	5.0	5.5	9.8	14.0
Minor in-service problems	48* 48†	2.46 1.96	143.95 220.56	451.07 733.94	160.92 268.88	204.02 294.49	3.9	1.0	7.5	40.0
Noise	1* 1†	0.03 0.05	7.99 8.48	30.76 29.63	11.34 10.94	4.25 6.14	16.0	16.0	16.0	16.0
Other	50* 50†	2.35 1.96	149.40 229.31	470.94 766.94	168.70 281.31	212.52 306.76	11.2	2.0	19.6	192.0
Overheating	1* 1†	0.08 0.11	3.86 5.61	12.00 17.46	4.25 6.20	4.25 6.14	15.0	30.0	30.0	30.0
Parameter deviation	4* 4†	0.14 0.16	36.50 39.16	140.51 148.28	51.79 54.68	17.00 24.54	13.7	9.0	13.7	22.0
Structural deficiency	3* 3†	0.23 3.90	10.65 16.85	32.92 37.24	11.61 10.63	12.75 18.41	44.7	8.0	89.0	175.0
Unknown	8* 8†	0.29 0.32	74.52 80.08	286.56 305.52	105.58 112.59	34.00 49.08	28.8	14.0	22.8	35.0
Vibration	1* 1†	0.08 0.11	3.86 5.61	12.00 17.46	4.25 6.20	4.25 6.14	3.0	3.0	3.0	3.0
<b>Unknown</b>	<b>4*</b> <b>4†</b>	<b>4.58</b> <b>3.46</b>	<b>15.44</b> <b>21.62</b>	<b>31.53</b> <b>52.71</b>	<b>8.50</b> <b>15.99</b>	<b>17.00</b> <b>24.54</b>	<b>4.0</b>	<b>2.0</b>	<b>8.0</b>	<b>20.0</b>
Other	1* 1†	0.08 0.11	3.86 5.61	12.00 17.46	4.25 6.20	4.25 6.14	10.0	20.0	20.0	20.0
Unknown	3* 3†	0.23 3.90	10.65 16.85	32.92 37.24	11.61 10.63	12.75 18.41	1.0	2.0	2.0	2.0
<b>All modes</b>	<b>531*</b> <b>531†</b>	<b>319.05</b> <b>233.06</b>	<b>1773.35</b> <b>2601.35</b>	<b>4194.34</b> <b>7185.95</b>	<b>1248.17</b> <b>2329.68</b>	<b>2256.96</b> <b>3257.77</b>	<b>12.7</b>	<b>0.1</b>	<b>24.7</b>	<b>768.0</b>
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.2. 10-2										

Taxonomy no 1.2.1.4		Item Machinery Gas Turbines Aeroderivative (20000-40000)kW								
Population 15	Installations 5	Aggregated time in service (106 hours)					No of demands 3512			
		Calendar time * 0.6453			Operational time † 0.3408					
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>296*</b>	<b>2.07</b>	<b>373.37</b>	<b>1331.07</b>	<b>491.76</b>	<b>458.73</b>	<b>23.7</b>	<b>0.3</b>	<b>27.6</b>	<b>604.0</b>
	<b>296†</b>	<b>1.49</b>	<b>756.82</b>	<b>3032.67</b>	<b>1136.91</b>	<b>868.45</b>				
Abnormal instrument reading	1*	0.00	1.39	5.66	2.14	1.55	4.0	4.0	4.0	4.0
	1†	0.00	2.73	12.95	5.30	2.93				
Breakdown	7*	1.60	10.24	25.12	7.65	10.85	30.6	2.0	63.4	286.0
	7†	0.85	20.03	60.20	20.32	20.54				
Erratic output	8*	5.34	12.72	22.67	5.38	12.40	84.4	3.0	75.1	284.0
	8†	3.10	23.18	58.84	18.25	23.47				
External leakage - Fuel	22*	0.36	37.02	121.93	44.54	34.09	10.7	0.3	16.2	78.0
	22†	0.80	62.39	200.07	72.35	64.55				
External leakage - Utility medium	1*	0.00	1.64	8.07	3.40	1.55	-	12.0	12.0	12.0
	1†	0.00	2.76	13.20	5.44	2.93				
Fail to start on demand	87*	0.76	104.78	357.87	131.76	134.83	28.9	1.0	29.1	324.0
	87†	0.70	218.94	851.34	315.38	255.25				
Fail to stop on demand	6*	3.61	8.80	15.83	3.80	9.30	4.0	2.0	5.2	10.0
	6†	1.08	16.38	47.56	15.73	17.60				
High output	4*	0.01	4.97	19.86	7.43	6.20	11.9	5.0	21.0	52.0
	4†	0.00	10.30	47.26	18.91	11.74				
Internal leakage	2*	0.44	2.90	7.17	2.19	3.10	18.5	9.0	18.5	28.0
	2†	0.05	5.51	18.42	6.75	5.87				
Low output	12*	0.00	28.47	127.58	50.51	18.60	45.9	5.0	68.6	604.0
	12†	0.00	38.28	179.26	72.91	35.21				
Other	5*	0.65	7.52	20.90	6.79	7.75	42.8	12.0	53.4	114.0
	5†	5.58	14.43	26.63	6.56	14.67				
Overheating	7*	0.08	9.36	31.56	11.60	10.85	42.0	3.0	60.1	243.0
	7†	0.03	18.49	75.34	28.47	20.54				
Parameter deviation	7*	0.00	7.89	37.47	15.36	10.85	10.7	4.0	12.7	26.0
	7†	0.00	17.45	86.10	36.40	20.54				
Spurious stop	122*	0.02	139.73	638.98	254.96	189.07	18.3	1.0	19.4	565.0
	122†	0.01	304.75	1433.65	584.76	357.94				
Vibration	5*	1.02	7.06	17.65	5.43	7.75	10.1	3.0	8.9	28.5
	5†	0.12	13.28	44.09	16.14	14.67				
<b>Degraded</b>	<b>167*</b>	<b>41.28</b>	<b>272.44</b>	<b>673.23</b>	<b>205.91</b>	<b>258.81</b>	<b>17.6</b>	<b>1.0</b>	<b>17.7</b>	<b>560.0</b>
	<b>167†</b>	<b>47.50</b>	<b>462.24</b>	<b>1241.15</b>	<b>396.62</b>	<b>489.97</b>				
Abnormal instrument reading	12*	1.79	21.34	59.68	19.45	18.60	10.0	2.0	10.3	20.0
	12†	6.94	34.60	79.67	23.36	35.21				
Erratic output	9*	0.34	13.70	42.00	14.68	13.95	24.7	6.0	25.9	66.0
	9†	0.30	25.04	80.86	29.33	26.41				
External leakage - Fuel	21*	0.06	27.46	109.14	40.76	32.54	9.1	2.0	14.0	84.0
	21†	0.02	55.37	242.10	94.50	61.61				
<b>Comments</b>										

(cont.)

Taxonomy no 1.2.1.4		Item Machinery Gas Turbines Aeroderivative (20000-40000)kW								
Population 15	Installations 5	Aggregated time in service (106 hours)					No of demands 3512			
		Calendar time * 0.6453			Operational time † 0.3408					
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
External leakage - Utility medium	31*	3.54	42.70	119.66	39.04	48.04	10.4	1.0	12.4	58.0
	31†	1.65	79.46	245.94	86.83	90.95				
Fail to start on demand	1*	0.00	1.39	5.66	2.14	1.55	6.0	10.0	10.0	10.0
	1†	0.00	2.73	12.95	5.30	2.93				
High output	3*	0.02	4.58	16.76	6.19	4.65	2.0	2.0	2.0	2.0
	3†	2.34	8.71	18.39	5.08	8.80				
Internal leakage	8*	0.39	13.76	41.92	14.52	12.40	16.5	2.0	15.8	34.0
	8†	2.69	23.45	61.30	19.28	23.47				
Low output	22*	0.61	39.70	125.33	44.94	34.09	15.6	1.0	15.6	77.0
	22†	1.03	64.53	203.15	72.71	64.55				
Minor in-service problems	7*	0.10	12.71	42.98	15.80	10.85	5.5	1.0	17.0	36.0
	7†	0.22	19.60	63.60	23.12	20.54				
Noise	2*	0.00	3.35	14.33	5.54	3.10	10.0	10.0	15.0	20.0
	2†	0.03	5.84	21.34	7.88	5.87				
Other	28*	10.33	55.31	129.69	38.42	43.39	15.4	2.0	13.8	36.0
	28†	27.38	84.44	166.97	43.83	82.15				
Overheating	2*	0.00	4.60	20.55	8.13	3.10	37.5	1.0	41.5	82.0
	2†	0.00	6.35	27.36	10.60	5.87				
Parameter deviation	11*	0.02	14.35	59.13	22.44	17.05	6.0	2.0	9.1	39.0
	11†	0.01	29.55	131.93	52.14	32.27				
Structural deficiency	6*	0.16	10.17	32.05	11.48	9.30	15.4	2.0	15.8	53.0
	6†	1.05	17.46	51.29	17.03	17.60				
Unknown	1*	0.00	1.39	5.66	2.14	1.55	14.0	14.0	14.0	14.0
	1†	0.00	2.73	12.95	5.30	2.93				
Vibration	3*	0.02	4.58	16.76	6.19	4.65	189.0	3.0	189.0	560.0
	3†	2.34	8.71	18.39	5.08	8.80				
<b>Incipient</b>	<b>454*</b>	<b>59.51</b>	<b>660.98</b>	<b>1824.18</b>	<b>591.14</b>	<b>703.59</b>	<b>8.4</b>	<b>1.0</b>	<b>13.6</b>	<b>358.0</b>
	<b>454†</b>	<b>22.75</b>	<b>1233.57</b>	<b>3845.96</b>	<b>1366.69</b>	<b>1332.01</b>				
Abnormal instrument reading	177*	25.57	268.67	733.36	236.39	274.31	7.2	1.0	9.8	172.0
	177†	10.44	484.81	1497.56	527.72	519.31				
External leakage - Fuel	9*	0.14	14.27	47.08	17.21	13.95	10.6	2.0	11.2	25.0
	9†	0.14	26.83	97.21	35.92	26.41				
External leakage - Utility medium	65*	0.36	72.69	265.49	98.09	100.73	10.7	1.0	18.4	235.0
	65†	0.39	162.52	644.05	240.30	190.71				
Internal leakage	8*	0.03	9.50	36.92	13.67	12.40	13.9	2.0	16.2	48.0
	8†	0.01	20.36	88.02	34.15	23.47				
Low output	4*	0.01	4.97	19.86	7.43	6.20	10.0	8.0	10.0	12.0
	4†	0.00	10.30	47.26	18.91	11.74				
Minor in-service problems	112*	0.82	164.77	599.92	221.66	173.57	5.9	1.0	8.1	117.0
	112†	0.78	299.12	1177.78	438.50	328.60				
<b>Comments</b>										

(cont.)

Taxonomy no 1.2.1.4		Item Machinery Gas Turbines Aeroderivative (20000-40000)kW									
Population 15	Installations 5	Aggregated time in service (106 hours)					No of demands 3512				
		Calendar time * 0.6453		Operational time † 0.3408							
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Noise	2*	0.44	2.90	7.17	2.19	3.10	-	16.0	16.0	16.0	
Other	2†	0.05	5.51	18.42	6.75	5.87	17.8	1.0	26.7	358.0	
	56*	24.86	98.72	212.80	59.75	86.79					
Overheating	56†	40.81	172.65	379.31	107.84	164.30	1.5	1.0	1.5	2.0	
	2*	0.44	2.90	7.17	2.19	3.10					
Parameter deviation	2†	0.05	5.51	18.42	6.75	5.87	3.0	3.0	5.0	7.0	
	2*	0.16	2.87	8.50	2.83	3.10					
Structural deficiency	2†	0.05	5.62	18.73	6.87	5.87	15.6	4.0	34.4	94.0	
	14*	1.34	17.73	50.44	16.56	21.70					
Vibration	14†	0.37	37.04	121.70	44.43	41.08	14.0	4.0	21.0	38.0	
	3*	0.08	4.69	14.64	5.21	4.65					
Unknown	3†	0.82	8.73	23.92	7.72	8.80	9.8	6.0	47.0	212.0	
	8*	2.41	16.25	40.34	12.37	12.40					
Other	8†	12.23	24.07	39.15	8.30	23.47	8.0	8.0	34.3	78.0	
	3*	1.35	4.75	9.84	2.68	4.65					
Unknown	3†	0.10	9.37	30.71	11.20	8.80	10.3	6.0	54.6	212.0	
	5*	0.30	11.61	35.54	12.40	7.75					
All modes	5†	1.47	16.00	43.96	14.22	14.67	15.2	0.3	19.1	604.0	
	925*	96.73	1326.04	3792.70	1247.64	1433.52					
		925†	32.85	2477.48	7916.43	2858.08	2713.90				
Comments											
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 2.2, 10-2											

Taxonomy no 1.2.1.5		Item Machinery Gas Turbines Aeroderivative Unknown								
Population 5	Installations 1	Aggregated time in service (106 hours)					No of demands 597			
		Calendar time * 0.2628		Operational time † 0.1518						
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>55*</b>	<b>165.14</b>	<b>209.30</b>	<b>262.01</b>	<b>209.30</b>	<b>209.30</b>	<b>32.6</b>	<b>2.0</b>	<b>35.8</b>	<b>301.0</b>
	<b>55†</b>	<b>285.80</b>	<b>362.23</b>	<b>453.45</b>	<b>362.23</b>	<b>362.23</b>				
Breakdown	6*	9.95	22.83	45.06	22.83	22.83	76.0	6.0	99.0	301.0
	6†	17.22	39.52	77.98	39.52	39.52				
Fail to start on demand	16*	38.19	60.89	92.47	60.89	60.89	24.0	2.0	25.2	120.0
	16†	66.09	105.38	160.03	105.38	105.38				
Fail to stop on demand	1*	0.19	3.81	18.06	3.81	3.81	12.0	12.0	12.0	12.0
	1†	0.33	6.59	31.25	6.59	6.59				
Internal leakage	1*	0.19	3.81	18.06	3.81	3.81	6.0	6.0	6.0	6.0
	1†	0.33	6.59	31.25	6.59	6.59				
Low output	4*	5.19	15.22	34.84	15.22	15.22	34.6	8.0	34.6	106.5
	4†	8.99	26.34	60.29	26.34	26.34				
Overheating	2*	1.35	7.61	23.96	7.61	7.61	22.0	12.0	22.0	32.0
	2†	2.34	13.17	41.46	13.17	13.17				
Parameter deviation	7*	12.50	26.64	50.04	26.64	26.64	31.3	3.0	34.1	96.0
	7†	21.63	46.10	86.61	46.10	46.10				
Spurious stop	17*	41.22	64.69	97.03	64.69	64.69	29.5	3.0	29.5	238.0
	17†	71.33	111.96	167.92	111.96	111.96				
Vibration	1*	0.19	3.81	18.06	3.81	3.81	18.0	26.0	26.0	26.0
	1†	0.33	6.59	31.25	6.59	6.59				
<b>Degraded</b>	<b>52*</b>	<b>155.01</b>	<b>197.89</b>	<b>249.32</b>	<b>197.89</b>	<b>197.89</b>	<b>15.8</b>	<b>1.0</b>	<b>21.5</b>	<b>312.0</b>
	<b>52†</b>	<b>268.27</b>	<b>342.47</b>	<b>431.48</b>	<b>342.47</b>	<b>342.47</b>				
Erratic output	3*	3.12	11.42	29.51	11.42	11.42	10.0	4.0	56.7	150.0
	3†	5.40	19.76	51.07	19.76	19.76				
External leakage - Fuel	1*	0.19	3.81	18.06	3.81	3.81	8.0	8.0	8.0	8.0
	1†	0.33	6.59	31.25	6.59	6.59				
External leakage - Utility medium	13*	29.26	49.47	78.64	49.47	49.47	16.5	2.0	17.5	122.0
	13†	50.63	85.62	136.10	85.62	85.62				
Internal leakage	2*	1.35	7.61	23.96	7.61	7.61	53.5	17.0	63.0	109.0
	2†	2.34	13.17	41.46	13.17	13.17				
Low output	8*	15.15	30.44	54.93	30.44	30.44	7.0	3.0	7.0	22.0
	8†	26.21	52.69	95.07	52.69	52.69				
Minor in-service problems	2*	1.35	7.61	23.96	7.61	7.61	3.0	1.0	2.0	3.0
	2†	2.34	13.17	41.46	13.17	13.17				
Noise	1*	0.19	3.81	18.06	3.81	3.81	145.0	312.0	312.0	312.0
	1†	0.33	6.59	31.25	6.59	6.59				
Other	9*	17.87	34.25	59.77	34.25	34.25	10.9	3.0	10.9	30.0
	9†	30.92	59.27	103.43	59.27	59.27				
Overheating	1*	0.19	3.81	18.06	3.81	3.81	16.0	16.0	16.0	16.0
	1†	0.33	6.59	31.25	6.59	6.59				
<b>Comments</b>										

(cont.)

Taxonomy no 1.2.1.5		Item Machinery Gas Turbines Aeroderivative Unknown								
Population 5	Installations 1	Aggregated time in service (106 hours)					No of demands 597			
		Calendar time * 0.2628		Operational time † 0.1518						
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Parameter deviation	11*	23.48	41.86	69.30	41.86	41.86	7.8	1.5	7.9	24.0
	11†	40.64	72.45	119.93	72.45	72.45				
Structural deficiency	1*	0.19	3.81	18.06	3.81	3.81	-	3.0	3.0	3.0
	1†	0.33	6.59	31.25	6.59	6.59				
<b>Incipient</b>	<b>163*</b>	<b>542.60</b>	<b>620.30</b>	<b>706.38</b>	<b>620.30</b>	<b>620.30</b>	<b>15.4</b>	<b>0.5</b>	<b>17.4</b>	<b>294.0</b>
	<b>163†</b>	<b>939.04</b>	<b>1073.51</b>	<b>1222.48</b>	<b>1073.51</b>	<b>1073.51</b>				
Abnormal instrument reading	47*	138.21	178.86	228.09	178.86	178.86	19.9	0.5	19.4	184.0
	47†	239.20	309.54	394.73	309.54	309.54				
External leakage - Fuel	2*	1.35	7.61	23.96	7.61	7.61	3.5	3.0	3.5	4.0
	2†	2.34	13.17	41.46	13.17	13.17				
External leakage - Utility medium	11*	23.48	41.86	69.30	41.86	41.86	6.4	3.0	6.7	12.0
	11†	40.64	72.45	119.93	72.45	72.45				
Minor in-service problems	83*	261.07	315.86	379.12	315.86	315.86	12.9	1.0	12.2	187.0
	83†	451.82	546.64	656.11	546.64	546.64				
Noise	5*	7.50	19.03	40.02	19.03	19.03	38.5	6.0	110.8	294.0
	5†	12.97	32.93	69.25	32.93	32.93				
Other	9*	17.87	34.25	59.77	34.25	34.25	23.0	1.0	27.0	52.0
	9†	30.92	59.27	103.43	59.27	59.27				
Overheating	1*	0.19	3.81	18.06	3.81	3.81	4.0	4.0	4.0	4.0
	1†	0.33	6.59	31.25	6.59	6.59				
Parameter deviation	3*	3.12	11.42	29.51	11.42	11.42	5.7	3.0	5.7	8.0
	3†	5.40	19.76	51.07	19.76	19.76				
Vibration	2*	1.35	7.61	23.96	7.61	7.61	-	-	-	-
	2†	2.34	13.17	41.46	13.17	13.17				
<b>Unknown</b>	<b>2*</b>	<b>1.35</b>	<b>7.61</b>	<b>23.96</b>	<b>7.61</b>	<b>7.61</b>	<b>14.0</b>	<b>14.0</b>	<b>14.0</b>	<b>14.0</b>
	<b>2†</b>	<b>2.34</b>	<b>13.17</b>	<b>41.46</b>	<b>13.17</b>	<b>13.17</b>				
Other	1*	0.19	3.81	18.06	3.81	3.81	-	-	-	-
	1†	0.33	6.59	31.25	6.59	6.59				
Unknown	1*	0.19	3.81	18.06	3.81	3.81	14.0	14.0	14.0	14.0
	1†	0.33	6.59	31.25	6.59	6.59				
<b>All modes</b>	<b>272*</b>	<b>934.07</b>	<b>1035.10</b>	<b>1144.46</b>	<b>1035.10</b>	<b>1035.10</b>	<b>19.2</b>	<b>0.5</b>	<b>22.0</b>	<b>312.0</b>
	<b>272†</b>	<b>1616.53</b>	<b>1791.38</b>	<b>1980.64</b>	<b>1791.38</b>	<b>1791.38</b>				

**Comments**

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 3.4. 10-3



Taxonomy no 1.2.2		Item Machinery Gas Turbines Industrial								
Population 45	Installations 14	Aggregated time in service (106 hours)					No of demands 4232			
		Calendar time * 1.1807			Operational time † 0.9008					
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max
<b>Critical</b>	<b>337*</b>	<b>52.29</b>	<b>362.73</b>	<b>906.50</b>	<b>278.95</b>	<b>285.43</b>	<b>37.6</b>	<b>1.0</b>	<b>61.5</b>	<b>3001.0</b>
	<b>337†</b>	<b>116.38</b>	<b>535.26</b>	<b>1205.37</b>	<b>348.51</b>	<b>374.12</b>				
Abnormal instrument reading	2*	0.00	2.70	14.87	7.27	1.69	48.5	31.0	97.0	163.0
	2†	0.00	3.32	17.99	8.36	2.22				
Breakdown	11*	0.12	9.22	29.42	10.62	9.32	77.8	10.0	88.3	229.0
	11†	1.92	11.87	28.87	8.75	12.21				
Erratic output	13*	0.02	12.33	49.52	18.59	11.01	14.7	1.0	28.3	93.0
	13†	0.08	15.09	54.69	20.21	14.43				
External leakage - Fuel	10*	0.03	16.77	67.03	25.09	8.47	48.6	2.0	154.1	1113.0
	10†	0.14	23.65	83.16	30.71	11.10				
External leakage - Utility medium	10*	0.06	11.15	40.28	14.88	8.47	14.1	2.0	26.4	92.0
	10†	0.15	13.51	44.00	16.02	11.10				
Fail to start on demand	118*	24.53	119.73	274.16	80.12	99.94	33.7	1.0	46.1	511.0
	118†	37.75	195.22	453.79	133.80	131.00				
Fail to stop on demand	1*	0.00	0.97	4.50	1.82	0.85	-	-	-	-
	1†	0.00	1.31	7.57	4.11	1.11				
Internal leakage	2*	0.00	1.70	8.78	3.85	1.69	91.8	12.0	177.5	343.0
	2†	0.00	2.64	11.91	4.73	2.22				
Low output	9*	0.59	7.91	22.57	7.42	7.62	11.4	2.0	21.0	64.0
	9†	1.33	10.73	27.63	8.63	9.99				
Other	5*	0.05	4.94	16.35	5.98	4.23	24.2	2.0	38.5	115.0
	5†	0.08	7.02	22.85	8.31	5.55				
Overheating	4*	0.00	4.84	20.17	7.69	3.39	11.3	2.0	16.5	33.0
	4†	0.03	5.68	20.93	7.73	4.44				
Parameter deviation	17*	0.12	21.76	78.05	28.84	14.40	22.7	1.0	44.1	249.0
	17†	0.23	26.28	87.67	32.14	18.87				
Spurious stop	123*	0.70	124.27	442.04	163.30	104.18	28.5	1.0	44.3	1024.0
	123†	3.70	177.45	549.10	193.83	136.55				
Structural deficiency	5*	0.35	4.28	12.02	3.93	4.23	346.5	12.0	693.2	3001.0
	5†	2.24	5.62	10.23	2.49	5.55				
Unknown	2*	0.00	1.55	8.03	3.52	1.69	68.0	68.0	68.0	68.0
	2†	0.00	2.02	9.83	4.10	2.22				
Vibration	5*	0.02	4.05	15.12	5.58	4.23	80.8	22.0	138.3	307.0
	5†	0.01	5.68	23.06	8.70	5.55				
<b>Degraded</b>	<b>330*</b>	<b>47.74</b>	<b>290.63</b>	<b>704.12</b>	<b>212.83</b>	<b>279.50</b>	<b>21.3</b>	<b>1.0</b>	<b>32.7</b>	<b>939.0</b>
	<b>330†</b>	<b>100.77</b>	<b>379.13</b>	<b>803.19</b>	<b>222.67</b>	<b>366.35</b>				
Abnormal instrument reading	13*	0.11	8.57	27.37	9.88	11.01	6.3	1.0	10.8	48.0
	13†	1.24	12.11	32.56	10.41	14.43				
Erratic output	33*	5.10	25.66	59.23	17.40	27.95	8.5	1.0	15.1	72.0
	33†	13.62	34.98	64.38	15.81	36.63				
<b>Comments</b>										

(cont.)

Taxonomy no 1.2.2		Item Machinery Gas Turbines Industrial									
Population 45	Installations 14	Aggregated time in service (106 hours)					No of demands 4232				
		Calendar time * 1.1807		Operational time † 0.9008							
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
External leakage - Fuel	27*	4.19	22.26	52.10	15.42	22.87	15.2	3.0	16.2	47.0	
	27†	1.44	33.01	99.17	33.43	29.97					
External leakage - Utility medium	52*	8.61	48.61	115.42	34.42	44.04	42.3	2.0	59.3	939.0	
	52†	18.15	63.58	131.55	35.83	57.73					
High output	1*	0.00	0.74	3.24	1.27	0.85	8.0	8.0	8.0	8.0	
	1†	0.00	0.98	3.58	1.32	1.11					
Internal leakage	2*	0.17	1.79	4.90	1.58	1.69	22.0	22.0	22.0	22.0	
	2†	0.00	2.60	12.93	5.50	2.22					
Low output	34*	0.03	31.82	132.14	50.27	28.80	26.7	1.0	28.2	224.0	
	34†	0.08	38.48	153.93	57.64	37.74					
Minor in-service problems	2*	0.00	6.36	32.15	13.82	1.69	-	8.0	8.0	8.0	
	2†	0.00	7.07	36.37	15.77	2.22					
Noise	1*	0.04	0.87	2.62	0.88	0.85	-	23.0	23.0	23.0	
	1†	0.00	1.19	6.62	3.39	1.11					
Other	60*	6.25	59.99	160.59	51.23	50.82	33.7	1.0	49.3	354.0	
	60†	10.97	81.85	207.69	64.40	66.61					
Overheating	29*	0.29	22.71	72.87	26.36	24.56	18.8	2.0	36.3	110.0	
	29†	2.24	29.96	85.36	28.04	32.19					
Parameter deviation	40*	0.00	38.27	202.47	92.25	33.88	7.0	1.0	13.1	76.0	
	40†	0.00	46.73	242.84	107.75	44.41					
Structural deficiency	17*	0.00	15.31	76.05	32.33	14.40	11.3	2.0	15.5	46.0	
	17†	0.00	18.36	88.95	36.81	18.87					
Unknown	13*	0.00	9.90	53.23	24.62	11.01	44.8	2.0	44.8	116.0	
	13†	0.00	12.49	65.76	29.79	14.43					
Vibration	6*	0.09	5.07	15.84	5.63	5.08	26.9	12.0	61.2	224.0	
	6†	0.38	6.82	20.19	6.72	6.66					
<b>Incipient</b>	<b>667*</b>	<b>178.60</b>	<b>566.53</b>	<b>1131.95</b>	<b>299.63</b>	<b>564.93</b>	<b>16.3</b>	<b>1.0</b>	<b>26.9</b>	<b>1519.0</b>	
	<b>667†</b>	<b>534.63</b>	<b>1760.86</b>	<b>3566.39</b>	<b>954.77</b>	<b>740.47</b>					
Abnormal instrument reading	206*	69.55	174.08	316.87	76.94	174.48	7.9	1.0	12.9	75.0	
	206†	142.45	691.10	1579.90	461.27	228.69					
Erratic output	12*	0.60	9.09	26.40	8.73	10.16	8.9	2.0	12.9	28.0	
	12†	3.35	12.47	26.31	7.27	13.32					
External leakage - Fuel	16*	0.00	12.57	69.22	34.43	13.55	13.0	2.0	13.1	32.0	
	16†	0.00	15.76	86.63	42.24	17.76					
External leakage - Utility medium	55*	11.69	45.69	97.99	27.42	46.58	13.8	2.0	20.3	102.0	
	55†	12.97	180.04	515.90	169.83	61.06					
Fail to start on demand	1*	0.00	0.77	4.04	1.82	0.85	4.0	8.0	8.0	8.0	
	1†	0.00	1.01	4.75	1.93	1.11					
Internal leakage	2*	0.00	2.02	10.94	5.09	1.69	4.0	2.0	4.0	6.0	
	2†	0.00	5.61	29.54	13.38	2.22					
<b>Comments</b>											

(cont.)

Taxonomy no 1.2.2		Item Machinery Gas Turbines Industrial									
Population 45	Installations 14	Aggregated time in service (106 hours)					No of demands 4232				
		Calendar time * 1.1807		Operational time † 0.9008							
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Minor in-service problems	151*	4.24	164.83	504.51	175.95	127.89	16.9	1.0	29.0	963.0	
	151†	43.88	346.31	888.37	276.87	167.63					
Noise	3*	0.00	2.31	11.28	4.71	2.54	39.7	12.0	79.5	208.5	
	3†	0.02	3.47	11.90	4.39	3.33					
Other	117*	0.35	86.88	331.07	122.02	99.10	27.4	1.0	52.3	1519.0	
	117†	1.35	157.59	526.58	193.11	129.89					
Overheating	15*	2.32	11.61	26.78	7.86	12.70	23.4	4.0	39.7	165.0	
	15†	8.67	16.05	25.27	5.11	16.65					
Parameter deviation	43*	0.00	36.05	183.00	78.88	36.42	13.1	1.0	19.0	215.0	
	43†	0.00	44.42	224.94	96.83	47.74					
Structural deficiency	13*	3.43	11.03	22.16	5.89	11.01	22.4	1.0	34.9	134.0	
	13†	0.06	14.53	55.15	20.33	14.43					
Unknown	27*	0.00	18.50	101.10	47.26	22.87	24.7	5.0	24.7	222.0	
	27†	0.00	22.90	123.03	56.85	29.97					
Vibration	6*	0.04	4.99	16.76	6.15	5.08	17.3	4.0	27.0	57.0	
	6†	0.00	16.48	77.78	31.78	6.66					
<b>Unknown</b>	<b>8*</b>	<b>0.80</b>	<b>6.88</b>	<b>17.92</b>	<b>5.62</b>	<b>6.78</b>	<b>5.9</b>	<b>2.0</b>	<b>8.1</b>	<b>14.0</b>	
	<b>8†</b>	<b>1.48</b>	<b>9.53</b>	<b>23.42</b>	<b>7.14</b>	<b>8.88</b>					
Abnormal instrument reading	4*	0.00	3.62	15.04	5.72	3.39	3.5	2.0	4.5	7.0	
	4†	0.04	4.74	16.01	5.88	4.44					
External leakage - Fuel	1*	0.00	0.82	4.49	2.24	0.85	4.0	8.5	8.5	8.5	
	1†	0.00	1.31	7.56	4.09	1.11					
Other	1*	0.00	0.82	4.49	2.24	0.85	7.0	14.0	14.0	14.0	
	1†	0.00	1.31	7.56	4.09	1.11					
Unknown	1*	0.00	0.93	3.92	1.50	0.85	9.0	9.0	9.0	9.0	
	1†	0.00	1.30	7.49	4.05	1.11					
Vibration	1*	0.00	0.78	4.15	1.91	0.85	-	-	-	-	
	1†	0.00	1.08	5.64	2.54	1.11					
<b>All modes</b>	<b>1342*</b>	<b>312.24</b>	<b>1224.19</b>	<b>2628.48</b>	<b>735.99</b>	<b>1136.63</b>	<b>23.0</b>	<b>1.0</b>	<b>37.1</b>	<b>3001.0</b>	
	<b>1342†</b>	<b>959.77</b>	<b>2687.13</b>	<b>5122.24</b>	<b>1301.57</b>	<b>1489.81</b>					
<b>Comments</b>											
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.8. 10-2											

Maintainable item versus failure mode, to be continued

Item: Gas Turbines - Industrial

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.07	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00
Air inlet	0.37	0.00	0.07	0.15	0.00	0.11	0.00	0.00	0.30	0.00
Burners/fuel nozzles	0.00	0.00	0.19	0.00	0.07	0.30	0.00	0.00	0.07	0.00
Cabling & junction boxes	0.45	0.00	0.00	0.00	0.15	0.19	0.00	0.00	0.00	0.00
Casing	0.00	0.07	0.07	0.34	0.00	0.00	0.00	0.00	0.00	0.00
Combustion chambers	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Compressor rotor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Compressor stator	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00
Control unit	1.34	0.00	0.00	0.00	0.45	0.75	0.07	0.00	0.15	0.00
Cooler(s)	0.00	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00
Exhaust	0.00	0.07	0.00	0.67	0.07	0.00	0.00	0.00	0.00	0.07
Filter(s)	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Fuel control	0.07	0.00	0.15	0.00	0.60	0.41	0.00	0.07	0.00	0.00
Fuel filter	0.00	0.00	0.07	0.00	0.00	0.07	0.00	0.00	0.45	0.00
Fuel pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel scrubber/coalescer	0.00	0.00	0.15	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Hood	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
HP turbine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, flame	0.52	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00
Instrument, flow	0.15	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00
Instrument, general	1.56	0.00	0.00	0.00	0.07	0.04	0.00	0.00	0.00	0.07
Instrument, level	0.75	0.00	0.00	0.07	0.07	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	1.79	0.00	0.00	0.00	0.07	0.07	0.00	0.00	0.00	0.00
Instrument, speed	0.52	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	3.09	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Instrument, vibration	0.56	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.30	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
Monitoring	1.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.52	0.07	0.15	0.45	0.22	0.15	0.00	0.07	0.07	0.00
Piping	0.00	0.00	0.97	1.53	0.00	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.00	0.45	0.07	0.07	0.00	0.00	0.00	0.07
Purge air	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Radial bearing	0.00	0.07	0.00	0.15	0.00	0.07	0.00	0.00	0.00	0.00
Reservoir w/heating system	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Rotor	0.00	0.30	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00
Seals	0.00	0.00	0.22	1.64	0.00	0.00	0.00	0.00	0.00	0.00
Start control	0.00	0.00	0.00	0.00	0.02	0.22	0.00	0.00	0.00	0.00
Start energy (battery, air)	0.00	0.00	0.00	0.00	0.07	0.30	0.00	0.00	0.00	0.00
Starting unit	0.00	0.00	0.00	0.15	0.07	1.27	0.00	0.00	0.07	0.00
Stator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	0.07	0.07	0.00	0.15	0.00	0.97	0.00	0.00	1.42	0.00
Thrust bearing	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	2.53	0.15	0.52	0.97	0.15	2.46	0.00	0.07	0.30	0.00
Valves	0.45	0.00	1.30	1.04	1.79	0.67	0.00	0.22	0.37	0.00
Total	16.77	0.82	4.02	8.72	4.32	8.87	0.07	0.45	3.20	0.30

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Maintainable item versus failure mode, continued

Item: Gas Turbines - Industrial

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60
Air inlet	0.60	1.42	1.68	1.04	0.07	0.00	0.45	0.48	0.07	6.82
Burners/fuel nozzles	0.07	0.07	0.07	0.15	0.15	0.00	0.00	0.07	0.00	1.23
Cabling & junction boxes	0.22	0.45	0.07	0.30	0.00	0.00	0.07	0.07	0.00	1.97
Casing	0.07	0.15	0.07	0.15	0.07	0.00	0.00	0.00	0.07	1.08
Combustion chambers	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.37
Compressor rotor	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.11
Compressor stator	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Control unit	0.00	0.93	0.67	0.37	0.07	0.00	0.15	0.67	0.00	5.63
Cooler(s)	0.30	0.19	0.15	0.15	0.00	0.00	0.00	0.15	0.04	1.42
Exhaust	0.00	0.37	0.07	0.45	0.89	0.00	0.07	0.34	0.00	3.09
Filter(s)	0.00	0.22	0.60	0.00	0.00	0.00	0.00	0.00	0.00	1.04
Fuel control	0.00	0.15	0.30	0.22	0.00	0.00	0.00	0.75	0.00	2.72
Fuel filter	0.00	0.07	0.45	0.45	0.00	0.00	0.15	0.30	0.00	2.01
Fuel pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.22
Fuel scrubber/coalescer	0.00	0.00	0.07	0.00	0.00	0.00	0.15	0.00	0.00	0.45
Hood	0.07	0.89	0.00	0.22	0.07	0.00	0.00	0.15	0.00	1.56
HP turbine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.07
Instrument, flame	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.15	0.00	0.82
Instrument, flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
Instrument, general	0.00	1.01	0.00	0.07	0.00	0.00	0.00	0.45	0.00	3.28
Instrument, level	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Instrument, pressure	0.37	0.07	0.30	0.15	0.07	0.07	0.00	0.34	0.00	3.32
Instrument, speed	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.30	0.00	1.14
Instrument, temperature	0.22	0.30	0.30	0.07	0.00	0.00	0.00	0.26	0.00	4.35
Instrument, vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.22	1.01
Internal power supply	0.00	0.22	0.00	0.07	0.00	0.00	0.00	0.07	0.00	0.82
Monitoring	0.00	0.00	0.07	0.37	0.00	0.00	0.00	0.00	0.00	1.94
Oil	0.00	0.30	0.30	0.22	0.07	0.00	0.00	0.00	0.00	0.97
Other	0.30	0.60	0.30	1.42	0.30	0.00	0.60	0.15	0.22	5.59
Piping	0.00	0.45	0.00	0.45	0.15	0.00	0.07	0.11	0.00	3.73
Pump w/motor	0.00	0.63	0.19	0.37	0.00	0.00	0.22	0.15	0.04	2.27
Purge air	0.00	0.07	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.89
Radial bearing	0.00	0.22	0.00	0.00	0.07	0.00	0.07	0.22	0.07	0.97
Reservoir w/heating system	0.00	0.15	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.37
Rotor	0.00	0.00	0.00	0.07	0.07	0.00	0.00	0.00	0.00	0.52
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	1.94
Start control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
Start energy (battery, air)	0.00	0.15	0.22	0.07	0.07	0.00	0.00	0.00	0.00	0.89
Starting unit	0.00	0.30	0.00	0.15	0.00	0.00	0.15	0.00	0.00	2.16
Stator	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.07
Subunit	0.15	0.82	0.30	0.67	0.00	0.00	0.00	0.30	0.22	5.14
Thrust bearing	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.22
Unknown	0.60	1.71	0.45	2.01	0.22	0.00	0.30	2.61	0.22	15.28
Valves	0.37	1.34	0.37	0.75	0.15	0.00	0.67	0.48	0.00	9.99
Total	3.58	13.64	7.45	11.40	2.61	0.07	3.20	9.17	1.34	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Gas Turbines - Industrial

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	0.30	0.00	0.00	0.15	0.07	0.15	0.00	0.00	0.52	0.00
Breakage	0.60	0.15	0.15	0.07	0.00	0.22	0.00	0.00	0.00	0.00
Burst	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Combined causes	0.00	0.00	0.07	0.00	0.07	0.00	0.00	0.00	0.00	0.00
Contamination	0.07	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.52	0.00
Control failure	0.30	0.00	0.00	0.07	0.52	0.67	0.07	0.00	0.30	0.00
Corrosion	0.45	0.00	0.30	0.15	0.22	0.00	0.00	0.07	0.00	0.00
Deformation	0.00	0.00	0.15	0.52	0.07	0.07	0.00	0.00	0.00	0.07
Earth/isolation fault	0.15	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
Electrical failure - general	1.04	0.00	0.00	0.00	0.75	0.89	0.00	0.00	0.15	0.00
Erosion	0.07	0.00	0.15	0.30	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.00
Fatigue	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty power/voltage	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	4.55	0.00	0.00	0.15	0.30	0.60	0.00	0.00	0.00	0.00
Instrument failure - general	3.80	0.07	0.00	0.00	0.30	0.75	0.00	0.07	0.00	0.00
Leakage	0.07	0.00	0.37	2.83	0.07	0.37	0.00	0.15	0.00	0.00
Looseness	0.07	0.00	0.22	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.15	0.00	0.82	1.27	0.07	0.07	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.15	0.60	1.27	1.42	0.89	2.31	0.00	0.07	0.52	0.07
Misc. external influences	0.45	0.00	0.07	0.15	0.30	0.07	0.00	0.00	0.15	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00
No cause found	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No power/ voltage	0.22	0.00	0.00	0.00	0.07	0.15	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.37	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00
Open circuit	0.22	0.00	0.00	0.00	0.07	0.07	0.00	0.00	0.00	0.00
Other	0.15	0.00	0.07	0.00	0.00	0.22	0.00	0.00	0.07	0.07
Out of adjustment	2.16	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00
Overheating	0.15	0.00	0.00	0.07	0.00	0.22	0.00	0.00	0.00	0.00
Short circuiting	0.15	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.07	0.00
Software failure	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
Sticking	0.07	0.00	0.00	0.00	0.15	0.15	0.00	0.07	0.00	0.00
Unknown	0.30	0.00	0.15	0.07	0.15	0.89	0.00	0.00	0.30	0.00
Vibration	0.00	0.00	0.00	0.00	0.07	0.15	0.00	0.00	0.00	0.00
Wear	0.37	0.00	0.15	0.82	0.07	0.07	0.00	0.00	0.15	0.07
Total	16.77	0.82	4.02	8.72	4.32	8.87	0.07	0.45	3.20	0.30

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

**Item:** Gas Turbines - Industrial

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.15	0.45	1.34	0.67	0.15	0.00	0.00	0.60	0.00	4.55
Breakage	0.15	0.52	0.00	0.60	0.60	0.00	0.07	0.22	0.07	3.43
Burst	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.30
Cavitation	0.00	0.07	0.00	0.07	0.07	0.00	0.00	0.00	0.00	0.67
Clearance/ alignment failure	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.30
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.37
Contamination	0.37	0.30	1.56	0.22	0.00	0.00	0.45	0.15	0.00	3.73
Control failure	0.07	0.15	0.45	0.15	0.07	0.00	0.37	0.89	0.00	4.10
Corrosion	0.00	0.37	0.00	0.45	0.07	0.00	0.37	0.00	0.00	2.46
Deformation	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04
Earth/isolation fault	0.07	0.45	0.15	0.07	0.00	0.00	0.00	0.00	0.00	1.04
Electrical failure - general	0.15	0.97	0.07	1.64	0.00	0.00	0.15	0.52	0.00	6.33
Erosion	0.07	0.00	0.00	0.07	0.00	0.00	0.07	0.07	0.00	0.82
External influence - general	0.15	0.89	0.37	0.97	0.00	0.00	0.00	0.07	0.00	2.98
Fatigue	0.00	0.00	0.00	0.07	0.15	0.00	0.00	0.00	0.07	0.30
Faulty power/voltage	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.22
Faulty signal/indication/alarm	0.45	1.04	0.15	0.07	0.00	0.00	0.00	0.52	0.15	7.97
Instrument failure - general	0.07	0.97	0.67	0.75	0.00	0.00	0.00	0.75	0.00	8.20
Leakage	0.07	0.22	0.15	0.45	0.00	0.00	0.15	0.07	0.00	4.99
Looseness	0.00	0.22	0.00	0.15	0.00	0.00	0.00	0.07	0.07	1.04
Material failure - general	0.07	0.30	0.07	0.22	0.22	0.00	0.15	0.07	0.07	3.58
Mechanical Failure - general	0.82	2.09	0.52	2.09	0.60	0.00	0.89	1.12	0.22	15.65
Misc. external influences	0.37	0.97	0.22	0.67	0.00	0.00	0.00	0.67	0.07	4.17
Miscellaneous - general	0.00	0.07	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.37
No cause found	0.07	0.07	0.00	0.00	0.00	0.07	0.00	0.30	0.15	0.89
No power/ voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45
No signal/indication/alarm	0.00	0.07	0.15	0.15	0.00	0.00	0.00	0.00	0.00	0.82
Open circuit	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.67
Other	0.07	1.19	0.07	0.22	0.00	0.00	0.00	0.07	0.00	2.24
Out of adjustment	0.07	0.45	0.67	0.22	0.07	0.00	0.00	0.75	0.00	4.62
Overheating	0.15	0.07	0.22	0.00	0.00	0.00	0.00	0.37	0.00	1.27
Short circuiting	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
Sticking	0.00	0.07	0.00	0.22	0.00	0.00	0.00	0.07	0.00	0.82
Unknown	0.00	0.67	0.52	0.22	0.00	0.00	0.37	0.37	0.15	4.17
Vibration	0.00	0.07	0.07	0.15	0.07	0.00	0.00	0.82	0.00	1.42
Wear	0.00	0.30	0.00	0.60	0.30	0.00	0.15	0.15	0.15	3.35
Total	3.58	13.64	7.45	11.40	2.61	0.07	3.20	9.17	1.34	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 1.2.2.1		Item Machinery Gas Turbines Industrial (-1000) kW								
Population 4	Installations 1	Aggregated time in service (106 hours)					No of demands 100			
		Calendar time * 0.0650		Operational time † 0.0651						
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>13*</b>	<b>118.29</b>	<b>200.02</b>	<b>317.98</b>	<b>200.02</b>	<b>200.02</b>				
	<b>13†</b>	<b>118.12</b>	<b>199.73</b>	<b>317.51</b>	<b>199.73</b>	<b>199.73</b>				
Fail to start on demand	4*	21.00	61.55	140.86	61.55	61.55				
	4†	20.97	61.46	140.66	61.46	61.46				
Fail to stop on demand	1*	0.77	15.39	73.01	15.39	15.39				
	1†	0.77	15.36	72.90	15.36	15.36				
Spurious stop	8*	61.24	123.09	222.10	123.09	123.09				
	8†	61.15	122.91	221.78	122.91	122.91				
<b>Degraded</b>	<b>15*</b>	<b>142.25</b>	<b>230.80</b>	<b>355.35</b>	<b>230.80</b>	<b>230.80</b>				
	<b>15†</b>	<b>142.04</b>	<b>230.46</b>	<b>354.82</b>	<b>230.46</b>	<b>230.46</b>				
Erratic output	1*	0.77	15.39	73.01	15.39	15.39				
	1†	0.77	15.36	72.90	15.36	15.36				
External leakage - Fuel	1*	0.77	15.39	73.01	15.39	15.39				
	1†	0.77	15.36	72.90	15.36	15.36				
External leakage - Utility medium	6*	40.24	92.32	182.18	92.32	92.32				
	6†	40.18	92.18	181.91	92.18	92.18				
Internal leakage	1*	0.77	15.39	73.01	15.39	15.39				
	1†	0.77	15.36	72.90	15.36	15.36				
Other	5*	30.31	76.93	161.79	76.93	76.93				
	5†	30.27	76.82	161.55	76.82	76.82				
Overheating	1*	0.77	15.39	73.01	15.39	15.39				
	1†	0.77	15.36	72.90	15.36	15.36				
<b>Incipient</b>	<b>16*</b>	<b>154.40</b>	<b>246.18</b>	<b>373.88</b>	<b>246.18</b>	<b>246.18</b>	<b>1.0</b>			
	<b>16†</b>	<b>154.17</b>	<b>245.82</b>	<b>373.33</b>	<b>245.82</b>	<b>245.82</b>				
Abnormal instrument reading	4*	21.00	61.55	140.86	61.55	61.55				
	4†	20.97	61.46	140.66	61.46	61.46				
External leakage - Utility medium	2*	5.46	30.77	96.86	30.77	30.77				
	2†	5.45	30.73	96.72	30.73	30.73				
Minor in-service problems	9*	72.24	138.48	241.65	138.48	138.48	1.0			
	9†	72.13	138.27	241.29	138.27	138.27				
Vibration	1*	0.77	15.39	73.01	15.39	15.39				
	1†	0.77	15.36	72.90	15.36	15.36				
<b>All modes</b>	<b>44*</b>	<b>518.31</b>	<b>677.01</b>	<b>870.45</b>	<b>677.01</b>	<b>677.01</b>	<b>1.0</b>			
	<b>44†</b>	<b>517.54</b>	<b>676.01</b>	<b>869.17</b>	<b>676.01</b>	<b>676.01</b>				
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 4.0. 10-2										



Taxonomy no 1.2.2.2		Item Machinery Gas Turbines Industrial (1000-3000)kW									
Population 4	Installations 2	Aggregated time in service (106 hours)					No of demands 740				
		Calendar time * 0.1337		Operational time † 0.0342							
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	21*	2.00	268.89	915.73	337.01	157.06	13.0	2.0	22.6	83.0	
	21†	113.28	1396.44	3927.00	1283.19	613.32					
Fail to start on demand	6*	4.44	62.78	180.36	59.43	44.88	9.2	4.0	15.0	32.0	
	6†	6.52	848.34	2876.11	1057.72	175.23					
Parameter deviation	3*	0.16	40.37	154.15	56.80	22.44	13.8	6.0	25.7	42.0	
	3†	12.02	83.47	208.63	64.20	87.62					
Spurious stop	12*	0.86	159.21	569.93	210.58	89.75	14.8	2.0	25.9	83.0	
	12†	63.83	455.81	1146.19	353.84	350.47					
<b>Degraded</b>	28*	1.55	396.86	1523.38	561.06	209.42	8.8	2.0	12.4	40.0	
	28†	556.81	792.79	1062.90	154.54	817.76					
External leakage - Fuel	1*	0.05	11.85	43.84	16.19	7.48	4.0	4.0	4.0	4.0	
	1†	1.02	28.31	85.53	29.21	29.21					
External leakage - Utility medium	1*	0.05	11.85	43.84	16.19	7.48	-	-	-	-	
	1†	1.02	28.31	85.53	29.21	29.21					
Low output	4*	0.22	54.63	208.99	77.00	29.92	14.8	6.0	17.0	30.0	
	4†	15.10	109.68	276.80	85.61	116.82					
Other	1*	0.05	11.85	43.84	16.19	7.48	8.0	16.0	16.0	16.0	
	1†	1.02	28.31	85.53	29.21	29.21					
Overheating	1*	0.05	11.85	43.84	16.19	7.48	20.0	40.0	40.0	40.0	
	1†	1.02	28.31	85.53	29.21	29.21					
Parameter deviation	17*	0.94	240.00	921.03	339.22	127.15	7.3	2.0	10.5	40.0	
	17†	35.95	405.17	1121.28	363.83	496.50					
Structural deficiency	2*	0.11	26.11	99.21	36.57	14.96	6.0	4.0	6.0	8.0	
	2†	8.51	56.51	139.84	42.80	58.41					
Vibration	1*	0.05	11.85	43.84	16.19	7.48	6.0	12.0	12.0	12.0	
	1†	1.02	28.31	85.53	29.21	29.21					
<b>Incipient</b>	56*	99.03	543.43	1281.52	380.78	418.84	9.2	1.0	15.4	75.0	
	56†	66.89	11658.49	41328.83	15266.15	1635.51					
Abnormal instrument reading	23*	102.61	185.52	288.28	57.08	172.02	11.2	1.0	18.6	75.0	
	23†	28.76	5945.86	21759.91	8038.94	671.73					
External leakage - Utility medium	5*	5.18	32.13	78.19	23.70	37.40	4.0	3.0	6.8	10.0	
	5†	7.84	2069.26	7964.16	2935.56	146.03					
Minor in-service problems	21*	4.02	249.94	786.60	281.47	157.06	9.4	2.0	16.4	62.0	
	21†	35.28	2258.59	7123.18	2552.49	613.32					
Other	5*	6.37	47.65	120.98	37.52	37.40	4.5	1.0	5.8	10.0	
	5†	5.25	841.52	2941.39	1085.64	146.03					
Structural deficiency	1*	0.05	11.85	43.84	16.19	7.48	-	-	-	-	
	1†	1.02	28.31	85.53	29.21	29.21					
Vibration	1*	0.13	6.81	21.13	7.48	7.48	3.0	6.0	6.0	6.0	
	1†	1.32	402.59	1562.74	578.46	29.21					

Comments

(cont.)

<b>Taxonomy no</b> 1.2.2.2		<b>Item</b> Machinery Gas Turbines Industrial (1000-3000)kW								
<b>Population</b> 4	<b>Installations</b> 2	<b>Aggregated time in service (106 hours)</b>					<b>No of demands</b> 740			
		<b>Calendar time *</b> 0.1337			<b>Operational time †</b> 0.0342					
<b>Failure mode</b>	<b>No of failures</b>	<b>Failure rate (per 106 hours).</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
		<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/t</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>	105* 105†	33.29 151.48	1217.61 13580.82	3716.70 44092.89	1291.54 16031.31	785.32 3066.59	9.9	1.0	16.1	83.0
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 8.1. 10 <sup>-3</sup>										

Taxonomy no 1.2.2.3		Item Machinery Gas Turbines Industrial (3000-10000)kW								
Population 22	Installations 7	Aggregated time in service (106 hours)					No of demands 2604			
		Calendar time * 0.6050		Operational time † 0.4910						
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>128*</b>	<b>22.66</b>	<b>235.25</b>	<b>640.55</b>	<b>206.21</b>	<b>211.57</b>	<b>50.3</b>	<b>1.0</b>	<b>59.9</b>	<b>1024.0</b>
	<b>128†</b>	<b>36.13</b>	<b>365.72</b>	<b>990.49</b>	<b>317.99</b>	<b>260.67</b>				
Breakdown	6*	0.05	10.47	39.20	14.47	9.92	119.5	10.0	82.3	229.0
	6†	0.16	12.40	39.62	14.30	12.22				
Erratic output	3*	0.10	4.97	15.43	5.47	4.96	4.0	3.0	6.7	13.0
	3†	0.76	6.15	15.84	4.94	6.11				
External leakage - Fuel	3*	0.07	5.68	18.20	6.58	4.96	9.5	7.0	9.5	12.0
	3†	0.01	12.21	50.22	19.05	6.11				
External leakage - Utility medium	1*	0.00	5.20	24.05	9.69	1.65	-	8.0	8.0	8.0
	1†	0.00	5.67	26.54	10.79	2.04				
Fail to start on demand	58*	4.10	104.43	314.64	106.83	95.87	48.7	1.0	53.7	511.0
	58†	9.03	166.07	493.12	164.25	118.12				
Internal leakage	1*	0.05	1.77	5.37	1.85	1.65	12.0	12.0	12.0	12.0
	1†	0.00	4.54	21.67	8.91	2.04				
Low output	2*	0.72	3.50	8.01	2.34	3.31	4.8	2.0	8.5	15.0
	2†	0.03	6.12	22.63	8.36	4.07				
Other	2*	0.00	3.82	16.35	6.32	3.31	-	9.0	9.0	9.0
	2†	0.03	6.14	22.68	8.38	4.07				
Overheating	2*	0.00	3.85	16.56	6.42	3.31	16.5	2.0	17.5	33.0
	2†	0.01	4.61	18.10	6.73	4.07				
Parameter deviation	1*	0.03	1.79	5.68	2.04	1.65	52.0	104.0	104.0	104.0
	1†	0.17	2.19	6.21	2.04	2.04				
Spurious stop	44*	4.57	81.93	242.60	80.74	72.73	61.9	2.0	77.8	1024.0
	44†	9.58	123.08	348.47	114.19	89.61				
Structural deficiency	1*	0.03	1.79	5.68	2.04	1.65	6.0	12.0	12.0	12.0
	1†	0.17	2.19	6.21	2.04	2.04				
Unknown	2*	0.00	3.02	12.63	4.83	3.31	68.0	68.0	68.0	68.0
	2†	0.01	3.76	15.05	5.64	4.07				
Vibration	2*	0.00	3.85	16.56	6.42	3.31	78.0	48.0	112.0	176.0
	2†	0.01	4.61	18.10	6.73	4.07				
<b>Degraded</b>	<b>155*</b>	<b>79.06</b>	<b>256.05</b>	<b>515.42</b>	<b>137.25</b>	<b>256.20</b>	<b>22.0</b>	<b>1.0</b>	<b>25.4</b>	<b>224.0</b>
	<b>155†</b>	<b>103.27</b>	<b>359.05</b>	<b>741.05</b>	<b>201.45</b>	<b>315.66</b>				
Abnormal instrument reading	9*	0.04	10.13	37.79	13.95	14.88	6.3	1.0	10.8	48.0
	9†	0.22	13.44	42.29	15.13	18.33				
Erratic output	24*	4.70	37.10	95.17	29.66	39.67	5.3	1.0	12.3	45.0
	24†	1.72	52.29	158.44	54.42	48.88				
External leakage - Fuel	22*	12.60	37.22	72.37	18.72	36.36	17.5	3.0	17.6	47.0
	22†	6.29	63.16	170.78	54.78	44.80				
External leakage - Utility medium	18*	1.11	31.80	96.15	32.89	29.75	33.5	2.0	32.8	155.0
	18†	3.83	42.02	115.71	37.46	36.66				
<b>Comments</b>										

(cont.)

Taxonomy no 1.2.2.3		Item Machinery Gas Turbines Industrial (3000-10000)kW								
Population 22	Installations 7	Aggregated time in service (106 hours)					No of demands 2604			
		Calendar time * 0.6050		Operational time † 0.4910			Active rep.hrs	Repair (manhours)		
Failure mode	No of failures	Failure rate (per 106 hours).						Active rep.hrs	Repair (manhours)	
		Lower	Mean	Upper	SD	n/t	Min		Mean	Max
High output	1*	0.01	1.43	4.88	1.80	1.65	8.0	8.0	8.0	8.0
	1†	0.02	1.77	5.64	2.04	2.04				
Internal leakage	1*	0.12	1.74	5.01	1.65	1.65	22.0	22.0	22.0	22.0
	1†	0.17	2.19	6.21	2.04	2.04				
Low output	23*	0.17	39.93	150.97	55.68	38.02	30.0	1.0	22.3	99.0
	23†	0.19	45.74	173.18	63.86	46.84				
Minor in-service problems	2*	0.01	12.73	53.35	20.42	3.31	-	8.0	8.0	8.0
	2†	0.00	13.47	58.99	23.05	4.07				
Noise	1*	0.12	1.74	5.01	1.65	1.65	-	23.0	23.0	23.0
	1†	0.00	2.23	11.19	4.79	2.04				
Other	20*	0.34	37.61	124.85	45.71	33.06	31.8	1.0	34.6	106.0
	20†	1.57	53.30	162.19	56.11	40.73				
Overheating	4*	0.00	7.08	30.39	11.76	6.61	-	12.0	27.7	45.0
	4†	0.00	12.22	55.34	22.01	8.15				
Parameter deviation	7*	3.76	11.76	23.38	6.16	11.57	7.8	2.0	19.4	55.0
	7†	3.34	15.71	35.62	10.35	14.26				
Structural deficiency	6*	0.43	8.43	25.19	8.40	9.92	20.0	12.0	12.0	12.0
	6†	0.16	10.52	33.28	11.95	12.22				
Unknown	13*	0.01	19.24	84.10	32.82	21.49	44.8	2.0	44.8	116.0
	13†	0.01	23.18	100.98	39.31	26.47				
Vibration	4*	0.40	6.80	20.04	6.66	6.61	42.0	12.0	80.0	224.0
	4†	0.09	8.97	29.39	10.72	8.15				
<b>Incipient</b>	<b>291*</b>	<b>136.73</b>	<b>457.78</b>	<b>932.62</b>	<b>250.91</b>	<b>481.00</b>	<b>16.5</b>	<b>1.0</b>	<b>22.6</b>	<b>1519.0</b>
	<b>291†</b>	<b>156.56</b>	<b>709.82</b>	<b>1591.76</b>	<b>458.91</b>	<b>592.62</b>				
Abnormal instrument reading	91*	60.35	143.74	256.05	60.74	150.42	6.6	1.0	9.5	65.0
	91†	71.46	212.12	413.36	107.11	185.32				
Erratic output	6*	0.51	9.00	26.57	8.84	9.92	12.5	4.0	12.5	28.0
	6†	1.31	11.34	29.58	9.29	12.22				
External leakage - Fuel	16*	0.00	24.51	115.29	47.02	26.45	13.0	2.0	13.1	32.0
	16†	0.00	29.24	139.06	57.05	32.58				
External leakage - Utility medium	33*	11.48	57.95	133.88	39.33	54.55	12.5	2.0	14.6	61.0
	33†	8.75	93.80	257.05	83.02	67.20				
Fail to start on demand	1*	0.03	1.79	5.68	2.04	1.65	4.0	8.0	8.0	8.0
	1†	0.17	2.19	6.21	2.04	2.04				
Internal leakage	2*	0.00	3.89	18.20	7.40	3.31	4.0	2.0	4.0	6.0
	2†	0.00	10.62	48.81	19.57	4.07				
Minor in-service problems	35*	2.12	66.80	202.68	69.79	57.85	7.4	1.0	13.8	66.0
	35†	2.41	145.02	455.32	162.66	71.28				
Other	24*	4.43	40.97	108.72	34.51	39.67	65.9	1.0	110.6	1519.0
	24†	8.59	54.92	134.69	41.02	48.88				
<b>Comments</b>										

(cont.)

Taxonomy no 1.2.2.3		Item Machinery Gas Turbines Industrial (3000-10000)kW									
Population 22	Installations 7	Aggregated time in service (106 hours)					No of demands 2604				
		Calendar time * 0.6050			Operational time † 0.4910						
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
Overheating	10*	4.32	14.95	30.81	8.37	16.53	22.6	4.0	34.1	159.0	
	10†	7.06	19.09	35.89	9.00	20.36					
Parameter deviation	35*	0.00	55.78	267.56	110.19	57.85	14.0	1.0	17.6	215.0	
	35†	0.00	65.28	320.22	134.59	71.28					
Structural deficiency	10*	0.92	15.65	46.05	15.30	16.53	22.3	1.0	36.6	134.0	
	10†	0.39	20.03	62.19	22.03	20.36					
Unknown	27*	0.01	36.29	157.55	61.21	44.63	24.7	5.0	24.7	222.0	
	27†	0.02	42.85	186.02	72.27	54.99					
Vibration	1*	0.01	1.84	6.39	2.36	1.65	-	4.0	4.0	4.0	
	1†	0.00	3.29	15.29	6.19	2.04					
<b>Unknown</b>	<b>1*</b>	<b>0.00</b>	<b>5.20</b>	<b>24.05</b>	<b>9.69</b>	<b>1.65</b>	-	<b>2.0</b>	<b>2.0</b>	<b>2.0</b>	
	<b>1†</b>	<b>0.00</b>	<b>5.67</b>	<b>26.54</b>	<b>10.79</b>	<b>2.04</b>					
Abnormal instrument reading	1*	0.00	5.20	24.05	9.69	1.65	-	2.0	2.0	2.0	
	1†	0.00	5.67	26.54	10.79	2.04					
<b>All modes</b>	<b>575*</b>	<b>280.99</b>	<b>944.62</b>	<b>1927.23</b>	<b>519.11</b>	<b>950.43</b>	<b>25.5</b>	<b>1.0</b>	<b>32.2</b>	<b>1519.0</b>	
	<b>575†</b>	<b>352.61</b>	<b>1445.23</b>	<b>3145.80</b>	<b>889.13</b>	<b>1170.98</b>					
<b>Comments</b>											
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.3. 10-2											

Taxonomy no 1.2.2.4		Item Machinery Gas Turbines Industrial (10000-20000)kW									
Population 10	Installations 5	Aggregated time in service (106 hours)					No of demands 488				
		Calendar time * 0.2227		Operational time † 0.2121							
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	<b>87*</b>	<b>203.08</b>	<b>446.49</b>	<b>766.59</b>	<b>174.45</b>	<b>390.67</b>	<b>32.6</b>	<b>1.0</b>	<b>71.2</b>	<b>1113.0</b>	
	<b>87†</b>	<b>222.61</b>	<b>472.58</b>	<b>797.92</b>	<b>177.90</b>	<b>410.14</b>					
Abnormal instrument reading	2*	0.04	9.47	35.24	13.01	8.98	48.5	31.0	97.0	163.0	
	2†	0.04	10.22	39.19	14.44	9.43					
Breakdown	4*	0.05	14.81	57.42	21.24	17.96	70.5	132.0	141.3	150.5	
	4†	0.06	15.65	60.19	22.18	18.86					
Erratic output	5*	4.61	22.22	50.72	14.79	22.45	28.9	17.0	57.8	93.0	
	5†	4.07	23.61	56.45	16.92	23.57					
External leakage - Fuel	4*	0.19	43.58	163.65	60.39	17.96	110.1	6.2	378.4	1113.0	
	4†	0.18	44.16	167.78	61.85	18.86					
External leakage - Utility medium	6*	7.49	26.38	54.69	14.91	26.94	19.3	9.0	38.8	92.0	
	6†	7.01	27.93	60.29	16.94	28.29					
Fail to start on demand	26*	55.32	133.23	238.41	56.84	116.75	14.2	1.0	40.0	176.0	
	26†	57.02	143.31	261.33	63.57	122.57					
Internal leakage	1*	0.01	4.10	16.28	6.08	4.49	171.5	343.0	343.0	343.0	
	1†	0.01	4.33	17.03	6.34	4.71					
Low output	5*	8.49	22.02	40.70	10.04	22.45	14.7	2.0	29.4	64.0	
	5†	9.03	23.27	42.87	10.54	23.57					
Other	3*	3.72	13.52	28.31	7.78	13.47	24.2	2.0	48.3	115.0	
	3†	4.00	14.31	29.83	8.17	14.14					
Overheating	2*	0.09	13.36	46.05	16.98	8.98	8.8	4.0	15.5	27.0	
	2†	0.11	14.01	47.19	17.34	9.43					
Parameter deviation	11*	5.48	62.00	171.71	55.73	49.39	24.7	1.0	48.0	249.0	
	11†	6.23	65.03	177.24	57.09	51.86					
Spurious stop	16*	21.74	75.64	156.16	42.46	71.85	14.5	1.0	22.9	116.0	
	16†	25.97	79.10	155.67	40.70	75.43					
Structural deficiency	1*	0.01	4.10	16.28	6.08	4.49	204.0	408.0	408.0	408.0	
	1†	0.01	4.33	17.03	6.34	4.71					
Vibration	1*	0.01	4.15	16.89	6.38	4.49	-	-	-	-	
	1†	0.01	4.34	17.12	6.38	4.71					
<b>Degraded</b>	<b>66*</b>	<b>89.32</b>	<b>287.13</b>	<b>576.44</b>	<b>153.15</b>	<b>296.37</b>	<b>38.6</b>	<b>1.0</b>	<b>67.0</b>	<b>939.0</b>	
	<b>66†</b>	<b>86.82</b>	<b>312.74</b>	<b>653.01</b>	<b>179.05</b>	<b>311.14</b>					
Abnormal instrument reading	3*	0.12	11.98	39.49	14.43	13.47	-	-	-	-	
	3†	0.25	12.58	39.03	13.81	14.14					
External leakage - Fuel	2*	0.71	8.40	23.43	7.63	8.98	3.0	6.0	6.0	6.0	
	2†	0.83	8.82	24.13	7.79	9.43					
External leakage - Utility medium	13*	12.49	60.39	137.92	40.24	58.38	93.4	6.0	136.8	939.0	
	13†	10.33	66.00	161.84	49.28	61.28					
Other	25*	32.52	120.50	253.96	70.13	112.26	41.3	10.0	65.1	354.0	
	25†	27.90	133.26	303.33	88.32	117.86					
<b>Comments</b>											

(cont.)

Taxonomy no 1.2.2.4		Item Machinery Gas Turbines Industrial (10000-20000)kW									
Population 10	Installations 5	Aggregated time in service (106 hours)					No of demands 488				
		Calendar time * 0.2227		Operational time † 0.2121							
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
Overheating	17*	0.49	59.78	201.10	73.85	76.34	20.9	2.0	41.7	110.0	
	17†	0.55	63.34	211.31	77.46	80.14					
Parameter deviation	5*	1.52	22.12	63.81	21.05	22.45	10.8	1.0	21.2	76.0	
	5†	1.24	23.75	70.81	23.61	23.57					
Structural deficiency	1*	0.00	4.73	22.32	9.12	4.49	23.0	46.0	46.0	46.0	
	1†	0.00	5.11	24.21	9.92	4.71					
<b>Incipient</b>	<b>163*</b>	<b>274.88</b>	<b>700.62</b>	<b>1285.21</b>	<b>314.53</b>	<b>731.94</b>	<b>24.6</b>	<b>1.0</b>	<b>43.4</b>	<b>963.0</b>	
	<b>163†</b>	<b>271.05</b>	<b>767.27</b>	<b>1468.71</b>	<b>374.63</b>	<b>768.42</b>					
Abnormal instrument reading	49*	91.38	215.54	382.33	90.29	220.03	7.8	1.0	14.9	43.0	
	49†	90.48	230.31	422.23	103.27	231.00					
Erratic output	5*	0.01	17.68	75.26	29.03	22.45	5.6	2.0	11.2	18.0	
	5†	0.01	18.68	78.95	30.35	23.57					
External leakage - Utility medium	9*	7.39	35.66	81.42	23.75	40.41	23.5	4.0	47.0	102.0	
	9†	8.75	37.70	83.25	23.75	42.43					
Minor in-service problems	46*	31.35	242.52	619.77	192.82	206.56	53.3	2.0	67.6	963.0	
	46†	31.10	276.17	725.54	228.89	216.85					
Noise	1*	0.01	4.10	16.28	6.08	4.49	6.0	12.0	12.0	12.0	
	1†	0.01	4.33	17.03	6.34	4.71					
Other	38*	2.51	138.53	432.38	153.78	170.64	30.2	1.0	57.7	402.0	
	38†	2.97	148.55	460.84	163.06	179.14					
Overheating	4*	0.05	14.81	57.42	21.24	17.96	24.9	9.5	49.5	165.0	
	4†	0.06	15.65	60.19	22.18	18.86					
Parameter deviation	8*	3.75	34.33	90.88	28.81	35.92	9.4	2.0	23.9	80.0	
	8†	3.85	36.73	98.20	31.30	37.71					
Structural deficiency	2*	0.31	11.34	34.59	12.01	8.98	23.0	10.0	28.0	46.0	
	2†	0.15	13.20	42.68	15.49	9.43					
Vibration	1*	0.01	4.10	16.28	6.08	4.49	-	-	-	-	
	1†	0.01	4.33	17.03	6.34	4.71					
<b>Unknown</b>	<b>4*</b>	<b>0.16</b>	<b>15.56</b>	<b>50.93</b>	<b>18.57</b>	<b>17.96</b>	<b>3.5</b>	<b>7.0</b>	<b>7.0</b>	<b>7.0</b>	
	<b>4†</b>	<b>0.23</b>	<b>16.29</b>	<b>51.71</b>	<b>18.60</b>	<b>18.86</b>					
Abnormal instrument reading	3*	0.38	12.13	36.82	12.68	13.47	3.5	7.0	7.0	7.0	
	3†	0.63	12.73	38.14	12.75	14.14					
Vibration	1*	0.01	4.15	16.89	6.38	4.49	-	-	-	-	
	1†	0.01	4.34	17.12	6.38	4.71					
<b>All modes</b>	<b>320*</b>	<b>903.70</b>	<b>1454.99</b>	<b>2112.76</b>	<b>370.41</b>	<b>1436.94</b>	<b>29.7</b>	<b>1.0</b>	<b>56.0</b>	<b>1113.0</b>	
	<b>320†</b>	<b>884.49</b>	<b>1580.48</b>	<b>2439.92</b>	<b>478.14</b>	<b>1508.55</b>					
<b>Comments</b>											
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 2.7. 10-2											

Taxonomy no 1.2.2.5		Item Machinery Gas Turbines Industrial (20000-40000)kW								
Population 5	Installations 2	Aggregated time in service (106 hours)					No of demands 300			
		Calendar time * 0.1543			Operational time † 0.0983					
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>88*</b>	<b>23.99</b>	<b>969.11</b>	<b>2971.80</b>	<b>1038.86</b>	<b>570.33</b>	<b>33.8</b>	<b>1.0</b>	<b>65.9</b>	<b>3001.0</b>
	<b>88†</b>	<b>110.89</b>	<b>1118.20</b>	<b>3026.02</b>	<b>971.08</b>	<b>895.30</b>				
Breakdown	1*	0.05	11.97	46.01	16.94	6.48	9.0	18.0	18.0	18.0
	1†	0.13	12.63	41.30	15.05	10.17				
Erratic output	5*	0.26	69.01	265.46	97.82	32.41	4.9	1.0	7.8	23.0
	5†	0.31	73.20	275.13	101.51	50.87				
External leakage - Fuel	3*	1.42	28.69	85.94	28.72	19.44	13.2	2.0	26.3	61.0
	3†	9.77	32.90	67.17	18.10	30.52				
External leakage - Utility medium	3*	0.15	40.49	155.87	57.46	19.44	3.8	2.0	7.7	11.0
	3†	0.20	42.91	158.61	58.58	30.52				
Fail to start on demand	24*	75.61	179.28	318.71	75.45	155.55	20.4	1.0	39.7	232.0
	24†	170.46	246.34	333.63	49.84	244.17				
Low output	2*	1.25	15.48	43.56	14.24	12.96	9.8	11.0	12.5	14.0
	2†	4.14	21.11	48.89	14.39	20.35				
Parameter deviation	2*	0.33	11.27	34.29	11.86	12.96	11.3	22.0	22.5	23.0
	2†	2.75	18.80	46.83	14.39	20.35				
Spurious stop	43*	3.51	549.98	1915.85	706.94	278.69	10.5	1.0	18.5	110.0
	43†	6.17	603.05	1975.34	720.45	437.48				
Structural deficiency	3*	1.42	28.69	85.94	28.72	19.44	507.5	14.0	1015.3	3001.0
	3†	9.77	32.90	67.17	18.10	30.52				
Vibration	2*	0.33	11.27	34.29	11.86	12.96	82.3	22.0	164.5	307.0
	2†	2.75	18.80	46.83	14.39	20.35				
<b>Degraded</b>	<b>66*</b>	<b>44.85</b>	<b>674.75</b>	<b>1955.60</b>	<b>646.38</b>	<b>427.75</b>	<b>15.1</b>	<b>1.0</b>	<b>29.6</b>	<b>255.0</b>
	<b>66†</b>	<b>144.22</b>	<b>798.68</b>	<b>1887.46</b>	<b>561.44</b>	<b>671.48</b>				
Abnormal instrument reading	1*	0.11	5.89	18.29	6.48	6.48	-	-	-	-
	1†	0.12	9.33	29.94	10.83	10.17				
Erratic output	8*	4.91	79.43	232.42	77.06	51.85	12.1	2.0	22.4	72.0
	8†	19.95	92.92	210.01	60.87	81.39				
External leakage - Fuel	1*	0.05	11.97	46.01	16.94	6.48	-	-	-	-
	1†	0.13	12.63	41.30	15.05	10.17				
External leakage - Utility medium	14*	19.61	122.69	299.32	90.86	90.73	16.2	3.0	32.4	85.0
	14†	81.01	149.45	234.80	47.31	142.43				
Low output	7*	0.57	86.94	301.90	111.37	45.37	27.6	2.0	55.2	224.0
	7†	1.21	95.31	305.64	110.54	71.22				
Other	9*	3.59	45.52	128.60	42.10	58.33	28.3	8.0	56.6	255.0
	9†	0.91	73.91	237.79	86.13	91.56				
Overheating	6*	9.62	48.88	113.10	33.26	38.89	13.8	5.0	27.5	62.0
	6†	22.22	64.14	123.66	31.74	61.04				
Parameter deviation	11*	0.75	144.20	520.53	192.34	71.29	4.9	1.0	8.7	29.0
	11†	1.12	156.17	534.70	196.94	111.91				
<b>Comments</b>										

(cont.)



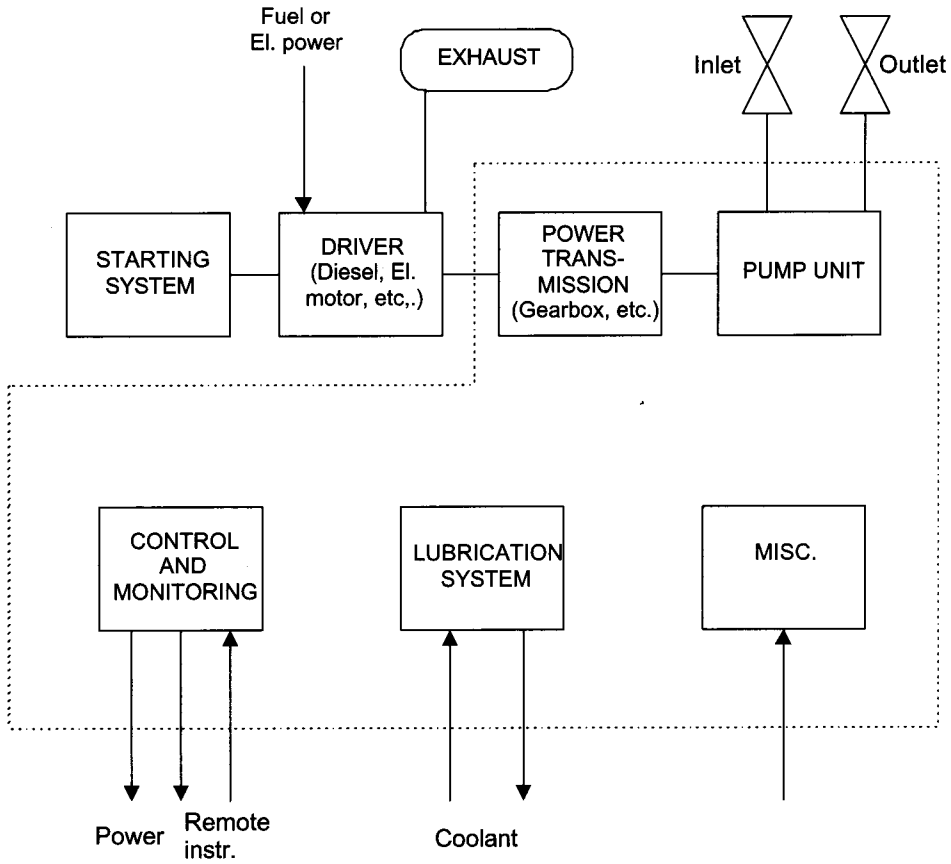
Taxonomy no 1.2.2.5		Item Machinery Gas Turbines Industrial (20000-40000)kW									
Population 5	Installations 2	Aggregated time in service (106 hours)					No of demands 300				
		Calendar time * 0.1543		Operational time † 0.0983			Active rep.hrs	Repair (manhours)			
Failure mode	No of failures	Failure rate (per 106 hours).						Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ	Min		Mean	Max	
Structural deficiency	8*	0.43	111.79	429.81	158.34	51.85	7.4	2.0	14.4	37.0	
	8†	0.49	118.63	449.70	165.81	81.39					
Vibration	1*	0.11	5.89	18.29	6.48	6.48	17.5	35.0	35.0	35.0	
	1†	0.12	9.33	29.94	10.83	10.17					
<b>Incipient</b>	<b>141*</b>	<b>272.61</b>	<b>1207.06</b>	<b>2687.59</b>	<b>770.93</b>	<b>913.83</b>	<b>13.0</b>	<b>1.0</b>	<b>25.1</b>	<b>388.0</b>	
	<b>141†</b>	<b>888.27</b>	<b>1527.91</b>	<b>2308.09</b>	<b>435.82</b>	<b>1434.52</b>					
Abnormal instrument reading	39*	35.49	379.75	1040.39	335.97	252.76	8.2	1.0	15.1	71.0	
	39†	119.00	456.04	972.03	270.73	396.78					
Erratic output	1*	0.11	5.89	18.29	6.48	6.48	11.5	23.0	23.0	23.0	
	1†	0.12	9.33	29.94	10.83	10.17					
External leakage - Utility medium	6*	17.71	40.67	71.28	16.61	38.89	16.7	14.0	33.4	81.0	
	6†	26.57	61.01	106.94	24.92	61.04					
Minor in-service problems	40*	4.98	476.56	1557.41	567.58	259.24	12.6	1.0	23.3	388.0	
	40†	17.05	534.55	1621.55	558.10	406.95					
Noise	2*	0.33	11.27	34.29	11.86	12.96	56.5	18.0	113.3	208.5	
	2†	2.75	18.80	46.83	14.39	20.35					
Other	50*	125.27	286.55	501.47	116.64	324.05	14.2	2.0	28.6	127.0	
	50†	64.98	435.64	1080.42	331.11	508.69					
Overheating	1*	0.05	11.97	46.01	16.94	6.48	-	-	-	-	
	1†	0.13	12.63	41.30	15.05	10.17					
Vibration	2*	0.33	11.27	34.29	11.86	12.96	24.5	41.0	49.0	57.0	
	2†	2.75	18.80	46.83	14.39	20.35					
<b>Unknown</b>	<b>3*</b>	<b>5.96</b>	<b>20.28</b>	<b>41.54</b>	<b>11.23</b>	<b>19.44</b>	<b>6.7</b>	<b>8.5</b>	<b>10.5</b>	<b>14.0</b>	
	<b>3†</b>	<b>8.33</b>	<b>30.50</b>	<b>64.03</b>	<b>17.62</b>	<b>30.52</b>					
External leakage - Fuel	1*	0.11	5.89	18.29	6.48	6.48	4.0	8.5	8.5	8.5	
	1†	0.12	9.33	29.94	10.83	10.17					
Other	1*	0.11	5.89	18.29	6.48	6.48	7.0	14.0	14.0	14.0	
	1†	0.12	9.33	29.94	10.83	10.17					
Unknown	1*	0.05	11.97	46.01	16.94	6.48	9.0	9.0	9.0	9.0	
	1†	0.13	12.63	41.30	15.05	10.17					
<b>All modes</b>	<b>298*</b>	<b>295.09</b>	<b>2884.92</b>	<b>7754.12</b>	<b>2479.29</b>	<b>1931.35</b>	<b>19.4</b>	<b>1.0</b>	<b>37.7</b>	<b>3001.0</b>	
	<b>298†</b>	<b>960.99</b>	<b>3494.44</b>	<b>7318.44</b>	<b>2010.94</b>	<b>3031.81</b>					
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 7.0. 10-2											

### Pumps

#### Inventory description

The boundary applies both to general service- and fire pumps, as shown in Figure 12. The Pump system is further subdivided in Subunits and Maintainable Items as shown in Table 7.

Pump driver (e.g. el.motor) is not included. Inlet and outlet valves and suction strainer is not within boundary.



..... Boundary

Figure 12 Pumps, Boundary Definition

**Table 7 Pumps, Subdivision in Maintainable Items**

PUMP				
Power transmission	Pump	Control and Monitoring	Lubrication system	Miscellaneous
<ul style="list-style-type: none"> <li>• Gearbox/var. drive</li> <li>• Bearing</li> <li>• Seals</li> <li>• Lubrication</li> <li>• Coupling to driver</li> <li>• Coupling to driven unit</li> <li>• Instruments</li> </ul>	<ul style="list-style-type: none"> <li>• Support</li> <li>• Casing</li> <li>• Impeller</li> <li>• Shaft</li> <li>• Radial bearing</li> <li>• Thrust bearing</li> <li>• Seals</li> <li>• Valves &amp; piping</li> <li>• Cylinder liner<sup>5</sup></li> <li>• Piston</li> <li>• Diaphragm<sup>6</sup></li> <li>• Instruments</li> </ul>	<ul style="list-style-type: none"> <li>• Instruments</li> <li>• Cabling &amp; junction boxes</li> <li>• Control unit</li> <li>• Actuating device</li> <li>• Monitoring</li> <li>• Internal power supply</li> <li>• Valves</li> </ul>	<ul style="list-style-type: none"> <li>• Instruments</li> <li>• Reservoir w/heating system</li> <li>• Pump w/motor</li> <li>• Filter</li> <li>• Cooler</li> <li>• Valves &amp; piping</li> <li>• Oil</li> <li>• Seals</li> </ul>	<ul style="list-style-type: none"> <li>• Purge air</li> <li>• Cooling/heating system</li> <li>• Filter, cyclone</li> <li>• Pulsation damper</li> </ul>

(For all subunits the MIs "Unknown" and "Subunit" are included.)

<sup>5</sup> Reciprocating pumps.

<sup>6</sup>Diaphragm pumps

## List of failure modes

AIR	Abnormal instrument reading
BRD	Breakdown
ERO	Erratic output
ELP	External leakage - Process medium
ELU	External leakage - Utility medium
FTS	Fail to start on demand
STP	Fail to stop on demand
HIO	High output
INL	Internal leakage
LOO	Low output
SER	Minor in-service problems
NOI	Noise
OTH	Other
OHE	Overheating
PDE	Parameter deviation
UST	Spurious stop
STD	Structural deficiency
UNK	Unknown
VIB	Vibration

Taxonomy no 1.3		Item Machinery Pumps								
Population 449	Installations 61	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 11200			
		Calendar time * 19.0224			Operational time † 8.6743					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	524*	0.00	20.52	108.44	49.34	27.55	37.3	1.0	53.1	1025.0
	524†	1.14	65.40	204.64	72.93	60.41				
Breakdown	45*	0.00	1.27	6.56	5.17	2.37	16.1	3.0	52.5	766.0
	45†	0.01	3.85	15.72	5.95	5.19				
Erratic output	2*	0.00	0.14	0.72	0.58	0.11	19.8	11.0	39.5	68.0
	2†	0.00	0.38	2.00	0.91	0.23				
External leakage - Process medium	86*	0.00	2.38	12.29	9.53	4.52	28.4	2.0	38.3	444.0
	86†	0.00	7.07	33.87	13.94	9.91				
External leakage - Utility medium	46*	0.00	1.20	5.04	5.60	2.42	16.0	2.0	29.8	90.0
	46†	0.00	3.59	16.82	6.84	5.30				
Fail to start on demand	50*	0.01	2.52	9.77	3.62	2.63	52.0	1.0	56.6	551.0
	50†	0.08	13.75	48.28	17.83	5.76				
Fail to stop on demand	2*	0.00	0.10	0.21	0.54	0.11	3.5	3.0	3.5	4.0
	2†	0.00	0.26	1.30	0.56	0.23				
High output	3*	0.00	0.67	3.51	2.44	0.16	-	1.0	3.3	6.0
	3†	0.00	2.31	12.00	5.32	0.35				
Internal leakage	8*	0.00	0.34	1.39	0.52	0.42	95.5	3.0	48.3	188.0
	8†	0.16	0.98	2.37	0.72	0.92				
Low output	46*	0.00	2.50	3.96	15.25	2.42	35.4	3.0	41.2	508.0
	46†	0.00	4.57	13.58	22.90	5.30				
Noise	6*	0.15	0.33	0.56	0.13	0.32	23.3	16.0	60.5	122.0
	6†	0.01	1.03	3.73	1.38	0.69				
Other	8*	0.00	0.57	2.99	2.43	0.42	275.5	2.0	424.5	734.0
	8†	0.00	1.53	7.57	3.21	0.92				
Overheating	5*	0.00	0.27	0.95	0.35	0.26	183.2	3.0	265.0	1025.0
	5†	0.00	6.41	32.56	14.04	0.58				
Parameter deviation	18*	0.00	0.66	3.49	2.31	0.95	11.0	1.0	20.8	88.0
	18†	0.14	1.96	5.66	1.87	2.08				
Spurious stop	133*	0.00	5.69	27.65	11.50	6.99	37.5	1.0	42.1	714.0
	133†	1.57	19.07	53.52	17.47	15.33				
Structural deficiency	33*	0.00	0.41	0.51	4.91	1.73	20.6	5.0	40.5	211.0
	33†	0.00	1.24	3.74	6.18	3.80				
Unknown	1*	0.00	0.05	0.15	0.05	0.05	-	-	-	-
	1†	0.00	0.11	0.33	0.12	0.12				
Vibration	32*	0.00	1.67	7.70	3.10	1.68	81.2	5.0	118.3	896.0
	32†	0.47	5.11	14.03	4.53	3.69				
<b>Degraded</b>	754*	0.00	44.20	210.34	86.32	39.64	20.2	0.3	26.4	798.0
	754†	11.39	238.41	714.72	239.40	86.92				
Abnormal instrument reading	9*	0.00	0.80	4.56	2.45	0.47	9.0	2.0	16.0	65.0
	9†	0.00	2.53	11.22	4.42	1.04				
Erratic output	23*	0.00	2.27	12.50	6.03	1.21	14.8	2.0	16.8	65.0
	23†	0.00	7.88	35.25	13.95	2.65				

Comments

(cont)

Taxonomy no 1.3		Item Machinery Pumps									
Population 449	Installations 61	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 11200				
		Calendar time *			Operational time †						
		19.0224					8.6743				
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
External leakage - Process medium	160*	0.00	11.61	66.33	35.66	8.41	11.2	1.0	18.7	278.0	
	160†	0.00	22.20	121.98	58.38	18.45					
External leakage - Utility medium	192*	0.00	7.98	35.67	14.11	10.09	29.5	1.0	34.5	219.0	
	192†	0.02	51.23	222.63	86.52	22.13					
Fail to stop on demand	3*	0.00	0.25	1.34	0.91	0.16	3.8	6.0	7.7	10.0	
	3†	0.01	8.74	36.88	14.16	0.35					
High output	1*	0.00	0.05	0.19	0.07	0.05	2.0	2.0	2.0	2.0	
	1†	0.00	0.11	0.33	0.12	0.12					
Internal leakage	53*	0.00	5.76	33.26	18.05	2.79	27.2	0.3	17.6	304.0	
	53†	0.00	16.00	79.64	33.91	6.11					
Low output	37*	0.03	2.21	7.07	2.55	1.95	7.9	0.5	13.3	144.0	
	37†	5.47	33.01	79.81	24.09	4.27					
Minor in-service problems	3*	0.00	0.26	1.47	0.79	0.16	13.0	18.0	22.0	26.0	
	3†	0.01	8.78	36.90	14.14	0.35					
Noise	15*	0.00	0.60	3.22	1.49	0.79	8.3	1.0	26.0	112.0	
	15†	0.00	1.87	9.63	4.18	1.73					
Other	61*	0.00	5.32	25.64	10.58	3.21	18.5	1.0	22.2	165.0	
	61†	0.01	26.51	116.49	45.63	7.03					
Overheating	9*	0.00	0.75	4.13	1.94	0.47	45.6	7.0	66.0	112.0	
	9†	0.00	5.72	31.01	14.42	1.04					
Parameter deviation	76*	0.00	2.48	7.60	12.33	4.00	4.5	1.0	7.7	67.0	
	76†	0.00	5.93	33.65	17.96	8.76					
Structural deficiency	66*	0.00	1.22	1.44	8.86	3.47	25.3	1.0	31.8	798.0	
	66†	0.00	3.85	14.51	18.37	7.61					
Vibration	46*	0.00	1.89	10.54	5.51	2.42	33.1	1.0	76.1	737.0	
	46†	0.01	6.21	24.60	9.18	5.30					
<b>Incipient</b>	<b>1124*</b>	<b>0.08</b>	<b>55.97</b>	<b>228.31</b>	<b>86.32</b>	<b>59.09</b>	<b>10.3</b>	<b>0.5</b>	<b>15.1</b>	<b>697.0</b>	
	<b>1124†</b>	<b>127.07</b>	<b>760.29</b>	<b>1833.66</b>	<b>552.65</b>	<b>129.58</b>					
Abnormal instrument reading	550*	0.01	24.76	105.79	40.87	28.91	5.5	0.5	8.5	169.0	
	550†	8.45	238.23	719.96	246.09	63.41					
Erratic output	8*	0.00	0.67	3.74	2.20	0.42	4.1	2.0	13.0	26.0	
	8†	0.00	2.29	10.78	4.40	0.92					
External leakage - Process medium	56*	0.00	2.68	15.38	8.57	2.94	14.8	0.5	22.6	206.0	
	56†	0.00	8.16	38.89	15.97	6.46					
External leakage - Utility medium	125*	0.00	4.83	25.46	11.55	6.57	22.4	1.0	26.6	179.0	
	125†	0.42	15.24	46.51	16.15	14.41					
Internal leakage	9*	0.00	0.39	1.94	0.83	0.47	42.6	0.5	41.2	172.0	
	9†	0.09	1.04	2.90	0.94	1.04					
Low output	1*	0.00	0.05	0.29	0.14	0.05	2.0	2.0	2.0	2.0	
	1†	0.00	0.13	0.51	0.19	0.12					
Minor in-service problems	249*	0.00	15.57	76.10	31.87	13.09	5.8	0.5	9.6	111.0	
	249†	53.83	360.26	893.12	273.64	28.71					

Comments

(cont.)

Taxonomy no 1.3		Item Machinery Pumps								
Population 449	Installations 61	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 11200			
		Calendar time * 19.0224			Operational time † 8.6743					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Noise	15*	0.00	0.74	2.77	1.02	0.79	6.6	0.5	17.3	46.0
	15†	0.47	2.04	4.52	1.29	1.73				
Other	52*	0.00	3.24	16.91	7.57	2.73	26.0	1.0	46.1	697.0
	52†	0.00	19.56	90.09	36.18	5.99				
Overheating	4*	0.07	0.21	0.41	0.11	0.21	30.3	3.0	34.3	64.0
	4†	0.00	0.55	2.61	1.07	0.46				
Parameter deviation	24*	0.00	1.12	6.03	3.87	1.26	9.3	2.0	14.4	81.0
	24†	0.00	3.34	14.31	5.53	2.77				
Structural deficiency	15*	0.00	0.79	4.42	2.29	0.79	35.0	1.0	55.7	213.5
	15†	0.04	2.23	6.94	2.46	1.73				
Unknown	4*	0.00	0.39	0.88	2.09	0.21	45.3	8.0	38.5	70.0
	4†	0.00	1.33	7.71	4.23	0.46				
Vibration	12*	0.00	0.69	3.19	1.28	0.63	9.9	1.0	26.7	96.0
	12†	0.00	1.98	8.31	3.18	1.38				
<b>Unknown</b>	<b>21*</b>	<b>0.00</b>	<b>2.04</b>	<b>9.97</b>	<b>4.16</b>	<b>1.10</b>	<b>6.8</b>	<b>1.0</b>	<b>13.1</b>	<b>52.0</b>
	<b>21†</b>	<b>0.09</b>	<b>6.97</b>	<b>22.41</b>	<b>8.12</b>	<b>2.42</b>				
External leakage - Utility medium	1*	0.00	0.20	0.90	0.94	0.05	-	29.0	29.0	29.0
	1†	0.00	0.78	4.28	2.03	0.12				
Noise	2*	0.00	0.35	1.71	1.57	0.11	-	6.0	29.0	52.0
	2†	0.00	0.89	4.87	2.43	0.23				
Other	4*	0.00	0.44	2.35	1.59	0.21	-	8.0	11.5	14.0
	4†	0.00	1.64	8.01	3.35	0.46				
Unknown	13*	0.00	0.86	4.78	2.87	0.68	6.8	1.0	9.2	48.0
	13†	0.00	3.22	15.01	6.08	1.50				
Vibration	1*	0.00	0.15	0.48	0.72	0.05	-	15.0	15.0	15.0
	1†	0.00	0.39	2.15	1.01	0.12				
<b>All modes</b>	<b>2423*</b>	<b>0.12</b>	<b>123.75</b>	<b>515.05</b>	<b>196.22</b>	<b>127.38</b>	<b>20.0</b>	<b>0.3</b>	<b>27.4</b>	<b>1025.0</b>
	<b>2423†</b>	<b>230.16</b>	<b>1184.82</b>	<b>2751.06</b>	<b>810.62</b>	<b>279.33</b>				
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.5 10 <sup>-3</sup>										

**Maintainable item versus failure mode, to be continued**

**Item: Pumps**

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.41	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
Bearing	0.00	0.00	0.04	0.06	0.00	0.04	0.00	0.00	0.00	0.04
Cabling & junction boxes	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Casing	0.00	0.37	0.47	0.25	0.00	0.00	0.00	0.00	0.04	0.00
Check valves	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Control unit	0.95	0.00	0.00	0.00	0.25	0.21	0.00	0.00	0.04	0.00
Cooler(s)	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00
Cooling/heating system	0.04	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driven unit	0.04	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.25
Coupling to driver	0.04	0.00	0.00	0.04	0.00	0.12	0.00	0.00	0.00	0.00
Cylinder liner	0.00	0.04	0.01	0.08	0.00	0.00	0.00	0.01	0.04	0.00
Diaphragm	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.04	0.00	0.00
Filter(s)	0.04	0.00	0.00	0.25	0.00	0.00	0.04	0.04	0.00	0.00
Filter, cyclone	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.04	0.00
Gearbox/var.drive	0.00	0.04	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
Impeller	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
Instrument, flow	6.60	0.00	0.00	0.04	0.00	0.00	0.00	0.06	0.04	0.00
Instrument, general	1.03	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00
Instrument, level	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	4.40	0.00	0.02	0.21	0.12	0.00	0.00	0.00	0.00	0.00
Instrument, speed	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	3.65	0.00	0.00	0.08	0.04	0.04	0.00	0.00	0.00	0.00
Instrument, vibration	1.94	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lubrication	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	0.89	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.21	0.00	0.04	0.00	0.00	0.76	0.00
Other	0.04	0.00	0.04	0.41	0.00	0.04	0.00	0.14	0.21	0.08
Piping	0.00	0.04	1.57	1.63	0.00	0.00	0.00	0.01	0.39	0.00
Piston(s)	0.00	0.04	0.72	0.08	0.00	0.00	0.00	0.00	0.00	0.00
Pulsation damper	0.00	0.00	0.25	0.04	0.12	0.00	0.00	0.19	0.00	0.04
Pump w/motor	0.00	0.00	0.00	0.41	0.00	0.04	0.00	0.00	0.00	0.12
Purge air	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Radial bearing	0.00	0.12	0.04	0.02	0.00	0.04	0.00	0.00	0.00	0.14
Reservoir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reservoir w/heating system	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00
Seals	0.00	0.08	5.85	7.18	0.00	0.00	0.00	0.57	0.04	0.08
Shaft	0.04	0.17	0.00	0.04	0.00	0.04	0.00	0.00	0.00	0.12
Subunit	0.12	0.58	0.10	0.21	0.00	0.33	0.00	0.08	0.54	0.04
Support	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thrust bearing	0.00	0.12	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	1.40	0.21	0.99	1.11	0.21	0.87	0.12	0.21	1.11	0.37
Valves	0.04	0.00	2.31	1.57	0.37	0.04	0.00	1.53	0.17	0.23
Total	23.07	1.86	12.46	15.02	1.36	2.06	0.17	2.89	3.47	1.57

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.



Maintainable item versus failure mode, continued

Item: Pumps

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.25	0.00	0.50	0.00	0.00	0.00	0.08	0.00	1.28
Bearing	0.00	0.04	0.00	0.04	0.12	0.00	0.00	0.10	0.08	0.58
Cabling & junction boxes	0.00	0.04	0.17	0.21	0.00	0.00	0.00	0.08	0.00	1.05
Casing	0.04	0.00	0.00	0.04	0.27	0.00	0.00	0.00	0.08	1.57
Check valves	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
Control unit	0.00	0.12	0.25	0.21	0.12	0.17	0.00	0.29	0.02	2.62
Cooler(s)	0.12	0.04	0.04	0.12	0.12	0.00	0.00	0.00	0.00	0.74
Cooling/heating system	0.08	0.04	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.83
Coupling to driven unit	0.00	0.00	0.00	0.10	0.37	0.00	0.04	0.12	0.04	1.09
Coupling to driver	0.00	0.00	0.00	0.10	0.04	0.00	0.00	0.04	0.12	0.52
Cylinder liner	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.32
Diaphragm	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.02	0.00	0.14
Filter(s)	0.00	0.33	0.17	0.54	0.08	0.00	0.00	0.00	0.00	1.49
Filter, cyclone	0.00	0.04	0.00	0.12	0.00	0.00	0.04	0.00	0.00	0.37
Gearbox/var.drive	0.04	0.04	0.00	0.04	0.04	0.00	0.00	0.12	0.00	0.37
Impeller	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.08	0.12	0.34
Instrument, flow	0.00	0.04	0.62	0.17	0.04	0.00	0.00	0.12	0.00	7.74
Instrument, general	0.00	0.21	0.08	0.45	0.00	0.04	0.00	0.17	0.00	2.19
Instrument, level	0.00	0.00	0.04	0.17	0.04	0.00	0.00	0.04	0.00	0.62
Instrument, pressure	0.04	0.08	0.37	0.50	0.12	0.00	0.04	0.50	0.00	6.40
Instrument, speed	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50
Instrument, temperature	0.04	0.00	0.29	0.56	0.02	0.00	0.00	0.54	0.00	5.26
Instrument, vibration	0.00	0.00	0.45	0.45	0.00	0.00	0.04	0.33	0.39	3.65
Internal power supply	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.08	0.00	0.25
Lubrication	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.12
Monitoring	0.00	0.04	0.08	0.14	0.00	0.00	0.00	0.12	0.00	1.40
Oil	0.04	0.12	0.04	0.45	0.00	0.00	0.00	0.00	0.00	1.67
Other	0.04	0.08	0.50	0.58	0.12	0.00	0.12	0.00	0.04	2.46
Piping	0.00	0.29	0.45	0.33	0.66	0.00	0.00	0.00	0.04	5.42
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84
Pulsation damper	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72
Pump w/motor	0.00	0.04	0.08	0.04	0.00	0.00	0.00	0.00	0.00	0.74
Purge air	0.00	0.08	0.00	0.04	0.00	0.00	0.00	0.04	0.00	0.21
Radial bearing	0.00	0.08	0.12	0.08	0.31	0.00	0.00	0.04	0.61	1.62
Reservoir	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.04
Reservoir w/heating system	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.12
Seals	0.12	0.21	0.08	0.29	0.56	0.00	0.00	0.35	0.01	15.44
Shaft	0.04	0.00	0.00	0.00	0.04	0.00	0.00	0.08	0.11	0.69
Subunit	0.00	0.50	0.25	0.37	0.45	0.00	0.00	0.37	0.41	4.35
Support	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.91	1.03
Thrust bearing	0.04	0.00	0.00	0.04	0.19	0.00	0.00	0.00	0.18	0.67
Unknown	0.08	1.20	0.29	1.73	0.62	0.00	0.45	1.53	0.58	13.08
Valves	0.00	1.03	0.50	1.32	0.17	0.00	0.00	0.10	0.00	9.37
Total	0.74	5.16	4.87	10.40	4.70	0.21	0.74	5.49	3.76	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Pumps

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	1.36	0.08	0.25	0.29	0.12	0.04	0.00	0.00	0.91	0.00
Breakage	0.74	0.12	0.37	0.41	0.08	0.08	0.00	0.04	0.00	0.00
Burst	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cavitation	0.00	0.12	0.12	0.21	0.00	0.00	0.00	0.00	0.00	0.12
Clearance/ alignment failure	0.21	0.00	0.12	0.12	0.00	0.04	0.00	0.00	0.00	0.21
Combined causes	0.00	0.08	0.08	0.00	0.00	0.00	0.00	0.04	0.04	0.04
Contamination	0.00	0.00	0.00	0.04	0.08	0.00	0.00	0.04	0.95	0.00
Control failure	0.33	0.00	0.00	0.00	0.04	0.08	0.00	0.00	0.00	0.00
Corrosion	0.45	0.04	0.37	0.33	0.00	0.00	0.00	0.00	0.21	0.00
Deformation	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.25	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Electrical failure - general	0.50	0.00	0.00	0.00	0.08	0.25	0.00	0.00	0.00	0.04
Erosion	0.00	0.08	0.00	0.12	0.00	0.00	0.00	0.00	0.04	0.00
External influence - general	0.04	0.00	0.33	0.00	0.00	0.04	0.00	0.08	0.00	0.00
Fatigue	0.04	0.00	0.12	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	2.85	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.00
Instrument failure - general	6.56	0.00	0.08	0.17	0.08	0.25	0.04	0.00	0.08	0.00
Leakage	0.17	0.00	2.56	5.86	0.08	0.00	0.00	0.58	0.17	0.04
Looseness	0.08	0.00	0.37	0.12	0.00	0.04	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.21	0.58	0.04	0.04	0.08	0.12	0.00	0.00
Mechanical Failure - general	0.54	0.78	4.21	4.54	0.21	0.41	0.00	0.95	0.33	0.45
Misc. external influences	0.41	0.29	0.37	0.37	0.12	0.00	0.00	0.00	0.12	0.00
Miscellaneous - general	0.00	0.00	0.00	0.08	0.04	0.00	0.00	0.00	0.04	0.00
No cause found	0.17	0.00	0.00	0.04	0.08	0.08	0.00	0.04	0.00	0.00
No power/ voltage	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
Open circuit	0.33	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Other	0.04	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	5.98	0.00	0.00	0.00	0.12	0.08	0.00	0.00	0.04	0.00
Overheating	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.08	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.00
Software failure	0.08	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Sticking	0.17	0.00	0.04	0.00	0.00	0.00	0.00	0.04	0.00	0.21
Unknown	0.25	0.04	0.12	0.08	0.00	0.25	0.04	0.08	0.04	0.21
Vibration	0.29	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Wear	0.33	0.12	2.64	1.53	0.08	0.12	0.00	0.87	0.45	0.21
Total	23.07	1.86	12.46	15.02	1.36	2.06	0.17	2.89	3.47	1.57

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

Item: Pumps

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.04	1.53	0.62	0.21	0.00	0.00	0.08	0.04	5.57
Breakage	0.04	0.12	0.04	0.33	0.04	0.00	0.00	0.21	0.25	2.89
Burst	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Cavitation	0.00	0.08	0.08	0.04	0.12	0.00	0.00	0.00	0.04	0.95
Clearance/ alignment failure	0.04	0.04	0.17	0.08	0.17	0.00	0.00	0.00	0.78	1.98
Combined causes	0.00	0.04	0.00	0.04	0.00	0.00	0.00	0.00	0.04	0.41
Contamination	0.00	0.21	0.00	0.50	0.00	0.00	0.00	0.00	0.00	1.82
Control failure	0.00	0.08	0.00	0.17	0.00	0.08	0.00	0.25	0.04	1.07
Corrosion	0.00	0.29	0.00	0.70	0.41	0.00	0.00	0.17	0.00	2.97
Deformation	0.04	0.00	0.00	0.08	0.04	0.00	0.00	0.08	0.04	0.37
Earth/isolation fault	0.04	0.08	0.00	0.08	0.00	0.00	0.00	0.04	0.00	0.54
Electrical failure - general	0.04	0.21	0.12	0.21	0.08	0.00	0.04	0.45	0.00	2.02
Erosion	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.29
External influence - general	0.00	0.37	0.21	0.50	0.00	0.00	0.00	0.00	0.04	1.61
Fatigue	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.04	0.29
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.04
Faulty signal/indication/alarm	0.08	0.08	0.08	0.12	0.00	0.00	0.00	0.54	0.12	3.96
Instrument failure - general	0.00	0.41	1.07	1.73	0.00	0.08	0.12	1.16	0.08	11.93
Leakage	0.00	0.08	0.08	0.33	0.21	0.00	0.04	0.17	0.04	10.40
Looseness	0.00	0.00	0.00	0.29	0.04	0.00	0.00	0.04	0.04	1.03
Material failure - general	0.00	0.12	0.00	0.33	0.62	0.00	0.00	0.04	0.08	2.27
Mechanical Failure - general	0.12	1.07	0.54	1.44	2.31	0.00	0.21	0.78	0.70	19.60
Misc. external influences	0.00	0.50	0.17	0.95	0.08	0.00	0.00	0.08	0.45	3.92
Miscellaneous - general	0.00	0.08	0.00	0.04	0.00	0.00	0.00	0.04	0.00	0.33
No cause found	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.74
No power/ voltage	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.08
No signal/indication/alarm	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.99
Open circuit	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.45
Other	0.04	0.17	0.04	0.12	0.00	0.00	0.04	0.08	0.00	0.58
Out of adjustment	0.00	0.00	0.54	0.29	0.00	0.00	0.00	0.21	0.08	7.35
Overheating	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.17
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.21
Software failure	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.21
Sticking	0.00	0.29	0.00	0.37	0.00	0.00	0.00	0.04	0.00	1.16
Unknown	0.17	0.29	0.08	0.25	0.00	0.04	0.29	0.12	0.12	2.48
Vibration	0.00	0.04	0.12	0.04	0.17	0.00	0.00	0.41	0.37	1.57
Wear	0.00	0.29	0.00	0.62	0.12	0.00	0.00	0.12	0.21	7.72
Total	0.74	5.16	4.87	10.40	4.70	0.21	0.74	5.49	3.76	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 1.3.1		Item Machinery Pumps Centrifugal								
Population 350	Installations 59	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 10340			
		Calendar time *		Operational time †						
		13.9546		5.7455						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>464*</b>	<b>0.00</b>	<b>21.60</b>	<b>124.23</b>	<b>67.21</b>	<b>33.25</b>	<b>39.7</b>	<b>1.0</b>	<b>57.6</b>	<b>1025.0</b>
	<b>464†</b>	<b>0.12</b>	<b>70.52</b>	<b>284.09</b>	<b>106.81</b>	<b>80.76</b>				
Breakdown	37*	0.00	1.20	1.67	7.82	2.65	16.4	3.0	57.1	766.0
	37†	0.00	3.70	21.16	11.38	6.44				
Erratic output	2*	0.00	0.15	0.79	0.54	0.14	19.8	11.0	39.5	68.0
	2†	0.00	0.46	2.22	0.92	0.35				
External leakage - Process medium	77*	0.00	2.25	5.52	11.84	5.52	30.2	2.0	42.0	444.0
	77†	0.00	7.04	38.07	17.67	13.40				
External leakage - Utility medium	46*	0.00	1.61	2.94	9.28	3.30	16.0	2.0	29.8	90.0
	46†	0.00	4.81	26.68	13.65	8.01				
Fail to start on demand	42*	0.01	2.28	8.52	3.14	3.01	55.8	1.0	63.0	551.0
	42†	0.02	13.74	55.88	21.10	7.31				
Fail to stop on demand	2*	0.00	0.13	0.65	0.57	0.14	3.5	3.0	3.5	4.0
	2†	0.00	0.38	1.55	0.58	0.35				
High output	3*	0.00	0.69	3.58	2.77	0.21	-	1.0	3.3	6.0
	3†	0.00	2.49	13.73	6.44	0.52				
Internal leakage	3*	0.00	0.16	0.87	0.57	0.21	188.0	36.0	90.7	188.0
	3†	0.00	0.56	2.63	1.08	0.52				
Low output	40*	0.00	2.58	3.33	17.49	2.87	38.2	3.0	45.3	508.0
	40†	0.00	4.68	7.79	27.92	6.96				
Noise	4*	0.00	0.25	1.29	0.57	0.29	25.0	16.0	67.3	122.0
	4†	0.03	0.78	2.34	0.80	0.70				
Other	8*	0.00	0.60	3.20	2.68	0.57	275.5	2.0	424.5	734.0
	8†	0.00	1.85	8.07	3.14	1.39				
Overheating	5*	0.11	0.36	0.72	0.19	0.36	183.2	3.0	265.0	1025.0
	5†	0.00	6.83	37.16	17.32	0.87				
Parameter deviation	16*	0.00	0.65	2.84	3.03	1.15	11.6	1.0	21.7	88.0
	16†	0.15	2.58	7.60	2.53	2.78				
Spurious stop	120*	0.00	6.33	33.92	15.65	8.60	39.7	1.0	45.0	714.0
	120†	0.51	22.56	69.52	24.44	20.89				
Structural deficiency	27*	0.00	0.61	0.72	6.77	1.93	23.9	7.0	47.3	211.0
	27†	0.00	1.77	3.32	10.06	4.70				
Vibration	32*	0.00	2.12	10.93	4.76	2.29	81.2	5.0	118.3	896.0
	32†	0.62	6.76	18.55	6.00	5.57				
<b>Degraded</b>	<b>537*</b>	<b>0.00</b>	<b>32.39</b>	<b>163.45</b>	<b>70.23</b>	<b>38.48</b>	<b>22.3</b>	<b>0.5</b>	<b>32.1</b>	<b>798.0</b>
	<b>537†</b>	<b>3.74</b>	<b>237.30</b>	<b>747.95</b>	<b>267.91</b>	<b>93.46</b>				
Abnormal instrument reading	9*	0.00	0.85	4.95	2.70	0.64	9.0	2.0	16.0	65.0
	9†	0.00	2.95	12.59	4.86	1.57				
Erratic output	10*	0.00	1.95	10.27	6.99	0.72	20.3	2.0	17.4	65.0
	10†	0.00	4.87	26.99	13.79	1.74				
<b>Comments</b>										

(cont)

Taxonomy no 1.3.1		Item Machinery Pumps Centrifugal								
Population 350	Installations 59	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 10340			
		Calendar time * 13.9546		Operational time † 5.7455						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Process medium	56*	0.00	3.25	18.02	9.21	4.01	14.1	2.0	31.7	278.0
	56†	0.02	10.52	41.84	15.63	9.75				
External leakage - Utility medium	178*	0.00	9.26	45.08	18.79	12.76	30.2	1.0	36.3	219.0
	178†	0.00	57.14	265.19	107.20	30.98				
Fail to stop on demand	3*	0.00	0.30	1.59	1.11	0.21	3.8	6.0	7.7	10.0
	3†	0.00	9.30	43.28	17.53	0.52				
High output	1*	0.00	0.07	0.20	0.07	0.07	2.0	2.0	2.0	2.0
	1†	0.00	0.15	0.48	0.17	0.17				
Internal leakage	11*	0.00	0.87	4.75	2.22	0.79	56.8	2.0	56.0	304.0
	11†	0.00	6.17	34.28	17.67	1.91				
Low output	30*	1.32	2.15	3.15	0.56	2.15	8.4	0.5	14.4	144.0
	30†	4.96	37.34	94.91	29.45	5.22				
Minor in-service problems	3*	0.00	0.29	1.61	0.83	0.21	13.0	18.0	22.0	26.0
	3†	0.00	9.27	43.11	17.46	0.52				
Noise	5*	0.00	0.32	1.72	1.08	0.36	17.7	6.0	35.3	75.0
	5†	0.00	0.95	4.61	1.91	0.87				
Other	46*	0.00	4.29	21.19	8.96	3.30	18.5	1.0	21.8	165.0
	46†	0.00	27.99	132.88	54.47	8.01				
Overheating	9*	0.00	0.83	4.58	2.14	0.64	45.6	7.0	66.0	112.0
	9†	0.00	6.15	34.20	17.71	1.57				
Parameter deviation	70*	0.00	2.60	3.48	17.29	5.02	4.5	1.0	7.3	67.0
	70†	0.00	5.71	19.81	27.67	12.18				
Structural deficiency	61*	0.00	1.73	1.92	13.81	4.37	26.9	1.0	33.9	798.0
	61†	0.00	5.75	20.30	27.74	10.62				
Vibration	45*	0.00	2.89	16.73	9.18	3.22	34.2	1.0	78.1	737.0
	45†	0.00	8.58	37.96	14.93	7.83				
<b>Incipient</b>	<b>936*</b>	<b>0.00</b>	<b>56.57</b>	<b>262.99</b>	<b>106.45</b>	<b>67.07</b>	<b>10.8</b>	<b>0.5</b>	<b>15.6</b>	<b>697.0</b>
	<b>936†</b>	<b>95.49</b>	<b>834.30</b>	<b>2182.80</b>	<b>686.83</b>	<b>162.91</b>				
Abnormal instrument reading	445*	0.00	25.76	128.63	54.90	31.89	5.7	0.5	8.1	144.0
	445†	4.46	274.18	862.22	308.37	77.45				
Erratic output	5*	0.00	0.39	2.04	1.41	0.36	4.1	2.0	8.2	16.0
	5†	0.00	1.36	5.38	2.01	0.87				
External leakage - Process medium	46*	0.00	2.73	14.38	9.89	3.30	15.3	0.5	24.4	206.0
	46†	0.00	8.60	44.48	19.52	8.01				
External leakage - Utility medium	108*	0.00	5.29	28.69	13.34	7.74	23.5	1.0	28.0	179.0
	108†	0.57	17.63	53.47	18.40	18.80				
Internal leakage	9*	0.00	0.45	2.09	0.84	0.64	42.6	0.5	41.2	172.0
	9†	0.28	1.42	3.27	0.96	1.57				
Low output	1*	0.00	0.06	0.33	0.15	0.07	2.0	2.0	2.0	2.0
	1†	0.00	0.18	0.55	0.20	0.17				
<b>Comments</b>										

(cont.)

Taxonomy no 1.3.1		Item Machinery Pumps Centrifugal								
Population 350	Installations 59	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 10340			
		Calendar time * 13.9546		Operational time † 5.7455						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Minor in-service problems	213*	0.00	15.38	80.97	36.69	15.26	6.1	0.5	10.4	111.0
	213†	39.27	391.65	1057.33	338.88	37.07				
Noise	8*	0.00	0.64	3.23	1.39	0.57	7.3	0.5	20.1	46.0
	8†	0.04	2.12	6.58	2.32	1.39				
Other	47*	0.00	3.14	17.24	8.40	3.37	27.3	1.0	46.0	697.0
	47†	0.00	20.65	103.50	44.28	8.18				
Overheating	4*	0.00	0.23	0.95	1.08	0.29	30.3	3.0	34.3	64.0
	4†	0.00	0.67	2.83	1.09	0.70				
Parameter deviation	23*	0.00	1.08	5.59	4.15	1.65	9.3	2.0	14.1	81.0
	23†	0.02	3.82	13.98	5.17	4.00				
Structural deficiency	12*	0.00	0.79	4.43	2.30	0.86	42.1	1.0	70.0	213.5
	12†	1.32	2.21	3.28	0.60	2.09				
Unknown	4*	0.00	0.41	0.74	2.34	0.29	45.3	8.0	38.5	70.0
	4†	0.00	1.48	8.16	4.96	0.70				
Vibration	11*	0.00	0.78	3.33	1.28	0.79	9.9	1.0	26.7	96.0
	11†	0.01	2.48	9.16	3.38	1.91				
<b>Unknown</b>	12*	<b>0.00</b>	<b>1.17</b>	<b>6.41</b>	<b>3.08</b>	<b>0.86</b>	<b>6.8</b>	<b>2.0</b>	<b>13.6</b>	<b>48.0</b>
	12†	<b>0.01</b>	<b>4.50</b>	<b>17.83</b>	<b>6.65</b>	<b>2.09</b>				
External leakage - Utility medium	1*	0.00	0.21	0.59	1.05	0.07	-	29.0	29.0	29.0
	1†	0.00	0.84	4.67	2.38	0.17				
Other	2*	0.01	0.15	0.43	0.14	0.14	-	12.0	12.0	12.0
	2†	0.00	0.60	3.14	1.42	0.35				
Unknown	9*	0.00	0.82	4.48	2.79	0.64	6.8	2.0	12.1	48.0
	9†	0.00	3.20	15.07	6.15	1.57				
<b>All modes</b>	<b>1949*</b>	<b>0.00</b>	<b>112.64</b>	<b>546.74</b>	<b>226.89</b>	<b>139.67</b>	<b>21.3</b>	<b>0.5</b>	<b>30.5</b>	<b>1025.0</b>
	<b>1949†</b>	<b>172.90</b>	<b>1277.00</b>	<b>3233.73</b>	<b>1001.75</b>	<b>339.22</b>				

**Comments**

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.3 · 10<sup>-3</sup>

**Maintainable item versus failure mode, to be continued**

Item: Pumps - Centrifugal

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.51	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
Bearing	0.00	0.00	0.05	0.08	0.00	0.05	0.00	0.00	0.00	0.05
Cabling & junction boxes	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Casing	0.00	0.46	0.59	0.31	0.00	0.00	0.00	0.00	0.05	0.00
Check valves	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Control unit	1.18	0.00	0.00	0.00	0.31	0.21	0.00	0.00	0.05	0.00
Cooler(s)	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00
Cooling/heating system	0.05	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driven unit	0.05	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.05
Coupling to driver	0.05	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Filter(s)	0.00	0.00	0.00	0.31	0.00	0.00	0.05	0.05	0.00	0.00
Filter, cyclone	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.05	0.00
Gearbox/var.drive	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Impeller	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
Instrument, flow	3.95	0.00	0.00	0.05	0.00	0.00	0.00	0.08	0.05	0.00
Instrument, general	1.13	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00
Instrument, level	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	4.90	0.00	0.03	0.21	0.15	0.00	0.00	0.00	0.00	0.00
Instrument, speed	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	4.54	0.00	0.00	0.10	0.05	0.05	0.00	0.00	0.00	0.00
Instrument, vibration	2.41	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lubrication	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	1.10	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.26	0.00	0.05	0.00	0.00	0.95	0.00
Other	0.05	0.00	0.05	0.51	0.00	0.05	0.00	0.05	0.10	0.10
Piping	0.00	0.05	1.80	2.03	0.00	0.00	0.00	0.00	0.49	0.00
Pump w/motor	0.00	0.00	0.00	0.51	0.00	0.05	0.00	0.00	0.00	0.15
Purge air	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Radial bearing	0.00	0.15	0.05	0.03	0.00	0.05	0.00	0.00	0.00	0.13
Reservoir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reservoir w/heating system	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Seals	0.00	0.10	5.11	8.16	0.00	0.00	0.00	0.59	0.00	0.03
Shaft	0.05	0.21	0.00	0.05	0.00	0.05	0.00	0.00	0.00	0.10
Subunit	0.15	0.56	0.08	0.26	0.00	0.36	0.00	0.05	0.51	0.05
Support	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thrust bearing	0.00	0.15	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	1.49	0.15	0.46	1.08	0.05	0.92	0.15	0.15	1.23	0.10
Valves	0.00	0.00	0.92	1.74	0.10	0.05	0.00	0.21	0.10	0.05
Total	23.29	1.90	9.18	17.09	0.87	2.15	0.21	1.18	3.64	0.87

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

Item: Pumps - Centrifugal

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.26	0.00	0.62	0.00	0.00	0.00	0.05	0.00	1.49
Bearing	0.00	0.00	0.00	0.05	0.15	0.00	0.00	0.13	0.10	0.67
Cabling & junction boxes	0.00	0.05	0.21	0.26	0.00	0.00	0.00	0.10	0.00	1.26
Casing	0.05	0.00	0.00	0.05	0.33	0.00	0.00	0.00	0.10	1.95
Check valves	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Control unit	0.00	0.15	0.21	0.26	0.10	0.21	0.00	0.36	0.03	3.05
Cooler(s)	0.15	0.05	0.05	0.15	0.15	0.00	0.00	0.00	0.00	0.92
Cooling/heating system	0.10	0.05	0.00	0.51	0.00	0.00	0.00	0.00	0.00	1.03
Coupling to driven unit	0.00	0.00	0.00	0.08	0.41	0.00	0.05	0.15	0.05	1.00
Coupling to driver	0.00	0.00	0.00	0.03	0.05	0.00	0.00	0.00	0.15	0.33
Diaphragm	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.05
Filter(s)	0.00	0.41	0.21	0.46	0.10	0.00	0.00	0.00	0.00	1.59
Filter, cyclone	0.00	0.05	0.00	0.15	0.00	0.00	0.05	0.00	0.00	0.46
Gearbox/var.drive	0.05	0.00	0.00	0.05	0.05	0.00	0.00	0.15	0.00	0.36
Impeller	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.10	0.15	0.38
Instrument, flow	0.00	0.05	0.77	0.21	0.05	0.00	0.00	0.15	0.00	5.36
Instrument, general	0.00	0.26	0.10	0.51	0.00	0.05	0.00	0.15	0.00	2.46
Instrument, level	0.00	0.00	0.05	0.10	0.05	0.00	0.00	0.05	0.00	0.67
Instrument, pressure	0.05	0.10	0.36	0.56	0.15	0.00	0.05	0.46	0.00	7.03
Instrument, speed	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Instrument, temperature	0.05	0.00	0.36	0.69	0.03	0.00	0.00	0.67	0.00	6.54
Instrument, vibration	0.00	0.00	0.56	0.56	0.00	0.00	0.05	0.41	0.49	4.54
Internal power supply	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.10	0.00	0.31
Lubrication	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.15
Monitoring	0.00	0.05	0.10	0.18	0.00	0.00	0.00	0.15	0.00	1.74
Oil	0.05	0.15	0.05	0.26	0.00	0.00	0.00	0.00	0.00	1.77
Other	0.05	0.10	0.62	0.72	0.15	0.00	0.15	0.00	0.05	2.77
Piping	0.00	0.31	0.56	0.41	0.72	0.00	0.00	0.00	0.05	6.41
Pump w/motor	0.00	0.05	0.10	0.05	0.00	0.00	0.00	0.00	0.00	0.92
Purge air	0.00	0.10	0.00	0.05	0.00	0.00	0.00	0.05	0.00	0.26
Radial bearing	0.00	0.10	0.15	0.10	0.38	0.00	0.00	0.05	0.76	1.97
Reservoir	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.05
Reservoir w/heating system	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.15
Seals	0.15	0.21	0.10	0.36	0.54	0.00	0.00	0.44	0.02	15.79
Shaft	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.14	0.70
Subunit	0.00	0.56	0.31	0.46	0.46	0.00	0.00	0.46	0.51	4.80
Support	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	1.08	1.23
Thrust bearing	0.05	0.00	0.00	0.05	0.23	0.00	0.00	0.00	0.22	0.84
Unknown	0.10	0.97	0.31	1.54	0.56	0.00	0.31	1.85	0.62	12.06
Valves	0.00	1.08	0.41	1.28	0.21	0.00	0.00	0.05	0.00	6.21
Total	0.92	5.28	5.59	11.08	5.13	0.26	0.67	6.16	4.52	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.



**Failure descriptor versus failure mode, to be continued**

Item: Pumps - Centrifugal

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	1.44	0.05	0.31	0.36	0.15	0.05	0.00	0.00	0.92	0.00
Breakage	0.77	0.05	0.05	0.46	0.00	0.05	0.00	0.00	0.00	0.00
Burst	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cavitation	0.00	0.15	0.15	0.26	0.00	0.00	0.00	0.00	0.00	0.15
Clearance/ alignment failure	0.26	0.00	0.15	0.15	0.00	0.05	0.00	0.00	0.00	0.00
Combined causes	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
Contamination	0.00	0.00	0.00	0.05	0.10	0.00	0.00	0.05	1.18	0.00
Control failure	0.41	0.00	0.00	0.00	0.05	0.10	0.00	0.00	0.00	0.00
Corrosion	0.51	0.05	0.41	0.41	0.00	0.00	0.00	0.00	0.26	0.00
Deformation	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.31	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
Electrical failure - general	0.62	0.00	0.00	0.00	0.05	0.21	0.00	0.00	0.00	0.05
Erosion	0.00	0.10	0.00	0.15	0.00	0.00	0.00	0.00	0.05	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
Fatigue	0.05	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	3.34	0.00	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.00
Instrument failure - general	7.75	0.00	0.10	0.21	0.10	0.26	0.05	0.00	0.10	0.00
Leakage	0.21	0.00	2.72	6.88	0.00	0.00	0.00	0.56	0.05	0.05
Looseness	0.10	0.00	0.36	0.15	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.26	0.67	0.00	0.05	0.10	0.00	0.00	0.00
Mechanical Failure - general	0.67	0.82	3.59	5.39	0.00	0.46	0.00	0.26	0.15	0.41
Misc. external influences	0.46	0.31	0.46	0.46	0.15	0.00	0.00	0.00	0.15	0.00
Miscellaneous - general	0.00	0.00	0.00	0.10	0.05	0.00	0.00	0.00	0.05	0.00
No cause found	0.21	0.00	0.00	0.05	0.00	0.10	0.00	0.00	0.00	0.00
No power/ voltage	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
Open circuit	0.41	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
Other	0.05	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	3.39	0.00	0.00	0.00	0.15	0.10	0.00	0.00	0.00	0.00
Overheating	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.10	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
Software failure	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.31	0.05	0.05	0.10	0.00	0.31	0.05	0.10	0.05	0.10
Vibration	0.36	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Wear	0.41	0.15	0.36	1.08	0.00	0.15	0.00	0.21	0.56	0.05
Total	23.29	1.90	9.18	17.09	0.87	2.15	0.21	1.18	3.64	0.87

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

**Item: Pumps - Centrifugal**

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.05	1.90	0.72	0.21	0.00	0.00	0.10	0.05	6.31
Breakage	0.05	0.05	0.05	0.31	0.05	0.00	0.00	0.05	0.31	2.26
Burst	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Cavitation	0.00	0.10	0.10	0.05	0.15	0.00	0.00	0.00	0.05	1.18
Clearance/ alignment failure	0.05	0.05	0.21	0.05	0.21	0.00	0.00	0.00	0.97	2.15
Combined causes	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.05	0.21
Contamination	0.00	0.21	0.00	0.56	0.00	0.00	0.00	0.00	0.00	2.15
Control failure	0.00	0.10	0.00	0.15	0.00	0.10	0.00	0.21	0.05	1.18
Corrosion	0.00	0.36	0.00	0.77	0.51	0.00	0.00	0.15	0.00	3.44
Deformation	0.05	0.00	0.00	0.10	0.05	0.00	0.00	0.10	0.05	0.46
Earth/isolation fault	0.05	0.10	0.00	0.10	0.00	0.00	0.00	0.05	0.00	0.67
Electrical failure - general	0.05	0.26	0.15	0.26	0.05	0.00	0.05	0.51	0.00	2.26
Erosion	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.36
External influence - general	0.00	0.46	0.26	0.15	0.00	0.00	0.00	0.00	0.05	0.97
Fatigue	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.05	0.31
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.05
Faulty signal/indication/alarm	0.10	0.10	0.10	0.15	0.00	0.00	0.00	0.67	0.15	4.72
Instrument failure - general	0.00	0.46	1.23	2.00	0.00	0.10	0.15	1.39	0.10	14.01
Leakage	0.00	0.05	0.00	0.36	0.26	0.00	0.05	0.21	0.05	11.44
Looseness	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.05	0.05	0.97
Material failure - general	0.00	0.15	0.00	0.36	0.51	0.00	0.00	0.05	0.10	2.26
Mechanical Failure - general	0.15	0.87	0.51	1.49	2.67	0.00	0.15	0.97	0.82	19.39
Misc. external influences	0.00	0.56	0.21	1.13	0.10	0.00	0.00	0.10	0.51	4.62
Miscellaneous - general	0.00	0.10	0.00	0.05	0.00	0.00	0.00	0.05	0.00	0.41
No cause found	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.15	0.10	0.72
No power/ voltage	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.10
No signal/indication/alarm	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.05	0.00	1.08
Open circuit	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.56
Other	0.05	0.21	0.05	0.15	0.00	0.00	0.05	0.10	0.00	0.72
Out of adjustment	0.00	0.00	0.56	0.36	0.00	0.00	0.00	0.21	0.10	4.87
Overheating	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.21
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.21
Software failure	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.21
Sticking	0.00	0.26	0.00	0.41	0.00	0.00	0.00	0.05	0.00	0.87
Unknown	0.21	0.36	0.10	0.31	0.00	0.05	0.21	0.15	0.15	2.67
Vibration	0.00	0.05	0.15	0.05	0.21	0.00	0.00	0.51	0.46	1.90
Wear	0.00	0.15	0.00	0.56	0.05	0.00	0.00	0.05	0.26	4.05
Total	0.92	5.28	5.59	11.08	5.13	0.26	0.67	6.16	4.52	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 1.3.1.1		Item Machinery Pumps Centrifugal Chemical injection									
Population 3	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 4				
		Calendar time * 0.0964		Operational time † 0.0961			Active rep.hrs	Repair (manhours)			
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ	Min		Mean	Max	
Degraded	1*	0.24	12.04	37.31	13.19	10.38	-	26.0	26.0	26.0	
	1†	0.23	12.12	37.67	13.35	10.41					
External leakage - Utility medium	1*	0.24	12.04	37.31	13.19	10.38	-	26.0	26.0	26.0	
	1†	0.23	12.12	37.67	13.35	10.41					
All modes	1*	0.24	12.04	37.31	13.19	10.38	-	26.0	26.0	26.0	
	1†	0.23	12.12	37.67	13.35	10.41					
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10 <sup>0</sup>											

Taxonomy no 1.3.1.2		Item Machinery Pumps Centrifugal Combined function								
Population 9	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *			Operational time †					
		0.3503			0.2991					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	6*	0.14	15.63	52.07	19.08	17.13	58.2	1.0	58.8	96.0
	6†	0.12	20.47	72.16	26.65	20.06				
External leakage - Process medium	5*	0.15	13.09	42.52	15.46	14.27	69.6	34.0	70.4	96.0
	5†	0.11	17.04	59.06	21.78	16.71				
Fail to start on demand	1*	0.01	2.72	9.71	3.59	2.85	1.0	1.0	1.0	1.0
	1†	0.18	3.37	10.03	3.34	3.34				
<b>Degraded</b>	2*	0.75	5.48	13.85	4.29	5.71	3.0	2.0	3.0	4.0
	2†	0.24	6.77	20.47	7.01	6.69				
External leakage - Process medium	1*	0.01	2.72	9.71	3.59	2.85	2.0	2.0	2.0	2.0
	1†	0.18	3.37	10.03	3.34	3.34				
External leakage - Utility medium	1*	0.01	2.72	9.71	3.59	2.85	4.0	4.0	4.0	4.0
	1†	0.18	3.37	10.03	3.34	3.34				
<b>Incipient</b>	5*	0.15	13.09	42.52	15.46	14.27	35.1	1.0	29.1	136.0
	5†	0.11	17.04	59.06	21.78	16.71				
Abnormal instrument reading	1*	0.01	2.72	9.71	3.59	2.85	1.5	1.5	1.5	1.5
	1†	0.18	3.37	10.03	3.34	3.34				
External leakage - Process medium	3*	0.34	8.02	24.10	8.14	8.56	1.5	1.0	2.7	5.0
	3†	0.12	10.20	33.03	12.00	10.03				
External leakage - Utility medium	1*	0.01	2.72	9.71	3.59	2.85	136.0	136.0	136.0	136.0
	1†	0.18	3.37	10.03	3.34	3.34				
<b>All modes</b>	13*	0.18	33.39	119.82	44.27	37.11	41.3	1.0	38.8	136.0
	13†	0.21	44.44	164.09	60.60	43.46				
<b>Comments</b>										

Taxonomy no 1.3.1.3		Item Machinery Pumps Centrifugal Completion fluid								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0306			Operational time † 0.0306					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0 <sup>*</sup> 0 <sup>†</sup>	0.06	14.25	54.72	20.15	0.00	-	-	-	-
		0.06	16.12	61.90	22.80	0.00				
Comments										

Taxonomy no 1.3.1.4		Item Machinery Pumps Centrifugal Condensate processing								
Population 15	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 834			
		Calendar time * 0.3189			Operational time † 0.2207					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>17*</b> <b>17†</b>	<b>5.37</b> <b>8.34</b>	<b>80.59</b> <b>136.72</b>	<b>233.46</b> <b>400.61</b>	<b>77.15</b> <b>132.89</b>	<b>53.31</b> <b>77.03</b>	<b>22.5</b>	<b>2.0</b>	<b>31.0</b>	<b>223.0</b>
Breakdown	1* 1†	0.23 0.00	3.30 4.36	9.51 19.00	3.14 7.39	3.14 4.53	22.5	45.0	45.0	45.0
External leakage - Utility medium	1* 1†	0.24 0.00	3.33 4.36	9.53 18.97	3.14 7.38	3.14 4.53	-	9.0	9.0	9.0
Fail to start on demand	3* 3†	0.08 0.17	13.10 25.41	46.37 87.89	17.13 32.41	9.41 13.59	-	6.0	8.3	12.0
High output	2* 2†	0.01 0.07	12.10 23.69	50.63 92.76	19.35 34.46	6.27 9.06	-	3.0	4.5	6.0
Internal leakage	1* 1†	0.02 0.00	2.76 4.35	9.66 18.92	3.57 7.35	3.14 4.53	-	48.0	48.0	48.0
Overheating	1* 1†	0.24 0.00	3.33 4.36	9.53 18.97	3.14 7.38	3.14 4.53	-	223.0	223.0	223.0
Spurious stop	7* 7†	0.81 1.12	32.37 48.99	99.21 150.82	34.66 52.97	21.95 31.72	-	2.0	20.2	76.0
Vibration	1* 1†	0.00 0.01	5.19 9.93	22.07 41.62	8.51 15.93	3.14 4.53	-	5.0	5.0	5.0
<b>Degraded</b>	<b>35*</b> <b>35†</b>	<b>29.29</b> <b>42.31</b>	<b>110.01</b> <b>166.26</b>	<b>232.93</b> <b>357.22</b>	<b>64.55</b> <b>100.07</b>	<b>109.75</b> <b>158.60</b>	<b>37.0</b>	<b>2.0</b>	<b>40.3</b>	<b>250.0</b>
Erratic output	1* 1†	0.24 0.00	3.33 4.36	9.53 18.97	3.14 7.38	3.14 4.53	-	-	-	-
External leakage - Process medium	1* 1†	0.24 0.00	3.33 4.36	9.53 18.97	3.14 7.38	3.14 4.53	-	68.0	68.0	68.0
External leakage - Utility medium	17* 17†	19.08 9.78	50.90 87.63	95.18 230.73	23.75 72.89	53.31 77.03	37.0	2.0	37.2	178.0
Minor in-service problems	1* 1†	0.24 0.00	3.33 4.36	9.53 18.97	3.14 7.38	3.14 4.53	-	-	-	-
Other	8* 8†	4.96 8.67	23.81 37.20	54.28 82.04	15.82 23.38	25.09 36.25	-	3.0	16.0	60.0
Overheating	1* 1†	0.24 0.00	3.33 4.36	9.53 18.97	3.14 7.38	3.14 4.53	-	-	-	-
Parameter deviation	1* 1†	0.24 0.00	3.33 4.36	9.53 18.97	3.14 7.38	3.14 4.53	-	-	-	-
Structural deficiency	3* 3†	0.01 0.05	10.81 12.74	46.54 49.04	18.03 18.08	9.41 13.59	-	23.0	23.0	23.0
Vibration	2* 2†	0.01 0.23	7.14 8.78	28.70 26.84	10.78 9.35	6.27 9.06	-	250.0	250.0	250.0
<b>Incipient</b>	<b>52*</b> <b>52†</b>	<b>0.79</b> <b>2.24</b>	<b>192.25</b> <b>244.56</b>	<b>729.04</b> <b>811.02</b>	<b>268.80</b> <b>296.87</b>	<b>163.05</b> <b>235.63</b>	<b>-</b>	<b>2.0</b>	<b>18.4</b>	<b>108.0</b>
<b>Comments</b>										

(cont)

Taxonomy no 1.3.1.4		Item Machinery Pumps Centrifugal Condensate processing									
Population 15	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 834				
		Calendar time * 0.3189			Operational time † 0.2207						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Abnormal instrument reading	30* 30†	1.07 5.64	118.26 159.08	392.84 480.77	143.86 164.34	94.07 135.94	-	2.0	15.1	108.0	
External leakage - Process medium	4* 4†	0.00 0.02	14.43 16.61	63.98 69.22	25.20 26.39	12.54 18.13	-	-	-	-	
Minor in-service problems	9* 9†	0.00 0.00	32.35 35.47	150.26 165.41	60.77 67.09	28.22 40.78	-	16.0	32.5	53.0	
Other	3* 3†	1.46 0.05	8.33 12.72	19.84 48.86	5.93 17.99	9.41 13.59	-	3.0	20.3	48.0	
Parameter deviation	2* 2†	0.01 0.23	7.14 8.78	28.70 26.84	10.78 9.35	6.27 9.06	-	4.0	5.0	6.0	
Structural deficiency	1* 1†	0.24 0.00	3.33 4.36	9.53 18.97	3.14 7.38	3.14 4.53	-	-	-	-	
Vibration	3* 3†	0.01 0.05	10.81 12.74	46.54 49.04	18.03 18.08	9.41 13.59	-	18.0	26.3	40.0	
<b>Unknown</b>	<b>5* 5†</b>	<b>3.19 2.24</b>	<b>17.17 30.02</b>	<b>40.29 85.56</b>	<b>11.94 28.11</b>	<b>15.68 22.66</b>	-	<b>2.0</b>	<b>6.4</b>	<b>12.0</b>	
Other	1* 1†	0.24 0.00	3.33 4.36	9.53 18.97	3.14 7.38	3.14 4.53	-	12.0	12.0	12.0	
Unknown	4* 4†	0.34 0.39	14.60 28.11	44.92 89.57	15.76 32.29	12.54 18.13	-	2.0	5.0	6.0	
<b>All modes</b>	<b>109* 109†</b>	<b>31.51 87.99</b>	<b>407.61 595.24</b>	<b>1155.40 1479.27</b>	<b>378.76 453.84</b>	<b>341.79 493.91</b>	<b>29.8</b>	<b>2.0</b>	<b>27.6</b>	<b>250.0</b>	
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.2 10 <sup>-3</sup>											

Taxonomy no 1.3.1.5		Item Machinery Pumps Centrifugal Cooling systems								
Population 18	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 150			
		Calendar time * 0.4729		Operational time † 0.4276						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	2*	<b>0.38</b>	<b>5.12</b>	<b>14.61</b>	<b>4.80</b>	<b>4.23</b>	<b>4.0</b>	<b>4.0</b>	<b>63.0</b>	<b>122.0</b>
	2†	<b>0.43</b>	<b>7.34</b>	<b>21.63</b>	<b>7.19</b>	<b>4.68</b>				
Fail to start on demand	1*	0.04	1.92	5.97	2.11	2.11	4.0	4.0	4.0	4.0
	1†	0.05	2.15	6.64	2.34	2.34				
Noise	1*	0.01	4.00	15.41	5.68	2.11	-	122.0	122.0	122.0
	1†	0.02	7.34	28.92	10.77	2.34				
<b>Incipient</b>	1*	<b>0.04</b>	<b>1.92</b>	<b>5.97</b>	<b>2.11</b>	<b>2.11</b>	<b>2.0</b>	<b>2.0</b>	<b>2.0</b>	<b>2.0</b>
	1†	<b>0.05</b>	<b>2.15</b>	<b>6.64</b>	<b>2.34</b>	<b>2.34</b>				
Abnormal instrument reading	1*	0.04	1.92	5.97	2.11	2.11	2.0	2.0	2.0	2.0
	1†	0.05	2.15	6.64	2.34	2.34				
<b>All modes</b>	3*	<b>1.96</b>	<b>6.63</b>	<b>13.57</b>	<b>3.66</b>	<b>6.34</b>	<b>3.0</b>	<b>2.0</b>	<b>42.7</b>	<b>122.0</b>
	3†	<b>0.84</b>	<b>8.95</b>	<b>24.53</b>	<b>7.92</b>	<b>7.02</b>				
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0. 10 <sup>0</sup>										



Taxonomy no 1.3.1.6		Item Machinery Pumps Centrifugal Crude oil handling									
Population 11	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 750				
		Calendar time * 0.3596		Operational time † 0.2235							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	<b>17*</b>	<b>18.63</b>	<b>49.27</b>	<b>91.81</b>	<b>22.83</b>	<b>47.28</b>	<b>4.3</b>	<b>1.0</b>	<b>63.1</b>	<b>231.0</b>	
	<b>17†</b>	<b>49.53</b>	<b>77.17</b>	<b>109.79</b>	<b>18.44</b>	<b>76.05</b>					
Breakdown	2*	0.77	5.17	12.83	3.93	5.56	-	22.0	57.0	92.0	
	2†	1.37	8.55	20.85	6.33	8.95					
External leakage - Process medium	3*	0.67	7.42	20.49	6.64	8.34	-	56.0	90.7	148.0	
	3†	0.22	12.13	37.91	13.49	13.42					
External leakage - Utility medium	1*	0.02	2.53	8.92	3.29	2.78	-	54.0	54.0	54.0	
	1†	0.02	4.17	16.06	5.92	4.47					
Spurious stop	8*	11.17	22.36	36.68	7.87	22.25	4.3	1.0	22.1	96.0	
	8†	17.63	35.59	58.64	12.65	35.79					
Vibration	3*	0.07	17.18	66.06	24.34	8.34	-	72.0	151.7	231.0	
	3†	0.09	25.80	100.05	37.02	13.42					
<b>Degraded</b>	<b>51*</b>	<b>47.42</b>	<b>176.59</b>	<b>372.82</b>	<b>103.08</b>	<b>141.84</b>	<b>26.1</b>	<b>2.0</b>	<b>44.3</b>	<b>210.0</b>	
	<b>51†</b>	<b>77.24</b>	<b>276.56</b>	<b>576.35</b>	<b>157.81</b>	<b>228.15</b>					
Abnormal instrument reading	5*	4.85	13.15	24.76	6.22	13.91	9.0	6.0	21.4	65.0	
	5†	6.40	21.23	43.11	11.56	22.37					
Erratic output	6*	0.15	36.12	136.17	50.23	16.69	-	8.0	12.3	24.0	
	6†	0.21	54.25	207.98	76.61	26.84					
External leakage - Process medium	10*	0.02	20.89	86.60	32.93	27.81	-	20.0	53.9	100.0	
	10†	0.02	36.35	154.26	59.41	44.73					
External leakage - Utility medium	9*	8.27	26.94	54.34	14.50	25.03	4.0	2.0	29.0	88.0	
	9†	12.79	43.68	89.61	24.24	40.26					
Internal leakage	2*	0.03	10.90	42.37	15.69	5.56	-	16.0	20.0	24.0	
	2†	0.05	16.38	64.06	23.79	8.95					
Low output	1*	0.01	4.72	18.72	6.99	2.78	-	12.0	12.0	12.0	
	1†	0.02	7.09	28.03	10.45	4.47					
Minor in-service problems	1*	0.02	2.53	8.92	3.29	2.78	-	18.0	18.0	18.0	
	1†	0.02	4.17	16.06	5.92	4.47					
Other	4*	3.15	11.73	24.76	6.85	11.12	17.0	8.0	56.3	128.0	
	4†	6.17	18.34	35.74	9.26	17.89					
Overheating	4*	3.50	11.02	21.95	5.80	11.12	48.0	38.0	69.8	104.0	
	4†	5.69	17.37	34.20	8.95	17.89					
Vibration	9*	2.05	38.67	115.11	38.37	25.03	16.3	18.0	79.6	210.0	
	9†	3.15	57.47	170.51	56.78	40.26					
<b>Incipient</b>	<b>91*</b>	<b>150.29</b>	<b>247.90</b>	<b>365.30</b>	<b>65.92</b>	<b>253.08</b>	<b>13.3</b>	<b>1.0</b>	<b>17.6</b>	<b>72.0</b>	
	<b>91†</b>	<b>301.67</b>	<b>398.33</b>	<b>506.06</b>	<b>62.31</b>	<b>407.09</b>					
Abnormal instrument reading	28*	55.97	78.51	104.17	14.72	77.87	6.1	1.0	11.9	30.0	
	28†	89.52	125.76	167.06	23.67	125.26					
External leakage - Process medium	13*	0.01	26.62	113.78	43.96	36.15	52.0	20.0	41.8	72.0	
	13†	0.02	46.64	202.84	78.85	58.16					
<b>Comments</b>											

(cont)

Taxonomy no 1.3.1.6		Item Machinery Pumps Centrifugal Crude oil handling									
Population 11	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 750				
		Calendar time * 0.3596		Operational time † 0.2235							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
External leakage - Utility medium	16*	13.38	43.62	88.03	23.49	44.50	5.0	2.0	12.9	55.0	
	16†	32.41	69.26	117.31	26.26	71.58					
Minor in-service problems	22*	1.28	66.41	206.51	73.22	61.18	6.3	1.0	11.7	33.0	
	22†	3.05	98.25	298.37	102.88	98.42					
Other	5*	1.29	13.08	35.48	11.40	13.91	4.5	4.0	14.5	36.0	
	5†	2.62	20.80	53.39	16.65	22.37					
Parameter deviation	1*	0.00	2.80	11.56	4.39	2.78	2.0	3.0	3.0	3.0	
	1†	0.01	4.28	16.99	6.34	4.47					
Unknown	4*	0.14	9.37	29.56	10.60	11.12	45.3	8.0	38.5	70.0	
	4†	0.10	15.64	54.83	20.24	17.89					
Vibration	2*	0.12	5.61	17.33	6.11	5.56	4.5	4.0	11.0	18.0	
	2†	0.79	8.64	23.75	7.68	8.95					
<b>Unknown</b>	2*	<b>0.77</b>	<b>5.17</b>	<b>12.83</b>	<b>3.93</b>	<b>5.56</b>	-	<b>12.0</b>	<b>30.0</b>	<b>48.0</b>	
	2†	<b>1.37</b>	<b>8.55</b>	<b>20.85</b>	<b>6.33</b>	<b>8.95</b>					
Other	1*	0.02	2.53	8.92	3.29	2.78	-	12.0	12.0	12.0	
	1†	0.02	4.17	16.06	5.92	4.47					
Unknown	1*	0.02	2.53	8.92	3.29	2.78	-	48.0	48.0	48.0	
	1†	0.02	4.17	16.06	5.92	4.47					
<b>All modes</b>	161*	<b>382.61</b>	<b>456.58</b>	<b>535.97</b>	<b>46.67</b>	<b>447.76</b>	<b>14.9</b>	<b>1.0</b>	<b>31.1</b>	<b>231.0</b>	
	161†	<b>549.77</b>	<b>735.77</b>	<b>944.04</b>	<b>120.23</b>	<b>720.23</b>					
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0: 10 <sup>0</sup>											

<b>Taxonomy no</b> 1.3.1.7		<b>Item</b> Machinery Pumps Centrifugal Emergency power									
<b>Population</b> 2	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>				
		<b>Calendar time *</b> 0.0613			<b>Operational time †</b> 0.0612						
<b>Failure mode</b>	<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours)</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>			
		<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/τ</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>	
<b>All modes</b>		0 <sup>*</sup> 0 <sup>†</sup>	0.03 0.03	7.61 8.11	29.21 31.15	10.76 11.47	0.00 0.00	-	-	-	-
<b>Comments</b>											

Taxonomy no 1.3.1.8		Item Machinery Pumps Centrifugal Flare, vent & blow-down								
Population 4	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1971		Operational time † 0.1460						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	1*	0.25	5.07	24.08	5.07	5.07	25.0	25.0	25.0	25.0
	1†	0.34	6.85	32.50	6.85	6.85				
External leakage - Process medium	1*	0.25	5.07	24.08	5.07	5.07	25.0	25.0	25.0	25.0
	1†	0.34	6.85	32.50	6.85	6.85				
All modes	1*	0.25	5.07	24.08	5.07	5.07	25.0	25.0	25.0	25.0
	1†	0.34	6.85	32.50	6.85	6.85				
Comments										

Taxonomy no 1.3.1.9		Item Machinery Pumps Centrifugal Gas processing									
Population 26	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 155				
		Calendar time * 0.7360			Operational time † 0.6181						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
<b>Critical</b>	<b>28*</b>	<b>0.02</b>	<b>43.80</b>	<b>190.94</b>	<b>74.37</b>	<b>38.04</b>	<b>11.4</b>	<b>1.0</b>	<b>22.1</b>	<b>73.0</b>	
	<b>28†</b>	<b>0.01</b>	<b>48.01</b>	<b>214.94</b>	<b>85.06</b>	<b>45.30</b>					
Breakdown	5*	0.01	8.06	33.93	13.02	6.79	10.1	14.0	20.2	33.0	
	5†	0.01	9.25	38.61	14.74	8.09					
External leakage - Process medium	2*	0.01	3.21	11.92	4.40	2.72	12.3	12.0	24.5	37.0	
	2†	0.03	3.79	12.99	4.79	3.24					
External leakage - Utility medium	6*	0.01	9.66	41.13	15.87	8.15	15.8	2.0	31.5	73.0	
	6†	0.01	11.00	46.76	18.02	9.71					
Fail to start on demand	2*	0.01	3.21	11.92	4.40	2.72	3.0	3.0	4.5	6.0	
	2†	0.03	3.79	12.99	4.79	3.24					
Fail to stop on demand	1*	0.12	1.49	4.16	1.36	1.36	3.0	3.0	3.0	3.0	
	1†	0.15	1.78	4.97	1.62	1.62					
Parameter deviation	1*	0.12	1.49	4.16	1.36	1.36	4.0	4.0	4.0	4.0	
	1†	0.15	1.78	4.97	1.62	1.62					
Spurious stop	4*	0.43	5.82	16.61	5.46	5.43	3.0	1.0	3.3	5.0	
	4†	0.91	6.93	17.67	5.49	6.47					
Structural deficiency	5*	0.01	8.06	33.93	13.02	6.79	14.9	10.0	29.8	51.0	
	5†	0.01	9.25	38.61	14.74	8.09					
Vibration	2*	0.01	3.21	11.92	4.40	2.72	25.5	50.0	51.0	52.0	
	2†	0.03	3.79	12.99	4.79	3.24					
<b>Degraded</b>	<b>37*</b>	<b>0.01</b>	<b>58.82</b>	<b>262.92</b>	<b>103.97</b>	<b>50.27</b>	<b>4.8</b>	<b>2.0</b>	<b>9.1</b>	<b>45.0</b>	
	<b>37†</b>	<b>0.00</b>	<b>64.08</b>	<b>296.16</b>	<b>119.32</b>	<b>59.86</b>					
External leakage - Process medium	5*	0.01	8.06	33.93	13.02	6.79	5.7	5.0	11.4	24.0	
	5†	0.01	9.25	38.61	14.74	8.09					
External leakage - Utility medium	10*	0.01	16.02	69.90	27.25	13.59	4.2	2.0	8.3	39.0	
	10†	0.00	17.92	79.17	31.11	16.18					
Noise	1*	0.12	1.49	4.16	1.36	1.36	3.0	6.0	6.0	6.0	
	1†	0.15	1.78	4.97	1.62	1.62					
Parameter deviation	4*	0.01	6.46	26.74	10.16	5.43	2.3	2.0	3.0	6.0	
	4†	0.01	7.47	30.35	11.45	6.47					
Structural deficiency	8*	0.01	12.84	55.55	21.56	10.87	8.2	3.0	14.2	45.0	
	8†	0.01	14.47	63.09	24.57	12.94					
Vibration	9*	0.01	14.43	62.77	24.40	12.23	4.3	4.0	8.5	14.0	
	9†	0.00	16.20	71.12	27.84	14.56					
<b>Incipient</b>	<b>16*</b>	<b>0.19</b>	<b>25.47</b>	<b>86.95</b>	<b>32.01</b>	<b>21.74</b>	<b>4.5</b>	<b>1.0</b>	<b>18.0</b>	<b>179.0</b>	
	<b>16†</b>	<b>0.38</b>	<b>30.99</b>	<b>99.82</b>	<b>36.18</b>	<b>25.88</b>					
Abnormal instrument reading	11*	0.02	16.89	68.72	25.96	14.95	3.7	1.0	4.8	21.0	
	11†	0.03	19.06	77.69	29.37	17.80					
External leakage - Utility medium	1*	0.02	1.21	3.83	1.37	1.36	16.0	179.0	179.0	179.0	
	1†	0.03	1.46	4.55	1.62	1.62					
<b>Comments</b>										(cont.)	

Taxonomy no 1.3.1.9		Item Machinery Pumps Centrifugal Gas processing									
Population 26	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 155				
		Calendar time * 0.7360		Operational time † 0.6181							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Minor in-service problems	2*	0.01	3.21	11.92	4.40	2.72	2.0	2.0	3.0	4.0	
	2†	0.03	3.79	12.99	4.79	3.24					
Noise	1*	0.01	2.42	9.62	3.60	1.36	8.0	46.0	46.0	46.0	
	1†	0.02	5.00	18.39	6.79	1.62					
Vibration	1*	0.12	1.49	4.16	1.36	1.36	4.0	4.0	4.0	4.0	
	1†	0.15	1.78	4.97	1.62	1.62					
<b>All modes</b>	<b>81*</b>	<b>0.06</b>	<b>127.76</b>	<b>549.81</b>	<b>212.98</b>	<b>110.06</b>	<b>7.3</b>	<b>1.0</b>	<b>16.0</b>	<b>179.0</b>	
	<b>81†</b>	<b>0.04</b>	<b>141.62</b>	<b>622.44</b>	<b>243.83</b>	<b>131.04</b>					
<b>Comments</b>											
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 · 10 <sup>6</sup>											

Taxonomy no 1.3.1.10		Item Machinery Pumps Centrifugal Gas production								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0306		Operational time † 0.0306						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.06 0.06	14.25 16.12	54.72 61.90	20.15 22.80	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 1.3.1.11		Item Machinery Pumps Centrifugal Gas treatment									
Population 22	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 2574				
		Calendar time * 0.1927		Operational time † 0.0723							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
Incipient	1*	0.00	4.75	20.83	8.15	5.19	-	40.0	40.0	40.0	
	1†	0.08	12.75	44.21	16.31	13.83					
Noise	1*	0.00	4.75	20.83	8.15	5.19	-	40.0	40.0	40.0	
	1†	0.08	12.75	44.21	16.31	13.83					
Unknown	1*	0.00	5.03	23.46	9.51	5.19	-	29.0	29.0	29.0	
	1†	0.05	13.33	51.51	19.03	13.83					
External leakage - Utility medium	1*	0.00	5.03	23.46	9.51	5.19	-	29.0	29.0	29.0	
	1†	0.05	13.33	51.51	19.03	13.83					
All modes	2*	0.34	9.89	29.94	10.26	10.38	-	29.0	34.5	40.0	
	2†	3.72	26.46	66.49	20.52	27.67					
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10 <sup>0</sup>											



Taxonomy no 1.3.1.12		Item Machinery Pumps Centrifugal Heating medium								
Population 13	Installations 5	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 12			
		Calendar time * 0.3522		Operational time † 0.2933						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	7*	<b>3.19</b>	<b>19.73</b>	<b>48.01</b>	<b>14.55</b>	<b>19.87</b>	<b>11.8</b>	<b>2.0</b>	<b>23.3</b>	<b>54.0</b>
	7†	<b>3.62</b>	<b>24.45</b>	<b>60.76</b>	<b>18.64</b>	<b>23.87</b>				
External leakage - Process medium	3*	0.11	9.00	28.96	10.49	8.52	15.5	25.0	31.0	34.0
	3†	0.78	10.68	30.53	10.04	10.23				
External leakage - Utility medium	2*	0.00	5.51	23.16	8.87	5.68	15.3	7.0	30.5	54.0
	2†	0.38	7.29	21.73	7.25	6.82				
Fail to start on demand	1*	0.21	3.00	8.61	2.84	2.84	2.0	2.0	2.0	2.0
	1†	0.00	3.72	17.76	7.30	3.41				
Spurious stop	1*	0.01	2.45	8.64	3.19	2.84	3.5	7.0	7.0	7.0
	1†	0.04	2.98	9.47	3.41	3.41				
<b>Degraded</b>	7*	<b>0.00</b>	<b>12.73</b>	<b>56.47</b>	<b>22.25</b>	<b>19.87</b>	<b>6.6</b>	<b>4.0</b>	<b>12.4</b>	<b>31.0</b>
	7†	<b>0.06</b>	<b>15.53</b>	<b>59.58</b>	<b>21.94</b>	<b>23.87</b>				
Structural deficiency	4*	0.24	8.83	26.96	9.38	11.36	9.8	5.0	18.3	31.0
	4†	3.32	11.92	24.88	6.82	13.64				
Vibration	3*	1.64	7.55	17.00	4.92	8.52	2.3	4.0	4.7	5.0
	3†	0.05	7.68	26.84	9.91	10.23				
<b>Incipient</b>	20*	<b>0.43</b>	<b>42.08</b>	<b>137.73</b>	<b>50.22</b>	<b>56.78</b>	<b>7.6</b>	<b>1.0</b>	<b>12.8</b>	<b>70.0</b>
	20†	<b>1.81</b>	<b>54.95</b>	<b>166.49</b>	<b>57.18</b>	<b>68.20</b>				
Abnormal instrument reading	15*	0.00	26.79	120.88	48.00	42.59	4.9	1.0	7.1	39.0
	15†	0.06	33.15	133.55	50.21	51.15				
External leakage - Utility medium	2*	0.84	6.37	16.22	5.04	5.68	30.5	52.0	61.0	70.0
	2†	0.16	9.74	30.61	10.94	6.82				
Minor in-service problems	2*	0.02	4.47	17.26	6.38	5.68	1.0	1.0	1.0	1.0
	2†	0.05	5.48	18.07	6.60	6.82				
Noise	1*	0.01	3.35	13.06	4.84	2.84	-	-	-	-
	1†	0.00	6.53	29.14	11.51	3.41				
<b>All modes</b>	34*	<b>1.38</b>	<b>72.21</b>	<b>224.64</b>	<b>79.68</b>	<b>96.53</b>	<b>8.3</b>	<b>1.0</b>	<b>15.0</b>	<b>70.0</b>
	34†	<b>7.20</b>	<b>92.14</b>	<b>260.69</b>	<b>85.40</b>	<b>115.94</b>				
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10 <sup>0</sup>										

Taxonomy no 1.3.1.13		Item Machinery Pumps Centrifugal Materials handling								
Population 3	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0919		Operational time † 0.0919						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
All modes	0* 0†	0.02 0.02	5.19 5.42	19.92 20.81	7.34 7.66	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 1.3.1.14		Item Machinery Pumps Centrifugal Oil export								
Population 20	Installations 6	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 1430			
		Calendar time * 0.6575			Operational time † 0.5886					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>84*</b> <b>84†</b>	<b>4.19</b> <b>6.06</b>	<b>183.60</b> <b>204.98</b>	<b>565.36</b> <b>623.64</b>	<b>198.57</b> <b>215.67</b>	<b>127.75</b> <b>142.72</b>	<b>53.3</b>	<b>1.0</b>	<b>65.2</b>	<b>734.0</b>
Breakdown	3*	0.00	5.08	24.27	9.97	4.56	34.7	3.0	68.3	132.0
	3†	0.00	6.17	29.68	12.23	5.10				
External leakage - Process medium	8*	0.06	23.59	93.53	34.90	12.17	21.7	2.0	37.4	155.0
	8†	0.09	30.54	118.96	44.10	13.59				
External leakage - Utility medium	10*	0.00	16.28	85.19	38.27	15.21	17.8	3.0	35.6	90.0
	10†	0.00	19.98	103.81	46.06	16.99				
Fail to start on demand	5*	0.37	5.70	16.57	5.48	7.60	38.4	4.0	38.4	96.0
	5†	0.96	6.72	16.81	5.17	8.50				
Fail to stop on demand	1*	0.00	2.41	11.13	4.48	1.52	4.0	4.0	4.0	4.0
	1†	0.00	2.60	11.70	4.65	1.70				
Internal leakage	1*	0.02	1.32	4.22	1.52	1.52	188.0	188.0	188.0	188.0
	1†	0.02	1.47	4.70	1.70	1.70				
Low output	32*	0.01	100.62	467.76	189.31	48.67	44.0	3.0	49.2	508.0
	32†	0.00	103.56	495.72	203.97	54.37				
Noise	1*	0.00	2.53	11.75	4.76	1.52	-	-	-	-
	1†	0.00	3.33	15.55	6.31	1.70				
Other	1*	0.00	2.41	11.13	4.48	1.52	397.0	734.0	734.0	734.0
	1†	0.00	2.60	11.70	4.65	1.70				
Parameter deviation	1*	0.12	1.62	4.62	1.52	1.52	4.5	9.0	9.0	9.0
	1†	0.09	1.87	5.61	1.88	1.70				
Spurious stop	16*	2.67	19.03	47.81	14.75	24.33	103.3	1.0	105.5	714.0
	16†	3.65	21.89	52.85	15.94	27.19				
Structural deficiency	1*	0.12	1.62	4.62	1.52	1.52	14.0	28.0	28.0	28.0
	1†	0.09	1.87	5.61	1.88	1.70				
Vibration	4*	1.90	6.34	12.90	3.47	6.08	14.4	8.0	21.8	31.0
	4†	1.69	7.28	16.09	4.59	6.80				
<b>Degraded</b>	<b>82*</b> <b>82†</b>	<b>6.37</b> <b>5.77</b>	<b>113.74</b> <b>135.44</b>	<b>336.65</b> <b>407.14</b>	<b>112.02</b> <b>137.47</b>	<b>124.71</b> <b>139.32</b>	<b>45.2</b>	<b>1.0</b>	<b>51.3</b>	<b>304.0</b>
Abnormal instrument reading	2*	0.05	4.23	13.61	4.93	3.04	3.0	2.0	3.5	5.0
	2†	0.06	5.03	16.32	5.93	3.40				
External leakage - Process medium	3*	0.00	6.84	33.03	13.64	4.56	31.7	42.0	63.8	106.0
	3†	0.00	9.12	43.11	17.63	5.10				
External leakage - Utility medium	37*	0.65	38.27	120.02	42.84	56.27	75.3	1.0	81.4	210.0
	37†	1.61	44.59	134.69	45.98	62.87				
High output	1*	0.02	1.32	4.22	1.52	1.52	2.0	2.0	2.0	2.0
	1†	0.02	1.47	4.70	1.70	1.70				
Internal leakage	3*	0.00	4.18	19.25	7.74	4.56	130.0	20.0	135.3	304.0
	3†	0.00	4.59	20.28	7.96	5.10				

Comments

(cont.)

Taxonomy no 1.3.1.14		Item Machinery Pumps Centrifugal Oil export								
Population 20	Installations 6	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 1430			
		Calendar time * 0.6575		Operational time † 0.5886						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Low output	1*	0.00	1.98	8.38	3.22	1.52	5.5	11.0	11.0	11.0
	1†	0.00	2.59	11.66	4.63	1.70				
Other	1*	0.02	1.32	4.22	1.52	1.52	2.0	2.0	2.0	2.0
	1†	0.02	1.47	4.70	1.70	1.70				
Overheating	1*	0.02	1.32	4.22	1.52	1.52	64.0	64.0	64.0	64.0
	1†	0.02	1.47	4.70	1.70	1.70				
Parameter deviation	14*	0.00	22.63	119.54	54.38	21.29	2.8	1.0	3.0	6.0
	14†	0.00	27.81	145.50	65.34	23.79				
Structural deficiency	9*	0.00	14.69	76.62	34.24	13.69	12.9	5.0	25.3	70.0
	9†	0.00	18.02	93.41	41.24	15.29				
Vibration	10*	0.13	19.09	65.67	24.20	15.21	16.1	1.0	19.0	96.0
	10†	0.14	22.00	76.74	28.32	16.99				
<b>Incipient</b>	<b>170*</b>	<b>50.54</b>	<b>254.48</b>	<b>587.55</b>	<b>172.56</b>	<b>258.54</b>	<b>15.9</b>	<b>1.0</b>	<b>17.6</b>	<b>172.0</b>
	<b>170†</b>	<b>52.56</b>	<b>307.91</b>	<b>738.48</b>	<b>221.75</b>	<b>288.84</b>				
Abnormal instrument reading	81*	20.53	129.64	316.99	96.36	123.19	5.4	1.0	6.7	73.0
	81†	21.16	156.40	396.12	122.72	137.62				
Erratic output	1*	0.00	1.98	8.38	3.22	1.52	2.0	4.0	4.0	4.0
	1†	0.00	2.59	11.66	4.63	1.70				
External leakage - Utility medium	34*	0.00	28.33	135.12	55.51	51.71	42.0	1.0	43.5	172.0
	34†	0.00	32.19	147.83	59.23	57.77				
Internal leakage	3*	0.02	3.36	12.05	4.45	4.56	106.7	70.0	112.7	172.0
	3†	0.03	3.79	12.86	4.73	5.10				
Minor in-service problems	40*	2.18	74.63	227.15	78.61	60.83	7.5	1.0	9.6	50.0
	40†	2.31	92.65	284.03	99.25	67.96				
Other	6*	0.72	9.69	27.65	9.08	9.13	6.9	1.0	7.0	18.0
	6†	0.44	11.70	35.31	12.03	10.19				
Overheating	1*	0.02	1.32	4.22	1.52	1.52	52.0	64.0	64.0	64.0
	1†	0.02	1.47	4.70	1.70	1.70				
Structural deficiency	2*	0.00	3.42	14.94	5.82	3.04	5.3	4.0	8.5	13.0
	2†	0.00	4.12	18.47	7.31	3.40				
Vibration	2*	0.14	3.73	11.25	3.83	3.04	3.5	2.0	6.0	10.0
	2†	0.24	4.23	12.49	4.15	3.40				
<b>Unknown</b>	<b>1*</b>	<b>0.12</b>	<b>1.62</b>	<b>4.62</b>	<b>1.52</b>	<b>1.52</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>
	<b>1†</b>	<b>0.09</b>	<b>1.87</b>	<b>5.61</b>	<b>1.88</b>	<b>1.70</b>				
Unknown	1*	0.12	1.62	4.62	1.52	1.52	-	-	-	-
	1†	0.09	1.87	5.61	1.88	1.70				
<b>All modes</b>	<b>337*</b>	<b>103.86</b>	<b>551.43</b>	<b>1290.20</b>	<b>381.77</b>	<b>512.53</b>	<b>32.7</b>	<b>1.0</b>	<b>38.1</b>	<b>734.0</b>
	<b>337†</b>	<b>113.97</b>	<b>649.67</b>	<b>1546.45</b>	<b>461.99</b>	<b>572.59</b>				

**Comments**

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10<sup>0</sup>

Taxonomy no 1.3.1.15		Item Machinery Pumps Centrifugal Oil processing									
Population 5	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 85				
		Calendar time * 0.2037		Operational time † 0.1302							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
<b>Critical</b>	<b>15*</b>	<b>0.34</b>	<b>75.95</b>	<b>282.27</b>	<b>104.22</b>	<b>73.62</b>	<b>14.6</b>	<b>2.0</b>	<b>14.9</b>	<b>80.0</b>	
	<b>15†</b>	<b>0.55</b>	<b>98.46</b>	<b>351.20</b>	<b>129.75</b>	<b>115.23</b>					
Breakdown	1*	0.27	4.96	14.74	4.91	4.91	-	-	-	-	
	1†	0.05	7.18	24.72	9.11	7.68					
External leakage - Process medium	10*	0.25	50.58	184.90	68.31	49.08	11.2	2.0	11.2	20.0	
	10†	0.45	66.25	228.19	84.11	76.82					
Fail to start on demand	1*	0.27	4.96	14.74	4.91	4.91	6.0	6.0	6.0	6.0	
	1†	0.05	7.18	24.72	9.11	7.68					
Spurious stop	2*	0.31	9.99	30.35	10.46	9.82	3.5	3.0	3.5	4.0	
	2†	2.28	14.56	35.69	10.86	15.36					
Vibration	1*	0.27	4.96	14.74	4.91	4.91	76.5	80.0	80.0	80.0	
	1†	0.05	7.18	24.72	9.11	7.68					
<b>Degraded</b>	<b>14*</b>	<b>13.79</b>	<b>67.80</b>	<b>155.57</b>	<b>45.52</b>	<b>68.72</b>	<b>6.2</b>	<b>3.0</b>	<b>48.6</b>	<b>167.0</b>	
	<b>14†</b>	<b>9.46</b>	<b>122.03</b>	<b>345.75</b>	<b>113.32</b>	<b>107.55</b>					
External leakage - Utility medium	11*	22.62	53.63	95.34	22.57	53.99	6.2	3.0	55.8	167.0	
	11†	13.55	93.14	232.30	71.41	84.50					
Internal leakage	1*	0.02	4.83	18.22	6.72	4.91	-	56.0	56.0	56.0	
	1†	0.64	8.28	23.44	7.68	7.68					
Other	1*	0.02	4.83	18.22	6.72	4.91	-	4.0	4.0	4.0	
	1†	0.64	8.28	23.44	7.68	7.68					
Parameter deviation	1*	0.02	4.83	18.22	6.72	4.91	-	6.0	6.0	6.0	
	1†	0.64	8.28	23.44	7.68	7.68					
<b>Incipient</b>	<b>18*</b>	<b>24.22</b>	<b>89.39</b>	<b>188.13</b>	<b>51.89</b>	<b>88.35</b>	<b>7.9</b>	<b>1.0</b>	<b>8.6</b>	<b>36.0</b>	
	<b>18†</b>	<b>87.19</b>	<b>136.01</b>	<b>193.66</b>	<b>32.59</b>	<b>138.27</b>					
Abnormal instrument reading	5*	5.81	24.80	54.62	15.55	24.54	1.8	1.0	2.2	4.0	
	5†	8.82	36.96	80.99	22.99	38.41					
External leakage - Process medium	2*	0.31	9.99	30.35	10.46	9.82	21.0	6.0	21.0	36.0	
	2†	2.28	14.56	35.69	10.86	15.36					
External leakage - Utility medium	3*	4.07	14.78	30.95	8.50	14.72	23.5	12.0	19.7	24.0	
	3†	6.15	22.83	48.16	13.31	23.05					
Minor in-service problems	8*	17.58	39.41	68.29	15.71	39.27	1.4	1.0	5.4	30.0	
	8†	30.37	61.23	100.80	21.73	61.46					
<b>All modes</b>	<b>47*</b>	<b>91.36</b>	<b>232.89</b>	<b>427.22</b>	<b>104.56</b>	<b>230.69</b>	<b>10.7</b>	<b>1.0</b>	<b>22.9</b>	<b>167.0</b>	
	<b>47†</b>	<b>254.18</b>	<b>357.03</b>	<b>474.20</b>	<b>67.17</b>	<b>361.05</b>					
<b>Comments</b>											
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0: 10 <sup>0</sup>											

Taxonomy no 1.3.1.16		Item Machinery Pumps Centrifugal Oily water treatment								
Population 9	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1987		Operational time † 0.1467						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>90*</b> <b>90†</b>	<b>377.42</b> <b>511.23</b>	<b>453.01</b> <b>613.61</b>	<b>539.78</b> <b>731.14</b>	<b>453.01</b> <b>613.61</b>	<b>453.01</b> <b>613.61</b>	<b>12.1</b>	<b>2.0</b>	<b>23.9</b>	<b>66.0</b>
Breakdown	22*	74.96	110.74	158.12	110.74	110.74	15.4	18.0	30.9	60.0
External leakage - Process medium	22*	74.96	110.74	158.12	110.74	110.74	9.1	3.0	17.8	38.0
External leakage - Utility medium	19*	62.62	95.64	140.32	95.64	95.64	11.4	3.0	22.8	49.0
Fail to start on demand	1*	0.25	5.03	23.88	5.03	5.03	7.5	15.0	15.0	15.0
Low output	4*	6.87	20.13	46.08	20.13	20.13	14.0	15.0	28.0	45.0
Overheating	1*	0.25	5.03	23.88	5.03	5.03	22.5	45.0	45.0	45.0
Parameter deviation	1*	0.25	5.03	23.88	5.03	5.03	7.5	15.0	15.0	15.0
Spurious stop	7*	16.53	35.23	66.19	35.23	35.23	12.5	2.0	23.1	66.0
Structural deficiency	11*	31.06	55.37	91.66	55.37	55.37	11.6	8.0	23.3	36.0
Vibration	2*	1.79	10.07	31.69	10.07	10.07	-	-	-	-
<b>Degraded</b>	<b>84*</b> <b>84†</b>	<b>349.89</b> <b>473.93</b>	<b>422.81</b> <b>572.70</b>	<b>506.93</b> <b>686.64</b>	<b>422.81</b> <b>572.70</b>	<b>422.81</b> <b>572.70</b>	<b>5.8</b>	<b>1.0</b>	<b>10.6</b>	<b>75.0</b>
External leakage - Process medium	15*	46.53	75.50	116.25	75.50	75.50	7.0	2.0	12.4	40.0
External leakage - Utility medium	27*	95.92	135.90	187.41	135.90	135.90	4.1	1.0	7.7	24.0
Low output	5*	9.92	25.17	52.93	25.17	25.17	2.5	3.0	4.0	5.0
Noise	2*	1.79	10.07	31.69	10.07	10.07	25.0	25.0	50.0	75.0
Parameter deviation	7*	16.53	35.23	66.19	35.23	35.23	3.3	2.0	3.8	7.0
Structural deficiency	21*	70.82	105.70	152.21	105.70	105.70	5.8	1.0	10.7	29.0
Vibration	7*	16.53	35.23	66.19	35.23	35.23	10.2	18.0	20.3	22.0
<b>Incipient</b>	<b>53*</b> <b>53†</b>	<b>209.49</b> <b>283.76</b>	<b>266.77</b> <b>361.35</b>	<b>335.37</b> <b>454.27</b>	<b>266.77</b> <b>361.35</b>	<b>266.77</b> <b>361.35</b>	<b>2.3</b>	<b>1.0</b>	<b>2.8</b>	<b>10.0</b>
<b>Comments</b>										

(cont.)

Taxonomy no 1.3.1.16		Item Machinery Pumps Centrifugal Oily water treatment								
Population 9	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1987		Operational time † 0.1467						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Abnormal instrument reading	39*	147.61	196.30	256.40	196.30	196.30	2.2	1.0	2.3	6.0
	39†	199.94	265.90	347.30	265.90	265.90				
Minor in-service problems	14*	42.59	70.47	110.15	70.47	70.47	2.7	1.0	4.2	10.0
	14†	57.70	95.45	149.20	95.45	95.45				
<b>Unknown</b>	1*	<b>0.25</b>	<b>5.03</b>	<b>23.88</b>	<b>5.03</b>	<b>5.03</b>	<b>1.5</b>	<b>3.0</b>	<b>3.0</b>	<b>3.0</b>
	1†	<b>0.34</b>	<b>6.82</b>	<b>32.35</b>	<b>6.82</b>	<b>6.82</b>				
Unknown	1*	0.25	5.03	23.88	5.03	5.03	1.5	3.0	3.0	3.0
	1†	0.34	6.82	32.35	6.82	6.82				
<b>All modes</b>	<b>228*</b>	<b>1025.52</b>	<b>1147.62</b>	<b>1280.75</b>	<b>1147.62</b>	<b>1147.62</b>	<b>7.7</b>	<b>1.0</b>	<b>14.6</b>	<b>75.0</b>
	<b>228†</b>	<b>1389.10</b>	<b>1554.48</b>	<b>1734.80</b>	<b>1554.48</b>	<b>1554.48</b>				
<b>Comments</b>										

Taxonomy no 1.3.1.17		Item Machinery Pumps Centrifugal Sea water lift									
Population 33	Installations 7	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 976				
		Calendar time * 0.9527		Operational time † 0.8433							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	<b>39*</b> <b>39†</b>	<b>16.33</b>	<b>47.12</b>	<b>90.83</b>	<b>23.31</b>	<b>40.94</b>	<b>159.8</b>	<b>1.0</b>	<b>199.7</b>	<b>766.0</b>	
Breakdown	2* 2†	0.27 0.23	2.35 2.78	6.17 7.81	1.94 2.55	2.10 2.37	-	766.0	766.0	766.0	
External leakage - Process medium	8* 8†	0.22 0.13	10.01 12.01	30.84 39.23	10.84 14.29	8.40 9.49	88.9	7.0	105.5	444.0	
External leakage - Utility medium	2* 2†	0.06 0.05	2.60 3.08	8.02 9.66	2.82 3.45	2.10 2.37	52.8	34.0	57.0	80.0	
Fail to start on demand	8* 8†	0.60 0.35	7.91 9.25	22.49 27.90	7.38 9.49	8.40 9.49	230.3	2.0	196.7	510.0	
High output	1* 1†	0.00 0.00	1.08 1.45	5.53 5.90	2.40 2.23	1.05 1.19	-	1.0	1.0	1.0	
Internal leakage	1* 1†	0.00 0.00	1.08 1.45	5.53 5.90	2.40 2.23	1.05 1.19	-	36.0	36.0	36.0	
Low output	1* 1†	0.00 0.00	1.14 1.28	5.97 6.63	2.69 2.91	1.05 1.19	57.5	115.0	115.0	115.0	
Other	4* 4†	0.00 0.00	6.97 7.28	34.44 36.63	14.58 15.71	4.20 4.74	313.8	370.0	452.8	630.0	
Overheating	1* 1†	0.00 0.00	1.08 1.45	5.53 5.90	2.40 2.23	1.05 1.19	-	3.0	3.0	3.0	
Spurious stop	8* 8†	1.10 1.80	9.80 10.66	25.79 25.61	8.14 7.70	8.40 9.49	172.0	2.0	209.0	446.0	
Structural deficiency	1* 1†	0.00 0.00	1.14 1.28	5.97 6.63	2.69 2.91	1.05 1.19	15.0	15.0	15.0	15.0	
Vibration	2* 2†	0.00 0.00	2.16 3.22	8.87 15.61	3.37 6.46	2.10 2.37	-	250.0	285.0	320.0	
<b>Degraded</b>	<b>45*</b> <b>45†</b>	<b>5.97</b>	<b>64.47</b>	<b>176.93</b>	<b>57.19</b>	<b>47.23</b>	<b>19.9</b>	<b>2.0</b>	<b>19.4</b>	<b>157.0</b>	
External leakage - Process medium	8* 8†	1.26 1.75	11.11 12.01	29.14 29.95	9.19 9.20	8.40 9.49	7.8	2.0	8.3	20.0	
External leakage - Utility medium	13* 13†	0.01 0.03	14.44 16.14	60.29 64.98	23.02 24.42	13.65 15.42	14.0	3.0	12.3	28.0	
Internal leakage	1* 1†	0.00 0.00	1.25 1.62	5.09 7.26	1.92 2.88	1.05 1.19	2.0	2.0	2.0	2.0	
Low output	1* 1†	0.01 0.01	0.91 1.03	3.06 3.28	1.12 1.19	1.05 1.19	144.0	144.0	144.0	144.0	
Other	9* 9†	0.01 0.02	13.71 14.70	57.13 60.68	21.78 23.04	9.45 10.67	-	4.0	8.0	12.0	
Overheating	1* 1†	0.00 0.04	1.21 1.30	4.58 3.94	1.69 1.36	1.05 1.19	-	-	-	-	

Comments

(cont.)



Taxonomy no 1.3.1.17		Item Machinery Pumps Centrifugal Sea water lift								
Population 33	Installations 7	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 976			
		Calendar time * 0.9527		Operational time † 0.8433						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Parameter deviation	9* 9†	0.07 0.06	15.88 16.76	60.08 64.83	22.16 23.96	9.45 10.67	3.8	2.0	8.2	27.0
Structural deficiency	3* 3†	0.06 0.14	3.67 4.10	11.54 12.42	4.12 4.26	3.15 3.56	28.3	3.0	55.0	157.0
<b>Incipient</b>	<b>55* 55†</b>	<b>5.40 6.97</b>	<b>71.30 78.20</b>	<b>202.78 216.24</b>	<b>66.56 70.14</b>	<b>57.73 65.22</b>	<b>14.6</b>	<b>1.0</b>	<b>12.9</b>	<b>144.0</b>
Abnormal instrument reading	18* 18†	3.89 4.52	21.84 24.60	51.77 57.91	15.42 17.19	18.89 21.35	22.5	1.0	21.3	144.0
External leakage - Process medium	2* 2†	0.00 0.00	2.69 2.85	12.87 13.32	5.30 5.41	2.10 2.37	-	-	-	-
External leakage - Utility medium	11* 11†	0.53 0.85	10.58 12.39	31.69 35.78	10.58 11.81	11.55 13.04	17.4	1.0	14.7	67.0
Internal leakage	2* 2†	0.00 0.00	2.81 3.64	13.57 17.75	5.61 7.41	2.10 2.37	2.0	2.0	5.0	8.0
Minor in-service problems	18* 18†	0.04 0.03	25.15 25.96	102.05 107.13	38.50 40.68	18.89 21.35	3.8	2.0	5.8	12.0
Noise	1* 1†	0.00 0.00	1.44 1.56	6.63 6.87	2.66 2.69	1.05 1.19	4.0	4.0	4.0	4.0
Other	2* 2†	0.27 0.23	2.35 2.78	6.17 7.81	1.94 2.55	2.10 2.37	-	-	-	-
Structural deficiency	1* 1†	0.00 0.00	2.69 2.79	12.86 13.48	5.29 5.57	1.05 1.19	-	10.0	10.0	10.0
<b>Unknown</b>	<b>1* 1†</b>	<b>0.00 0.00</b>	<b>1.08 1.45</b>	<b>5.53 5.90</b>	<b>2.40 2.23</b>	<b>1.05 1.19</b>	<b>-</b>	<b>2.0</b>	<b>2.0</b>	<b>2.0</b>
Unknown	1* 1†	0.00 0.00	1.08 1.45	5.53 5.90	2.40 2.23	1.05 1.19	-	2.0	2.0	2.0
<b>All modes</b>	<b>140* 140†</b>	<b>32.93 42.35</b>	<b>185.36 206.31</b>	<b>439.69 472.19</b>	<b>131.04 137.96</b>	<b>146.95 166.02</b>	<b>75.0</b>	<b>1.0</b>	<b>81.7</b>	<b>766.0</b>
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 4.1 · 10 <sup>-3</sup>										

Taxonomy no 1.3.1.18		Item Machinery Pumps Centrifugal Water fire fighting									
Population 108	Installations 37	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 1060				
		Calendar time * 7.2284		Operational time † 0.1834							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
<b>Critical</b>	<b>11*</b> <b>11†</b>	<b>0.00</b>	<b>1.70</b>	<b>6.67</b>	<b>2.48</b>	<b>1.52</b>	<b>50.0</b>	<b>1.0</b>	<b>104.6</b>	<b>1025.0</b>	
Fail to start on demand	5*	0.00	0.74	3.49	1.42	0.69	3.6	1.0	12.8	29.0	
	5†	0.00	31.38	172.43	83.57	27.27					
Low output	1*	0.00	0.25	1.17	1.14	0.14	1.5	3.0	3.0	3.0	
	1†	0.00	25.80	137.19	90.97	5.45					
Overheating	1*	0.00	0.24	1.13	1.09	0.14	512.5	1025.0	1025.0	1025.0	
	1†	0.00	23.67	124.17	86.13	5.45					
Spurious stop	4*	0.00	0.54	2.98	1.41	0.55	4.5	12.0	14.8	21.0	
	4†	7.62	22.02	42.47	10.91	21.81					
<b>Degraded</b>	<b>35*</b> <b>35†</b>	<b>0.00</b>	<b>8.77</b>	<b>45.70</b>	<b>20.38</b>	<b>4.84</b>	<b>18.8</b>	<b>2.0</b>	<b>40.7</b>	<b>798.0</b>	
External leakage - Process medium	1*	0.00	0.25	1.17	1.14	0.14	1.0	2.0	2.0	2.0	
	1†	0.00	25.80	137.19	90.97	5.45					
External leakage - Utility medium	10*	0.00	3.38	18.76	9.62	1.38	7.1	2.0	14.2	30.0	
	10†	0.06	372.70	1679.89	666.78	54.53					
Fail to stop on demand	2*	0.00	0.49	2.77	1.57	0.28	3.3	6.0	6.5	7.0	
	2†	0.00	49.37	268.34	125.03	10.91					
Internal leakage	1*	0.00	0.24	1.13	1.09	0.14	2.5	5.0	5.0	5.0	
	1†	0.00	23.67	124.17	86.13	5.45					
Low output	15*	1.28	2.07	3.03	0.54	2.08	4.2	5.0	14.9	26.0	
	15†	20.95	82.44	177.21	49.66	81.80					
Minor in-service problems	1*	0.00	0.24	1.13	1.09	0.14	13.0	26.0	26.0	26.0	
	1†	0.00	23.67	124.17	86.13	5.45					
Other	3*	0.00	0.93	4.85	3.87	0.42	8.8	5.0	17.5	30.0	
	3†	0.00	98.94	544.74	270.97	16.36					
Overheating	1*	0.00	0.24	1.13	1.09	0.14	56.0	112.0	112.0	112.0	
	1†	0.00	23.67	124.17	86.13	5.45					
Structural deficiency	1*	0.00	0.24	1.13	1.09	0.14	399.0	798.0	798.0	798.0	
	1†	0.00	23.67	124.17	86.13	5.45					
<b>Incipient</b>	<b>87*</b> <b>87†</b>	<b>0.00</b>	<b>32.35</b>	<b>177.30</b>	<b>83.00</b>	<b>12.04</b>	<b>8.3</b>	<b>1.0</b>	<b>16.5</b>	<b>697.0</b>	
Abnormal instrument reading	40*	0.00	14.67	80.64	38.51	5.53	3.8	1.0	7.6	57.0	
	40†	2.22	1700.03	6962.93	2636.94	218.13					
Erratic output	1*	0.00	0.25	1.17	1.14	0.14	1.0	2.0	2.0	2.0	
	1†	0.00	25.80	137.19	90.97	5.45					
External leakage - Utility medium	6*	0.00	2.13	11.01	8.27	0.83	2.8	1.0	5.5	12.0	
	6†	0.00	240.50	1268.10	575.48	32.72					
Minor in-service problems	37*	0.00	13.47	74.05	35.07	5.12	5.0	1.0	9.8	42.0	
	37†	2.21	1555.54	6340.65	2396.72	201.77					
<b>Comments</b>											

(cont.)

Taxonomy no 1.3.1.18		Item Machinery Pumps Centrifugal Water fire fighting								
Population 108	Installations 37	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 1060			
		Calendar time * 7.2284			Operational time † 0.1834					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Other	3*	0.00	0.86	4.97	2.75	0.42	120.0	4.0	239.0	697.0
	3†	0.00	104.14	514.53	217.76	16.36				
All modes	133*	0.00	43.63	230.15	104.49	18.40	14.6	1.0	30.2	1025.0
	133†	12.76	4869.01	19166.04	7134.91	725.27				
Comments On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 9.4 · 10 <sup>-4</sup>										

Taxonomy no 1.3.1.19		Item Machinery Pumps Centrifugal Water injection									
Population 44	Installations 8	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 2310				
		Calendar time * 1.3310		Operational time † 1.1506							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	<b>147*</b> <b>147†</b>	<b>0.80</b>	<b>122.12</b>	<b>423.59</b>	<b>156.24</b>	<b>110.44</b>	<b>36.6</b>	<b>1.0</b>	<b>50.6</b>	<b>896.0</b>	
Breakdown	1* 1†	0.01 0.01	0.80 0.93	2.71 3.22	1.00 1.19	0.75 0.87	4.0	8.0	8.0	8.0	
Erratic output	2* 2†	0.22 0.27	1.44 1.66	3.53 4.05	1.07 1.23	1.50 1.74	19.8	11.0	39.5	68.0	
External leakage - Process medium	15* 15†	0.00 0.00	9.22 11.47	40.63 52.42	15.94 20.91	11.27 13.04	39.0	2.0	52.0	286.0	
External leakage - Utility medium	5* 5†	0.00 0.00	2.86 3.27	14.80 16.94	6.50 7.45	3.76 4.35	15.1	6.0	30.4	49.0	
Fail to start on demand	14* 14†	0.15 0.18	11.74 13.76	37.60 44.09	13.59 15.94	10.52 12.17	57.2	2.0	63.4	551.0	
Low output	2* 2†	0.00 0.00	1.78 2.05	8.69 10.10	3.65 4.26	1.50 1.74	1.5	3.0	3.0	3.0	
Noise	2* 2†	0.01 0.01	1.37 1.61	4.87 6.18	1.80 2.28	1.50 1.74	25.0	16.0	40.0	64.0	
Other	3* 3†	0.00 0.00	1.91 2.19	8.06 9.22	3.10 3.54	2.25 2.61	1.0	2.0	2.0	2.0	
Overheating	1* 1†	0.01 0.01	0.80 0.93	2.71 3.22	1.00 1.19	0.75 0.87	14.5	29.0	29.0	29.0	
Parameter deviation	13* 13†	0.00 0.00	9.86 11.38	44.57 51.70	17.71 20.58	9.77 11.30	13.0	1.0	24.5	88.0	
Spurious stop	63* 63†	0.27 0.27	61.24 68.60	228.86 263.13	84.47 96.92	47.33 54.76	23.6	1.0	29.9	622.0	
Structural deficiency	9* 9†	0.00 0.00	8.16 9.47	44.00 51.15	20.40 23.73	6.76 7.82	46.1	7.0	92.2	211.0	
Vibration	17* 17†	1.99 2.37	13.94 16.07	34.90 39.97	10.75 12.27	12.77 14.78	108.6	6.0	133.3	896.0	
<b>Degraded</b>	<b>144*</b> <b>144†</b>	<b>4.86</b>	<b>120.63</b>	<b>363.17</b>	<b>123.09</b>	<b>108.19</b>	<b>23.8</b>	<b>0.5</b>	<b>31.2</b>	<b>737.0</b>	
Abnormal instrument reading	2* 2†	0.00 0.00	2.17 2.28	10.88 11.45	4.66 4.90	1.50 1.74	15.0	10.0	15.0	20.0	
Erratic output	3* 3†	0.00 0.00	2.04 2.40	8.10 9.81	3.02 3.71	2.25 2.61	20.3	2.0	27.7	65.0	
External leakage - Process medium	12* 12†	3.65 3.77	9.48 11.22	17.53 21.90	4.33 5.68	9.02 10.43	32.5	4.0	53.4	278.0	
External leakage - Utility medium	42* 42†	4.44 4.68	32.31 37.36	81.56 96.04	25.23 29.96	31.56 36.50	17.2	1.0	25.7	219.0	
Fail to stop on demand	1* 1†	0.00 0.00	0.94 1.04	4.35 4.69	1.76 1.86	0.75 0.87	5.0	10.0	10.0	10.0	
<b>Comments</b>											

(cont.)

Taxonomy no 1.3.1.19		Item Machinery Pumps Centrifugal Water injection									
Population 44	Installations 8	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 2310				
		Calendar time * 1.3310			Operational time † 1.1506						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max	
Internal leakage	3* 3†	0.68 0.00	2.33 3.03	4.80 12.28	1.30 4.63	2.25 2.61	20.0	4.0	35.7	93.0	
Low output	7* 7†	0.04 0.02	4.80 5.76	16.39 22.24	6.03 8.22	5.26 6.08	1.8	0.5	1.9	4.0	
Noise	2* 2†	0.00 0.00	5.49 5.53	24.12 25.22	9.45 10.05	1.50 1.74	-	-	-	-	
Other	20* 20†	0.07 0.06	14.59 17.86	53.03 69.33	19.59 25.66	15.03 17.38	23.3	1.0	22.3	165.0	
Overheating	1* 1†	0.00 0.00	0.94 1.01	4.36 4.37	1.76 1.70	0.75 0.87	7.0	7.0	7.0	7.0	
Parameter deviation	34* 34†	0.00 0.00	30.30 35.44	165.32 192.70	77.21 89.80	25.54 29.55	5.8	1.0	10.2	67.0	
Structural deficiency	12* 12†	0.00 0.00	9.70 11.21	47.28 54.83	19.74 22.97	9.02 10.43	52.9	3.0	22.3	115.0	
Vibration	5* 5†	0.01 0.01	5.09 5.69	20.70 23.10	7.82 8.72	3.76 4.35	164.8	26.0	332.8	737.0	
<b>Incipient</b>	<b>367* 367†</b>	<b>84.43 94.78</b>	<b>298.43 339.42</b>	<b>619.31 707.38</b>	<b>169.05 193.69</b>	<b>275.73 318.98</b>	<b>9.6</b>	<b>0.5</b>	<b>15.7</b>	<b>213.5</b>	
Abnormal instrument reading	176* 176†	14.21 16.17	151.20 170.57	413.80 465.98	133.55 150.26	132.23 152.97	6.4	0.5	8.3	87.0	
Erratic output	3* 3†	0.61 0.69	2.24 2.58	4.72 5.45	1.30 1.51	2.25 2.61	5.8	3.0	11.7	16.0	
External leakage - Process medium	22* 22†	0.03 0.02	16.30 19.48	65.65 79.92	24.68 30.29	16.53 19.12	5.5	0.5	17.3	206.0	
External leakage - Utility medium	34* 34†	0.73 1.46	23.43 25.74	71.14 76.09	24.53 25.31	25.54 29.55	10.1	1.0	17.0	136.0	
Internal leakage	4* 4†	0.04 0.08	2.92 3.34	9.36 10.27	3.39 3.60	3.01 3.48	4.6	0.5	5.6	8.0	
Low output	1* 1†	0.00 0.00	0.69 0.83	3.39 4.34	1.44 1.94	0.75 0.87	2.0	2.0	2.0	2.0	
Minor in-service problems	61* 61†	0.74 0.75	60.53 68.79	194.85 223.97	70.59 81.52	45.83 53.02	7.7	0.5	12.5	111.0	
Noise	4* 4†	0.23 0.03	2.77 3.23	7.75 10.81	2.52 3.96	3.01 3.48	8.2	0.5	10.2	18.0	
Other	28* 28†	0.10 0.13	18.48 21.54	65.75 75.93	24.29 28.04	21.04 24.34	21.8	1.0	39.0	192.0	
Overheating	3* 3†	0.02 0.02	3.09 3.21	11.28 11.09	4.17 4.09	2.25 2.61	19.5	3.0	19.5	36.0	
Parameter deviation	20* 20†	0.00 0.00	11.06 13.70	50.65 64.18	20.24 26.11	15.03 17.38	9.7	2.0	15.9	81.0	
<b>Comments</b>											

(cont.)

Taxonomy no 1.3.1.19		Item Machinery Pumps Centrifugal Water injection									
Population 44	Installations 8	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 2310				
		Calendar time * 1.3310		Operational time † 1.1506							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
Structural deficiency	8*	0.20	5.79	17.51	5.99	6.01	52.6	1.0	92.8	213.5	
	8†	0.24	6.63	20.03	6.84	6.95					
Vibration	3*	0.04	2.13	6.60	2.33	2.25	24.5	1.0	59.0	96.0	
	3†	0.02	2.44	8.00	2.92	2.61					
<b>Unknown</b>	1*	<b>0.00</b>	<b>0.94</b>	<b>4.35</b>	<b>1.76</b>	<b>0.75</b>	<b>12.0</b>	<b>24.0</b>	<b>24.0</b>	<b>24.0</b>	
	1†	<b>0.00</b>	<b>1.04</b>	<b>4.69</b>	<b>1.86</b>	<b>0.87</b>					
Unknown	1*	0.00	0.94	4.35	1.76	0.75	12.0	24.0	24.0	24.0	
	1†	0.00	1.04	4.69	1.86	0.87					
<b>All modes</b>	<b>659*</b>	<b>62.60</b>	<b>541.32</b>	<b>1412.51</b>	<b>443.69</b>	<b>495.12</b>	<b>19.0</b>	<b>0.5</b>	<b>27.0</b>	<b>896.0</b>	
	<b>659†</b>	<b>69.21</b>	<b>619.88</b>	<b>1632.05</b>	<b>515.57</b>	<b>572.77</b>					
<b>Comments</b>											
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 3.0 10 <sup>-3</sup>											

Taxonomy no 1.3.1.20		Item Machinery Pumps Centrifugal Well servicing									
Population 3	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0919		Operational time † 0.0919							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
All modes	0* 0†	0.02 0.02	5.19 5.42	19.92 20.81	7.34 7.66	0.00 0.00	-	-	-	-	
Comments											

Taxonomy no 1.3.2		Item Machinery Pumps Reciprocating								
Population 98	Installations 9	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 860			
		Calendar time * 5.0327			Operational time † 2.8960					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>46*</b> <b>46†</b>	<b>4.67</b> <b>11.38</b>	<b>40.61</b> <b>67.24</b>	<b>106.11</b> <b>161.62</b>	<b>33.36</b> <b>48.60</b>	<b>9.14</b> <b>15.88</b>	<b>8.3</b>	<b>2.0</b>	<b>13.9</b>	<b>50.0</b>
Breakdown	5*	0.05	5.00	16.33	5.95	0.99	12.0	4.0	26.0	50.0
	5†	0.15	7.49	23.23	8.22	1.73				
External leakage - Process medium	9*	0.39	6.24	18.24	6.04	1.79	4.2	2.0	6.1	16.0
	9†	1.10	10.50	28.08	8.95	3.11				
Fail to start on demand	7*	0.39	10.22	30.79	10.47	1.39	16.5	2.0	17.4	48.0
	7†	0.88	15.05	44.35	14.74	2.42				
Internal leakage	5*	0.00	2.78	11.47	4.35	0.99	3.0	3.0	6.0	10.0
	5†	0.05	7.60	26.17	9.65	1.73				
Low output	4*	0.04	1.85	5.74	2.04	0.79	6.3	3.0	10.8	19.0
	4†	0.03	3.54	12.11	4.46	1.38				
Noise	2*	0.00	2.10	9.40	3.71	0.40	20.0	40.0	40.0	40.0
	2†	0.00	3.46	14.38	5.47	0.69				
Parameter deviation	1*	0.01	1.99	7.79	2.89	0.20	-	26.0	26.0	26.0
	1†	0.01	2.86	10.80	3.98	0.35				
Spurious stop	10*	0.22	5.73	17.29	5.88	1.99	9.5	2.0	16.6	40.0
	10†	0.69	8.47	23.81	7.78	3.45				
Structural deficiency	2*	0.06	0.56	1.52	0.49	0.40	4.5	6.0	6.0	6.0
	2†	0.02	0.75	2.27	0.78	0.69				
Unknown	1*	0.00	0.17	0.55	0.20	0.20	-	-	-	-
	1†	0.00	0.30	0.96	0.35	0.35				
<b>Degraded</b>	<b>211*</b> <b>211†</b>	<b>16.33</b> <b>43.53</b>	<b>257.64</b> <b>410.27</b>	<b>751.38</b> <b>1093.53</b>	<b>248.87</b> <b>348.00</b>	<b>41.93</b> <b>72.86</b>	<b>4.0</b>	<b>0.3</b>	<b>10.6</b>	<b>112.0</b>
Erratic output	13*	1.25	13.18	36.01	11.62	2.58	4.0	4.0	16.3	32.0
	13†	4.52	27.15	65.57	19.78	4.49				
External leakage - Process medium	103*	2.55	112.66	347.06	121.96	20.47	4.5	1.0	8.5	31.0
	103†	3.37	155.68	480.69	169.33	35.57				
External leakage - Utility medium	11*	0.90	15.72	46.41	15.43	2.19	-	4.0	11.0	18.0
	11†	3.84	36.64	97.94	31.22	3.80				
Internal leakage	42*	1.91	60.81	184.58	63.59	8.35	3.5	0.3	7.3	40.0
	42†	10.92	107.68	289.98	92.81	14.50				
Low output	6*	0.10	7.74	24.76	8.95	1.19	3.0	3.0	8.5	16.0
	6†	1.00	14.02	40.24	13.25	2.07				
Noise	10*	0.02	3.99	14.63	5.40	1.99	4.3	1.0	22.5	112.0
	10†	0.06	6.10	20.22	7.40	3.45				
Other	15*	0.53	20.99	64.28	22.43	2.98	-	3.0	23.5	61.0
	15†	0.94	29.48	89.43	30.78	5.18				
Parameter deviation	6*	0.11	14.32	48.64	17.89	1.19	-	3.0	11.8	24.0
	6†	0.14	19.74	67.58	24.89	2.07				
<b>Comments</b>										

(cont.)



Taxonomy no 1.3.2		Item Machinery Pumps Reciprocating								
Population 98	Installations 9	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 860			
		Calendar time *		Operational time †						
		5.0327		2.8960						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Structural deficiency	5*	0.01	1.58	5.32	1.95	0.99	4.0	3.0	4.0	5.0
	5†	0.82	1.93	3.42	0.81	1.73				
<b>Incipient</b>	<b>172*</b>	<b>8.36</b>	<b>113.08</b>	<b>322.79</b>	<b>106.11</b>	<b>34.18</b>	<b>3.2</b>	<b>1.0</b>	<b>11.6</b>	<b>169.0</b>
	<b>172†</b>	<b>13.34</b>	<b>160.65</b>	<b>449.98</b>	<b>146.79</b>	<b>59.39</b>				
Abnormal instrument reading	97*	0.82	45.19	141.03	50.15	19.27	3.6	2.0	13.7	169.0
	97†	1.27	64.86	201.48	71.37	33.49				
Erratic output	3*	0.01	3.67	14.33	5.32	0.60	-	24.0	25.0	26.0
	3†	0.06	7.28	24.69	9.08	1.04				
External leakage - Process medium	10*	0.06	3.30	10.35	3.69	1.99	1.0	1.0	4.8	9.0
	10†	0.44	4.90	13.55	4.39	3.45				
External leakage - Utility medium	17*	0.85	3.39	7.31	2.05	3.38	3.0	2.0	8.4	32.0
	17†	1.96	5.79	11.25	2.91	5.87				
Minor in-service problems	30*	1.53	44.70	135.27	46.34	5.96	2.2	2.0	5.5	14.0
	30†	1.96	61.42	186.29	64.11	10.36				
Noise	7*	0.26	1.46	3.46	1.03	1.39	3.0	6.0	9.0	12.0
	7†	0.02	2.49	8.69	3.21	2.42				
Other	5*	0.21	3.72	11.00	3.66	0.99	4.0	3.0	47.7	130.0
	5†	0.46	5.85	16.55	5.42	1.73				
Parameter deviation	1*	0.01	1.99	7.79	2.89	0.20	-	20.0	20.0	20.0
	1†	0.01	2.86	10.80	3.98	0.35				
Structural deficiency	1*	0.01	1.99	7.79	2.89	0.20	-	4.0	4.0	4.0
	1†	0.01	2.86	10.80	3.98	0.35				
Vibration	1*	0.00	0.57	2.48	0.96	0.20	-	-	-	-
	1†	0.00	0.73	2.65	0.98	0.35				
<b>Unknown</b>	<b>9*</b>	<b>1.45</b>	<b>13.97</b>	<b>37.41</b>	<b>11.94</b>	<b>1.79</b>	<b>-</b>	<b>1.0</b>	<b>12.4</b>	<b>52.0</b>
	<b>9†</b>	<b>4.65</b>	<b>28.08</b>	<b>67.88</b>	<b>20.49</b>	<b>3.11</b>				
Noise	2*	0.02	4.42	15.95	5.89	0.40	-	6.0	29.0	52.0
	2†	0.04	6.24	22.11	8.17	0.69				
Other	2*	0.00	2.68	11.32	4.35	0.40	-	8.0	11.0	14.0
	2†	0.02	5.37	20.13	7.43	0.69				
Unknown	4*	0.01	4.62	18.57	6.98	0.79	-	1.0	1.3	2.0
	4†	0.21	13.26	41.71	14.92	1.38				
Vibration	1*	0.01	1.99	7.79	2.89	0.20	-	15.0	15.0	15.0
	1†	0.01	2.86	10.80	3.98	0.35				
<b>All modes</b>	<b>438*</b>	<b>36.27</b>	<b>430.87</b>	<b>1203.92</b>	<b>392.32</b>	<b>87.03</b>	<b>4.6</b>	<b>0.3</b>	<b>11.3</b>	<b>169.0</b>
	<b>438†</b>	<b>80.35</b>	<b>672.63</b>	<b>1743.97</b>	<b>546.05</b>	<b>151.24</b>				

**Comments**

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 4.7 · 10<sup>-3</sup>

**Maintainable item versus failure mode, to be continued**

**Item: Pumps - Reciprocating**

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driven unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.14
Coupling to driver	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00
Cylinder liner	0.00	0.23	0.08	0.46	0.00	0.00	0.00	0.08	0.23	0.00
Diaphragm	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.23	0.00	0.00
Filter(s)	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gearbox/var.drive	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
Instrument, flow	18.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, level	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	1.60	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.68	0.00
Piping	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.08	0.00	0.00
Piston(s)	0.00	0.23	3.96	0.46	0.00	0.00	0.00	0.00	0.00	0.00
Pulsation damper	0.00	0.00	1.37	0.23	0.68	0.00	0.00	1.03	0.00	0.23
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Seals	0.00	0.00	9.67	3.20	0.00	0.00	0.00	0.53	0.23	0.34
Shaft	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Subunit	0.00	0.23	0.23	0.00	0.00	0.23	0.00	0.23	0.23	0.00
Unknown	1.14	0.46	3.42	1.37	0.91	0.68	0.00	0.46	0.46	1.60
Valves	0.23	0.00	8.68	0.46	1.60	0.00	0.00	7.53	0.46	1.03
Total	22.15	1.14	27.85	6.39	3.65	1.60	0.00	10.73	2.28	4.79

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

Item: Pumps - Reciprocating

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.46
Bearing	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Control unit	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.46
Coupling to driven unit	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	1.37
Coupling to driver	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.23	0.00	1.37
Cylinder liner	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00	1.75
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.57
Filter(s)	0.00	0.00	0.00	0.91	0.00	0.00	0.00	0.00	0.00	1.14
Gearbox/var.drive	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46
Instrument, flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.26
Instrument, general	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.23	0.00	1.14
Instrument, level	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.46
Instrument, pressure	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	2.05
Oil	0.00	0.00	0.00	1.37	0.00	0.00	0.00	0.00	0.00	1.37
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.26
Piping	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.64
Pulsation damper	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Seals	0.00	0.23	0.00	0.00	0.68	0.00	0.00	0.00	0.00	14.88
Shaft	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.23	0.00	0.68
Subunit	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.37
Unknown	0.00	2.28	0.23	2.74	0.91	0.00	1.14	0.23	0.46	18.49
Valves	0.00	0.91	0.91	0.46	0.00	0.00	0.00	0.34	0.00	22.60
Total	0.00	5.02	1.83	6.85	1.83	0.00	1.14	2.28	0.46	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Pumps - Reciprocating

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00
Breakage	0.68	0.46	1.83	0.23	0.46	0.23	0.00	0.23	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.14
Combined causes	0.00	0.23	0.46	0.00	0.00	0.00	0.00	0.23	0.00	0.23
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	0.23	0.46	0.00	0.00	0.00	0.00
External influence - general	0.23	0.00	1.83	0.00	0.00	0.00	0.00	0.46	0.00	0.00
Fatigue	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	1.14	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	2.05	1.83	0.46	0.00	0.00	0.68	0.68	0.00
Looseness	0.00	0.00	0.46	0.00	0.00	0.23	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.23	0.23	0.00	0.00	0.68	0.00	0.00
Mechanical Failure - general	0.00	0.46	7.31	0.46	1.14	0.00	0.00	4.11	0.68	0.68
Misc. external influences	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.23	0.00	0.00
No signal/indication/alarm	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	17.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00
Short circuiting	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
Software failure	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00
Sticking	0.23	0.00	0.23	0.00	0.00	0.00	0.00	0.23	0.00	1.14
Unknown	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.68
Vibration	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	13.01	3.65	0.46	0.00	0.00	3.88	0.00	0.91
Total	22.15	1.14	27.85	6.39	3.65	1.60	0.00	10.73	2.28	4.79

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

Item: Pumps - Reciprocating

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	1.37
Breakage	0.00	0.46	0.00	0.46	0.00	0.00	0.00	0.91	0.00	5.94
Clearance/ alignment failure	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	1.37
Combined causes	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.37
Contamination	0.00	0.23	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.46
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.23
Corrosion	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.68
Electrical failure - general	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.23	0.00	1.14
External influence - general	0.00	0.00	0.00	2.05	0.00	0.00	0.00	0.00	0.00	4.57
Fatigue	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91
Instrument failure - general	0.00	0.23	0.46	0.46	0.00	0.00	0.00	0.00	0.00	2.51
Leakage	0.00	0.23	0.23	0.23	0.00	0.00	0.00	0.00	0.00	6.39
Looseness	0.00	0.00	0.00	0.46	0.23	0.00	0.00	0.00	0.00	1.37
Material failure - general	0.00	0.00	0.00	0.23	0.68	0.00	0.00	0.00	0.00	2.05
Mechanical Failure - general	0.00	2.05	0.68	0.68	0.68	0.00	0.46	0.00	0.23	19.63
Misc. external influences	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.91
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.68
Out of adjustment	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.23	0.00	18.72
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Sticking	0.00	0.46	0.00	0.23	0.00	0.00	0.00	0.00	0.00	2.51
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00	1.83
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Wear	0.00	0.91	0.00	0.91	0.00	0.00	0.00	0.46	0.00	24.20
Total	0.00	5.02	1.83	6.85	1.83	0.00	1.14	2.28	0.46	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 1.3.2.1		Item Machinery Pumps Reciprocating Chemical injection								
Population 35	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 759			
		Calendar time * 1.1667		Operational time † 1.0942						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>20*</b> <b>20†</b>	<b>8.74</b> <b>13.58</b>	<b>78.88</b> <b>105.34</b>	<b>208.08</b> <b>269.32</b>	<b>65.81</b> <b>83.81</b>	<b>17.14</b> <b>18.28</b>	<b>4.6</b>	<b>2.0</b>	<b>11.8</b>	<b>50.0</b>
Breakdown	2* 2†	0.58 1.33	13.32 18.16	40.01 51.90	13.49 17.07	1.71 1.83	-	4.0	27.0	50.0
External leakage - Process medium	4* 4†	0.60 1.19	12.66 17.16	37.97 49.44	12.72 16.31	3.43 3.66	3.5	2.0	3.3	4.0
Fail to start on demand	4* 4†	1.63 2.82	21.61 29.18	61.47 79.43	20.18 25.56	3.43 3.66	-	2.0	7.0	16.0
Low output	2* 2†	0.06 0.05	2.00 2.26	6.08 7.01	2.10 2.48	1.71 1.83	9.5	15.0	17.0	19.0
Parameter deviation	1* 1†	0.11 0.33	5.99 8.23	18.62 24.77	6.60 8.40	0.86 0.91	-	26.0	26.0	26.0
Spurious stop	5* 5†	1.39 2.04	14.74 19.60	40.33 52.45	13.02 16.73	4.29 4.57	2.0	2.0	12.8	31.0
Structural deficiency	2* 2†	0.15 0.18	1.51 1.62	4.09 4.29	1.32 1.36	1.71 1.83	4.5	6.0	6.0	6.0
<b>Degraded</b>	<b>121*</b> <b>121†</b>	<b>69.24</b> <b>109.93</b>	<b>663.94</b> <b>889.47</b>	<b>1776.74</b> <b>2292.20</b>	<b>566.71</b> <b>715.83</b>	<b>103.71</b> <b>110.58</b>	<b>4.0</b>	<b>1.0</b>	<b>10.6</b>	<b>112.0</b>
Erratic output	8* 8†	0.64 0.91	14.75 18.21	44.33 54.53	14.95 18.21	6.86 7.31	4.0	4.0	9.6	17.0
External leakage - Process medium	53* 53†	30.94 49.39	320.18 430.32	871.22 1125.08	280.38 353.85	45.43 48.44	-	1.0	8.3	31.0
External leakage - Utility medium	4* 4†	1.26 1.99	15.03 20.03	42.03 54.21	13.70 17.39	3.43 3.66	-	4.0	8.0	12.0
Internal leakage	25* 25†	14.32 23.57	160.15 215.84	442.60 571.35	143.52 181.09	21.43 22.85	-	1.0	6.8	29.0
Low output	3* 3†	1.18 2.35	20.73 28.20	61.26 78.93	20.37 25.74	2.57 2.74	-	6.0	12.0	16.0
Noise	3* 3†	0.98 1.71	14.04 18.95	40.43 52.29	13.33 16.94	2.57 2.74	-	15.0	63.5	112.0
Other	14* 14†	6.44 10.01	58.83 78.07	155.62 199.81	49.30 62.21	12.00 12.79	-	3.0	22.7	61.0
Parameter deviation	6* 6†	2.96 5.45	43.08 58.44	124.31 160.20	41.03 51.75	5.14 5.48	-	3.0	11.8	24.0
Structural deficiency	5* 5†	1.02 1.09	4.10 4.45	8.89 9.67	2.51 2.73	4.29 4.57	4.0	3.0	4.0	5.0
<b>Incipient</b>	<b>65*</b> <b>65†</b>	<b>34.45</b> <b>55.01</b>	<b>297.12</b> <b>394.91</b>	<b>774.78</b> <b>994.19</b>	<b>243.26</b> <b>307.09</b>	<b>55.71</b> <b>59.40</b>	<b>2.5</b>	<b>2.0</b>	<b>12.0</b>	<b>169.0</b>
Abnormal instrument reading	25* 25†	13.81 21.76	135.30 181.26	363.83 469.54	116.36 146.96	21.43 22.85	-	2.0	20.0	169.0
<b>Comments</b>										

(cont.)

Taxonomy no 1.3.2.1		Item Machinery Pumps Reciprocating Chemical injection								
Population 35	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 759			
		Calendar time * 1.1667		Operational time † 1.0942						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Process medium	4*	0.60	9.51	27.77	9.20	3.43		4.0	6.0	9.0
	4†	0.87	12.12	34.75	11.44	3.66				
External leakage - Utility medium	3*	0.00	4.51	18.91	7.24	2.57		2.0	13.3	32.0
	3†	0.00	5.32	22.46	8.63	2.74				
Minor in-service problems	25*	13.15	121.83	323.39	102.67	21.43	2.0	2.0	5.7	14.0
	25†	20.76	162.68	416.74	129.80	22.85				
Noise	2*	0.01	3.03	12.15	4.56	1.71		12.0	12.0	12.0
	2†	0.01	3.58	14.52	5.47	1.83				
Other	3*	0.28	3.45	9.71	3.17	2.57	3.0	3.0	3.0	3.0
	3†	0.18	4.04	12.11	4.07	2.74				
Parameter deviation	1*	0.11	5.99	18.62	6.60	0.86		20.0	20.0	20.0
	1†	0.33	8.23	24.77	8.40	0.91				
Structural deficiency	1*	0.11	5.99	18.62	6.60	0.86		4.0	4.0	4.0
	1†	0.33	8.23	24.77	8.40	0.91				
Vibration	1*	0.01	1.41	4.93	1.82	0.86				
	1†	0.01	1.69	6.14	2.27	0.91				
<b>Unknown</b>	4*	<b>1.25</b>	<b>20.58</b>	<b>60.33</b>	<b>20.02</b>	<b>3.43</b>		<b>6.0</b>	<b>24.3</b>	<b>52.0</b>
	4†	<b>2.36</b>	<b>27.92</b>	<b>77.93</b>	<b>25.38</b>	<b>3.66</b>				
Noise	2*	0.58	13.32	40.01	13.49	1.71		6.0	29.0	52.0
	2†	1.33	18.16	51.90	17.07	1.83				
Unknown	1*	0.01	0.77	2.40	0.86	0.86				
	1†	0.01	0.82	2.56	0.91	0.91				
Vibration	1*	0.11	5.99	18.62	6.60	0.86		15.0	15.0	15.0
	1†	0.33	8.23	24.77	8.40	0.91				
<b>All modes</b>	210*	<b>117.60</b>	<b>1069.01</b>	<b>2824.79</b>	<b>894.36</b>	<b>180.00</b>	<b>4.0</b>	<b>1.0</b>	<b>11.3</b>	<b>169.0</b>
	210†	<b>187.62</b>	<b>1428.28</b>	<b>3638.66</b>	<b>1130.43</b>	<b>191.91</b>				
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 5.3·10 <sup>-3</sup>										

Taxonomy no 1.3.2.2		Item Machinery Pumps Reciprocating Gas processing									
Population 51	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 90				
		Calendar time * 3.6030		Operational time † 1.6922							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	<b>14*</b>	<b>0.63</b>	<b>3.36</b>	<b>7.86</b>	<b>2.33</b>	<b>3.89</b>	<b>6.9</b>	<b>2.0</b>	<b>12.1</b>	<b>40.0</b>	
	<b>14†</b>	<b>1.29</b>	<b>7.09</b>	<b>16.72</b>	<b>4.97</b>	<b>8.27</b>					
Breakdown	2*	0.09	0.54	1.30	0.39	0.56	-	-	-	-	
	2†	0.19	1.14	2.76	0.84	1.18					
External leakage - Process medium	3*	0.19	0.80	1.76	0.50	0.83	3.0	2.0	5.0	8.0	
	3†	0.40	1.71	3.75	1.06	1.77					
Internal leakage	3*	0.19	0.80	1.76	0.50	0.83	3.0	3.0	3.0	3.0	
	3†	0.40	1.71	3.75	1.06	1.77					
Low output	1*	0.01	0.27	0.81	0.28	0.28	3.0	3.0	3.0	3.0	
	1†	0.02	0.57	1.73	0.59	0.59					
Spurious stop	4*	0.25	1.06	2.33	0.67	1.11	12.0	3.0	23.0	40.0	
	4†	0.52	2.25	4.97	1.42	2.36					
Unknown	1*	0.01	0.27	0.81	0.28	0.28	-	-	-	-	
	1†	0.02	0.57	1.73	0.59	0.59					
<b>Degraded</b>	<b>71*</b>	<b>5.51</b>	<b>31.89</b>	<b>76.24</b>	<b>22.84</b>	<b>19.71</b>	<b>3.8</b>	<b>0.3</b>	<b>9.7</b>	<b>40.0</b>	
	<b>71†</b>	<b>12.25</b>	<b>64.20</b>	<b>149.73</b>	<b>44.23</b>	<b>41.96</b>					
Erratic output	3*	0.09	18.83	69.22	25.57	0.83	-	24.0	26.7	32.0	
	3†	0.18	37.63	138.47	51.15	1.77					
External leakage - Process medium	47*	1.11	11.23	30.40	9.75	13.04	3.9	4.0	8.1	21.0	
	47†	2.58	23.58	62.38	19.76	27.77					
Internal leakage	11*	0.54	2.71	6.24	1.83	3.05	3.5	0.3	5.7	40.0	
	11†	1.12	5.73	13.27	3.90	6.50					
Low output	2*	0.09	0.54	1.30	0.39	0.56	3.0	6.0	6.0	6.0	
	2†	0.19	1.14	2.76	0.84	1.18					
Noise	7*	0.39	1.79	4.03	1.16	1.94	4.3	1.0	8.8	21.0	
	7†	0.82	3.80	8.58	2.48	4.14					
Other	1*	0.00	4.17	17.69	6.81	0.28	-	32.0	32.0	32.0	
	1†	0.01	8.34	35.34	13.60	0.59					
<b>Incipient</b>	<b>101*</b>	<b>8.57</b>	<b>26.79</b>	<b>53.26</b>	<b>14.04</b>	<b>28.03</b>	<b>3.2</b>	<b>1.0</b>	<b>11.9</b>	<b>130.0</b>	
	<b>101†</b>	<b>19.11</b>	<b>55.93</b>	<b>108.38</b>	<b>27.94</b>	<b>59.68</b>					
Abnormal instrument reading	72*	5.45	15.43	29.53	7.53	19.98	3.6	2.0	6.7	8.0	
	72†	9.22	31.41	64.38	17.41	42.55					
Erratic output	3*	0.06	12.48	45.51	16.81	0.83	-	24.0	25.0	26.0	
	3†	0.12	24.94	90.94	33.60	1.77					
External leakage - Process medium	6*	0.35	1.55	3.47	1.00	1.67	1.0	1.0	1.0	1.0	
	6†	0.73	3.30	7.39	2.13	3.55					
External leakage - Utility medium	13*	0.60	3.14	7.32	2.16	3.61	2.3	3.0	3.8	4.0	
	13†	1.24	6.64	15.58	4.61	7.68					
Minor in-service problems	1*	0.01	0.27	0.81	0.28	0.28	-	-	-	-	
	1†	0.02	0.57	1.73	0.59	0.59					
<b>Comments</b>											

(cont.)



Taxonomy no 1.3.2.2		Item Machinery Pumps Reciprocating Gas processing								
Population 51	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 90			
		Calendar time * 3.6030		Operational time † 1.6922						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Noise	5* 5†	0.30 0.63	1.31 2.78	2.91 6.19	0.83 1.77	1.39 2.95	3.0	6.0	6.0	6.0
Other	1*	0.03	6.14	22.86	8.44	0.28	-	130.0	130.0	130.0
	1†	0.05	12.26	45.69	16.87	0.59	-			
Unknown	2*	<b>0.01</b>	<b>8.40</b>	<b>35.74</b>	<b>13.78</b>	<b>0.56</b>	-	<b>8.0</b>	<b>11.0</b>	<b>14.0</b>
	2†	<b>0.01</b>	<b>16.80</b>	<b>71.45</b>	<b>27.54</b>	<b>1.18</b>	-			
Other	2*	0.01	8.40	35.74	13.78	0.56	-	8.0	11.0	14.0
	2†	0.01	16.80	71.45	27.54	1.18	-			
All modes	188*	<b>24.71</b>	<b>67.20</b>	<b>126.67</b>	<b>31.84</b>	<b>52.18</b>	<b>3.9</b>	<b>0.3</b>	<b>10.8</b>	<b>130.0</b>
	188†	<b>54.31</b>	<b>136.24</b>	<b>248.22</b>	<b>60.33</b>	<b>111.10</b>				
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0· 10 <sup>0</sup>										

Taxonomy no 1.3.2.3		Item Machinery Pumps Reciprocating Gas treatment								
Population 9	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 11			
		Calendar time * 0.2104			Operational time † 0.1089					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>12*</b> <b>12†</b>	<b>29.50</b> <b>50.47</b>	<b>54.36</b> <b>107.19</b>	<b>85.35</b> <b>181.01</b>	<b>17.18</b> <b>40.37</b>	<b>57.03</b> <b>110.20</b>	<b>14.6</b>	<b>5.0</b>	<b>19.7</b>	<b>48.0</b>
Breakdown	1* 1†	0.03 0.12	4.27 8.07	14.87 25.56	5.48 9.18	4.75 9.18	12.0	24.0	24.0	24.0
External leakage - Process medium	2* 2†	1.24 0.25	9.24 19.41	23.43 62.18	7.26 22.48	9.50 18.37	8.0	10.0	13.0	16.0
Fail to start on demand	3* 3†	1.40 0.25	12.61 21.52	33.26 69.49	10.52 25.21	14.26 27.55	16.5	18.0	33.0	48.0
Internal leakage	2* 2†	0.09 0.05	9.95 27.73	33.21 111.95	12.18 42.13	9.50 18.37	-	5.0	7.5	10.0
Low output	1* 1†	0.31 0.06	4.91 12.60	14.34 45.73	4.75 16.90	4.75 9.18	-	6.0	6.0	6.0
Noise	2* 2†	0.04 0.28	8.05 15.19	29.70 47.33	10.97 16.81	9.50 18.37	20.0	40.0	40.0	40.0
Spurious stop	1* 1†	0.03 0.12	4.27 8.07	14.87 25.56	5.48 9.18	4.75 9.18	-	-	-	-
<b>Degraded</b>	<b>19*</b> <b>19†</b>	<b>17.75</b> <b>31.52</b>	<b>120.10</b> <b>268.51</b>	<b>298.45</b> <b>698.29</b>	<b>91.56</b> <b>218.91</b>	<b>90.29</b> <b>174.49</b>	<b>6.7</b>	<b>3.0</b>	<b>12.3</b>	<b>40.0</b>
Erratic output	2* 2†	0.04 0.06	16.52 34.24	65.22 137.59	24.31 51.67	9.50 18.37	-	14.0	17.5	21.0
External leakage - Process medium	3* 3†	1.40 0.25	12.61 21.52	33.26 69.49	10.52 25.21	14.26 27.55	6.7	6.0	13.3	24.0
External leakage - Utility medium	7* 7†	0.23 0.27	33.04 91.64	113.26 357.96	41.72 132.86	33.26 64.29	-	6.0	12.0	18.0
Internal leakage	6* 6†	0.16 0.20	54.37 110.28	212.27 443.88	78.77 166.80	28.51 55.10	-	4.0	12.0	40.0
Low output	1* 1†	0.02 0.04	7.20 15.27	28.29 60.48	10.52 22.56	4.75 9.18	-	3.0	3.0	3.0
<b>Incipient</b>	<b>6*</b> <b>6†</b>	<b>0.11</b> <b>3.77</b>	<b>22.13</b> <b>42.25</b>	<b>80.55</b> <b>116.79</b>	<b>29.76</b> <b>37.87</b>	<b>28.51</b> <b>55.10</b>	<b>3.3</b>	<b>2.0</b>	<b>6.7</b>	<b>12.0</b>
External leakage - Utility medium	1* 1†	0.03 0.12	4.27 8.07	14.87 25.56	5.48 9.18	4.75 9.18	6.0	12.0	12.0	12.0
Minor in-service problems	4* 4†	0.34 9.06	15.78 32.28	48.74 67.16	17.18 18.37	19.01 36.73	2.3	2.0	4.5	6.0
Other	1* 1†	0.03 0.12	4.27 8.07	14.87 25.56	5.48 9.18	4.75 9.18	5.0	10.0	10.0	10.0
<b>Unknown</b>	<b>3*</b> <b>3†</b>	<b>0.06</b> <b>0.05</b>	<b>14.87</b> <b>42.58</b>	<b>57.21</b> <b>175.97</b>	<b>21.08</b> <b>66.85</b>	<b>14.26</b> <b>27.55</b>	<b>-</b>	<b>1.0</b>	<b>1.3</b>	<b>2.0</b>
Unknown	3* 3†	0.06 0.05	14.87 42.58	57.21 175.97	21.08 66.85	14.26 27.55	-	1.0	1.3	2.0
<b>Comments</b>										

(cont.)

Taxonomy no 1.3.2.3		Item Machinery Pumps Reciprocating Gas treatment									
Population 9	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 11				
		Calendar time * 0.2104		Operational time † 0.1089							
Failure mode		No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
			Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes		40* 40†	126.40 208.70	195.09 426.04	275.92 705.84	45.75 153.45	190.09 367.34	8.1	1.0	12.3	48.0
Comments On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10 <sup>0</sup>											

<b>Taxonomy no</b> 1.3.2.4		<b>Item</b> Machinery Pumps Reciprocating Main power								
<b>Population</b> 3	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>			
		<b>Calendar time *</b> 0.0526			<b>Operational time †</b> 0.0007					
<b>Failure mode</b>	<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours)</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
		<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/τ</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>	0 <sup>*</sup> 0 <sup>†</sup>	0.04 1.36	9.29 348.59	35.69 1338.59	13.15 492.98	0.00 0.00	-	-	-	-
<b>Comments</b>										

Taxonomy no 1.3.3		Item Machinery Pumps Rotary								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0351		Operational time † 0.0327						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>14*</b> <b>14†</b>	<b>241.34</b>	<b>399.27</b>	<b>624.12</b>	<b>399.27</b>	<b>399.27</b>	<b>7.7</b>	<b>2.0</b>	<b>14.1</b>	<b>52.0</b>
Breakdown	3*	23.39	85.56	221.17	85.56	85.56	15.0	19.0	30.0	52.0
	3†	25.05	91.64	236.90	91.64	91.64				
Fail to start on demand	1*	1.43	28.52	135.32	28.52	28.52	2.0	2.0	2.0	2.0
	1†	1.53	30.55	144.95	30.55	30.55				
Low output	2*	10.12	57.04	179.53	57.04	57.04	10.0	9.0	20.0	31.0
	2†	10.84	61.09	192.30	61.09	61.09				
Parameter deviation	1*	1.43	28.52	135.32	28.52	28.52	2.0	2.0	2.0	2.0
	1†	1.53	30.55	144.95	30.55	30.55				
Spurious stop	3*	23.39	85.56	221.17	85.56	85.56	5.0	5.0	5.0	5.0
	3†	25.05	91.64	236.90	91.64	91.64				
Structural deficiency	4*	38.93	114.08	261.09	114.08	114.08	6.0	5.0	12.0	20.0
	4†	41.70	122.19	279.66	122.19	122.19				
<b>Degraded</b>	<b>6*</b> <b>6†</b>	<b>74.58</b>	<b>171.12</b>	<b>337.67</b>	<b>171.12</b>	<b>171.12</b>	<b>3.5</b>	<b>3.0</b>	<b>5.3</b>	<b>10.0</b>
External leakage - Process medium	1*	1.43	28.52	135.32	28.52	28.52	3.0	3.0	3.0	3.0
	1†	1.53	30.55	144.95	30.55	30.55				
External leakage - Utility medium	3*	23.39	85.56	221.17	85.56	85.56	3.0	3.0	3.7	4.0
	3†	25.05	91.64	236.90	91.64	91.64				
Low output	1*	1.43	28.52	135.32	28.52	28.52	4.0	8.0	8.0	8.0
	1†	1.53	30.55	144.95	30.55	30.55				
Vibration	1*	1.43	28.52	135.32	28.52	28.52	5.0	10.0	10.0	10.0
	1†	1.53	30.55	144.95	30.55	30.55				
<b>Incipient</b>	<b>16*</b> <b>16†</b>	<b>286.18</b>	<b>456.31</b>	<b>692.99</b>	<b>456.31</b>	<b>456.31</b>	<b>3.0</b>	<b>1.0</b>	<b>3.0</b>	<b>5.0</b>
Abnormal instrument reading	8*	113.51	228.15	411.68	228.15	228.15	2.7	1.0	2.7	5.0
	8†	121.58	244.38	440.95	244.38	244.38				
Minor in-service problems	6*	74.58	171.12	337.67	171.12	171.12	3.3	2.0	3.3	4.0
	6†	79.88	183.28	361.68	183.28	183.28				
Structural deficiency	2*	10.12	57.04	179.53	57.04	57.04	3.0	2.0	3.0	4.0
	2†	10.84	61.09	192.30	61.09	61.09				
<b>All modes</b>	<b>36*</b> <b>36†</b>	<b>762.33</b>	<b>1026.69</b>	<b>1355.81</b>	<b>1026.69</b>	<b>1026.69</b>	<b>5.0</b>	<b>1.0</b>	<b>7.8</b>	<b>52.0</b>
		<b>816.54</b>	<b>1099.71</b>	<b>1452.23</b>	<b>1099.71</b>	<b>1099.71</b>				
<b>Comments</b>										

**Maintainable item versus failure mode, to be continued**

**Item: Pumps - Rotary**

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Cabling & junction boxes	2.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	0.00	0.00	0.00	0.00	0.00	2.78	0.00	0.00	0.00	0.00
Coupling to driven unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Impeller	0.00	2.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, flow	8.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	11.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	2.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seals	0.00	0.00	0.00	2.78	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	5.56	0.00	0.00	0.00	0.00	0.00	0.00	5.56	0.00
Support	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78	0.00
Valves	0.00	0.00	0.00	5.56	0.00	0.00	0.00	0.00	0.00	0.00
Total	22.22	8.33	2.78	8.33	0.00	2.78	0.00	0.00	8.33	0.00

**Maintainable item versus failure mode, continued**

**Item: Pumps - Rotary**

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78
Control unit	0.00	0.00	0.00	0.00	2.78	0.00	0.00	0.00	0.00	5.56
Coupling to driven unit	0.00	0.00	0.00	0.00	2.78	0.00	0.00	0.00	0.00	2.78
Impeller	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78
Instrument, flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.33
Instrument, pressure	0.00	0.00	2.78	2.78	0.00	0.00	0.00	8.33	0.00	25.00
Piping	0.00	0.00	0.00	0.00	5.56	0.00	0.00	0.00	0.00	8.33
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78
Subunit	0.00	0.00	0.00	0.00	5.56	0.00	0.00	0.00	0.00	16.67
Support	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78	2.78
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78
Valves	0.00	0.00	0.00	13.89	0.00	0.00	0.00	0.00	0.00	19.44
Total	0.00	0.00	2.78	16.67	16.67	0.00	0.00	8.33	2.78	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Pumps - Rotary

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	8.33	2.78	0.00	0.00	0.00	0.00	0.00	0.00	2.78	0.00
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	0.00	0.00	2.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	8.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	2.78	0.00	8.33	0.00	2.78	0.00	0.00	5.56	0.00
Misc. external influences	2.78	2.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	2.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	22.22	8.33	2.78	8.33	0.00	2.78	0.00	0.00	8.33	0.00

**Failure descriptor versus failure mode, continued**

Item: Pumps - Rotary

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	2.78	0.00	0.00	0.00	0.00	16.67
Control failure	0.00	0.00	0.00	2.78	0.00	0.00	0.00	2.78	0.00	5.56
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78	0.00	5.56
Instrument failure - general	0.00	0.00	0.00	2.78	0.00	0.00	0.00	2.78	0.00	13.89
Leakage	0.00	0.00	2.78	0.00	0.00	0.00	0.00	0.00	0.00	2.78
Material failure - general	0.00	0.00	0.00	0.00	5.56	0.00	0.00	0.00	0.00	5.56
Mechanical Failure - general	0.00	0.00	0.00	8.33	2.78	0.00	0.00	0.00	0.00	30.56
Misc. external influences	0.00	0.00	0.00	2.78	0.00	0.00	0.00	0.00	2.78	11.11
Out of adjustment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78
Wear	0.00	0.00	0.00	0.00	5.56	0.00	0.00	0.00	0.00	5.56
Total	0.00	0.00	2.78	16.67	16.67	0.00	0.00	8.33	2.78	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 1.3.3.1		Item Machinery Pumps Rotary Oily water treatment								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0351			Operational time † 0.0327		Active rep.hrs	Repair (manhours)		
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)	
		Lower	Mean	Upper	SD	n/t	Min		Mean	Max
<b>Critical</b>	<b>14*</b> <b>14†</b>	<b>241.34</b> <b>258.50</b>	<b>399.27</b> <b>427.66</b>	<b>624.12</b> <b>668.50</b>	<b>399.27</b> <b>427.66</b>	<b>399.27</b> <b>427.66</b>	<b>7.7</b>	<b>2.0</b>	<b>14.1</b>	<b>52.0</b>
Breakdown	3*	23.39	85.56	221.17	85.56	85.56	15.0	19.0	30.0	52.0
Fail to start on demand	3†	25.05	91.64	236.90	91.64	91.64				
	1*	1.43	28.52	135.32	28.52	28.52	2.0	2.0	2.0	2.0
Low output	1†	1.53	30.55	144.95	30.55	30.55				
	2*	10.12	57.04	179.53	57.04	57.04	10.0	9.0	20.0	31.0
Parameter deviation	2†	10.84	61.09	192.30	61.09	61.09				
	1*	1.43	28.52	135.32	28.52	28.52	2.0	2.0	2.0	2.0
Spurious stop	1†	1.53	30.55	144.95	30.55	30.55				
	3*	23.39	85.56	221.17	85.56	85.56	5.0	5.0	5.0	5.0
Structural deficiency	3†	25.05	91.64	236.90	91.64	91.64				
	4*	38.93	114.08	261.09	114.08	114.08	6.0	5.0	12.0	20.0
4†	4†	41.70	122.19	279.66	122.19	122.19				
	<b>Degraded</b>	<b>6*</b>	<b>74.58</b>	<b>171.12</b>	<b>337.67</b>	<b>171.12</b>	<b>171.12</b>	<b>3.5</b>	<b>3.0</b>	<b>5.3</b>
External leakage - Process medium	6†	79.88	183.28	361.68	183.28	183.28				
	1*	1.43	28.52	135.32	28.52	28.52	3.0	3.0	3.0	3.0
External leakage - Utility medium	1†	1.53	30.55	144.95	30.55	30.55				
	3*	23.39	85.56	221.17	85.56	85.56	3.0	3.0	3.7	4.0
Low output	3†	25.05	91.64	236.90	91.64	91.64				
	1*	1.43	28.52	135.32	28.52	28.52	4.0	8.0	8.0	8.0
Vibration	1†	1.53	30.55	144.95	30.55	30.55				
	1*	1.43	28.52	135.32	28.52	28.52	5.0	10.0	10.0	10.0
1†	1†	1.53	30.55	144.95	30.55	30.55				
	<b>Incipient</b>	<b>16*</b>	<b>286.18</b>	<b>456.31</b>	<b>692.99</b>	<b>456.31</b>	<b>456.31</b>	<b>3.0</b>	<b>1.0</b>	<b>3.0</b>
Abnormal instrument reading	16†	306.53	488.76	742.27	488.76	488.76				
	8*	113.51	228.15	411.68	228.15	228.15	2.7	1.0	2.7	5.0
Minor in-service problems	8†	121.58	244.38	440.95	244.38	244.38				
	6*	74.58	171.12	337.67	171.12	171.12	3.3	2.0	3.3	4.0
Structural deficiency	6†	79.88	183.28	361.68	183.28	183.28				
	2*	10.12	57.04	179.53	57.04	57.04	3.0	2.0	3.0	4.0
2†	2†	10.84	61.09	192.30	61.09	61.09				
	<b>All modes</b>	<b>36*</b>	<b>762.33</b>	<b>1026.69</b>	<b>1355.81</b>	<b>1026.69</b>	<b>1026.69</b>	<b>5.0</b>	<b>1.0</b>	<b>7.8</b>
	<b>36†</b>	<b>816.54</b>	<b>1099.71</b>	<b>1452.23</b>	<b>1099.71</b>	<b>1099.71</b>				
Comments										



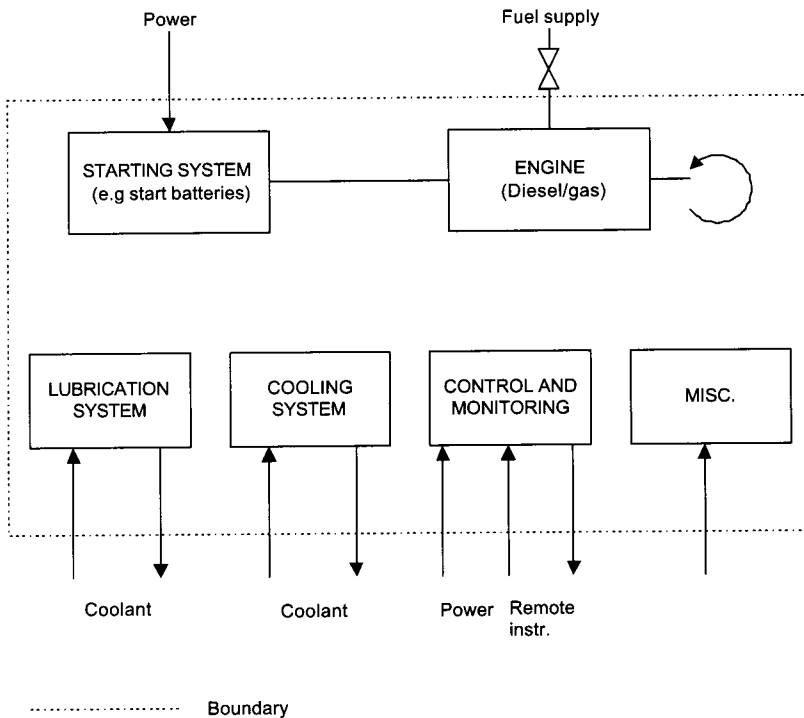
### Combustion Engines

#### Inventory description

The boundary definition is shown in Figure 13 and corresponding subdivision in Maintainable Items in Table 8.

The boundary definition applies to combustion engines (diesel/gas) driving equipment such as compressors, generators and pumps. The combustion engines are further subdivided in Subunits and Maintainable Items as shown in Table 8. Included within the boundary is the starting system and auxiliaries related to the engine.

Subunits that are common to the *driver* (i.e. the combustion engine) and the *driven unit* (e.g. generator) are a part of the *driven unit*. Power transmission systems are also regarded as part of the driven unit.



**Figure 13-Combustion engines, Boundary Definition**

**Table 8 Combustion Engine, Subdivision in Maintainable Items**

COMBUSTION ENGINE					
Starting system	Engine	Control & Monitoring	Lubrication system	Cooling system	Miscellaneous
<ul style="list-style-type: none"> <li>• Instruments</li> <li>• Start control</li> <li>• Start energy (battery, air)</li> <li>• Starting unit</li> </ul>	<ul style="list-style-type: none"> <li>• Air inlet</li> <li>• Cam shaft</li> <li>• Cylinders</li> <li>• Exhaust</li> <li>• Filter</li> <li>• Pump</li> <li>• Injections</li> <li>• Instruments</li> <li>• Piping</li> <li>• Piston</li> <li>• Radial bearing</li> <li>• Seals</li> <li>• Shaft</li> <li>• Super charger</li> <li>• Thrust bearing</li> <li>• Timing chain/V-belt</li> <li>• Valves</li> </ul>	<ul style="list-style-type: none"> <li>• Actuating device</li> <li>• Cabling &amp; junction boxes</li> <li>• Control unit</li> <li>• Instruments</li> <li>• Internal power supply</li> <li>• Monitoring</li> <li>• Valves</li> </ul>	<ul style="list-style-type: none"> <li>• Reservoir</li> <li>• Pump w/motor</li> <li>• Filter</li> <li>• Cooler</li> <li>• Valves &amp; piping</li> <li>• Oil</li> <li>• Instrument</li> <li>• Seals</li> </ul>	<ul style="list-style-type: none"> <li>• Heat exchanger</li> <li>• Fan w/motor</li> <li>• Filter</li> <li>• Valves &amp; piping</li> <li>• Pump</li> <li>• Instruments</li> </ul>	<ul style="list-style-type: none"> <li>• Hood</li> <li>• Heater</li> </ul>

(For all subunits the MIs "Unknown" and "Subunit" are included.)

**List of failure modes**

AIR	Abnormal instrument reading
BRD	Breakdown
ERO	Erratic output
ELF	External leakage - Fuel
ELU	External leakage - Utility medium
FTS	Fail to start on demand
STP	Fail to stop on demand
HIO	High output
INL	Internal leakage
LOO	Low output
SER	Minor in-service problems
NOI	Noise
OTH	Other
OHE	Overheating
PDE	Parameter deviation
UST	Spurious stop
STD	Structural deficiency
UNK	Unknown
VIB	Vibration

Taxonomy no		Item								
1.4		Machinery Combustion Enigens								
Population	Installations	Aggregated time in service (106 hours)						No of demands		
		Calendar time *			Operational time †			20010		
103	63	3.3923			0.3523					
Failure mode	No of failures	Failure rate (per 106 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>83*</b>	<b>0.07</b>	<b>28.05</b>	<b>111.22</b>	<b>41.51</b>	<b>24.47</b>	<b>45.4</b>	<b>0.5</b>	<b>66.7</b>	<b>2730.0</b>
	<b>83†</b>	<b>920.74</b>	<b>3291.31</b>	<b>6855.40</b>	<b>1876.34</b>	<b>235.56</b>				
Breakdown	6*	0.00	1.82	7.26	2.71	1.77	37.3	4.0	37.7	108.0
	6†	0.00	87.81	434.84	184.39	17.03				
External leakage - Utility medium	3*	0.00	1.91	10.62	6.34	0.88	-	1.0	3.5	6.0
	3†	1.40	290.21	1062.72	392.60	8.51				
Fail to start on demand	34*	0.00	11.51	60.10	26.92	10.02	17.2	1.0	21.7	121.0
	34†	708.84	2838.32	6134.52	1725.63	96.50				
Fail to stop on demand	1*	0.00	0.47	1.20	2.43	0.29	-	6.0	6.0	6.0
	1†	0.00	3.68	21.19	11.48	2.84				
Low output	2*	0.00	0.96	4.99	3.52	0.59	50.0	0.5	50.3	100.0
	2†	0.00	16.42	90.99	46.56	5.68				
Minor in-service problems	1*	0.00	0.47	1.20	2.43	0.29	-	1.0	1.0	1.0
	1†	0.00	3.68	21.19	11.48	2.84				
Other	4*	0.00	1.25	6.26	2.67	1.18	16.0	4.0	39.8	111.0
	4†	0.16	10.12	31.86	11.41	11.35				
Overheating	6*	0.00	1.69	9.34	4.69	1.77	29.5	1.0	36.0	120.0
	6†	0.00	35.06	195.49	101.58	17.03				
Parameter deviation	2*	0.00	1.12	5.78	4.26	0.59	6.0	1.0	6.5	12.0
	2†	0.00	17.74	97.49	47.57	5.68				
Spurious stop	19*	0.08	5.10	16.07	5.76	5.60	7.8	2.0	11.4	40.0
	19†	3.99	305.04	975.87	352.53	53.92				
Structural deficiency	1*	0.00	0.47	1.20	2.43	0.29	-	6.0	6.0	6.0
	1†	0.00	3.15	16.74	7.67	2.84				
Vibration	4*	0.38	1.15	2.26	0.59	1.18	516.7	140.0	1116.7	2730.0
	4†	0.04	10.34	39.44	14.53	11.35				
<b>Degraded</b>	<b>173*</b>	<b>0.02</b>	<b>54.08</b>	<b>236.00</b>	<b>91.99</b>	<b>51.00</b>	<b>15.1</b>	<b>0.1</b>	<b>22.9</b>	<b>221.0</b>
	<b>173†</b>	<b>624.54</b>	<b>3644.98</b>	<b>8732.86</b>	<b>2620.50</b>	<b>490.99</b>				
Abnormal instrument reading	1*	0.00	0.26	1.31	0.56	0.29	1.5	3.0	3.0	3.0
	1†	0.05	2.73	8.53	3.03	2.84				
Erratic output	7*	0.95	2.05	3.48	0.78	2.06	11.3	1.0	21.8	60.0
	7†	16.97	314.07	933.17	310.88	19.87				
External leakage - Fuel	6*	0.00	1.46	8.08	4.09	1.77	8.9	3.0	11.2	32.0
	6†	0.00	19.21	105.57	51.42	17.03				
External leakage - Utility medium	52*	0.00	13.14	70.63	32.66	15.33	12.7	1.0	18.4	78.0
	52†	21.44	983.71	3036.60	1069.34	147.58				
Fail to start on demand	4*	0.00	2.01	11.02	5.31	1.18	-	1.0	10.3	18.0
	4†	0.03	14.03	55.77	20.83	11.35				
High output	3*	0.00	0.90	4.08	1.63	0.88	7.3	4.0	7.3	12.0
	3†	0.00	29.20	165.00	87.63	8.51				
Internal leakage	10*	0.00	2.71	14.01	6.17	2.95	21.0	2.0	31.4	80.0
	10†	10.86	446.64	1370.83	479.70	28.38				
<b>Comments</b>										
(cont.)										

Taxonomy no 1.4		Item Machinery Combustion Engines								
Population	Installations	Aggregated time in service (106 hours)					No of demands			
		Calendar time *			Operational time †		20010			
103	63	3.3923			0.3523					
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Low output	16*	0.02	4.81	17.61	6.51	4.72	9.4	1.0	20.5	74.0
	16†	0.07	134.68	578.06	223.69	45.41				
Minor in-service problems	1*	0.00	0.47	1.20	2.43	0.29	-	2.0	2.0	2.0
	1†	0.00	3.68	21.19	11.48	2.84				
Noise	4*	0.00	1.34	7.79	4.24	1.18	35.0	10.0	26.5	56.0
	4†	9.67	327.31	995.83	344.39	11.35				
Other	41*	0.00	13.71	66.30	27.39	12.09	17.6	0.1	21.7	82.0
	41†	1.72	368.58	1359.12	501.99	116.36				
Overheating	15*	0.00	3.96	19.53	8.26	4.42	17.3	4.0	32.5	207.0
	15†	0.01	159.79	741.30	299.55	42.57				
Parameter deviation	2*	0.00	0.67	3.77	1.98	0.59	116.0	4.0	60.0	116.0
	2†	0.00	5.05	26.18	11.58	5.68				
Spurious stop	1*	0.00	0.47	1.20	2.43	0.29	-	25.0	25.0	25.0
	1†	0.00	3.68	21.19	11.48	2.84				
Structural deficiency	8*	0.00	2.58	14.60	7.78	2.36	5.8	3.0	47.9	221.0
	8†	0.42	158.95	625.26	232.71	22.70				
Unknown	1*	0.00	0.47	1.20	2.43	0.29	-	4.0	4.0	4.0
	1†	0.00	3.15	16.74	7.67	2.84				
Vibration	1*	0.00	0.29	0.61	1.60	0.29	42.0	42.0	42.0	42.0
	1†	0.00	3.19	17.23	8.00	2.84				
<b>Incipient</b>	<b>347*</b>	<b>0.00</b>	<b>103.04</b>	<b>490.55</b>	<b>201.35</b>	<b>102.29</b>	<b>7.4</b>	<b>0.5</b>	<b>13.6</b>	<b>170.0</b>
	<b>347†</b>	<b>1418.30</b>	<b>6832.28</b>	<b>15588.95</b>	<b>4545.85</b>	<b>984.82</b>				
Abnormal instrument reading	111*	0.00	19.30	91.17	88.13	32.72	4.6	1.0	9.3	84.0
	111†	26.26	1620.90	5098.32	1823.67	315.03				
Erratic output	6*	0.00	2.72	14.60	6.74	1.77	-	6.0	32.7	65.0
	6†	0.45	266.35	1075.06	404.56	17.03				
External leakage - Fuel	5*	0.56	1.47	2.74	0.68	1.47	2.5	2.5	3.7	6.0
	5†	44.20	450.40	1221.59	392.48	14.19				
External leakage - Utility medium	39*	0.00	12.69	55.69	21.80	11.50	9.6	2.0	15.6	100.0
	39†	89.74	922.89	2507.93	806.57	110.69				
Fail to start on demand	15*	0.00	10.10	51.31	22.13	4.42	-	1.0	19.0	148.0
	15†	4.01	57.96	167.08	55.12	42.57				
Fail to stop on demand	1*	0.00	0.47	1.20	2.43	0.29	-	8.0	8.0	8.0
	1†	0.00	3.68	21.19	11.48	2.84				
Internal leakage	6*	0.00	1.34	7.09	3.24	1.77	26.7	6.0	48.3	110.0
	6†	0.00	16.01	88.72	53.08	17.03				
Minor in-service problems	86*	0.00	16.85	87.35	68.86	25.35	5.0	1.0	11.5	132.0
	86†	42.40	1812.54	5573.97	1954.95	244.08				
Noise	6*	0.00	1.62	8.29	3.59	1.77	3.8	1.0	9.3	44.0
	6†	71.47	474.93	1175.46	359.83	17.03				
Other	51*	0.00	22.55	102.03	40.56	15.03	18.9	0.5	15.4	170.0
	51†	9.44	155.59	456.22	151.38	144.74				

Comments  
(cont.)

Taxonomy no 1.4		Item Machinery Combustion Engines								
Population 103	Installations 63	Aggregated time in service (106 hours)					No of demands 20010			
		Calendar time * 3.3923		Operational time † 0.3523						
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Overheating	7*	0.00	2.16	12.02	6.19	2.06	18.8	3.0	17.9	35.0
	7†	0.00	22.81	123.97	77.56	19.87				
Parameter deviation	1*	0.00	0.47	1.20	2.43	0.29	-	18.0	18.0	18.0
	1†	0.00	3.68	21.19	11.48	2.84				
Spurious stop	9*	0.00	5.26	26.01	11.02	2.65	-	4.0	15.8	66.0
	9†	0.25	34.35	117.53	43.28	25.54				
Structural deficiency	3*	0.00	0.99	5.76	3.14	0.88	10.0	10.0	62.0	128.0
	3†	3.66	237.62	750.15	268.98	8.51				
Vibration	1*	0.00	0.63	1.42	3.41	0.29	-	16.0	16.0	16.0
	1†	0.00	3.68	21.22	11.51	2.84				
<b>Unknown</b>	<b>21*</b>	<b>0.00</b>	<b>16.30</b>	<b>77.55</b>	<b>31.82</b>	<b>6.19</b>	-	<b>1.0</b>	<b>17.9</b>	<b>142.0</b>
	<b>21†</b>	<b>0.10</b>	<b>451.81</b>	<b>2004.63</b>	<b>789.72</b>	<b>59.60</b>				
Fail to start on demand	2*	0.00	1.09	5.64	4.17	0.59	-	2.0	2.0	2.0
	2†	0.00	6.75	32.89	13.72	5.68				
Minor in-service problems	1*	0.00	0.63	1.42	3.41	0.29	-	1.0	1.0	1.0
	1†	0.00	3.68	21.22	11.51	2.84				
Other	10*	0.00	7.06	40.86	22.22	2.95	-	1.0	28.8	142.0
	10†	0.05	35.73	145.37	54.90	28.38				
Parameter deviation	1*	0.00	0.63	1.42	3.41	0.29	-	1.0	1.0	1.0
	1†	0.00	3.68	21.22	11.51	2.84				
Unknown	7*	0.00	6.09	33.73	17.21	2.06	-	2.0	6.0	12.0
	7†	30.84	771.70	2323.76	788.01	19.87				
<b>All modes</b>	<b>624*</b>	<b>0.20</b>	<b>206.03</b>	<b>857.85</b>	<b>326.91</b>	<b>183.95</b>	<b>14.7</b>	<b>0.1</b>	<b>23.1</b>	<b>2730.0</b>
	<b>624†</b>	<b>5840.31</b>	<b>16184.89</b>	<b>30730.22</b>	<b>7779.92</b>	<b>1770.98</b>				
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.5. 10-3										

Maintainable item versus failure mode, to be continued

Item: Combustion Engines

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.48	0.00	0.00	0.16	0.32	0.16	0.00	0.00	0.16	0.00
Air inlet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00
Cabling & junction boxes	0.16	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00
Cam shaft	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	2.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.16	0.00
Cooler(s)	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00
Cylinders	0.00	0.00	0.00	0.16	0.00	0.16	0.00	0.32	0.00	0.00
Exhaust	0.00	0.00	0.16	0.48	0.00	0.00	0.00	0.00	0.00	0.96
Fan w/motor	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.16
Filter(s)	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00
Fuel filter	0.00	0.00	0.16	0.00	0.32	0.32	0.00	0.08	0.00	0.00
Fuel pump	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.32	0.16	0.00
Heat exchanger	0.00	0.00	0.00	0.64	0.00	0.16	0.00	0.16	0.00	0.00
Heater	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hood	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00
Injections	0.00	0.00	0.00	1.28	0.08	0.00	0.00	0.08	0.48	0.00
Instrument, flow	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, level	1.76	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00
Instrument, pressure	2.24	0.00	0.00	0.16	0.00	0.16	0.00	0.00	0.00	0.00
Instrument, speed	0.48	0.00	0.00	0.16	0.32	0.48	0.16	0.00	0.00	0.00
Instrument, temperature	6.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.64	0.00
Monitoring	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.32	0.96	0.16	0.64	0.00	0.00	0.32	0.00
Piping	0.00	0.00	0.48	5.13	0.00	0.00	0.00	0.00	0.00	0.00
Piston(s)	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00
Pump	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.16
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Seals	0.00	0.00	0.32	0.96	0.00	0.16	0.00	0.72	0.16	0.00
Shaft	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start control	0.32	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00
Start energy (battery, air)	0.16	0.00	0.00	0.80	0.00	1.44	0.00	0.16	0.00	0.00
Starting unit	0.32	0.00	0.00	0.32	0.00	1.12	0.00	0.00	0.00	0.00
Subunit	0.16	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00
Super charger	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.16	0.00
Timing chain/V-belt	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.88	0.64	0.16	1.12	0.48	1.92	0.32	0.48	0.48	0.16
Valves	0.48	0.16	0.00	0.16	0.08	0.32	0.00	0.24	0.00	0.00
Total	17.95	0.96	1.76	15.06	2.08	8.81	0.48	2.56	2.88	1.60

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Maintainable Item versus failure mode, continued

Item: Combustion Engines

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.16	0.00	0.32	0.00	0.16	0.00	0.16	0.00	2.08
Air inlet	0.00	0.00	0.00	1.12	0.16	0.00	0.00	0.00	0.00	1.44
Cabling & junction boxes	0.00	0.00	0.00	0.16	0.00	0.00	0.16	0.00	0.00	0.64
Cam shaft	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Control unit	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.16	0.00	2.96
Cooler(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.48
Cylinders	0.00	0.24	0.00	0.00	0.16	0.00	0.00	0.00	0.00	1.04
Exhaust	0.00	0.80	0.00	0.16	0.32	0.00	0.00	0.00	0.00	2.88
Fan w/motor	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.96
Filter(s)	0.00	0.16	0.00	2.08	0.00	0.00	0.00	0.00	0.00	2.40
Fuel filter	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.16	0.00	1.36
Fuel pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.96
Heat exchanger	0.48	0.32	0.00	0.16	0.16	0.00	0.00	0.00	0.00	2.08
Heater	0.00	0.32	0.00	0.48	0.00	0.00	0.00	0.00	0.00	1.28
Hood	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.80
Injections	1.04	0.16	0.00	0.08	0.00	0.00	0.00	0.00	0.00	3.21
Instrument, flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Instrument, general	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.64
Instrument, level	0.00	0.16	0.00	0.80	0.00	0.00	0.00	0.48	0.00	3.53
Instrument, pressure	0.00	0.16	0.00	0.48	0.00	0.00	0.00	0.48	0.00	3.69
Instrument, speed	0.00	0.16	0.00	0.32	0.00	0.00	0.00	0.00	0.00	2.08
Instrument, temperature	0.48	0.64	0.00	0.48	0.00	0.00	0.00	0.16	0.00	8.49
Internal power supply	0.16	0.64	0.00	0.16	0.00	0.00	0.16	0.00	0.00	1.92
Monitoring	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80
Oil	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.48
Other	0.16	3.85	0.32	0.48	0.00	0.00	0.16	0.96	0.16	8.49
Piping	0.00	0.00	0.00	0.72	0.32	0.00	0.00	0.16	0.00	6.81
Piston(s)	0.00	0.16	0.16	0.00	0.16	0.00	0.00	0.00	0.08	0.72
Pump	0.64	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60
Pump w/motor	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Seals	0.08	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	2.56
Shaft	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08
Start control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.96
Start energy (battery, air)	0.00	2.08	0.00	0.48	0.00	0.00	0.00	0.00	0.00	5.13
Starting unit	0.00	0.16	0.00	0.32	0.00	0.16	0.00	0.00	0.00	2.40
Subunit	0.00	0.96	0.00	0.80	0.16	0.00	0.00	0.00	0.00	2.40
Super charger	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.80
Timing chain/V-belt	0.16	0.24	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.72
Unknown	0.96	4.49	0.32	1.12	0.48	0.00	0.80	1.28	0.16	16.27
Valves	0.16	0.16	0.00	1.76	0.00	0.00	0.00	0.16	0.00	3.69
Total	4.49	16.99	0.96	14.26	1.92	0.32	1.28	4.65	0.96	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.



**Failure descriptor versus failure mode, to be continued**

**Item: Combustion Enigens**

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
ERROR	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blockage/plugged	0.00	0.00	0.00	0.00	0.16	0.32	0.00	0.00	0.00	0.00
Breakage	0.32	0.32	0.32	1.28	0.16	0.48	0.16	0.00	0.00	0.80
Burst	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.16	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Combined causes	0.16	0.00	0.00	0.32	0.32	0.00	0.00	0.00	0.16	0.00
Common mode failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00
Control failure	1.12	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.32	0.00
Corrosion	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	1.44	0.00	0.00	0.00	0.16	1.92	0.00	0.00	0.16	0.00
Erosion	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fatigue	0.00	0.00	0.00	0.16	0.00	0.16	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.16	0.00
Faulty signal/indication/alarm	2.88	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00
Instrument failure - general	1.92	0.00	0.00	0.00	0.32	0.32	0.16	0.00	0.00	0.00
Leakage	0.00	0.00	1.12	6.57	0.16	0.16	0.00	0.00	0.32	0.00
Looseness	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.16	0.00	0.00
Material failure - general	0.32	0.16	0.16	2.40	0.00	0.16	0.00	0.64	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	0.96	0.32	1.12	0.00	0.48	0.64	0.00
Misc. external influences	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.16	0.00	0.16	0.00	0.00	0.00	0.00
No cause found	0.48	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.16	0.00
No power/ voltage	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00
No signal/indication/alarm	1.76	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00
Open circuit	1.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.16	0.16	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.16
Out of adjustment	4.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00
Overheating	0.16	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Short circuiting	0.16	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.16	0.00
Software failure	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.48	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.16	0.00
Unknown	0.00	0.00	0.00	0.48	0.00	0.96	0.00	0.00	0.16	0.00
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.16	0.00	0.00	1.28	0.16	0.32	0.16	0.96	0.00	0.48
Total	17.95	0.96	1.76	15.06	2.08	8.81	0.48	2.56	2.88	1.60

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Failure descriptor versus failure mode, continued

Item: Combustion Enigens

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
ERROR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Blockage/plugged	0.32	0.16	0.00	0.00	0.00	0.00	0.00	0.16	0.00	1.12
Breakage	0.00	0.32	0.00	0.16	0.16	0.00	0.00	0.16	0.16	4.81
Burst	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48
Cavitation	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.16
Clearance/ alignment failure	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.16
Combined causes	0.16	0.32	0.16	0.32	0.16	0.00	0.00	0.32	0.00	2.40
Common mode failure	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.32
Contamination	0.00	0.00	0.00	3.69	0.00	0.00	0.00	0.00	0.00	4.33
Control failure	0.16	0.64	0.00	0.00	0.00	0.00	0.00	0.64	0.00	3.04
Corrosion	0.00	0.32	0.00	0.16	0.48	0.00	0.00	0.00	0.00	1.60
Deformation	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.16	0.48
Earth/isolation fault	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.64
Electrical failure - general	0.48	1.44	0.00	0.80	0.00	0.16	0.32	0.00	0.00	6.89
Erosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.48
External influence - general	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.16
Fatigue	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32
Faulty power/voltage	0.00	0.48	0.00	0.32	0.00	0.00	0.00	0.00	0.00	1.28
Faulty signal/indication/alarm	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.32	0.00	3.69
Instrument failure - general	0.00	0.80	0.16	0.64	0.00	0.00	0.00	0.16	0.00	4.49
Leakage	0.00	0.64	0.00	0.80	0.16	0.00	0.00	0.32	0.00	10.26
Looseness	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.00	1.60
Material failure - general	0.16	0.48	0.00	1.12	0.48	0.00	0.00	0.00	0.00	6.09
Mechanical Failure - general	0.32	2.40	0.16	0.80	0.00	0.00	0.16	0.80	0.00	8.17
Misc. external influences	0.00	0.16	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.32
Miscellaneous - general	0.32	0.80	0.00	0.00	0.16	0.00	0.16	0.16	0.00	1.92
No cause found	0.00	0.16	0.00	0.00	0.00	0.00	0.32	0.00	0.00	1.44
No power/ voltage	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	2.08
Open circuit	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.16	0.00	1.92
Other	0.00	3.37	0.32	0.00	0.00	0.00	0.00	0.64	0.00	4.97
Out of adjustment	0.80	0.48	0.16	1.12	0.00	0.00	0.00	0.16	0.00	7.37
Overheating	0.16	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.28
Short circuiting	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.80
Software failure	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32
Sticking	0.16	0.16	0.00	0.64	0.00	0.00	0.00	0.00	0.00	2.08
Unknown	0.32	0.80	0.00	0.80	0.00	0.00	0.32	0.16	0.00	4.01
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.32
Wear	1.12	0.96	0.00	0.96	0.32	0.16	0.00	0.00	0.16	7.21
Total	4.49	16.99	0.96	14.26	1.92	0.32	1.28	4.65	0.96	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 1.4.1		Item Machinery Combustion Engines Diesel engine									
Population 69	Installations 56	Aggregated time in service (106 hours)					No of demands				
		Calendar time * 3.0067		Operational time † 0.0872			18474				
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	<b>52*</b>	<b>0.00</b>	<b>19.10</b>	<b>90.16</b>	<b>36.84</b>	<b>17.29</b>	<b>53.8</b>	<b>1.0</b>	<b>95.3</b>	<b>2730.0</b>	
Breakdown	52†	756.39	5359.16	13454.01	4149.86	596.01					
	3*	0.00	1.11	6.05	2.83	1.00	38.7	4.0	39.3	108.0	
	3†	0.00	183.24	922.91	396.07	34.39					
External leakage - Utility medium	1*	0.00	1.31	6.90	5.72	0.33					
	1†	3.02	646.59	2383.85	880.47	11.46					
Fail to start on demand	29*	0.00	12.22	63.54	28.24	9.65	9.5	1.0	16.9	52.0	
	29†	283.72	4049.45	11650.76	3840.96	332.39					
Low output	1*	0.00	0.58	2.14	2.76	0.33	50.0	100.0	100.0	100.0	
	1†	0.01	42.18	189.31	75.00	11.46					
Overheating	3*	0.00	0.81	4.18	1.81	1.00	28.7	1.0	57.0	120.0	
	3†	0.00	78.13	405.69	179.68	34.39					
Parameter deviation	1*	0.00	0.58	2.14	2.76	0.33	6.0	12.0	12.0	12.0	
	1†	0.01	42.18	189.31	75.00	11.46					
Spurious stop	11*	0.55	3.35	8.12	2.46	3.66	7.2	2.0	13.3	40.0	
	11†	17.47	694.47	2127.98	743.18	126.08					
Vibration	3*	0.00	0.74	3.91	1.79	1.00	516.7	140.0	1116.7	2730.0	
	3†	5.53	28.86	67.24	19.85	34.39					
<b>Degraded</b>	<b>123*</b>	<b>0.00</b>	<b>33.40</b>	<b>183.95</b>	<b>91.72</b>	<b>40.91</b>	<b>12.3</b>	<b>1.0</b>	<b>21.6</b>	<b>207.0</b>	
	123†	247.06	5683.27	17075.33	5757.31	1409.80					
Abnormal instrument reading	1*	0.00	0.29	1.43	0.60	0.33	1.5	3.0	3.0	3.0	
	1†	0.10	9.62	31.45	11.46	11.46					
Erratic output	6*	0.00	1.78	9.49	7.97	2.00	11.3	1.0	21.5	60.0	
	6†	6.35	564.26	1830.47	665.32	68.77					
External leakage - Fuel	5*	0.00	1.33	7.31	3.58	1.66	9.1	3.0	11.8	32.0	
	5†	0.00	72.89	415.45	222.87	57.31					
External leakage - Utility medium	45*	0.00	12.10	67.00	34.19	14.97	10.2	1.0	17.3	60.0	
	45†	3.62	1543.60	6123.04	2285.30	515.78					
Fail to start on demand	1*	0.00	1.31	6.90	5.72	0.33		12.0	12.0	12.0	
	1†	3.02	646.59	2383.85	880.47	11.46					
High output	1*	0.00	0.37	0.69	2.08	0.33	4.0	4.0	4.0	4.0	
	1†	0.00	88.49	445.73	191.30	11.46					
Internal leakage	9*	0.00	2.85	14.99	6.78	2.99	21.8	2.0	33.1	80.0	
	9†	3.41	760.77	2829.38	1044.60	103.16					
Low output	9*	0.00	2.63	11.34	4.40	2.99	7.9	6.0	15.9	30.0	
	9†	0.68	300.00	1192.33	445.28	103.16					
Noise	3*	0.00	1.28	6.67	4.78	1.00	14.0	10.0	16.7	28.0	
	3†	1.15	512.08	2037.89	761.36	34.39					
Other	25*	0.00	6.22	34.99	18.45	8.31	16.1	2.0	27.7	82.0	
	25†	1.96	701.82	2751.26	1022.64	286.55					
<b>Comments</b>											
(cont.)											

Taxonomy no		Item								
1.4.1		Machinery Combustion Engines Diesel engine								
Population	Installations	Aggregated time in service (106 hours)					No of demands			
		Calendar time *			Operational time †		18474			
69	56	3.0067			0.0872					
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Overheating	12*	0.00	3.12	17.02	7.95	3.99	17.3	4.0	33.0	207.0
Structural deficiency	12†	0.03	325.76	1494.13	597.80	137.54	5.8	3.0	12.8	30.0
	6*	0.02	1.90	6.26	2.29	2.00				
<b>Incipient</b>	6†	0.38	305.63	1256.44	476.48	68.77	<b>5.6</b>	<b>0.5</b>	<b>12.6</b>	<b>132.0</b>
	<b>255*</b>	<b>0.00</b>	<b>63.08</b>	<b>359.49</b>	<b>202.95</b>	<b>84.81</b>				
Abnormal instrument reading	<b>255†</b>	<b>1250.46</b>	<b>11839.88</b>	<b>31591.96</b>	<b>10059.92</b>	<b>2922.76</b>	4.6	1.0	9.4	84.0
	107*	0.00	21.40	112.73	93.38	35.59				
Erratic output	107†	2.98	2444.38	10052.24	3812.55	1226.41	-	27.0	27.0	27.0
	3*	0.00	2.48	14.39	7.87	1.00				
External leakage - Fuel	3†	50.78	1239.32	3729.28	1262.50	34.39	2.5	2.5	2.5	2.5
	4*	0.00	1.23	6.78	3.34	1.33				
External leakage - Utility medium	4†	5.41	695.72	2354.81	865.76	45.85	8.7	2.0	17.3	100.0
	28*	0.00	8.99	45.81	19.78	9.31				
Fail to start on demand	28†	83.00	1923.42	5779.95	1949.83	320.93	-	1.0	12.0	23.0
	2*	0.00	2.62	14.99	8.08	0.67				
Internal leakage	2†	83.53	1293.10	3761.97	1245.03	22.92	25.6	6.0	51.5	110.0
	5*	0.00	1.22	6.54	3.02	1.66				
Minor in-service problems	5†	0.00	66.62	366.57	222.86	57.31	4.8	1.0	11.4	132.0
	81*	0.00	17.80	92.29	72.96	26.94				
Noise	81†	1.64	2589.30	10985.22	4230.24	928.41	3.8	1.0	9.3	44.0
	6*	0.00	1.87	9.10	3.79	2.00				
Other	6†	30.18	762.09	2295.42	778.89	68.77	5.6	0.5	11.2	44.0
	14*	0.00	3.19	18.25	10.24	4.66				
Overheating	14†	0.01	450.41	2179.75	900.69	160.47	9.0	3.0	9.0	15.0
	2*	0.00	0.77	4.01	3.25	0.67				
Structural deficiency	2†	0.00	82.44	400.37	166.28	22.92	10.0	10.0	62.0	128.0
	3*	0.00	1.15	6.41	3.32	1.00				
<b>Unknown</b>	3†	0.64	384.99	1555.54	585.67	34.39	-	<b>8.0</b>	<b>8.0</b>	<b>8.0</b>
	<b>2*</b>	<b>0.00</b>	<b>3.20</b>	<b>16.67</b>	<b>11.98</b>	<b>0.67</b>				
Unknown	<b>2†</b>	<b>16.29</b>	<b>1492.13</b>	<b>4854.89</b>	<b>1766.56</b>	<b>22.92</b>	-	8.0	8.0	8.0
	2*	0.00	3.20	16.67	11.98	0.67				
<b>All modes</b>	2†	16.29	1492.13	4854.89	1766.56	22.92	<b>12.7</b>	<b>0.5</b>	<b>24.3</b>	<b>2730.0</b>
	<b>432*</b>	<b>0.00</b>	<b>120.77</b>	<b>663.66</b>	<b>321.98</b>	<b>143.68</b>				
		<b>432†</b>	<b>4999.51</b>	<b>25193.92</b>	<b>58179.77</b>	<b>17089.44</b>	<b>4951.51</b>			
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.4. 10-3										

Maintainable item versus failure mode, to be continued

Item: Combustion Engines - Diesel engine

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.69	0.00	0.00	0.23	0.46	0.23	0.00	0.00	0.23	0.00
Air inlet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00
Cabling & junction boxes	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	2.89	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00
Cooler(s)	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00
Cylinders	0.00	0.00	0.00	0.23	0.00	0.23	0.00	0.46	0.00	0.00
Exhaust	0.00	0.00	0.23	0.46	0.00	0.00	0.00	0.00	0.00	1.39
Fan w/motor	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.23
Filter(s)	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00
Fuel filter	0.00	0.00	0.23	0.00	0.46	0.46	0.00	0.12	0.00	0.00
Fuel pump	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.46	0.23	0.00
Heat exchanger	0.00	0.00	0.00	0.93	0.00	0.23	0.00	0.23	0.00	0.00
Heater	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hood	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00
Injections	0.00	0.00	0.00	1.85	0.12	0.00	0.00	0.12	0.69	0.00
Instrument, flow	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, level	2.55	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00
Instrument, pressure	3.24	0.00	0.00	0.23	0.00	0.23	0.00	0.00	0.00	0.00
Instrument, speed	0.69	0.00	0.00	0.00	0.46	0.69	0.00	0.00	0.00	0.00
Instrument, temperature	9.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.23	0.23	0.23	0.00	0.00	0.23	0.00
Piping	0.00	0.00	0.69	6.48	0.00	0.00	0.00	0.00	0.00	0.00
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pump	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.23
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Seals	0.00	0.00	0.46	1.16	0.00	0.00	0.00	1.04	0.23	0.00
Shaft	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start control	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start energy (battery, air)	0.23	0.00	0.00	1.16	0.00	1.16	0.00	0.23	0.00	0.00
Starting unit	0.46	0.00	0.00	0.46	0.00	0.46	0.00	0.00	0.00	0.00
Subunit	0.23	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00
Super charger	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.23	0.00
Timing chain/V-belt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.58	0.46	0.23	0.46	0.23	1.62	0.23	0.23	0.23	0.00
Valves	0.69	0.23	0.00	0.23	0.12	0.46	0.00	0.35	0.00	0.00
Total	25.00	0.69	2.08	17.13	2.08	7.41	0.23	3.24	2.31	2.08

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Maintainable item versus failure mode, continued

Item: Combustion Enigens - Diesel engine

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.23	0.00	0.46	0.00	0.00	0.00	0.00	0.00	2.55
Air inlet	0.00	0.00	0.00	1.62	0.23	0.00	0.00	0.00	0.00	2.08
Cabling & junction boxes	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.46
Control unit	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23	0.00	3.82
Cooler(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.69
Cylinders	0.00	0.23	0.00	0.00	0.23	0.00	0.00	0.00	0.00	1.39
Exhaust	0.00	0.23	0.00	0.23	0.46	0.00	0.00	0.00	0.00	3.01
Fan w/motor	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69
Filter(s)	0.00	0.23	0.00	3.01	0.00	0.00	0.00	0.00	0.00	3.47
Fuel filter	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.23	0.00	1.97
Fuel pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.39
Heat exchanger	0.69	0.46	0.00	0.00	0.23	0.00	0.00	0.00	0.00	2.78
Heater	0.00	0.46	0.00	0.69	0.00	0.00	0.00	0.00	0.00	1.85
Hood	0.00	0.00	0.00	0.93	0.00	0.00	0.00	0.00	0.00	1.16
Injections	1.50	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	4.40
Instrument, flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Instrument, general	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.69
Instrument, level	0.00	0.00	0.00	1.16	0.00	0.00	0.00	0.46	0.00	4.63
Instrument, pressure	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.46	0.00	4.86
Instrument, speed	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.08
Instrument, temperature	0.00	0.46	0.00	0.69	0.00	0.00	0.00	0.00	0.00	10.88
Internal power supply	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23
Monitoring	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.16
Oil	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.69
Other	0.00	0.23	0.00	0.46	0.00	0.00	0.00	0.00	0.00	1.62
Piping	0.00	0.00	0.00	1.04	0.23	0.00	0.00	0.00	0.00	8.45
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12
Pump	0.93	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.39
Pump w/motor	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Seals	0.12	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	3.24
Shaft	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12
Start control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.93
Start energy (battery, air)	0.00	3.01	0.00	0.69	0.00	0.00	0.00	0.00	0.00	6.48
Starting unit	0.00	0.23	0.00	0.46	0.00	0.00	0.00	0.00	0.00	2.08
Subunit	0.00	1.39	0.00	1.16	0.23	0.00	0.00	0.00	0.00	3.47
Super charger	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	1.16
Timing chain/V-belt	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23
Unknown	0.23	0.46	0.23	0.69	0.46	0.00	0.46	0.23	0.00	7.06
Valves	0.23	0.23	0.00	2.55	0.00	0.00	0.00	0.23	0.00	5.32
Total	3.94	9.03	0.23	18.75	2.08	0.00	0.46	2.55	0.69	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptor versus failure mode, to be continued

Item: Combustion Engines - Diesel engine

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
ERROR	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blockage/plugged	0.00	0.00	0.00	0.00	0.23	0.46	0.00	0.00	0.00	0.00
Breakage	0.46	0.23	0.46	1.62	0.23	0.69	0.00	0.00	0.00	1.16
Burst	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.23	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Combined causes	0.23	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
Contamination	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00
Control failure	1.16	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	2.08	0.00	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.00
Erosion	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fatigue	0.00	0.00	0.00	0.23	0.00	0.23	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.23	0.00
Faulty signal/indication/alarm	4.17	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00
Instrument failure - general	2.78	0.00	0.00	0.00	0.23	0.46	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	1.16	7.41	0.23	0.00	0.00	0.00	0.46	0.00
Looseness	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.23	0.00	0.00
Material failure - general	0.23	0.00	0.23	3.01	0.00	0.00	0.00	0.69	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	1.16	0.46	0.00	0.00	0.69	0.46	0.00
Misc. external influences	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.69	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.23	0.00
No power/ voltage	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00
No signal/indication/alarm	2.55	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
Open circuit	2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.23	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	6.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00
Overheating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Short circuiting	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Software failure	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.69	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.23	0.00
Unknown	0.00	0.00	0.00	0.69	0.00	0.46	0.00	0.00	0.23	0.00
Wear	0.23	0.00	0.00	1.16	0.00	0.46	0.23	1.16	0.00	0.69
Total	25.00	0.69	2.08	17.13	2.08	7.41	0.23	3.24	2.31	2.08

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

**Item: Combustion Engines - Diesel engine**

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
ERROR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Blockage/plugged	0.46	0.23	0.00	0.00	0.00	0.00	0.00	0.23	0.00	1.62
Breakage	0.00	0.46	0.00	0.00	0.23	0.00	0.00	0.23	0.23	6.02
Burst	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69
Cavitation	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23
Clearance/ alignment failure	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23
Combined causes	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.69
Contamination	0.00	0.00	0.00	5.09	0.00	0.00	0.00	0.00	0.00	6.02
Control failure	0.23	0.69	0.00	0.00	0.00	0.00	0.00	0.69	0.00	3.01
Corrosion	0.00	0.23	0.00	0.23	0.46	0.00	0.00	0.00	0.00	1.62
Deformation	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.23	0.69
Earth/isolation fault	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.93
Electrical failure - general	0.23	0.93	0.00	0.93	0.00	0.00	0.00	0.00	0.00	6.25
Erosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46
External influence - general	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23
Fatigue	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46
Faulty power/voltage	0.00	0.69	0.00	0.46	0.00	0.00	0.00	0.00	0.00	1.85
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.63
Instrument failure - general	0.00	0.93	0.00	0.93	0.00	0.00	0.00	0.23	0.00	5.56
Leakage	0.00	0.69	0.00	0.93	0.00	0.00	0.00	0.46	0.00	11.34
Looseness	0.00	0.00	0.00	1.16	0.00	0.00	0.00	0.00	0.00	2.08
Material failure - general	0.00	0.00	0.00	1.62	0.69	0.00	0.00	0.00	0.00	6.48
Mechanical Failure - general	0.46	0.69	0.23	0.69	0.00	0.00	0.00	0.00	0.00	4.86
Misc. external influences	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23
Miscellaneous - general	0.23	0.23	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.69
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	1.85
No power/ voltage	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78
Open circuit	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.23	0.00	2.78
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46
Out of adjustment	1.16	0.46	0.00	1.62	0.00	0.00	0.00	0.23	0.00	9.95
Overheating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Short circuiting	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.46
Software failure	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46
Sticking	0.23	0.23	0.00	0.93	0.00	0.00	0.00	0.00	0.00	2.78
Unknown	0.23	0.93	0.00	1.16	0.00	0.00	0.00	0.00	0.00	3.70
Wear	0.69	0.00	0.00	1.39	0.46	0.00	0.00	0.00	0.23	6.71
Total	3.94	9.03	0.23	18.75	2.08	0.00	0.46	2.55	0.69	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.



Taxonomy no 1.4.1.1		Item Machinery Combustion Enigens Diesel engine Compressed air									
Population 1	Installations 1	Aggregated time in service (106 hours)					No of demands				
		Calendar time * 0.0245			Operational time † 0.0010						
Failure mode		No of failures	Failure rate (per 106 hours).				Active rep.hrs	Repair (manhours)			
			Lower	Mean	Upper	SD	n/t	Min	Mean	Max	
<b>Critical</b>		<b>3*</b>	<b>33.43</b>	<b>122.31</b>	<b>316.17</b>	<b>122.31</b>	<b>122.31</b>	<b>19.8</b>	<b>7.0</b>	<b>39.7</b>	<b>100.0</b>
Fail to start on demand		3†	820.00	3000.00	7755.00	3000.00	3000.00				
		1*	2.04	40.77	193.45	40.77	40.77	3.5	7.0	7.0	7.0
		1†	50.00	1000.00	4745.00	1000.00	1000.00				
Low output		1*	2.04	40.77	193.45	40.77	40.77	50.0	100.0	100.0	100.0
		1†	50.00	1000.00	4745.00	1000.00	1000.00				
Parameter deviation		1*	2.04	40.77	193.45	40.77	40.77	6.0	12.0	12.0	12.0
		1†	50.00	1000.00	4745.00	1000.00	1000.00				
<b>Incipient</b>		<b>5*</b>	<b>80.32</b>	<b>203.85</b>	<b>428.69</b>	<b>203.85</b>	<b>203.85</b>	<b>15.8</b>	<b>4.0</b>	<b>31.5</b>	<b>100.0</b>
Abnormal instrument reading		5†	1970.00	5000.00	10515.00	5000.00	5000.00				
		3*	33.43	122.31	316.17	122.31	122.31	4.3	4.0	8.7	17.0
		3†	820.00	3000.00	7755.00	3000.00	3000.00				
External leakage - Utility medium		1*	2.04	40.77	193.45	40.77	40.77	50.0	100.0	100.0	100.0
		1†	50.00	1000.00	4745.00	1000.00	1000.00				
Minor in-service problems		1*	2.04	40.77	193.45	40.77	40.77	-	-	-	-
		1†	50.00	1000.00	4745.00	1000.00	1000.00				
<b>All modes</b>		<b>8*</b>	<b>162.26</b>	<b>326.16</b>	<b>588.51</b>	<b>326.16</b>	<b>326.16</b>	<b>17.5</b>	<b>4.0</b>	<b>35.0</b>	<b>100.0</b>
		8†	3980.00	8000.00	14435.00	8000.00	8000.00				
Comments											

Taxonomy no 1.4.1.2		Item Machinery Combustion Enigens Diesel engine Emergency power									
Population 52	Installations 50	Aggregated time in service (106 hours)						No of demands 16614			
		Calendar time * 2.4802			Operational time † 0.0216						
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
<b>Critical</b>	<b>21*</b>	<b>0.00</b>	<b>15.67</b>	<b>73.92</b>	<b>30.19</b>	<b>8.47</b>	<b>5.5</b>	<b>1.0</b>	<b>10.3</b>	<b>32.0</b>	
	<b>21†</b>	<b>82.54</b>	<b>6651.97</b>	<b>21380.05</b>	<b>7740.64</b>	<b>970.80</b>					
External leakage - Utility medium	1*	0.00	1.50	7.80	6.26	0.40	-	-	-	-	
	1†	0.00	720.29	3732.01	1645.12	46.23					
Fail to start on demand	14*	0.00	12.30	64.18	28.68	5.64	8.2	1.0	12.7	32.0	
	14†	16.10	5020.01	19507.96	7224.67	647.20					
Overheating	1*	0.00	0.38	1.95	1.47	0.40	1.0	1.0	1.0	1.0	
	1†	0.00	136.35	702.77	305.29	46.23					
Spurious stop	5*	0.00	2.09	10.80	8.44	2.02	4.3	2.0	7.3	16.0	
	5†	5.04	979.03	3539.44	1307.85	231.14					
<b>Degraded</b>	<b>29*</b>	<b>0.00</b>	<b>21.01</b>	<b>99.24</b>	<b>40.57</b>	<b>11.69</b>	<b>23.4</b>	<b>1.0</b>	<b>18.4</b>	<b>56.0</b>	
	<b>29†</b>	<b>15.84</b>	<b>5235.02</b>	<b>20416.35</b>	<b>7572.89</b>	<b>1340.63</b>					
Erratic output	4*	0.35	1.62	3.66	1.06	1.61	1.0	1.0	10.0	19.0	
	4†	1.06	734.11	2989.45	1129.53	184.91					
External leakage - Fuel	1*	0.00	0.63	3.32	2.73	0.40	32.0	32.0	32.0	32.0	
	1†	1.25	43.78	133.39	46.23	46.23					
External leakage - Utility medium	8*	0.00	5.36	28.74	13.26	3.23	20.0	1.0	13.4	39.0	
	8†	0.00	1111.10	5737.73	2507.52	369.83					
Fail to start on demand	1*	0.00	1.50	7.80	6.26	0.40	-	12.0	12.0	12.0	
	1†	0.00	720.29	3732.01	1645.12	46.23					
Internal leakage	3*	0.00	2.70	14.90	7.55	1.21	-	2.0	12.0	24.0	
	3†	0.17	1089.59	4901.90	1944.11	138.69					
Low output	2*	0.00	0.86	4.18	1.74	0.81	4.0	8.0	8.0	8.0	
	2†	0.00	150.79	815.66	516.42	92.46					
Noise	3*	0.00	1.49	8.12	5.07	1.21	14.0	10.0	16.7	28.0	
	3†	0.00	624.22	3132.14	1341.05	138.69					
Other	4*	0.00	2.58	13.07	5.63	1.61	48.0	8.0	36.0	56.0	
	4†	0.00	445.06	2167.76	903.69	184.91					
Overheating	3*	0.00	1.90	10.87	6.10	1.21	-	18.0	25.5	33.0	
	3†	0.00	394.71	2181.30	1105.90	138.69					
<b>Incipient</b>	<b>47*</b>	<b>0.03</b>	<b>35.10</b>	<b>147.19</b>	<b>56.34</b>	<b>18.95</b>	<b>8.1</b>	<b>0.5</b>	<b>21.6</b>	<b>132.0</b>	
	<b>47†</b>	<b>545.43</b>	<b>11563.88</b>	<b>34676.61</b>	<b>11625.88</b>	<b>2172.74</b>					
Abnormal instrument reading	10*	0.00	7.11	36.64	15.90	4.03	14.9	1.5	21.1	84.0	
	10†	0.03	1500.09	7226.57	2981.08	462.28					
Erratic output	3*	0.00	2.85	16.11	8.56	1.21	-	27.0	27.0	27.0	
	3†	0.55	1383.41	6013.80	2337.35	138.69					
External leakage - Fuel	4*	0.00	1.47	7.76	3.53	1.61	2.5	2.5	2.5	2.5	
	4†	0.12	848.13	3824.78	1518.45	184.91					
External leakage - Utility medium	8*	0.00	6.21	34.17	16.15	3.23	5.0	5.0	15.1	48.0	
	8†	1.43	2145.75	9081.64	3493.19	369.83					
<b>Comments</b>											
(cont.)											

Taxonomy no 1.4.1.2		Item Machinery Combustion Engines Diesel engine Emergency power								
Population 52	Installations 50	Aggregated time in service (106 hours)					No of demands 16614			
		Calendar time *			Operational time †					
		2.4802					0.0216			
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Fail to start on demand	2*	0.00	2.99	16.80	8.83	0.81	-	1.0	12.0	23.0
	2†	1.08	1440.23	6062.55	2325.42	92.46				
Minor in-service problems	9*	0.00	6.84	36.82	23.63	3.63	18.0	2.0	30.0	132.0
	9†	0.00	1907.37	10114.51	4619.75	416.06				
Noise	6*	0.00	2.23	10.06	4.00	2.42	3.8	1.0	9.3	44.0
	6†	6.24	973.78	3389.83	1250.75	277.37				
Other	2*	0.00	1.43	7.42	5.90	0.81	0.5	0.5	0.5	0.5
	2†	0.00	693.33	3663.27	1666.48	92.46				
Overheating	1*	0.00	0.63	3.32	2.73	0.40	15.0	15.0	15.0	15.0
	1†	1.25	43.78	133.39	46.23	46.23				
Structural deficiency	2*	0.00	1.34	7.64	4.31	0.81	-	48.0	88.0	128.0
	2†	0.00	491.38	2445.33	1040.98	92.46				
<b>Unknown</b>	<b>2*</b>	<b>0.00</b>	<b>3.64</b>	<b>19.14</b>	<b>13.16</b>	<b>0.81</b>	-	<b>8.0</b>	<b>8.0</b>	<b>8.0</b>
	<b>2†</b>	<b>0.03</b>	<b>1666.36</b>	<b>8058.67</b>	<b>3329.08</b>	<b>92.46</b>				
Unknown	2*	0.00	3.64	19.14	13.16	0.81	-	8.0	8.0	8.0
	2†	0.03	1666.36	8058.67	3329.08	92.46				
<b>All modes</b>	<b>99*</b>	<b>0.31</b>	<b>79.15</b>	<b>303.91</b>	<b>111.93</b>	<b>39.92</b>	<b>11.6</b>	<b>0.5</b>	<b>18.5</b>	<b>132.0</b>
	<b>99†</b>	<b>2617.64</b>	<b>25955.46</b>	<b>69982.38</b>	<b>22414.22</b>	<b>4576.62</b>				
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 7.2. 10-4										

Taxonomy no 1.4.1.3		Item Machinery Combustion Engines Diesel engine Main power								
Population 6	Installations 2	Aggregated time in service (106 hours)					No of demands 800			
		Calendar time * 0.1761			Operational time † 0.0487					
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>23*</b>	<b>2.84</b>	<b>90.12</b>	<b>273.49</b>	<b>94.20</b>	<b>130.63</b>	<b>78.8</b>	<b>1.0</b>	<b>168.5</b>	<b>2730.0</b>
	<b>23†</b>	<b>7.78</b>	<b>324.68</b>	<b>997.26</b>	<b>349.29</b>	<b>472.18</b>				
Fail to start on demand	12*	7.69	53.39	133.46	41.07	68.16	10.5	1.0	21.0	52.0
	12†	22.10	190.24	495.81	155.62	246.36				
Overheating	2*	0.78	10.14	28.79	9.44	11.36	42.5	50.0	85.0	120.0
	2†	2.57	36.47	104.88	34.57	41.06				
Spurious stop	6*	12.36	31.23	57.07	13.91	34.08	8.7	4.0	17.3	40.0
	6†	44.45	112.61	206.04	50.29	123.18				
Vibration	3*	0.91	14.62	42.73	14.16	17.04	516.7	140.0	1116.7	2730.0
	3†	2.89	52.52	155.74	51.85	61.59				
<b>Degraded</b>	<b>30*</b>	<b>25.74</b>	<b>132.99</b>	<b>309.07</b>	<b>91.12</b>	<b>170.39</b>	<b>11.9</b>	<b>3.0</b>	<b>23.7</b>	<b>80.0</b>
	<b>30†</b>	<b>76.78</b>	<b>473.57</b>	<b>1151.17</b>	<b>348.68</b>	<b>615.89</b>				
Abnormal instrument reading	1*	0.11	5.21	16.10	5.68	5.68	1.5	3.0	3.0	3.0
	1†	0.39	18.77	58.12	20.53	20.53				
Erratic output	1*	0.11	5.21	16.10	5.68	5.68	30.0	60.0	60.0	60.0
	1†	0.39	18.77	58.12	20.53	20.53				
External leakage - Utility medium	11*	31.06	60.17	97.05	20.33	62.48	14.0	6.0	27.5	60.0
	11†	99.59	214.70	365.21	82.19	225.83				
Internal leakage	5*	0.84	22.93	69.21	23.61	28.40	25.2	12.0	50.4	80.0
	5†	2.50	82.38	250.34	86.42	102.65				
Low output	1*	0.11	5.21	16.10	5.68	5.68	7.0	14.0	14.0	14.0
	1†	0.39	18.77	58.12	20.53	20.53				
Other	3*	0.91	14.62	42.73	14.16	17.04	4.0	6.0	8.0	12.0
	3†	2.89	52.52	155.74	51.85	61.59				
Overheating	7*	15.71	36.44	64.16	15.03	39.76	3.0	4.0	6.0	12.0
	7†	48.07	129.13	242.16	60.58	143.71				
Structural deficiency	1*	0.11	5.21	16.10	5.68	5.68	6.0	12.0	12.0	12.0
	1†	0.39	18.77	58.12	20.53	20.53				
<b>Incipient</b>	<b>77*</b>	<b>1.66</b>	<b>270.41</b>	<b>947.72</b>	<b>349.86</b>	<b>437.34</b>	<b>6.3</b>	<b>1.0</b>	<b>12.3</b>	<b>110.0</b>
	<b>77†</b>	<b>5.76</b>	<b>984.66</b>	<b>3478.68</b>	<b>1284.78</b>	<b>1580.78</b>				
Abnormal instrument reading	34*	1.67	126.84	405.58	146.48	193.11	3.0	1.0	5.9	40.0
	34†	5.23	459.12	1487.62	540.45	698.01				
External leakage - Utility medium	8*	13.43	40.04	78.15	20.28	45.44	11.9	4.0	23.8	100.0
	8†	39.04	141.35	295.61	81.15	164.24				
Internal leakage	4*	0.93	18.85	56.49	18.89	22.72	25.8	6.0	51.5	110.0
	4†	2.72	67.74	203.95	69.14	82.12				
Minor in-service problems	22*	3.15	86.78	262.06	89.43	124.95	4.8	1.0	9.5	40.0
	22†	8.44	312.46	954.27	331.85	451.65				
Other	8*	13.43	40.04	78.15	20.28	45.44	7.8	2.5	15.7	44.0
	8†	39.04	141.35	295.61	81.15	164.24				
<b>Comments</b>										
(cont.)										

<b>Taxonomy no</b> 1.4.1.3		<b>Item</b> Machinery Combustion Engines Diesel engine Main power									
<b>Population</b> 6	<b>Installations</b> 2	<b>Aggregated time in service (106 hours)</b>					<b>No of demands</b> 800				
		<b>Calendar time *</b> 0.1761			<b>Operational time †</b> 0.0487						
<b>Failure mode</b>		<b>No of failures</b>	<b>Failure rate (per 106 hours).</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
			<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/t</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
Structural deficiency		1* 1†	0.11 0.39	5.21 18.77	16.10 58.12	5.68 20.53	5.68 20.53	10.0	10.0	10.0	10.0
<b>All modes</b>		130* 130†	4.01 13.43	463.75 1686.51	1548.70 5690.29	567.86 2090.88	738.37 2668.86	20.6	1.0	43.0	2730.0
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.5. 10 <sup>-2</sup>											

Taxonomy no		Item								
1.4.1.4		Machinery Combustion Engines Diesel engine Process shutdown and ESD								
Population	Installations	Aggregated time in service (106 hours)					No of demands			
		Calendar time *			Operational time †					
2	2	0.0526			0.0105					
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	1*	<b>0.95</b>	<b>19.01</b>	<b>56.93</b>	<b>19.01</b>	<b>19.01</b>	<b>108.0</b>	<b>108.0</b>	<b>108.0</b>	<b>108.0</b>
Breakdown	1†	<b>4.76</b>	<b>95.24</b>	<b>285.24</b>	<b>95.24</b>	<b>95.24</b>				
	1*	0.95	19.01	56.93	19.01	19.01	108.0	108.0	108.0	108.0
<b>Degraded</b>	1†	<b>4.76</b>	<b>95.24</b>	<b>285.24</b>	<b>95.24</b>	<b>95.24</b>				
	1*	<b>0.95</b>	<b>19.01</b>	<b>56.93</b>	<b>19.01</b>	<b>19.01</b>	<b>28.0</b>	<b>28.0</b>	<b>28.0</b>	<b>28.0</b>
External leakage - Utility medium	1†	<b>4.76</b>	<b>95.24</b>	<b>285.24</b>	<b>95.24</b>	<b>95.24</b>				
	1*	0.95	19.01	56.93	19.01	19.01	28.0	28.0	28.0	28.0
<b>All modes</b>	2*	<b>1.90</b>	<b>38.02</b>	<b>113.86</b>	<b>38.02</b>	<b>38.02</b>	<b>68.0</b>	<b>28.0</b>	<b>68.0</b>	<b>108.0</b>
	2†	<b>9.52</b>	<b>190.48</b>	<b>570.48</b>	<b>190.48</b>	<b>190.48</b>				
<b>Comments</b>										

Taxonomy no 1.4.1.5		Item Machinery Combustion Engines Diesel engine Water fire fighting								
Population 8	Installations 4	Aggregated time in service (106 hours)						No of demands 1060		
		Calendar time *			Operational time †					
		0.2734			0.0054					
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>4*</b>	<b>1.45</b>	<b>14.66</b>	<b>39.68</b>	<b>12.74</b>	<b>14.63</b>	<b>6.1</b>	<b>4.0</b>	<b>10.8</b>	<b>19.0</b>
	<b>4†</b>	<b>110.15</b>	<b>1994.21</b>	<b>5911.31</b>	<b>1967.93</b>	<b>740.12</b>				
Breakdown	2*	0.02	7.56	29.97	11.18	7.32	4.0	4.0	5.0	6.0
	2†	2.84	1328.14	5300.98	1982.68	370.06				
Fail to start on demand	2*	0.12	7.17	22.43	7.99	7.32	8.3	14.0	16.5	19.0
	2†	29.45	709.73	2134.96	722.15	370.06				
<b>Degraded</b>	<b>63*</b>	<b>14.06</b>	<b>219.65</b>	<b>639.78</b>	<b>211.82</b>	<b>230.47</b>	<b>10.8</b>	<b>2.0</b>	<b>21.7</b>	<b>207.0</b>
	<b>63†</b>	<b>489.73</b>	<b>25587.76</b>	<b>79588.78</b>	<b>28226.98</b>	<b>11656.95</b>				
Erratic output	1*	0.00	3.52	16.48	6.71	3.66	3.0	6.0	6.0	6.0
	1†	0.42	352.65	1452.02	550.95	185.03				
External leakage - Fuel	4*	1.31	14.20	39.00	12.61	14.63	3.4	3.0	6.8	12.0
	4†	9.24	1533.90	5392.51	1991.09	740.12				
External leakage - Utility medium	25*	5.86	87.61	253.68	83.82	91.45	6.7	2.0	13.3	34.0
	25†	106.51	9607.19	31210.58	11350.16	4625.77				
High output	1*	0.20	3.70	10.99	3.66	3.66	4.0	4.0	4.0	4.0
	1†	0.69	596.62	2462.06	934.91	185.03				
Internal leakage	1*	0.00	3.61	17.31	7.12	3.66	5.0	10.0	10.0	10.0
	1†	0.35	377.90	1577.91	602.40	185.03				
Low output	6*	3.43	21.42	52.23	15.85	21.95	8.9	6.0	17.8	30.0
	6†	32.71	2356.20	7500.02	2702.29	1110.19				
Other	18*	0.81	62.27	199.31	72.02	65.85	14.6	2.0	29.2	82.0
	18†	45.67	7045.47	24480.12	9031.03	3330.56				
Overheating	2*	0.12	7.17	22.43	7.99	7.32	67.5	63.0	135.0	207.0
	2†	29.45	709.73	2134.96	722.15	370.06				
Structural deficiency	5*	2.41	18.28	46.53	14.45	18.29	5.7	3.0	13.0	30.0
	5†	188.46	2404.53	6800.70	2227.43	925.15				
<b>Incipient</b>	<b>126*</b>	<b>7.91</b>	<b>435.34</b>	<b>1358.55</b>	<b>483.14</b>	<b>460.93</b>	<b>4.5</b>	<b>1.0</b>	<b>9.1</b>	<b>65.0</b>
	<b>126†</b>	<b>540.45</b>	<b>50699.91</b>	<b>165361.90</b>	<b>60223.28</b>	<b>23313.90</b>				
Abnormal instrument reading	60*	2.12	206.49	675.97	246.49	219.49	4.7	1.0	9.5	65.0
	60†	159.75	23565.99	81326.02	29981.86	11101.86				
External leakage - Utility medium	11*	10.47	39.44	83.59	23.18	40.24	3.0	2.0	6.5	18.0
	11†	350.04	4832.51	13836.45	4553.42	2035.34				
Internal leakage	1*	0.00	3.61	17.31	7.12	3.66	25.0	51.5	51.5	51.5
	1†	0.35	377.90	1577.91	602.40	185.03				
Minor in-service problems	49*	2.91	169.62	531.39	189.54	179.25	4.4	1.0	8.7	45.0
	49†	167.63	19394.84	64764.33	23746.48	9066.52				
Other	4*	4.87	14.47	28.22	7.32	14.63	2.5	1.0	4.8	12.0
	4†	27.63	1546.03	4830.02	1719.20	740.12				
Overheating	1*	0.20	3.70	10.99	3.66	3.66	3.0	3.0	3.0	3.0
	1†	0.69	596.62	2462.06	934.91	185.03				

Comments  
(cont.)

<b>Taxonomy no</b> 1.4.1.5		<b>Item</b> Machinery Combustion Engines Diesel engine Water fire fighting									
<b>Population</b> 8	<b>Installations</b> 4	<b>Aggregated time in service (106 hours)</b>					<b>No of demands</b>				
		<b>Calendar time *</b> 0.2734			<b>Operational time †</b> 0.0054		1060				
<b>Failure mode</b>		<b>No of failures</b>	<b>Failure rate (per 106 hours).</b>				<b>Active rep.hrs</b>	<b>Repair (manhours)</b>			
			<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>		<b>n/τ</b>	<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>		193*	20.47	668.91	2032.32	701.31	706.03	6.6	1.0	13.2	207.0
		193†	1161.52	78593.05	248915.80	89429.38	35710.98				
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.9. 10 <sup>-3</sup>											



Taxonomy no 1.4.2		Item Machinery Combustion Engines Gas engine									
Population 34	Installations 18	Aggregated time in service (106 hours)					No of demands				
		Calendar time * 0.3856			Operational time † 0.2651		1536				
Failure mode		No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
			Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>		<b>31*</b>	<b>11.95</b>	<b>69.68</b>	<b>166.92</b>	<b>50.08</b>	<b>80.40</b>	<b>26.8</b>	<b>0.5</b>	<b>20.8</b>	<b>121.0</b>
		<b>31†</b>	<b>0.79</b>	<b>122.33</b>	<b>425.38</b>	<b>156.94</b>	<b>116.94</b>				
Breakdown		3*	0.00	6.01	26.61	10.47	7.78	36.0	8.0	36.0	84.0
		3†	1.17	10.24	26.84	8.45	11.32				
External leakage - Utility medium		2*	0.00	5.54	30.70	15.72	5.19	-	1.0	3.5	6.0
		2†	1.18	8.04	20.03	6.15	7.54				
Fail to start on demand		5*	0.01	9.13	38.04	14.51	12.97	44.8	6.0	44.8	121.0
		5†	0.32	13.98	43.06	15.12	18.86				
Fail to stop on demand		1*	0.00	2.84	13.31	5.42	2.59	-	6.0	6.0	6.0
		1†	0.00	4.62	23.30	10.00	3.77				
Low output		1*	0.00	2.55	13.55	8.97	2.59	-	0.5	0.5	0.5
		1†	0.00	4.10	21.85	14.35	3.77				
Minor in-service problems		1*	0.00	2.84	13.31	5.42	2.59	-	1.0	1.0	1.0
		1†	0.00	4.62	23.30	10.00	3.77				
Other		4*	0.01	8.44	34.78	13.20	10.37	16.0	4.0	39.8	111.0
		4†	0.00	13.46	72.60	46.27	15.09				
Overheating		3*	0.00	8.57	42.06	17.68	7.78	32.0	1.0	4.5	8.0
		3†	0.00	17.27	87.24	37.51	11.32				
Parameter deviation		1*	0.00	2.84	13.31	5.42	2.59	-	1.0	1.0	1.0
		1†	0.00	4.62	23.30	10.00	3.77				
Spurious stop		8*	4.65	19.44	42.57	12.08	20.75	8.8	4.0	8.6	16.0
		8†	0.00	36.45	176.90	73.38	30.18				
Structural deficiency		1*	0.00	2.55	13.55	8.97	2.59	-	6.0	6.0	6.0
		1†	0.00	4.10	21.85	14.35	3.77				
Vibration		1*	0.00	2.84	13.31	5.42	2.59	-	-	-	-
		1†	0.00	4.62	23.30	10.00	3.77				
<b>Degraded</b>		<b>50*</b>	<b>66.26</b>	<b>127.41</b>	<b>204.68</b>	<b>42.64</b>	<b>129.68</b>	<b>29.5</b>	<b>0.1</b>	<b>26.1</b>	<b>221.0</b>
		<b>50†</b>	<b>76.84</b>	<b>196.97</b>	<b>362.21</b>	<b>88.87</b>	<b>188.61</b>				
Erratic output		1*	0.00	2.84	13.31	5.42	2.59	-	23.0	23.0	23.0
		1†	0.00	4.62	23.30	10.00	3.77				
External leakage - Fuel		1*	0.00	2.55	13.55	8.96	2.59	8.0	8.0	8.0	8.0
		1†	0.00	3.62	19.93	9.43	3.77				
External leakage - Utility medium		7*	3.74	18.21	41.65	12.17	18.16	36.0	1.0	25.1	78.0
		7†	1.46	28.33	84.60	28.22	26.41				
Fail to start on demand		3*	0.00	8.60	44.67	19.82	7.78	-	1.0	9.5	18.0
		3†	2.26	12.28	28.89	8.57	11.32				
High output		2*	0.01	4.02	16.00	5.97	5.19	9.0	6.0	9.0	12.0
		2†	0.31	6.20	18.56	6.20	7.54				
Internal leakage		1*	0.01	2.25	8.08	2.99	2.59	16.0	16.0	16.0	16.0
		1†	0.04	3.24	10.42	3.77	3.77				
<b>Comments</b>											
(cont.)											

Taxonomy no 1.4.2		Item Machinery Combustion Engines Gas engine									
Population 34	Installations 18	Aggregated time in service (106 hours)					No of demands				
		Calendar time *		Operational time †			1536				
		0.3856		0.2651							
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
Low output	7*	0.07	16.79	62.97	23.24	18.16	12.7	1.0	25.1	74.0	
	7†	0.08	25.07	97.35	36.04	26.41					
Minor in-service problems	1*	0.00	2.84	13.31	5.42	2.59	-	2.0	2.0	2.0	
	1†	0.00	4.62	23.30	10.00	3.77					
Noise	1*	0.01	2.25	8.08	2.99	2.59	56.0	56.0	56.0	56.0	
	1†	0.04	3.24	10.42	3.77	3.77					
Other	16*	0.55	42.49	136.07	49.18	41.50	24.6	0.1	11.7	63.0	
	16†	0.72	69.60	227.74	83.03	60.35					
Overheating	3*	0.00	8.06	40.61	17.43	7.78	-	8.0	29.5	51.0	
	3†	0.00	12.20	61.09	26.12	11.32					
Parameter deviation	2*	0.00	4.30	24.93	13.61	5.19	116.0	4.0	60.0	116.0	
	2†	0.00	6.34	34.41	21.57	7.54					
Spurious stop	1*	0.00	2.84	13.31	5.42	2.59	-	25.0	25.0	25.0	
	1†	0.00	4.62	23.30	10.00	3.77					
Structural deficiency	2*	0.00	6.19	35.49	19.14	5.19	-	85.0	153.0	221.0	
	2†	0.00	10.07	57.41	30.79	7.54					
Unknown	1*	0.00	2.55	13.55	8.97	2.59	-	4.0	4.0	4.0	
	1†	0.00	4.10	21.85	14.35	3.77					
Vibration	1*	0.00	2.55	13.55	8.96	2.59	42.0	42.0	42.0	42.0	
	1†	0.00	7.36	42.32	22.88	3.77					
<b>Incipient</b>	<b>92*</b>	<b>56.57</b>	<b>229.52</b>	<b>498.06</b>	<b>140.49</b>	<b>238.61</b>	<b>23.8</b>	<b>1.0</b>	<b>16.6</b>	<b>170.0</b>	
	<b>92†</b>	<b>89.33</b>	<b>371.06</b>	<b>810.90</b>	<b>229.79</b>	<b>347.04</b>					
Abnormal instrument reading	4*	0.00	7.70	40.73	18.55	10.37	5.5	1.0	5.5	12.0	
	4†	0.00	16.96	93.29	46.10	15.09					
Erratic output	3*	0.00	6.87	35.65	15.76	7.78	-	6.0	35.5	65.0	
	3†	0.00	10.46	55.20	25.09	11.32					
External leakage - Fuel	1*	0.00	2.84	13.31	5.42	2.59	-	6.0	6.0	6.0	
	1†	0.00	4.62	23.30	10.00	3.77					
External leakage - Utility medium	11*	1.23	27.19	81.60	27.44	28.53	15.3	3.0	11.0	33.0	
	11†	0.98	41.91	128.89	45.21	41.49					
Fail to start on demand	13*	0.17	42.97	165.14	60.82	33.72	-	2.0	20.2	148.0	
	13†	0.29	70.02	265.43	97.87	49.04					
Fail to stop on demand	1*	0.00	2.84	13.31	5.42	2.59	-	8.0	8.0	8.0	
	1†	0.00	4.62	23.30	10.00	3.77					
Internal leakage	1*	0.01	2.25	8.08	2.99	2.59	32.0	32.0	32.0	32.0	
	1†	0.04	3.24	10.42	3.77	3.77					
Minor in-service problems	5*	0.00	8.80	42.34	17.46	12.97	11.7	6.0	13.3	18.0	
	5†	0.00	12.14	58.61	24.20	18.86					
Other	37*	13.07	92.44	231.98	71.54	95.96	38.0	1.0	17.2	170.0	
	37†	18.27	148.06	381.69	119.21	139.57					
<b>Comments</b> (cont.)											

Taxonomy no		Item									
1.4.2		Machinery Combustion Engines Gas engine									
Population	Installations	Aggregated time in service (106 hours)					No of demands				
		Calendar time *			Operational time †		1536				
34		0.3856			0.2651						
Failure mode	No of failures	Failure rate (per 106 hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
Overheating	5*	0.01	9.13	38.05	14.51	12.97	23.8	12.0	21.4	35.0	
	5†	0.05	13.19	49.90	18.40	18.86					
Parameter deviation	1*	0.00	2.84	13.31	5.42	2.59	-	18.0	18.0	18.0	
	1†	0.00	4.62	23.30	10.00	3.77					
Spurious stop	9*	2.94	26.53	69.94	22.11	23.34	-	4.0	15.8	66.0	
	9†	3.73	43.57	121.38	39.51	33.95					
Vibration	1*	0.00	2.84	13.31	5.42	2.59	-	16.0	16.0	16.0	
	1†	0.00	4.62	23.30	10.00	3.77					
<b>Unknown</b>	<b>19*</b>	<b>0.43</b>	<b>56.33</b>	<b>190.93</b>	<b>70.22</b>	<b>49.28</b>	-	<b>1.0</b>	<b>18.5</b>	<b>142.0</b>	
	<b>19†</b>	<b>0.69</b>	<b>91.38</b>	<b>310.34</b>	<b>114.16</b>	<b>71.67</b>					
Fail to start on demand	2*	0.00	5.54	30.70	15.72	5.19	-	2.0	2.0	2.0	
	2†	1.18	8.04	20.03	6.15	7.54					
Minor in-service problems	1*	0.00	2.84	13.31	5.42	2.59	-	1.0	1.0	1.0	
	1†	0.00	4.62	23.30	10.00	3.77					
Other	10*	0.00	28.96	139.97	57.81	25.94	-	1.0	28.8	142.0	
	10†	0.00	46.89	224.39	92.31	37.72					
Parameter deviation	1*	0.00	2.84	13.31	5.42	2.59	-	1.0	1.0	1.0	
	1†	0.00	4.62	23.30	10.00	3.77					
Unknown	5*	0.00	15.61	81.08	35.91	12.97	-	2.0	5.5	12.0	
	5†	0.00	25.37	131.10	57.43	18.86					
<b>All modes</b>		<b>192*</b>	<b>200.77</b>	<b>475.20</b>	<b>844.18</b>	<b>199.69</b>	<b>497.98</b>	<b>26.5</b>	<b>0.1</b>	<b>20.0</b>	<b>221.0</b>
		<b>192†</b>	<b>246.19</b>	<b>786.94</b>	<b>1576.63</b>	<b>418.23</b>	<b>724.25</b>				
<b>Comments</b>											
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 2.6. 10-3											

Maintainable item versus failure mode, to be continued

Item: Combustion Engines - Gas engine

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00
Cam shaft	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00
Cylinders	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exhaust	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00
Fan w/motor	0.00	0.00	0.00	0.00	0.00	1.04	0.00	0.00	0.00	0.00
Heat exchanger	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Injections	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, level	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, speed	0.00	0.00	0.00	0.52	0.00	0.00	0.52	0.00	0.00	0.00
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00	2.08	0.00
Other	0.00	0.00	1.04	2.60	0.00	1.56	0.00	0.00	0.52	0.00
Piping	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.00	0.00	0.00
Piston(s)	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00
Pump	0.00	0.00	0.00	1.56	0.00	0.00	0.00	0.00	0.00	0.00
Seals	0.00	0.00	0.00	0.52	0.00	0.52	0.00	0.00	0.00	0.00
Start control	0.00	0.00	0.00	0.00	0.00	1.04	0.00	0.00	0.00	0.00
Start energy (battery, air)	0.00	0.00	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.00
Starting unit	0.00	0.00	0.00	0.00	0.00	2.60	0.00	0.00	0.00	0.00
Timing chain/V-belt	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	1.56	1.04	0.00	2.60	1.04	2.60	0.52	1.04	1.04	0.52
Total	2.08	1.56	1.04	10.42	2.08	11.98	1.04	1.04	4.17	0.52

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Maintainable item versus failure mode, continued

Item: Combustion Engines - Gas engine

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.52	0.00	1.04
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	1.04
Cam shaft	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.52
Control unit	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04
Cylinders	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26
Exhaust	0.00	2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.60
Fan w/motor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	1.56
Heat exchanger	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.52
Injections	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52
Instrument, general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52
Instrument, level	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.52	0.00	1.04
Instrument, pressure	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.52	0.00	1.04
Instrument, speed	0.00	0.00	0.00	1.04	0.00	0.00	0.00	0.00	0.00	2.08
Instrument, temperature	1.56	1.04	0.00	0.00	0.00	0.00	0.00	0.52	0.00	3.12
Internal power supply	0.52	2.08	0.00	0.00	0.00	0.00	0.52	0.00	0.00	5.73
Other	0.52	11.98	1.04	0.52	0.00	0.00	0.52	3.12	0.52	23.96
Piping	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.52	0.00	3.12
Piston(s)	0.00	0.52	0.52	0.00	0.52	0.00	0.00	0.00	0.00	2.08
Pump	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.08
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04
Start control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04
Start energy (battery, air)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.08
Starting unit	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00	3.12
Timing chain/V-belt	0.52	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.82
Unknown	2.60	13.54	0.52	2.08	0.52	0.00	1.56	3.65	0.52	36.98
Total	5.73	34.90	2.60	4.17	1.56	1.04	3.13	9.38	1.56	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Combustion Enigens - Gas engine

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Breakage	0.00	0.52	0.00	0.52	0.00	0.00	0.52	0.00	0.00	0.00
Combined causes	0.00	0.00	0.00	1.04	0.52	0.00	0.00	0.00	0.52	0.00
Common mode failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04	0.00
Corrosion	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	0.52	1.56	0.00	0.00	0.52	0.00
Erosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	0.00	0.00	0.00	0.00	0.52	0.00	0.52	0.00	0.00	0.00
Leakage	0.00	0.00	1.04	4.69	0.00	0.52	0.00	0.00	0.00	0.00
Looseness	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.52	0.52	0.00	1.04	0.00	0.52	0.00	0.52	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	0.52	0.00	3.65	0.00	0.00	1.04	0.00
Misc. external influences	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.52	0.00	0.52	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No power/ voltage	0.00	0.00	0.00	0.00	0.00	1.04	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.52
Out of adjustment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00
Overheating	0.52	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.00	0.00	0.00	0.00	0.00	1.04	0.00	0.00	0.52	0.00
Sticking	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.00
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	0.00	1.56	0.52	0.00	0.00	0.52	0.00	0.00
Total	2.08	1.56	1.04	10.42	2.08	11.98	1.04	1.04	4.17	0.52

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

**Item:** Combustion Engines - Gas engine

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Breakage	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	2.08
Combined causes	0.52	1.04	0.52	0.52	0.52	0.00	0.00	1.04	0.00	6.25
Common mode failure	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.52	0.00	1.04
Contamination	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.52
Control failure	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.52	0.00	3.12
Corrosion	0.00	0.52	0.00	0.00	0.52	0.00	0.00	0.00	0.00	1.56
Electrical failure - general	1.04	2.60	0.00	0.52	0.00	0.52	1.04	0.00	0.00	8.33
Erosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.52
Faulty signal/indication/alarm	0.00	0.52	0.00	0.00	0.00	0.00	0.00	1.04	0.00	1.56
Instrument failure - general	0.00	0.52	0.52	0.00	0.00	0.00	0.00	0.00	0.00	2.08
Leakage	0.00	0.52	0.00	0.52	0.52	0.00	0.00	0.00	0.00	7.81
Looseness	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.52
Material failure - general	0.52	1.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.21
Mechanical Failure - general	0.00	6.25	0.00	1.04	0.00	0.00	0.52	2.60	0.00	15.62
Misc. external influences	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52
Miscellaneous - general	0.52	2.08	0.00	0.00	0.00	0.00	0.52	0.52	0.00	4.69
No cause found	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52
No power/ voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.52
Other	0.00	10.94	1.04	0.00	0.00	0.00	0.00	2.08	0.00	15.10
Out of adjustment	0.00	0.52	0.52	0.00	0.00	0.00	0.00	0.00	0.00	1.56
Overheating	0.52	2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.65
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.56
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52
Unknown	0.52	0.52	0.00	0.00	0.00	0.00	1.04	0.52	0.00	4.69
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04	1.04
Wear	2.08	3.12	0.00	0.00	0.00	0.52	0.00	0.00	0.00	8.33
Total	5.73	34.90	2.60	4.17	1.56	1.04	3.13	9.38	1.56	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 1.4.2.1		Item Machinery Combustion Engines Gas engine Crude oil handling								
Population 3	Installations 1	Aggregated time in service (106 hours)						No of demands 144		
		Calendar time * 0.0789			Operational time † 0.0761					
Failure mode	No of failures	Failure rate (per 106 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/ft		Min	Mean	Max
<b>Critical</b>	<b>11*</b>	<b>78.19</b>	<b>139.40</b>	<b>230.76</b>	<b>139.40</b>	<b>139.40</b>	<b>33.6</b>	<b>4.0</b>	<b>33.6</b>	<b>121.0</b>
	<b>11†</b>	<b>81.10</b>	<b>144.59</b>	<b>239.37</b>	<b>144.59</b>	<b>144.59</b>				
Breakdown	2*	4.50	25.34	79.77	25.34	25.34	50.0	16.0	50.0	84.0
	2†	4.67	26.29	82.75	26.29	26.29				
Fail to start on demand	4*	17.30	50.69	116.02	50.69	50.69	54.5	12.0	54.5	121.0
	4†	17.94	52.58	120.34	52.58	52.58				
Other	2*	4.50	25.34	79.77	25.34	25.34	10.0	4.0	10.0	16.0
	2†	4.67	26.29	82.75	26.29	26.29				
Spurious stop	3*	10.39	38.02	98.27	38.02	38.02	10.7	8.0	10.7	16.0
	3†	10.78	39.43	101.94	39.43	39.43				
<b>Degraded</b>	<b>11*</b>	<b>78.19</b>	<b>139.40</b>	<b>230.76</b>	<b>139.40</b>	<b>139.40</b>	<b>32.1</b>	<b>6.0</b>	<b>32.1</b>	<b>116.0</b>
	<b>11†</b>	<b>81.10</b>	<b>144.59</b>	<b>239.37</b>	<b>144.59</b>	<b>144.59</b>				
External leakage - Utility medium	1*	0.63	12.67	60.13	12.67	12.67	30.0	30.0	30.0	30.0
	1†	0.66	13.14	62.37	13.14	13.14				
High output	2*	4.50	25.34	79.77	25.34	25.34	9.0	6.0	9.0	12.0
	2†	4.67	26.29	82.75	26.29	26.29				
Internal leakage	1*	0.63	12.67	60.13	12.67	12.67	16.0	16.0	16.0	16.0
	1†	0.66	13.14	62.37	13.14	13.14				
Low output	2*	4.50	25.34	79.77	25.34	25.34	12.0	8.0	12.0	16.0
	2†	4.67	26.29	82.75	26.29	26.29				
Noise	1*	0.63	12.67	60.13	12.67	12.67	56.0	56.0	56.0	56.0
	1†	0.66	13.14	62.37	13.14	13.14				
Other	3*	10.39	38.02	98.27	38.02	38.02	31.0	6.0	31.0	63.0
	3†	10.78	39.43	101.94	39.43	39.43				
Parameter deviation	1*	0.63	12.67	60.13	12.67	12.67	116.0	116.0	116.0	116.0
	1†	0.66	13.14	62.37	13.14	13.14				
<b>Incipient</b>	<b>23*</b>	<b>199.19</b>	<b>291.46</b>	<b>412.92</b>	<b>291.46</b>	<b>291.46</b>	<b>25.9</b>	<b>4.0</b>	<b>25.9</b>	<b>170.0</b>
	<b>23†</b>	<b>206.62</b>	<b>302.33</b>	<b>428.31</b>	<b>302.33</b>	<b>302.33</b>				
Abnormal instrument reading	2*	4.50	25.34	79.77	25.34	25.34	10.0	8.0	10.0	12.0
	2†	4.67	26.29	82.75	26.29	26.29				
Erratic output	1*	0.63	12.67	60.13	12.67	12.67	-	-	-	-
	1†	0.66	13.14	62.37	13.14	13.14				
External leakage - Utility medium	3*	10.39	38.02	98.27	38.02	38.02	15.3	14.0	15.3	16.0
	3†	10.78	39.43	101.94	39.43	39.43				
Internal leakage	1*	0.63	12.67	60.13	12.67	12.67	32.0	32.0	32.0	32.0
	1†	0.66	13.14	62.37	13.14	13.14				
Minor in-service problems	4*	17.30	50.69	116.02	50.69	50.69	11.7	6.0	11.7	16.0
	4†	17.94	52.58	120.34	52.58	52.58				
Other	8*	50.44	101.38	182.93	101.38	101.38	39.5	4.0	39.5	170.0
	8†	52.32	105.16	189.74	105.16	105.16				
<b>Comments</b> (cont.)										



<b>Taxonomy no</b> 1.4.2.1		<b>Item</b> Machinery Combustion Engines Gas engine Crude oil handling									
<b>Population</b> 3	<b>Installations</b> 1	<b>Aggregated time in service (106 hours)</b>					<b>No of demands</b> 144				
		<b>Calendar time *</b> 0.0789			<b>Operational time †</b> 0.0761						
<b>Failure mode</b>		<b>No of failures</b>	<b>Failure rate (per 106 hours).</b>				<b>Active rep.hrs</b>	<b>Repair (manhours)</b>			
			<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>		<b>n/τ</b>	<b>Min</b>	<b>Mean</b>	<b>Max</b>
Overheating		4*	17.30	50.69	116.02	50.69	50.69	23.8	12.0	23.8	35.0
		4†	17.94	52.58	120.34	52.58	52.58				
<b>All modes</b>		45*	437.98	570.26	731.13	570.26	570.26	29.5	4.0	29.5	170.0
		45†	454.31	591.51	758.38	591.51	591.51				
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 2.8. 10-2											

Taxonomy no 1.4.2.2		Item Machinery Combustion Enigens Gas engine Emergency power								
Population 1	Installations 1	Aggregated time in service (106 hours)					No of demands			
		Calendar time *			Operational time †					
		0.0263			0.0053					
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>6*</b>	<b>99.41</b>	<b>228.10</b>	<b>450.12</b>	<b>228.10</b>	<b>228.10</b>	<b>16.0</b>	<b>4.0</b>	<b>12.0</b>	<b>28.0</b>
	<b>6†</b>	<b>498.10</b>	<b>1142.86</b>	<b>2255.24</b>	<b>1142.86</b>	<b>1142.86</b>				
Breakdown	1*	1.90	38.02	180.39	38.02	38.02	8.0	8.0	8.0	8.0
	1†	9.52	190.48	903.81	190.48	190.48				
Other	1*	1.90	38.02	180.39	38.02	38.02	28.0	28.0	28.0	28.0
	1†	9.52	190.48	903.81	190.48	190.48				
Overheating	1*	1.90	38.02	180.39	38.02	38.02	32.0	-	-	-
	1†	9.52	190.48	903.81	190.48	190.48				
Spurious stop	3*	31.17	114.05	294.82	114.05	114.05	6.0	4.0	6.0	8.0
	3†	156.19	571.43	1477.14	571.43	571.43				
<b>Degraded</b>	<b>3*</b>	<b>31.17</b>	<b>114.05</b>	<b>294.82</b>	<b>114.05</b>	<b>114.05</b>	<b>28.0</b>	<b>18.0</b>	<b>28.0</b>	<b>42.0</b>
	<b>3†</b>	<b>156.19</b>	<b>571.43</b>	<b>1477.14</b>	<b>571.43</b>	<b>571.43</b>				
External leakage - Utility medium	1*	1.90	38.02	180.39	38.02	38.02	24.0	24.0	24.0	24.0
	1†	9.52	190.48	903.81	190.48	190.48				
Other	1*	1.90	38.02	180.39	38.02	38.02	18.0	18.0	18.0	18.0
	1†	9.52	190.48	903.81	190.48	190.48				
Vibration	1*	1.90	38.02	180.39	38.02	38.02	42.0	42.0	42.0	42.0
	1†	9.52	190.48	903.81	190.48	190.48				
<b>Incipient</b>	<b>3*</b>	<b>31.17</b>	<b>114.05</b>	<b>294.82</b>	<b>114.05</b>	<b>114.05</b>	<b>9.3</b>	<b>1.0</b>	<b>9.3</b>	<b>26.0</b>
	<b>3†</b>	<b>156.19</b>	<b>571.43</b>	<b>1477.14</b>	<b>571.43</b>	<b>571.43</b>				
Abnormal instrument reading	2*	13.50	76.03	239.32	76.03	76.03	1.0	1.0	1.0	1.0
	2†	67.62	380.95	1199.05	380.95	380.95				
Other	1*	1.90	38.02	180.39	38.02	38.02	26.0	26.0	26.0	26.0
	1†	9.52	190.48	903.81	190.48	190.48				
<b>All modes</b>	<b>12*</b>	<b>263.27</b>	<b>456.20</b>	<b>739.04</b>	<b>456.20</b>	<b>456.20</b>	<b>17.5</b>	<b>1.0</b>	<b>16.0</b>	<b>42.0</b>
	<b>12†</b>	<b>1319.05</b>	<b>2285.71</b>	<b>3702.80</b>	<b>2285.71</b>	<b>2285.71</b>				
<b>Comments</b>										

Taxonomy no 1.4.2.3		Item Machinery Combustion Engines Gas engine Main power								
Population 30	Installations 16	Aggregated time in service (106 hours)					No of demands			
		Calendar time * 0.2803			Operational time † 0.1838		1392			
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>14*</b>	<b>5.74</b>	<b>48.00</b>	<b>124.44</b>	<b>38.96</b>	<b>49.94</b>	<b>6.0</b>	<b>0.5</b>	<b>12.6</b>	<b>111.0</b>
	<b>14†</b>	<b>7.17</b>	<b>74.26</b>	<b>202.13</b>	<b>65.06</b>	<b>76.18</b>				
External leakage - Utility medium	2*	0.00	6.64	35.83	16.61	7.13	-	1.0	3.5	6.0
	2†	0.00	10.44	56.93	26.58	10.88				
Fail to start on demand	1*	0.00	3.13	17.79	9.50	3.57	6.0	6.0	6.0	6.0
	1†	0.00	4.60	23.25	10.00	5.44				
Fail to stop on demand	1*	0.18	3.58	10.69	3.57	3.57	-	6.0	6.0	6.0
	1†	0.30	5.50	16.33	5.44	5.44				
Low output	1*	0.00	3.13	17.80	9.51	3.57	-	0.5	0.5	0.5
	1†	0.00	4.89	28.14	15.22	5.44				
Minor in-service problems	1*	0.18	3.58	10.69	3.57	3.57	-	1.0	1.0	1.0
	1†	0.30	5.50	16.33	5.44	5.44				
Other	1*	0.00	3.13	17.80	9.51	3.57	-	111.0	111.0	111.0
	1†	0.00	4.89	28.14	15.22	5.44				
Overheating	2*	0.00	7.26	40.05	20.22	7.13	-	1.0	4.5	8.0
	2†	0.00	11.48	63.57	32.49	10.88				
Parameter deviation	1*	0.18	3.58	10.69	3.57	3.57	-	1.0	1.0	1.0
	1†	0.30	5.50	16.33	5.44	5.44				
Spurious stop	2*	0.00	7.25	39.88	19.50	7.13	-	6.0	8.0	10.0
	2†	0.00	11.47	63.09	31.19	10.88				
Structural deficiency	1*	0.00	3.13	17.80	9.51	3.57	-	6.0	6.0	6.0
	1†	0.00	4.89	28.14	15.22	5.44				
Vibration	1*	0.18	3.58	10.69	3.57	3.57	-	-	-	-
	1†	0.30	5.50	16.33	5.44	5.44				
<b>Degraded</b>	<b>36*</b>	<b>46.64</b>	<b>125.42</b>	<b>235.31</b>	<b>58.89</b>	<b>128.41</b>	<b>24.8</b>	<b>0.1</b>	<b>23.9</b>	<b>221.0</b>
	<b>36†</b>	<b>78.06</b>	<b>191.95</b>	<b>346.71</b>	<b>83.51</b>	<b>195.89</b>				
Erratic output	1*	0.18	3.58	10.69	3.57	3.57	-	23.0	23.0	23.0
	1†	0.30	5.50	16.33	5.44	5.44				
External leakage - Fuel	1*	0.00	3.13	17.79	9.50	3.57	8.0	8.0	8.0	8.0
	1†	0.00	4.60	23.25	10.00	5.44				
External leakage - Utility medium	5*	0.73	17.29	51.98	17.57	17.84	45.0	1.0	24.4	78.0
	5†	3.45	26.09	66.36	20.60	27.21				
Fail to start on demand	3*	0.00	10.25	49.96	20.84	10.70	-	1.0	9.5	18.0
	3†	0.00	16.14	79.25	33.35	16.32				
Low output	5*	0.06	16.98	65.71	24.28	17.84	14.0	1.0	30.4	74.0
	5†	0.06	25.76	101.70	37.90	27.21				
Minor in-service problems	1*	0.18	3.58	10.69	3.57	3.57	-	2.0	2.0	2.0
	1†	0.30	5.50	16.33	5.44	5.44				
Other	12*	0.20	43.39	160.37	59.23	42.80	12.0	0.1	5.9	24.0
	12†	0.28	67.68	257.13	94.79	65.30				
<b>Comments</b>										
(cont.)										

Taxonomy no 1.4.2.3		Item Machinery Combustion Engines Gas engine Main power								
Population 30	Installations 16	Aggregated time in service (106 hours)					No of demands 1392			
		Calendar time * 0.2803			Operational time † 0.1838					
Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Overheating	3*	0.00	9.77	45.35	18.34	10.70	-	8.0	29.5	51.0
	3†	0.00	14.51	67.73	27.49	16.32	-			
Parameter deviation	1*	0.18	3.58	10.69	3.57	3.57	-	4.0	4.0	4.0
	1†	0.30	5.50	16.33	5.44	5.44	-			
Spurious stop	1*	0.18	3.58	10.69	3.57	3.57	-	25.0	25.0	25.0
	1†	0.30	5.50	16.33	5.44	5.44	-			
Structural deficiency	2*	0.00	7.26	40.05	20.22	7.13	-	85.0	153.0	221.0
	2†	0.00	11.48	63.57	32.49	10.88	-			
Unknown	1*	0.00	3.13	17.80	9.51	3.57	-	4.0	4.0	4.0
	1†	0.00	4.89	28.14	15.22	5.44	-			
<b>Incipient</b>	<b>66*</b>	<b>42.54</b>	<b>231.95</b>	<b>546.16</b>	<b>162.15</b>	<b>235.43</b>	-	<b>1.0</b>	<b>13.5</b>	<b>148.0</b>
	<b>66†</b>	<b>60.65</b>	<b>368.70</b>	<b>892.92</b>	<b>269.83</b>	<b>359.13</b>	-			
Erratic output	2*	0.00	6.64	35.83	16.61	7.13	-	6.0	35.5	65.0
	2†	0.00	10.44	56.93	26.58	10.88	-			
External leakage - Fuel	1*	0.18	3.58	10.69	3.57	3.57	-	6.0	6.0	6.0
	1†	0.30	5.50	16.33	5.44	5.44	-			
External leakage - Utility medium	8*	0.26	27.76	91.79	33.57	28.54	-	3.0	9.1	33.0
	8†	0.31	43.69	149.91	55.23	43.53	-			
Fail to start on demand	13*	0.35	49.40	169.66	62.51	46.37	-	2.0	20.2	148.0
	13†	0.51	78.53	273.08	100.75	70.74	-			
Fail to stop on demand	1*	0.18	3.58	10.69	3.57	3.57	-	8.0	8.0	8.0
	1†	0.30	5.50	16.33	5.44	5.44	-			
Minor in-service problems	1*	0.18	3.58	10.69	3.57	3.57	-	18.0	18.0	18.0
	1†	0.30	5.50	16.33	5.44	5.44	-			
Other	28*	8.91	95.11	260.45	84.09	99.88	-	1.0	8.7	20.0
	28†	12.07	150.44	423.89	138.62	152.36	-			
Overheating	1*	0.00	3.13	17.80	9.51	3.57	-	12.0	12.0	12.0
	1†	0.00	4.89	28.14	15.22	5.44	-			
Parameter deviation	1*	0.18	3.58	10.69	3.57	3.57	-	18.0	18.0	18.0
	1†	0.30	5.50	16.33	5.44	5.44	-			
Spurious stop	9*	16.86	32.22	51.60	10.70	32.10	-	4.0	15.8	66.0
	9†	21.29	49.72	87.82	20.64	48.97	-			
Vibration	1*	0.18	3.58	10.69	3.57	3.57	-	16.0	16.0	16.0
	1†	0.30	5.50	16.33	5.44	5.44	-			
<b>Unknown</b>	<b>19*</b>	<b>2.28</b>	<b>65.82</b>	<b>199.08</b>	<b>68.15</b>	<b>67.77</b>	-	<b>1.0</b>	<b>18.5</b>	<b>142.0</b>
	<b>19†</b>	<b>2.64</b>	<b>104.14</b>	<b>318.97</b>	<b>111.33</b>	<b>103.39</b>	-			
Fail to start on demand	2*	0.00	6.64	35.83	16.61	7.13	-	2.0	2.0	2.0
	2†	0.00	10.44	56.93	26.58	10.88	-			
Minor in-service problems	1*	0.18	3.58	10.69	3.57	3.57	-	1.0	1.0	1.0
	1†	0.30	5.50	16.33	5.44	5.44	-			

Comments  
(cont.)

<b>Taxonomy no</b> 1.4.2.3		<b>Item</b> Machinery Combustion Engines Gas engine Main power									
<b>Population</b> 30	<b>Installations</b> 16	<b>Aggregated time in service (106 hours)</b>					<b>No of demands</b> 1392				
		<b>Calendar time *</b> 0.2803			<b>Operational time †</b> 0.1838						
<b>Failure mode</b>		<b>No of failures</b>	<b>Failure rate (per 106 hours).</b>				<b>Active rep.hrs</b>	<b>Repair (manhours)</b>			
			<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>		<b>n/t</b>	<b>Min</b>	<b>Mean</b>	<b>Max</b>
Other		10*	0.00	33.58	153.94	61.56	35.67	-	1.0	28.8	142.0
		10†	0.00	53.30	245.23	98.40	54.41	-			
Parameter deviation		1*	0.18	3.58	10.69	3.57	3.57	-	1.0	1.0	1.0
		1†	0.30	5.50	16.33	5.44	5.44	-			
Unknown		5*	0.00	18.14	90.19	38.37	17.84	-	2.0	5.5	12.0
		5†	0.00	28.77	143.74	61.37	27.21	-			
<b>All modes</b>		<b>135*</b>	<b>154.18</b>	<b>465.50</b>	<b>913.12</b>	<b>238.02</b>	<b>481.55</b>	<b>21.7</b>	<b>0.1</b>	<b>17.0</b>	<b>221.0</b>
		<b>135†</b>	<b>213.84</b>	<b>730.59</b>	<b>1498.93</b>	<b>405.58</b>	<b>734.59</b>				
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0, 100											

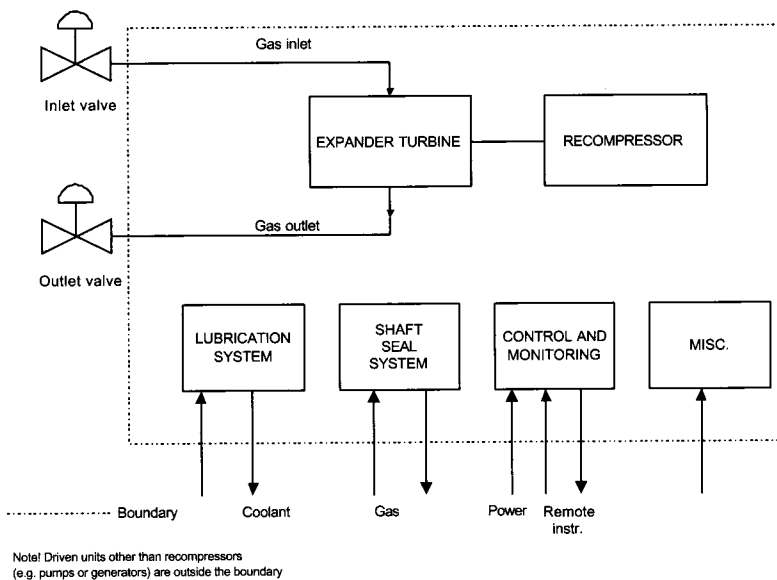
### Turboexpanders

#### Inventory description

The boundary definition is shown in Figure 14 and corresponding subdivision in Maintainable Items in Table 9. The Turboexpander boundary includes the expander turbine and recompressor with auxiliaries. Included in the boundary are any inlet mesh screens, but any quick closure valve in the inlet stream is excluded. Also included is any system for glycol injection in the inlet stream, but not the power or the glycol feed to such a system.

**Note! The boundary for Turboexpanders used for other purposes than recompression (e.g. driving an electric generator or pump) does not include the driven unit (e.g. the generator).**

Subunits that are common to the *driver* (i.e. the turboexpander) and the *driven unit* (e.g. a pump or an electric generator) are a part of the *driven unit*.



**Figure 14 – Turboexpanders, Boundary Definition**

**Table 9 Turboexpanders, Subdivision in Maintainable Items**

TURBOEXPANDERS					
Expander turbine	Control & monitoring	Lubrication system	Shaft seal system	Miscellaneous	Recompressor
<ul style="list-style-type: none"> <li>• Casing</li> <li>• Inlet screen</li> <li>• Inlet vanes</li> <li>• Instruments</li> <li>• Piping</li> <li>• Radial bearing</li> <li>• Rotor w/impeller</li> <li>• Seals</li> <li>• Thrust bearing</li> <li>• Valves</li> </ul>	<ul style="list-style-type: none"> <li>• Actuating device</li> <li>• Cabling &amp; junction boxes</li> <li>• Control unit</li> <li>• Instruments</li> <li>• Internal power supply</li> <li>• Monitoring</li> <li>• Valves</li> </ul>	<ul style="list-style-type: none"> <li>• Reservoir</li> <li>• Pump w/motor</li> <li>• Filter</li> <li>• Cooler</li> <li>• Valves &amp; piping</li> <li>• Oil</li> <li>• Instruments</li> <li>• Seals</li> </ul>	<ul style="list-style-type: none"> <li>• Buffer gas system</li> <li>• Dry gas seal</li> <li>• Filters</li> <li>• Instruments</li> <li>• Overhead tank</li> <li>• Pump w/motor/gear</li> <li>• Reservoir</li> <li>• Scrubber</li> <li>• Seal gas</li> <li>• Seal oil</li> <li>• Valves</li> </ul>	<ul style="list-style-type: none"> <li>• Other</li> </ul>	<ul style="list-style-type: none"> <li>• Casing</li> <li>• Instruments</li> <li>• Piping</li> <li>• Radial bearing</li> <li>• Rotor w/impeller</li> <li>• Seals</li> <li>• Thrust bearing</li> <li>• Valves</li> </ul>

(For all subunits the MIs "Unknown" and "Subunit" are included.)

**List of failure modes**

- AIR Abnormal instrument reading
- BRD Breakdown
- ERO Erratic output
- ELP External leakage - Process medium
- ELU External leakage - Utility medium
- FTS Fail to start on demand
- INL Internal leakage
- SER Minor in-service problems
- OTH Other
- UST Spurious stop
- UNK Unknown
- VIB Vibration

Taxonomy no 1.5		Item Machinery Turboexpanders								
Population 11	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 96			
		Calendar time *			Operational time †					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>23*</b>	<b>34.23</b>	<b>72.61</b>	<b>122.56</b>	<b>27.31</b>	<b>77.20</b>	-	<b>4.0</b>	<b>73.4</b>	<b>531.0</b>
	<b>23†</b>	<b>30.50</b>	<b>81.90</b>	<b>153.57</b>	<b>38.41</b>	<b>88.12</b>				
Breakdown	2*	0.27	6.61	19.91	6.74	6.71	-	6.0	98.0	190.0
	2†	0.09	7.67	24.66	8.93	7.66				
Erratic output	2*	0.27	6.61	19.91	6.74	6.71	-	8.0	19.0	30.0
	2†	0.09	7.67	24.66	8.93	7.66				
External leakage - Utility medium	1*	0.04	2.93	9.32	3.36	3.36	-	4.0	4.0	4.0
	1†	0.04	3.32	10.61	3.83	3.83				
Fail to start on demand	3*	1.27	13.62	37.35	12.06	10.07	-	8.0	10.0	12.0
	3†	1.12	16.09	46.32	15.27	11.49				
Other	2*	0.27	6.61	19.91	6.74	6.71	-	152.0	196.0	240.0
	2†	0.09	7.67	24.66	8.93	7.66				
Spurious stop	12*	15.95	36.36	63.52	14.75	40.28	-	6.0	61.9	531.0
	12†	22.53	42.37	67.27	13.78	45.97				
Unknown	1*	0.04	2.93	9.32	3.36	3.36	-	210.0	210.0	210.0
	1†	0.04	3.32	10.61	3.83	3.83				
<b>Degraded</b>	<b>31*</b>	<b>24.34</b>	<b>91.82</b>	<b>194.68</b>	<b>54.01</b>	<b>104.05</b>	-	<b>1.0</b>	<b>12.7</b>	<b>98.0</b>
	<b>31†</b>	<b>82.94</b>	<b>115.65</b>	<b>152.83</b>	<b>21.33</b>	<b>118.77</b>				
Abnormal instrument reading	4*	0.15	10.03	31.75	11.41	13.43	-	1.0	4.0	8.0
	4†	0.17	11.32	35.80	12.85	15.32				
External leakage - Process medium	2*	1.45	7.09	16.24	4.75	6.71	-	20.0	20.0	20.0
	2†	0.01	8.62	35.64	13.54	7.66				
External leakage - Utility medium	5*	2.96	16.62	39.40	11.74	16.78	-	3.0	5.8	12.0
	5†	4.34	18.92	41.92	11.98	19.16				
Internal leakage	2*	0.23	5.60	16.84	5.70	6.71	-	2.0	2.0	2.0
	2†	0.28	6.35	19.08	6.42	7.66				
Minor in-service problems	1*	0.04	2.93	9.32	3.36	3.36	-	2.0	2.0	2.0
	1†	0.04	3.32	10.61	3.83	3.83				
Other	17*	32.17	56.65	86.72	16.76	57.06	-	2.0	18.2	98.0
	17†	20.04	63.94	128.01	33.94	65.13				
<b>Incipient</b>	<b>59*</b>	<b>30.93</b>	<b>302.06</b>	<b>811.68</b>	<b>259.49</b>	<b>198.03</b>	-	<b>2.0</b>	<b>8.1</b>	<b>36.0</b>
	<b>59†</b>	<b>34.84</b>	<b>326.31</b>	<b>868.44</b>	<b>276.13</b>	<b>226.04</b>				
Abnormal instrument reading	27*	7.74	126.25	369.72	122.62	90.62	-	2.0	10.7	36.0
	27†	8.79	140.45	410.29	135.97	103.44				
External leakage - Process medium	1*	0.01	6.03	24.68	9.34	3.36	-	-	-	-
	1†	0.01	6.16	24.83	9.34	3.83				
External leakage - Utility medium	4*	1.70	23.28	66.55	21.89	13.43	-	2.0	2.0	2.0
	4†	1.99	23.67	66.12	21.55	15.32				
Minor in-service problems	9*	1.07	74.77	237.45	85.44	30.21	-	-	-	-
	9†	0.78	75.06	245.39	89.44	34.46				
Other	15*	19.49	53.45	101.07	25.49	50.35	-	2.0	5.6	12.0
	15†	13.98	62.10	138.41	39.73	57.47				
<b>Comments</b>										

(cont.)



Taxonomy no 1.5		Item Machinery Turboexpanders								
Population 11	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 96			
		Calendar time *			Operational time †					
		0.2979					0.2610			
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Unknown	1*	0.04	2.93	9.32	3.36	3.36	-	4.0	4.0	4.0
	1†	0.04	3.32	10.61	3.83	3.83	-	-	-	-
Vibration	2*	0.01	13.43	56.35	21.57	6.71	-	-	-	-
	2†	0.01	13.63	57.99	22.37	7.66	-	-	-	-
<b>Unknown</b>	7*	<b>1.29</b>	<b>17.16</b>	<b>48.86</b>	<b>16.04</b>	<b>23.49</b>	-	<b>1.0</b>	<b>95.7</b>	<b>220.0</b>
	7†	<b>1.76</b>	<b>19.58</b>	<b>54.07</b>	<b>17.53</b>	<b>26.82</b>	-	-	-	-
Abnormal instrument reading	2*	0.23	5.60	16.84	5.70	6.71	-	30.0	39.0	48.0
	2†	0.28	6.35	19.08	6.42	7.66	-	-	-	-
External leakage - Utility medium	1*	0.04	2.93	9.32	3.36	3.36	-	1.0	1.0	1.0
	1†	0.04	3.32	10.61	3.83	3.83	-	-	-	-
Other	2*	0.23	5.60	16.84	5.70	6.71	-	220.0	220.0	220.0
	2†	0.28	6.35	19.08	6.42	7.66	-	-	-	-
Unknown	2*	0.23	5.60	16.84	5.70	6.71	-	3.0	75.5	148.0
	2†	0.28	6.35	19.08	6.42	7.66	-	-	-	-
<b>All modes</b>	120*	<b>181.79</b>	<b>459.16</b>	<b>839.00</b>	<b>204.50</b>	<b>402.77</b>	-	<b>1.0</b>	<b>32.4</b>	<b>531.0</b>
	120†	<b>211.78</b>	<b>510.39</b>	<b>913.66</b>	<b>217.90</b>	<b>459.74</b>	-	-	-	-
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode; Fail to start on demand = 1.0 · 10 <sup>-2</sup>										

**Maintainable item versus failure mode, to be continued**

**Item:** Turboexpanders

	AIR	BRD	ELP	ELU	ERO	FTS	INL
Actuating device	0.83	0.00	0.00	0.00	0.83	0.00	0.00
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	0.83	0.00	0.00	0.00	0.00	0.00	0.00
Filter(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, flow	0.83	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	6.67	0.00	0.00	0.83	0.00	0.83	0.00
Instrument, speed	0.83	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	9.17	0.00	0.83	0.83	0.00	0.00	0.00
Instrument, vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	2.50	0.00	0.00	1.67	0.00	0.83	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.83	0.00	0.83	1.67	0.00	0.00	1.67
Piping	0.00	0.00	0.00	0.83	0.00	0.00	0.00
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rotor w/ impellers	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seal gas equipment	2.50	0.00	0.83	0.83	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thrust bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	2.50	1.67	0.00	1.67	0.83	0.83	0.00
Valves	0.00	0.00	0.00	0.83	0.00	0.00	0.00
Total	27.50	1.67	2.50	9.17	1.67	2.50	1.67

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

**Item: Turboexpanders**

	OTH	SER	UNK	UST	VIB	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	1.67
Cabling & junction boxes	1.67	0.00	0.00	0.00	0.00	1.67
Control unit	0.00	0.00	0.83	2.50	0.00	4.17
Filter(s)	0.00	0.83	0.00	0.00	0.00	0.83
Instrument, flow	0.00	0.00	0.00	0.83	0.00	1.67
Instrument, general	1.67	0.00	0.00	0.83	0.00	2.50
Instrument, pressure	0.00	0.00	0.00	0.00	0.00	8.33
Instrument, speed	0.00	0.00	0.00	0.00	0.00	0.83
Instrument, temperature	0.83	0.83	0.00	0.83	0.00	13.33
Instrument, vibration	0.00	0.00	0.00	0.00	1.67	1.67
Monitoring	0.83	0.00	0.00	0.83	0.00	6.67
Oil	0.83	1.67	0.00	0.00	0.00	2.50
Other	4.17	0.83	0.00	0.83	0.00	10.83
Piping	0.00	0.83	0.00	0.00	0.00	1.67
Radial bearing	1.67	0.00	0.00	0.00	0.00	1.67
Rotor w/ impellers	1.67	0.00	0.83	0.00	0.00	2.50
Seal gas equipment	0.83	0.83	0.00	0.00	0.00	5.83
Subunit	1.67	0.00	0.00	1.67	0.00	3.33
Thrust bearing	0.00	0.00	0.00	0.83	0.00	0.83
Unknown	10.83	0.00	1.67	0.83	0.00	20.83
Valves	3.33	2.50	0.00	0.00	0.00	6.67
<b>Total</b>	<b>30.00</b>	<b>8.33</b>	<b>3.33</b>	<b>10.00</b>	<b>1.67</b>	<b>100.0</b>

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item: Turboexpanders**

	AIR	BRD	ELP	ELU	ERO	FTS	INL
Breakage	0.00	0.83	0.00	0.83	0.00	0.00	0.00
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.00	0.00	0.00	0.00	0.00	0.83	0.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	1.67	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	8.33	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	4.17	0.00	0.00	0.00	0.83	1.67	0.00
Leakage	0.00	0.00	0.83	5.83	0.00	0.00	1.67
Looseness	0.00	0.00	0.83	0.83	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.83	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.83	0.83	0.00	0.83	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.83	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	3.33	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	6.67	0.00	0.00	0.00	0.00	0.00	0.00
Overheating	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.83	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.83	0.00	0.00	0.83	0.83	0.00	0.00
Total	27.50	1.67	2.50	9.17	1.67	2.50	1.67

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

**Item:** Turboexpanders

	OTH	SER	UNK	UST	VIB	Sum
Breakage	0.00	1.67	0.00	0.00	0.00	3.33
Contamination	0.00	0.83	0.00	0.00	0.00	0.83
Control failure	0.00	0.00	0.00	2.50	0.00	3.33
Deformation	0.83	0.00	0.00	0.00	0.00	0.83
Electrical failure - general	3.33	0.83	0.00	2.50	0.83	9.17
External influence - general	0.00	0.83	0.00	0.00	0.00	0.83
Faulty power/voltage	0.83	0.00	0.00	0.83	0.00	1.67
Faulty signal/indication/alarm	0.00	0.00	0.00	0.83	0.83	10.00
Instrument failure - general	9.17	0.00	1.67	3.33	0.00	20.83
Leakage	0.83	0.83	0.00	0.00	0.00	10.00
Looseness	0.00	0.00	0.00	0.00	0.00	1.67
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.83
Mechanical Failure - general	4.17	0.00	1.67	0.00	0.00	8.33
Miscellaneous - general	0.83	0.83	0.00	0.00	0.00	1.67
No cause found	0.00	0.83	0.00	0.00	0.00	1.67
No signal/indication/alarm	0.83	0.00	0.00	0.00	0.00	4.17
Other	3.33	0.00	0.00	0.00	0.00	3.33
Out of adjustment	2.50	0.00	0.00	0.00	0.00	9.17
Overheating	1.67	0.00	0.00	0.00	0.00	1.67
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.83
Sticking	0.83	1.67	0.00	0.00	0.00	2.50
Unknown	0.83	0.00	0.00	0.00	0.00	3.33
Total	30.00	8.33	3.33	10.00	1.67	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 1.5.1		Item Machinery Turboexpanders Combined function								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
		0.0175		0.0175						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-
Spurious stop	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-
<b>Incipient</b>	3*	46.80	171.23	442.64	171.23	171.23	-	-	-	-
	3†	46.80	171.23	442.64	171.23	171.23	-	-	-	-
External leakage - Utility medium	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-
Minor in-service problems	2*	20.26	114.16	359.30	114.16	114.16	-	-	-	-
	2†	20.26	114.16	359.30	114.16	114.16	-	-	-	-
<b>All modes</b>	4*	77.91	228.31	522.55	228.31	228.31	-	-	-	-
	4†	77.91	228.31	522.55	228.31	228.31	-	-	-	-
<b>Comments</b>										

**Maintainable item versus failure mode, to be continued**

**Item:** Turboexpanders - Combined function

	AIR	BRD	ELP	ELU	ERO	FTS	INL
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	0.00	25.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	25.00	0.00	0.00	0.00

**Maintainable item versus failure mode, continued**

**Item:** Turboexpanders - Combined function

	OTH	SER	UNK	UST	VIB	Sum
Instrument, temperature	0.00	25.00	0.00	25.00	0.00	50.00
Piping	0.00	25.00	0.00	0.00	0.00	50.00
Total	0.00	50.00	0.00	25.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Turboexpanders - Combined function

	AIR	BRD	ELP	ELU	ERO	FTS	INL
Breakage	0.00	0.00	0.00	25.00	0.00	0.00	0.00
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	25.00	0.00	0.00	0.00

**Failure descriptor versus failure mode, continued**

**Item:** Turboexpanders - Combined function

	OTH	SER	UNK	UST	VIB	Sum
Breakage	0.00	25.00	0.00	0.00	0.00	50.00
Instrument failure - general	0.00	0.00	0.00	25.00	0.00	25.00
Leakage	0.00	25.00	0.00	0.00	0.00	25.00
Total	0.00	50.00	0.00	25.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 1.5.1.1		Item Machinery Turboexpanders Combined function Centrifugal									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0175		Operational time † 0.0175							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-	
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-	
Spurious stop	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-	
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-	
<b>Incipient</b>	3*	46.80	171.23	442.64	171.23	171.23	-	-	-	-	
	3†	46.80	171.23	442.64	171.23	171.23	-	-	-	-	
External leakage - Utility medium	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-	
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-	
Minor in-service problems	2*	20.26	114.16	359.30	114.16	114.16	-	-	-	-	
	2†	20.26	114.16	359.30	114.16	114.16	-	-	-	-	
<b>All modes</b>	4*	77.91	228.31	522.55	228.31	228.31	-	-	-	-	
	4†	77.91	228.31	522.55	228.31	228.31	-	-	-	-	
<b>Comments</b>											



Taxonomy no 1.5.2		Item Machinery Turboexpanders Gas processing									
Population 8	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.2454		Operational time † 0.2085							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/r		Min	Mean	Max	
<b>Critical</b>	21*	57.35	85.59	118.43	18.68	85.58	-	4.0	73.4	531.0	
	21†	68.64	101.91	140.56	21.98	100.74	-				
Breakdown	2*	1.63	8.72	20.45	6.06	8.15	-	6.0	98.0	190.0	
	2†	1.25	10.81	28.19	8.85	9.59	-				
Erratic output	2*	1.63	8.72	20.45	6.06	8.15	-	8.0	19.0	30.0	
	2†	1.25	10.81	28.19	8.85	9.59	-				
External leakage - Utility medium	1*	0.08	3.72	11.53	4.08	4.08	-	4.0	4.0	4.0	
	1†	0.09	4.36	13.55	4.80	4.80	-				
Fail to start on demand	2*	0.06	13.05	48.92	18.05	8.15	-	8.0	10.0	12.0	
	2†	0.07	17.36	66.26	24.42	9.59	-				
Other	2*	1.63	8.72	20.45	6.06	8.15	-	152.0	196.0	240.0	
	2†	1.25	10.81	28.19	8.85	9.59	-				
Spurious stop	11*	12.32	40.15	81.00	21.62	44.83	-	6.0	61.9	531.0	
	11†	22.49	48.89	83.48	18.87	52.77	-				
Unknown	1*	0.08	3.72	11.53	4.08	4.08	-	210.0	210.0	210.0	
	1†	0.09	4.36	13.55	4.80	4.80	-				
<b>Degraded</b>	28*	81.10	114.11	151.74	21.56	114.11	-	1.0	12.7	98.0	
	28†	96.99	135.89	180.15	25.38	134.32	-				
Abnormal instrument reading	4*	2.83	14.47	33.55	9.88	16.30	-	1.0	4.0	8.0	
	4†	5.19	17.45	35.61	9.59	19.19	-				
External leakage - Process medium	1*	0.08	3.72	11.53	4.08	4.08	-	20.0	20.0	20.0	
	1†	0.09	4.36	13.55	4.80	4.80	-				
External leakage - Utility medium	4*	5.42	16.12	31.44	8.15	16.30	-	3.0	5.8	12.0	
	4†	6.53	19.17	37.18	9.59	19.19	-				
Internal leakage	2*	0.10	7.06	22.42	8.07	8.15	-	2.0	2.0	2.0	
	2†	0.17	8.31	25.73	9.08	9.59	-				
Minor in-service problems	1*	0.08	3.72	11.53	4.08	4.08	-	2.0	2.0	2.0	
	1†	0.09	4.36	13.55	4.80	4.80	-				
Other	16*	36.85	69.86	111.39	22.96	65.21	-	2.0	18.2	98.0	
	16†	32.01	88.79	168.66	42.72	76.76	-				
<b>Incipient</b>	31*	23.88	162.54	404.51	124.20	126.34	-	2.0	8.1	36.0	
	31†	22.19	208.65	555.86	176.84	148.71	-				
Abnormal instrument reading	16*	5.87	90.57	263.40	87.16	65.21	-	2.0	10.7	36.0	
	16†	4.44	117.54	354.53	120.69	76.76	-				
External leakage - Utility medium	1*	0.08	3.72	11.53	4.08	4.08	-	2.0	2.0	2.0	
	1†	0.09	4.36	13.55	4.80	4.80	-				
Other	13*	14.56	63.60	141.02	40.33	52.98	-	2.0	5.6	12.0	
	13†	13.02	81.43	198.62	60.29	62.36	-				
Unknown	1*	0.08	3.72	11.53	4.08	4.08	-	4.0	4.0	4.0	
	1†	0.09	4.36	13.55	4.80	4.80	-				
<b>Comments</b>											

(cont.)

Taxonomy no 1.5.2		Item Machinery Turboexpanders Gas processing									
Population 8	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *		Operational time †							
		0.2454		0.2085							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Unknown	7*	1.31	23.03	68.05	22.64	28.53	-	1.0	95.7	220.0	
	7†	2.48	27.16	74.74	24.19	33.58					
Abnormal instrument reading	2*	0.10	7.06	22.42	8.07	8.15	-	30.0	39.0	48.0	
	2†	0.17	8.31	25.73	9.08	9.59					
External leakage - Utility medium	1*	0.08	3.72	11.53	4.08	4.08	-	1.0	1.0	1.0	
	1†	0.09	4.36	13.55	4.80	4.80					
Other	2*	0.10	7.06	22.42	8.07	8.15	-	220.0	220.0	220.0	
	2†	0.17	8.31	25.73	9.08	9.59					
Unknown	2*	0.10	7.06	22.42	8.07	8.15	-	3.0	75.5	148.0	
	2†	0.17	8.31	25.73	9.08	9.59					
<b>All modes</b>	<b>87*</b>	<b>251.11</b>	<b>374.56</b>	<b>518.14</b>	<b>81.64</b>	<b>354.56</b>	-	<b>1.0</b>	<b>32.4</b>	<b>531.0</b>	
	<b>87†</b>	<b>236.62</b>	<b>469.46</b>	<b>766.58</b>	<b>163.41</b>	<b>417.36</b>					
Comments											

**Maintainable item versus failure mode, to be continued**

**Item:** Turboexpanders - Gas processing

	AIR	BRD	ELP	ELU	ERO	FTS	INL
Actuating device	0.00	0.00	0.00	0.00	1.15	0.00	0.00
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	1.15	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	4.60	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, speed	1.15	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	10.34	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	3.45	0.00	0.00	2.30	0.00	1.15	0.00
Other	1.15	0.00	1.15	2.30	0.00	0.00	2.30
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rotor w/ impellers	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seal gas equipment	0.00	0.00	0.00	1.15	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thrust bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	3.45	2.30	0.00	2.30	1.15	1.15	0.00
Valves	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	25.29	2.30	1.15	8.05	2.30	2.30	2.30

**Maintainable item versus failure mode, continued**

**Item:** Turboexpanders - Gas processing

	OTH	SER	UNK	UST	VIB	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	1.15
Cabling & junction boxes	2.30	0.00	0.00	0.00	0.00	2.30
Control unit	0.00	0.00	1.15	3.45	0.00	5.75
Instrument, flow	0.00	0.00	0.00	1.15	0.00	1.15
Instrument, general	2.30	0.00	0.00	1.15	0.00	3.45
Instrument, pressure	0.00	0.00	0.00	0.00	0.00	4.60
Instrument, speed	0.00	0.00	0.00	0.00	0.00	1.15
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	10.34
Monitoring	1.15	0.00	0.00	1.15	0.00	9.20
Other	5.75	1.15	0.00	1.15	0.00	14.94
Radial bearing	2.30	0.00	0.00	0.00	0.00	2.30
Rotor w/ impellers	2.30	0.00	1.15	0.00	0.00	3.45
Seal gas equipment	0.00	0.00	0.00	0.00	0.00	1.15
Subunit	2.30	0.00	0.00	2.30	0.00	4.60
Thrust bearing	0.00	0.00	0.00	1.15	0.00	1.15
Unknown	14.94	0.00	2.30	1.15	0.00	28.74
Valves	4.60	0.00	0.00	0.00	0.00	4.60
Total	37.93	1.15	4.60	12.64	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Turboexpanders - Gas processing

	AIR	BRD	ELP	ELU	ERO	FTS	INL
Breakage	0.00	1.15	0.00	0.00	0.00	0.00	0.00
Control failure	0.00	0.00	0.00	0.00	0.00	1.15	0.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	9.20	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	5.75	0.00	0.00	0.00	1.15	1.15	0.00
Leakage	0.00	0.00	1.15	8.05	0.00	0.00	2.30
Mechanical Failure - general	1.15	1.15	0.00	0.00	0.00	0.00	0.00
No cause found	1.15	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	4.60	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	2.30	0.00	0.00	0.00	0.00	0.00	0.00
Overheating	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	1.15	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	1.15	0.00	0.00
Total	25.29	2.30	1.15	8.05	2.30	2.30	2.30

**Failure descriptor versus failure mode, continued**

**Item:** Turboexpanders - Gas processing

	OTH	SER	UNK	UST	VIB	Sum
Breakage	0.00	0.00	0.00	0.00	0.00	1.15
Control failure	0.00	0.00	0.00	3.45	0.00	4.60
Deformation	1.15	0.00	0.00	0.00	0.00	1.15
Electrical failure - general	4.60	0.00	0.00	3.45	0.00	8.05
Faulty power/voltage	1.15	0.00	0.00	1.15	0.00	2.30
Faulty signal/indication/alarm	0.00	0.00	0.00	1.15	0.00	10.34
Instrument failure - general	11.49	0.00	2.30	3.45	0.00	25.29
Leakage	1.15	0.00	0.00	0.00	0.00	12.64
Mechanical Failure - general	5.75	0.00	2.30	0.00	0.00	10.34
No cause found	0.00	0.00	0.00	0.00	0.00	1.15
No signal/indication/alarm	1.15	0.00	0.00	0.00	0.00	5.75
Other	4.60	0.00	0.00	0.00	0.00	4.60
Out of adjustment	3.45	0.00	0.00	0.00	0.00	5.75
Overheating	2.30	0.00	0.00	0.00	0.00	2.30
Short circuiting	0.00	0.00	0.00	0.00	0.00	1.15
Sticking	1.15	1.15	0.00	0.00	0.00	2.30
Unknown	0.00	0.00	0.00	0.00	0.00	1.15
Total	37.93	1.15	4.60	12.64	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 1.5.2.1		Item Machinery Turboexpanders Gas processing Centrifugal									
Population 8	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.2454		Operational time † 0.2085							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
<b>Critical</b>	<b>21*</b>	<b>57.35</b>	<b>85.59</b>	<b>118.43</b>	<b>18.68</b>	<b>85.58</b>	-	<b>4.0</b>	<b>73.4</b>	<b>531.0</b>	
	<b>21†</b>	<b>68.64</b>	<b>101.91</b>	<b>140.56</b>	<b>21.98</b>	<b>100.74</b>					
Breakdown	2*	1.63	8.72	20.45	6.06	8.15	-	6.0	98.0	190.0	
	2†	1.25	10.81	28.19	8.85	9.59					
Erratic output	2*	1.63	8.72	20.45	6.06	8.15	-	8.0	19.0	30.0	
	2†	1.25	10.81	28.19	8.85	9.59					
External leakage - Utility medium	1*	0.08	3.72	11.53	4.08	4.08	-	4.0	4.0	4.0	
	1†	0.09	4.36	13.55	4.80	4.80					
Fail to start on demand	2*	0.06	13.05	48.92	18.05	8.15	-	8.0	10.0	12.0	
	2†	0.07	17.36	66.26	24.42	9.59					
Other	2*	1.63	8.72	20.45	6.06	8.15	-	152.0	196.0	240.0	
	2†	1.25	10.81	28.19	8.85	9.59					
Spurious stop	11*	12.32	40.15	81.00	21.62	44.83	-	6.0	61.9	531.0	
	11†	22.49	48.89	83.48	18.87	52.77					
Unknown	1*	0.08	3.72	11.53	4.08	4.08	-	210.0	210.0	210.0	
	1†	0.09	4.36	13.55	4.80	4.80					
<b>Degraded</b>	<b>28*</b>	<b>81.10</b>	<b>114.11</b>	<b>151.74</b>	<b>21.56</b>	<b>114.11</b>	-	<b>1.0</b>	<b>12.7</b>	<b>98.0</b>	
	<b>28†</b>	<b>96.99</b>	<b>135.89</b>	<b>180.15</b>	<b>25.38</b>	<b>134.32</b>					
Abnormal instrument reading	4*	2.83	14.47	33.55	9.88	16.30	-	1.0	4.0	8.0	
	4†	5.19	17.45	35.61	9.59	19.19					
External leakage - Process medium	1*	0.08	3.72	11.53	4.08	4.08	-	20.0	20.0	20.0	
	1†	0.09	4.36	13.55	4.80	4.80					
External leakage - Utility medium	4*	5.42	16.12	31.44	8.15	16.30	-	3.0	5.8	12.0	
	4†	6.53	19.17	37.18	9.59	19.19					
Internal leakage	2*	0.10	7.06	22.42	8.07	8.15	-	2.0	2.0	2.0	
	2†	0.17	8.31	25.73	9.08	9.59					
Minor in-service problems	1*	0.08	3.72	11.53	4.08	4.08	-	2.0	2.0	2.0	
	1†	0.09	4.36	13.55	4.80	4.80					
Other	16*	36.85	69.86	111.39	22.96	65.21	-	2.0	18.2	98.0	
	16†	32.01	88.79	168.66	42.72	76.76					
<b>Incipient</b>	<b>31*</b>	<b>23.88</b>	<b>162.54</b>	<b>404.51</b>	<b>124.20</b>	<b>126.34</b>	-	<b>2.0</b>	<b>8.1</b>	<b>36.0</b>	
	<b>31†</b>	<b>22.19</b>	<b>208.65</b>	<b>555.86</b>	<b>176.84</b>	<b>148.71</b>					
Abnormal instrument reading	16*	5.87	90.57	263.40	87.16	65.21	-	2.0	10.7	36.0	
	16†	4.44	117.54	354.53	120.69	76.76					
External leakage - Utility medium	1*	0.08	3.72	11.53	4.08	4.08	-	2.0	2.0	2.0	
	1†	0.09	4.36	13.55	4.80	4.80					
Other	13*	14.56	63.60	141.02	40.33	52.98	-	2.0	5.6	12.0	
	13†	13.02	81.43	198.62	60.29	62.36					
Unknown	1*	0.08	3.72	11.53	4.08	4.08	-	4.0	4.0	4.0	
	1†	0.09	4.36	13.55	4.80	4.80					
<b>Comments</b>											

(cont.)

Taxonomy no 1.5.2.1		Item Machinery Turboexpanders Gas processing Centrifugal									
Population 8	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.2454		Operational time † 0.2085							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
Unknown	7*	1.31	23.03	68.05	22.64	28.53	-	1.0	95.7	220.0	
	7†	2.48	27.16	74.74	24.19	33.58	-				
Abnormal instrument reading	2*	0.10	7.06	22.42	8.07	8.15	-	30.0	39.0	48.0	
	2†	0.17	8.31	25.73	9.08	9.59	-				
External leakage - Utility medium	1*	0.08	3.72	11.53	4.08	4.08	-	1.0	1.0	1.0	
	1†	0.09	4.36	13.55	4.80	4.80	-				
Other	2*	0.10	7.06	22.42	8.07	8.15	-	220.0	220.0	220.0	
	2†	0.17	8.31	25.73	9.08	9.59	-				
Unknown	2*	0.10	7.06	22.42	8.07	8.15	-	3.0	75.5	148.0	
	2†	0.17	8.31	25.73	9.08	9.59	-				
All modes	87*	251.11	374.56	518.14	81.64	354.56	-	1.0	32.4	531.0	
	87†	236.62	469.46	766.58	163.41	417.36	-				
Comments											

Taxonomy no 1.5.3		Item Machinery Turboexpanders Gas treatment								
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 96			
		Calendar time * 0.0350		Operational time † 0.0350						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	1.43	28.54	135.42	28.54	28.54	-	-	-	-
Fail to start on demand	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	1.43	28.54	135.42	28.54	28.54	-	-	-	-
<b>Degraded</b>	3*	23.40	85.62	221.32	85.62	85.62	-	-	-	-
	3†	23.40	85.62	221.32	85.62	85.62	-	-	-	-
External leakage - Process medium	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	1.43	28.54	135.42	28.54	28.54	-	-	-	-
External leakage - Utility medium	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	1.43	28.54	135.42	28.54	28.54	-	-	-	-
Other	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	1.43	28.54	135.42	28.54	28.54	-	-	-	-
<b>Incipient</b>	25*	496.04	713.47	996.43	713.47	713.47	-	-	-	-
	25†	496.04	713.47	996.43	713.47	713.47	-	-	-	-
Abnormal instrument reading	11*	176.08	313.93	519.69	313.93	313.93	-	-	-	-
	11†	176.08	313.93	519.69	313.93	313.93	-	-	-	-
External leakage - Process medium	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	1.43	28.54	135.42	28.54	28.54	-	-	-	-
External leakage - Utility medium	2*	10.13	57.08	179.65	57.08	57.08	-	-	-	-
	2†	10.13	57.08	179.65	57.08	57.08	-	-	-	-
Minor in-service problems	7*	93.75	199.77	375.29	199.77	199.77	-	-	-	-
	7†	93.75	199.77	375.29	199.77	199.77	-	-	-	-
Other	2*	10.13	57.08	179.65	57.08	57.08	-	-	-	-
	2†	10.13	57.08	179.65	57.08	57.08	-	-	-	-
Vibration	2*	10.13	57.08	179.65	57.08	57.08	-	-	-	-
	2†	10.13	57.08	179.65	57.08	57.08	-	-	-	-
<b>All modes</b>	29*	592.04	827.63	1128.43	827.63	827.63	-	-	-	-
	29†	592.04	827.63	1128.43	827.63	827.63	-	-	-	-
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.0 · 10 <sup>-2</sup>										

**Maintainable item versus failure mode, to be continued**

**Item:** Turboexpanders - Gas treatment

	AIR	BRD	ELP	ELU	ERO	FTS	INL
Actuating device	3.45	0.00	0.00	0.00	0.00	0.00	0.00
Filter(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, flow	3.45	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	13.79	0.00	0.00	3.45	0.00	3.45	0.00
Instrument, temperature	6.90	0.00	3.45	3.45	0.00	0.00	0.00
Instrument, vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seal gas equipment	10.34	0.00	3.45	0.00	0.00	0.00	0.00
Valves	0.00	0.00	0.00	3.45	0.00	0.00	0.00
Total	37.93	0.00	6.90	10.34	0.00	3.45	0.00

**Maintainable item versus failure mode, continued**

**Item:** Turboexpanders - Gas treatment

	OTH	SER	UNK	UST	VIB	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	3.45
Filter(s)	0.00	3.45	0.00	0.00	0.00	3.45
Instrument, flow	0.00	0.00	0.00	0.00	0.00	3.45
Instrument, pressure	0.00	0.00	0.00	0.00	0.00	20.69
Instrument, temperature	3.45	0.00	0.00	0.00	0.00	17.24
Instrument, vibration	0.00	0.00	0.00	0.00	6.90	6.90
Oil	3.45	6.90	0.00	0.00	0.00	10.34
Seal gas equipment	3.45	3.45	0.00	0.00	0.00	20.69
Valves	0.00	10.34	0.00	0.00	0.00	13.79
Total	10.34	24.14	0.00	0.00	6.90	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.



**Failure descriptor versus failure mode, to be continued**

**Item:** Turboexpanders - Gas treatment

	AIR	BRD	ELP	ELU	ERO	FTS	INL
Breakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	6.90	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	6.90	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	3.45	0.00
Looseness	0.00	0.00	3.45	3.45	0.00	0.00	0.00
Material failure - general	0.00	0.00	3.45	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	3.45	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	20.69	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	3.45	0.00	0.00	3.45	0.00	0.00	0.00
Total	37.93	0.00	6.90	10.34	0.00	3.45	0.00

**Failure descriptor versus failure mode, continued**

**Item:** Turboexpanders - Gas treatment

	OTH	SER	UNK	UST	VIB	Sum
Breakage	0.00	3.45	0.00	0.00	0.00	3.45
Contamination	0.00	3.45	0.00	0.00	0.00	3.45
Electrical failure - general	0.00	3.45	0.00	0.00	3.45	13.79
External influence - general	0.00	3.45	0.00	0.00	0.00	3.45
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	3.45	10.34
Instrument failure - general	3.45	0.00	0.00	0.00	0.00	6.90
Looseness	0.00	0.00	0.00	0.00	0.00	6.90
Material failure - general	0.00	0.00	0.00	0.00	0.00	3.45
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	3.45
Miscellaneous - general	3.45	3.45	0.00	0.00	0.00	6.90
No cause found	0.00	3.45	0.00	0.00	0.00	3.45
Out of adjustment	0.00	0.00	0.00	0.00	0.00	20.69
Sticking	0.00	3.45	0.00	0.00	0.00	3.45
Unknown	3.45	0.00	0.00	0.00	0.00	10.34
Total	10.34	24.14	0.00	0.00	6.90	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 1.5.3.1		Item Machinery Turboexpanders Gas treatment Centrifugal								
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 96			
		Calendar time * 0.0350		Operational time † 0.0350						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	1.43	28.54	135.42	28.54	28.54	-	-	-	-
Fail to start on demand	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	1.43	28.54	135.42	28.54	28.54	-	-	-	-
<b>Degraded</b>	3*	23.40	85.62	221.32	85.62	85.62	-	-	-	-
	3†	23.40	85.62	221.32	85.62	85.62	-	-	-	-
External leakage - Process medium	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	1.43	28.54	135.42	28.54	28.54	-	-	-	-
External leakage - Utility medium	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	1.43	28.54	135.42	28.54	28.54	-	-	-	-
Other	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	1.43	28.54	135.42	28.54	28.54	-	-	-	-
<b>Incipient</b>	25*	496.04	713.47	996.43	713.47	713.47	-	-	-	-
	25†	496.04	713.47	996.43	713.47	713.47	-	-	-	-
Abnormal instrument reading	11*	176.08	313.93	519.69	313.93	313.93	-	-	-	-
	11†	176.08	313.93	519.69	313.93	313.93	-	-	-	-
External leakage - Process medium	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	1.43	28.54	135.42	28.54	28.54	-	-	-	-
External leakage - Utility medium	2*	10.13	57.08	179.65	57.08	57.08	-	-	-	-
	2†	10.13	57.08	179.65	57.08	57.08	-	-	-	-
Minor in-service problems	7*	93.75	199.77	375.29	199.77	199.77	-	-	-	-
	7†	93.75	199.77	375.29	199.77	199.77	-	-	-	-
Other	2*	10.13	57.08	179.65	57.08	57.08	-	-	-	-
	2†	10.13	57.08	179.65	57.08	57.08	-	-	-	-
Vibration	2*	10.13	57.08	179.65	57.08	57.08	-	-	-	-
	2†	10.13	57.08	179.65	57.08	57.08	-	-	-	-
<b>All modes</b>	29*	592.04	827.63	1128.43	827.63	827.63	-	-	-	-
	29†	592.04	827.63	1128.43	827.63	827.63	-	-	-	-
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.0 10 <sup>-2</sup>										

**ELECTRIC EQUIPMENT**

***Electric Generators***

**Inventory description**

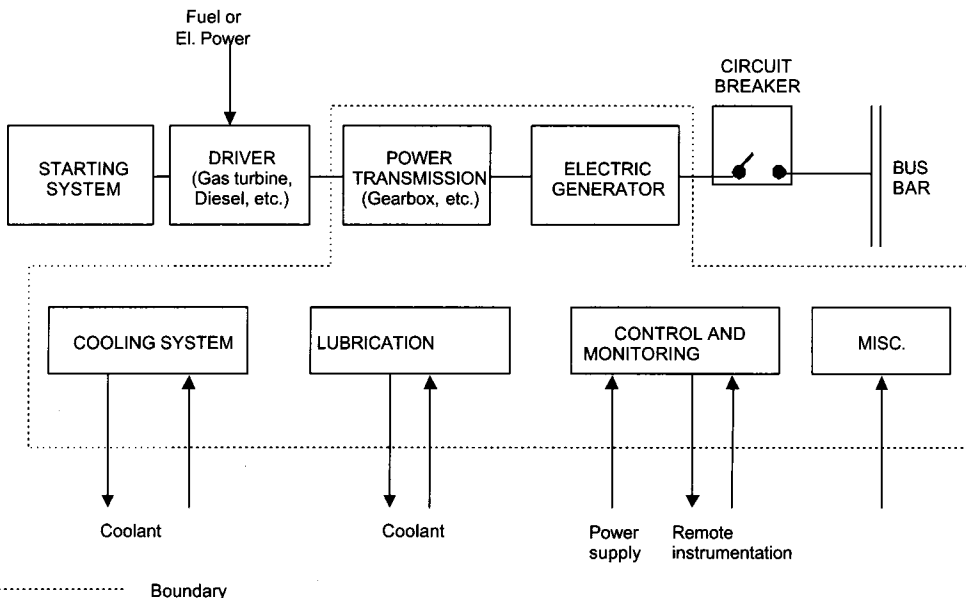
The boundary definition is shown in Figure 15 and corresponding subdivision in Maintainable Items in Table 10.

The generator is identified by its interface with the electric distribution system, i.e. terminal box (included), connecting the electrical cables to the bus bar circuit breaker.

The following specific auxiliary equipment/subunits are included in the boundary:

- Generator control, protection and trip devices
- Generator cooling system
- Bearing lubrication system

Remote instrumentation/alarms is excluded from the boundary as well as the generator separate enclosure with its equipment.



**Figure 15 Electric Generators, Boundary Definition**

**Table 10 Electric Generators, Subdivision in Maintainable Items**

ELECTRIC GENERATOR					
Power transmission	Electric generator unit	Control and Monitoring	Lubrication system	Cooling system	Miscellaneous
<ul style="list-style-type: none"> <li>• Gearbox</li> <li>• Bearing</li> <li>• Seals</li> <li>• Lubrication</li> <li>• Coupling to driver</li> <li>• Coupling to driven unit</li> <li>• Instruments</li> </ul>	<ul style="list-style-type: none"> <li>• Automatic voltage regulator</li> <li>• Stator</li> <li>• Rotor</li> <li>• Excitation</li> <li>• Instruments</li> <li>• Radial bearing</li> <li>• Thrust bearing</li> </ul>	<ul style="list-style-type: none"> <li>• Instruments</li> <li>• Cabling &amp; junction boxes</li> <li>• Control unit</li> <li>• Actuating device</li> <li>• Monitoring</li> <li>• Internal power supply</li> <li>• Valves</li> </ul>	<ul style="list-style-type: none"> <li>• Reservoir w/heating system</li> <li>• Pump w/motor</li> <li>• Filter</li> <li>• Cooler</li> <li>• Valves &amp; piping</li> <li>• Oil</li> <li>• Instruments</li> <li>• Seals</li> </ul>	<ul style="list-style-type: none"> <li>• Heat exchanger</li> <li>• Fan w/motor</li> <li>• Filter</li> <li>• Valves &amp; piping</li> <li>• Pump</li> <li>• Instruments</li> </ul>	<ul style="list-style-type: none"> <li>• Hood</li> <li>• Purge air</li> <li>• Anti condensation heater</li> </ul>

(For all subunits the MIs "Unknown" and "Subunit" are included.)

**List of failure modes**

- AIR Abnormal instrument reading
- BRD Breakdown
- ELU External leakage - Utility medium
- FTS Fail to start on demand
- STP Fail to stop on demand
- SYN Fail to synchronize
- FOF Faulty output frequency
- FOV Faulty output voltage
- LOO Low output
- SER Minor in-service problems
- NOI Noise
- OTH Other
- OHE Overheating
- PDE Parameter deviation
- UST Spurious stop
- STD Structural deficiency
- UNK Unknown
- VIB Vibration

Taxonomy no 2.1		Item Electric Equipment Electric Generators								
Population 105	Installations 59	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 24231			
		Calendar time * 4.6865		Operational time † 0.9353						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>148*</b>	<b>5.48</b>	<b>32.23</b>	<b>77.37</b>	<b>23.25</b>	<b>31.58</b>	<b>15.6</b>	<b>1.0</b>	<b>23.8</b>	<b>566.0</b>
	<b>148†</b>	<b>6835.57</b>	<b>9743.18</b>	<b>13072.43</b>	<b>1904.58</b>	<b>158.24</b>				
Breakdown	4*	0.00	1.08	6.13	3.46	0.85	71.7	29.0	103.0	251.0
	4†	1.55	4.39	8.39	2.14	4.28				
External leakage - Utility medium	1*	0.00	0.22	1.23	0.60	0.21	8.5	17.0	17.0	17.0
	1†	0.00	1.09	4.95	1.97	1.07				
Fail to start on demand	66*	1.39	14.31	38.91	12.52	14.08	5.6	1.0	6.5	69.0
	66†	4553.71	6567.14	8881.91	1322.09	70.57				
Fail to stop on demand	5*	0.00	1.37	7.21	4.97	1.07	10.3	1.0	10.3	22.0
	5†	16.78	171.24	464.58	149.29	5.35				
Fail to synchronize	2*	0.00	0.38	2.02	1.36	0.43	15.5	2.0	31.0	60.0
	2†	0.00	2.24	9.27	3.52	2.14				
Faulty output voltage	5*	0.00	1.11	4.51	1.70	1.07	35.4	1.0	137.4	566.0
	5†	36.65	213.68	511.80	153.55	5.35				
Low output	4*	0.00	0.78	4.23	2.68	0.85	21.9	1.0	43.5	121.0
	4†	0.04	60.33	254.58	97.78	4.28				
Other	5*	0.00	1.24	3.75	6.17	1.07	3.0	6.0	6.0	6.0
	5†	0.02	5.33	20.66	7.64	5.35				
Parameter deviation	2*	0.00	0.45	1.41	2.21	0.43	6.0	4.0	7.0	10.0
	2†	0.14	44.37	172.84	64.08	2.14				
Spurious stop	50*	0.79	10.64	30.35	9.97	10.67	9.3	1.0	10.8	109.5
	50†	1068.96	1989.27	3140.52	637.62	53.46				
Structural deficiency	1*	0.00	0.22	1.23	0.60	0.21	8.0	16.0	16.0	16.0
	1†	0.00	1.09	4.95	1.97	1.07				
Vibration	3*	0.00	0.65	3.71	2.09	0.64	216.0	100.0	253.0	390.0
	3†	0.01	3.33	12.66	4.67	3.21				
<b>Degraded</b>	<b>81*</b>	<b>0.00</b>	<b>18.67</b>	<b>86.07</b>	<b>34.60</b>	<b>17.28</b>	<b>52.5</b>	<b>1.0</b>	<b>83.7</b>	<b>1611.0</b>
	<b>81†</b>	<b>1044.21</b>	<b>2031.08</b>	<b>3282.68</b>	<b>689.80</b>	<b>86.60</b>				
Abnormal instrument reading	3*	0.00	0.67	3.74	2.19	0.64	8.3	9.0	10.0	11.0
	3†	0.34	77.93	290.66	107.29	3.21				
External leakage - Utility medium	12*	0.00	3.15	17.59	9.19	2.56	8.8	2.0	12.8	51.0
	12†	0.00	24.92	128.48	55.89	12.83				
Fail to stop on demand	4*	0.00	0.94	4.90	3.43	0.85	7.0	1.0	7.0	14.0
	4†	56.03	320.43	763.46	228.22	4.28				
Fail to synchronize	5*	0.41	1.05	1.94	0.48	1.07	18.5	2.0	15.2	54.0
	5†	0.00	26.05	131.41	56.44	5.35				
Faulty output frequency	1*	0.00	0.42	0.80	2.36	0.21	3.0	1.0	1.0	1.0
	1†	0.43	50.20	167.97	61.62	1.07				
Faulty output voltage	9*	0.00	2.19	11.38	5.05	1.92	10.5	1.0	15.1	70.0
	9†	136.11	415.52	818.54	214.15	9.62				
Low output	7*	0.00	1.64	8.64	5.89	1.49	21.4	2.0	21.4	82.0
	7†	0.01	57.50	263.65	105.45	7.48				
<b>Comments</b>										

(cont.)

Taxonomy no 2.1		Item Electric Equipment Electric Generators									
Population 105	Installations 59	Aggregated time in service (10 <sup>6</sup> hours)						No of demands 24231			
		Calendar time * 4.6865			Operational time † 0.9353						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
Minor in-service problems	2*	0.00	0.42	2.23	1.87	0.43	3.5	1.0	6.5	12.0	
	2†	1.96	68.53	208.78	72.34	2.14					
Other	8*	0.00	1.64	9.08	4.61	1.71	273.6	1.0	467.1	1611.0	
	8†	1.78	122.85	389.63	140.10	8.55					
Overheating	1*	0.01	0.21	0.64	0.21	0.21	-	14.0	14.0	14.0	
	1†	0.00	1.14	5.57	2.34	1.07					
Parameter deviation	19*	0.00	4.23	23.27	11.33	4.05	4.9	1.0	7.9	32.0	
	19†	267.73	724.73	1363.36	342.08	20.31					
Structural deficiency	5*	0.00	1.21	6.25	4.94	1.07	133.0	2.0	240.4	1135.0	
	5†	0.03	5.52	19.56	7.22	5.35					
Vibration	5*	0.01	1.03	3.28	1.18	1.07	130.8	4.0	147.8	274.0	
	5†	0.38	5.24	15.00	4.94	5.35					
<b>Incipient</b>	<b>248*</b>	<b>0.24</b>	<b>47.67</b>	<b>172.62</b>	<b>63.78</b>	<b>52.92</b>	<b>8.6</b>	<b>1.0</b>	<b>12.6</b>	<b>178.0</b>	
	<b>248†</b>	<b>6831.68</b>	<b>10786.58</b>	<b>15475.07</b>	<b>2646.55</b>	<b>265.16</b>					
Abnormal instrument reading	120*	0.00	23.05	115.79	49.61	25.61	7.1	1.0	8.6	62.5	
	120†	2660.85	5202.04	8429.84	1777.89	128.30					
Breakdown	1*	0.00	0.42	0.80	2.36	0.21	11.0	19.0	19.0	19.0	
	1†	0.43	50.20	167.97	61.62	1.07					
External leakage - Utility medium	25*	0.00	4.06	21.95	10.18	5.33	17.4	1.0	27.4	156.0	
	25†	0.00	60.04	282.67	115.34	26.73					
Fail to start on demand	1*	0.00	0.42	0.80	2.36	0.21	4.0	3.0	3.0	3.0	
	1†	0.43	50.20	167.97	61.62	1.07					
Fail to stop on demand	2*	0.00	0.42	2.18	1.89	0.43	3.0	1.0	5.5	10.0	
	2†	37.35	198.79	465.40	137.76	2.14					
Fail to synchronize	1*	0.00	0.42	0.80	2.36	0.21	11.0	19.0	19.0	19.0	
	1†	0.43	50.20	167.97	61.62	1.07					
Faulty output voltage	2*	0.00	0.55	2.83	2.23	0.43	3.5	9.0	11.5	14.0	
	2†	18.21	144.06	369.70	115.24	2.14					
Low output	2*	0.00	0.44	1.02	2.37	0.43	26.3	12.0	46.5	81.0	
	2†	0.08	38.42	153.86	57.65	2.14					
Minor in-service problems	32*	0.00	5.67	28.81	12.42	6.83	8.0	1.0	11.6	60.0	
	32†	11.84	232.78	696.00	232.28	34.21					
Noise	9*	0.00	2.01	8.93	3.52	1.92	9.8	1.0	27.8	178.0	
	9†	274.36	691.23	1261.71	307.21	9.62					
Other	21*	0.00	3.79	18.14	7.47	4.48	8.0	1.0	13.8	102.0	
	21†	6.40	119.65	355.94	118.62	22.45					
Overheating	1*	0.00	0.42	0.80	2.36	0.21	6.0	6.0	6.0	6.0	
	1†	0.43	50.20	167.97	61.62	1.07					
Parameter deviation	24*	0.00	4.76	26.14	12.54	5.12	3.9	1.0	4.4	16.0	
	24†	1700.05	3247.01	5197.90	1077.36	25.66					
Unknown	3*	0.00	0.76	4.37	2.36	0.64	31.7	22.0	42.5	63.0	
	3†	0.01	4.12	16.77	6.33	3.21					

Comments

(cont.)

Taxonomy no 2.1		Item Electric Equipment Electric Generators								
Population 105	Installations 59	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 24231			
		Calendar time * 4.6865			Operational time † 0.9353					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Vibration	4*	0.00	0.89	4.81	3.05	0.85	14.5	6.0	22.0	52.0
	4†	15.02	153.93	418.00	134.38	4.28				
Unknown	4*	0.00	0.84	4.86	2.63	0.85	-	-	-	-
	4†	150.99	418.77	795.37	201.42	4.28				
Unknown	4*	0.00	0.84	4.86	2.63	0.85	-	-	-	-
	4†	150.99	418.77	795.37	201.42	4.28				
<b>All modes</b>	<b>481*</b>	<b>3.32</b>	<b>98.26</b>	<b>297.46</b>	<b>102.00</b>	<b>102.64</b>	<b>18.0</b>	<b>1.0</b>	<b>28.4</b>	<b>1611.0</b>
	<b>481†</b>	<b>17779.86</b>	<b>25033.73</b>	<b>33303.98</b>	<b>4739.28</b>	<b>514.28</b>				
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 2.6 10 <sup>-3</sup>										

**Maintainable item versus failure mode, to be continued**

**Item: Electric Generators**

	AIR	BRD	ELU	FOF	FOV	FTS	LOO	NOI	OHE
Actuating device	1.77	0.00	0.21	0.00	1.25	1.46	0.00	0.00	0.00
Anti condensation heater	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Automatic voltage regulator (AVR)	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00
Bearing	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	2.39	0.00	0.00	0.00	0.00	0.42	0.62	0.21	0.00
Cooler(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00
Coupling to driven unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driver	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Excitation	0.00	0.21	0.00	0.00	0.21	0.00	0.00	0.00	0.00
Fan w/motor	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00
Filter(s)	0.21	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00
Gearbox	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00
Heat exchanger	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00
Hood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, current	1.25	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00
Instrument, frequency/RPM	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	2.49	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00
Instrument, level	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	3.95	0.00	0.21	0.00	0.00	0.00	0.21	0.00	0.00
Instrument, vibration	1.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, voltage	0.83	0.00	0.00	0.00	0.21	0.21	0.21	0.21	0.00
Internal power supply	2.39	0.00	0.00	0.00	0.00	1.25	0.21	0.00	0.00
Lubrication	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	4.26	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00
Other	0.21	0.00	0.62	0.00	0.00	7.48	0.00	0.62	0.00
Piping	0.00	0.00	2.29	0.00	0.00	0.00	0.00	0.00	0.00
Piping, pipe support + bellows	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.21	0.00	0.00	0.00	0.21	0.00	0.00
Purge air	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00
Radial bearing	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Rotor	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00
Seals	0.00	0.00	1.66	0.00	0.00	0.00	0.00	0.00	0.00
Stator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	1.04	0.62	0.42	0.00	0.00	1.25	0.42	0.00	0.00
Unknown	1.04	0.21	0.62	0.21	0.62	1.04	0.21	0.21	0.42
Valves	0.21	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Total	25.57	1.04	7.90	0.21	3.33	13.93	2.70	1.87	0.42

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.



**Maintainable Item versus failure mode, continued**

**Item: Electric Generators**

	OTH	PDE	SER	STD	STP	SYN	UNK	UST	VIB	Sum
Actuating device	0.00	1.46	0.62	0.00	0.21	0.00	0.21	1.25	0.00	8.42
Anti condensation heater	0.00	0.42	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Automatic voltage regulator (AVR)	0.00	0.83	0.00	0.21	0.00	0.00	0.21	0.21	0.00	2.29
Bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Cabling & junction boxes	0.94	0.83	0.00	0.21	0.00	0.00	0.21	0.00	0.21	2.81
Control unit	1.25	0.00	0.00	0.00	1.04	0.83	0.21	1.25	0.00	8.21
Cooler(s)	0.21	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Coupling to driven unit	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.21
Coupling to driver	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Excitation	0.00	0.21	0.42	0.00	0.00	0.00	0.00	0.21	0.00	1.25
Fan w/motor	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.42	0.42	1.87
Filter(s)	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Gearbox	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.21	0.21	1.04
Heat exchanger	0.21	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.83
Hood	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Instrument, current	0.00	0.21	0.00	0.00	0.00	0.21	0.00	0.62	0.00	2.49
Instrument, frequency/RPM	0.00	0.42	0.00	0.00	0.21	0.00	0.00	0.21	0.00	1.25
Instrument, general	0.94	0.00	0.00	0.00	0.42	0.00	0.00	0.62	0.00	4.89
Instrument, level	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.83
Instrument, temperature	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.62	0.00	5.41
Instrument, vibration	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.62	0.21	2.91
Instrument, voltage	0.21	0.42	0.00	0.00	0.00	0.00	0.00	0.42	0.00	2.70
Internal power supply	0.00	2.70	0.21	0.00	0.21	0.00	0.00	0.83	0.00	7.80
Lubrication	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.21
Monitoring	0.21	0.00	0.42	0.00	0.00	0.00	0.00	0.21	0.00	5.30
Other	0.21	0.83	1.04	0.00	0.00	0.00	0.00	0.62	0.00	11.64
Piping	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	2.70
Piping, pipe support + bellows	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Pump	0.00	0.21	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Pump w/motor	0.00	0.00	0.62	0.00	0.00	0.00	0.21	0.00	0.00	1.25
Purge air	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Radial bearing	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.62
Rotor	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.62
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.66
Stator	0.21	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Subunit	1.04	0.21	0.21	0.42	0.00	0.00	0.00	0.42	0.83	6.86
Unknown	0.83	0.00	0.83	0.00	0.21	0.62	0.42	1.25	0.21	8.94
Valves	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.83
Total	7.07	9.36	7.07	1.25	2.29	1.66	1.46	10.40	2.49	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item: Electric Generators**

	AIR	BRD	ELU	FOF	FOV	FTS	LOO	NOI	OHE
Blockage/plugged	0.21	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00
Breakage	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Burst	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Combined causes	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00
Contamination	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	1.04	0.00	0.00	0.21	0.62	0.62	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deformation	0.00	0.00	1.04	0.00	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.83	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00
Electrical failure - general	1.25	0.21	0.00	0.00	0.42	1.04	0.21	0.21	0.21
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	1.04	0.42	0.00	0.00	0.00
Faulty signal/indication/alarm	6.86	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00
Instrument failure - general	4.16	0.00	0.00	0.00	0.21	1.25	0.62	0.21	0.00
Leakage	0.21	0.00	1.46	0.00	0.00	0.00	0.00	0.00	0.00
Looseness	1.46	0.00	0.62	0.00	0.00	0.00	0.21	0.00	0.00
Material failure - general	0.00	0.00	1.04	0.00	0.00	0.21	0.00	0.00	0.00
Mechanical Failure - general	0.62	0.42	1.25	0.00	0.00	0.21	0.00	0.21	0.00
Misc. external influences	0.21	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.21	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.21	0.00	0.21	0.00	0.21	0.42	0.21	0.21	0.00
No power/ voltage	0.00	0.00	0.00	0.00	0.00	4.78	0.00	0.00	0.00
No signal/indication/alarm	1.66	0.00	0.00	0.00	0.21	0.21	0.00	0.00	0.00
Open circuit	1.04	0.00	0.00	0.00	0.00	0.42	0.21	0.00	0.21
Other	0.00	0.00	0.42	0.00	0.00	0.21	0.00	0.00	0.00
Out of adjustment	2.08	0.00	0.00	0.00	0.00	0.83	0.42	0.00	0.00
Overheating	0.00	0.21	0.00	0.00	0.21	0.00	0.00	0.00	0.00
Short circuiting	1.46	0.00	0.00	0.00	0.00	0.21	0.21	0.00	0.00
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	1.04	0.00	0.42	0.00	0.00	1.46	0.21	0.00	0.00
Vibration	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.21	0.00
Wear	0.21	0.00	0.62	0.00	0.00	1.04	0.42	0.83	0.00
Total	25.57	1.04	7.90	0.21	3.33	13.93	2.70	1.87	0.42

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

Item: Electric Generators

	OTH	PDE	SER	STD	STP	SYN	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.62
Breakage	0.21	0.42	1.66	0.00	0.00	0.00	0.00	0.00	0.21	2.70
Burst	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Cavitation	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Clearance/ alignment failure	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.21	0.21	0.83
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Contamination	0.21	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	1.25
Control failure	0.42	0.42	0.21	0.00	0.21	0.42	0.00	1.46	0.00	5.61
Corrosion	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.21
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04
Earth/isolation fault	1.25	0.62	0.21	0.00	0.00	0.00	0.00	0.00	0.21	3.33
Electrical failure - general	1.25	3.53	0.83	0.21	0.62	0.42	0.62	2.08	0.21	13.31
External influence - general	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.00	1.87
Faulty signal/indication/alarm	0.42	0.00	0.00	0.00	0.21	0.21	0.00	0.42	0.00	8.32
Instrument failure - general	0.83	1.04	0.62	0.00	0.42	0.00	0.42	1.66	0.00	11.43
Leakage	0.21	0.00	0.21	0.00	0.00	0.00	0.00	0.42	0.00	2.49
Looseness	0.00	0.00	0.21	0.00	0.00	0.21	0.00	0.62	0.21	3.53
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25
Mechanical Failure - general	0.62	0.21	0.83	0.21	0.21	0.00	0.21	0.42	0.62	6.03
Misc. external influences	0.21	0.42	0.00	0.42	0.00	0.00	0.00	0.21	0.00	1.66
Miscellaneous - general	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04
No cause found	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.21	0.42	2.49
No power/ voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.78
No signal/indication/alarm	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.29
Open circuit	0.00	0.42	0.21	0.00	0.00	0.00	0.00	0.21	0.00	2.70
Other	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.21	0.00	1.04
Out of adjustment	0.62	0.00	0.21	0.00	0.00	0.00	0.00	0.62	0.00	4.78
Overheating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.62
Short circuiting	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.42	0.00	2.91
Software failure	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Sticking	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.21	0.00	0.62
Unknown	0.00	0.00	0.00	0.00	0.42	0.00	0.21	0.00	0.00	3.74
Vibration	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.83
Wear	0.00	0.83	0.62	0.21	0.00	0.00	0.00	0.21	0.21	5.20
Total	7.07	9.36	7.07	1.25	2.29	1.66	1.46	10.40	2.49	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 2.1.1		Item Electric Equipment Electric Generators Motor driven (diesel, gas motor)									
Population 73	Installations 50	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 21089				
		Calendar time *		Operational time †							
		3.7919		0.2323							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	<b>102*</b>	<b>4.57</b>	<b>27.08</b>	<b>65.15</b>	<b>19.61</b>	<b>26.90</b>	<b>6.3</b>	<b>1.0</b>	<b>7.8</b>	<b>108.0</b>	
	<b>102†</b>	<b>6411.94</b>	<b>12432.75</b>	<b>20061.29</b>	<b>4205.82</b>	<b>439.12</b>					
Breakdown	1*	0.00	0.50	1.26	2.59	0.26	49.0	49.0	49.0	49.0	
	1†	0.00	13.20	64.44	26.94	4.31					
Fail to start on demand	64*	2.94	16.82	40.05	11.97	16.88	5.5	1.0	6.1	69.0	
	64†	4006.87	8140.51	13454.00	2915.43	275.53					
Fail to stop on demand	5*	0.00	2.01	11.47	6.15	1.32	10.3	1.0	10.3	22.0	
	5†	1.33	246.28	882.49	326.07	21.53					
Fail to synchronize	1*	0.00	0.23	1.19	0.94	0.26	1.0	2.0	2.0	2.0	
	1†	0.30	4.50	13.03	4.31	4.31					
Faulty output voltage	3*	0.00	0.87	4.70	2.19	0.79	8.3	1.0	39.0	108.0	
	3†	12.21	328.75	992.10	338.09	12.92					
Low output	1*	0.00	0.26	0.47	1.47	0.26	1.0	1.0	1.0	1.0	
	1†	0.08	132.04	560.82	216.08	4.31					
Parameter deviation	1*	0.00	0.26	0.47	1.47	0.26	10.0	10.0	10.0	10.0	
	1†	0.00	73.35	344.39	140.31	4.31					
Spurious stop	26*	1.86	6.85	14.41	3.97	6.86	6.0	1.0	6.2	58.0	
	26†	1041.37	2911.25	5546.30	1408.58	111.93					
<b>Degraded</b>	<b>36*</b>	<b>0.12</b>	<b>9.62</b>	<b>31.01</b>	<b>11.25</b>	<b>9.49</b>	<b>9.5</b>	<b>1.0</b>	<b>14.6</b>	<b>116.0</b>	
	<b>36†</b>	<b>1098.85</b>	<b>3107.24</b>	<b>5945.47</b>	<b>1515.96</b>	<b>154.98</b>					
Abnormal instrument reading	1*	0.00	0.26	0.47	1.47	0.26	5.0	10.0	10.0	10.0	
	1†	0.19	152.19	625.82	237.36	4.31					
External leakage - Utility medium	1*	0.00	0.29	1.63	0.92	0.26	12.0	12.0	12.0	12.0	
	1†	0.00	64.31	306.36	125.79	4.31					
Fail to stop on demand	4*	0.00	1.13	6.30	3.71	1.05	7.0	1.0	7.0	14.0	
	4†	3.27	406.69	1370.30	503.38	17.22					
Fail to synchronize	4*	0.08	1.00	2.83	0.93	1.05	10.0	2.0	5.5	10.0	
	4†	0.00	47.81	249.16	111.16	17.22					
Faulty output frequency	1*	0.00	0.50	1.26	2.59	0.26	3.0	1.0	1.0	1.0	
	1†	0.00	69.14	326.83	133.67	4.31					
Faulty output voltage	8*	0.00	2.56	13.18	5.73	2.11	11.0	1.0	16.1	70.0	
	8†	74.02	584.87	1500.65	467.73	34.44					
Low output	3*	0.00	0.78	4.07	1.80	0.79	82.0	82.0	82.0	82.0	
	3†	0.00	114.75	554.09	228.77	12.92					
Minor in-service problems	2*	0.00	0.51	2.64	2.03	0.53	3.5	1.0	6.5	12.0	
	2†	0.10	97.94	407.30	155.09	8.61					
Other	2*	0.00	0.51	2.65	2.05	0.53	1.5	1.0	2.5	4.0	
	2†	3.77	271.52	864.21	311.37	8.61					
Parameter deviation	9*	0.00	2.28	11.58	5.00	2.37	5.2	1.0	8.6	32.0	
	9†	227.33	1121.84	2576.44	754.33	38.75					
<b>Comments</b>											

(cont.)

Taxonomy no 2.1.1		Item Electric Equipment Electric Generators Motor driven (diesel, gas motor)									
Population 73	Installations 50	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 21089				
		Calendar time *			Operational time †						
		3.7919					0.2323				
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Vibration	1*	0.00	0.23	1.27	0.67	0.26	-	116.0	116.0	116.0	
	1†	0.05	3.73	11.93	4.31	4.31					
<b>Incipient</b>	<b>144*</b>	<b>0.05</b>	<b>38.78</b>	<b>159.60</b>	<b>60.54</b>	<b>37.98</b>	<b>5.3</b>	<b>1.0</b>	<b>8.6</b>	<b>178.0</b>	
	<b>144†</b>	<b>5577.20</b>	<b>13572.90</b>	<b>24403.72</b>	<b>5848.52</b>	<b>619.94</b>					
Abnormal instrument reading	74*	0.00	19.75	108.52	52.28	19.52	5.1	1.0	6.9	28.0	
	74†	1649.55	6516.63	14025.51	3933.89	318.58					
Breakdown	1*	0.00	0.50	1.26	2.59	0.26	11.0	19.0	19.0	19.0	
	1†	0.00	69.14	326.83	133.67	4.31					
External leakage - Utility medium	5*	0.00	1.36	7.08	3.13	1.32	7.0	1.0	7.6	20.0	
	5†	0.19	160.41	661.31	251.03	21.53					
Fail to start on demand	1*	0.00	0.50	1.26	2.59	0.26	4.0	3.0	3.0	3.0	
	1†	0.00	69.14	326.83	133.67	4.31					
Fail to stop on demand	2*	0.00	0.51	2.65	2.05	0.53	3.0	1.0	5.5	10.0	
	2†	3.29	261.02	837.81	303.14	8.61					
Fail to synchronize	1*	0.00	0.50	1.26	2.59	0.26	11.0	19.0	19.0	19.0	
	1†	0.00	69.14	326.83	133.67	4.31					
Faulty output voltage	2*	0.00	0.66	3.43	2.41	0.53	3.5	9.0	11.5	14.0	
	2†	1.07	191.87	683.56	252.54	8.61					
Low output	1*	0.00	0.29	1.63	0.92	0.26	12.0	12.0	12.0	12.0	
	1†	0.00	64.31	306.36	125.79	4.31					
Minor in-service problems	13*	0.00	2.75	15.85	8.78	3.43	3.5	1.0	7.6	37.0	
	13†	1.83	375.55	1372.33	507.01	55.97					
Noise	8*	0.00	2.16	9.58	3.77	2.11	6.9	1.0	27.1	178.0	
	8†	140.46	904.06	2220.82	676.93	34.44					
Other	7*	0.11	1.85	5.45	1.81	1.85	4.3	1.0	7.6	18.0	
	7†	5.18	234.57	723.54	254.60	30.14					
Overheating	1*	0.00	0.50	1.26	2.59	0.26	6.0	6.0	6.0	6.0	
	1†	0.00	69.14	326.83	133.67	4.31					
Parameter deviation	24*	0.00	5.72	30.04	13.55	6.33	3.9	1.0	4.4	16.0	
	24†	994.81	3945.89	8503.31	2387.12	103.32					
Unknown	2*	0.00	0.78	4.08	2.86	0.53	16.0	22.0	22.0	22.0	
	2†	0.01	16.13	70.00	27.19	8.61					
Vibration	2*	0.00	0.51	2.65	2.05	0.53	14.5	6.0	29.0	52.0	
	2†	2.91	252.39	816.78	296.58	8.61					
<b>Unknown</b>	<b>4*</b>	<b>0.00</b>	<b>1.02</b>	<b>5.65</b>	<b>2.84</b>	<b>1.05</b>	-	-	-	-	
	<b>4†</b>	<b>66.82</b>	<b>548.76</b>	<b>1417.98</b>	<b>443.34</b>	<b>17.22</b>					
Unknown	4*	0.00	1.02	5.65	2.84	1.05	-	-	-	-	
	4†	66.82	548.76	1417.98	443.34	17.22					
<b>All modes</b>	<b>286*</b>	<b>1.62</b>	<b>75.98</b>	<b>234.83</b>	<b>82.80</b>	<b>75.42</b>	<b>6.2</b>	<b>1.0</b>	<b>9.1</b>	<b>178.0</b>	
	<b>286†</b>	<b>15891.73</b>	<b>30877.46</b>	<b>49876.79</b>	<b>10472.44</b>	<b>1231.27</b>					

**Comments**

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 2.9 10<sup>-3</sup>

**Maintainable item versus failure mode, to be continued**

**Item:** Electric Generators - Motor driven (diesel, gas motor)

	AIR	BRD	ELU	FOF	FOV	FTS	LOO	NOI	OHE
Actuating device	2.62	0.00	0.35	0.00	2.10	2.45	0.00	0.00	0.00
Anti condensation heater	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Automatic voltage regulator (AVR)	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	2.10	0.00	0.00	0.00	0.00	0.35	0.00	0.35	0.00
Excitation	0.00	0.35	0.00	0.00	0.35	0.00	0.00	0.00	0.00
Fan w/motor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05	0.00
Heat exchanger	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, current	1.75	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00
Instrument, frequency/RPM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	3.85	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00
Instrument, level	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	3.50	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00
Instrument, voltage	0.35	0.00	0.00	0.00	0.35	0.35	0.35	0.00	0.00
Internal power supply	3.67	0.00	0.00	0.00	0.00	2.10	0.35	0.00	0.00
Monitoring	5.24	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00
Other	0.00	0.00	0.35	0.00	0.00	12.59	0.00	1.05	0.00
Piping	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00
Piping, pipe support + bellows	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	1.40	0.00	0.00	0.00	0.00	2.10	0.70	0.00	0.00
Unknown	1.05	0.35	0.70	0.35	1.05	1.40	0.00	0.35	0.35
Valves	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	26.22	0.70	2.10	0.35	4.55	22.73	1.75	2.80	0.35

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

**Item:** Electric Generators - Motor driven (diesel, gas motor)

	OTH	PDE	SER	STD	STP	SYN	UNK	UST	VIB	Sum
Actuating device	0.00	2.45	1.05	0.00	0.35	0.00	0.35	2.10	0.00	13.81
Anti condensation heater	0.00	0.70	0.35	0.00	0.00	0.00	0.00	0.00	0.00	1.05
Automatic voltage regulator (AVR)	0.00	0.70	0.00	0.00	0.00	0.00	0.35	0.35	0.00	2.10
Cabling & junction boxes	0.00	0.35	0.00	0.00	0.00	0.00	0.35	0.00	0.35	1.40
Control unit	1.05	0.00	0.00	0.00	1.75	0.70	0.35	1.05	0.00	7.69
Excitation	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	1.05
Fan w/motor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.35	2.10
Heat exchanger	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Instrument, current	0.00	0.35	0.00	0.00	0.00	0.35	0.00	0.35	0.00	3.15
Instrument, frequency/RPM	0.00	0.70	0.00	0.00	0.35	0.00	0.00	0.35	0.00	1.40
Instrument, general	1.40	0.00	0.00	0.00	0.70	0.00	0.00	0.70	0.00	7.34
Instrument, level	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.35
Instrument, temperature	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	4.20
Instrument, voltage	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.70	0.00	2.45
Internal power supply	0.00	4.55	0.00	0.00	0.35	0.00	0.00	0.70	0.00	11.71
Monitoring	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.35	0.00	6.64
Other	0.00	1.05	0.35	0.00	0.00	0.00	0.00	0.70	0.00	16.08
Piping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Piping, pipe support + bellows	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.35
Stator	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Subunit	0.00	0.35	0.35	0.00	0.00	0.00	0.00	0.00	0.00	4.90
Unknown	0.70	0.00	1.40	0.00	0.35	1.05	0.70	0.70	0.00	10.49
Valves	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Total	3.15	11.89	5.24	0.00	3.85	2.10	2.10	9.09	1.05	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Electric Generators - Motor driven (diesel, gas motor)

	AIR	BRD	ELU	FOF	FOV	FTS	LOO	NOI	OHE
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00
Breakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Burst	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Combined causes	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.35	0.00	0.00	0.35	1.05	0.70	0.00	0.00	0.00
Earth/isolation fault	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	1.75	0.00	0.00	0.00	0.35	1.75	0.00	0.35	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	1.75	0.70	0.00	0.00	0.00
Faulty signal/indication/alarm	8.39	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00
Instrument failure - general	4.90	0.00	0.00	0.00	0.35	2.10	0.35	0.00	0.00
Leakage	0.35	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00
Looseness	0.70	0.00	0.35	0.00	0.00	0.00	0.35	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00
Mechanical Failure - general	1.05	0.00	0.00	0.00	0.00	0.35	0.00	0.35	0.00
Misc. external influences	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.35	0.70	0.35	0.35	0.00
No power/ voltage	0.00	0.00	0.00	0.00	0.00	8.04	0.00	0.00	0.00
No signal/indication/alarm	1.40	0.00	0.00	0.00	0.35	0.35	0.00	0.00	0.00
Open circuit	1.05	0.00	0.00	0.00	0.00	0.35	0.35	0.00	0.35
Other	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00
Out of adjustment	1.40	0.00	0.00	0.00	0.00	1.40	0.00	0.00	0.00
Overheating	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	2.45	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00
Sticking	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	1.05	0.00	0.70	0.00	0.00	2.45	0.35	0.00	0.00
Vibration	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.35	0.00
Wear	0.35	0.00	0.35	0.00	0.00	1.75	0.00	1.40	0.00
Total	26.22	0.70	2.10	0.35	4.55	22.73	1.75	2.80	0.35

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.



**Failure descriptor versus failure mode, continued**

**Item:** Electric Generators - Motor driven (diesel, gas motor)

	OTH	PDE	SER	STD	STP	SYN	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.70
Breakage	0.00	0.70	1.40	0.00	0.00	0.00	0.00	0.00	0.35	2.45
Burst	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Contamination	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Control failure	0.35	0.70	0.00	0.00	0.35	0.70	0.00	1.40	0.00	5.94
Earth/isolation fault	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.35	1.75
Electrical failure - general	0.35	4.90	1.05	0.00	1.05	0.00	1.05	1.40	0.00	13.99
External influence - general	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.70
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	2.80
Faulty signal/indication/alarm	0.35	0.00	0.00	0.00	0.35	0.35	0.00	0.00	0.00	9.79
Instrument failure - general	1.40	0.70	0.35	0.00	0.70	0.00	0.70	2.45	0.00	13.99
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	1.40
Looseness	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.70	0.35	2.80
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Mechanical Failure - general	0.35	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00	2.45
Misc. external influences	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
No cause found	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	2.45
No power/ voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.04
No signal/indication/alarm	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.45
Open circuit	0.00	0.35	0.35	0.00	0.00	0.00	0.00	0.00	0.00	2.80
Other	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70
Out of adjustment	0.35	0.00	0.35	0.00	0.00	0.00	0.00	0.70	0.00	4.20
Overheating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Short circuiting	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.70	0.00	4.55
Sticking	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.35	0.00	1.05
Unknown	0.00	0.00	0.00	0.00	0.70	0.00	0.35	0.00	0.00	5.59
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70
Wear	0.00	1.40	0.70	0.00	0.00	0.00	0.00	0.35	0.00	6.29
Total	3.15	11.89	5.24	0.00	3.85	2.10	2.10	9.09	1.05	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no		Item								
2.1.1.1		Electric Equipment Electric Generators Motor driven (diesel, gas motor) Emergency power								
Population	Installations	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †			20289			
65	47	3.5632		0.1533						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>96*</b>	<b>4.05</b>	<b>26.77</b>	<b>66.17</b>	<b>20.24</b>	<b>26.94</b>	<b>5.3</b>	<b>1.0</b>	<b>7.1</b>	<b>108.0</b>
	<b>96†</b>	<b>5382.20</b>	<b>13579.71</b>	<b>24802.36</b>	<b>6042.84</b>	<b>626.14</b>				
Breakdown	1*	0.00	0.53	1.50	2.68	0.28	49.0	49.0	49.0	49.0
	1†	0.06	19.13	74.81	27.78	6.52				
Fail to start on demand	62*	3.32	17.18	39.95	11.78	17.40	5.0	1.0	6.0	69.0
	62†	3340.96	8945.95	16755.19	4186.65	404.38				
Fail to stop on demand	4*	0.00	1.60	8.43	5.80	1.12	4.5	1.0	4.5	8.0
	4†	0.40	301.15	1231.35	466.02	26.09				
Faulty output voltage	3*	0.00	0.92	4.91	2.25	0.84	8.3	1.0	39.0	108.0
	3†	2.37	375.93	1311.71	484.08	19.57				
Low output	1*	0.00	0.27	0.54	1.51	0.28	1.0	1.0	1.0	1.0
	1†	0.00	151.07	739.24	309.88	6.52				
Parameter deviation	1*	0.00	0.27	0.54	1.51	0.28	10.0	10.0	10.0	10.0
	1†	0.00	83.06	438.86	199.65	6.52				
Spurious stop	24*	1.25	6.70	15.73	4.66	6.74	3.6	1.0	3.6	18.0
	24†	787.26	3268.75	7142.40	2023.77	156.53				
<b>Degraded</b>	<b>36*</b>	<b>0.18</b>	<b>10.20</b>	<b>31.85</b>	<b>11.34</b>	<b>10.10</b>	<b>9.5</b>	<b>1.0</b>	<b>14.6</b>	<b>116.0</b>
	<b>36†</b>	<b>818.51</b>	<b>3470.04</b>	<b>7628.20</b>	<b>2169.68</b>	<b>234.80</b>				
Abnormal instrument reading	1*	0.00	0.27	0.54	1.51	0.28	5.0	10.0	10.0	10.0
	1†	0.00	174.82	830.82	340.72	6.52				
External leakage - Utility medium	1*	0.00	0.30	1.75	0.95	0.28	12.0	12.0	12.0	12.0
	1†	0.00	72.92	388.62	178.38	6.52				
Fail to stop on demand	4*	0.00	1.20	6.88	3.82	1.12	7.0	1.0	7.0	14.0
	4†	0.37	450.56	1888.69	722.76	26.09				
Fail to synchronize	4*	0.11	1.07	2.88	0.93	1.12	10.0	2.0	5.5	10.0
	4†	0.00	62.31	324.86	145.02	26.09				
Faulty output frequency	1*	0.00	0.53	1.50	2.68	0.28	3.0	1.0	1.0	1.0
	1†	0.00	78.31	415.56	189.94	6.52				
Faulty output voltage	8*	0.00	2.71	13.70	5.90	2.25	11.0	1.0	16.1	70.0
	8†	39.24	680.18	2006.40	666.97	52.18				
Low output	3*	0.00	0.83	4.27	1.85	0.84	82.0	82.0	82.0	82.0
	3†	0.00	138.59	724.35	324.70	19.57				
Minor in-service problems	2*	0.00	0.54	2.80	2.09	0.56	3.5	1.0	6.5	12.0
	2†	0.00	112.57	533.73	218.63	13.04				
Other	2*	0.00	0.54	2.81	2.12	0.56	1.5	1.0	2.5	4.0
	2†	1.02	310.90	1206.55	446.57	13.04				
Parameter deviation	9*	0.00	2.42	12.04	5.13	2.53	5.2	1.0	8.6	32.0
	9†	129.22	1260.56	3386.50	1082.50	58.70				
Vibration	1*	0.00	0.24	1.33	0.69	0.28	-	116.0	116.0	116.0
	1†	0.07	5.61	18.02	6.52	6.52				
<b>Comments</b>										

(cont.)

Taxonomy no 2.1.1.1		Item Electric Equipment Electric Generators Motor driven (diesel, gas motor) Emergency power									
Population 65	Installations 47	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 20289				
		Calendar time * 3.5632		Operational time † 0.1533							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Incipient</b>	<b>128*</b>	<b>0.01</b>	<b>36.69</b>	<b>159.63</b>	<b>62.07</b>	<b>35.92</b>	<b>5.3</b>	<b>1.0</b>	<b>8.9</b>	<b>178.0</b>	
	<b>128†</b>	<b>4061.48</b>	<b>14673.29</b>	<b>30667.11</b>	<b>8414.32</b>	<b>834.85</b>					
Abnormal instrument reading	66*	0.00	18.42	103.12	54.00	18.52	5.1	1.0	7.1	28.0	
	66†	870.72	7038.43	18135.29	5663.08	430.47					
Breakdown	1*	0.00	0.53	1.50	2.68	0.28	11.0	19.0	19.0	19.0	
	1†	0.00	78.31	415.56	189.94	6.52					
External leakage - Utility medium	3*	0.00	0.77	4.00	2.86	0.84	10.5	1.0	10.3	20.0	
	3†	0.05	208.77	923.81	363.38	19.57					
Fail to start on demand	1*	0.00	0.53	1.50	2.68	0.28	4.0	3.0	3.0	3.0	
	1†	0.00	78.31	415.56	189.94	6.52					
Fail to stop on demand	2*	0.00	0.54	2.81	2.12	0.56	3.0	1.0	5.5	10.0	
	2†	0.84	298.53	1169.60	434.64	13.04					
Fail to synchronize	1*	0.00	0.53	1.50	2.68	0.28	11.0	19.0	19.0	19.0	
	1†	0.00	78.31	415.56	189.94	6.52					
Faulty output voltage	2*	0.00	0.70	3.68	2.49	0.56	3.5	9.0	11.5	14.0	
	2†	0.12	218.74	934.81	361.14	13.04					
Low output	1*	0.00	0.30	1.75	0.95	0.28	12.0	12.0	12.0	12.0	
	1†	0.00	72.92	388.62	178.38	6.52					
Minor in-service problems	9*	0.00	2.14	11.05	8.52	2.53	4.3	1.0	9.2	37.0	
	9†	0.19	435.88	1882.25	729.99	58.70					
Noise	8*	0.00	2.29	9.94	3.86	2.25	6.9	1.0	27.1	178.0	
	8†	64.96	1008.10	2933.76	971.03	52.18					
Other	6*	0.01	1.72	6.68	2.48	1.68	4.2	1.0	7.2	18.0	
	6†	1.44	271.88	977.27	361.10	39.13					
Overheating	1*	0.00	0.53	1.50	2.68	0.28	6.0	6.0	6.0	6.0	
	1†	0.00	78.31	415.56	189.94	6.52					
Parameter deviation	24*	0.00	6.08	31.50	13.89	6.74	3.9	1.0	4.4	16.0	
	24†	535.77	4283.81	11015.61	3436.80	156.53					
Unknown	1*	0.00	0.53	1.50	2.68	0.28	10.0	-	-	-	
	1†	0.06	19.13	74.81	27.78	6.52					
Vibration	2*	0.00	0.54	2.81	2.12	0.56	14.5	6.0	29.0	52.0	
	2†	0.71	288.44	1140.28	425.12	13.04					
<b>Unknown</b>	<b>4*</b>	<b>0.00</b>	<b>1.09</b>	<b>5.98</b>	<b>2.92</b>	<b>1.12</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	
	<b>4†</b>	<b>27.78</b>	<b>628.53</b>	<b>1887.64</b>	<b>635.72</b>	<b>26.09</b>					
Unknown	4*	0.00	1.09	5.98	2.92	1.12	-	-	-	-	
	4†	27.78	628.53	1887.64	635.72	26.09					
<b>All modes</b>	<b>264*</b>	<b>1.00</b>	<b>74.00</b>	<b>236.03</b>	<b>85.13</b>	<b>74.09</b>	<b>5.9</b>	<b>1.0</b>	<b>9.1</b>	<b>178.0</b>	
	<b>264†</b>	<b>12896.16</b>	<b>33218.32</b>	<b>61214.46</b>	<b>15052.99</b>	<b>1721.88</b>					

**Comments**

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 3.0 · 10<sup>-3</sup>

Taxonomy no 2.1.1.1.1		Item Electric Equipment Electric Generators Motor driven (diesel, gas motor) Emergency power (-1000)kVA								
Population 28	Installations 28	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 15789			
		Calendar time *		Operational time †						
		2.4656		0.0143						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max
<b>Critical</b>	<b>88*</b>	<b>13.47</b>	<b>35.71</b>	<b>66.60</b>	<b>16.58</b>	<b>35.69</b>	<b>4.7</b>	<b>1.0</b>	<b>5.5</b>	<b>69.0</b>
	<b>88†</b>	<b>4626.18</b>	<b>22581.24</b>	<b>51708.18</b>	<b>15112.06</b>	<b>6173.40</b>				
Breakdown	1*	0.00	0.82	4.27	3.35	0.41	49.0	49.0	49.0	49.0
	1†	1.34	64.21	198.71	70.15	70.15				
Fail to start on demand	59*	10.95	23.77	40.57	9.17	23.93	4.7	1.0	5.9	69.0
	59†	2847.29	15167.28	35516.13	10513.91	4138.98				
Fail to stop on demand	4*	0.00	2.49	13.85	7.19	1.62	4.5	1.0	4.5	8.0
	4†	0.02	538.70	2518.39	1023.23	280.61				
Faulty output voltage	2*	0.00	0.79	4.29	2.72	0.81	2.5	1.0	4.5	8.0
	2†	0.01	555.57	2708.67	1130.55	140.30				
Low output	1*	0.00	0.40	1.25	1.96	0.41	1.0	1.0	1.0	1.0
	1†	0.00	272.44	1517.35	786.63	70.15				
Parameter deviation	1*	0.00	0.40	1.25	1.96	0.41	10.0	10.0	10.0	10.0
	1†	0.00	175.17	910.28	403.84	70.15				
Spurious stop	20*	4.69	8.09	12.26	2.32	8.11	2.3	1.0	2.3	10.0
	20†	425.82	5432.13	15363.24	5031.86	1403.05				
<b>Degraded</b>	<b>23*</b>	<b>0.13</b>	<b>9.90</b>	<b>31.69</b>	<b>11.45</b>	<b>9.33</b>	<b>7.3</b>	<b>1.0</b>	<b>9.0</b>	<b>82.0</b>
	<b>23†</b>	<b>381.01</b>	<b>5442.52</b>	<b>15660.65</b>	<b>5163.14</b>	<b>1613.50</b>				
Abnormal instrument reading	1*	0.00	0.40	1.25	1.96	0.41	5.0	10.0	10.0	10.0
	1†	0.00	307.28	1709.55	884.09	70.15				
Fail to stop on demand	2*	0.00	0.79	4.25	2.75	0.81	1.0	1.0	1.0	1.0
	2†	0.00	572.64	3205.97	1679.21	140.30				
Faulty output voltage	6*	0.00	3.05	15.78	6.91	2.43	3.5	1.0	3.5	13.0
	6†	4.98	1072.21	3956.77	1461.37	420.91				
Low output	2*	0.00	1.05	6.02	3.24	0.81	82.0	82.0	82.0	82.0
	2†	0.00	274.04	1507.37	744.09	140.30				
Minor in-service problems	1*	0.00	0.40	1.25	1.96	0.41	1.0	1.0	1.0	1.0
	1†	0.00	178.47	935.93	421.69	70.15				
Other	2*	0.00	0.79	4.29	2.72	0.81	1.5	1.0	2.5	4.0
	2†	0.01	557.11	2716.10	1133.62	140.30				
Parameter deviation	9*	1.90	3.65	5.85	1.22	3.65	5.2	1.0	8.6	32.0
	9†	19.75	2258.72	7531.91	2760.75	631.37				
<b>Incipient</b>	<b>74*</b>	<b>2.84</b>	<b>29.60</b>	<b>80.65</b>	<b>25.97</b>	<b>30.01</b>	<b>3.4</b>	<b>1.0</b>	<b>4.9</b>	<b>52.0</b>
	<b>74†</b>	<b>2319.15</b>	<b>20694.26</b>	<b>54433.21</b>	<b>17185.74</b>	<b>5191.27</b>				
Abnormal instrument reading	31*	2.35	12.38	28.89	8.54	12.57	2.3	1.0	3.6	18.0
	31†	896.92	8746.39	23495.26	7509.99	2174.72				
External leakage - Utility medium	1*	0.00	0.40	1.25	1.96	0.41	1.0	1.0	1.0	1.0
	1†	0.00	286.67	1596.67	827.84	70.15				
Fail to stop on demand	2*	0.00	0.79	4.29	2.72	0.81	3.0	1.0	5.5	10.0
	2†	0.01	539.13	2626.65	1095.35	140.30				
<b>Comments</b>										

(cont.)

Taxonomy no 2.1.1.1.1		Item Electric Equipment Electric Generators Motor driven (diesel, gas motor) Emergency power (-1000)kVA								
Population 28	Installations 28	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 15789			
		Calendar time *		Operational time †						
		2.4656		0.0143						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Faulty output voltage	1*	0.00	0.40	1.25	1.96	0.41	3.0	9.0	9.0	9.0
	1†	0.00	269.80	1502.45	778.72	70.15				
Minor in-service problems	2*	0.00	0.79	4.29	2.72	0.81	1.5	1.0	1.5	2.0
	2†	0.01	568.71	2773.10	1157.63	140.30				
Noise	7*	0.01	2.80	10.85	4.02	2.84	3.6	1.0	5.6	15.0
	7†	5.74	1707.02	6614.88	2446.60	491.07				
Other	3*	0.00	1.37	7.06	3.06	1.22	1.3	1.0	1.3	2.0
	3†	1.97	370.07	1329.20	491.14	210.46				
Parameter deviation	24*	0.00	9.31	41.65	16.48	9.73	3.9	1.0	4.4	16.0
	24†	47.70	7345.17	25514.17	9412.26	1683.65				
Unknown	1*	0.00	0.82	4.27	3.35	0.41	10.0	-	-	-
	1†	1.34	64.21	198.71	70.15	70.15				
Vibration	2*	0.00	0.79	4.29	2.72	0.81	14.5	6.0	29.0	52.0
	2†	0.01	524.27	2553.67	1064.62	140.30				
<b>Unknown</b>	4*	<b>0.00</b>	<b>1.59</b>	<b>8.28</b>	<b>3.70</b>	<b>1.62</b>	-	-	-	-
	4†	<b>3.95</b>	<b>1121.79</b>	<b>4335.08</b>	<b>1601.24</b>	<b>280.61</b>				
Unknown	4*	0.00	1.59	8.28	3.70	1.62	-	-	-	-
	4†	3.95	1121.79	4335.08	1601.24	280.61				
<b>All modes</b>	<b>189*</b>	<b>17.55</b>	<b>77.29</b>	<b>171.80</b>	<b>49.22</b>	<b>76.65</b>	<b>4.6</b>	<b>1.0</b>	<b>5.7</b>	<b>82.0</b>
	<b>189†</b>	<b>9870.39</b>	<b>50604.91</b>	<b>117379.20</b>	<b>34566.35</b>	<b>13258.78</b>				

**Comments**

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 3.7 · 10<sup>-3</sup>

Taxonomy no 2.1.1.1.2		Item Electric Equipment Electric Generators Motor driven (diesel, gas motor) Emergency power (1000-3000)kVA								
Population 12	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 1470			
		Calendar time * 0.3703		Operational time † 0.0987						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	5*	0.06	25.86	102.47	38.23	13.50	9.0	2.0	9.0	18.0
	5†	247.63	4942.87	14801.03	4941.65	50.65				
Fail to start on demand	2*	0.02	9.59	38.19	14.27	5.40	8.0	2.0	8.0	14.0
	2†	94.14	1966.76	5895.82	1974.63	20.26				
Spurious stop	3*	0.03	15.00	59.63	22.27	8.10	10.0	2.0	10.0	18.0
	3†	145.30	2958.78	8864.81	2963.64	30.39				
<b>Degraded</b>	11*	14.26	31.83	55.06	12.64	29.71	12.2	2.0	22.6	116.0
	11†	394.62	4497.46	12472.62	4050.92	111.43				
External leakage - Utility medium	1*	0.01	4.22	16.62	6.19	2.70	12.0	12.0	12.0	12.0
	1†	43.25	974.82	2927.34	985.62	10.13				
Fail to stop on demand	2*	0.02	9.59	38.19	14.27	5.40	13.0	12.0	13.0	14.0
	2†	94.14	1966.76	5895.82	1974.63	20.26				
Fail to synchronize	4*	1.03	10.26	27.72	8.89	10.80	10.0	2.0	5.5	10.0
	4†	33.54	935.44	2826.09	965.32	40.52				
Faulty output voltage	1*	0.13	3.04	9.13	3.08	2.70	19.0	38.0	38.0	38.0
	1†	0.03	281.73	1289.18	514.58	10.13				
Low output	1*	0.03	2.40	7.63	2.74	2.70	-	-	-	-
	1†	0.42	9.98	30.00	10.13	10.13				
Minor in-service problems	1*	0.13	3.04	9.13	3.08	2.70	6.0	12.0	12.0	12.0
	1†	0.03	281.73	1289.18	514.58	10.13				
Vibration	1*	0.03	2.40	7.63	2.74	2.70	-	116.0	116.0	116.0
	1†	0.42	9.98	30.00	10.13	10.13				
<b>Incipient</b>	45*	8.58	198.29	595.82	200.96	121.52	7.4	1.0	9.9	37.0
	45†	2617.94	31102.25	86907.11	28320.80	455.85				
Abnormal instrument reading	33*	1.30	157.82	529.97	194.56	89.12	7.2	1.0	8.8	24.0
	33†	1784.92	26893.21	77958.66	25769.08	334.29				
External leakage - Utility medium	2*	0.03	6.17	22.72	8.39	5.40	20.0	10.0	15.0	20.0
	2†	39.60	961.35	2892.42	978.85	20.26				
Low output	1*	0.01	4.22	16.62	6.19	2.70	12.0	12.0	12.0	12.0
	1†	43.25	974.82	2927.34	985.62	10.13				
Minor in-service problems	7*	0.09	21.98	82.71	30.51	18.90	5.4	1.0	11.4	37.0
	7†	0.12	1675.33	7733.27	3112.26	70.91				
Other	2*	0.02	6.61	25.49	9.40	5.40	9.0	15.0	16.5	18.0
	2†	0.04	559.81	2578.31	1035.63	20.26				
<b>All modes</b>	61*	14.06	261.78	778.33	259.34	164.73	8.2	1.0	12.0	116.0
	61†	3328.36	40602.46	113977.20	37215.61	617.93				
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.4 · 10 <sup>-3</sup>										

Taxonomy no 2.1.1.1.3		Item Electric Equipment Electric Generators Motor driven (diesel, gas motor) Emergency power Unknown																																																																																																																																																																																																																																																																																																																																																				
Population 25	Installations 16	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 3030																																																																																																																																																																																																																																																																																																																																															
		Calendar time * 0.7273		Operational time † 0.0403																																																																																																																																																																																																																																																																																																																																																		
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)																																																																																																																																																																																																																																																																																																																																														
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max																																																																																																																																																																																																																																																																																																																																												
<b>Critical</b>	3*	<b>0.47</b>	<b>4.18</b>	<b>11.00</b>	<b>3.47</b>	<b>4.12</b>	<b>15.7</b>	<b>10.0</b>	<b>44.3</b>	<b>108.0</b>																																																																																																																																																																																																																																																																																																																																												
	3†	<b>0.07</b>	<b>377.42</b>	<b>1687.59</b>	<b>667.46</b>	<b>74.35</b>					Fail to start on demand	1*	0.00	1.89	10.37	4.96	1.37	12.0	10.0	10.0	10.0		1†	0.00	194.40	1059.06	494.15	24.78					Faulty output voltage	1*	0.00	1.89	10.37	4.96	1.37	20.0	108.0	108.0	108.0		1†	0.00	194.40	1059.06	494.15	24.78					Spurious stop	1*	0.01	1.21	4.08	1.50	1.37	15.0	15.0	15.0	15.0		1†	0.34	21.88	69.10	24.78	24.78					<b>Degraded</b>	2*	<b>0.00</b>	<b>3.73</b>	<b>16.89</b>	<b>6.71</b>	<b>2.75</b>	<b>25.5</b>	<b>1.0</b>	<b>35.5</b>	<b>70.0</b>	2†	<b>0.06</b>	<b>388.59</b>	<b>1752.73</b>	<b>695.89</b>	<b>49.57</b>	Faulty output frequency	1*	0.00	1.89	10.37	4.96	1.37	3.0	1.0	1.0	1.0		1†	0.00	194.40	1059.06	494.15	24.78					Faulty output voltage	1*	0.00	1.89	10.37	4.96	1.37	48.0	70.0	70.0	70.0		1†	0.00	194.40	1059.06	494.15	24.78					<b>Incipient</b>	9*	<b>0.07</b>	<b>16.07</b>	<b>59.23</b>	<b>21.88</b>	<b>12.37</b>	<b>9.7</b>	<b>3.0</b>	<b>31.9</b>	<b>178.0</b>	9†	<b>8.34</b>	<b>1514.06</b>	<b>5406.11</b>	<b>1997.36</b>	<b>223.05</b>	Abnormal instrument reading	2*	0.51	2.78	6.55	1.94	2.75	6.5	14.0	21.0	28.0		2†	0.00	250.94	1241.13	525.73	49.57					Breakdown	1*	0.00	1.89	10.37	4.96	1.37	11.0	19.0	19.0	19.0		1†	0.00	194.40	1059.06	494.15	24.78					Fail to start on demand	1*	0.00	1.89	10.37	4.96	1.37	4.0	3.0	3.0	3.0		1†	0.00	194.40	1059.06	494.15	24.78					Fail to synchronize	1*	0.00	1.89	10.37	4.96	1.37	11.0	19.0	19.0	19.0		1†	0.00	194.40	1059.06	494.15	24.78					Faulty output voltage	1*	0.00	1.89	10.37	4.96	1.37	4.0	14.0	14.0	14.0		1†	0.00	194.40	1059.06	494.15	24.78					Noise	1*	0.00	1.89	10.37	4.96	1.37	30.0	178.0	178.0	178.0		1†	0.00	194.40	1059.06	494.15	24.78					Other	1*	0.00	1.22	5.81	2.38	1.37	8.0	6.0	6.0	6.0		1†	0.00	81.19	424.66	190.58	24.78					Overheating	1*	0.00	1.89	10.37	4.96	1.37	6.0	6.0	6.0	6.0		1†	0.00	194.40	1059.06	494.15	24.78					<b>All modes</b>	14*	<b>0.75</b>	<b>24.68</b>	<b>75.01</b>	<b>25.90</b>	<b>19.25</b>	<b>13.2</b>	<b>1.0</b>	<b>35.1</b>	<b>178.0</b>	14†
Fail to start on demand	1*	0.00	1.89	10.37	4.96	1.37	12.0	10.0	10.0	10.0																																																																																																																																																																																																																																																																																																																																												
	1†	0.00	194.40	1059.06	494.15	24.78																																																																																																																																																																																																																																																																																																																																																
Faulty output voltage	1*	0.00	1.89	10.37	4.96	1.37	20.0	108.0	108.0	108.0																																																																																																																																																																																																																																																																																																																																												
	1†	0.00	194.40	1059.06	494.15	24.78																																																																																																																																																																																																																																																																																																																																																
Spurious stop	1*	0.01	1.21	4.08	1.50	1.37	15.0	15.0	15.0	15.0																																																																																																																																																																																																																																																																																																																																												
	1†	0.34	21.88	69.10	24.78	24.78																																																																																																																																																																																																																																																																																																																																																
<b>Degraded</b>	2*	<b>0.00</b>	<b>3.73</b>	<b>16.89</b>	<b>6.71</b>	<b>2.75</b>	<b>25.5</b>	<b>1.0</b>	<b>35.5</b>	<b>70.0</b>																																																																																																																																																																																																																																																																																																																																												
	2†	<b>0.06</b>	<b>388.59</b>	<b>1752.73</b>	<b>695.89</b>	<b>49.57</b>					Faulty output frequency	1*	0.00	1.89	10.37	4.96	1.37	3.0	1.0	1.0	1.0		1†	0.00	194.40	1059.06	494.15	24.78					Faulty output voltage	1*	0.00	1.89	10.37	4.96	1.37	48.0	70.0	70.0	70.0		1†	0.00	194.40	1059.06	494.15	24.78					<b>Incipient</b>	9*	<b>0.07</b>	<b>16.07</b>	<b>59.23</b>	<b>21.88</b>	<b>12.37</b>	<b>9.7</b>	<b>3.0</b>	<b>31.9</b>	<b>178.0</b>	9†	<b>8.34</b>	<b>1514.06</b>	<b>5406.11</b>	<b>1997.36</b>	<b>223.05</b>	Abnormal instrument reading	2*	0.51	2.78	6.55	1.94	2.75	6.5	14.0	21.0	28.0		2†	0.00	250.94	1241.13	525.73	49.57					Breakdown	1*	0.00	1.89	10.37	4.96	1.37	11.0	19.0	19.0	19.0		1†	0.00	194.40	1059.06	494.15	24.78					Fail to start on demand	1*	0.00	1.89	10.37	4.96	1.37	4.0	3.0	3.0	3.0		1†	0.00	194.40	1059.06	494.15	24.78					Fail to synchronize	1*	0.00	1.89	10.37	4.96	1.37	11.0	19.0	19.0	19.0		1†	0.00	194.40	1059.06	494.15	24.78					Faulty output voltage	1*	0.00	1.89	10.37	4.96	1.37	4.0	14.0	14.0	14.0		1†	0.00	194.40	1059.06	494.15	24.78					Noise	1*	0.00	1.89	10.37	4.96	1.37	30.0	178.0	178.0	178.0		1†	0.00	194.40	1059.06	494.15	24.78					Other	1*	0.00	1.22	5.81	2.38	1.37	8.0	6.0	6.0	6.0		1†	0.00	81.19	424.66	190.58	24.78					Overheating	1*	0.00	1.89	10.37	4.96	1.37	6.0	6.0	6.0	6.0		1†	0.00	194.40	1059.06	494.15	24.78					<b>All modes</b>	14*	<b>0.75</b>	<b>24.68</b>	<b>75.01</b>	<b>25.90</b>	<b>19.25</b>	<b>13.2</b>	<b>1.0</b>	<b>35.1</b>	<b>178.0</b>	14†	<b>49.80</b>	<b>2318.46</b>	<b>7162.47</b>	<b>2524.28</b>	<b>346.96</b>																																																																														
Faulty output frequency	1*	0.00	1.89	10.37	4.96	1.37	3.0	1.0	1.0	1.0																																																																																																																																																																																																																																																																																																																																												
	1†	0.00	194.40	1059.06	494.15	24.78																																																																																																																																																																																																																																																																																																																																																
Faulty output voltage	1*	0.00	1.89	10.37	4.96	1.37	48.0	70.0	70.0	70.0																																																																																																																																																																																																																																																																																																																																												
	1†	0.00	194.40	1059.06	494.15	24.78																																																																																																																																																																																																																																																																																																																																																
<b>Incipient</b>	9*	<b>0.07</b>	<b>16.07</b>	<b>59.23</b>	<b>21.88</b>	<b>12.37</b>	<b>9.7</b>	<b>3.0</b>	<b>31.9</b>	<b>178.0</b>																																																																																																																																																																																																																																																																																																																																												
	9†	<b>8.34</b>	<b>1514.06</b>	<b>5406.11</b>	<b>1997.36</b>	<b>223.05</b>					Abnormal instrument reading	2*	0.51	2.78	6.55	1.94	2.75	6.5	14.0	21.0	28.0		2†	0.00	250.94	1241.13	525.73	49.57					Breakdown	1*	0.00	1.89	10.37	4.96	1.37	11.0	19.0	19.0	19.0		1†	0.00	194.40	1059.06	494.15	24.78					Fail to start on demand	1*	0.00	1.89	10.37	4.96	1.37	4.0	3.0	3.0	3.0		1†	0.00	194.40	1059.06	494.15	24.78					Fail to synchronize	1*	0.00	1.89	10.37	4.96	1.37	11.0	19.0	19.0	19.0		1†	0.00	194.40	1059.06	494.15	24.78					Faulty output voltage	1*	0.00	1.89	10.37	4.96	1.37	4.0	14.0	14.0	14.0		1†	0.00	194.40	1059.06	494.15	24.78					Noise	1*	0.00	1.89	10.37	4.96	1.37	30.0	178.0	178.0	178.0		1†	0.00	194.40	1059.06	494.15	24.78					Other	1*	0.00	1.22	5.81	2.38	1.37	8.0	6.0	6.0	6.0		1†	0.00	81.19	424.66	190.58	24.78					Overheating	1*	0.00	1.89	10.37	4.96	1.37	6.0	6.0	6.0	6.0		1†	0.00	194.40	1059.06	494.15	24.78					<b>All modes</b>	14*	<b>0.75</b>	<b>24.68</b>	<b>75.01</b>	<b>25.90</b>	<b>19.25</b>	<b>13.2</b>	<b>1.0</b>	<b>35.1</b>	<b>178.0</b>	14†	<b>49.80</b>	<b>2318.46</b>	<b>7162.47</b>	<b>2524.28</b>	<b>346.96</b>																																																																																																																																											
Abnormal instrument reading	2*	0.51	2.78	6.55	1.94	2.75	6.5	14.0	21.0	28.0																																																																																																																																																																																																																																																																																																																																												
	2†	0.00	250.94	1241.13	525.73	49.57																																																																																																																																																																																																																																																																																																																																																
Breakdown	1*	0.00	1.89	10.37	4.96	1.37	11.0	19.0	19.0	19.0																																																																																																																																																																																																																																																																																																																																												
	1†	0.00	194.40	1059.06	494.15	24.78																																																																																																																																																																																																																																																																																																																																																
Fail to start on demand	1*	0.00	1.89	10.37	4.96	1.37	4.0	3.0	3.0	3.0																																																																																																																																																																																																																																																																																																																																												
	1†	0.00	194.40	1059.06	494.15	24.78																																																																																																																																																																																																																																																																																																																																																
Fail to synchronize	1*	0.00	1.89	10.37	4.96	1.37	11.0	19.0	19.0	19.0																																																																																																																																																																																																																																																																																																																																												
	1†	0.00	194.40	1059.06	494.15	24.78																																																																																																																																																																																																																																																																																																																																																
Faulty output voltage	1*	0.00	1.89	10.37	4.96	1.37	4.0	14.0	14.0	14.0																																																																																																																																																																																																																																																																																																																																												
	1†	0.00	194.40	1059.06	494.15	24.78																																																																																																																																																																																																																																																																																																																																																
Noise	1*	0.00	1.89	10.37	4.96	1.37	30.0	178.0	178.0	178.0																																																																																																																																																																																																																																																																																																																																												
	1†	0.00	194.40	1059.06	494.15	24.78																																																																																																																																																																																																																																																																																																																																																
Other	1*	0.00	1.22	5.81	2.38	1.37	8.0	6.0	6.0	6.0																																																																																																																																																																																																																																																																																																																																												
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Overheating	1*	0.00	1.89	10.37	4.96	1.37	6.0	6.0	6.0	6.0																																																																																																																																																																																																																																																																																																																																												
	1†	0.00	194.40	1059.06	494.15	24.78																																																																																																																																																																																																																																																																																																																																																
<b>All modes</b>	14*	<b>0.75</b>	<b>24.68</b>	<b>75.01</b>	<b>25.90</b>	<b>19.25</b>	<b>13.2</b>	<b>1.0</b>	<b>35.1</b>	<b>178.0</b>																																																																																																																																																																																																																																																																																																																																												
	14†	<b>49.80</b>	<b>2318.46</b>	<b>7162.47</b>	<b>2524.28</b>	<b>346.96</b>																																																																																																																																																																																																																																																																																																																																																

**Comments**

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 3.3 · 10<sup>-4</sup>

Taxonomy no 2.1.1.2		Item Electric Equipment Electric Generators Motor driven (diesel, gas motor) Main power								
Population 8	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 800			
		Calendar time * 0.2287		Operational time † 0.0790						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>6*</b> <b>6†</b>	<b>10.67</b>	<b>30.48</b>	<b>58.54</b>	<b>14.98</b>	<b>26.24</b>	<b>20.3</b>	<b>2.0</b>	<b>19.8</b>	<b>58.0</b>
Fail to start on demand	2*	0.03	12.59	50.36	18.86	8.75	18.0	8.0	8.0	8.0
	2†	2.75	25.67	68.29	21.71	25.33				
Fail to stop on demand	1*	0.02	9.91	39.33	14.68	4.37	22.0	22.0	22.0	22.0
	1†	0.33	46.70	160.18	59.01	12.66				
Fail to synchronize	1*	0.06	3.85	12.18	4.37	4.37	1.0	2.0	2.0	2.0
	1†	0.12	11.84	38.72	14.11	12.66				
Spurious stop	2*	0.27	9.16	27.88	9.64	8.75	31.3	9.0	33.5	58.0
	2†	4.21	24.80	59.58	17.91	25.33				
<b>Incipient</b>	<b>16*</b> <b>16†</b>	<b>45.34</b>	<b>71.49</b>	<b>102.47</b>	<b>17.49</b>	<b>69.97</b>	<b>5.1</b>	<b>1.0</b>	<b>6.3</b>	<b>22.0</b>
Abnormal instrument reading	8*	16.10	37.24	65.50	15.32	34.98	4.9	1.0	5.6	16.0
	8†	33.86	105.83	210.32	55.43	101.32				
External leakage - Utility medium	2*	0.03	12.59	50.36	18.86	8.75	3.5	1.0	3.5	6.0
	2†	2.75	25.67	68.29	21.71	25.33				
Minor in-service problems	4*	4.34	15.41	32.01	8.75	17.49	2.0	2.0	4.0	6.0
	4†	2.24	44.63	133.62	44.61	50.66				
Other	1*	0.06	3.85	12.18	4.37	4.37	5.0	10.0	10.0	10.0
	1†	0.12	11.84	38.72	14.11	12.66				
Unknown	1*	0.05	5.78	19.45	7.14	4.37	22.0	22.0	22.0	22.0
	1†	0.06	12.81	47.68	17.60	12.66				
<b>All modes</b>	<b>22*</b> <b>22†</b>	<b>47.97</b>	<b>104.76</b>	<b>179.28</b>	<b>40.64</b>	<b>96.21</b>	<b>9.2</b>	<b>1.0</b>	<b>9.5</b>	<b>58.0</b>
		<b>186.26</b>	<b>281.53</b>	<b>392.83</b>	<b>63.17</b>	<b>278.62</b>				
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10 <sup>0</sup>										



Taxonomy no 2.1.1.2.1		Item Electric Equipment Electric Generators Motor driven (diesel, gas motor) Main power (-1000)kVA								
Population 3	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0789		Operational time † 0.0381						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>4*</b>	<b>16.53</b>	<b>49.71</b>	<b>97.37</b>	<b>25.34</b>	<b>50.69</b>	<b>29.0</b>	<b>8.0</b>	<b>29.3</b>	<b>58.0</b>
	<b>4†</b>	<b>29.20</b>	<b>115.76</b>	<b>249.43</b>	<b>70.01</b>	<b>105.12</b>				
Fail to start on demand	2*	0.21	22.18	73.46	26.88	25.34	18.0	8.0	8.0	8.0
	2†	3.93	47.21	132.19	43.12	52.56				
Fail to stop on demand	1*	0.16	15.84	52.06	19.01	12.67	22.0	22.0	22.0	22.0
	1†	0.22	84.20	331.55	123.44	26.28				
Spurious stop	1*	0.15	11.62	37.19	13.44	12.67	58.0	58.0	58.0	58.0
	1†	0.52	24.16	74.60	26.28	26.28				
<b>Incipient</b>	<b>7*</b>	<b>38.14</b>	<b>84.81</b>	<b>146.39</b>	<b>33.53</b>	<b>88.71</b>	<b>8.9</b>	<b>1.0</b>	<b>8.9</b>	<b>22.0</b>
	<b>7†</b>	<b>86.81</b>	<b>184.49</b>	<b>311.67</b>	<b>69.53</b>	<b>183.97</b>				
Abnormal instrument reading	4*	16.53	49.71	97.37	25.34	50.69	8.3	1.0	8.3	16.0
	4†	29.20	115.76	249.43	70.01	105.12				
External leakage - Utility medium	2*	0.21	22.18	73.46	26.88	25.34	3.5	1.0	3.5	6.0
	2†	3.93	47.21	132.19	43.12	52.56				
Unknown	1*	0.15	11.62	37.19	13.44	12.67	22.0	22.0	22.0	22.0
	1†	0.52	24.16	74.60	26.28	26.28				
<b>All modes</b>	<b>11*</b>	<b>73.61</b>	<b>134.52</b>	<b>210.27</b>	<b>42.03</b>	<b>139.40</b>	<b>16.2</b>	<b>1.0</b>	<b>15.0</b>	<b>58.0</b>
	<b>11†</b>	<b>169.10</b>	<b>296.51</b>	<b>452.89</b>	<b>87.16</b>	<b>289.09</b>				
Comments										

Taxonomy no		Item									
2.1.1.2.2		Electric Equipment Electric Generators Motor driven (diesel, gas motor) Main power (1000-3000)kVA									
Population	Installations	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *		Operational time †			800				
5	1	0.1498		0.0409							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Critical	2*	2.37	13.35	42.03	13.35	13.35	2.8	2.0	5.5	9.0	
	2†	8.68	48.89	153.87	48.89	48.89					
Fail to synchronize	1*	0.33	6.68	31.68	6.68	6.68	1.0	2.0	2.0	2.0	
	1†	1.22	24.44	115.99	24.44	24.44					
Spurious stop	1*	0.33	6.68	31.68	6.68	6.68	4.5	9.0	9.0	9.0	
	1†	1.22	24.44	115.99	24.44	24.44					
Incipient	9*	31.35	60.10	104.87	60.10	60.10	2.1	2.0	4.2	10.0	
	9†	114.76	220.00	383.89	220.00	220.00					
Abnormal instrument reading	4*	9.11	26.71	61.13	26.71	26.71	1.5	2.0	3.0	5.0	
	4†	33.37	97.78	223.78	97.78	97.78					
Minor in-service problems	4*	9.11	26.71	61.13	26.71	26.71	2.0	2.0	4.0	6.0	
	4†	33.37	97.78	223.78	97.78	97.78					
Other	1*	0.33	6.68	31.68	6.68	6.68	5.0	10.0	10.0	10.0	
	1†	1.22	24.44	115.99	24.44	24.44					
All modes	11*	41.20	73.45	121.59	73.45	73.45	2.2	2.0	4.5	10.0	
	11†	150.82	268.88	445.12	268.88	268.88					
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10 <sup>0</sup>											

Taxonomy no		Item								
2.1.2		Electric Equipment Electric Generators Turbine driven (gas, steam)								
Population	Installations	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †			3142			
32	11	0.8946		0.7030						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>46*</b>	<b>15.99</b>	<b>53.26</b>	<b>108.31</b>	<b>29.10</b>	<b>51.42</b>	<b>39.1</b>	<b>1.0</b>	<b>58.6</b>	<b>566.0</b>
	<b>46†</b>	<b>25.17</b>	<b>67.06</b>	<b>125.33</b>	<b>31.26</b>	<b>65.43</b>				
Breakdown	3*	0.00	3.64	15.01	5.70	3.35	83.0	29.0	121.0	251.0
	3†	0.02	4.42	16.35	6.04	4.27				
External leakage - Utility medium	1*	0.01	1.16	4.23	1.56	1.12	8.5	17.0	17.0	17.0
	1†	0.00	1.45	8.38	4.56	1.42				
Fail to start on demand	2*	0.43	2.28	5.34	1.58	2.24	9.5	3.0	17.5	32.0
	2†	0.00	2.88	14.26	6.05	2.84				
Fail to synchronize	1*	0.00	0.99	5.33	2.46	1.12	30.0	60.0	60.0	60.0
	1†	0.00	1.32	7.26	3.64	1.42				
Faulty output voltage	2*	0.00	2.15	10.72	4.56	2.24	76.0	4.0	285.0	566.0
	2†	0.00	2.74	13.23	5.46	2.84				
Low output	3*	0.00	2.83	14.53	6.30	3.35	28.8	6.0	57.7	121.0
	3†	0.00	4.35	23.89	11.42	4.27				
Other	5*	0.00	6.41	32.53	14.02	5.59	3.0	6.0	6.0	6.0
	5†	0.00	6.94	34.52	14.69	7.11				
Parameter deviation	1*	0.02	1.14	3.57	1.27	1.12	2.0	4.0	4.0	4.0
	1†	0.00	1.43	8.23	4.46	1.42				
Spurious stop	24*	8.96	27.72	54.90	14.43	26.83	13.6	1.0	15.5	109.5
	24†	12.22	35.26	67.99	17.45	34.14				
Structural deficiency	1*	0.01	1.16	4.23	1.56	1.12	8.0	16.0	16.0	16.0
	1†	0.00	1.45	8.38	4.56	1.42				
Vibration	3*	0.02	3.32	11.90	4.40	3.35	216.0	100.0	253.0	390.0
	3†	0.02	4.42	17.09	6.31	4.27				
<b>Degraded</b>	<b>45*</b>	<b>0.45</b>	<b>56.38</b>	<b>189.91</b>	<b>69.76</b>	<b>50.30</b>	<b>86.5</b>	<b>1.0</b>	<b>139.6</b>	<b>1611.0</b>
	<b>45†</b>	<b>0.60</b>	<b>67.00</b>	<b>222.85</b>	<b>81.63</b>	<b>64.01</b>				
Abnormal instrument reading	2*	0.00	2.36	12.26	5.45	2.24	10.0	9.0	10.0	11.0
	2†	0.00	3.01	15.70	7.03	2.84				
External leakage - Utility medium	11*	0.09	14.74	51.64	19.06	12.30	8.4	2.0	12.9	51.0
	11†	0.15	17.33	57.78	21.18	15.65				
Fail to synchronize	1*	0.00	0.99	5.33	2.46	1.12	27.0	54.0	54.0	54.0
	1†	0.00	1.32	7.26	3.64	1.42				
Faulty output voltage	1*	0.00	1.09	6.18	3.28	1.12	6.5	6.5	6.5	6.5
	1†	0.00	1.38	7.79	4.13	1.42				
Low output	4*	0.00	4.74	26.16	13.21	4.47	6.3	2.0	6.3	11.0
	4†	0.00	6.05	33.45	16.95	5.69				
Other	6*	0.04	6.80	23.91	8.83	6.71	382.5	6.0	622.0	1611.0
	6†	0.08	8.59	28.28	10.33	8.53				
Overheating	1*	0.06	1.13	3.36	1.12	1.12	-	14.0	14.0	14.0
	1†	0.01	1.47	5.19	1.92	1.42				
<b>Comments</b>										

(cont.)

Taxonomy no 2.1.2		Item Electric Equipment Electric Generators Turbine driven (gas, steam)								
Population 32	Installations 11	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 3142			
		Calendar time *		Operational time †						
		0.8946					0.7030			
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Parameter deviation	10*	0.00	12.78	62.28	25.97	11.18	4.4	1.0	7.3	26.0
	10†	0.00	14.39	69.94	29.07	14.22				
Structural deficiency	5*	0.00	6.18	27.56	10.88	5.59	133.0	2.0	240.4	1135.0
	5†	0.00	7.34	31.62	12.25	7.11				
Vibration	4*	0.43	4.59	12.58	4.06	4.47	130.8	4.0	155.8	274.0
	4†	0.65	5.77	15.18	4.79	5.69				
<b>Incipient</b>	<b>104*</b>	<b>1.09</b>	<b>106.69</b>	<b>349.61</b>	<b>127.53</b>	<b>116.25</b>	<b>13.0</b>	<b>1.0</b>	<b>17.9</b>	<b>156.0</b>
	<b>104†</b>	<b>1.41</b>	<b>136.73</b>	<b>447.44</b>	<b>163.14</b>	<b>147.94</b>				
Abnormal instrument reading	46*	0.28	48.74	172.67	63.78	51.42	9.8	1.0	10.9	62.5
	46†	0.35	61.30	217.70	80.42	65.43				
External leakage - Utility medium	20*	0.01	19.99	84.26	32.34	22.36	19.7	1.0	32.9	156.0
	20†	0.02	25.84	108.72	41.69	28.45				
Low output	1*	0.00	1.00	5.43	2.53	1.12	40.5	81.0	81.0	81.0
	1†	0.00	1.45	8.39	4.62	1.42				
Minor in-service problems	19*	0.13	22.08	77.44	28.59	21.24	10.8	1.0	14.4	60.0
	19†	0.19	26.70	91.58	33.74	27.03				
Noise	1*	0.06	1.13	3.36	1.12	1.12	33.0	33.0	33.0	33.0
	1†	0.08	1.44	4.27	1.42	1.42				
Other	14*	0.09	13.31	45.95	16.94	15.65	10.0	1.0	17.2	102.0
	14†	0.05	18.85	74.39	27.72	19.91				
Unknown	1*	0.00	1.04	5.73	2.87	1.12	63.0	63.0	63.0	63.0
	1†	0.00	1.24	6.52	2.93	1.42				
Vibration	2*	0.42	2.27	5.33	1.58	2.24	-	8.0	8.0	8.0
	2†	0.00	2.97	15.20	6.57	2.84				
<b>All modes</b>	<b>195*</b>	<b>28.39</b>	<b>216.14</b>	<b>550.63</b>	<b>171.06</b>	<b>217.97</b>	<b>35.1</b>	<b>1.0</b>	<b>55.3</b>	<b>1611.0</b>
	<b>195†</b>	<b>40.20</b>	<b>270.40</b>	<b>671.09</b>	<b>205.75</b>	<b>277.38</b>				
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 3.2 · 10 <sup>-4</sup>										

**Maintainable item versus failure mode, to be continued**

**Item: Electric Generators - Turbine driven (gas, steam)**

	AIR	BRD	ELU	FOF	FOV	FTS	LOO	NOI	OHE
Actuating device	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Automatic voltage regulator (AVR)	0.00	0.00	0.00	0.00	1.03	0.00	0.00	0.00	0.00
Bearing	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	2.82	0.00	0.00	0.00	0.00	0.51	1.54	0.00	0.00
Cooler(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00
Coupling to driven unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driver	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Excitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fan w/motor	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Filter(s)	0.51	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00
Gearbox	0.00	0.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00
Heat exchanger	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Hood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, current	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, frequency/RPM	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, level	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	4.62	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, vibration	4.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, voltage	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00
Internal power supply	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lubrication	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	2.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.51	0.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	5.13	0.00	0.00	0.00	0.00	0.00	0.00
Pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.51	0.00	0.00	0.00	0.51	0.00	0.00
Purge air	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00
Radial bearing	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Rotor	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00
Seals	0.00	0.00	4.10	0.00	0.00	0.00	0.00	0.00	0.00
Stator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	0.51	1.54	1.03	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	1.03	0.00	0.51	0.00	0.00	0.51	0.51	0.00	0.51
Valves	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Total	24.62	1.54	16.41	0.00	1.54	1.03	4.10	0.51	0.51

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

**Item:** Electric Generators - Turbine driven (gas, steam)

	OTH	PDE	SER	STD	STP	SYN	UNK	UST	VIB	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51
Automatic voltage regulator (AVR)	0.00	1.03	0.00	0.51	0.00	0.00	0.00	0.00	0.00	2.56
Bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51
Cabling & junction boxes	2.31	1.54	0.00	0.51	0.00	0.00	0.00	0.00	0.00	4.87
Control unit	1.54	0.00	0.00	0.00	0.00	1.03	0.00	1.54	0.00	8.97
Cooler(s)	0.51	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	1.54
Coupling to driven unit	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.51
Coupling to driver	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51
Excitation	0.00	0.51	0.51	0.00	0.00	0.00	0.00	0.51	0.00	1.54
Fan w/motor	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.51	1.54
Filter(s)	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	1.54
Gearbox	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.51	0.51	2.56
Heat exchanger	0.51	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	1.54
Hood	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.51
Instrument, current	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03	0.00	1.54
Instrument, frequency/RPM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03
Instrument, general	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	1.28
Instrument, level	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.54
Instrument, temperature	0.00	0.00	0.51	0.00	0.00	0.00	0.00	1.54	0.00	7.18
Instrument, vibration	0.00	0.51	0.00	0.00	0.00	0.00	0.00	1.54	0.51	7.18
Instrument, voltage	0.51	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.08
Internal power supply	0.00	0.00	0.51	0.00	0.00	0.00	0.00	1.03	0.00	2.05
Lubrication	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.51
Monitoring	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.33
Other	0.51	0.51	2.05	0.00	0.00	0.00	0.00	0.51	0.00	5.13
Piping	0.00	0.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00	6.15
Pump	0.00	0.51	0.51	0.00	0.00	0.00	0.00	0.00	0.00	1.03
Pump w/motor	0.00	0.00	1.54	0.00	0.00	0.00	0.51	0.00	0.00	3.08
Purge air	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.54
Radial bearing	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03
Rotor	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	1.54
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.10
Stator	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51
Subunit	2.56	0.00	0.00	1.03	0.00	0.00	0.00	1.03	2.05	9.74
Unknown	1.03	0.00	0.00	0.00	0.00	0.00	0.00	2.05	0.51	6.67
Valves	0.00	0.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00	1.54
Total	12.82	5.64	9.74	3.08	0.00	1.03	0.51	12.31	4.62	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item: Electric Generators - Turbine driven (gas, steam)**

	AIR	BRD	ELU	FOF	FOV	FTS	LOO	NOI	OHE
Blockage/plugged	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Breakage	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	2.05	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deformation	0.00	0.00	2.56	0.00	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	1.54	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00
Electrical failure - general	0.51	0.51	0.00	0.00	0.51	0.00	0.51	0.00	0.51
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	4.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	3.08	0.00	0.00	0.00	0.00	0.00	1.03	0.51	0.00
Leakage	0.00	0.00	2.56	0.00	0.00	0.00	0.00	0.00	0.00
Looseness	2.56	0.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	2.56	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	1.03	3.08	0.00	0.00	0.00	0.00	0.00	0.00
Misc. external influences	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.51	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	2.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open circuit	1.03	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00
Other	0.00	0.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	3.08	0.00	0.00	0.00	0.00	0.00	1.03	0.00	0.00
Overheating	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	1.03	0.00	0.00	0.00	1.03	0.00	0.00
Total	24.62	1.54	16.41	0.00	1.54	1.03	4.10	0.51	0.51

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

**Item:** Electric Generators - Turbine driven (gas, steam)

	OTH	PDE	SER	STD	STP	SYN	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51
Breakage	0.51	0.00	2.05	0.00	0.00	0.00	0.00	0.00	0.00	3.08
Cavitation	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	1.03
Clearance/ alignment failure	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.51	0.51	2.05
Contamination	0.51	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	2.56
Control failure	0.51	0.00	0.51	0.00	0.00	0.00	0.00	1.54	0.00	5.13
Corrosion	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.51
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.56
Earth/isolation fault	3.08	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	5.64
Electrical failure - general	2.56	1.54	0.51	0.51	0.00	1.03	0.00	3.08	0.51	12.31
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.51
Faulty signal/indication/alarm	0.51	0.00	0.00	0.00	0.00	0.00	0.00	1.03	0.00	6.15
Instrument failure - general	0.00	1.54	1.03	0.00	0.00	0.00	0.00	0.51	0.00	7.69
Leakage	0.51	0.00	0.51	0.00	0.00	0.00	0.00	0.51	0.00	4.10
Looseness	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.51	0.00	4.62
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.56
Mechanical Failure - general	1.03	0.51	2.05	0.51	0.00	0.00	0.51	1.03	1.54	11.28
Misc. external influences	0.51	1.03	0.00	1.03	0.00	0.00	0.00	0.51	0.00	3.59
Miscellaneous - general	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.05
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	1.03	2.56
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.05
Open circuit	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.51	0.00	2.56
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	1.54
Out of adjustment	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	5.64
Overheating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	1.03
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51
Software failure	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03
Vibration	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.51	1.03
Wear	0.00	0.00	0.51	0.51	0.00	0.00	0.00	0.00	0.51	3.59
Total	12.82	5.64	9.74	3.08	0.00	1.03	0.51	12.31	4.62	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.



Taxonomy no 2.1.2.1		Item Electric Equipment Electric Generators Turbine driven (gas, steam) Essential power									
Population 8	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 166				
		Calendar time * 0.1840		Operational time † 0.1588			Active rep.hrs	Repair (manhours)			
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t	Min		Mean	Max	
<b>Critical</b>	<b>15*</b> <b>15†</b>	<b>52.25</b> <b>41.29</b>	<b>83.61</b> <b>98.74</b>	<b>120.97</b> <b>176.17</b>	<b>21.05</b> <b>41.87</b>	<b>81.53</b> <b>94.48</b>	<b>35.9</b>	<b>1.0</b>	<b>42.6</b>	<b>251.0</b>	
Breakdown	3*	1.02	19.75	58.98	19.68	16.31	83.0	29.0	121.0	251.0	
	3†	1.73	22.52	63.90	20.96	18.90					
Fail to start on demand	1*	0.03	7.27	27.75	10.22	5.44	3.0	3.0	3.0	3.0	
	1†	0.04	7.88	28.65	10.59	6.30					
Other	4*	0.07	20.25	78.33	28.94	21.74	-	-	-	-	
	4†	0.14	21.47	74.73	27.57	25.20					
Spurious stop	7*	10.14	38.89	82.90	23.09	38.05	5.3	1.0	10.0	30.0	
	7†	21.81	45.33	75.77	16.67	44.09					
<b>Degraded</b>	<b>8*</b> <b>8†</b>	<b>8.67</b> <b>11.31</b>	<b>50.08</b> <b>57.62</b>	<b>119.62</b> <b>133.44</b>	<b>35.82</b> <b>39.26</b>	<b>43.48</b> <b>50.39</b>	<b>3.5</b>	<b>1.0</b>	<b>6.0</b>	<b>14.0</b>	
External leakage - Utility medium	1*	0.01	5.25	21.69	8.24	5.44	-	-	-	-	
	1†	0.02	5.75	22.28	8.24	6.30					
Other	1*	0.01	5.03	19.71	7.32	5.44	-	6.0	6.0	6.0	
	1†	0.00	6.29	26.86	10.38	6.30					
Overheating	1*	0.01	5.03	19.71	7.32	5.44	-	14.0	14.0	14.0	
	1†	0.00	6.29	26.86	10.38	6.30					
Parameter deviation	3*	1.02	19.75	58.98	19.68	16.31	4.0	1.0	5.3	8.0	
	3†	1.73	22.52	63.90	20.96	18.90					
Structural deficiency	1*	0.03	7.27	27.75	10.22	5.44	2.0	2.0	2.0	2.0	
	1†	0.04	7.88	28.65	10.59	6.30					
Vibration	1*	0.03	7.27	27.75	10.22	5.44	4.0	4.0	4.0	4.0	
	1†	0.04	7.88	28.65	10.59	6.30					
<b>Incipient</b>	<b>10*</b> <b>10†</b>	<b>5.26</b> <b>6.64</b>	<b>70.87</b> <b>76.24</b>	<b>202.15</b> <b>211.69</b>	<b>66.43</b> <b>68.79</b>	<b>54.35</b> <b>62.99</b>	<b>3.3</b>	<b>1.0</b>	<b>5.0</b>	<b>14.0</b>	
Abnormal instrument reading	5*	0.32	39.54	133.33	48.99	27.18	2.3	1.0	2.3	6.0	
	5†	0.32	42.01	142.37	52.35	31.49					
Minor in-service problems	3*	1.08	20.19	60.07	20.02	16.31	5.5	4.0	9.0	14.0	
	3†	1.67	21.59	61.21	20.07	18.90					
Vibration	2*	1.66	10.51	25.72	7.82	10.87	-	8.0	8.0	8.0	
	2†	1.70	12.20	30.72	9.49	12.60					
<b>All modes</b>	<b>33*</b> <b>33†</b>	<b>46.59</b> <b>60.47</b>	<b>215.80</b> <b>240.24</b>	<b>486.97</b> <b>517.96</b>	<b>140.99</b> <b>145.46</b>	<b>179.36</b> <b>207.86</b>	<b>14.2</b>	<b>1.0</b>	<b>21.0</b>	<b>251.0</b>	
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 6.0 · 10 <sup>-3</sup>											

Taxonomy no 2.1.2.1.1		Item Electric Equipment Electric Generators Turbine driven (gas, steam) Essential power (-1000)kVA								
Population 4	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 26			
		Calendar time * 0.0701		Operational time † 0.0701						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Critical	5*	28.11	71.35	150.04	71.35	71.35	-	-	-	-
	5†	28.11	71.35	150.04	71.35	71.35	-	-	-	-
Other	4*	19.48	57.08	130.64	57.08	57.08	-	-	-	-
	4†	19.48	57.08	130.64	57.08	57.08	-	-	-	-
Spurious stop	1*	0.71	14.27	67.71	14.27	14.27	-	-	-	-
	1†	0.71	14.27	67.71	14.27	14.27	-	-	-	-
Degraded	1*	0.71	14.27	67.71	14.27	14.27	-	-	-	-
	1†	0.71	14.27	67.71	14.27	14.27	-	-	-	-
External leakage - Utility medium	1*	0.71	14.27	67.71	14.27	14.27	-	-	-	-
	1†	0.71	14.27	67.71	14.27	14.27	-	-	-	-
Incipient	3*	11.70	42.81	110.66	42.81	42.81	-	-	-	-
	3†	11.70	42.81	110.66	42.81	42.81	-	-	-	-
Abnormal instrument reading	1*	0.71	14.27	67.71	14.27	14.27	-	-	-	-
	1†	0.71	14.27	67.71	14.27	14.27	-	-	-	-
Minor in-service problems	1*	0.71	14.27	67.71	14.27	14.27	-	-	-	-
	1†	0.71	14.27	67.71	14.27	14.27	-	-	-	-
Vibration	1*	0.71	14.27	67.71	14.27	14.27	-	-	-	-
	1†	0.71	14.27	67.71	14.27	14.27	-	-	-	-
All modes	9*	66.99	128.42	224.10	128.42	128.42	-	-	-	-
	9†	66.99	128.42	224.10	128.42	128.42	-	-	-	-
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10 <sup>0</sup>										

Taxonomy no 2.1.2.1.2		Item Electric Equipment Electric Generators Turbine driven (gas, steam) Essential power (1000-3000)kVA								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 140			
		Calendar time * 0.0351		Operational time † 0.0330						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	5*	<b>56.18</b>	<b>142.60</b>	<b>299.88</b>	<b>142.60</b>	<b>142.60</b>	<b>35.9</b>	<b>1.0</b>	<b>71.4</b>	<b>251.0</b>
	5†	<b>59.62</b>	<b>151.33</b>	<b>318.25</b>	<b>151.33</b>	<b>151.33</b>				
Breakdown	2*	10.12	57.04	179.53	57.04	57.04	83.0	83.0	167.0	251.0
	2†	10.74	60.53	190.53	60.53	60.53				
Fail to start on demand	1*	1.43	28.52	135.32	28.52	28.52	3.0	3.0	3.0	3.0
	1†	1.51	30.27	143.61	30.27	30.27				
Spurious stop	2*	10.12	57.04	179.53	57.04	57.04	5.3	1.0	10.0	19.0
	2†	10.74	60.53	190.53	60.53	60.53				
<b>Degraded</b>	4*	<b>38.93</b>	<b>114.08</b>	<b>261.09</b>	<b>114.08</b>	<b>114.08</b>	<b>3.5</b>	<b>1.0</b>	<b>3.5</b>	<b>7.0</b>
	4†	<b>41.31</b>	<b>121.07</b>	<b>277.09</b>	<b>121.07</b>	<b>121.07</b>				
Parameter deviation	2*	10.12	57.04	179.53	57.04	57.04	4.0	1.0	4.0	7.0
	2†	10.74	60.53	190.53	60.53	60.53				
Structural deficiency	1*	1.43	28.52	135.32	28.52	28.52	2.0	2.0	2.0	2.0
	1†	1.51	30.27	143.61	30.27	30.27				
Vibration	1*	1.43	28.52	135.32	28.52	28.52	4.0	4.0	4.0	4.0
	1†	1.51	30.27	143.61	30.27	30.27				
<b>Incipient</b>	6*	<b>74.58</b>	<b>171.12</b>	<b>337.67</b>	<b>171.12</b>	<b>171.12</b>	<b>3.3</b>	<b>1.0</b>	<b>4.5</b>	<b>14.0</b>
	6†	<b>79.15</b>	<b>181.60</b>	<b>358.35</b>	<b>181.60</b>	<b>181.60</b>				
Abnormal instrument reading	4*	38.93	114.08	261.09	114.08	114.08	2.3	1.0	2.3	6.0
	4†	41.31	121.07	277.09	121.07	121.07				
Minor in-service problems	2*	10.12	57.04	179.53	57.04	57.04	5.5	4.0	9.0	14.0
	2†	10.74	60.53	190.53	60.53	60.53				
<b>All modes</b>	15*	<b>263.66</b>	<b>427.79</b>	<b>658.65</b>	<b>427.79</b>	<b>427.79</b>	<b>14.2</b>	<b>1.0</b>	<b>26.5</b>	<b>251.0</b>
	15†	<b>279.81</b>	<b>454.00</b>	<b>699.00</b>	<b>454.00</b>	<b>454.00</b>				
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 7.1 · 10 <sup>-3</sup>										

Taxonomy no 2.1.2.1.3		Item Electric Equipment Electric Generators Turbine driven (gas, steam) Essential power (3000-10000)kVA								
Population 3	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0788		Operational time † 0.0556						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max
<b>Critical</b>	5*	<b>24.99</b>	<b>63.42</b>	<b>133.37</b>	<b>63.42</b>	<b>63.42</b>	-	<b>1.0</b>	<b>13.8</b>	<b>30.0</b>
	5†	<b>35.41</b>	<b>89.87</b>	<b>188.99</b>	<b>89.87</b>	<b>89.87</b>	-			
Breakdown	1*	0.63	12.68	60.19	12.68	12.68	-	29.0	29.0	29.0
	1†	0.90	17.97	85.28	17.97	17.97	-			
Spurious stop	4*	17.31	50.74	116.12	50.74	50.74	-	1.0	10.0	30.0
	4†	24.53	71.89	164.55	71.89	71.89	-			
<b>Degraded</b>	3*	<b>10.40</b>	<b>38.05</b>	<b>98.36</b>	<b>38.05</b>	<b>38.05</b>	-	<b>6.0</b>	<b>9.3</b>	<b>14.0</b>
	3†	<b>14.74</b>	<b>53.92</b>	<b>139.39</b>	<b>53.92</b>	<b>53.92</b>	-			
Other	1*	0.63	12.68	60.19	12.68	12.68	-	6.0	6.0	6.0
	1†	0.90	17.97	85.28	17.97	17.97	-			
Overheating	1*	0.63	12.68	60.19	12.68	12.68	-	14.0	14.0	14.0
	1†	0.90	17.97	85.28	17.97	17.97	-			
Parameter deviation	1*	0.63	12.68	60.19	12.68	12.68	-	8.0	8.0	8.0
	1†	0.90	17.97	85.28	17.97	17.97	-			
<b>Incipient</b>	1*	<b>0.63</b>	<b>12.68</b>	<b>60.19</b>	<b>12.68</b>	<b>12.68</b>	-	<b>8.0</b>	<b>8.0</b>	<b>8.0</b>
	1†	<b>0.90</b>	<b>17.97</b>	<b>85.28</b>	<b>17.97</b>	<b>17.97</b>	-			
Vibration	1*	0.63	12.68	60.19	12.68	12.68	-	8.0	8.0	8.0
	1†	0.90	17.97	85.28	17.97	17.97	-			
<b>All modes</b>	9*	<b>59.55</b>	<b>114.16</b>	<b>199.20</b>	<b>114.16</b>	<b>114.16</b>	-	<b>1.0</b>	<b>11.7</b>	<b>30.0</b>
	9†	<b>84.39</b>	<b>161.76</b>	<b>282.28</b>	<b>161.76</b>	<b>161.76</b>	-			
<b>Comments</b>										

Taxonomy no 2.1.2.2		Item Electric Equipment Electric Generators Turbine driven (gas, steam) Main power									
Population 24	Installations 9	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 2976				
		Calendar time * 0.7106		Operational time † 0.5442							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
<b>Critical</b>	<b>31*</b> <b>31†</b>	<b>12.59</b>	<b>47.63</b>	<b>101.09</b>	<b>28.07</b>	<b>43.62</b>	<b>39.6</b>	<b>1.0</b>	<b>64.0</b>	<b>566.0</b>	
External leakage - Utility medium	1* 1†	0.00 0.00	2.22 2.48	11.52 12.53	5.07 5.39	1.41 1.84	8.5	17.0	17.0	17.0	
Fail to start on demand	1* 1†	0.09 0.00	1.44 1.83	4.24 10.06	1.41 4.93	1.41 1.84	16.0	32.0	32.0	32.0	
Fail to synchronize	1* 1†	0.00 0.00	1.26 1.70	6.34 8.91	2.72 4.02	1.41 1.84	30.0	60.0	60.0	60.0	
Faulty output voltage	2* 2†	0.00 0.00	2.73 3.52	12.49 15.33	4.98 5.96	2.81 3.67	76.0	4.0	285.0	566.0	
Low output	3* 3†	0.00 0.00	3.61 5.51	16.87 28.67	6.86 12.77	4.22 5.51	28.8	6.0	57.7	121.0	
Other	1* 1†	0.09 0.00	1.44 1.83	4.24 10.06	1.41 4.93	1.41 1.84	3.0	6.0	6.0	6.0	
Parameter deviation	1* 1†	0.09 0.00	1.44 1.83	4.24 10.06	1.41 4.93	1.41 1.84	2.0	4.0	4.0	4.0	
Spurious stop	17* 17†	5.18 8.40	26.75 34.30	62.15 74.59	18.32 21.07	23.92 31.24	14.6	1.0	17.6	109.5	
Structural deficiency	1* 1†	0.00 0.00	2.22 2.48	11.52 12.53	5.07 5.39	1.41 1.84	8.0	16.0	16.0	16.0	
Vibration	3* 3†	0.10 0.08	4.22 5.67	12.95 18.05	4.53 6.50	4.22 5.51	216.0	100.0	253.0	390.0	
<b>Degraded</b>	<b>37*</b> <b>37†</b>	<b>0.83</b>	<b>73.71</b>	<b>239.14</b>	<b>86.92</b>	<b>52.07</b>	<b>96.2</b>	<b>2.0</b>	<b>166.3</b>	<b>1611.0</b>	
Abnormal instrument reading	2* 2†	0.00 0.00	2.98 3.83	14.53 18.66	6.05 7.77	2.81 3.67	10.0	9.0	10.0	11.0	
External leakage - Utility medium	10* 10†	0.11 0.13	23.74 27.14	87.12 99.97	32.18 36.93	14.07 18.37	8.4	2.0	12.9	51.0	
Fail to synchronize	1* 1†	0.00 0.00	1.26 1.70	6.34 8.91	2.72 4.02	1.41 1.84	27.0	54.0	54.0	54.0	
Faulty output voltage	1* 1†	0.00 0.00	1.39 1.77	7.63 9.74	3.62 4.57	1.41 1.84	6.5	6.5	6.5	6.5	
Low output	4* 4†	0.00 0.00	5.95 7.60	32.01 41.15	14.81 19.12	5.63 7.35	6.3	2.0	6.3	11.0	
Other	5* 5†	0.04 0.10	7.12 9.01	25.30 29.24	9.35 10.63	7.04 9.19	382.5	8.0	745.2	1611.0	
Parameter deviation	7* 7†	0.00 0.00	17.51 18.98	79.57 89.07	31.68 36.28	9.85 12.86	4.6	3.0	8.4	26.0	
Structural deficiency	4* 4†	0.01 0.01	7.82 9.24	32.79 37.98	12.55 14.41	5.63 7.35	165.8	5.0	300.0	1135.0	
<b>Comments</b>											

(cont.)

Taxonomy no 2.1.2.2		Item Electric Equipment Electric Generators Turbine driven (gas, steam) Main power									
Population 24	Installations 9	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 2976				
		Calendar time * 0.7106		Operational time † 0.5442							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Vibration	3* 3†	0.06 0.10	4.34 5.60	13.78 17.51	4.96 6.24	4.22 5.51	173.0	88.0	206.3	274.0	
<b>Incipient</b>	<b>94*</b> <b>94†</b>	<b>2.27</b> <b>3.08</b>	<b>123.99</b> <b>160.49</b>	<b>386.74</b> <b>499.14</b>	<b>137.48</b> <b>177.01</b>	<b>132.28</b> <b>172.72</b>	<b>13.7</b>	<b>1.0</b>	<b>18.9</b>	<b>156.0</b>	
Abnormal instrument reading	41* 41†	0.41 0.54	54.89 70.18	186.59 237.86	68.65 87.47	57.70 75.33	10.5	1.0	11.8	62.5	
External leakage - Utility medium	20* 20†	0.12 0.16	25.18 32.59	92.68 119.52	34.23 44.15	28.14 36.75	19.7	1.0	32.9	156.0	
Low output	1* 1†	0.00 0.00	1.27 1.86	6.48 10.24	2.80 5.11	1.41 1.84	40.5	81.0	81.0	81.0	
Minor in-service problems	16* 16†	0.24 0.33	26.80 32.64	89.31 107.08	32.73 39.08	22.52 29.40	11.4	1.0	15.1	60.0	
Noise	1* 1†	0.08 0.00	1.43 1.92	4.23 10.63	1.41 5.45	1.41 1.84	33.0	33.0	33.0	33.0	
Other	14* 14†	1.03 0.22	17.16 23.95	50.40 79.22	16.73 28.98	19.70 25.72	10.0	1.0	17.2	102.0	
Unknown	1* 1†	0.00 0.00	1.32 1.61	6.97 7.82	3.17 3.24	1.41 1.84	63.0	63.0	63.0	63.0	
<b>All modes</b>	<b>162*</b> <b>162†</b>	<b>36.64</b> <b>49.96</b>	<b>247.72</b> <b>310.18</b>	<b>615.52</b> <b>755.22</b>	<b>188.83</b> <b>228.98</b>	<b>227.97</b> <b>297.66</b>	<b>37.1</b>	<b>1.0</b>	<b>60.6</b>	<b>1611.0</b>	
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0: 10 <sup>0</sup>											

Taxonomy no 2.1.2.2.1		Item Electric Equipment Electric Generators Turbine driven (gas, steam) Main power (-1000)kVA									
Population 5	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 285				
		Calendar time * 0.1512		Operational time † 0.1393							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	3*	<b>3.99</b>	<b>22.93</b>	<b>54.68</b>	<b>16.36</b>	<b>19.84</b>	17.3	12.0	17.3	22.0	
	3†	<b>2.62</b>	<b>28.04</b>	<b>76.82</b>	<b>24.81</b>	<b>21.54</b>					
Spurious stop	3*	3.99	22.93	54.68	16.36	19.84	17.3	12.0	17.3	22.0	
	3†	2.62	28.04	76.82	24.81	21.54					
<b>Degraded</b>	3*	<b>0.13</b>	<b>30.76</b>	<b>115.56</b>	<b>42.64</b>	<b>19.84</b>	<b>52.8</b>	<b>6.5</b>	<b>63.5</b>	<b>96.0</b>	
	3†	<b>0.15</b>	<b>38.78</b>	<b>148.08</b>	<b>54.56</b>	<b>21.54</b>					
Faulty output voltage	1*	0.06	9.01	31.28	11.54	6.61	6.5	6.5	6.5	6.5	
	1†	0.05	11.38	42.12	15.56	7.18					
Other	1*	0.06	9.01	31.28	11.54	6.61	96.0	96.0	96.0	96.0	
	1†	0.05	11.38	42.12	15.56	7.18					
Vibration	1*	0.06	9.01	31.28	11.54	6.61	56.0	88.0	88.0	88.0	
	1†	0.05	11.38	42.12	15.56	7.18					
<b>Incipient</b>	26*	<b>1.91</b>	<b>262.11</b>	<b>894.88</b>	<b>329.46</b>	<b>171.96</b>	<b>20.2</b>	<b>1.0</b>	<b>25.3</b>	<b>156.0</b>	
	26†	<b>2.07</b>	<b>326.88</b>	<b>1140.25</b>	<b>420.79</b>	<b>186.65</b>					
Abnormal instrument reading	12*	1.35	115.79	374.28	135.84	79.37	12.2	2.0	12.2	60.0	
	12†	1.27	143.71	478.77	175.45	86.15					
External leakage - Utility medium	6*	0.26	63.38	241.01	88.84	39.68	36.7	1.0	58.3	156.0	
	6†	0.31	79.87	306.04	112.73	43.07					
Minor in-service problems	5*	0.22	52.51	199.22	73.45	33.07	13.8	3.0	17.8	60.0	
	5†	0.26	66.17	253.41	93.35	35.90					
Other	2*	0.09	19.89	73.62	27.19	13.23	6.0	4.0	5.0	6.0	
	2†	0.10	25.08	95.31	35.13	14.36					
Unknown	1*	0.11	6.05	18.89	6.72	6.61	63.0	63.0	63.0	63.0	
	1†	0.13	6.53	20.28	7.18	7.18					
<b>All modes</b>	32*	<b>2.50</b>	<b>321.19</b>	<b>1086.84</b>	<b>399.56</b>	<b>211.64</b>	<b>23.0</b>	<b>1.0</b>	<b>28.1</b>	<b>156.0</b>	
	32†	<b>2.66</b>	<b>400.19</b>	<b>1384.89</b>	<b>510.70</b>	<b>229.73</b>					
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0: 10 <sup>6</sup>											

Taxonomy no 2.1.2.2.2		Item Electric Equipment Electric Generators Turbine driven (gas, steam) Main power (3000-10000)kVA								
Population 5	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1400		Operational time † 0.1085						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>8*</b> <b>8†</b>	<b>28.25</b> <b>36.65</b>	<b>56.94</b> <b>73.69</b>	<b>93.73</b> <b>121.15</b>	<b>20.20</b> <b>26.06</b>	<b>57.14</b> <b>73.71</b>	<b>18.0</b>	<b>3.0</b>	<b>22.6</b>	<b>109.5</b>
Fail to start on demand	1*	0.03	6.98	26.03	9.61	7.14	16.0	32.0	32.0	32.0
	1†	0.07	8.53	28.51	10.46	9.21				
Faulty output voltage	1*	0.03	6.98	26.03	9.61	7.14	2.0	4.0	4.0	4.0
	1†	0.07	8.53	28.51	10.46	9.21				
Other	1*	0.03	6.98	26.03	9.61	7.14	3.0	6.0	6.0	6.0
	1†	0.07	8.53	28.51	10.46	9.21				
Parameter deviation	1*	0.03	6.98	26.03	9.61	7.14	2.0	4.0	4.0	4.0
	1†	0.07	8.53	28.51	10.46	9.21				
Spurious stop	4*	9.98	28.84	55.62	14.28	28.57	30.3	3.0	33.6	109.5
	4†	5.94	41.03	102.42	31.50	36.86				
<b>Degraded</b>	<b>4*</b> <b>4†</b>	<b>0.30</b> <b>1.85</b>	<b>27.56</b> <b>32.58</b>	<b>89.79</b> <b>96.30</b>	<b>32.69</b> <b>32.03</b>	<b>28.57</b> <b>36.86</b>	<b>378.6</b>	<b>3.0</b>	<b>757.3</b>	<b>1611.0</b>
Other	2*	1.13	13.97	39.29	12.84	14.28	755.8	1412.0	1511.5	1611.0
	2†	2.63	17.26	42.63	13.03	18.43				
Parameter deviation	2*	1.13	13.97	39.29	12.84	14.28	1.5	3.0	3.0	3.0
	2†	2.63	17.26	42.63	13.03	18.43				
<b>Incipient</b>	<b>6*</b> <b>6†</b>	<b>18.49</b> <b>23.74</b>	<b>42.65</b> <b>54.88</b>	<b>74.90</b> <b>96.51</b>	<b>17.49</b> <b>22.57</b>	<b>42.85</b> <b>55.29</b>	<b>1.1</b>	<b>1.0</b>	<b>1.9</b>	<b>2.5</b>
Abnormal instrument reading	1*	0.41	7.27	21.48	7.14	7.14	2.0	2.0	2.0	2.0
	1†	0.33	10.40	31.57	10.87	9.21				
External leakage - Utility medium	3*	0.40	20.77	64.58	22.90	21.43	1.0	2.5	2.5	2.5
	3†	2.79	25.19	66.44	21.01	27.64				
Minor in-service problems	2*	2.54	14.30	33.90	10.10	14.28	0.8	1.0	1.0	1.0
	2†	3.54	18.81	44.03	13.03	18.43				
<b>All modes</b>	<b>18*</b> <b>18†</b>	<b>49.32</b> <b>90.23</b>	<b>126.89</b> <b>162.16</b>	<b>233.73</b> <b>251.13</b>	<b>57.45</b> <b>49.47</b>	<b>128.56</b> <b>165.86</b>	<b>92.5</b>	<b>1.0</b>	<b>178.9</b>	<b>1611.0</b>
<b>Comments</b>										



Taxonomy no 2.1.2.2.3		Item Electric Equipment Electric Generators Turbine driven (gas, steam) Main power (10000-20000)kVA									
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0175		Operational time † 0.0175							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max	
Degraded  External leakage - Utility medium	1*	2.85	57.08	270.83	57.08	57.08	-	16.0	16.0	16.0	
	1†	2.85	57.08	270.83	57.08	57.08	-	16.0	16.0	16.0	
	1*	2.85	57.08	270.83	57.08	57.08	-	16.0	16.0	16.0	
	1†	2.85	57.08	270.83	57.08	57.08	-	16.0	16.0	16.0	
All modes	1*	2.85	57.08	270.83	57.08	57.08	-	16.0	16.0	16.0	
	1†	2.85	57.08	270.83	57.08	57.08	-	16.0	16.0	16.0	
Comments											

Taxonomy no 2.1.2.2.4		Item Electric Equipment Electric Generators Turbine driven (gas, steam) Main power (20000-30000)kVA									
Population 12	Installations 5	Aggregated time in service (10 <sup>6</sup> hours)						No of demands 2691			
		Calendar time * 0.4019			Operational time † 0.2789						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	<b>20*</b> <b>20†</b>	<b>12.48</b> <b>25.66</b>	<b>57.67</b> <b>75.99</b>	<b>130.04</b> <b>147.94</b>	<b>37.63</b> <b>38.30</b>	<b>49.77</b> <b>71.71</b>	<b>52.2</b>	<b>1.0</b>	<b>88.7</b>	<b>566.0</b>	
External leakage - Utility medium	1* 1†	0.00 0.00	4.07 4.57	18.31 19.53	7.26 7.55	2.49 3.59	8.5	17.0	17.0	17.0	
Fail to synchronize	1* 1†	0.00 0.00	2.25 3.19	9.48 13.88	3.64 5.39	2.49 3.59	30.0	60.0	60.0	60.0	
Faulty output voltage	1* 1†	0.00 0.00	2.25 3.19	9.48 13.88	3.64 5.39	2.49 3.59	150.0	566.0	566.0	566.0	
Low output	3* 3†	0.03 0.00	6.47 10.05	23.61 43.70	8.72 16.99	7.46 10.76	28.8	6.0	57.7	121.0	
Spurious stop	10* 10†	3.52 8.59	32.17 39.98	85.13 90.35	26.98 26.18	24.88 35.85	6.8	1.0	10.6	38.0	
Structural deficiency	1* 1†	0.00 0.00	4.07 4.57	18.31 19.53	7.26 7.55	2.49 3.59	8.0	16.0	16.0	16.0	
Vibration	3* 3†	1.73 2.91	7.51 10.71	16.61 22.53	4.74 6.21	7.46 10.76	216.0	100.0	253.0	390.0	
<b>Degraded</b>	<b>29*</b> <b>29†</b>	<b>1.80</b> <b>2.06</b>	<b>105.59</b> <b>123.98</b>	<b>330.87</b> <b>389.30</b>	<b>118.04</b> <b>139.09</b>	<b>72.16</b> <b>103.98</b>	<b>59.2</b>	<b>2.0</b>	<b>95.8</b>	<b>1135.0</b>	
Abnormal instrument reading	2* 2†	0.01 0.02	5.32 7.07	21.82 27.43	8.27 10.15	4.98 7.17	10.0	9.0	10.0	11.0	
External leakage - Utility medium	9* 9†	0.31 0.44	34.65 40.54	115.28 131.95	42.23 48.02	22.39 32.27	8.4	2.0	12.6	51.0	
Fail to synchronize	1* 1†	0.00 0.00	2.25 3.19	9.48 13.88	3.64 5.39	2.49 3.59	27.0	54.0	54.0	54.0	
Low output	4* 4†	0.00 0.00	10.56 13.73	49.42 64.08	20.10 26.01	9.95 14.34	6.3	2.0	6.3	11.0	
Other	2* 2†	0.04 0.08	4.83 6.74	16.16 21.81	5.93 7.92	4.98 7.17	152.5	8.0	303.5	599.0	
Parameter deviation	5* 5†	0.01 0.00	26.54 28.59	114.46 131.05	44.37 52.41	12.44 17.93	6.7	4.0	12.0	26.0	
Structural deficiency	4* 4†	0.14 0.33	13.90 16.58	45.74 51.43	16.71 18.19	9.95 14.34	165.8	5.0	300.0	1135.0	
Vibration	2* 2†	0.01 0.02	5.32 7.07	21.82 27.43	8.27 10.15	4.98 7.17	231.5	257.0	265.5	274.0	
<b>Incipient</b>	<b>62*</b> <b>62†</b>	<b>50.03</b> <b>81.26</b>	<b>180.80</b> <b>238.48</b>	<b>377.91</b> <b>462.64</b>	<b>103.70</b> <b>119.38</b>	<b>154.27</b> <b>222.30</b>	<b>12.2</b>	<b>1.0</b>	<b>17.7</b>	<b>102.0</b>	
Abnormal instrument reading	28* 28†	12.62 19.65	85.01 109.80	211.06 260.01	64.72 77.42	69.67 100.39	10.2	1.0	11.9	62.5	
External leakage - Utility medium	11* 11†	1.56 2.80	28.35 39.14	84.06 112.25	27.98 36.96	27.37 39.44	14.6	2.0	26.1	50.0	
<b>Comments</b>											

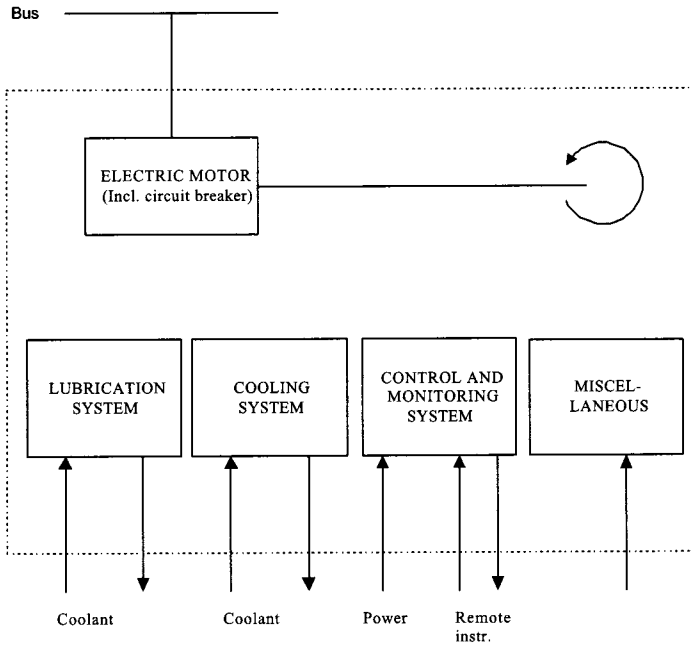
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<b>Taxonomy no</b> 2.1.2.2.4		<b>Item</b> Electric Equipment Electric Generators Turbine driven (gas, steam) Main power (20000-30000)kVA									
<b>Population</b> 12	<b>Installations</b> 5	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>				
		<b>Calendar time *</b> 0.4019			<b>Operational time †</b> 0.2789		2691				
<b>Failure mode</b>		<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours)</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
			<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/t</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
Low output		1* 1†	0.00 0.00	2.26 3.44	9.70 16.60	3.75 6.85	2.49 3.59	40.5	81.0	81.0	81.0
Minor in-service problems		9* 9†	1.84 2.95	35.52 41.81	106.02 120.16	35.36 39.60	22.39 32.27	12.5	3.0	16.8	51.0
Noise		1* 1†	0.16 0.00	2.57 3.53	7.51 17.36	2.49 7.31	2.49 3.59	33.0	33.0	33.0	33.0
Other		12* 12†	12.59 8.42	28.72 41.24	50.20 94.52	11.66 27.64	29.86 43.03	10.4	1.0	19.4	102.0
<b>All modes</b>		<b>111* 111†</b>	<b>114.48 208.60</b>	<b>348.04 437.81</b>	<b>684.53 735.24</b>	<b>178.85 162.76</b>	<b>276.20 397.99</b>	<b>31.7</b>	<b>1.0</b>	<b>50.7</b>	<b>1135.0</b>
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0-10 <sup>0</sup>											

### Electric Motors

#### Inventory description

The boundary definition is shown in Figure 16 and corresponding subdivision in Maintainable Items in Table 11. The boundary definition applies to electric motors. Included within the boundary are the starting system and possible auxiliaries related to the motor. Subunits that are common to the driver (i.e. the electric motor) and the *driven unit* (e.g. a pump) are a part of the *driven unit*. The power transmission system is also regarded as part of the driven unit.



**Figure 16 - Electric motors, Boundary Definition**

**Table 11 Electric Motors, Subdivision in Maintainable Items**

ELECTRICAL MOTORS				
Control & monitoring	Cooling system	Electric motor	Lubrication system	Miscellaneous
<ul style="list-style-type: none"> <li>• Actuating device</li> <li>• Cabling &amp; junction boxes</li> <li>• Control unit</li> <li>• Instruments</li> <li>• Internal power supply</li> <li>• Monitoring</li> <li>• Valves</li> </ul>	<ul style="list-style-type: none"> <li>• Heat exchanger</li> <li>• Fan w/motor</li> <li>• Filter</li> <li>• Valves &amp; piping</li> <li>• Pump</li> <li>• Instruments</li> </ul>	<ul style="list-style-type: none"> <li>• Casing</li> <li>• Circuit breaker</li> <li>• Coupling</li> <li>• Excitation</li> <li>• Instruments</li> <li>• Overload protection</li> <li>• Radial bearing</li> <li>• Rotor</li> <li>• Stator</li> <li>• Thrust bearing</li> </ul>	<ul style="list-style-type: none"> <li>• Reservoir</li> <li>• Pump w/motor</li> <li>• Filter</li> <li>• Cooler</li> <li>• Valves &amp; piping</li> <li>• Oil</li> <li>• Instruments</li> <li>• Seals</li> </ul>	<ul style="list-style-type: none"> <li>• Hood</li> </ul>

(For all subunits the MIs "Unknown" and "Subunit" are included.)

**List of failure modes**

- AIR Abnormal instrument reading
- BRD Breakdown
- ERO Erratic output
- ELU External leakage - Utility medium
- FTS Fail to start on demand
- STP Fail to stop on demand
- LOO Low output
- SER Minor in-service problems
- NOI Noise
- OTH Other
- OHE Overheating
- PDE Parameter deviation
- UST Spurious stop
- STD Structural deficiency
- UNK Unknown
- VIB Vibration

Taxonomy no 2.2		Item Electric Equipment Electric motors								
Population 178	Installations 16	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 6368			
		Calendar time * 5.4324			Operational time † 4.3894					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>119*</b> <b>119†</b>	<b>2.24</b>	<b>28.44</b>	<b>80.34</b>	<b>26.30</b>	<b>21.91</b>	<b>35.3</b>	<b>1.0</b>	<b>55.6</b>	<b>1140.0</b>
Breakdown	9*	0.16	1.53	4.06	1.29	1.66	12.4	4.0	21.9	45.0
External leakage - Utility medium	9†	0.75	1.93	3.54	0.87	2.05				
	2*	0.00	0.48	2.22	0.89	0.37	34.5	38.0	45.5	53.0
Fail to start on demand	2†	0.00	0.56	2.19	0.81	0.46				
	22*	2.08	3.97	6.36	1.32	4.05	17.2	1.0	27.4	250.0
Fail to stop on demand	22†	0.04	4.77	15.81	5.79	5.01				
	2*	0.00	0.52	2.45	1.00	0.37	11.0	2.0	20.5	39.0
Low output	2†	0.00	0.64	3.02	1.23	0.46				
	13*	0.00	5.89	27.44	11.12	2.39	13.9	1.0	19.2	48.0
Noise	13†	0.00	6.51	31.06	12.76	2.96				
	3*	0.01	0.49	1.51	0.53	0.55	6.3	5.0	26.7	60.0
Other	3†	0.00	0.58	2.50	0.97	0.68				
	5*	0.00	1.31	7.37	3.89	0.92	15.5	3.0	30.6	37.5
Overheating	5†	0.00	1.57	8.80	4.64	1.14				
	2*	0.00	0.44	1.95	0.77	0.37	3.0	2.0	3.0	4.0
Parameter deviation	2†	0.00	0.50	1.88	0.69	0.46				
	4*	0.00	0.66	3.76	2.09	0.74	5.0	2.0	9.5	26.0
Spurious stop	4†	0.00	0.76	4.24	2.22	0.91				
	37*	0.03	13.62	54.22	20.26	6.81	99.1	1.0	145.5	1140.0
Structural deficiency	37†	0.03	14.98	60.06	22.52	8.43				
	11*	0.00	1.13	4.70	1.80	2.02	17.1	4.0	33.2	146.0
Vibration	11†	0.19	1.70	4.48	1.42	2.51				
	9*	0.12	1.32	3.60	1.16	1.66	17.1	4.0	25.4	57.0
<b>Degraded</b>	9†	0.14	1.60	4.43	1.44	2.05				
	<b>76*</b>	<b>1.23</b>	<b>15.95</b>	<b>45.23</b>	<b>14.83</b>	<b>13.99</b>	<b>16.1</b>	<b>1.0</b>	<b>22.7</b>	<b>484.0</b>
Abnormal instrument reading	76†	<b>1.93</b>	<b>18.54</b>	<b>49.60</b>	<b>15.82</b>	<b>17.31</b>				
	1*	0.00	0.24	1.31	0.61	0.18	6.0	6.0	6.0	6.0
Erratic output	1†	0.00	0.28	1.45	0.63	0.23				
	4*	0.00	2.15	9.99	4.05	0.74	3.0	3.0	5.8	12.0
External leakage - Utility medium	4†	0.00	2.82	13.11	5.30	0.91				
	7*	0.04	2.13	6.63	2.36	1.29	8.0	1.5	13.6	74.0
Low output	7†	0.10	2.40	7.22	2.43	1.59				
	1*	0.00	0.46	2.45	1.11	0.18	3.5	7.0	7.0	7.0
Noise	1†	0.00	0.53	2.75	1.22	0.23				
	4*	0.00	1.82	9.02	3.83	0.74	3.5	4.0	5.0	6.0
Other	4†	0.00	1.96	9.83	4.21	0.91				
	5*	0.00	2.30	10.59	4.26	0.92	161.0	19.0	174.0	484.0
Overheating	5†	0.00	2.49	11.57	4.68	1.14				
	5*	0.00	0.99	5.07	2.20	0.92	3.0	2.0	3.6	6.0
5†	0.00	1.15	5.53	2.28	1.14					
<b>Comments</b>										

(cont.)

Taxonomy no 2.2		Item Electric Equipment Electric motors								
Population 178	Installations 16	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 6368			
		Calendar time * 5.4324			Operational time † 4.3894					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Parameter deviation	18*	0.01	2.97	11.94	4.48	3.31	3.9	1.0	6.1	34.0
	18†	0.01	3.57	14.51	5.48	4.10				
Structural deficiency	27*	0.00	2.82	14.56	6.36	4.97	14.3	3.0	27.0	173.0
	27†	0.00	3.51	17.28	7.29	6.15				
Vibration	4*	0.04	0.58	1.67	0.55	0.74	5.5	10.0	11.0	12.0
	4†	0.08	0.72	1.89	0.60	0.91				
<b>Incipient</b>	<b>80*</b>	<b>4.39</b>	<b>19.93</b>	<b>44.69</b>	<b>12.88</b>	<b>14.73</b>	<b>6.9</b>	<b>1.0</b>	<b>11.4</b>	<b>100.0</b>
	<b>80†</b>	<b>5.73</b>	<b>24.71</b>	<b>54.60</b>	<b>15.58</b>	<b>18.23</b>				
Abnormal instrument reading	24*	0.93	4.61	10.61	3.11	4.42	6.8	1.0	11.0	100.0
	24†	0.97	5.64	13.51	4.05	5.47				
External leakage - Utility medium	2*	0.00	0.57	2.91	1.26	0.37	5.0	4.0	10.0	16.0
	2†	0.00	0.74	3.85	1.70	0.46				
Minor in-service problems	37*	0.77	7.91	21.52	6.93	6.81	4.7	1.0	6.8	57.0
	37†	0.82	10.02	28.10	9.17	8.43				
Other	6*	0.01	2.27	8.29	3.06	1.10	1.2	1.0	1.4	2.0
	6†	0.01	3.14	11.86	4.37	1.37				
Parameter deviation	3*	0.00	1.04	5.36	2.33	0.55	1.3	1.0	1.3	2.0
	3†	0.00	1.18	6.04	2.61	0.68				
Structural deficiency	4*	0.00	1.08	5.96	3.03	0.74	39.0	77.5	77.5	77.5
	4†	0.00	1.29	7.13	3.61	0.91				
Unknown	3*	0.00	1.52	6.79	2.69	0.55	4.5	1.0	4.7	12.0
	3†	0.00	1.72	7.67	3.03	0.68				
Vibration	1*	0.00	0.46	2.45	1.11	0.18	1.5	1.5	1.5	1.5
	1†	0.00	0.53	2.75	1.22	0.23				
<b>Unknown</b>	<b>4*</b>	<b>0.00</b>	<b>1.51</b>	<b>6.53</b>	<b>2.53</b>	<b>0.74</b>	<b>4.0</b>	<b>4.0</b>	<b>4.0</b>	<b>4.0</b>
	<b>4†</b>	<b>0.00</b>	<b>1.72</b>	<b>7.30</b>	<b>2.81</b>	<b>0.91</b>				
Overheating	1*	0.00	0.46	2.45	1.11	0.18	-	-	-	-
	1†	0.00	0.53	2.75	1.22	0.23				
Unknown	3*	0.00	0.87	3.45	1.29	0.55	4.0	4.0	4.0	4.0
	3†	0.00	0.98	3.54	1.31	0.68				
<b>All modes</b>	<b>279*</b>	<b>13.12</b>	<b>67.45</b>	<b>156.55</b>	<b>46.12</b>	<b>51.36</b>	<b>21.4</b>	<b>1.0</b>	<b>33.3</b>	<b>1140.0</b>
	<b>279†</b>	<b>20.44</b>	<b>79.84</b>	<b>171.25</b>	<b>47.91</b>	<b>63.56</b>				
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.7· 10 <sup>-3</sup>										

**Maintainable item versus failure mode, to be continued**

Item: Electric motors

	AIR	BRD	ELU	ERO	FTS	LOO	NOI	OHE	OTH
Actuating device	0.00	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00
Cabling & junction boxes	1.08	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00
Circuit breaker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	0.72	0.00	0.00	0.72	2.51	0.72	0.00	0.00	0.00
Coupling	0.00	0.00	0.00	0.00	0.00	0.72	0.00	0.36	0.00
Excitation	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.00
Fan w/motor	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00
Hood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, current	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, speed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, vibration	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, voltage	0.00	0.00	0.00	0.72	0.00	0.00	0.00	1.43	0.00
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72
Other	0.00	0.00	0.36	0.00	0.00	1.79	0.00	0.00	0.00
Overload protection	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Piping	0.00	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Radial bearing	0.00	1.08	0.00	0.00	0.00	0.00	1.79	0.00	0.36
Rotor	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stator	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.72	0.00
Subunit	0.00	1.08	1.43	0.00	0.36	0.72	0.00	0.36	1.43
Thrust bearing	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.36	0.72	0.72	0.00	2.87	0.72	0.72	0.00	2.51
Valves	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00
Total	8.96	3.23	3.94	1.43	7.89	5.02	2.51	2.87	5.73

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.



**Maintainable item versus failure mode, continued**

**Item: Electric motors**

	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.36	0.00	0.00	0.00	0.00	0.00	1.08
Cabling & junction boxes	0.00	1.08	0.36	0.00	0.00	0.36	0.00	3.58
Circuit breaker	0.00	1.43	0.00	0.36	0.00	1.08	0.00	2.87
Control unit	1.08	0.72	2.15	0.00	0.00	1.79	0.00	10.39
Coupling	0.00	0.00	0.00	0.00	0.00	0.36	0.00	1.43
Excitation	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.72
Fan w/motor	2.51	0.36	0.00	0.00	0.00	0.00	0.00	3.23
Hood	0.00	0.36	1.08	0.00	0.00	0.00	0.00	1.43
Instrument, current	0.00	0.36	0.00	0.00	0.00	0.00	0.00	1.43
Instrument, general	0.72	1.08	0.00	0.00	0.00	0.00	0.00	3.58
Instrument, speed	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.72
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.79
Instrument, vibration	0.36	0.72	0.00	0.00	0.00	0.36	0.36	3.58
Instrument, voltage	0.00	0.36	0.00	0.00	0.00	0.00	0.00	2.51
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.36
Monitoring	0.00	0.72	0.00	0.00	0.00	0.00	0.00	1.08
Oil	0.72	0.00	0.00	0.00	0.00	0.00	0.00	1.43
Other	0.72	1.08	1.08	0.00	0.36	0.72	0.00	6.09
Overload protection	0.00	0.72	0.00	0.00	0.00	0.00	0.00	1.08
Piping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72
Pump w/motor	0.36	0.72	0.00	0.00	0.00	0.00	0.00	1.43
Radial bearing	0.00	0.36	2.87	0.00	0.00	0.00	1.79	8.24
Rotor	0.36	0.00	0.72	0.00	0.00	0.00	0.00	1.43
Stator	0.00	0.00	0.00	0.00	0.00	0.36	0.00	1.43
Subunit	0.36	1.08	4.66	0.36	0.00	0.72	0.72	13.26
Thrust bearing	0.00	0.00	0.36	0.00	0.36	0.00	1.43	2.51
Unknown	1.79	1.08	1.79	0.00	1.08	7.17	0.72	22.22
Valves	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Total	8.96	13.26	15.05	0.72	2.15	13.26	5.02	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Electric motors

	AIR	BRD	ELU	ERO	FTS	LOO	NOI	OHE	OTH
Blockage/plugged	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Breakage	0.00	0.36	0.36	0.00	0.36	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.00
Contamination	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.00	0.00	0.00	0.00	1.08	0.00	0.00	0.00	0.00
Corrosion	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Deformation	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Electrical failure - general	0.72	0.00	0.00	0.00	3.94	2.51	0.36	1.79	0.72
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	2.51	0.00	0.00	0.72	1.08	1.43	0.00	0.36	1.08
Leakage	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72
Looseness	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.36	1.43	1.43	0.00	0.36	0.72	1.79	0.00	0.36
Misc. external influences	0.36	0.00	0.00	0.00	0.36	0.36	0.00	0.00	0.36
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open circuit	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.43
Out of adjustment	0.36	0.00	0.00	0.72	0.36	0.00	0.00	0.00	0.00
Short circuiting	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00
Software failure	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vibration	0.36	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.72	1.43	0.00	0.00	0.00	0.00	0.72	0.36
Total	8.96	3.23	3.94	1.43	7.89	5.02	2.51	2.87	5.73

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

Item: Electric motors

	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72
Breakage	0.00	0.36	0.00	0.00	0.00	0.00	0.36	1.79
Cavitation	0.36	0.36	1.43	0.00	0.00	0.00	0.00	2.15
Clearance/ alignment failure	0.00	0.72	0.72	0.00	0.00	0.00	1.08	2.87
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Control failure	0.36	0.36	0.00	0.00	0.00	0.36	0.00	2.15
Corrosion	0.00	0.72	0.36	0.00	0.00	0.00	0.00	2.51
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Earth/isolation fault	0.00	0.36	0.00	0.00	0.00	2.15	0.00	2.87
Electrical failure - general	2.15	1.79	1.08	0.00	0.36	5.02	0.00	20.43
Faulty signal/indication/alarm	0.00	0.36	0.00	0.00	0.00	0.36	0.00	0.72
Instrument failure - general	4.30	2.15	0.00	0.00	0.72	0.36	0.36	15.05
Leakage	0.36	0.36	0.00	0.00	0.00	0.00	0.00	1.79
Looseness	0.00	0.36	0.00	0.00	0.00	0.00	0.00	1.08
Material failure - general	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.72
Mechanical Failure - general	0.36	1.08	4.30	0.00	0.72	2.15	0.36	15.41
Misc. external influences	0.36	1.43	2.87	0.00	0.36	0.00	0.00	6.45
Miscellaneous - general	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.36
Open circuit	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.72
Other	0.00	0.36	0.00	0.00	0.00	0.36	0.00	2.15
Out of adjustment	0.36	0.72	0.00	0.00	0.00	0.00	0.00	2.51
Short circuiting	0.00	0.00	0.36	0.00	0.00	1.08	0.00	1.79
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Unknown	0.00	0.00	0.36	0.36	0.00	0.36	0.72	2.15
Vibration	0.36	0.00	0.72	0.00	0.00	1.08	1.08	4.30
Wear	0.00	1.08	2.87	0.00	0.00	0.00	1.08	8.24
Total	8.96	13.26	15.05	0.72	2.15	13.26	5.02	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 2.2.1		Item Electric Equipment Electric motors Compressor								
Population 43	Installations 10	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 1348			
		Calendar time *			Operational time †					
		1.2443					0.9931			
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>41*</b>	<b>2.81</b>	<b>53.66</b>	<b>159.96</b>	<b>53.34</b>	<b>32.95</b>	<b>47.5</b>	<b>2.0</b>	<b>61.7</b>	<b>847.0</b>
	<b>41†</b>	<b>3.42</b>	<b>58.64</b>	<b>172.80</b>	<b>57.42</b>	<b>41.29</b>				
External leakage - Utility medium	2*	0.01	1.62	6.18	2.28	1.61	34.5	38.0	45.5	53.0
	2†	0.33	1.97	4.74	1.42	2.01				
Fail to start on demand	6*	0.06	7.90	26.91	9.90	4.82	32.9	3.0	59.6	250.0
	6†	0.07	9.47	32.04	11.78	6.04				
Fail to stop on demand	2*	0.00	1.70	7.48	2.93	1.61	11.0	2.0	20.5	39.0
	2†	0.00	2.09	10.23	4.28	2.01				
Low output	11*	0.00	9.74	48.24	20.46	8.84	16.2	4.0	22.5	48.0
	11†	0.00	10.62	52.69	22.39	11.08				
Overheating	1*	0.06	0.85	2.44	0.80	0.80	4.0	4.0	4.0	4.0
	1†	0.00	1.06	5.80	2.79	1.01				
Parameter deviation	2*	0.00	2.51	11.03	4.32	1.61	1.8	2.0	2.5	3.0
	2†	0.00	2.79	12.13	4.71	2.01				
Spurious stop	17*	0.07	28.76	113.61	42.34	13.66	140.6	3.0	166.3	847.0
	17†	0.05	30.46	122.67	46.12	17.12				
<b>Degraded</b>	<b>29*</b>	<b>0.31</b>	<b>45.69</b>	<b>157.27</b>	<b>57.96</b>	<b>23.31</b>	<b>3.6</b>	<b>1.0</b>	<b>4.8</b>	<b>34.0</b>
	<b>29†</b>	<b>0.26</b>	<b>49.79</b>	<b>178.94</b>	<b>66.12</b>	<b>29.20</b>				
Abnormal instrument reading	1*	0.00	0.80	4.15	1.82	0.80	6.0	6.0	6.0	6.0
	1†	0.00	0.93	4.52	1.88	1.01				
Erratic output	2*	0.01	1.62	6.18	2.28	1.61	3.0	3.0	3.0	3.0
	2†	0.33	1.97	4.74	1.42	2.01				
External leakage - Utility medium	5*	0.52	4.26	11.00	3.44	4.02	3.5	1.5	3.7	7.0
	5†	1.98	5.03	9.21	2.25	5.03				
Low output	1*	0.06	0.85	2.44	0.80	0.80	3.5	7.0	7.0	7.0
	1†	0.00	1.06	5.80	2.79	1.01				
Noise	2*	0.00	3.29	17.07	7.54	1.61	-	-	-	-
	2†	0.00	3.40	17.80	8.00	2.01				
Other	2*	0.00	3.29	17.07	7.54	1.61	-	-	-	-
	2†	0.00	3.40	17.80	8.00	2.01				
Overheating	2*	0.01	1.62	6.18	2.28	1.61	2.0	2.0	2.0	2.0
	2†	0.33	1.97	4.74	1.42	2.01				
Parameter deviation	12*	0.01	26.56	117.28	46.07	9.64	3.8	1.0	6.1	34.0
	12†	0.00	29.71	134.77	53.62	12.08				
Structural deficiency	2*	0.00	4.62	22.86	9.68	1.61	3.5	3.0	3.5	4.0
	2†	0.00	5.20	26.16	11.22	2.01				
<b>Incipient</b>	<b>27*</b>	<b>3.88</b>	<b>25.28</b>	<b>62.29</b>	<b>19.02</b>	<b>21.70</b>	<b>5.4</b>	<b>1.0</b>	<b>8.8</b>	<b>100.0</b>
	<b>27†</b>	<b>6.24</b>	<b>29.33</b>	<b>66.45</b>	<b>19.29</b>	<b>27.19</b>				
Abnormal instrument reading	6*	0.08	7.49	24.34	8.85	4.82	11.7	1.0	23.9	100.0
	6†	0.11	8.57	27.39	9.89	6.04				
<b>Comments</b>										

(cont.)

Taxonomy no 2.2.1		Item Electric Equipment Electric motors Compressor								
Population 43	Installations 10	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 1348			
		Calendar time * 1.2443		Operational time † 0.9931						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
External leakage - Utility medium	2*	0.00	1.82	8.87	3.70	1.61	5.0	4.0	10.0	16.0
	2†	0.00	2.58	13.37	5.89	2.01				
Minor in-service problems	10*	0.06	7.10	23.79	8.73	8.04	4.9	1.0	4.8	18.0
	10†	0.17	8.59	26.67	9.45	10.07				
Other	2*	0.00	1.86	9.21	3.89	1.61	1.5	1.0	1.5	2.0
	2†	0.00	2.11	9.78	3.95	2.01				
Parameter deviation	3*	0.00	3.50	14.73	5.65	2.41	1.3	1.0	1.3	2.0
	3†	0.00	3.88	16.00	6.07	3.02				
Unknown	3*	0.02	2.78	9.52	3.51	2.41	4.5	1.0	4.7	12.0
	3†	0.21	3.17	9.22	3.05	3.02				
Vibration	1*	0.06	0.85	2.44	0.80	0.80	1.5	1.5	1.5	1.5
	1†	0.00	1.06	5.80	2.79	1.01				
<b>Unknown</b>	3*	<b>0.02</b>	<b>2.78</b>	<b>9.52</b>	<b>3.51</b>	<b>2.41</b>	<b>4.0</b>	<b>4.0</b>	<b>4.0</b>	<b>4.0</b>
	3†	<b>0.21</b>	<b>3.17</b>	<b>9.22</b>	<b>3.05</b>	<b>3.02</b>				
Overheating	1*	0.06	0.85	2.44	0.80	0.80	-	-	-	-
	1†	0.00	1.06	5.80	2.79	1.01				
Unknown	2*	0.00	1.87	8.67	3.51	1.61	4.0	4.0	4.0	4.0
	2†	0.00	2.12	9.42	3.72	2.01				
<b>All modes</b>	<b>100*</b>	<b>10.97</b>	<b>130.06</b>	<b>363.29</b>	<b>118.37</b>	<b>80.37</b>	<b>20.8</b>	<b>1.0</b>	<b>27.1</b>	<b>847.0</b>
	<b>100†</b>	<b>12.07</b>	<b>142.95</b>	<b>399.19</b>	<b>130.05</b>	<b>100.70</b>				
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 3.0 10 <sup>-3</sup>										

**Maintainable item versus failure mode, to be continued**

**Item:** Electric motors - Compressor

	AIR	BRD	ELU	ERO	FTS	LOO	NOI	OHE	OTH
Actuating device	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Circuit breaker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
Coupling	0.00	0.00	0.00	0.00	0.00	2.00	0.00	1.00	0.00
Excitation	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
Fan w/motor	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
Hood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, current	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, speed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, vibration	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, voltage	0.00	0.00	0.00	2.00	0.00	0.00	0.00	2.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	1.00	0.00	0.00	5.00	0.00	0.00	0.00
Overload protection	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Stator	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	4.00	0.00	0.00	2.00	0.00	1.00	0.00
Thrust bearing	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	2.00	2.00	2.00	0.00	2.00
Valves	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	7.00	0.00	9.00	2.00	6.00	12.00	2.00	4.00	4.00

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

**Item:** Electric motors - Compressor

	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Cabling & junction boxes	0.00	0.00	1.00	0.00	0.00	1.00	0.00	2.00
Circuit breaker	0.00	4.00	0.00	1.00	0.00	2.00	0.00	7.00
Control unit	1.00	0.00	0.00	0.00	0.00	3.00	0.00	6.00
Coupling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00
Excitation	0.00	0.00	0.00	0.00	1.00	0.00	0.00	2.00
Fan w/motor	7.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00
Hood	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00
Instrument, current	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Instrument, general	2.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00
Instrument, speed	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
Instrument, vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Instrument, voltage	0.00	1.00	0.00	0.00	0.00	0.00	0.00	5.00
Oil	2.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
Other	2.00	0.00	1.00	0.00	1.00	0.00	0.00	10.00
Overload protection	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00
Piping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
Pump w/motor	1.00	2.00	0.00	0.00	0.00	0.00	0.00	4.00
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Stator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Subunit	0.00	0.00	0.00	1.00	0.00	0.00	1.00	9.00
Thrust bearing	0.00	0.00	0.00	0.00	1.00	0.00	0.00	2.00
Unknown	2.00	0.00	0.00	0.00	2.00	11.00	0.00	23.00
Valves	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Total	17.00	10.00	2.00	2.00	5.00	17.00	1.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Electric motors - Compressor

	AIR	BRD	ELU	ERO	FTS	LOO	NOI	OHE	OTH
Breakage	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Deformation	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	3.00	5.00	1.00	2.00	0.00
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	5.00	0.00	0.00	0.00	2.00	4.00	0.00	0.00	1.00
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	1.00	0.00	3.00	0.00	0.00	2.00	1.00	0.00	1.00
Misc. external influences	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
Open circuit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
Unknown	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	4.00	0.00	0.00	0.00	0.00	2.00	1.00
Total	7.00	0.00	9.00	2.00	6.00	12.00	2.00	4.00	4.00

**Failure descriptor versus failure mode, continued**

Item: Electric motors - Compressor

	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Breakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Earth/isolation fault	0.00	1.00	0.00	0.00	0.00	3.00	0.00	4.00
Electrical failure - general	3.00	4.00	1.00	0.00	1.00	10.00	0.00	30.00
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00
Instrument failure - general	10.00	2.00	0.00	0.00	2.00	0.00	1.00	27.00
Leakage	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Mechanical Failure - general	1.00	2.00	1.00	0.00	2.00	2.00	0.00	16.00
Misc. external influences	1.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
Open circuit	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00
Other	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00
Out of adjustment	1.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00
Short circuiting	0.00	0.00	0.00	0.00	0.00	1.00	0.00	2.00
Unknown	0.00	0.00	0.00	1.00	0.00	0.00	0.00	2.00
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00
Total	17.00	10.00	2.00	2.00	5.00	17.00	1.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.



Taxonomy no 2.2.1.1		Item Electric Equipment Electric motors Compressor Compressed air								
Population 5	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1279			Operational time † 0.1219					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0 0†	0.01 0.02	3.80 3.99	14.57 15.31	5.37 5.64	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 2.2.1.2		Item Electric Equipment Electric motors Compressor Cooling systems								
Population 5	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.2464		Operational time † 0.1825						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Incipient	4*	5.54	16.24	37.16	16.24	16.24	6.0	2.0	6.0	18.0
	4†	7.48	21.92	50.16	21.92	21.92				
Minor in-service problems	4*	5.54	16.24	37.16	16.24	16.24	6.0	2.0	6.0	18.0
	4†	7.48	21.92	50.16	21.92	21.92				
All modes	4*	5.54	16.24	37.16	16.24	16.24	6.0	2.0	6.0	18.0
	4†	7.48	21.92	50.16	21.92	21.92				
Comments										

<b>Taxonomy no</b> 2.2.1.3		<b>Item</b> Electric Equipment Electric motors Compressor Gas (re)injection									
<b>Population</b> 2	<b>Installations</b> 2	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>				
		<b>Calendar time *</b> 0.0917			<b>Operational time †</b> 0.0367						
<b>Failure mode</b>	<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours).</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>			
		<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/τ</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>	
<b>All modes</b>		0* 0†	0.02 0.05	5.23 12.42	20.10 47.71	7.40 17.57	0.00 0.00	-	-	-	-
<b>Comments</b>											

Taxonomy no 2.2.1.4		Item Electric Equipment Electric motors Compressor Gas export								
Population 3	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0767		Operational time † 0.0437						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
All modes	0* 0†	0.02 0.04	6.21 10.59	23.84 40.67	8.78 14.98	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 2.2.1.5		Item Electric Equipment Electric motors Compressor Gas processing								
Population 26	Installations 7	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 1348			
		Calendar time * 0.6031			Operational time † 0.5352					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>41*</b> <b>41†</b>	<b>15.29</b>	<b>80.43</b>	<b>187.74</b>	<b>55.48</b>	<b>67.98</b>	<b>47.5</b>	<b>2.0</b>	<b>61.7</b>	<b>847.0</b>
External leakage - Utility medium	2*	0.00	3.63	17.03	6.93	3.32	34.5	38.0	45.5	53.0
	2†	0.00	3.87	17.63	7.03	3.74				
Fail to start on demand	6*	0.91	11.25	31.63	10.33	9.95	32.9	3.0	59.6	250.0
	6†	0.89	13.33	38.59	12.75	11.21				
Fail to stop on demand	2*	0.00	3.24	13.61	5.21	3.32	11.0	2.0	20.5	39.0
	2†	0.00	3.85	16.37	6.31	3.74				
Low output	11*	0.01	14.65	62.79	24.28	18.24	16.2	4.0	22.5	48.0
	11†	0.01	15.81	66.70	25.61	20.55				
Overheating	1*	0.00	1.52	7.46	3.14	1.66	4.0	4.0	4.0	4.0
	1†	0.00	1.67	8.07	3.33	1.87				
Parameter deviation	2*	0.03	3.68	12.33	4.52	3.32	1.8	2.0	2.5	3.0
	2†	0.04	4.06	13.50	4.95	3.74				
Spurious stop	17*	0.26	43.11	151.58	55.97	28.19	140.6	3.0	166.3	847.0
	17†	0.29	45.40	158.45	58.48	31.76				
<b>Degraded</b>	<b>29*</b> <b>29†</b>	<b>1.80</b>	<b>73.13</b>	<b>224.32</b>	<b>78.45</b>	<b>48.09</b>	<b>3.6</b>	<b>1.0</b>	<b>4.8</b>	<b>34.0</b>
Abnormal instrument reading	1*	0.10	1.70	5.00	1.66	1.66	6.0	6.0	6.0	6.0
	1†	0.00	1.93	10.54	4.92	1.87				
Erratic output	2*	0.00	3.63	17.03	6.93	3.32	3.0	3.0	3.0	3.0
	2†	0.00	3.87	17.63	7.03	3.74				
External leakage - Utility medium	5*	0.22	8.33	25.46	8.87	8.29	3.5	1.5	3.7	7.0
	5†	0.69	9.06	25.74	8.45	9.34				
Low output	1*	0.00	1.52	7.46	3.14	1.66	3.5	7.0	7.0	7.0
	1†	0.00	1.67	8.07	3.33	1.87				
Noise	2*	0.00	4.78	23.54	9.92	3.32	-	-	-	-
	2†	0.00	4.91	24.10	10.15	3.74				
Other	2*	0.00	4.78	23.54	9.92	3.32	-	-	-	-
	2†	0.00	4.91	24.10	10.15	3.74				
Overheating	2*	0.00	3.63	17.03	6.93	3.32	2.0	2.0	2.0	2.0
	2†	0.00	3.87	17.63	7.03	3.74				
Parameter deviation	12*	0.02	38.01	163.70	63.43	19.90	3.8	1.0	6.1	34.0
	12†	0.02	42.43	183.42	71.17	22.42				
Structural deficiency	2*	0.00	6.64	31.96	13.18	3.32	3.5	3.0	3.5	4.0
	2†	0.00	7.42	35.85	14.80	3.74				
<b>Incipient</b>	<b>23*</b> <b>23†</b>	<b>25.10</b>	<b>37.99</b>	<b>53.05</b>	<b>8.55</b>	<b>38.14</b>	<b>5.3</b>	<b>1.0</b>	<b>9.3</b>	<b>100.0</b>
Abnormal instrument reading	6*	1.60	10.73	26.62	8.16	9.95	11.7	1.0	23.9	100.0
	6†	1.78	12.13	30.16	9.26	11.21				
<b>Comments</b>										

(cont.)

Taxonomy no 2.2.1.5		Item Electric Equipment Electric motors Compressor Gas processing								
Population 26	Installations 7	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 1348			
		Calendar time * 0.6031		Operational time † 0.5352						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Utility medium	2*	0.11	3.10	9.38	3.22	3.32	5.0	4.0	10.0	16.0
	2†	0.00	3.84	17.41	6.92	3.74				
Minor in-service problems	6*	2.23	9.95	22.19	6.37	9.95	3.8	1.0	3.8	7.0
	6†	4.30	11.05	20.33	4.99	11.21				
Other	2*	0.04	3.10	10.06	3.66	3.32	1.5	1.0	1.5	2.0
	2†	0.18	3.49	10.38	3.46	3.74				
Parameter deviation	3*	0.09	5.21	16.31	5.81	4.97	1.3	1.0	1.3	2.0
	3†	0.14	5.72	17.55	6.13	5.61				
Unknown	3*	0.01	4.43	17.55	6.54	4.97	4.5	1.0	4.7	12.0
	3†	0.02	4.87	18.79	6.94	5.61				
Vibration	1*	0.00	1.52	7.46	3.14	1.66	1.5	1.5	1.5	1.5
	1†	0.00	1.67	8.07	3.33	1.87				
<b>Unknown</b>	<b>3*</b>	<b>0.01</b>	<b>4.43</b>	<b>17.55</b>	<b>6.54</b>	<b>4.97</b>	<b>4.0</b>	<b>4.0</b>	<b>4.0</b>	<b>4.0</b>
	<b>3†</b>	<b>0.02</b>	<b>4.87</b>	<b>18.79</b>	<b>6.94</b>	<b>5.61</b>				
Overheating	1*	0.00	1.52	7.46	3.14	1.66	-	-	-	-
	1†	0.00	1.67	8.07	3.33	1.87				
Unknown	2*	0.02	3.07	10.98	4.06	3.32	4.0	4.0	4.0	4.0
	2†	0.02	3.39	11.67	4.30	3.74				
<b>All modes</b>	<b>96*</b>	<b>42.28</b>	<b>197.45</b>	<b>446.61</b>	<b>129.51</b>	<b>159.18</b>	<b>21.6</b>	<b>1.0</b>	<b>28.2</b>	<b>847.0</b>
	<b>96†</b>	<b>48.25</b>	<b>214.56</b>	<b>478.35</b>	<b>137.34</b>	<b>179.37</b>				
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 3.0 · 10 <sup>-3</sup>										

<b>Taxonomy no</b> 2.2.1.6		<b>Item</b> Electric Equipment Electric motors Compressor Gas treatment								
<b>Population</b> 2	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>			
		<b>Calendar time *</b> 0.0985			<b>Operational time †</b> 0.0730					
<b>Failure mode</b>	<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours).</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
		<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/τ</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>		0* 0†	0.02 0.03	4.88 6.54	18.75 25.10	6.91 9.24	0.00 0.00	-	-	-
<b>Comments</b>										

Taxonomy no 2.2.2		Item Electric Equipment Electric motors Pump								
Population 135	Installations 11	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 5020			
		Calendar time * 4.1881		Operational time † 3.3963						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>78*</b> <b>78†</b>	<b>1.62</b>	<b>15.09</b>	<b>40.10</b>	<b>12.74</b>	<b>18.62</b>	<b>30.0</b>	<b>1.0</b>	<b>53.2</b>	<b>1140.0</b>
Breakdown	9*	0.22	2.04	5.43	1.72	2.15	12.4	4.0	21.9	45.0
	9†	0.67	2.51	5.30	1.47	2.65				
Fail to start on demand	16*	0.29	3.43	9.57	3.12	3.82	11.6	1.0	17.3	146.0
	16†	0.48	4.36	11.53	3.65	4.71				
Low output	2*	0.05	0.41	1.08	0.34	0.48	1.5	1.0	1.5	2.0
	2†	0.06	0.50	1.32	0.42	0.59				
Noise	3*	0.03	0.63	1.90	0.64	0.72	6.3	5.0	26.7	60.0
	3†	0.00	0.78	3.10	1.16	0.88				
Other	5*	0.00	2.10	11.24	5.17	1.19	15.5	3.0	30.6	37.5
	5†	0.00	2.55	13.68	6.31	1.47				
Overheating	1*	0.00	0.21	0.66	0.24	0.24	2.0	2.0	2.0	2.0
	1†	0.00	0.25	0.81	0.29	0.29				
Parameter deviation	2*	0.05	0.41	1.08	0.34	0.48	8.3	7.0	16.5	26.0
	2†	0.06	0.50	1.32	0.42	0.59				
Spurious stop	20*	0.92	4.71	10.92	3.21	4.78	82.0	1.0	138.2	1140.0
	20†	1.72	5.98	12.35	3.36	5.89				
Structural deficiency	11*	0.01	1.51	5.50	2.03	2.63	17.1	4.0	33.2	146.0
	11†	0.52	2.34	5.23	1.50	3.24				
Vibration	9*	0.09	1.67	5.00	1.67	2.15	17.1	4.0	25.4	57.0
	9†	0.17	2.10	5.91	1.93	2.65				
<b>Degraded</b>	<b>47*</b> <b>47†</b>	<b>0.93</b>	<b>10.86</b>	<b>30.26</b>	<b>9.85</b>	<b>11.22</b>	<b>23.8</b>	<b>3.0</b>	<b>32.9</b>	<b>484.0</b>
		<b>1.45</b>	<b>13.28</b>	<b>35.16</b>	<b>11.14</b>	<b>13.84</b>				
Erratic output	2*	0.00	2.90	12.30	4.74	0.48	-	5.0	8.5	12.0
	2†	0.01	4.09	16.78	6.36	0.59				
External leakage - Utility medium	2*	0.00	0.82	3.97	1.64	0.48	19.3	3.0	38.5	74.0
	2†	0.00	0.96	4.55	1.86	0.59				
Noise	2*	0.05	0.41	1.08	0.34	0.48	3.5	4.0	5.0	6.0
	2†	0.06	0.50	1.32	0.42	0.59				
Other	3*	0.00	1.33	6.89	3.03	0.72	161.0	19.0	174.0	484.0
	3†	0.00	1.50	7.73	3.38	0.88				
Overheating	3*	0.00	0.96	4.16	1.61	0.72	3.7	4.0	4.7	6.0
	3†	0.00	1.11	4.40	1.64	0.88				
Parameter deviation	6*	0.00	1.32	5.74	2.24	1.43	4.0	3.0	6.0	12.0
	6†	0.00	2.00	9.80	4.12	1.77				
Structural deficiency	25*	0.00	3.78	16.58	6.48	5.97	15.2	3.0	29.0	173.0
	25†	0.01	4.75	19.69	7.49	7.36				
Vibration	4*	0.06	0.74	2.08	0.68	0.96	5.5	10.0	11.0	12.0
	4†	0.13	0.93	2.36	0.73	1.18				
<b>Comments</b>										

(cont.)



Taxonomy no 2.2.2		Item Electric Equipment Electric motors Pump								
Population 135	Installations 11	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 5020			
		Calendar time * 4.1881		Operational time † 3.3963						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Incipient</b>	53*	<b>3.36</b>	<b>16.66</b>	<b>38.32</b>	<b>11.23</b>	<b>12.65</b>	<b>7.7</b>	<b>1.0</b>	<b>12.8</b>	<b>77.5</b>
	53†	<b>4.28</b>	<b>21.83</b>	<b>50.55</b>	<b>14.87</b>	<b>15.61</b>				
Abnormal instrument reading	18*	0.45	4.74	12.97	4.18	4.30	5.3	1.0	6.7	28.0
	18†	0.45	5.85	16.61	5.45	5.30				
Minor in-service problems	27*	0.15	7.97	24.85	8.84	6.45	4.7	1.0	7.7	57.0
	27†	0.17	10.54	33.16	11.86	7.95				
Other	4*	0.01	1.79	6.69	2.47	0.96	1.0	1.0	1.3	2.0
	4†	0.01	3.03	11.70	4.32	1.18				
Structural deficiency	4*	0.00	1.70	8.98	4.06	0.96	39.0	77.5	77.5	77.5
	4†	0.00	2.08	10.93	4.95	1.18				
<b>Unknown</b>	1*	<b>0.00</b>	<b>0.21</b>	<b>0.66</b>	<b>0.24</b>	<b>0.24</b>	<b>4.0</b>	<b>4.0</b>	<b>4.0</b>	<b>4.0</b>
	1†	<b>0.00</b>	<b>0.25</b>	<b>0.81</b>	<b>0.29</b>	<b>0.29</b>				
Unknown	1*	0.00	0.21	0.66	0.24	0.24	4.0	4.0	4.0	4.0
	1†	0.00	0.25	0.81	0.29	0.29				
<b>All modes</b>	179*	<b>10.31</b>	<b>42.95</b>	<b>93.94</b>	<b>26.63</b>	<b>42.74</b>	<b>21.6</b>	<b>1.0</b>	<b>36.3</b>	<b>1140.0</b>
	179†	<b>18.77</b>	<b>54.31</b>	<b>104.80</b>	<b>26.92</b>	<b>52.70</b>				
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.4 · 10 <sup>-3</sup>										

**Maintainable item versus failure mode, to be continued**

Item: Electric motors - Pump

	AIR	BRD	ELU	ERO	FTS	LOO	NOI	OHE	OTH
Actuating device	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00
Cabling & junction boxes	1.68	0.00	0.00	0.00	1.12	0.00	0.00	0.00	0.00
Circuit breaker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	0.56	0.00	0.00	1.12	3.35	1.12	0.00	0.00	0.00
Coupling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fan w/motor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, current	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	1.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, speed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	1.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, vibration	2.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12	0.00
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Overload protection	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
Radial bearing	0.00	1.68	0.00	0.00	0.00	0.00	2.79	0.00	0.00
Rotor	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12	0.00
Subunit	0.00	1.68	0.00	0.00	0.56	0.00	0.00	0.00	2.23
Thrust bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.56	1.12	1.12	0.00	3.35	0.00	0.00	0.00	2.79
Total	10.06	5.03	1.12	1.12	8.94	1.12	2.79	2.23	6.70

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

Item: Electric motors - Pump

	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.56	0.00	0.00	0.00	0.00	0.00	1.12
Cabling & junction boxes	0.00	1.68	0.00	0.00	0.00	0.00	0.00	4.47
Circuit breaker	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.56
Control unit	1.12	1.12	3.35	0.00	0.00	1.12	0.00	12.85
Coupling	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.56
Fan w/motor	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.56
Hood	0.00	0.00	1.68	0.00	0.00	0.00	0.00	1.68
Instrument, current	0.00	0.56	0.00	0.00	0.00	0.00	0.00	1.68
Instrument, general	0.00	1.68	0.00	0.00	0.00	0.00	0.00	3.35
Instrument, speed	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.56
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.68
Instrument, vibration	0.56	1.12	0.00	0.00	0.00	0.56	0.56	5.03
Instrument, voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.56
Monitoring	0.00	1.12	0.00	0.00	0.00	0.00	0.00	1.68
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Other	0.00	1.68	1.12	0.00	0.00	1.12	0.00	3.91
Overload protection	0.00	0.56	0.00	0.00	0.00	0.00	0.00	1.12
Radial bearing	0.00	0.56	4.47	0.00	0.00	0.00	2.79	12.29
Rotor	0.56	0.00	1.12	0.00	0.00	0.00	0.00	2.23
Stator	0.00	0.00	0.00	0.00	0.00	0.56	0.00	1.68
Subunit	0.56	1.68	7.26	0.00	0.00	1.12	0.56	15.64
Thrust bearing	0.00	0.00	0.56	0.00	0.00	0.00	2.23	2.79
Unknown	1.68	1.68	2.79	0.00	0.56	5.03	1.12	21.79
Total	4.47	15.08	22.35	0.00	0.56	11.17	7.26	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Electric motors - Pump

	AIR	BRD	ELU	ERO	FTS	LOO	NOI	OHE	OTH
Blockage/plugged	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Breakage	0.00	0.56	0.00	0.00	0.56	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00
Contamination	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.00	0.00	0.00	0.00	1.68	0.00	0.00	0.00	0.00
Corrosion	1.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
Electrical failure - general	1.12	0.00	0.00	0.00	4.47	1.12	0.00	1.68	1.12
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	1.12	0.00	0.00	1.12	0.56	0.00	0.00	0.56	1.12
Leakage	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Looseness	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	2.23	0.56	0.00	0.56	0.00	2.23	0.00	0.00
Misc. external influences	0.56	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.56
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open circuit	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.23
Out of adjustment	0.56	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Software failure	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vibration	0.56	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	10.06	5.03	1.12	1.12	8.94	1.12	2.79	2.23	6.70

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

**Item: Electric motors - Pump**

	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Breakage	0.00	0.56	0.00	0.00	0.00	0.00	0.56	2.23
Cavitation	0.56	0.56	2.23	0.00	0.00	0.00	0.00	3.35
Clearance/ alignment failure	0.00	1.12	1.12	0.00	0.00	0.00	1.68	4.47
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
Control failure	0.56	0.56	0.00	0.00	0.00	0.56	0.00	3.35
Corrosion	0.00	1.12	0.56	0.00	0.00	0.00	0.00	3.35
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	1.68	0.00	2.23
Electrical failure - general	1.68	0.56	1.12	0.00	0.00	2.23	0.00	15.08
Faulty signal/indication/alarm	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.56
Instrument failure - general	1.12	2.23	0.00	0.00	0.00	0.56	0.00	8.38
Leakage	0.00	0.56	0.00	0.00	0.00	0.00	0.00	2.23
Looseness	0.00	0.56	0.00	0.00	0.00	0.00	0.00	1.68
Material failure - general	0.00	0.56	0.00	0.00	0.00	0.00	0.00	1.12
Mechanical Failure - general	0.00	0.56	6.15	0.00	0.00	2.23	0.56	15.08
Misc. external influences	0.00	2.23	4.47	0.00	0.56	0.00	0.00	8.94
Miscellaneous - general	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.56
Open circuit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
Other	0.00	0.00	0.00	0.00	0.00	0.56	0.00	2.79
Out of adjustment	0.00	1.12	0.00	0.00	0.00	0.00	0.00	2.23
Short circuiting	0.00	0.00	0.56	0.00	0.00	1.12	0.00	1.68
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
Unknown	0.00	0.00	0.56	0.00	0.00	0.56	1.12	2.23
Vibration	0.56	0.00	1.12	0.00	0.00	1.68	1.68	6.70
Wear	0.00	1.68	4.47	0.00	0.00	0.00	1.68	8.94
Total	4.47	15.08	22.35	0.00	0.56	11.17	7.26	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 2.2.2.1		Item Electric Equipment Electric motors Pump Chemical injection									
Population 25	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *		Operational time †							
		0.8766		0.8660							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	2*	0.40	2.28	7.18	2.28	2.28	5.0	5.0	5.0	5.0	
	2†	0.41	2.31	7.27	2.31	2.31					
Structural deficiency	2*	0.40	2.28	7.18	2.28	2.28	5.0	5.0	5.0	5.0	
	2†	0.41	2.31	7.27	2.31	2.31					
<b>Degraded</b>	6*	2.98	6.84	13.51	6.84	6.84	9.0	5.0	9.0	14.0	
	6†	3.02	6.93	13.67	6.93	6.93					
Structural deficiency	6*	2.98	6.84	13.51	6.84	6.84	9.0	5.0	9.0	14.0	
	6†	3.02	6.93	13.67	6.93	6.93					
<b>Incipient</b>	1*	0.06	1.14	5.41	1.14	1.14	-	-	-	-	
	1†	0.06	1.15	5.48	1.15	1.15					
Minor in-service problems	1*	0.06	1.14	5.41	1.14	1.14	-	-	-	-	
	1†	0.06	1.15	5.48	1.15	1.15					
<b>All modes</b>	9*	5.36	10.27	17.92	10.27	10.27	8.0	5.0	8.0	14.0	
	9†	5.42	10.39	18.14	10.39	10.39					
<b>Comments</b>											

Taxonomy no 2.2.2.2		Item Electric Equipment Electric motors Pump Combined function								
Population 3	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1478		Operational time † 0.1095						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	2*	2.40	13.53	42.59	13.53	13.53	1.5	1.0	1.5	2.0
	2†	3.24	18.26	57.48	18.26	18.26				
Minor in-service problems	1*	0.34	6.77	32.10	6.77	6.77	2.0	2.0	2.0	2.0
	1†	0.46	9.13	43.33	9.13	9.13				
Other	1*	0.34	6.77	32.10	6.77	6.77	1.0	1.0	1.0	1.0
	1†	0.46	9.13	43.33	9.13	9.13				
All modes	2*	2.40	13.53	42.59	13.53	13.53	1.5	1.0	1.5	2.0
	2†	3.24	18.26	57.48	18.26	18.26				
Comments										

Taxonomy no 2.2.2.3		Item Electric Equipment Electric motors Pump Condensate processing								
Population 15	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 549			
		Calendar time * 0.3189		Operational time † 0.2216						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>6*</b>	<b>3.57</b>	<b>18.01</b>	<b>41.59</b>	<b>12.22</b>	<b>18.81</b>	<b>11.2</b>	<b>5.0</b>	<b>19.3</b>	<b>45.0</b>
	<b>6†</b>	<b>4.36</b>	<b>25.95</b>	<b>62.49</b>	<b>18.82</b>	<b>27.08</b>				
Breakdown	1*	0.23	3.30	9.51	3.14	3.14	22.5	45.0	45.0	45.0
	1†	0.00	4.35	18.98	7.39	4.51				
Fail to start on demand	2*	0.01	7.14	28.70	10.78	6.27	5.5	5.0	5.5	6.0
	2†	0.23	8.74	26.72	9.30	9.03				
Spurious stop	2*	0.02	5.10	19.35	7.13	6.27	-	12.0	18.0	24.0
	2†	0.27	8.72	26.50	9.15	9.03				
Vibration	1*	0.02	2.76	9.66	3.57	3.14	-	24.0	24.0	24.0
	1†	0.00	4.33	18.77	7.29	4.51				
<b>Degraded</b>	<b>2*</b>	<b>0.62</b>	<b>7.61</b>	<b>21.38</b>	<b>6.98</b>	<b>6.27</b>	<b>37.0</b>	<b>12.0</b>	<b>43.0</b>	<b>74.0</b>
	<b>2†</b>	<b>0.18</b>	<b>11.70</b>	<b>36.92</b>	<b>13.23</b>	<b>9.03</b>				
External leakage - Utility medium	1*	0.23	3.30	9.51	3.14	3.14	37.0	74.0	74.0	74.0
	1†	0.00	4.35	18.98	7.39	4.51				
Parameter deviation	1*	0.00	5.19	22.07	8.51	3.14	-	12.0	12.0	12.0
	1†	0.01	9.93	41.59	15.91	4.51				
<b>Incipient</b>	<b>1*</b>	<b>0.00</b>	<b>5.19</b>	<b>22.07</b>	<b>8.51</b>	<b>3.14</b>	<b>-</b>	<b>6.0</b>	<b>6.0</b>	<b>6.0</b>
	<b>1†</b>	<b>0.01</b>	<b>9.93</b>	<b>41.59</b>	<b>15.91</b>	<b>4.51</b>				
Abnormal instrument reading	1*	0.00	5.19	22.07	8.51	3.14	-	6.0	6.0	6.0
	1†	0.01	9.93	41.59	15.91	4.51				
<b>All modes</b>	<b>9*</b>	<b>9.35</b>	<b>30.01</b>	<b>60.21</b>	<b>15.99</b>	<b>28.22</b>	<b>17.6</b>	<b>5.0</b>	<b>23.1</b>	<b>74.0</b>
	<b>9†</b>	<b>4.56</b>	<b>47.21</b>	<b>128.46</b>	<b>41.34</b>	<b>40.61</b>				
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0: 10 <sup>6</sup>										



Taxonomy no 2.2.2.4		Item Electric Equipment Electric motors Pump Cooling systems									
Population 6	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 150				
		Calendar time * 0.1051		Operational time † 0.0601							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Critical	1*	0.48	9.51	45.14	9.51	9.51	-	4.0	4.0	4.0	
	1†	0.83	16.65	78.98	16.65	16.65	-	4.0	4.0	4.0	
Fail to start on demand	1*	0.48	9.51	45.14	9.51	9.51	-	4.0	4.0	4.0	
	1†	0.83	16.65	78.98	16.65	16.65	-	4.0	4.0	4.0	
All modes	1*	0.48	9.51	45.14	9.51	9.51	-	4.0	4.0	4.0	
	1†	0.83	16.65	78.98	16.65	16.65	-	4.0	4.0	4.0	
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 6.7 10 <sup>-3</sup>											

Taxonomy no 2.2.2.5		Item Electric Equipment Electric motors Pump Crude oil handling									
Population 5	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 1220				
		Calendar time * 0.2018		Operational time † 0.1424							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	1*	0.08	5.97	19.07	6.88	4.96	2.0	4.0	4.0	4.0	
	1†	0.15	8.20	25.55	9.08	7.02					
Spurious stop	1*	0.08	5.97	19.07	6.88	4.96	2.0	4.0	4.0	4.0	
	1†	0.15	8.20	25.55	9.08	7.02					
<b>Degraded</b>	3*	2.26	13.57	32.73	9.87	14.87	13.7	42.0	47.7	52.0	
	3†	2.67	19.19	48.31	14.92	21.07					
Structural deficiency	3*	2.26	13.57	32.73	9.87	14.87	13.7	42.0	47.7	52.0	
	3†	2.67	19.19	48.31	14.92	21.07					
<b>Incipient</b>	12*	35.12	60.33	91.05	17.17	59.47	3.4	1.0	6.5	28.0	
	12†	49.47	85.16	128.72	24.33	84.27					
Abnormal instrument reading	3*	0.10	20.22	74.20	27.41	14.87	6.8	6.0	13.7	28.0	
	3†	0.14	27.65	100.64	37.18	21.07					
Minor in-service problems	8*	18.99	38.83	64.40	14.02	39.64	2.2	1.0	4.1	8.0	
	8†	26.87	54.99	91.22	19.86	56.18					
Other	1*	0.05	4.55	14.78	5.37	4.96	1.0	2.0	2.0	2.0	
	1†	0.06	6.47	21.28	7.77	7.02					
<b>All modes</b>	16*	50.16	79.74	114.89	19.82	79.29	5.3	1.0	14.6	52.0	
	16†	70.76	112.66	162.47	28.09	112.36					
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10 <sup>0</sup>											

Taxonomy no 2.2.2.6		Item Electric Equipment Electric motors Pump Flare, vent & blow-down									
Population 4	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1971			Operational time † 0.1460						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
All modes		0* 0†	0.01 0.01	2.40 3.22	9.20 12.37	3.39 4.56	0.00 0.00	-	-	-	-
Comments											

Taxonomy no 2.2.2.7		Item Electric Equipment Electric motors Pump Gas processing									
Population 4	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1403			Operational time † 0.1319						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	3* 3†	5.85 6.22	21.39 22.75	55.29 58.80	21.39 22.75	21.39 22.75	7.8	2.0	14.5	27.0	
Spurious stop	1* 1†	0.36 0.38	7.13 7.58	33.83 35.98	7.13 7.58	7.13 7.58	2.0	2.0	2.0	2.0	
Structural deficiency	2* 2†	2.53 2.69	14.26 15.16	44.88 47.73	14.26 15.16	14.26 15.16	13.5	27.0	27.0	27.0	
<b>Degraded</b>	5* 5†	14.05 14.94	35.65 37.91	74.97 79.73	35.65 37.91	35.65 37.91	6.1	4.0	7.6	14.0	
Noise	2* 2†	2.53 2.69	14.26 15.16	44.88 47.73	14.26 15.16	14.26 15.16	3.5	4.0	5.0	6.0	
Structural deficiency	3* 3†	5.85 6.22	21.39 22.75	55.29 58.80	21.39 22.75	21.39 22.75	7.8	5.0	9.3	14.0	
<b>Incipient</b>	4* 4†	9.73 10.35	28.52 30.33	65.27 69.41	28.52 30.33	28.52 30.33	1.9	1.0	2.8	7.0	
Abnormal instrument reading	3* 3†	5.85 6.22	21.39 22.75	55.29 58.80	21.39 22.75	21.39 22.75	1.3	1.0	1.3	2.0	
Minor in-service problems	1* 1†	0.36 0.38	7.13 7.58	33.83 35.98	7.13 7.58	7.13 7.58	3.5	7.0	7.0	7.0	
<b>All modes</b>	12* 12†	49.37 52.51	85.56 90.99	138.60 147.40	85.56 90.99	85.56 90.99	4.9	1.0	7.1	27.0	
<b>Comments</b>											

Taxonomy no 2.2.2.8		Item Electric Equipment Electric motors Pump Gas production								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0493		Operational time † 0.0365						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
All modes	0* 0†	0.03 0.04	8.21 10.94	31.52 42.00	11.61 15.47	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 2.2.2.9		Item Electric Equipment Electric motors Pump Gas treatment								
Population 4	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 11			
		Calendar time * 0.0701		Operational time † 0.0227						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
All modes	0* 0†	0.02 0.06	6.12 15.69	23.49 60.23	8.65 22.18	0.00 0.00	-	-	-	-
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10 <sup>0</sup>										

Taxonomy no 2.2.2.10		Item Electric Equipment Electric motors Pump Heating medium								
Population 9	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 12			
		Calendar time * 0.2208		Operational time † 0.1619						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	5*	3.24	22.39	55.91	17.20	22.64	10.9	2.0	29.0	60.0
	5†	6.97	30.11	66.55	18.99	30.88				
Breakdown	2*	0.02	9.73	39.41	14.86	9.06	17.0	34.0	34.0	34.0
	2†	0.14	12.10	39.26	14.27	12.35				
Noise	2*	0.15	8.78	27.49	9.80	9.06	7.5	15.0	37.5	60.0
	2†	0.06	12.69	47.47	17.52	12.35				
Spurious stop	1*	0.00	4.13	18.18	7.13	4.53	2.0	2.0	2.0	2.0
	1†	0.02	5.47	20.76	7.65	6.18				
<b>Incipient</b>	2*	0.11	8.88	28.50	10.31	9.06	3.0	6.0	6.0	6.0
	2†	0.02	13.47	55.20	20.91	12.35				
Abnormal instrument reading	1*	0.00	4.13	18.18	7.13	4.53	3.0	6.0	6.0	6.0
	1†	0.02	5.47	20.76	7.65	6.18				
Other	1*	0.28	4.65	13.65	4.53	4.53	-	-	-	-
	1†	0.01	8.44	34.61	13.12	6.18				
<b>All modes</b>	7*	13.78	31.46	55.00	12.78	31.70	9.3	2.0	25.2	60.0
	7†	20.13	43.05	72.95	16.34	43.23				
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0: 10 <sup>0</sup>										

Taxonomy no 2.2.2.11		Item Electric Equipment Electric motors Pump Oil export								
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0526		Operational time † 0.0512						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	2*	6.75	38.05	119.77	38.05	38.05	165.0	13.0	165.0	317.0
	2†	6.93	39.05	122.91	39.05	39.05				
Fail to start on demand	1*	0.95	19.03	90.28	19.03	19.03	13.0	13.0	13.0	13.0
	1†	0.98	19.53	92.65	19.53	19.53				
Spurious stop	1*	0.95	19.03	90.28	19.03	19.03	317.0	317.0	317.0	317.0
	1†	0.98	19.53	92.65	19.53	19.53				
<b>Incipient</b>	2*	6.75	38.05	119.77	38.05	38.05	3.0	2.0	3.0	4.0
	2†	6.93	39.05	122.91	39.05	39.05				
Abnormal instrument reading	2*	6.75	38.05	119.77	38.05	38.05	3.0	2.0	3.0	4.0
	2†	6.93	39.05	122.91	39.05	39.05				
<b>All modes</b>	4*	25.97	76.10	174.18	76.10	76.10	84.0	2.0	84.0	317.0
	4†	26.65	78.10	178.75	78.10	78.10				
<b>Comments</b>										



Taxonomy no 2.2.2.12		Item Electric Equipment Electric motors Pump Oil processing									
Population 6	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 960				
		Calendar time * 0.2530		Operational time † 0.1948							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	20*	<b>0.39</b>	<b>94.49</b>	<b>358.06</b>	<b>132.03</b>	<b>79.05</b>	<b>9.5</b>	<b>1.0</b>	<b>16.5</b>	<b>146.0</b>	
	20†	<b>0.49</b>	<b>116.63</b>	<b>440.54</b>	<b>162.48</b>	<b>102.65</b>					
Breakdown	3*	0.09	13.69	47.73	17.61	11.86	7.3	4.0	8.3	15.0	
	3†	0.12	17.01	58.10	21.39	15.40					
Fail to start on demand	3*	0.09	13.69	47.73	17.61	11.86	2.0	1.0	2.0	3.0	
	3†	0.12	17.01	58.10	21.39	15.40					
Low output	2*	0.08	8.94	29.51	10.79	7.90	1.5	1.0	1.5	2.0	
	2†	0.14	11.15	35.79	12.95	10.26					
Noise	1*	0.31	4.21	12.03	3.95	3.95	5.0	5.0	5.0	5.0	
	1†	0.36	5.37	15.54	5.13	5.13					
Parameter deviation	1*	0.31	4.21	12.03	3.95	3.95	3.5	7.0	7.0	7.0	
	1†	0.36	5.37	15.54	5.13	5.13					
Spurious stop	4*	0.10	18.44	65.98	24.38	15.81	3.8	1.0	3.8	10.0	
	4†	0.14	22.87	80.55	29.75	20.53					
Structural deficiency	4*	0.10	18.44	65.98	24.38	15.81	28.8	25.0	57.5	146.0	
	4†	0.14	22.87	80.55	29.75	20.53					
Vibration	2*	0.08	8.94	29.51	10.79	7.90	11.0	22.0	22.0	22.0	
	2†	0.14	11.15	35.79	12.95	10.26					
<b>Degraded</b>	7*	<b>0.15</b>	<b>32.70</b>	<b>120.76</b>	<b>44.60</b>	<b>27.67</b>	<b>6.5</b>	<b>3.0</b>	<b>9.4</b>	<b>29.0</b>	
	7†	<b>0.20</b>	<b>40.45</b>	<b>148.02</b>	<b>54.69</b>	<b>35.93</b>					
Parameter deviation	2*	0.08	8.94	29.51	10.79	7.90	4.0	4.0	4.0	4.0	
	2†	0.14	11.15	35.79	12.95	10.26					
Structural deficiency	5*	0.12	23.20	84.24	31.13	19.76	7.1	3.0	10.8	29.0	
	5†	0.15	28.73	103.03	38.07	25.66					
<b>Incipient</b>	6*	<b>1.75</b>	<b>26.35</b>	<b>76.41</b>	<b>25.26</b>	<b>23.71</b>	<b>3.0</b>	<b>1.0</b>	<b>3.8</b>	<b>8.0</b>	
	6†	<b>2.81</b>	<b>33.06</b>	<b>92.24</b>	<b>30.04</b>	<b>30.79</b>					
Abnormal instrument reading	1*	0.31	4.21	12.03	3.95	3.95	4.0	4.0	4.0	4.0	
	1†	0.36	5.37	15.54	5.13	5.13					
Minor in-service problems	4*	0.10	18.44	65.98	24.38	15.81	3.3	2.0	4.7	8.0	
	4†	0.14	22.87	80.55	29.75	20.53					
Other	1*	0.02	3.72	12.96	4.78	3.95	1.0	1.0	1.0	1.0	
	1†	0.03	4.88	17.48	6.46	5.13					
<b>All modes</b>	33*	<b>0.78</b>	<b>154.88</b>	<b>562.35</b>	<b>207.78</b>	<b>130.43</b>	<b>7.9</b>	<b>1.0</b>	<b>13.1</b>	<b>146.0</b>	
	33†	<b>1.00</b>	<b>191.48</b>	<b>690.91</b>	<b>255.30</b>	<b>169.37</b>					
<b>Comments</b>											
On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 3.1 · 10 <sup>-3</sup>											

Taxonomy no 2.2.2.13		Item Electric Equipment Electric motors Pump Oily water treatment									
Population 9	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.3039		Operational time † 0.2406							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	15*	<b>30.42</b>	<b>49.36</b>	<b>76.00</b>	<b>49.36</b>	<b>49.36</b>	<b>9.8</b>	<b>3.0</b>	<b>18.3</b>	<b>39.0</b>	
	15†	<b>38.42</b>	<b>62.34</b>	<b>95.99</b>	<b>62.34</b>	<b>62.34</b>					
Breakdown	3*	2.70	9.87	25.52	9.87	9.87	11.2	8.0	19.7	27.0	
	3†	3.41	12.47	32.23	12.47	12.47					
Fail to start on demand	3*	2.70	9.87	25.52	9.87	9.87	8.2	3.0	14.3	37.0	
	3†	3.41	12.47	32.23	12.47	12.47					
Spurious stop	2*	1.17	6.58	20.72	6.58	6.58	4.0	5.0	5.5	6.0	
	2†	1.48	8.31	26.16	8.31	8.31					
Structural deficiency	3*	2.70	9.87	25.52	9.87	9.87	10.8	4.0	21.7	39.0	
	3†	3.41	12.47	32.23	12.47	12.47					
Vibration	4*	4.49	13.16	30.13	13.16	13.16	12.0	7.0	24.0	38.0	
	4†	5.67	16.62	38.05	16.62	16.62					
<b>Degraded</b>	10*	<b>17.85</b>	<b>32.91</b>	<b>55.81</b>	<b>32.91</b>	<b>32.91</b>	<b>6.4</b>	<b>3.0</b>	<b>11.9</b>	<b>32.0</b>	
	10†	<b>22.55</b>	<b>41.56</b>	<b>70.49</b>	<b>41.56</b>	<b>41.56</b>					
Overheating	1*	0.16	3.29	15.62	3.29	3.29	3.0	6.0	6.0	6.0	
	1†	0.21	4.16	19.72	4.16	4.16					
Structural deficiency	5*	6.48	16.45	34.60	16.45	16.45	7.4	3.0	13.4	32.0	
	5†	8.19	20.78	43.70	20.78	20.78					
Vibration	4*	4.49	13.16	30.13	13.16	13.16	5.5	10.0	11.0	12.0	
	4†	5.67	16.62	38.05	16.62	16.62					
<b>Incipient</b>	3*	<b>2.70</b>	<b>9.87</b>	<b>25.52</b>	<b>9.87</b>	<b>9.87</b>	<b>2.0</b>	<b>2.0</b>	<b>2.0</b>	<b>2.0</b>	
	3†	<b>3.41</b>	<b>12.47</b>	<b>32.23</b>	<b>12.47</b>	<b>12.47</b>					
Minor in-service problems	3*	2.70	9.87	25.52	9.87	9.87	2.0	2.0	2.0	2.0	
	3†	3.41	12.47	32.23	12.47	12.47					
<b>Unknown</b>	1*	<b>0.16</b>	<b>3.29</b>	<b>15.62</b>	<b>3.29</b>	<b>3.29</b>	<b>4.0</b>	<b>4.0</b>	<b>4.0</b>	<b>4.0</b>	
	1†	<b>0.21</b>	<b>4.16</b>	<b>19.72</b>	<b>4.16</b>	<b>4.16</b>					
Unknown	1*	0.16	3.29	15.62	3.29	3.29	4.0	4.0	4.0	4.0	
	1†	0.21	4.16	19.72	4.16	4.16					
<b>All modes</b>	29*	<b>68.27</b>	<b>95.44</b>	<b>130.12</b>	<b>95.44</b>	<b>95.44</b>	<b>7.9</b>	<b>2.0</b>	<b>14.5</b>	<b>39.0</b>	
	29†	<b>86.22</b>	<b>120.53</b>	<b>164.34</b>	<b>120.53</b>	<b>120.53</b>					
<b>Comments</b>											

Taxonomy no 2.2.2.14		Item Electric Equipment Electric motors Pump Sea water lift									
Population 18	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 528				
		Calendar time * 0.4753		Operational time † 0.3662							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
<b>Critical</b>	7*	2.18	14.73	36.61	11.23	14.73	94.9	6.0	110.3	426.0	
	7†	4.09	18.67	41.97	12.12	19.11					
Fail to start on demand	3*	0.74	6.35	16.55	5.19	6.31	48.5	15.0	61.7	146.0	
	3†	1.43	8.17	19.48	5.82	8.19					
Parameter deviation	1*	0.00	1.99	8.98	3.56	2.10	13.0	26.0	26.0	26.0	
	1†	0.00	2.43	10.11	3.85	2.73					
Spurious stop	3*	0.74	6.35	16.55	5.19	6.31	182.3	6.0	187.0	426.0	
	3†	1.43	8.17	19.48	5.82	8.19					
<b>Degraded</b>	8*	3.44	17.98	41.89	12.37	16.83	95.2	3.0	126.6	484.0	
	8†	10.64	21.59	35.67	7.72	21.84					
Other	3*	0.00	8.76	38.09	14.80	6.31	161.0	19.0	174.0	484.0	
	3†	0.00	9.39	40.87	15.90	8.19					
Parameter deviation	2*	0.04	4.30	14.08	5.14	4.21	3.0	3.0	3.0	3.0	
	2†	0.04	5.38	18.10	6.65	5.46					
Structural deficiency	3*	0.01	5.81	23.22	8.69	6.31	60.2	94.0	120.3	173.0	
	3†	0.05	6.98	23.58	8.67	8.19					
<b>Incipient</b>	4*	1.43	8.74	21.19	6.41	8.42	6.8	3.0	6.8	18.0	
	4†	2.28	10.76	24.41	7.09	10.92					
Abnormal instrument reading	4*	1.43	8.74	21.19	6.41	8.42	6.8	3.0	6.8	18.0	
	4†	2.28	10.76	24.41	7.09	10.92					
<b>All modes</b>		19*	10.79	42.03	90.05	25.18	39.97	73.0	3.0	93.6	484.0
		19†	30.52	51.15	76.08	13.98	51.88				
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.9 · 10 <sup>-3</sup>											

Taxonomy no 2.2.2.15		Item Electric Equipment Electric motors Pump Water injection									
Population 24	Installations 6	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 1590				
		Calendar time * 0.7757		Operational time † 0.6448							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max	
<b>Critical</b>	<b>16*</b> <b>16†</b>	<b>2.89</b> <b>3.66</b>	<b>24.00</b> <b>27.59</b>	<b>62.14</b> <b>70.15</b>	<b>19.44</b> <b>21.78</b>	<b>20.63</b> <b>24.81</b>	<b>52.2</b>	<b>1.0</b>	<b>127.9</b>	<b>1140.0</b>	
Fail to start on demand	3*	0.02	4.46	16.27	6.01	3.87	3.7	3.0	5.0	8.0	
	3†	0.03	5.18	18.70	6.91	4.65					
Other	5*	0.00	5.09	24.61	10.16	6.45	15.5	3.0	30.6	37.5	
	5†	0.00	6.07	29.20	12.04	7.75					
Overheating	1*	0.00	1.81	8.22	3.27	1.29	2.0	2.0	2.0	2.0	
	1†	0.00	2.12	9.54	3.79	1.55					
Spurious stop	5*	0.52	8.37	24.48	8.12	6.45	136.8	1.0	363.2	1140.0	
	5†	0.75	9.38	26.47	8.66	7.75					
Vibration	2*	0.15	3.06	9.17	3.06	2.58	30.5	4.0	30.5	57.0	
	2†	0.33	3.45	9.40	3.03	3.10					
<b>Degraded</b>	<b>6*</b> <b>6†</b>	<b>0.60</b> <b>0.57</b>	<b>11.89</b> <b>14.20</b>	<b>35.60</b> <b>42.78</b>	<b>11.89</b> <b>14.51</b>	<b>7.74</b> <b>9.31</b>	<b>3.6</b>	<b>3.0</b>	<b>5.5</b>	<b>12.0</b>	
Erratic output	2*	0.00	5.29	24.32	9.76	2.58	-	5.0	8.5	12.0	
	2†	0.00	7.11	32.04	12.72	3.10					
External leakage - Utility medium	1*	0.00	1.81	8.22	3.27	1.29	1.5	3.0	3.0	3.0	
	1†	0.00	2.12	9.54	3.79	1.55					
Overheating	2*	0.00	3.12	14.32	5.73	2.58	4.0	4.0	4.0	4.0	
	2†	0.00	3.39	14.87	5.82	3.10					
Parameter deviation	1*	0.00	1.81	8.22	3.27	1.29	5.0	5.0	5.0	5.0	
	1†	0.00	2.12	9.54	3.79	1.55					
<b>Incipient</b>	<b>16*</b> <b>16†</b>	<b>0.21</b> <b>0.25</b>	<b>26.26</b> <b>30.77</b>	<b>88.78</b> <b>103.67</b>	<b>32.63</b> <b>38.08</b>	<b>20.63</b> <b>24.81</b>	<b>16.7</b>	<b>2.0</b>	<b>29.9</b>	<b>77.5</b>	
Abnormal instrument reading	3*	0.00	6.55	30.93	12.64	3.87	8.7	3.0	8.7	17.0	
	3†	0.00	7.67	36.26	14.83	4.65					
Minor in-service problems	9*	0.11	15.66	53.97	19.90	11.60	8.5	2.0	14.1	57.0	
	9†	0.13	18.28	62.73	23.11	13.96					
Structural deficiency	4*	0.00	4.23	19.11	7.59	5.16	39.0	77.5	77.5	77.5	
	4†	0.00	5.04	22.66	8.98	6.20					
<b>All modes</b>	<b>38*</b> <b>38†</b>	<b>5.02</b> <b>6.06</b>	<b>64.59</b> <b>75.36</b>	<b>182.89</b> <b>212.21</b>	<b>59.93</b> <b>69.38</b>	<b>48.99</b> <b>58.94</b>	<b>31.4</b>	<b>1.0</b>	<b>68.4</b>	<b>1140.0</b>	
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.3 · 10 <sup>-3</sup>											

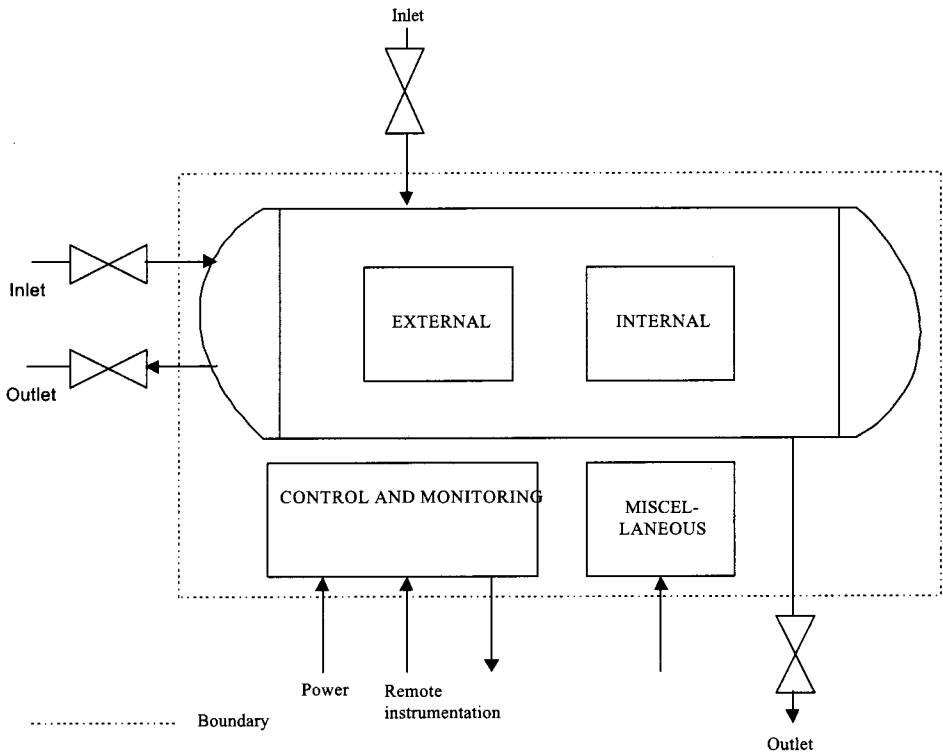
**MECHANICAL EQUIPMENT**

***Heat Exchangers***

**Inventory description**

The boundary definition is shown in Figure 17 and corresponding subdivision in Maintainable Items in Table 12.

Inlet, outlet, pressure relief and drain valves are specifically excluded. The only valves are calibration valves and instrument valves that form a pressure boundary (e.g. block valves, control valves, calibration valves, local indicators/gauges).



**Figure 17 Heat Exchangers, Boundary Definition**

**Table 12 Heat Exchangers, Subdivision in Maintainable Items**

HEAT EXCHANGERS			
External	Internal	Control and Monitoring	Miscellaneous
<ul style="list-style-type: none"> <li>• Support</li> <li>• Body/Shell</li> <li>• Valves &amp; piping</li> <li>• Instruments</li> </ul>	<ul style="list-style-type: none"> <li>• Body/shell</li> <li>• Instruments</li> <li>• Plates</li> <li>• Seals (gaskets)</li> <li>• Tubes</li> </ul>	<ul style="list-style-type: none"> <li>• Actuating device</li> <li>• Cabling &amp; junction boxes</li> <li>• Control unit</li> <li>• Instruments</li> <li>• Monitoring</li> <li>• Internal power supply</li> <li>• Valves</li> </ul>	<ul style="list-style-type: none"> <li>• Fan w/motor</li> </ul>

(For all subunits the MIs "Unknown" and "Subunit" are included.)

**List of failure modes**

- AIR Abnormal instrument reading
- ELP External leakage - Process medium
- ELU External leakage - Utility medium
- IHT Insufficient heat transfer
- INL Internal leakage
- SER Minor in-service problems
- OTH Other
- PDE Parameter deviation
- PLU Plugged/Choked
- STD Structural deficiency
- UNK Unknown

Taxonomy no 3.1		Item Mechanical Equipment Heat Exchangers								
Population 68	Installations 12	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 97740			
		Calendar time * 2.1078			Operational time † 1.6357					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>29*</b> <b>29†</b>	<b>0.06</b>	<b>13.64</b>	<b>50.42</b>	<b>18.62</b>	<b>13.76</b>	<b>23.5</b>	<b>2.0</b>	<b>45.5</b>	<b>311.0</b>
Abnormal instrument reading	1* 1†	0.01 0.00	0.53 0.70	1.69 3.86	0.61 1.93	0.47 0.61	-	12.0	12.0	12.0
External leakage - Process medium	7* 7†	0.01 0.03	4.30 5.14	17.10 18.30	6.39 6.76	3.32 4.28	12.3	6.0	24.5	60.0
External leakage - Utility medium	2* 2†	0.00 0.00	1.33 1.49	6.90 7.37	3.04 3.13	0.95 1.22	34.8	30.0	69.5	109.0
Insufficient heat transfer	2* 2†	0.02 0.00	0.78 1.00	2.41 4.16	0.85 1.58	0.95 1.22	5.0	4.0	8.0	12.0
Minor in-service problems	1* 1†	0.01 0.00	0.42 0.54	1.32 2.13	0.47 0.79	0.47 0.61	2.0	2.0	2.0	2.0
Other	1* 1†	0.01 0.00	0.42 0.54	1.32 2.13	0.47 0.79	0.47 0.61	6.0	14.0	14.0	14.0
Parameter deviation	4* 4†	0.19 0.00	1.97 2.39	5.37 10.83	1.73 4.31	1.90 2.45	12.9	4.0	24.8	60.0
Plugged/Choked	1* 1†	0.00 0.04	0.58 0.64	2.38 1.85	0.90 0.61	0.47 0.61	26.5	53.0	53.0	53.0
Structural deficiency	10* 10†	0.00 0.00	4.17 4.75	22.95 25.38	10.88 11.68	4.74 6.11	37.3	18.0	74.9	311.0
<b>Degraded</b>	<b>69*</b> <b>69†</b>	<b>0.07</b>	<b>22.17</b>	<b>86.33</b>	<b>32.00</b>	<b>32.73</b>	<b>4.4</b>	<b>1.0</b>	<b>5.2</b>	<b>24.0</b>
External leakage - Process medium	2* 2†	0.00 0.00	1.59 1.74	6.69 6.99	2.57 2.62	0.95 1.22	15.0	10.0	15.0	20.0
External leakage - Utility medium	4* 4†	0.00 0.00	2.54 3.59	11.39 16.68	4.51 6.75	1.90 2.45	1.0	1.0	2.8	6.0
Insufficient heat transfer	26* 26†	0.00 0.00	4.37 7.59	22.63 39.25	17.58 29.97	12.33 15.90	3.8	1.0	4.3	9.0
Internal leakage	2* 2†	0.20 0.00	1.00 1.29	2.29 6.61	0.67 2.86	0.95 1.22	7.0	10.0	17.0	24.0
Minor in-service problems	11* 11†	0.00 0.00	2.50 3.70	13.23 21.20	6.04 11.42	5.22 6.72	3.0	1.0	3.0	6.0
Other	9* 9†	0.00 0.00	2.30 3.18	10.83 17.59	4.42 8.91	4.27 5.50	5.9	3.0	6.5	17.0
Parameter deviation	6* 6†	0.30 0.27	2.96 3.92	7.97 11.34	2.55 3.75	2.85 3.67	4.5	4.0	7.7	16.0
Plugged/Choked	9* 9†	0.00 0.00	6.16 7.31	34.10 40.29	17.39 20.14	4.27 5.50	3.7	2.0	3.7	6.0
<b>Incipient</b>	<b>111*</b> <b>111†</b>	<b>8.34</b>	<b>50.46</b>	<b>122.05</b>	<b>36.85</b>	<b>52.66</b>	<b>18.0</b>	<b>1.0</b>	<b>21.1</b>	<b>279.0</b>
Abnormal instrument reading	28* 28†	1.13 0.83	14.40 19.94	40.69 59.97	13.32 20.27	13.28 17.12	2.9	1.0	5.1	24.0
<b>Comments</b>										

(cont.)

Taxonomy no 3.1		Item Mechanical Equipment Heat Exchangers								
Population 68	Installations 12	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 97740			
		Calendar time * 2.1078		Operational time † 1.6357						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Process medium	8*	0.00	4.72	26.39	13.79	3.80	-	2.0	2.4	4.0
	8†	0.00	5.37	29.87	15.42	4.89				
External leakage - Utility medium	5*	0.00	4.15	17.88	6.93	2.37	58.0	2.0	26.4	96.0
	5†	0.00	5.58	23.42	8.97	3.06				
Insufficient heat transfer	1*	0.01	0.42	1.32	0.47	0.47	-	4.0	4.0	4.0
	1†	0.00	0.54	2.13	0.79	0.61				
Internal leakage	1*	0.00	0.46	2.16	0.88	0.47	2.0	6.0	6.0	6.0
	1†	0.00	0.56	2.42	0.94	0.61				
Minor in-service problems	33*	0.06	12.07	43.29	16.00	15.66	4.1	1.0	8.1	76.0
	33†	0.04	18.27	73.30	27.50	20.17				
Other	12*	0.11	4.99	15.36	5.40	5.69	9.0	2.0	15.3	65.0
	12†	0.21	6.47	19.61	6.74	7.34				
Parameter deviation	11*	0.67	4.55	11.31	3.47	5.22	31.2	4.0	55.9	146.0
	11†	0.93	5.93	14.53	4.42	6.72				
Plugged/Choked	1*	0.01	0.53	1.69	0.61	0.47	-	5.0	5.0	5.0
	1†	0.00	0.78	3.64	1.47	0.61				
Structural deficiency	10*	0.00	4.71	21.96	8.90	4.74	58.1	2.0	78.7	279.0
	10†	0.00	6.02	26.63	10.47	6.11				
Unknown	1*	0.00	1.05	5.49	2.46	0.47	200.0	200.0	200.0	200.0
	1†	0.00	1.15	5.96	2.64	0.61				
<b>Unknown</b>	3*	<b>0.00</b>	<b>2.99</b>	<b>13.68</b>	<b>5.46</b>	<b>1.42</b>	<b>29.5</b>	<b>9.0</b>	<b>31.0</b>	<b>60.0</b>
	3†	<b>0.00</b>	<b>3.31</b>	<b>15.04</b>	<b>5.99</b>	<b>1.83</b>				
Other	2*	0.00	2.46	12.66	5.49	0.95	42.0	24.0	42.0	60.0
	2†	0.00	2.75	14.14	6.13	1.22				
Unknown	1*	0.00	0.58	2.38	0.90	0.47	4.5	9.0	9.0	9.0
	1†	0.04	0.64	1.85	0.61	0.61				
<b>All modes</b>	212*	<b>19.89</b>	<b>88.98</b>	<b>198.74</b>	<b>57.14</b>	<b>100.58</b>	<b>13.7</b>	<b>1.0</b>	<b>19.0</b>	<b>311.0</b>
	212†	<b>11.30</b>	<b>118.98</b>	<b>324.89</b>	<b>104.74</b>	<b>129.61</b>				
<b>Comments</b>										
On demand probability for consequence class: Critical and failure mode: *** = 0.0 10 <sup>0</sup>										



**Maintainable item versus failure mode, to be continued**

**Item: Heat Exchangers**

	AIR	ELP	ELU	IHT	INL	OTH
Actuating device	0.00	0.00	0.00	0.00	0.00	0.47
Body/shell	0.00	0.47	0.00	0.00	0.00	2.36
Cabling & junction boxes	0.47	0.00	0.00	0.00	0.00	0.00
Control unit	0.47	0.00	0.00	0.94	0.00	0.00
Fan w/motor	0.47	0.00	0.00	12.74	0.00	4.25
Instrument, flow	2.36	0.00	0.00	0.00	0.00	0.00
Instrument, general	2.83	0.00	0.00	0.00	0.00	0.47
Instrument, level	0.47	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	1.42	0.00	0.47	0.00	0.00	0.00
Instrument, temperature	3.77	0.00	0.47	0.00	0.00	0.00
Monitoring	0.47	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.47	0.00	0.00	0.47
Piping	0.00	0.94	0.00	0.00	0.47	0.00
Plates	0.00	0.94	0.47	0.00	0.47	0.47
Seals (gaskets)	0.00	0.47	0.94	0.00	0.00	0.47
Subunit	0.00	0.47	0.00	0.00	0.00	0.00
Support	0.00	0.00	0.00	0.00	0.00	0.00
Tubes	0.00	0.00	0.47	0.00	0.00	0.00
Unknown	0.00	0.94	0.47	0.00	0.00	2.36
Valves	0.94	3.77	1.42	0.00	0.47	0.00
Total	13.68	8.02	5.19	13.68	1.42	11.32

**Maintainable item versus failure mode, continued**

**Item: Heat Exchangers**

	PDE	PLU	SER	STD	UNK	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	0.47
Body/shell	0.94	0.00	0.94	2.83	0.00	7.55
Cabling & junction boxes	0.47	0.00	0.00	0.00	0.00	0.94
Control unit	0.00	0.00	3.77	0.00	0.00	5.19
Fan w/motor	2.83	0.00	11.32	0.00	0.00	31.60
Instrument, flow	0.47	0.00	0.47	0.00	0.00	3.30
Instrument, general	0.00	0.00	0.00	0.00	0.00	3.30
Instrument, level	0.00	0.00	0.00	0.00	0.00	0.47
Instrument, pressure	0.00	0.00	0.47	0.94	0.00	3.30
Instrument, temperature	0.24	0.00	0.47	0.00	0.00	4.95
Monitoring	0.00	0.00	0.00	0.00	0.00	0.47
Other	0.00	0.00	1.42	0.00	0.00	2.36
Piping	0.47	0.00	0.00	4.25	0.00	6.13
Plates	0.00	0.00	0.00	0.47	0.47	3.30
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	1.89
Subunit	0.00	2.36	0.00	0.00	0.00	2.83
Support	0.00	0.47	0.94	0.00	0.00	1.42
Tubes	2.36	0.47	0.00	0.00	0.00	3.30
Unknown	0.00	1.42	1.42	0.00	0.47	7.08
Valves	2.12	0.47	0.00	0.94	0.00	10.14
Total	9.91	5.19	21.23	9.43	0.94	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item: Heat Exchangers**

	AIR	ELP	ELU	IHT	INL	OTH
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00
Breakage	0.47	0.00	0.47	0.47	0.00	0.94
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.47	0.00	0.00
Control failure	0.47	0.00	0.00	0.00	0.00	0.00
Corrosion	0.94	0.47	0.47	0.00	0.00	0.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.00	0.00	0.00	0.94	0.00	0.00
Electrical failure - general	0.47	0.00	0.00	1.42	0.00	0.94
Erosion	0.00	0.00	0.00	0.00	0.47	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	3.30	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	3.30	0.00	0.94	0.00	0.00	0.47
Leakage	0.00	6.13	1.89	0.00	0.47	0.94
Looseness	0.00	0.00	0.47	1.89	0.00	0.94
Material failure - general	0.00	0.94	0.47	0.47	0.00	0.47
Mechanical Failure - general	0.47	0.00	0.00	1.89	0.00	1.42
Misc. external influences	0.00	0.00	0.00	0.00	0.00	1.89
Miscellaneous - general	0.00	0.00	0.00	1.42	0.47	0.00
No signal/indication/alarm	0.94	0.00	0.00	0.00	0.00	0.00
Open circuit	0.00	0.00	0.00	0.94	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.47
Out of adjustment	2.36	0.00	0.47	0.47	0.00	0.00
Sticking	0.47	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.47
Vibration	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.47	0.47	0.00	3.30	0.00	2.36
Total	13.68	8.02	5.19	13.68	1.42	11.32

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**  
**Item: Heat Exchangers**

	PDE	PLU	SER	STD	UNK	Sum
Blockage/plugged	0.94	0.00	0.00	0.94	0.00	1.89
Breakage	0.00	0.00	0.94	0.94	0.00	4.25
Cavitation	0.00	0.00	0.00	0.94	0.00	0.94
Clearance/ alignment failure	0.00	0.00	1.89	0.00	0.00	2.36
Control failure	0.47	0.00	0.00	0.00	0.00	0.94
Corrosion	0.47	0.00	1.89	3.30	0.00	7.55
Deformation	0.00	0.00	0.47	0.00	0.00	0.47
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.94
Electrical failure - general	0.94	0.00	0.47	0.00	0.00	4.25
Erosion	0.00	0.00	0.00	0.00	0.00	0.47
External influence - general	1.42	0.00	0.00	1.42	0.00	2.83
Faulty signal/indication/alarm	0.47	0.00	0.00	0.00	0.00	3.77
Instrument failure - general	0.47	0.00	0.00	0.00	0.47	5.66
Leakage	0.00	0.00	0.94	0.00	0.00	10.38
Looseness	0.00	0.00	5.19	0.00	0.00	8.49
Material failure - general	0.00	0.00	0.47	0.00	0.00	2.83
Mechanical Failure - general	1.89	0.00	2.83	0.47	0.00	8.96
Misc. external influences	0.94	0.47	0.00	0.00	0.00	3.30
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	1.89
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.94
Open circuit	0.00	0.00	0.00	0.00	0.00	0.94
Other	0.00	0.00	0.00	0.47	0.00	0.94
Out of adjustment	0.00	0.00	0.00	0.00	0.00	3.30
Sticking	0.47	0.47	0.00	0.00	0.00	1.42
Unknown	0.00	0.00	0.00	0.00	0.47	0.94
Vibration	0.94	0.00	0.94	0.94	0.00	2.83
Wear	0.47	4.25	5.19	0.00	0.00	16.51
Total	9.91	5.19	21.23	9.43	0.94	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 3.1.1		Item Mechanical Equipment Heat Exchangers Fin fan								
Population 10	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
		0.6134		0.2921						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/r		Min	Mean	Max
<b>Critical</b>	<b>6*</b> <b>6†</b>	<b>0.88</b>	<b>8.56</b>	<b>22.96</b>	<b>7.34</b>	<b>9.78</b>	<b>4.2</b>	<b>2.0</b>	<b>7.0</b>	<b>14.0</b>
External leakage - Process medium	1*	0.05	1.56	4.73	1.63	1.63	3.0	6.0	6.0	6.0
Insufficient heat transfer	1†	0.17	3.42	10.25	3.42	3.42				
	2*	0.41	3.09	7.88	2.45	3.26	5.0	4.0	8.0	12.0
Minor in-service problems	2†	1.21	6.84	16.24	4.84	6.85				
	1*	0.05	1.56	4.73	1.63	1.63	2.0	2.0	2.0	2.0
Other	1†	0.17	3.42	10.25	3.42	3.42				
	1*	0.05	1.56	4.73	1.63	1.63	6.0	14.0	14.0	14.0
Parameter deviation	1†	0.17	3.42	10.25	3.42	3.42				
	1*	0.05	1.56	4.73	1.63	1.63	4.0	4.0	4.0	4.0
<b>Degraded</b>	<b>48*</b> <b>48†</b>	<b>5.17</b>	<b>54.12</b>	<b>147.61</b>	<b>47.56</b>	<b>78.25</b>	<b>4.1</b>	<b>1.0</b>	<b>4.5</b>	<b>17.0</b>
Insufficient heat transfer	26*	10.49	35.10	71.50	19.24	42.39	3.8	1.0	4.3	9.0
	26†	15.56	88.59	210.79	62.95	89.00				
Minor in-service problems	11*	1.16	14.56	41.10	13.45	17.93	3.0	1.0	3.0	6.0
	11†	6.64	37.58	89.28	26.63	37.65				
Other	9*	1.08	12.24	33.90	11.00	14.67	5.9	3.0	6.5	17.0
	9†	5.44	30.76	73.06	21.79	30.81				
Parameter deviation	2*	0.41	3.09	7.88	2.45	3.26	6.8	5.0	6.5	8.0
	2†	1.21	6.84	16.24	4.84	6.85				
<b>Incipient</b>	<b>45*</b> <b>45†</b>	<b>5.43</b>	<b>51.53</b>	<b>137.53</b>	<b>43.80</b>	<b>73.36</b>	<b>4.0</b>	<b>1.0</b>	<b>4.7</b>	<b>24.0</b>
Abnormal instrument reading	10*	1.12	13.41	37.51	12.23	16.30	3.5	1.0	4.9	24.0
	10†	6.04	34.17	81.17	24.21	34.23				
Insufficient heat transfer	1*	0.05	1.56	4.73	1.63	1.63	-	4.0	4.0	4.0
	1†	0.17	3.42	10.25	3.42	3.42				
Minor in-service problems	23*	12.38	32.51	60.39	14.97	37.50	3.7	1.0	3.8	14.0
	23†	13.79	78.41	186.51	55.69	78.73				
Other	6*	0.88	8.56	22.96	7.34	9.78	3.7	2.0	3.7	4.0
	6†	3.63	20.52	48.72	14.53	20.54				
Parameter deviation	5*	0.79	7.26	19.26	6.11	8.15	6.4	5.0	10.2	14.0
	5†	3.03	17.10	40.60	12.11	17.12				
<b>All modes</b>	<b>99*</b> <b>99†</b>	<b>1.59</b>	<b>98.21</b>	<b>308.95</b>	<b>110.52</b>	<b>161.40</b>	<b>4.1</b>	<b>1.0</b>	<b>4.7</b>	<b>24.0</b>
		<b>56.96</b>	<b>333.11</b>	<b>798.54</b>	<b>239.71</b>	<b>338.88</b>				
<b>Comments</b>										

**Maintainable item versus failure mode, to be continued**

**Item:** Heat Exchangers - Fin fan

	AIR	ELP	ELU	IHT	INL	OTH
Actuating device	0.00	0.00	0.00	0.00	0.00	1.01
Body/shell	0.00	1.01	0.00	0.00	0.00	4.04
Cabling & junction boxes	1.01	0.00	0.00	0.00	0.00	0.00
Control unit	1.01	0.00	0.00	2.02	0.00	0.00
Fan w/motor	1.01	0.00	0.00	27.27	0.00	9.09
Instrument, flow	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	6.06	0.00	0.00	0.00	0.00	1.01
Monitoring	1.01	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	1.01
Total	10.10	1.01	0.00	29.29	0.00	16.16

**Maintainable item versus failure mode, continued**

**Item:** Heat Exchangers - Fin fan

	PDE	PLU	SER	STD	UNK	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	1.01
Body/shell	0.00	0.00	1.01	0.00	0.00	6.06
Cabling & junction boxes	1.01	0.00	0.00	0.00	0.00	2.02
Control unit	0.00	0.00	8.08	0.00	0.00	11.11
Fan w/motor	6.06	0.00	24.24	0.00	0.00	67.68
Instrument, flow	1.01	0.00	0.00	0.00	0.00	1.01
Instrument, general	0.00	0.00	0.00	0.00	0.00	7.07
Monitoring	0.00	0.00	0.00	0.00	0.00	1.01
Other	0.00	0.00	2.02	0.00	0.00	3.03
Total	8.08	0.00	35.35	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Heat Exchangers - Fin fan

	AIR	ELP	ELU	IHT	INL	OTH
Breakage	0.00	0.00	0.00	1.01	0.00	2.02
Clearance/ alignment failure	0.00	0.00	0.00	1.01	0.00	0.00
Control failure	1.01	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.00	0.00	0.00	2.02	0.00	0.00
Electrical failure - general	1.01	0.00	0.00	3.03	0.00	2.02
Faulty signal/indication/alarm	6.06	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	2.02	0.00	0.00	0.00	0.00	1.01
Leakage	0.00	1.01	0.00	0.00	0.00	0.00
Looseness	0.00	0.00	0.00	4.04	0.00	2.02
Material failure - general	0.00	0.00	0.00	1.01	0.00	1.01
Mechanical Failure - general	0.00	0.00	0.00	4.04	0.00	3.03
Miscellaneous - general	0.00	0.00	0.00	3.03	0.00	0.00
Open circuit	0.00	0.00	0.00	2.02	0.00	0.00
Out of adjustment	0.00	0.00	0.00	1.01	0.00	0.00
Vibration	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	0.00	7.07	0.00	5.05
Total	10.10	1.01	0.00	29.29	0.00	16.16

**Failure descriptor versus failure mode, continued**

**Item:** Heat Exchangers - Fin fan

	PDE	PLU	SER	STD	UNK	Sum
Breakage	0.00	0.00	2.02	0.00	0.00	5.05
Clearance/ alignment failure	0.00	0.00	4.04	0.00	0.00	5.05
Control failure	1.01	0.00	0.00	0.00	0.00	2.02
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	2.02
Electrical failure - general	2.02	0.00	1.01	0.00	0.00	9.09
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	6.06
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	3.03
Leakage	0.00	0.00	0.00	0.00	0.00	1.01
Looseness	0.00	0.00	11.11	0.00	0.00	17.17
Material failure - general	0.00	0.00	1.01	0.00	0.00	3.03
Mechanical Failure - general	2.02	0.00	3.03	0.00	0.00	12.12
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	3.03
Open circuit	0.00	0.00	0.00	0.00	0.00	2.02
Out of adjustment	0.00	0.00	0.00	0.00	0.00	1.01
Vibration	2.02	0.00	2.02	0.00	0.00	4.04
Wear	1.01	0.00	11.11	0.00	0.00	24.24
Total	8.08	0.00	35.35	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 3.1.1.1		Item Mechanical Equipment Heat Exchangers Fin fan Air->Sea Water								
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0351		Operational time † 0.0001						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
All modes	0 <sup>*</sup> 0 <sup>†</sup>	0.05 1.21	12.44 311.53	47.79 1196.27	17.60 440.57	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 3.1.1.2		Item Mechanical Equipment Heat Exchangers Fin fan Gas->Air								
Population 8	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.5783		Operational time † 0.2920						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>6*</b>	<b>4.52</b>	<b>10.38</b>	<b>20.47</b>	<b>10.38</b>	<b>10.38</b>	<b>4.2</b>	<b>2.0</b>	<b>7.0</b>	<b>14.0</b>
	<b>6†</b>	<b>8.95</b>	<b>20.55</b>	<b>40.54</b>	<b>20.55</b>	<b>20.55</b>				
External leakage - Process medium	1*	0.09	1.73	8.21	1.73	1.73	3.0	6.0	6.0	6.0
	1†	0.17	3.42	16.25	3.42	3.42				
Insufficient heat transfer	2*	0.61	3.46	10.89	3.46	3.46	5.0	4.0	8.0	12.0
	2†	1.22	6.85	21.56	6.85	6.85				
Minor in-service problems	1*	0.09	1.73	8.21	1.73	1.73	2.0	2.0	2.0	2.0
	1†	0.17	3.42	16.25	3.42	3.42				
Other	1*	0.09	1.73	8.21	1.73	1.73	6.0	14.0	14.0	14.0
	1†	0.17	3.42	16.25	3.42	3.42				
Parameter deviation	1*	0.09	1.73	8.21	1.73	1.73	4.0	4.0	4.0	4.0
	1†	0.17	3.42	16.25	3.42	3.42				
<b>Degraded</b>	<b>48*</b>	<b>64.33</b>	<b>83.00</b>	<b>105.57</b>	<b>83.00</b>	<b>83.00</b>	<b>4.1</b>	<b>1.0</b>	<b>4.5</b>	<b>17.0</b>
	<b>48†</b>	<b>127.38</b>	<b>164.37</b>	<b>209.07</b>	<b>164.37</b>	<b>164.37</b>				
Insufficient heat transfer	26*	31.50	44.96	62.38	44.96	44.96	3.8	1.0	4.3	9.0
	26†	62.38	89.03	123.53	89.03	89.03				
Minor in-service problems	11*	10.67	19.02	31.49	19.02	19.02	3.0	1.0	3.0	6.0
	11†	21.13	37.67	62.36	37.67	37.67				
Other	9*	8.12	15.56	27.16	15.56	15.56	5.9	3.0	6.5	17.0
	9†	16.08	30.82	53.78	30.82	30.82				
Parameter deviation	2*	0.61	3.46	10.89	3.46	3.46	6.8	5.0	6.5	8.0
	2†	1.22	6.85	21.56	6.85	6.85				
<b>Incipient</b>	<b>45*</b>	<b>59.76</b>	<b>77.81</b>	<b>99.77</b>	<b>77.81</b>	<b>77.81</b>	<b>4.0</b>	<b>1.0</b>	<b>4.7</b>	<b>24.0</b>
	<b>45†</b>	<b>118.35</b>	<b>154.09</b>	<b>197.56</b>	<b>154.09</b>	<b>154.09</b>				
Abnormal instrument reading	10*	9.38	17.29	29.33	17.29	17.29	3.5	1.0	4.9	24.0
	10†	18.58	34.24	58.08	34.24	34.24				
Insufficient heat transfer	1*	0.09	1.73	8.21	1.73	1.73	-	4.0	4.0	4.0
	1†	0.17	3.42	16.25	3.42	3.42				
Minor in-service problems	23*	27.18	39.77	56.34	39.77	39.77	3.7	1.0	3.8	14.0
	23†	53.82	78.76	111.58	78.76	78.76				
Other	6*	4.52	10.38	20.47	10.38	10.38	3.7	2.0	3.7	4.0
	6†	8.95	20.55	40.54	20.55	20.55				
Parameter deviation	5*	3.41	8.65	18.18	8.65	8.65	6.4	5.0	10.2	14.0
	5†	6.75	17.12	36.01	17.12	17.12				
<b>All modes</b>	<b>99*</b>	<b>143.90</b>	<b>171.19</b>	<b>202.31</b>	<b>171.19</b>	<b>171.19</b>	<b>4.1</b>	<b>1.0</b>	<b>4.7</b>	<b>24.0</b>
	<b>99†</b>	<b>284.97</b>	<b>339.00</b>	<b>400.63</b>	<b>339.00</b>	<b>339.00</b>				
<b>Comments</b>										



Taxonomy no 3.1.2		Item Mechanical Equipment Heat Exchangers Plate - compact								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0088		Operational time † 0.0088						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
All modes	0 <sup>*</sup> 0 <sup>†</sup>	0.14 0.15	34.77 38.57	133.52 148.12	49.18 54.55	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 3.1.2.1		Item Mechanical Equipment Heat Exchangers Plate - compact Gas->Water/glycol								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0088		Operational time † 0.0088			Active rep.hrs	Repair (manhours)		
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)	
		Lower	Mean	Upper	SD	n/τ	Min		Mean	Max
All modes	0* 0†	0.08 0.09	21.61 23.02	82.98 88.39	30.56 32.55	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 3.1.3		Item Mechanical Equipment Heat Exchangers Plate - conventional								
Population 14	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
		0.4823		0.4497						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	11*	0.01	20.89	88.56	34.09	22.81	18.7	8.0	37.4	109.0
	11†	0.01	21.75	92.05	35.41	24.46				
External leakage - Process medium	5*	0.26	10.15	31.06	10.82	10.37	15.3	8.0	30.7	60.0
	5†	0.38	10.65	32.16	10.98	11.12				
External leakage - Utility medium	2*	0.05	4.02	13.04	4.74	4.15	34.8	30.0	69.5	109.0
	2†	0.07	4.25	13.35	4.77	4.45				
Parameter deviation	2*	0.05	4.02	13.04	4.74	4.15	8.8	11.0	17.5	24.0
	2†	0.07	4.25	13.35	4.77	4.45				
Plugged/Choked	1*	0.00	2.00	8.99	3.56	2.07	26.5	53.0	53.0	53.0
	1†	0.00	2.11	9.39	3.71	2.22				
Structural deficiency	1*	0.00	2.00	8.99	3.56	2.07	9.0	18.0	18.0	18.0
	1†	0.00	2.11	9.39	3.71	2.22				
<b>Degraded</b>	6*	3.76	12.70	25.93	6.99	12.44	6.6	1.0	10.7	24.0
	6†	4.25	13.48	26.94	7.13	13.34				
External leakage - Process medium	1*	0.00	2.98	12.54	4.80	2.07	20.0	20.0	20.0	20.0
	1†	0.00	3.14	13.18	5.04	2.22				
External leakage - Utility medium	1*	0.00	2.00	8.99	3.56	2.07	1.0	1.0	1.0	1.0
	1†	0.00	2.11	9.39	3.71	2.22				
Internal leakage	2*	0.06	4.07	12.93	4.65	4.15	7.0	10.0	17.0	24.0
	2†	0.08	4.36	13.62	4.85	4.45				
Parameter deviation	2*	0.05	4.02	13.04	4.74	4.15	2.3	4.0	4.5	5.0
	2†	0.07	4.25	13.35	4.77	4.45				
<b>Incipient</b>	12*	4.34	27.00	65.78	19.95	24.88	40.6	2.0	42.0	200.0
	12†	4.93	28.37	67.70	20.26	26.68				
Abnormal instrument reading	4*	1.00	8.28	21.44	6.71	8.29	1.8	2.0	3.5	6.0
	4†	1.34	8.74	21.54	6.58	8.89				
External leakage - Utility medium	2*	0.00	6.94	29.41	11.32	4.15	58.0	20.0	58.0	96.0
	2†	0.00	7.31	31.01	11.95	4.45				
Internal leakage	1*	0.00	1.86	7.55	2.85	2.07	2.0	6.0	6.0	6.0
	1†	0.00	2.02	8.52	3.27	2.22				
Other	4*	0.00	7.67	32.86	12.71	8.29	-	-	-	-
	4†	0.00	8.03	34.13	13.15	8.89				
Unknown	1*	0.00	2.98	12.54	4.80	2.07	200.0	200.0	200.0	200.0
	1†	0.00	3.14	13.18	5.04	2.22				
<b>Unknown</b>	3*	0.08	8.27	27.44	10.05	6.22	29.5	9.0	31.0	60.0
	3†	0.08	8.69	28.78	10.53	6.67				
Other	2*	0.00	6.94	29.41	11.32	4.15	42.0	24.0	42.0	60.0
	2†	0.00	7.31	31.01	11.95	4.45				
Unknown	1*	0.00	2.00	8.99	3.56	2.07	4.5	9.0	9.0	9.0
	1†	0.00	2.11	9.39	3.71	2.22				
<b>Comments</b>										

(cont.)

Taxonomy no 3.1.3		Item Mechanical Equipment Heat Exchangers Plate - conventional								
Population 14	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
		0.4823		0.4497						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max
All modes	32*	5.50	71.15	201.72	66.13	66.35	23.9	1.0	31.9	200.0
	32†	6.18	74.50	208.68	68.07	71.15				
Comments										

**Maintainable item versus failure mode, to be continued**

Item: Heat Exchangers - Plate - conventional

	AIR	ELP	ELU	IHT	INL	OTH
Instrument, flow	6.25	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	6.25	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	3.13	0.00	0.00	0.00
Piping	0.00	6.25	0.00	0.00	3.13	0.00
Plates	0.00	6.25	3.13	0.00	3.13	3.13
Seals (gaskets)	0.00	3.13	3.13	0.00	0.00	3.13
Tubes	0.00	0.00	3.13	0.00	0.00	0.00
Unknown	0.00	3.13	3.13	0.00	0.00	12.50
Valves	0.00	0.00	0.00	0.00	3.13	0.00
Total	12.50	18.75	15.63	0.00	9.38	18.75

**Maintainable item versus failure mode, continued**

Item: Heat Exchangers - Plate - conventional

	PDE	PLU	SER	STD	UNK	Sum
Instrument, flow	0.00	0.00	0.00	0.00	0.00	6.25
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	6.25
Other	0.00	0.00	0.00	0.00	0.00	3.13
Piping	0.00	0.00	0.00	0.00	0.00	9.38
Plates	0.00	0.00	0.00	3.13	3.13	21.88
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	9.38
Tubes	6.25	3.13	0.00	0.00	0.00	12.50
Unknown	0.00	0.00	0.00	0.00	3.13	21.88
Valves	6.25	0.00	0.00	0.00	0.00	9.38
Total	12.50	3.13	0.00	3.13	6.25	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Heat Exchangers - Plate - conventional

	AIR	ELP	ELU	IHT	INL	OTH
Corrosion	0.00	0.00	3.13	0.00	0.00	0.00
Erosion	0.00	0.00	0.00	0.00	3.13	0.00
Instrument failure - general	6.25	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	12.50	12.50	0.00	3.13	6.25
Material failure - general	0.00	6.25	0.00	0.00	0.00	0.00
Mechanical Failure - general	3.13	0.00	0.00	0.00	0.00	0.00
Misc. external influences	0.00	0.00	0.00	0.00	0.00	12.50
Miscellaneous - general	0.00	0.00	0.00	0.00	3.13	0.00
Out of adjustment	3.13	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00
Total	12.50	18.75	15.63	0.00	9.38	18.75

**Failure descriptor versus failure mode, continued**

**Item:** Heat Exchangers - Plate - conventional

	PDE	PLU	SER	STD	UNK	Sum
Corrosion	0.00	0.00	0.00	0.00	0.00	3.13
Erosion	0.00	0.00	0.00	0.00	0.00	3.13
Instrument failure - general	0.00	0.00	0.00	0.00	3.13	9.38
Leakage	0.00	0.00	0.00	0.00	0.00	34.38
Material failure - general	0.00	0.00	0.00	0.00	0.00	6.25
Mechanical Failure - general	6.25	0.00	0.00	3.13	0.00	12.50
Misc. external influences	6.25	3.13	0.00	0.00	0.00	21.88
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	3.13
Out of adjustment	0.00	0.00	0.00	0.00	0.00	3.13
Unknown	0.00	0.00	0.00	0.00	3.13	3.13
Total	12.50	3.13	0.00	3.13	6.25	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 3.1.3.1		Item Mechanical Equipment Heat Exchangers Plate - conventional Crude Oil->Sea Water									
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0613			Operational time † 0.0582						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Degraded</b>	1*	0.82	16.30	77.35	16.30	16.30	20.0	20.0	20.0	20.0	
	1†	0.86	17.18	81.53	17.18	17.18					
External leakage - Process medium	1*	0.82	16.30	77.35	16.30	16.30	20.0	20.0	20.0	20.0	
	1†	0.86	17.18	81.53	17.18	17.18					
<b>Incipient</b>	3*	13.37	48.90	126.42	48.90	48.90	105.3	20.0	105.3	200.0	
	3†	14.09	51.55	133.25	51.55	51.55					
External leakage - Utility medium	2*	5.79	32.60	102.62	32.60	32.60	58.0	20.0	58.0	96.0	
	2†	6.10	34.36	108.16	34.36	34.36					
Unknown	1*	0.82	16.30	77.35	16.30	16.30	200.0	200.0	200.0	200.0	
	1†	0.86	17.18	81.53	17.18	17.18					
<b>Unknown</b>	2*	5.79	32.60	102.62	32.60	32.60	42.0	24.0	42.0	60.0	
	2†	6.10	34.36	108.16	34.36	34.36					
Other	2*	5.79	32.60	102.62	32.60	32.60	42.0	24.0	42.0	60.0	
	2†	6.10	34.36	108.16	34.36	34.36					
<b>All modes</b>	6*	42.63	97.81	193.01	97.81	97.81	70.0	20.0	70.0	200.0	
	6†	44.93	103.09	203.44	103.09	103.09					
<b>Comments</b>											

Taxonomy no 3.1.3.2		Item Mechanical Equipment Heat Exchangers Plate - conventional Water/glycol->Crude Oil								
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0701		Operational time † 0.0672						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	6*	37.29	85.56	168.83	85.56	85.56	16.1	8.0	32.2	60.0
	6†	38.89	89.24	176.10	89.24	89.24				
External leakage - Process medium	2*	5.06	28.52	89.76	28.52	28.52	17.0	8.0	34.0	60.0
	2†	5.28	29.75	93.63	29.75	29.75				
External leakage - Utility medium	1*	0.71	14.26	67.66	14.26	14.26	15.0	30.0	30.0	30.0
	1†	0.74	14.87	70.57	14.87	14.87				
Parameter deviation	1*	0.71	14.26	67.66	14.26	14.26	12.0	24.0	24.0	24.0
	1†	0.74	14.87	70.57	14.87	14.87				
Plugged/Choked	1*	0.71	14.26	67.66	14.26	14.26	26.5	53.0	53.0	53.0
	1†	0.74	14.87	70.57	14.87	14.87				
Structural deficiency	1*	0.71	14.26	67.66	14.26	14.26	9.0	18.0	18.0	18.0
	1†	0.74	14.87	70.57	14.87	14.87				
<b>Degraded</b>	3*	11.69	42.78	110.58	42.78	42.78	1.8	1.0	3.3	5.0
	3†	12.20	44.62	115.34	44.62	44.62				
External leakage - Utility medium	1*	0.71	14.26	67.66	14.26	14.26	1.0	1.0	1.0	1.0
	1†	0.74	14.87	70.57	14.87	14.87				
Parameter deviation	2*	5.06	28.52	89.76	28.52	28.52	2.3	4.0	4.5	5.0
	2†	5.28	29.75	93.63	29.75	29.75				
<b>Incipient</b>	5*	28.09	71.30	149.94	71.30	71.30	1.7	2.0	3.3	6.0
	5†	29.30	74.36	156.39	74.36	74.36				
Abnormal instrument reading	3*	11.69	42.78	110.58	42.78	42.78	1.7	2.0	3.3	6.0
	3†	12.20	44.62	115.34	44.62	44.62				
Other	2*	5.06	28.52	89.76	28.52	28.52	-	-	-	-
	2†	5.28	29.75	93.63	29.75	29.75				
<b>All modes</b>	14*	120.67	199.63	312.06	199.63	199.63	8.9	1.0	17.8	60.0
	14†	125.86	208.22	325.48	208.22	208.22				
<b>Comments</b>										



Taxonomy no 3.1.3.3		Item Mechanical Equipment Heat Exchangers Plate - conventional Water/glycol->Sea Water									
Population 8	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *		Operational time †							
		0.2807		0.2553							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	<b>4*</b>	<b>0.02</b>	<b>19.21</b>	<b>80.73</b>	<b>30.93</b>	<b>14.25</b>	<b>30.0</b>	<b>11.0</b>	<b>60.0</b>	<b>109.0</b>	
	<b>4†</b>	<b>0.02</b>	<b>19.94</b>	<b>83.26</b>	<b>31.79</b>	<b>15.67</b>					
External leakage - Process medium	2*	0.03	9.49	37.21	13.83	7.13	-	-	-	-	
	2†	0.04	9.86	38.03	14.04	7.83					
External leakage - Utility medium	1*	0.07	4.34	13.67	4.89	3.56	54.5	109.0	109.0	109.0	
	1†	0.17	4.51	13.61	4.63	3.92					
Parameter deviation	1*	0.07	4.34	13.67	4.89	3.56	5.5	11.0	11.0	11.0	
	1†	0.17	4.51	13.61	4.63	3.92					
<b>Degraded</b>	<b>1*</b>	<b>0.05</b>	<b>3.15</b>	<b>9.94</b>	<b>3.56</b>	<b>3.56</b>	<b>2.0</b>	<b>10.0</b>	<b>10.0</b>	<b>10.0</b>	
	<b>1†</b>	<b>0.06</b>	<b>3.48</b>	<b>10.95</b>	<b>3.92</b>	<b>3.92</b>					
Internal leakage	1*	0.05	3.15	9.94	3.56	3.56	2.0	10.0	10.0	10.0	
	1†	0.06	3.48	10.95	3.92	3.92					
<b>Incipient</b>	<b>3*</b>	<b>2.25</b>	<b>11.56</b>	<b>26.81</b>	<b>7.90</b>	<b>10.69</b>	<b>2.0</b>	<b>6.0</b>	<b>6.0</b>	<b>6.0</b>	
	<b>3†</b>	<b>3.47</b>	<b>12.30</b>	<b>25.56</b>	<b>6.98</b>	<b>11.75</b>					
Internal leakage	1*	0.05	3.15	9.94	3.56	3.56	2.0	6.0	6.0	6.0	
	1†	0.06	3.48	10.95	3.92	3.92					
Other	2*	0.03	9.49	37.21	13.83	7.13	-	-	-	-	
	2†	0.04	9.86	38.03	14.04	7.83					
<b>Unknown</b>	<b>1*</b>	<b>0.07</b>	<b>4.34</b>	<b>13.67</b>	<b>4.89</b>	<b>3.56</b>	<b>4.5</b>	<b>9.0</b>	<b>9.0</b>	<b>9.0</b>	
	<b>1†</b>	<b>0.17</b>	<b>4.51</b>	<b>13.61</b>	<b>4.63</b>	<b>3.92</b>					
Unknown	1*	0.07	4.34	13.67	4.89	3.56	4.5	9.0	9.0	9.0	
	1†	0.17	4.51	13.61	4.63	3.92					
<b>All modes</b>	<b>9*</b>	<b>0.21</b>	<b>37.86</b>	<b>134.63</b>	<b>49.74</b>	<b>32.07</b>	<b>13.7</b>	<b>6.0</b>	<b>29.0</b>	<b>109.0</b>	
	<b>9†</b>	<b>0.27</b>	<b>39.75</b>	<b>137.51</b>	<b>50.71</b>	<b>35.25</b>					
Comments											

Taxonomy no 3.1.3.4		Item Mechanical Equipment Heat Exchangers Plate - conventional Water/glycol->Water/glycol								
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0702		Operational time † 0.0690						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	1*	0.71	14.25	67.62	14.25	14.25	12.0	24.0	24.0	24.0
	1†	0.72	14.49	68.77	14.49	14.49				
External leakage - Process medium	1*	0.71	14.25	67.62	14.25	14.25	12.0	24.0	24.0	24.0
	1†	0.72	14.49	68.77	14.49	14.49				
<b>Degraded</b>	1*	0.71	14.25	67.62	14.25	14.25	12.0	24.0	24.0	24.0
	1†	0.72	14.49	68.77	14.49	14.49				
Internal leakage	1*	0.71	14.25	67.62	14.25	14.25	12.0	24.0	24.0	24.0
	1†	0.72	14.49	68.77	14.49	14.49				
<b>Incipient</b>	1*	0.71	14.25	67.62	14.25	14.25	2.0	4.0	4.0	4.0
	1†	0.72	14.49	68.77	14.49	14.49				
Abnormal instrument reading	1*	0.71	14.25	67.62	14.25	14.25	2.0	4.0	4.0	4.0
	1†	0.72	14.49	68.77	14.49	14.49				
<b>All modes</b>	3*	11.68	42.75	110.51	42.75	42.75	8.7	4.0	17.3	24.0
	3†	11.88	43.48	112.39	43.48	43.48				
<b>Comments</b>										

Taxonomy no 3.1.4		Item Mechanical Equipment Heat Exchangers Printed circuit								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0263		Operational time † 0.0165						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Degraded	9*	178.65	342.47	597.60	342.47	342.47	3.7	2.0	3.7	6.0
	9†	283.99	544.40	949.98	544.40	544.40				
Plugged/Choked	9*	178.65	342.47	597.60	342.47	342.47	3.7	2.0	3.7	6.0
		9†	283.99	544.40	949.98	544.40				
All modes	9*	178.65	342.47	597.60	342.47	342.47	3.7	2.0	3.7	6.0
	9†	283.99	544.40	949.98	544.40	544.40				
Comments										

**Maintainable item versus failure mode, to be continued**

Item: Heat Exchangers - Printed circuit

	AIR	ELP	ELU	IHT	INL	OTH
Subunit	0.00	0.00	0.00	0.00	0.00	0.00
Support	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00

**Maintainable item versus failure mode, continued**

Item: Heat Exchangers - Printed circuit

	PDE	PLU	SER	STD	UNK	Sum
Subunit	0.00	55.56	0.00	0.00	0.00	55.56
Support	0.00	11.11	0.00	0.00	0.00	11.11
Unknown	0.00	33.33	0.00	0.00	0.00	33.33
Total	0.00	100.0	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Heat Exchangers - Printed circuit

	AIR	ELP	ELU	IHT	INL	OTH
Wear	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00

**Failure descriptor versus failure mode, continued**

Item: Heat Exchangers - Printed circuit

	PDE	PLU	SER	STD	UNK	Sum
Wear	0.00	100.0	0.00	0.00	0.00	100.0
Total	0.00	100.0	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 3.1.4.1		Item Mechanical Equipment Heat Exchangers Printed circuit Gas->Water/glycol								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0263			Operational time † 0.0165					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	g*	178.65	342.47	597.60	342.47	342.47	3.7	2.0	3.7	6.0
Plugged/Choked	g†	283.99	544.40	949.98	544.40	544.40	3.7	2.0	3.7	6.0
	g*	178.65	342.47	597.60	342.47	342.47				
All modes	g*	178.65	342.47	597.60	342.47	342.47	3.7	2.0	3.7	6.0
	g†	283.99	544.40	949.98	544.40	544.40				
Comments										

Taxonomy no 3.1.5		Item Mechanical Equipment Heat Exchangers Shell and tube								
Population 42	Installations 7	Aggregated time in service (10 <sup>6</sup> hours)					No of demands 97740			
		Calendar time * 0.9771		Operational time † 0.8685						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>12*</b> <b>12†</b>	<b>0.00</b>	<b>8.58</b>	<b>36.72</b>	<b>14.20</b>	<b>12.28</b>	<b>39.5</b>	<b>12.0</b>	<b>73.0</b>	<b>311.0</b>
Abnormal instrument reading	1* 1†	0.00	1.03	5.36	2.40	1.02	-	12.0	12.0	12.0
External leakage - Process medium	1* 1†	0.00	1.03	5.36	2.40	1.02	-	-	-	-
Parameter deviation	1* 1†	0.00	0.89	3.68	1.40	1.02	30.0	60.0	60.0	60.0
Structural deficiency	9* 9†	0.00	5.72	30.70	14.19	9.21	40.5	28.0	81.2	311.0
<b>Degraded</b>	<b>6*</b> <b>6†</b>	<b>0.00</b>	<b>6.27</b>	<b>27.61</b>	<b>10.83</b>	<b>6.14</b>	<b>10.0</b>	<b>1.0</b>	<b>7.3</b>	<b>16.0</b>
External leakage - Process medium	1* 1†	0.00	1.15	4.58	1.71	1.02	10.0	10.0	10.0	10.0
External leakage - Utility medium	3* 3†	0.00	3.03	14.64	6.05	3.07	-	1.0	3.3	6.0
Parameter deviation	2* 2†	0.00	2.06	8.70	3.34	2.05	-	8.0	12.0	16.0
<b>Incipient</b>	<b>54*</b> <b>54†</b>	<b>5.54</b>	<b>55.58</b>	<b>150.24</b>	<b>48.19</b>	<b>55.26</b>	<b>46.1</b>	<b>1.5</b>	<b>32.1</b>	<b>279.0</b>
Abnormal instrument reading	14* 14†	0.31	17.39	54.31	19.33	14.33	1.5	1.5	5.8	23.0
External leakage - Process medium	8* 8†	0.00	7.67	41.17	19.02	8.19	-	2.0	2.4	4.0
External leakage - Utility medium	3* 3†	0.00	3.03	14.64	6.05	3.07	-	2.0	5.3	8.0
Minor in-service problems	10* 10†	0.16	13.29	42.86	15.55	10.23	12.0	2.0	18.1	76.0
Other	2* 2†	0.00	1.63	7.16	2.80	2.05	25.0	35.0	50.0	65.0
Parameter deviation	6* 6†	0.07	4.94	15.62	5.61	6.14	56.0	4.0	94.0	146.0
Plugged/Choked	1* 1†	0.00	1.03	5.36	2.40	1.02	-	5.0	5.0	5.0
Structural deficiency	10* 10†	0.08	8.07	26.45	9.65	10.23	58.1	2.0	78.7	279.0
<b>All modes</b>	<b>72*</b> <b>72†</b>	<b>6.93</b>	<b>69.62</b>	<b>188.25</b>	<b>60.39</b>	<b>73.69</b>	<b>42.2</b>	<b>1.0</b>	<b>36.5</b>	<b>311.0</b>
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: *** = 0.0- 10 <sup>0</sup>										

**Maintainable item versus failure mode, to be continued**

**Item:** Heat Exchangers - Shell and tube

	AIR	ELP	ELU	IHT	INL	OTH
Body/shell	0.00	0.00	0.00	0.00	0.00	1.39
Instrument, flow	4.17	0.00	0.00	0.00	0.00	0.00
Instrument, level	1.39	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	4.17	0.00	1.39	0.00	0.00	0.00
Instrument, temperature	8.33	0.00	1.39	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	0.00	0.00	0.00	0.00
Seals (gaskets)	0.00	0.00	1.39	0.00	0.00	0.00
Subunit	0.00	1.39	0.00	0.00	0.00	0.00
Support	0.00	0.00	0.00	0.00	0.00	0.00
Tubes	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	1.39	0.00	0.00	0.00	1.39
Valves	2.78	11.11	4.17	0.00	0.00	0.00
Total	20.83	13.89	8.33	0.00	0.00	2.78

**Maintainable item versus failure mode, continued**

**Item:** Heat Exchangers - Shell and tube

	PDE	PLU	SER	STD	UNK	Sum
Body/shell	2.78	0.00	1.39	8.33	0.00	13.89
Instrument, flow	0.00	0.00	1.39	0.00	0.00	5.56
Instrument, level	0.00	0.00	0.00	0.00	0.00	1.39
Instrument, pressure	0.00	0.00	1.39	2.78	0.00	9.72
Instrument, temperature	0.69	0.00	1.39	0.00	0.00	11.81
Other	0.00	0.00	1.39	0.00	0.00	1.39
Piping	1.39	0.00	0.00	12.50	0.00	13.89
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	1.39
Subunit	0.00	0.00	0.00	0.00	0.00	1.39
Support	0.00	0.00	2.78	0.00	0.00	2.78
Tubes	4.17	0.00	0.00	0.00	0.00	4.17
Unknown	0.00	0.00	4.17	0.00	0.00	6.94
Valves	3.47	1.39	0.00	2.78	0.00	25.69
Total	12.50	1.39	13.89	26.39	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Heat Exchangers - Shell and tube

	AIR	ELP	ELU	IHT	INL	OTH
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00
Breakage	1.39	0.00	1.39	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	2.78	1.39	0.00	0.00	0.00	0.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	1.39	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	4.17	0.00	2.78	0.00	0.00	0.00
Leakage	0.00	11.11	0.00	0.00	0.00	0.00
Looseness	0.00	0.00	1.39	0.00	0.00	0.00
Material failure - general	0.00	0.00	1.39	0.00	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	2.78	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	1.39
Out of adjustment	5.56	0.00	1.39	0.00	0.00	0.00
Sticking	1.39	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	1.39
Vibration	0.00	0.00	0.00	0.00	0.00	0.00
Wear	1.39	1.39	0.00	0.00	0.00	0.00
Total	20.83	13.89	8.33	0.00	0.00	2.78

**Failure descriptor versus failure mode, continued**

**Item:** Heat Exchangers - Shell and tube

	PDE	PLU	SER	STD	UNK	Sum
Blockage/plugged	2.78	0.00	0.00	2.78	0.00	5.56
Breakage	0.00	0.00	0.00	2.78	0.00	5.56
Cavitation	0.00	0.00	0.00	2.78	0.00	2.78
Corrosion	1.39	0.00	5.56	9.72	0.00	20.83
Deformation	0.00	0.00	1.39	0.00	0.00	1.39
External influence - general	4.17	0.00	0.00	4.17	0.00	8.33
Faulty signal/indication/alarm	1.39	0.00	0.00	0.00	0.00	2.78
Instrument failure - general	1.39	0.00	0.00	0.00	0.00	8.33
Leakage	0.00	0.00	2.78	0.00	0.00	13.89
Looseness	0.00	0.00	0.00	0.00	0.00	1.39
Material failure - general	0.00	0.00	0.00	0.00	0.00	1.39
Mechanical Failure - general	0.00	0.00	4.17	0.00	0.00	4.17
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	2.78
Other	0.00	0.00	0.00	1.39	0.00	2.78
Out of adjustment	0.00	0.00	0.00	0.00	0.00	6.94
Sticking	1.39	1.39	0.00	0.00	0.00	4.17
Unknown	0.00	0.00	0.00	0.00	0.00	1.39
Vibration	0.00	0.00	0.00	2.78	0.00	2.78
Wear	0.00	0.00	0.00	0.00	0.00	2.78
Total	12.50	1.39	13.89	26.39	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.



Taxonomy no 3.1.5.1		Item Mechanical Equipment Heat Exchangers Shell and tube Condensate->Gas								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0493		Operational time † 0.0365						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Incipient	1*	1.01	20.30	96.30	20.30	20.30	1.5	1.5	1.5	1.5
	1†	1.37	27.39	129.99	27.39	27.39				
Abnormal instrument reading	1*	1.01	20.30	96.30	20.30	20.30	1.5	1.5	1.5	1.5
	1†	1.37	27.39	129.99	27.39	27.39				
All modes	1*	1.01	20.30	96.30	20.30	20.30	1.5	1.5	1.5	1.5
	1†	1.37	27.39	129.99	27.39	27.39				
Comments										

Taxonomy no 3.1.5.2		Item Mechanical Equipment Heat Exchangers Shell and tube Crude Oil->Water/glycol									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0306		Operational time † 0.0306							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
All modes		0* 0†	0.05 0.05	13.22 13.76	50.75 52.83	18.69 19.46	0.00 0.00	-	-	-	-
Comments											

Taxonomy no 3.1.5.3		Item Mechanical Equipment Heat Exchangers Shell and tube Flare Gas->Water/glycol								
Population 4	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1226		Operational time † 0.1225						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
All modes	0* 0†	0.02 0.02	3.85 3.90	14.79 14.98	5.45 5.52	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 3.1.5.4		Item Mechanical Equipment Heat Exchangers Shell and tube Gas->Condensate								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0175		Operational time † 0.0175						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	2*	20.26	114.16	359.30	114.16	114.16	-	5.0	5.0	5.0
	2†	20.26	114.16	359.30	114.16	114.16				
Abnormal instrument reading	1*	2.85	57.08	270.83	57.08	57.08	-	5.0	5.0	5.0
	1†	2.85	57.08	270.83	57.08	57.08				
Structural deficiency	1*	2.85	57.08	270.83	57.08	57.08	-	5.0	5.0	5.0
	1†	2.85	57.08	270.83	57.08	57.08				
All modes	2*	20.26	114.16	359.30	114.16	114.16	-	5.0	5.0	5.0
	2†	20.26	114.16	359.30	114.16	114.16				
Comments										

Taxonomy no 3.1.5.5		Item Mechanical Equipment Heat Exchangers Shell and tube Gas->Freshwater									
Population 6	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1051		Operational time † 0.0701			Active rep.hrs	Repair (manhours)			
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ	Min		Mean	Max	
<b>Degraded</b>	2*	2.56	17.56	43.78	13.45	19.03	-	1.0	8.5	16.0	
	2†	1.43	28.52	85.40	28.51	28.53					
External leakage - Utility medium	1*	0.11	8.72	27.92	10.09	9.51	-	1.0	1.0	1.0	
	1†	0.06	14.26	54.76	20.17	14.26					
Parameter deviation	1*	0.11	8.72	27.92	10.09	9.51	-	16.0	16.0	16.0	
	1†	0.06	14.26	54.76	20.17	14.26					
<b>Incipient</b>	19*	113.41	175.62	248.91	41.47	180.75	-	2.0	7.6	27.0	
	19†	41.72	270.98	667.11	203.60	271.03					
Abnormal instrument reading	7*	30.60	65.86	111.94	25.17	66.59	-	2.0	6.8	23.0	
	7†	46.85	99.85	168.89	37.74	99.85					
External leakage - Utility medium	3*	5.38	26.16	59.84	17.48	28.54	-	2.0	5.3	8.0	
	3†	0.56	42.78	136.77	49.39	42.79					
Minor in-service problems	5*	19.37	48.30	87.76	21.27	47.56	-	2.0	13.0	27.0	
	5†	28.10	71.32	130.59	31.90	71.32					
Parameter deviation	1*	0.11	8.72	27.92	10.09	9.51	-	4.0	4.0	4.0	
	1†	0.06	14.26	54.76	20.17	14.26					
Plugged/Choked	1*	0.11	8.72	27.92	10.09	9.51	-	5.0	5.0	5.0	
	1†	0.06	14.26	54.76	20.17	14.26					
Structural deficiency	2*	2.56	17.56	43.78	13.45	19.03	-	3.0	3.0	3.0	
	2†	1.43	28.52	85.40	28.51	28.53					
<b>All modes</b>	21*	99.02	189.47	303.60	63.01	199.77	-	1.0	7.7	27.0	
	21†	34.71	299.50	781.08	245.26	299.55					
<b>Comments</b>											

<b>Taxonomy no</b> 3.1.5.6		<b>Item</b> Mechanical Equipment Heat Exchangers Shell and tube Gas->Gas								
<b>Population</b> 2	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b> 21720			
		<b>Calendar time *</b> 0.0350			<b>Operational time †</b> 0.0333					
<b>Failure mode</b>	<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours).</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
		<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n / <math>\tau</math></b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>		0* 0†	0.05 0.05	11.84 12.82	45.47 49.24	16.75 18.13	0.00 0.00	-	-	-
<b>Comments</b> On demand probability for consequence class: Critical and failure mode: *** = 0.0 10 <sup>0</sup>										

Taxonomy no 3.1.5.7		Item Mechanical Equipment Heat Exchangers Shell and tube Gas->Gas/condensate									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0175		Operational time † 0.0175							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
Incipient	1*	2.85	57.08	270.83	57.08	57.08	-	5.0	5.0	5.0	
	1†	2.85	57.08	270.83	57.08	57.08	-	5.0	5.0	5.0	
Minor in-service problems	1*	2.85	57.08	270.83	57.08	57.08	-	5.0	5.0	5.0	
	1†	2.85	57.08	270.83	57.08	57.08	-	5.0	5.0	5.0	
All modes	1*	2.85	57.08	270.83	57.08	57.08	-	5.0	5.0	5.0	
	1†	2.85	57.08	270.83	57.08	57.08	-	5.0	5.0	5.0	
Comments											

Taxonomy no 3.1.5.8		Item Mechanical Equipment Heat Exchangers Shell and tube Gas->Sea Water								
Population 7	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
		0.1717		0.1647						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>10*</b>	<b>31.60</b>	<b>58.24</b>	<b>98.78</b>	<b>58.24</b>	<b>58.24</b>	<b>39.5</b>	<b>28.0</b>	<b>79.1</b>	<b>311.0</b>
	<b>10†</b>	<b>32.94</b>	<b>60.72</b>	<b>102.98</b>	<b>60.72</b>	<b>60.72</b>				
Parameter deviation	1*	0.29	5.82	27.64	5.82	5.82	30.0	60.0	60.0	60.0
	1†	0.30	6.07	28.81	6.07	6.07				
Structural deficiency	9*	27.34	52.42	91.47	52.42	52.42	40.5	28.0	81.2	311.0
	9†	28.51	54.65	95.36	54.65	54.65				
<b>Incipient</b>	<b>13*</b>	<b>44.78</b>	<b>75.72</b>	<b>120.36</b>	<b>75.72</b>	<b>75.72</b>	<b>55.1</b>	<b>2.0</b>	<b>110.2</b>	<b>279.0</b>
	<b>13†</b>	<b>46.68</b>	<b>78.94</b>	<b>125.49</b>	<b>78.94</b>	<b>78.94</b>				
Other	1*	0.29	5.82	27.64	5.82	5.82	32.5	65.0	65.0	65.0
	1†	0.30	6.07	28.81	6.07	6.07				
Parameter deviation	5*	11.47	29.12	61.24	29.12	29.12	56.0	96.0	112.0	146.0
	5†	11.96	30.36	63.85	30.36	30.36				
Structural deficiency	7*	19.13	40.77	76.59	40.77	40.77	58.1	2.0	116.2	279.0
	7†	19.95	42.50	79.85	42.50	42.50				
<b>All modes</b>	<b>23*</b>	<b>91.55</b>	<b>133.96</b>	<b>189.78</b>	<b>133.96</b>	<b>133.96</b>	<b>48.0</b>	<b>2.0</b>	<b>96.0</b>	<b>311.0</b>
	<b>23†</b>	<b>95.44</b>	<b>139.66</b>	<b>197.85</b>	<b>139.66</b>	<b>139.66</b>				
<b>Comments</b>										



Taxonomy no		Item									
3.1.5.9		Mechanical Equipment Heat Exchangers Shell and tube Gas->Water/glycol									
Population	Installations	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *		Operational time †			76020				
11	2	0.2278		0.2189							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	1*	0.02	4.25	15.61	5.77	4.39	-	12.0	12.0	12.0	
	1†	0.02	4.44	16.44	6.07	4.57					
Abnormal instrument reading	1*	0.02	4.25	15.61	5.77	4.39	-	12.0	12.0	12.0	
	1†	0.02	4.44	16.44	6.07	4.57					
<b>Degraded</b>	1*	0.27	4.51	13.23	4.39	4.39	10.0	10.0	10.0	10.0	
	1†	0.27	4.67	13.75	4.57	4.57					
External leakage - Process medium	1*	0.27	4.51	13.23	4.39	4.39	10.0	10.0	10.0	10.0	
	1†	0.27	4.67	13.75	4.57	4.57					
<b>Incipient</b>	13*	1.28	54.12	166.32	58.29	57.08	12.0	2.0	4.8	18.0	
	13†	1.24	56.77	175.19	61.68	59.38					
Abnormal instrument reading	3*	0.31	12.60	38.65	13.52	13.17	-	4.0	7.3	12.0	
	3†	0.29	13.19	40.74	14.35	13.70					
External leakage - Process medium	8*	0.20	32.98	115.48	42.63	35.12	-	2.0	2.4	4.0	
	8†	0.21	34.65	121.82	44.98	36.54					
Minor in-service problems	2*	1.57	8.80	20.85	6.21	8.78	12.0	3.0	10.5	18.0	
	2†	1.63	9.15	21.69	6.46	9.14					
<b>All modes</b>	15*	5.60	63.03	174.38	56.57	65.86	11.0	2.0	5.6	18.0	
	15†	5.56	66.00	184.41	60.09	68.52					
<b>Comments</b>											
On demand probability for consequence class: Critical and failure mode: *** = 0.0 10 <sup>0</sup>											

Taxonomy no 3.1.5.10		Item Mechanical Equipment Heat Exchangers Shell and tube Hc-comb->Hc-comb								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0493		Operational time † 0.0365						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
All modes	0 <sup>*</sup> 0 <sup>†</sup>	0.03 0.05	8.86 11.84	34.01 45.48	12.53 16.75	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 3.1.5.11		Item Mechanical Equipment Heat Exchangers Shell and tube Oil->Fuel Gas									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0175		Operational time † 0.0088							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
Incipient	1*	2.85	57.08	270.83	57.08	57.08	-	2.0	2.0	2.0	
	1†	5.71	114.16	541.67	114.16	114.16	-	2.0	2.0	2.0	
Abnormal instrument reading	1*	2.85	57.08	270.83	57.08	57.08	-	2.0	2.0	2.0	
	1†	5.71	114.16	541.67	114.16	114.16	-	2.0	2.0	2.0	
All modes	1*	2.85	57.08	270.83	57.08	57.08	-	2.0	2.0	2.0	
	1†	5.71	114.16	541.67	114.16	114.16	-	2.0	2.0	2.0	
Comments											

Taxonomy no 3.1.5.12		Item Mechanical Equipment Heat Exchangers Shell and tube Oil->Water/glycol								
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0350		Operational time † 0.0175						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max
<b>Critical</b>	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-
External leakage - Process medium	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-
<b>Degraded</b>	3*	23.40	85.62	221.32	85.62	85.62	-	3.0	5.7	8.0
	3†	46.80	171.23	442.64	171.23	171.23	-	-	-	-
External leakage - Utility medium	2*	10.13	57.08	179.65	57.08	57.08	-	3.0	4.5	6.0
	2†	20.26	114.16	359.30	114.16	114.16	-	-	-	-
Parameter deviation	1*	1.43	28.54	135.42	28.54	28.54	-	8.0	8.0	8.0
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-
<b>Incipient</b>	3*	23.40	85.62	221.32	85.62	85.62	-	4.0	31.3	76.0
	3†	46.80	171.23	442.64	171.23	171.23	-	-	-	-
Abnormal instrument reading	1*	1.43	28.54	135.42	28.54	28.54	-	4.0	4.0	4.0
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-
Minor in-service problems	2*	10.13	57.08	179.65	57.08	57.08	-	14.0	45.0	76.0
	2†	20.26	114.16	359.30	114.16	114.16	-	-	-	-
<b>All modes</b>	7*	93.75	199.77	375.29	199.77	199.77	-	3.0	18.5	76.0
	7†	187.50	399.54	750.57	399.54	399.54	-	-	-	-
<b>Comments</b>										

Taxonomy no 3.1.5.13		Item Mechanical Equipment Heat Exchangers Shell and tube Water/glycol->Water/glycol									
Population 4	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0981		Operational time † 0.0941							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Incipient	1*	0.51	10.19	48.36	10.19	10.19	17.5	35.0	35.0	35.0	
	1†	0.53	10.63	50.43	10.63	10.63					
Other	1*	0.51	10.19	48.36	10.19	10.19	17.5	35.0	35.0	35.0	
	1†	0.53	10.63	50.43	10.63	10.63					
All modes	1*	0.51	10.19	48.36	10.19	10.19	17.5	35.0	35.0	35.0	
	1†	0.53	10.63	50.43	10.63	10.63					
Comments											

### Vessels

#### Inventory description

Boundary definition is shown in Figure 18, and definition of Subunits and Maintainable Items is shown in Table 13.

Inlet, outlet, pressure relief and drain valves are specifically excluded. The only valves are calibration valves and instrument valves that form a pressure boundary (e.g. block valves, control valves, calibration valves, local indicators/gauges).

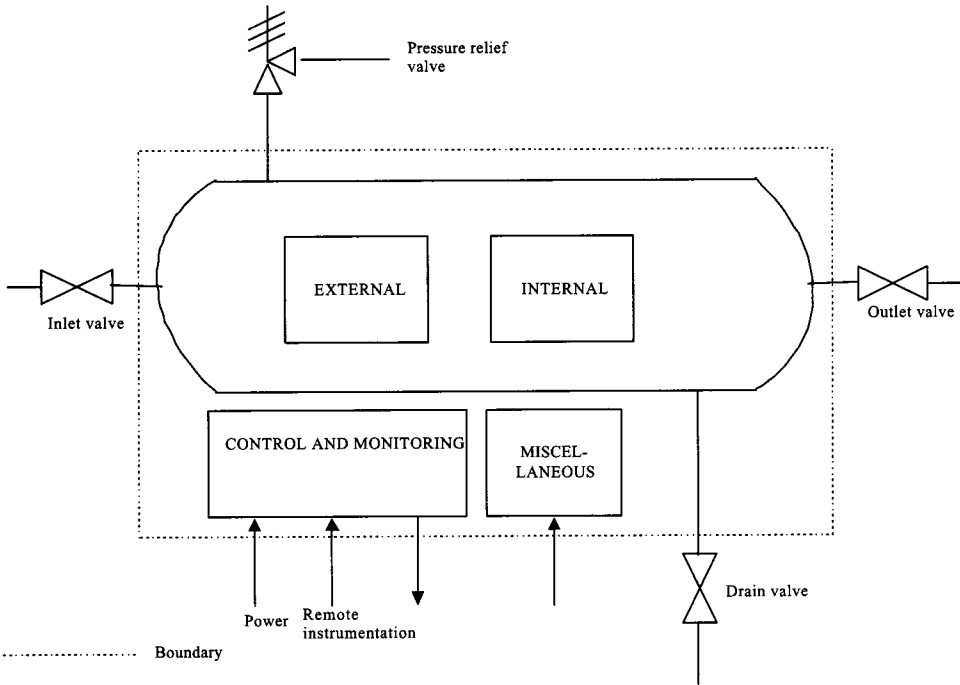


Figure 18 Vessels, Boundary Definition

**Table 13 Vessels, Subdivision in Maintainable Items**

VESSELS			
External	Internal	Control and Monitoring	Miscellaneous
<ul style="list-style-type: none"> <li>• Support</li> <li>• Body/Shell</li> <li>• Valves &amp; piping</li> <li>• Instruments</li> </ul>	<ul style="list-style-type: none"> <li>• Body/shell</li> <li>• Corrosion protection</li> <li>• Heater</li> <li>• Instruments</li> <li>• Plates, trays, vanes, pads</li> <li>• Sand trap system</li> </ul>	<ul style="list-style-type: none"> <li>• Actuating device</li> <li>• Cabling &amp; junction boxes</li> <li>• Control unit</li> <li>• Instruments</li> <li>• Monitoring</li> <li>• Internal power supply</li> <li>• Valves</li> </ul>	<ul style="list-style-type: none"> <li>• Others</li> </ul>

(For all subunits the MIs "Unknown" and "Subunit" are included.)

**List of failure modes**

- AIR Abnormal instrument reading
- ELP External leakage - Process medium
- ELU External leakage - Utility medium
- SER Minor in-service problems
- OTH Other
- PDE Parameter deviation
- PLU Plugged/Choked
- STD Structural deficiency
- UNK Unknown

Taxonomy no		Item								
3.2		Mechanical Equipment Vessels								
Population	Installations	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *			Operational time †					
199	20	7.9317			4.2609					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>124*</b>	<b>0.16</b>	<b>24.45</b>	<b>84.75</b>	<b>31.26</b>	<b>15.63</b>	<b>8.7</b>	<b>1.0</b>	<b>18.3</b>	<b>264.0</b>
	<b>124†</b>	<b>0.17</b>	<b>28.93</b>	<b>102.54</b>	<b>37.87</b>	<b>29.10</b>				
Abnormal instrument reading	57*	0.00	9.83	46.87	19.25	7.19	6.2	1.0	10.7	74.0
	57†	0.00	10.45	54.06	23.76	13.38				
External leakage - Process medium	28*	0.00	2.87	16.51	9.17	3.53	9.3	1.0	28.6	264.0
	28†	0.00	4.40	24.19	11.60	6.57				
External leakage - Utility medium	2*	0.00	0.70	3.34	1.38	0.25	9.0	4.0	18.0	32.0
	2†	0.00	0.75	3.67	1.55	0.47				
Other	11*	0.00	2.86	13.37	5.43	1.39	6.4	1.0	12.1	45.0
	11†	0.00	3.10	15.54	6.65	2.58				
Parameter deviation	10*	0.16	1.33	3.43	1.07	1.26	26.4	1.0	42.7	155.0
	10†	0.00	2.66	10.70	4.02	2.35				
Plugged/Choked	5*	0.00	1.53	8.01	3.60	0.63	2.5	2.0	9.2	22.0
	5†	0.00	2.04	10.59	4.71	1.17				
Structural deficiency	10*	0.00	4.71	23.11	9.71	1.26	9.7	4.0	19.4	36.0
	10†	0.00	4.97	27.35	12.90	2.35				
Unknown	1*	0.00	0.32	1.78	0.91	0.13	-	-	-	-
	1†	0.00	0.35	1.94	0.99	0.23				
<b>Degraded</b>	<b>240*</b>	<b>0.00</b>	<b>24.66</b>	<b>113.21</b>	<b>45.34</b>	<b>30.26</b>	<b>9.3</b>	<b>1.0</b>	<b>24.3</b>	<b>2228.9</b>
	<b>240†</b>	<b>0.14</b>	<b>46.92</b>	<b>183.48</b>	<b>68.13</b>	<b>56.33</b>				
Abnormal instrument reading	57*	0.00	4.35	17.71	20.39	7.19	6.3	1.0	9.5	64.0
	57†	0.00	5.58	26.32	25.49	13.38				
External leakage - Process medium	35*	0.01	4.77	19.14	7.18	4.41	5.8	1.0	7.3	25.0
	35†	0.06	8.11	27.92	10.29	8.21				
External leakage - Utility medium	12*	0.00	2.11	10.82	4.69	1.51	10.1	4.0	15.5	40.0
	12†	0.00	2.38	12.26	5.35	2.82				
Other	43*	0.01	6.56	26.49	9.97	5.42	11.7	1.0	15.9	249.0
	43†	0.06	9.46	33.14	12.23	10.09				
Parameter deviation	28*	0.00	2.44	13.82	7.38	3.53	13.0	1.0	24.1	199.0
	28†	0.00	5.25	25.34	10.46	6.57				
Plugged/Choked	50*	1.09	5.23	11.94	3.48	6.30	10.6	1.0	56.8	2228.9
	50†	0.00	15.21	69.25	27.59	11.73				
Structural deficiency	15*	0.00	2.14	11.15	4.97	1.89	10.4	1.0	43.3	380.0
	15†	0.00	2.43	12.63	5.61	3.52				
<b>Incipient</b>	<b>1105*</b>	<b>0.00</b>	<b>132.17</b>	<b>628.36</b>	<b>257.74</b>	<b>139.32</b>	<b>6.3</b>	<b>0.5</b>	<b>9.4</b>	<b>594.0</b>
	<b>1105†</b>	<b>0.03</b>	<b>175.51</b>	<b>781.36</b>	<b>308.37</b>	<b>259.34</b>				
Abnormal instrument reading	755*	0.00	69.22	388.80	204.72	95.19	5.2	1.0	6.4	97.0
	755†	0.00	93.66	514.84	251.96	177.19				
External leakage - Process medium	60*	0.01	11.22	46.82	17.87	7.56	3.7	1.0	14.4	79.0
	60†	0.02	20.86	87.22	33.33	14.08				
External leakage - Utility medium	18*	0.01	4.64	18.54	6.94	2.27	11.2	2.0	15.8	54.0
	18†	0.00	5.15	21.76	8.36	4.22				
<b>Comments</b>										

(cont.)



Taxonomy no 3.2		Item Mechanical Equipment Vessels								
Population 199	Installations 20	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
		7.9317		4.2609						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Minor in-service problems	132*	0.00	16.20	83.05	35.97	16.64	7.4	1.0	11.2	217.0
	132†	0.00	17.44	92.97	42.69	30.98				
Other	46*	0.55	11.65	34.94	11.71	5.80	24.6	1.0	35.8	594.0
	46†	0.40	12.57	38.13	13.12	10.80				
Parameter deviation	32*	0.13	8.76	27.71	9.95	4.03	4.8	0.5	6.9	40.0
	32†	0.15	12.98	41.86	15.18	7.51				
Plugged/Choked	34*	0.00	3.03	16.78	8.61	4.29	7.3	1.0	11.1	104.0
	34†	0.00	5.80	28.84	12.27	7.98				
Structural deficiency	24*	0.01	5.55	22.16	8.29	3.03	18.4	1.0	32.0	179.0
	24†	0.00	5.98	25.62	9.91	5.63				
Unknown	4*	0.00	0.60	2.74	1.09	0.50	4.0	1.0	4.5	11.0
	4†	0.00	0.73	4.02	2.06	0.94				
<b>Unknown</b>	24*	<b>0.00</b>	<b>3.94</b>	<b>18.74</b>	<b>7.69</b>	<b>3.03</b>	<b>10.3</b>	<b>1.0</b>	<b>20.1</b>	<b>84.0</b>
	24†	<b>0.00</b>	<b>4.68</b>	<b>22.29</b>	<b>9.15</b>	<b>5.63</b>				
Abnormal instrument reading	5*	0.00	0.65	2.85	1.11	0.63	15.2	6.0	33.5	49.0
	5†	0.00	0.89	3.59	1.35	1.17				
External leakage - Process medium	2*	0.00	0.36	2.00	0.97	0.25	-	9.0	9.5	10.0
	2†	0.00	0.47	2.05	0.80	0.47				
Other	3*	0.00	1.54	7.59	3.21	0.38	-	12.0	26.7	52.0
	3†	0.00	1.62	8.88	4.16	0.70				
Parameter deviation	1*	0.00	0.11	0.35	0.13	0.13	-	-	-	-
	1†	0.00	0.39	2.20	1.16	0.23				
Unknown	13*	0.00	1.66	9.11	4.29	1.64	8.6	1.0	15.4	84.0
	13†	0.00	1.91	10.28	4.75	3.05				
<b>All modes</b>	<b>1493*</b>	<b>0.03</b>	<b>185.04</b>	<b>826.67</b>	<b>326.82</b>	<b>188.23</b>	<b>7.0</b>	<b>0.5</b>	<b>12.8</b>	<b>2228.9</b>
	<b>1493†</b>	<b>0.37</b>	<b>255.91</b>	<b>1042.69</b>	<b>394.06</b>	<b>350.40</b>				
<b>Comments</b>										

**Maintainable item versus failure mode, to be continued**

**Item: Vessels**

	AIR	ELP	ELU	OTH	PDE
Actuating device	0.20	0.03	0.07	0.20	0.13
Body/shell	0.00	0.07	0.13	0.27	0.13
Cabling & junction boxes	0.13	0.00	0.00	0.13	0.00
Control unit	0.80	0.00	0.00	0.27	0.07
Heater	0.03	0.13	0.07	0.27	0.80
Instrument, flow	4.19	0.00	0.00	0.00	0.33
Instrument, general	0.67	0.00	0.00	0.00	0.00
Instrument, level	42.03	0.80	0.27	0.64	2.24
Instrument, pressure	2.34	0.07	0.07	0.27	0.00
Instrument, temperature	1.00	0.00	0.00	0.00	0.00
Internal power supply	0.20	0.00	0.07	0.07	0.00
Monitoring	0.27	0.00	0.00	0.13	0.00
Other	0.00	0.87	0.07	0.20	0.00
Piping	0.03	0.87	0.07	0.13	0.00
Plates, trays, vanes, pads	0.00	0.00	0.00	0.00	0.00
Sand trap system	0.00	0.00	0.00	0.00	0.00
Subunit	0.27	0.27	0.00	0.07	0.00
Support	0.00	0.00	0.00	0.07	0.00
Unknown	1.00	0.20	0.07	0.47	0.20
Valves	5.36	5.06	1.27	3.72	0.84
Total	58.54	8.37	2.14	6.90	4.76

**Maintainable item versus failure mode, continued**

**Item: Vessels**

	PLU	SER	STD	UNK	Sum
Actuating device	0.00	0.00	0.00	0.00	0.64
Body/shell	0.00	0.27	0.87	0.00	1.74
Cabling & junction boxes	0.00	0.13	0.07	0.00	0.47
Control unit	0.07	0.00	0.00	0.00	1.21
Heater	0.00	0.27	0.00	0.07	1.64
Instrument, flow	0.00	0.20	0.00	0.00	4.72
Instrument, general	0.00	0.33	0.03	0.00	1.04
Instrument, level	0.13	1.34	0.00	0.27	47.72
Instrument, pressure	0.00	0.20	0.00	0.07	3.01
Instrument, temperature	0.00	0.00	0.07	0.00	1.07
Internal power supply	0.00	0.07	0.00	0.00	0.40
Monitoring	0.00	0.07	0.00	0.00	0.47
Other	0.13	0.47	0.07	0.00	1.81
Piping	0.07	1.14	0.90	0.00	3.22
Plates, trays, vanes, pads	0.00	0.13	0.00	0.00	0.13
Sand trap system	0.47	0.00	0.00	0.00	0.47
Subunit	2.21	0.47	0.13	0.00	3.42
Support	0.00	0.07	0.13	0.00	0.27
Unknown	0.20	0.54	0.20	0.27	3.15
Valves	2.68	3.15	0.80	0.54	23.41
Total	5.96	8.84	3.28	1.21	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Vessels

	AIR	ELP	ELU	OTH	PDE
Blockage/plugged	7.37	0.07	0.00	0.33	0.20
Breakage	0.40	0.07	0.20	0.27	0.20
Burst	0.00	0.00	0.00	0.00	0.00
Cavitation	0.13	0.00	0.07	0.07	0.00
Clearance/ alignment failure	0.13	0.00	0.07	0.07	0.00
Combined causes	0.07	0.07	0.00	0.00	0.07
Common mode failure	0.07	0.00	0.00	0.00	0.07
Contamination	0.13	0.00	0.00	0.00	0.00
Control failure	0.47	0.00	0.00	0.20	0.20
Corrosion	0.47	0.07	0.07	0.74	0.00
Deformation	0.07	0.00	0.00	0.13	0.00
Earth/isolation fault	0.47	0.00	0.00	0.00	0.07
Electrical failure - general	0.54	0.00	0.00	0.20	0.54
Erosion	0.00	1.47	0.00	0.00	0.13
External influence - general	0.07	0.00	0.00	0.07	0.00
Fatigue	0.00	0.07	0.00	0.00	0.00
Faulty signal/indication/alarm	4.82	0.07	0.00	0.07	0.13
Instrument failure - general	18.62	0.00	0.13	0.67	1.14
Leakage	0.27	3.48	0.74	0.47	0.00
Looseness	0.13	0.47	0.07	0.00	0.00
Material failure - general	0.00	0.33	0.07	0.40	0.13
Mechanical Failure - general	2.14	0.67	0.20	0.80	0.13
Misc. external influences	1.41	0.00	0.00	0.33	0.20
Miscellaneous - general	0.00	0.00	0.00	0.27	0.00
No cause found	0.07	0.07	0.07	0.07	0.07
No signal/indication/alarm	1.41	0.00	0.00	0.07	0.00
Open circuit	0.13	0.00	0.00	0.00	0.00
Other	0.00	0.07	0.00	0.13	0.00
Out of adjustment	18.35	0.00	0.07	0.67	1.21
Overheating	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.07	0.00	0.00	0.13	0.00
Sticking	0.20	0.00	0.07	0.07	0.00
Unknown	0.13	0.07	0.07	0.20	0.20
Vibration	0.20	0.00	0.00	0.00	0.00
Wear	0.20	1.34	0.27	0.47	0.07
Total	58.54	8.37	2.14	6.90	4.76

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

Item: Vessels

	PLU	SER	STD	UNK	Sum
Blockage/plugged	3.68	0.74	0.00	0.07	12.46
Breakage	0.07	0.13	0.00	0.00	1.34
Burst	0.00	0.13	0.00	0.00	0.13
Cavitation	0.00	0.00	0.67	0.00	0.94
Clearance/ alignment failure	0.20	0.07	0.00	0.00	0.54
Combined causes	0.27	0.00	0.00	0.00	0.47
Common mode failure	0.00	0.00	0.00	0.00	0.13
Contamination	0.07	0.07	0.00	0.00	0.27
Control failure	0.07	0.00	0.00	0.00	0.94
Corrosion	0.20	0.87	1.34	0.00	3.75
Deformation	0.00	0.00	0.07	0.00	0.27
Earth/isolation fault	0.00	0.13	0.00	0.00	0.67
Electrical failure - general	0.00	0.20	0.00	0.07	1.54
Erosion	0.00	0.00	0.00	0.00	1.61
External influence - general	0.07	0.47	0.00	0.00	0.67
Fatigue	0.00	0.00	0.00	0.00	0.07
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	5.09
Instrument failure - general	0.33	1.21	0.13	0.67	22.91
Leakage	0.00	0.20	0.27	0.00	5.43
Looseness	0.00	0.00	0.00	0.00	0.67
Material failure - general	0.00	0.87	0.07	0.00	1.88
Mechanical Failure - general	0.33	0.87	0.40	0.07	5.63
Misc. external influences	0.13	1.61	0.27	0.00	3.95
Miscellaneous - general	0.00	0.00	0.00	0.00	0.27
No cause found	0.00	0.00	0.00	0.00	0.33
No signal/indication/alarm	0.00	0.00	0.00	0.07	1.54
Open circuit	0.00	0.00	0.00	0.00	0.13
Other	0.00	0.27	0.00	0.07	0.54
Out of adjustment	0.07	0.27	0.00	0.07	20.70
Overheating	0.07	0.00	0.00	0.00	0.07
Short circuiting	0.00	0.00	0.00	0.00	0.20
Sticking	0.13	0.20	0.00	0.00	0.67
Unknown	0.13	0.20	0.00	0.13	1.14
Vibration	0.00	0.07	0.07	0.00	0.33
Wear	0.13	0.27	0.00	0.00	2.75
Total	5.96	8.84	3.28	1.21	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 3.2.1		Item Mechanical Equipment Vessels Coalescer								
Population 7	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
		0.2147		0.1985						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max
<b>Critical</b>	7* 7†	<b>0.24</b> <b>0.18</b>	<b>30.21</b> <b>34.37</b>	<b>102.24</b> <b>124.30</b>	<b>37.59</b> <b>45.93</b>	<b>32.60</b> <b>35.27</b>	<b>28.0</b>	<b>2.0</b>	<b>55.4</b>	<b>155.0</b>
Abnormal instrument reading	3*	0.06	12.53	46.22	17.07	13.97	3.8	2.0	6.3	15.0
Parameter deviation	3†	0.03	14.25	57.12	21.42	15.12				
	4*	3.29	18.59	44.12	13.16	18.63	46.1	10.0	92.3	155.0
<b>Degraded</b>	4†	2.19	20.63	54.99	17.50	20.16				
	29*	<b>0.68</b>	<b>119.30</b>	<b>422.93</b>	<b>156.22</b>	<b>135.05</b>	<b>19.3</b>	<b>1.0</b>	<b>36.0</b>	<b>249.0</b>
Abnormal instrument reading	29†	<b>0.61</b>	<b>136.63</b>	<b>508.27</b>	<b>187.65</b>	<b>146.13</b>				
	5*	0.01	19.74	85.86	33.38	23.29	7.4	4.0	10.4	16.0
External leakage - Process medium	5†	0.00	23.00	102.33	40.37	25.19				
	3*	3.94	14.13	29.45	8.07	13.97	4.3	2.0	8.7	18.0
External leakage - Utility medium	3†	4.41	15.47	32.03	8.73	15.12				
	2*	0.05	10.10	36.93	13.64	9.31	12.0	4.0	22.0	40.0
Other	2†	0.07	10.98	38.26	14.12	10.08				
	5*	3.22	24.28	61.72	19.16	23.29	33.0	3.0	64.8	249.0
Parameter deviation	5†	3.04	26.78	70.23	22.13	25.19				
	12*	0.00	44.77	216.06	89.19	55.88	24.6	1.0	48.4	199.0
Plugged/Choked	12†	0.00	53.34	256.53	105.75	60.47				
	2*	1.33	8.73	21.55	6.59	9.31	14.5	14.0	14.5	15.0
<b>Incipient</b>	2†	1.35	9.30	23.18	7.13	10.08				
	124*	<b>0.54</b>	<b>479.75</b>	<b>1981.98</b>	<b>752.88</b>	<b>577.47</b>	<b>5.8</b>	<b>1.0</b>	<b>8.3</b>	<b>165.0</b>
Abnormal instrument reading	124†	<b>0.49</b>	<b>561.26</b>	<b>2348.37</b>	<b>897.68</b>	<b>624.81</b>				
	94*	0.13	352.80	1537.54	598.68	437.76	4.2	1.0	4.9	30.0
External leakage - Process medium	94†	0.13	415.25	1820.03	711.63	473.65				
	1*	0.00	4.34	18.49	7.13	4.66	2.0	2.0	2.0	2.0
Minor in-service problems	1†	0.00	4.88	21.85	8.65	5.04				
	18*	0.31	73.26	275.17	101.53	83.83	12.1	1.0	12.7	125.0
Other	18†	0.25	84.28	329.25	122.21	90.70				
	4*	1.63	20.85	58.99	19.33	18.63	3.0	3.0	43.8	165.0
Plugged/Choked	4†	1.73	23.02	65.53	21.52	20.16				
	5*	2.43	22.77	60.62	19.28	23.29	20.3	1.0	27.8	90.0
Structural deficiency	5†	9.98	25.25	46.18	11.27	25.19				
	2*	0.66	8.85	25.21	8.28	9.31	8.5	17.0	17.0	17.0
<b>Unknown</b>	2†	0.11	9.80	31.71	11.52	10.08				
	3*	<b>0.06</b>	<b>12.53</b>	<b>46.22</b>	<b>17.07</b>	<b>13.97</b>	<b>42.0</b>	<b>84.0</b>	<b>84.0</b>	<b>84.0</b>
Abnormal instrument reading	3†	<b>0.03</b>	<b>14.25</b>	<b>57.12</b>	<b>21.42</b>	<b>15.12</b>				
	1*	0.00	4.34	18.49	7.13	4.66	-	-	-	-
Unknown	1†	0.00	4.88	21.85	8.65	5.04				
	2*	0.66	8.85	25.21	8.28	9.31	42.0	84.0	84.0	84.0
Comments	2†	0.11	9.80	31.71	11.52	10.08				

(cont.)

Taxonomy no 3.2.1		Item Mechanical Equipment Vessels Coalescer								
Population 7	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.2147		Operational time † 0.1985						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
All modes	163* 163†	0.87 0.78	635.77 742.11	2597.63 3079.50	982.83 1171.42	759.10 821.32	9.6	1.0	16.1	249.0
Comments										

**Maintainable item versus failure mode, to be continued**

**Item:** Vessels - Coalescer

	AIR	ELP	ELU	OTH	PDE
Actuating device	0.61	0.00	0.00	0.00	0.61
Body/shell	0.00	0.00	0.00	0.00	0.00
Heater	0.31	1.23	0.61	2.45	7.36
Instrument, flow	1.23	0.00	0.00	0.00	0.00
Instrument, general	0.61	0.00	0.00	0.00	0.00
Instrument, level	54.29	0.61	0.00	0.00	0.92
Instrument, temperature	0.61	0.00	0.00	0.00	0.00
Internal power supply	1.23	0.00	0.61	0.61	0.00
Monitoring	0.00	0.00	0.00	0.61	0.00
Other	0.00	0.00	0.00	0.61	0.00
Piping	0.00	0.61	0.00	0.00	0.00
Sand trap system	0.00	0.00	0.00	0.00	0.00
Subunit	0.61	0.00	0.00	0.00	0.00
Unknown	1.23	0.00	0.00	0.61	0.61
Valves	2.45	0.00	0.00	0.61	0.31
Total	63.19	2.45	1.23	5.52	9.82

**Maintainable item versus failure mode, continued**

**Item:** Vessels - Coalescer

	PLU	SER	STD	UNK	Sum
Actuating device	0.00	0.00	0.00	0.00	1.23
Body/shell	0.00	0.61	1.23	0.00	1.84
Heater	0.00	1.84	0.00	0.61	14.42
Instrument, flow	0.00	0.00	0.00	0.00	1.23
Instrument, general	0.00	0.61	0.00	0.00	1.23
Instrument, level	0.00	0.61	0.00	0.61	57.06
Instrument, temperature	0.00	0.00	0.00	0.00	0.61
Internal power supply	0.00	0.61	0.00	0.00	3.07
Monitoring	0.00	0.00	0.00	0.00	0.61
Other	0.00	1.23	0.00	0.00	1.84
Piping	0.00	1.84	0.00	0.00	2.45
Sand trap system	1.23	0.00	0.00	0.00	1.23
Subunit	1.23	3.07	0.00	0.00	4.91
Unknown	0.00	0.00	0.00	0.00	2.45
Valves	1.84	0.61	0.00	0.00	5.83
Total	4.29	11.04	1.23	1.23	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Vessels - Coalescer

	AIR	ELP	ELU	OTH	PDE
Blockage/plugged	6.13	0.00	0.00	0.00	0.00
Corrosion	1.84	0.00	0.00	0.61	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.61
Electrical failure - general	0.61	0.00	0.00	0.61	4.91
Faulty signal/indication/alarm	3.68	0.00	0.00	0.00	0.61
Instrument failure - general	22.09	0.00	0.00	0.61	1.23
Leakage	0.00	0.61	1.23	0.00	0.00
Looseness	0.00	0.61	0.00	0.00	0.00
Material failure - general	0.00	1.23	0.00	0.00	0.61
Mechanical Failure - general	2.45	0.00	0.00	1.23	0.00
Misc. external influences	2.45	0.00	0.00	1.84	1.84
Other	0.00	0.00	0.00	0.00	0.00
Out of adjustment	23.31	0.00	0.00	0.00	0.00
Overheating	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.61	0.00	0.00	0.61	0.00
Unknown	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	0.00	0.00	0.00
Total	63.19	2.45	1.23	5.52	9.82

**Failure descriptor versus failure mode, continued**

Item: Vessels - Coalescer

	PLU	SER	STD	UNK	Sum
Blockage/plugged	1.23	1.23	0.00	0.00	8.59
Corrosion	0.00	0.00	1.23	0.00	3.68
Earth/isolation fault	0.00	0.00	0.00	0.00	0.61
Electrical failure - general	0.00	0.61	0.00	0.61	7.36
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	4.29
Instrument failure - general	0.61	0.61	0.00	0.61	25.77
Leakage	0.00	1.23	0.00	0.00	3.07
Looseness	0.00	0.00	0.00	0.00	0.61
Material failure - general	0.00	0.00	0.00	0.00	1.84
Mechanical Failure - general	0.00	1.23	0.00	0.00	4.91
Misc. external influences	0.61	4.91	0.00	0.00	11.66
Other	0.00	1.23	0.00	0.00	1.23
Out of adjustment	0.00	0.00	0.00	0.00	23.31
Overheating	0.61	0.00	0.00	0.00	0.61
Short circuiting	0.00	0.00	0.00	0.00	1.23
Unknown	0.61	0.00	0.00	0.00	0.61
Wear	0.61	0.00	0.00	0.00	0.61
Total	4.29	11.04	1.23	1.23	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.



Taxonomy no 3.2.1.1		Item Mechanical Equipment Vessels Coalescer (1-10)m3								
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0526		Operational time † 0.0512			Active rep.hrs	Repair (manhours)		
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).						Active rep.hrs	Repair (manhours)	
		Lower	Mean	Upper	SD	n/τ	Min		Mean	Max
Degraded	2*	6.75	38.05	119.77	38.05	38.05	14.5	14.0	14.5	15.0
	2†	6.93	39.05	122.91	39.05	39.05				
Plugged/Choked	2*	6.75	38.05	119.77	38.05	38.05	14.5	14.0	14.5	15.0
	2†	6.93	39.05	122.91	39.05	39.05				
Incipient	8*	75.72	152.21	274.64	152.21	152.21	35.0	6.0	37.0	125.0
	8†	77.71	156.20	281.85	156.20	156.20				
Abnormal instrument reading	6*	49.75	114.16	225.27	114.16	114.16	13.5	6.0	13.5	30.0
	6†	51.06	117.15	231.18	117.15	117.15				
Minor in-service problems	1*	0.95	19.03	90.28	19.03	19.03	125.0	125.0	125.0	125.0
	1†	0.98	19.53	92.65	19.53	19.53				
Plugged/Choked	1*	0.95	19.03	90.28	19.03	19.03	74.0	90.0	90.0	90.0
	1†	0.98	19.53	92.65	19.53	19.53				
All modes	10*	103.22	190.26	322.68	190.26	190.26	30.9	6.0	32.5	125.0
	10†	105.92	195.25	331.15	195.25	195.25				
Comments										

Taxonomy no 3.2.1.2		Item Mechanical Equipment Vessels Coalescer (50-100)m3									
Population 5	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1622			Operational time † 0.1472						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	7* 7†	3.42 1.20	35.45 38.85	96.50 118.01	31.06 40.70	43.17 47.54	28.0	2.0	55.4	155.0	
Abnormal instrument reading	3* 3†	2.38 0.67	16.15 17.31	40.16 52.17	12.32 17.73	18.50 20.37	3.8	2.0	6.3	15.0	
Parameter deviation	4* 4†	1.11 0.66	21.47 23.72	64.11 72.36	21.39 25.12	24.67 27.17	46.1	10.0	92.3	155.0	
<b>Degraded</b>	27* 27†	0.50 0.34	116.91 133.69	439.66 527.82	162.21 196.69	166.49 183.37	19.6	1.0	37.6	249.0	
Abnormal instrument reading	5* 5†	0.11 0.05	22.78 25.68	83.97 103.46	31.01 38.90	30.83 33.96	7.4	4.0	10.4	16.0	
External leakage - Process medium	3* 3†	0.98 0.97	16.82 18.56	49.54 55.34	16.46 18.45	18.50 20.37	4.3	2.0	8.7	18.0	
External leakage - Utility medium	2* 2†	0.15 0.27	11.77 12.90	37.74 39.96	13.64 14.12	12.33 13.58	12.0	4.0	22.0	40.0	
Other	5* 5†	0.75 1.01	27.69 30.49	84.53 92.35	29.38 31.70	30.83 33.96	33.0	3.0	64.8	249.0	
Parameter deviation	12* 12†	0.00 0.00	47.37 55.74	222.85 265.94	90.90 109.27	74.00 81.50	24.6	1.0	48.4	199.0	
<b>Incipient</b>	116* 116†	0.12 0.10	463.64 544.46	2046.82 2436.41	804.03 963.99	715.31 787.81	3.6	1.0	6.2	165.0	
Abnormal instrument reading	88* 88†	0.02 0.02	342.60 404.60	1590.81 1890.97	643.27 768.16	542.65 597.65	3.5	1.0	4.3	26.0	
External leakage - Process medium	1* 1†	0.03 0.02	5.38 5.96	19.30 23.29	7.13 8.65	6.17 6.79	2.0	2.0	2.0	2.0	
Minor in-service problems	17* 17†	0.30 0.17	73.81 84.38	281.11 337.55	103.61 126.42	104.83 115.45	4.0	1.0	4.6	16.0	
Other	4* 4†	8.20 9.02	24.39 26.84	47.56 52.36	12.33 13.58	24.67 27.17	3.0	3.0	43.8	165.0	
Plugged/Choked	4* 4†	0.88 0.61	21.72 24.19	65.39 74.14	22.15 25.90	24.67 27.17	2.3	1.0	12.3	42.0	
Structural deficiency	2* 2†	0.03 1.75	9.92 12.41	38.52 31.14	14.26 9.60	12.33 13.58	8.5	17.0	17.0	17.0	
<b>Unknown</b>	3* 3†	2.38 0.67	16.15 17.31	40.16 52.17	12.32 17.73	18.50 20.37	42.0	84.0	84.0	84.0	
Abnormal instrument reading	1* 1†	0.03 0.02	5.38 5.96	19.30 23.29	7.13 8.65	6.17 6.79	-	-	-	-	
Unknown	2* 2†	0.03 1.75	9.92 12.41	38.52 31.14	14.26 9.60	12.33 13.58	42.0	84.0	84.0	84.0	
<b>All modes</b>	153* 153†	0.21 0.16	613.51 718.96	2680.66 3185.61	1045.82 1254.03	943.47 1039.09	8.1	1.0	14.9	249.0	
<b>Comments</b>											

Taxonomy no 3.2.2		Item Mechanical Equipment Vessels Contactor								
Population 7	Installations 5	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1761		Operational time † 0.1696						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>21*</b> <b>21†</b>	<b>0.00</b>	<b>87.66</b>	<b>460.28</b>	<b>207.73</b>	<b>119.23</b>	<b>13.1</b>	<b>4.0</b>	<b>27.1</b>	<b>74.0</b>
Abnormal instrument reading	9*	0.00	38.78	195.84	84.19	51.10	14.5	13.0	31.2	74.0
	9†	0.00	40.39	204.04	87.71	53.07				
External leakage - Process medium	1*	0.00	5.06	22.92	9.12	5.68	20.5	41.0	41.0	41.0
	1†	0.00	5.26	23.88	9.51	5.90				
External leakage - Utility medium	1*	0.00	5.06	22.92	9.12	5.68	16.0	32.0	32.0	32.0
	1†	0.00	5.26	23.88	9.51	5.90				
Other	1*	0.00	5.06	22.92	9.12	5.68	9.5	19.0	19.0	19.0
	1†	0.00	5.26	23.88	9.51	5.90				
Parameter deviation	1*	0.00	5.06	22.92	9.12	5.68	20.0	40.0	40.0	40.0
	1†	0.00	5.26	23.88	9.51	5.90				
Structural deficiency	8*	0.00	34.71	173.16	73.86	45.42	9.8	4.0	19.5	36.0
	8†	0.00	36.15	180.41	76.96	47.17				
<b>Degraded</b>	<b>5*</b> <b>5†</b>	<b>4.80</b>	<b>28.58</b>	<b>68.82</b>	<b>20.72</b>	<b>28.39</b>	<b>46.3</b>	<b>1.0</b>	<b>42.8</b>	<b>177.0</b>
Abnormal instrument reading	1*	0.30	5.72	17.03	5.68	5.68	-	20.0	20.0	20.0
	1†	0.32	5.95	17.70	5.90	5.90				
External leakage - Process medium	3*	1.77	17.75	47.98	15.39	17.03	4.0	1.0	5.7	12.0
	3†	1.76	18.47	50.42	16.25	17.69				
Structural deficiency	1*	0.00	5.06	22.92	9.12	5.68	88.5	177.0	177.0	177.0
	1†	0.00	5.26	23.88	9.51	5.90				
<b>Incipient</b>	<b>41*</b> <b>41†</b>	<b>65.25</b>	<b>226.54</b>	<b>467.33</b>	<b>126.99</b>	<b>232.77</b>	<b>8.9</b>	<b>2.0</b>	<b>12.8</b>	<b>66.0</b>
Abnormal instrument reading	16*	0.78	103.11	350.42	128.92	90.84	8.2	3.0	5.9	12.0
	16†	0.82	106.37	360.60	132.62	94.34				
External leakage - Process medium	7*	0.01	38.81	169.67	66.22	39.74	1.0	2.0	13.7	40.0
	7†	0.01	40.70	178.11	69.56	41.27				
External leakage - Utility medium	2*	0.79	10.50	29.89	9.81	11.35	19.5	30.0	39.0	48.0
	2†	0.77	10.90	31.30	10.31	11.79				
Minor in-service problems	4*	0.24	22.03	71.81	26.15	22.71	4.0	8.0	8.0	8.0
	4†	0.29	22.71	72.81	26.33	23.59				
Other	8*	1.07	39.57	120.85	42.02	45.42	10.0	3.0	16.6	40.0
	8†	1.06	41.11	125.81	43.87	47.17				
Parameter deviation	2*	0.79	10.50	29.89	9.81	11.35	3.3	6.0	6.5	7.0
	2†	0.77	10.90	31.30	10.31	11.79				
Structural deficiency	2*	0.79	10.50	29.89	9.81	11.35	21.0	18.0	42.0	66.0
	2†	0.77	10.90	31.30	10.31	11.79				
<b>Unknown</b>	<b>1*</b> <b>1†</b>	<b>0.30</b>	<b>5.72</b>	<b>17.03</b>	<b>5.68</b>	<b>5.68</b>	<b>-</b>	<b>9.0</b>	<b>9.0</b>	<b>9.0</b>
		<b>0.32</b>	<b>5.95</b>	<b>17.70</b>	<b>5.90</b>	<b>5.90</b>				
<b>Comments</b>										

(cont.)

Taxonomy no 3.2.2		Item Mechanical Equipment Vessels Contractor									
Population 7	Installations 5	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1761		Operational time † 0.1696							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
External leakage - Process medium	1*	0.30	5.72	17.03	5.68	5.68	-	9.0	9.0	9.0	
	1†	0.32	5.95	17.70	5.90	5.90					
All modes	68*	32.18	348.66	957.62	309.61	386.07	12.0	1.0	19.8	177.0	
	68†	32.95	362.17	997.50	322.94	400.95					
Comments											

**Maintainable item versus failure mode, to be continued**

Item: Vessels - Contactor

	AIR	ELP	ELU	OTH	PDE
Body/shell	0.00	0.00	0.00	1.47	0.00
Cabling & junction boxes	0.00	0.00	0.00	1.47	0.00
Instrument, level	30.88	4.41	0.00	0.00	4.41
Instrument, pressure	5.88	0.00	0.00	0.00	0.00
Internal power supply	1.47	0.00	0.00	0.00	0.00
Monitoring	0.00	0.00	0.00	1.47	0.00
Other	0.00	0.00	0.00	1.47	0.00
Piping	0.00	1.47	0.00	0.00	0.00
Subunit	0.00	4.41	0.00	1.47	0.00
Unknown	0.00	0.00	0.00	2.94	0.00
Valves	0.00	7.35	4.41	2.94	0.00
Total	38.24	17.65	4.41	13.24	4.41

**Maintainable item versus failure mode, continued**

Item: Vessels - Contactor

	PLU	SER	STD	UNK	Sum
Body/shell	0.00	0.00	4.41	0.00	5.88
Cabling & junction boxes	0.00	0.00	0.00	0.00	1.47
Instrument, level	0.00	0.00	0.00	0.00	39.71
Instrument, pressure	0.00	0.00	0.00	0.00	5.88
Internal power supply	0.00	0.00	0.00	0.00	1.47
Monitoring	0.00	0.00	0.00	0.00	1.47
Other	0.00	0.00	0.00	0.00	1.47
Piping	0.00	0.00	8.82	0.00	10.29
Subunit	0.00	0.00	0.00	0.00	5.88
Unknown	0.00	0.00	0.00	0.00	2.94
Valves	0.00	5.88	2.94	0.00	23.53
Total	0.00	5.88	16.18	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Vessels - Contactor

	AIR	ELP	ELU	OTH	PDE
Blockage/plugged	4.41	0.00	0.00	0.00	0.00
Breakage	0.00	0.00	0.00	0.00	1.47
Cavitation	1.47	0.00	1.47	0.00	0.00
Contamination	1.47	0.00	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	1.47	0.00	0.00	1.47	0.00
Faulty signal/indication/alarm	5.88	1.47	0.00	0.00	0.00
Instrument failure - general	0.00	0.00	0.00	1.47	1.47
Leakage	0.00	13.24	1.47	2.94	0.00
Material failure - general	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	1.47	0.00	1.47	0.00	0.00
Misc. external influences	0.00	0.00	0.00	1.47	0.00
Miscellaneous - general	0.00	0.00	0.00	4.41	0.00
No signal/indication/alarm	5.88	0.00	0.00	0.00	0.00
Other	0.00	1.47	0.00	1.47	0.00
Out of adjustment	14.71	0.00	0.00	0.00	1.47
Sticking	1.47	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00
Wear	0.00	1.47	0.00	0.00	0.00
Total	38.24	17.65	4.41	13.24	4.41

**Failure descriptor versus failure mode, continued**

Item: Vessels - Contactor

	PLU	SER	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	4.41
Breakage	0.00	1.47	0.00	0.00	2.94
Cavitation	0.00	0.00	10.29	0.00	13.24
Contamination	0.00	0.00	0.00	0.00	1.47
Corrosion	0.00	0.00	2.94	0.00	2.94
Electrical failure - general	0.00	0.00	0.00	0.00	2.94
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	7.35
Instrument failure - general	0.00	0.00	0.00	0.00	2.94
Leakage	0.00	0.00	2.94	0.00	20.59
Material failure - general	0.00	1.47	0.00	0.00	1.47
Mechanical Failure - general	0.00	0.00	0.00	0.00	2.94
Misc. external influences	0.00	0.00	0.00	0.00	1.47
Miscellaneous - general	0.00	0.00	0.00	0.00	4.41
No signal/indication/alarm	0.00	0.00	0.00	0.00	5.88
Other	0.00	0.00	0.00	0.00	2.94
Out of adjustment	0.00	0.00	0.00	0.00	16.18
Sticking	0.00	1.47	0.00	0.00	2.94
Unknown	0.00	1.47	0.00	0.00	1.47
Wear	0.00	0.00	0.00	0.00	1.47
Total	0.00	5.88	16.18	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 3.2.2.1		Item Mechanical Equipment Vessels Contactor (1-10)m3								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *			Operational time †					
		0.0307			0.0291					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
All modes	0 <sup>*</sup> 0 <sup>†</sup>	0.06 0.06	15.57 16.40	59.80 62.99	22.02 23.20	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 3.2.2.2		Item Mechanical Equipment Vessels Contactor (10-50)m3								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0263		Operational time † 0.0256						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Degraded</b>	1*	1.90	38.05	180.56	38.05	38.05	4.0	4.0	4.0	4.0
	1†	1.95	39.05	185.29	39.05	39.05				
External leakage - Process medium	1*	1.90	38.05	180.56	38.05	38.05	4.0	4.0	4.0	4.0
	1†	1.95	39.05	185.29	39.05	39.05				
<b>Incipient</b>	10*	206.43	380.52	645.36	380.52	380.52	10.1	3.0	5.2	12.0
	10†	211.85	390.50	662.29	390.50	390.50				
Abnormal instrument reading	10*	206.43	380.52	645.36	380.52	380.52	10.1	3.0	5.2	12.0
	10†	211.85	390.50	662.29	390.50	390.50				
<b>All modes</b>	11*	234.78	418.57	692.92	418.57	418.57	9.5	3.0	5.1	12.0
	11†	240.94	429.55	711.11	429.55	429.55				
<b>Comments</b>										



Taxonomy no 3.2.2.3		Item Mechanical Equipment Vessels Contactor (50-100)m3								
Population 5	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1192		Operational time † 0.1149						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>21*</b>	<b>0.04</b>	<b>144.73</b>	<b>638.97</b>	<b>251.01</b>	<b>176.20</b>	<b>13.1</b>	<b>4.0</b>	<b>27.1</b>	<b>74.0</b>
	<b>21†</b>	<b>0.04</b>	<b>150.84</b>	<b>665.80</b>	<b>261.52</b>	<b>182.79</b>				
Abnormal instrument reading	9*	0.05	63.20	266.53	102.33	75.51	14.5	13.0	31.2	74.0
	9†	0.05	65.83	277.75	106.66	78.34				
External leakage - Process medium	1*	0.01	7.73	31.24	11.77	8.39	20.5	41.0	41.0	41.0
	1†	0.01	8.03	32.54	12.27	8.70				
External leakage - Utility medium	1*	0.01	7.73	31.24	11.77	8.39	16.0	32.0	32.0	32.0
	1†	0.01	8.03	32.54	12.27	8.70				
Other	1*	0.01	7.73	31.24	11.77	8.39	9.5	19.0	19.0	19.0
	1†	0.01	8.03	32.54	12.27	8.70				
Parameter deviation	1*	0.01	7.73	31.24	11.77	8.39	20.0	40.0	40.0	40.0
	1†	0.01	8.03	32.54	12.27	8.70				
Structural deficiency	8*	0.05	56.41	235.52	89.91	67.12	9.8	4.0	19.5	36.0
	8†	0.05	58.75	245.43	93.73	69.63				
<b>Degraded</b>	<b>4*</b>	<b>3.03</b>	<b>34.54</b>	<b>95.80</b>	<b>31.12</b>	<b>33.56</b>	<b>88.5</b>	<b>1.0</b>	<b>52.5</b>	<b>177.0</b>
	<b>4†</b>	<b>2.95</b>	<b>36.09</b>	<b>101.34</b>	<b>33.10</b>	<b>34.82</b>				
Abnormal instrument reading	1*	0.55	8.69	25.33	8.39	8.39	-	20.0	20.0	20.0
	1†	0.58	9.04	26.30	8.70	8.70				
External leakage - Process medium	2*	0.09	18.14	66.31	24.50	16.78	-	1.0	6.5	12.0
	2†	0.09	18.99	70.02	25.86	17.41				
Structural deficiency	1*	0.01	7.73	31.24	11.77	8.39	88.5	177.0	177.0	177.0
	1†	0.01	8.03	32.54	12.27	8.70				
<b>Incipient</b>	<b>31*</b>	<b>158.49</b>	<b>255.36</b>	<b>370.95</b>	<b>65.09</b>	<b>260.10</b>	<b>8.3</b>	<b>2.0</b>	<b>15.3</b>	<b>66.0</b>
	<b>31†</b>	<b>158.06</b>	<b>264.85</b>	<b>393.92</b>	<b>72.35</b>	<b>269.83</b>				
Abnormal instrument reading	6*	21.60	49.96	87.86	20.55	50.34	3.5	4.0	7.0	10.0
	6†	22.45	51.87	91.19	21.32	52.22				
External leakage - Process medium	7*	0.39	63.00	220.51	81.40	58.73	1.0	2.0	13.7	40.0
	7†	0.40	66.09	232.02	85.66	60.93				
External leakage - Utility medium	2*	1.60	15.75	42.39	13.56	16.78	19.5	30.0	39.0	48.0
	2†	1.60	16.35	44.38	14.27	17.41				
Minor in-service problems	4*	3.05	34.52	95.63	31.04	33.56	4.0	8.0	8.0	8.0
	4†	3.45	35.50	96.48	31.03	34.82				
Other	8*	15.47	63.48	138.23	39.08	67.12	10.0	3.0	16.6	40.0
	8†	15.60	65.88	144.68	41.12	69.63				
Parameter deviation	2*	1.60	15.75	42.39	13.56	16.78	3.3	6.0	6.5	7.0
	2†	1.60	16.35	44.38	14.27	17.41				
Structural deficiency	2*	1.60	15.75	42.39	13.56	16.78	21.0	18.0	42.0	66.0
	2†	1.60	16.35	44.38	14.27	17.41				
<b>Unknown</b>	<b>1*</b>	<b>0.55</b>	<b>8.69</b>	<b>25.33</b>	<b>8.39</b>	<b>8.39</b>	<b>-</b>	<b>9.0</b>	<b>9.0</b>	<b>9.0</b>
	<b>1†</b>	<b>0.58</b>	<b>9.04</b>	<b>26.30</b>	<b>8.70</b>	<b>8.70</b>				
<b>Comments</b>										

(cont.)

Taxonomy no 3.2.2.3		Item Mechanical Equipment Vessels Contactor (50-100)m3								
Population 5	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1192			Operational time † 0.1149					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
External leakage - Process medium	1*	0.55	8.69	25.33	8.39	8.39	-	9.0	9.0	9.0
	1†	0.58	9.04	26.30	8.70	8.70				
<b>All modes</b>	<b>57*</b> <b>57†</b>	<b>70.35</b> <b>71.78</b>	<b>440.13</b> <b>458.52</b>	<b>1073.70</b> <b>1124.32</b>	<b>325.93</b> <b>342.34</b>	<b>478.25</b> <b>496.14</b>	<b>12.7</b>	<b>1.0</b>	<b>22.5</b>	<b>177.0</b>
<b>Comments</b>										

Taxonomy no 3.2.3		Item Mechanical Equipment Vessels Distillation column								
Population 3	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0526		Operational time † 0.0522						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	2*	6.74	38.00	119.60	38.00	38.00	-	14.0	197.0	380.0
	2†	6.80	38.31	120.59	38.31	38.31				
Other	1*	0.95	19.00	90.15	19.00	19.00	-	14.0	14.0	14.0
	1†	0.96	19.16	90.90	19.16	19.16				
Structural deficiency	1*	0.95	19.00	90.15	19.00	19.00	-	380.0	380.0	380.0
	1†	0.96	19.16	90.90	19.16	19.16				
Incipient	13*	146.07	247.00	392.65	247.00	247.00	-	2.0	38.9	79.0
	13†	147.28	249.04	395.90	249.04	249.04				
External leakage - Process medium	13*	146.07	247.00	392.65	247.00	247.00	-	2.0	38.9	79.0
	13†	147.28	249.04	395.90	249.04	249.04				
All modes	15*	175.65	285.00	438.80	285.00	285.00	-	2.0	60.0	380.0
	15†	177.11	287.36	442.43	287.36	287.36				
Comments										

**Maintainable item versus failure mode, to be continued**

**Item:** Vessels - Distillation column

	AIR	ELP	ELU	OTH	PDE
Body/shell	0.00	0.00	0.00	0.00	0.00
Control unit	0.00	0.00	0.00	6.67	0.00
Other	0.00	66.67	0.00	0.00	0.00
Unknown	0.00	6.67	0.00	0.00	0.00
Valves	0.00	13.33	0.00	0.00	0.00
Total	0.00	86.67	0.00	6.67	0.00

**Maintainable item versus failure mode, continued**

**Item:** Vessels - Distillation column

	PLU	SER	STD	UNK	Sum
Body/shell	0.00	0.00	6.67	0.00	6.67
Control unit	0.00	0.00	0.00	0.00	6.67
Other	0.00	0.00	0.00	0.00	66.67
Unknown	0.00	0.00	0.00	0.00	6.67
Valves	0.00	0.00	0.00	0.00	13.33
Total	0.00	0.00	6.67	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Vessels - Distillation column

	AIR	ELP	ELU	OTH	PDE
Control failure	0.00	0.00	0.00	6.67	0.00
Corrosion	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	86.67	0.00	0.00	0.00
Total	0.00	86.67	0.00	6.67	0.00

**Failure descriptor versus failure mode, continued**

**Item:** Vessels - Distillation column

	PLU	SER	STD	UNK	Sum
Control failure	0.00	0.00	0.00	0.00	6.67
Corrosion	0.00	0.00	6.67	0.00	6.67
Leakage	0.00	0.00	0.00	0.00	86.67
Total	0.00	0.00	6.67	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 3.2.3.1		Item Mechanical Equipment Vessels Distillation column (100-300)m3									
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0351		Operational time † 0.0348							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Degraded	1* 1†	1.42 1.44	28.50 28.74	135.23 136.35	28.50 28.74	28.50 28.74	-	14.0	14.0	14.0	
Other	1*	1.42	28.50	135.23	28.50	28.50	-	14.0	14.0	14.0	
	1†	1.44	28.74	136.35	28.74	28.74	-				
Incipient	7*	93.62	199.50	374.77	199.50	199.50	-	19.0	51.4	79.0	
	7†	94.40	201.15	377.87	201.15	201.15	-				
External leakage - Process medium	7*	93.62	199.50	374.77	199.50	199.50	-	19.0	51.4	79.0	
	7†	94.40	201.15	377.87	201.15	201.15	-				
All modes	8*	113.43	228.00	411.39	228.00	228.00	-	14.0	46.8	79.0	
	8†	114.37	229.89	414.80	229.89	229.89	-				
Comments											

Taxonomy no 3.2.3.2		Item Mechanical Equipment Vessels Distillation column (300-1000)m3								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0175		Operational time † 0.0174						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max
<b>Degraded</b>	1*	2.85	57.00	270.46	57.00	57.00	-	380.0	380.0	380.0
	1†	2.87	57.47	272.70	57.47	57.47				
Structural deficiency	1*	2.85	57.00	270.46	57.00	57.00	-	380.0	380.0	380.0
	1†	2.87	57.47	272.70	57.47	57.47				
<b>Incipient</b>	6*	149.05	342.00	674.87	342.00	342.00	-	2.0	24.3	73.0
	6†	150.29	344.83	680.46	344.83	344.83				
External leakage - Process medium	6*	149.05	342.00	674.87	342.00	342.00	-	2.0	24.3	73.0
	6†	150.29	344.83	680.46	344.83	344.83				
<b>All modes</b>	7*	187.24	399.00	749.54	399.00	399.00	-	2.0	75.1	380.0
	7†	188.79	402.30	755.75	402.30	402.30				
<b>Comments</b>										

Taxonomy no 3.2.4		Item Mechanical Equipment Vessels Flash drum								
Population 34	Installations 7	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 1.1611		Operational time † 1.0038						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>21*</b> <b>21†</b>	<b>0.00</b>	<b>11.91</b>	<b>64.61</b>	<b>30.07</b>	<b>18.09</b>	<b>7.2</b>	<b>1.0</b>	<b>8.4</b>	<b>74.0</b>
Abnormal instrument reading	19*	0.00	9.65	54.53	28.97	16.36	3.4	1.0	4.3	17.0
	19†	0.00	10.10	56.80	29.96	18.93				
External leakage - Process medium	2*	0.21	1.87	4.89	1.54	1.72	41.3	17.0	45.5	74.0
	2†	0.01	2.31	8.06	2.97	1.99				
<b>Degraded</b>	<b>34*</b> <b>34†</b>	<b>0.06</b>	<b>24.42</b>	<b>96.38</b>	<b>35.91</b>	<b>29.28</b>	<b>12.0</b>	<b>1.0</b>	<b>86.3</b>	<b>2228.9</b>
		<b>0.14</b>	<b>27.39</b>	<b>99.66</b>	<b>36.82</b>	<b>33.87</b>				
Abnormal instrument reading	8*	0.00	4.66	24.44	11.02	6.89	5.7	1.0	9.1	48.0
	8†	0.00	5.04	25.69	11.10	7.97				
External leakage - Process medium	4*	0.01	3.29	13.02	4.86	3.45	4.8	2.0	4.8	10.0
	4†	0.00	3.88	17.91	7.21	3.98				
Other	4*	1.19	3.46	6.69	1.72	3.45	4.3	2.0	4.3	6.0
	4†	0.03	3.55	11.92	4.38	3.98				
Parameter deviation	3*	0.08	2.35	7.13	2.45	2.58	7.0	1.0	13.0	36.0
	3†	0.67	2.79	6.09	1.73	2.99				
Plugged/Choked	9*	0.27	9.75	29.74	10.33	7.75	34.7	2.0	312.7	2228.9
	9†	0.32	10.98	33.44	11.58	8.97				
Structural deficiency	6*	0.00	3.75	18.37	7.71	5.17	3.8	2.0	6.2	12.0
	6†	0.00	4.12	18.94	7.59	5.98				
<b>Incipient</b>	<b>202*</b> <b>202†</b>	<b>0.00</b>	<b>110.07</b>	<b>599.53</b>	<b>279.70</b>	<b>173.98</b>	<b>4.7</b>	<b>1.0</b>	<b>5.8</b>	<b>72.0</b>
		<b>0.00</b>	<b>119.72</b>	<b>635.66</b>	<b>290.72</b>	<b>201.23</b>				
Abnormal instrument reading	160*	0.00	82.37	459.10	238.38	137.80	4.8	1.0	5.1	72.0
	160†	0.00	88.75	490.49	248.75	159.39				
External leakage - Process medium	3*	0.06	2.25	6.89	2.40	2.58	3.0	2.0	5.3	7.0
	3†	0.16	2.59	7.59	2.52	2.99				
External leakage - Utility medium	2*	0.18	1.79	4.80	1.54	1.72	14.5	2.0	28.0	54.0
	2†	0.40	2.05	4.78	1.41	1.99				
Minor in-service problems	19*	1.59	14.48	38.27	12.12	16.36	4.8	1.0	8.3	43.0
	19†	3.45	16.60	37.84	11.03	18.93				
Other	4*	0.39	3.51	9.26	2.93	3.45	1.7	1.0	14.3	52.0
	4†	1.23	3.92	7.84	2.08	3.98				
Plugged/Choked	6*	0.00	3.75	18.37	7.71	5.17	6.0	2.0	9.8	21.0
	6†	0.00	4.12	18.94	7.59	5.98				
Structural deficiency	6*	0.04	4.82	15.96	5.84	5.17	2.3	1.0	2.7	7.0
	6†	0.08	5.38	16.96	6.08	5.98				
Unknown	2*	0.00	1.51	6.29	2.40	1.72	1.5	1.0	1.5	2.0
	2†	0.00	1.67	6.56	2.44	1.99				
<b>Unknown</b>	<b>10*</b> <b>10†</b>	<b>0.23</b>	<b>12.42</b>	<b>38.76</b>	<b>13.78</b>	<b>8.61</b>	<b>11.1</b>	<b>4.0</b>	<b>18.8</b>	<b>49.0</b>
		<b>0.28</b>	<b>13.09</b>	<b>40.46</b>	<b>14.26</b>	<b>9.96</b>				
<b>Comments</b>										

(cont.)

Taxonomy no 3.2.4		Item Mechanical Equipment Vessels Flash drum									
Population 34	Installations 7	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *		Operational time †							
		1.1611		1.0038							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Abnormal instrument reading	4*	0.39	3.51	9.26	2.93	3.45	15.2	6.0	33.5	49.0	
	4†	1.23	3.92	7.84	2.08	3.98					
External leakage - Process medium	1*	0.00	1.52	7.14	2.91	0.86	-	10.0	10.0	10.0	
	1†	0.00	1.62	7.53	3.05	1.00					
Other	2*	0.00	4.59	21.07	8.43	1.72	-	12.0	14.0	16.0	
	2†	0.00	4.85	22.49	9.08	1.99					
Unknown	3*	0.06	2.84	8.79	3.10	2.58	5.0	4.0	5.3	6.0	
	3†	0.27	3.06	8.50	2.76	2.99					
All modes	267*	0.00	158.03	813.27	352.77	229.96	5.9	1.0	16.2	2228.9	
	267†	0.00	172.64	859.33	365.87	265.99					
Comments											



**Maintainable item versus failure mode, to be continued**

Item: Vessels - Flash drum

	AIR	ELP	ELU	OTH	PDE
Body/shell	0.00	0.37	0.00	0.00	0.75
Instrument, flow	2.62	0.00	0.00	0.00	0.00
Instrument, general	1.87	0.00	0.00	0.00	0.00
Instrument, level	47.94	0.00	0.00	0.00	0.00
Instrument, pressure	1.87	0.00	0.00	0.37	0.00
Instrument, temperature	1.87	0.00	0.00	0.00	0.00
Other	0.00	0.75	0.37	0.00	0.00
Piping	0.00	1.50	0.00	0.75	0.00
Sand trap system	0.00	0.00	0.00	0.00	0.00
Subunit	0.37	0.37	0.00	0.00	0.00
Support	0.00	0.00	0.00	0.00	0.00
Unknown	2.62	0.00	0.00	0.75	0.00
Valves	12.36	0.75	0.37	1.87	0.37
Total	71.54	3.75	0.75	3.75	1.12

**Maintainable item versus failure mode, continued**

Item: Vessels - Flash drum

	PLU	SER	STD	UNK	Sum
Body/shell	0.00	0.00	0.00	0.00	1.12
Instrument, flow	0.00	0.00	0.00	0.00	2.62
Instrument, general	0.00	0.37	0.19	0.00	2.43
Instrument, level	0.75	1.12	0.00	0.00	49.81
Instrument, pressure	0.00	0.00	0.00	0.00	2.25
Instrument, temperature	0.00	0.00	0.37	0.00	2.25
Other	0.00	1.87	0.00	0.00	3.00
Piping	0.37	0.37	1.50	0.00	4.49
Sand trap system	0.75	0.00	0.00	0.00	0.75
Subunit	0.75	0.37	0.00	0.00	1.87
Support	0.00	0.00	0.37	0.00	0.37
Unknown	0.37	0.37	0.75	0.75	5.62
Valves	2.62	2.62	1.31	1.12	23.41
Total	5.62	7.12	4.49	1.87	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Vessels - Flash drum

	AIR	ELP	ELU	OTH	PDE
Blockage/plugged	18.35	0.00	0.00	0.00	0.00
Burst	0.00	0.00	0.00	0.00	0.00
Cavitation	0.37	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.37	0.00	0.00
Combined causes	0.00	0.00	0.00	0.00	0.00
Control failure	0.37	0.00	0.00	0.00	0.75
Corrosion	0.37	0.00	0.00	0.75	0.00
Earth/isolation fault	1.50	0.00	0.00	0.00	0.00
Electrical failure - general	0.37	0.00	0.00	0.00	0.00
Erosion	0.00	0.37	0.00	0.00	0.00
Faulty signal/indication/alarm	1.12	0.00	0.00	0.00	0.00
Instrument failure - general	26.59	0.00	0.00	0.75	0.37
Leakage	0.37	1.50	0.37	0.00	0.00
Looseness	0.00	0.37	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.37	0.00
Mechanical Failure - general	4.49	0.37	0.00	1.12	0.00
Misc. external influences	3.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00
Out of adjustment	13.86	0.00	0.00	0.75	0.00
Sticking	0.00	0.00	0.00	0.00	0.00
Unknown	0.37	0.00	0.00	0.00	0.00
Vibration	0.37	0.00	0.00	0.00	0.00
Wear	0.00	1.12	0.00	0.00	0.00
Total	71.54	3.75	0.75	3.75	1.12

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

Item: Vessels - Flash drum

	PLU	SER	STD	UNK	Sum
Blockage/plugged	3.00	0.37	0.00	0.37	22.10
Burst	0.00	0.75	0.00	0.00	0.75
Cavitation	0.00	0.00	0.00	0.00	0.37
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.37
Combined causes	1.12	0.00	0.00	0.00	1.12
Control failure	0.00	0.00	0.00	0.00	1.12
Corrosion	0.00	1.12	1.50	0.00	3.75
Earth/isolation fault	0.00	0.00	0.00	0.00	1.50
Electrical failure - general	0.00	0.00	0.00	0.00	0.37
Erosion	0.00	0.00	0.00	0.00	0.37
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	1.12
Instrument failure - general	0.00	1.12	0.37	1.12	30.34
Leakage	0.00	0.00	0.75	0.00	3.00
Looseness	0.00	0.00	0.00	0.00	0.37
Material failure - general	0.00	0.00	0.00	0.00	0.37
Mechanical Failure - general	0.37	1.50	0.75	0.00	8.61
Misc. external influences	0.37	0.37	0.75	0.00	4.49
Other	0.00	0.37	0.00	0.00	0.37
Out of adjustment	0.00	0.37	0.00	0.00	14.98
Sticking	0.37	0.37	0.00	0.00	0.75
Unknown	0.37	0.00	0.00	0.37	1.12
Vibration	0.00	0.00	0.37	0.00	0.75
Wear	0.00	0.75	0.00	0.00	1.87
Total	5.62	7.12	4.49	1.87	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 3.2.4.1		Item Mechanical Equipment Vessels Flash drum (1-10)m3									
Population 15	Installations 5	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.5399		Operational time † 0.4456							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	<b>7*</b> <b>7†</b>	<b>0.00</b> <b>0.00</b>	<b>11.57</b> <b>11.12</b>	<b>56.45</b> <b>54.48</b>	<b>23.58</b> <b>22.87</b>	<b>12.97</b> <b>13.09</b>	<b>4.9</b>	<b>2.0</b>	<b>5.9</b>	<b>13.0</b>	
Abnormal instrument reading	7* 7†	0.00 0.00	11.57 11.08	56.45 57.80	23.58 25.82	12.97 15.71	4.9	2.0	5.9	13.0	
<b>Degraded</b>	<b>19*</b> <b>19†</b>	<b>0.00</b> <b>0.00</b>	<b>30.90</b> <b>30.32</b>	<b>144.93</b> <b>141.18</b>	<b>59.01</b> <b>57.20</b>	<b>35.19</b> <b>35.53</b>	<b>5.7</b>	<b>1.0</b>	<b>8.4</b>	<b>48.0</b>	
Abnormal instrument reading	5* 5†	0.00 0.00	8.60 8.16	39.69 38.16	15.98 15.50	9.26 9.35	7.6	3.0	12.4	48.0	
External leakage - Process medium	2* 2†	0.09 0.06	3.81 3.60	11.73 11.30	4.11 4.03	3.70 3.74	3.5	2.0	3.5	5.0	
Other	3* 3†	0.01 0.01	5.50 5.16	22.01 21.16	8.24 8.02	5.56 5.61	3.5	2.0	3.5	5.0	
Parameter deviation	3* 3†	0.01 0.01	5.50 5.16	22.01 21.16	8.24 8.02	5.56 5.61	7.0	1.0	13.0	36.0	
Plugged/Choked	3* 3†	0.60 0.53	6.38 5.95	17.42 16.45	5.62 5.34	5.56 5.61	6.3	2.0	6.3	9.0	
Structural deficiency	3* 3†	0.01 0.01	5.50 5.16	22.01 21.16	8.24 8.02	5.56 5.61	3.3	2.0	6.0	10.0	
<b>Incipient</b>	<b>74*</b> <b>74†</b>	<b>0.01</b> <b>0.01</b>	<b>122.34</b> <b>114.49</b>	<b>561.87</b> <b>535.68</b>	<b>225.09</b> <b>217.76</b>	<b>137.07</b> <b>138.40</b>	<b>5.1</b>	<b>1.0</b>	<b>6.2</b>	<b>72.0</b>	
Abnormal instrument reading	61* 61†	0.00 0.00	101.75 92.53	490.31 459.57	202.29 195.34	112.99 114.09	5.4	1.0	5.6	72.0	
External leakage - Process medium	3* 3†	0.05 0.04	5.15 5.05	16.93 17.21	6.18 6.33	5.56 5.61	3.0	2.0	5.3	7.0	
Minor in-service problems	5* 5†	0.70 0.22	8.05 8.03	22.39 24.50	7.28 8.50	9.26 9.35	4.2	4.0	7.0	9.0	
Other	3* 3†	0.32 0.15	6.93 6.47	20.79 19.93	6.99 7.00	5.56 5.61	1.5	1.0	18.3	52.0	
Plugged/Choked	1* 1†	0.00 0.00	1.90 1.78	8.22 8.14	3.19 3.24	1.85 1.87	6.0	6.0	6.0	6.0	
Structural deficiency	1* 1†	0.00 0.00	1.90 1.78	8.22 8.14	3.19 3.24	1.85 1.87	2.0	2.0	2.0	2.0	
<b>Unknown</b>	<b>5*</b> <b>5†</b>	<b>0.15</b> <b>0.10</b>	<b>10.97</b> <b>10.27</b>	<b>35.00</b> <b>33.87</b>	<b>12.63</b> <b>12.38</b>	<b>9.26</b> <b>9.35</b>	<b>9.0</b>	<b>4.0</b>	<b>13.2</b>	<b>40.0</b>	
Abnormal instrument reading	2* 2†	0.09 0.06	3.81 3.60	11.73 11.30	4.11 4.03	3.70 3.74	13.0	6.0	23.0	40.0	
External leakage - Process medium	1* 1†	0.00 0.00	4.27 4.06	18.53 18.12	7.20 7.16	1.85 1.87	-	10.0	10.0	10.0	
Unknown	2* 2†	0.09 0.06	3.81 3.60	11.73 11.30	4.11 4.03	3.70 3.74	5.0	4.0	5.0	6.0	
<b>Comments</b>											

(cont.)

Taxonomy no 3.2.4.1		Item Mechanical Equipment Vessels Flash drum (1-10)m3									
Population 15	Installations 5	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.5399			Operational time † 0.4456						
Failure mode		No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
			Lower	Mean	Upper	SD	n/t		Min	Mean	Max
All modes		105* 105†	0.01 0.01	172.46 165.31	804.98 776.40	326.72 316.38	194.49 196.38	5.3	1.0	6.9	72.0
Comments											

Taxonomy no 3.2.4.2		Item Mechanical Equipment Vessels Flash drum (10-50)m3									
Population 9	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *		Operational time †							
		0.3440		0.3131							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	<b>13*</b>	<b>0.05</b>	<b>28.16</b>	<b>113.44</b>	<b>42.65</b>	<b>37.79</b>	<b>8.5</b>	<b>1.0</b>	<b>9.2</b>	<b>74.0</b>	
	<b>13†</b>	<b>0.09</b>	<b>29.30</b>	<b>114.51</b>	<b>42.51</b>	<b>41.52</b>					
Abnormal instrument reading	12*	0.00	23.42	111.16	45.56	34.89	2.5	1.0	3.3	17.0	
	12†	0.00	24.23	113.42	46.12	38.33					
External leakage - Process medium	1*	0.01	3.73	14.79	5.52	2.91	74.0	74.0	74.0	74.0	
	1†	0.02	3.93	15.10	5.56	3.19					
<b>Degraded</b>	<b>9*</b>	<b>2.52</b>	<b>25.08</b>	<b>67.66</b>	<b>21.68</b>	<b>26.17</b>	<b>29.8</b>	<b>1.0</b>	<b>34.3</b>	<b>147.0</b>	
	<b>9†</b>	<b>3.85</b>	<b>26.54</b>	<b>66.25</b>	<b>20.37</b>	<b>28.75</b>					
Abnormal instrument reading	3*	0.58	7.52	21.32	6.99	8.72	1.0	1.0	1.0	1.0	
	3†	1.62	8.49	19.79	5.85	9.58					
External leakage - Process medium	1*	0.01	3.73	14.79	5.52	2.91	10.0	10.0	10.0	10.0	
	1†	0.02	3.93	15.10	5.56	3.19					
Plugged/Choked	3*	0.16	10.00	31.52	11.29	8.72	72.0	8.0	82.0	147.0	
	3†	0.26	10.53	32.29	11.29	9.58					
Structural deficiency	2*	0.01	4.78	19.07	7.13	5.81	5.0	4.0	8.0	12.0	
	2†	0.02	5.14	19.58	7.22	6.39					
<b>Incipient</b>	<b>120*</b>	<b>0.01</b>	<b>234.55</b>	<b>1100.04</b>	<b>447.86</b>	<b>348.87</b>	<b>4.1</b>	<b>1.0</b>	<b>4.8</b>	<b>43.0</b>	
	<b>120†</b>	<b>0.01</b>	<b>239.34</b>	<b>1122.08</b>	<b>456.73</b>	<b>383.28</b>					
Abnormal instrument reading	97*	0.00	183.83	902.66	379.77	282.00	4.1	1.0	4.5	41.0	
	97†	0.00	186.79	920.48	388.61	309.82					
Minor in-service problems	13*	4.60	32.76	82.32	25.40	37.79	5.3	1.0	9.0	43.0	
	13†	8.41	35.87	79.00	22.49	41.52					
Other	1*	0.01	2.57	9.66	3.56	2.91	2.0	2.0	2.0	2.0	
	1†	0.02	2.79	9.78	3.61	3.19					
Plugged/Choked	2*	0.01	4.78	19.07	7.13	5.81	3.5	2.0	3.5	5.0	
	2†	0.02	5.14	19.58	7.22	6.39					
Structural deficiency	5*	3.34	13.59	29.51	8.33	14.54	2.4	1.0	2.8	7.0	
	5†	5.46	14.97	28.32	7.14	15.97					
Unknown	2*	0.01	4.78	19.07	7.13	5.81	1.5	1.0	1.5	2.0	
	2†	0.02	5.14	19.58	7.22	6.39					
<b>Unknown</b>	<b>4*</b>	<b>0.07</b>	<b>14.76</b>	<b>54.09</b>	<b>19.98</b>	<b>11.63</b>	<b>19.5</b>	<b>6.0</b>	<b>18.3</b>	<b>39.0</b>	
	<b>4†</b>	<b>0.08</b>	<b>15.56</b>	<b>56.98</b>	<b>21.05</b>	<b>12.78</b>					
Abnormal instrument reading	1*	0.01	2.57	9.66	3.56	2.91	19.5	39.0	39.0	39.0	
	1†	0.02	2.79	9.78	3.61	3.19					
Other	2*	0.00	8.45	36.05	13.92	5.81	-	12.0	14.0	16.0	
	2†	0.00	8.95	38.23	14.76	6.39					
Unknown	1*	0.01	3.72	14.78	5.52	2.91	-	6.0	6.0	6.0	
	1†	0.01	3.98	15.42	5.71	3.19					
<b>All modes</b>	<b>146*</b>	<b>0.12</b>	<b>301.67</b>	<b>1310.21</b>	<b>509.09</b>	<b>424.46</b>	<b>6.1</b>	<b>1.0</b>	<b>7.3</b>	<b>147.0</b>	
	<b>146†</b>	<b>0.14</b>	<b>308.13</b>	<b>1331.04</b>	<b>516.28</b>	<b>466.33</b>					
<b>Comments</b>											

Taxonomy no 3.2.4.3		Item Mechanical Equipment Vessels Flash drum (50-100)m <sup>3</sup>									
Population 2	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *			Operational time †						
		0.0377			0.0360						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
Incipient	1*	0.27	24.40	79.28	28.83	26.56	1.5	3.0	3.0	3.0	
	1†	0.29	25.50	82.71	30.06	27.76					
Minor in-service problems	1*	0.27	24.40	79.28	28.83	26.56	1.5	3.0	3.0	3.0	
	1†	0.29	25.50	82.71	30.06	27.76					
All modes		1*	0.27	24.40	79.28	28.83	26.56	1.5	3.0	3.0	3.0
		1†	0.29	25.50	82.71	30.06	27.76				
Comments											

<b>Taxonomy no</b> 3.2.4.4		<b>Item</b> Mechanical Equipment Vessels Flash drum (100-300)m3									
<b>Population</b> 1	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>				
		<b>Calendar time *</b> 0.0131			<b>Operational time †</b> 0.0125						
<b>Failure mode</b>		<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours)</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
			<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n / <math>\tau</math></b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>		0* 0†	0.12 0.13	30.69 32.48	117.85 124.71	43.40 45.93	0.00 0.00	-	-	-	
<b>Comments</b>											



Taxonomy no 3.2.4.5		Item Mechanical Equipment Vessels Flash drum Unknown									
Population 7	Installations 5	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.2264		Operational time † 0.1966							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	1*	0.04	5.11	17.15	6.29	4.42	8.5	17.0	17.0	17.0	
	1†	0.24	5.45	16.37	5.51	5.09					
External leakage - Process medium	1*	0.04	5.11	17.15	6.29	4.42	8.5	17.0	17.0	17.0	
	1†	0.24	5.45	16.37	5.51	5.09					
<b>Degraded</b>	6*	2.23	32.26	92.97	30.67	26.50	4.8	2.0	449.6	2228.9	
	6†	3.64	34.06	90.62	28.81	30.51					
External leakage - Process medium	1*	0.05	3.88	12.51	4.54	4.42	2.0	2.0	2.0	2.0	
	1†	0.02	4.46	16.59	6.13	5.09					
Other	1*	0.02	5.56	21.70	8.05	4.42	6.0	6.0	6.0	6.0	
	1†	0.05	5.71	19.11	7.01	5.09					
Plugged/Choked	3*	0.24	17.57	56.00	20.19	13.25	8.0	8.0	1118.4	2228.9	
	3†	0.51	18.08	55.11	19.11	15.26					
Structural deficiency	1*	0.04	5.11	17.15	6.29	4.42	3.0	3.0	3.0	3.0	
	1†	0.24	5.45	16.37	5.51	5.09					
<b>Incipient</b>	7*	2.88	36.03	101.56	33.22	30.91	12.6	2.0	19.7	54.0	
	7†	4.20	38.57	102.18	32.40	35.60					
Abnormal instrument reading	2*	1.75	9.97	23.71	7.08	8.83	18.0	5.0	18.0	31.0	
	2†	2.29	10.88	24.73	7.19	10.17					
External leakage - Utility medium	2*	0.15	8.21	25.62	9.11	8.83	14.5	2.0	28.0	54.0	
	2†	0.27	9.42	28.69	9.94	10.17					
Plugged/Choked	3*	0.00	17.30	79.35	31.75	13.25	7.7	10.0	15.3	21.0	
	3†	0.00	18.21	83.27	33.22	15.26					
<b>Unknown</b>	1*	0.00	10.55	46.49	18.24	4.42	-	49.0	49.0	49.0	
	1†	0.00	10.92	48.76	19.27	5.09					
Abnormal instrument reading	1*	0.00	10.55	46.49	18.24	4.42	-	49.0	49.0	49.0	
	1†	0.00	10.92	48.76	19.27	5.09					
<b>All modes</b>	15*	9.96	85.68	223.25	70.06	66.24	9.6	2.0	175.1	2228.9	
	15†	13.29	90.07	223.91	68.71	76.29					
<b>Comments</b>											

Taxonomy no 3.2.5		Item Mechanical Equipment Vessels Hydrocyclone								
Population 20	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.4854		Operational time † 0.4759						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	3*	0.04	6.15	21.55	7.95	6.18	5.0	5.0	169.7	264.0
	3†	0.04	6.25	21.55	7.94	6.30				
External leakage - Process medium	3*	0.04	6.15	21.55	7.95	6.18	5.0	5.0	169.7	264.0
	3†	0.04	6.25	21.55	7.94	6.30				
<b>Degraded</b>	4*	2.81	8.34	16.24	4.21	8.24	21.3	3.0	24.3	70.0
	4†	2.43	8.61	17.89	4.89	8.40				
Other	2*	0.02	3.57	12.73	4.70	4.12	2.5	3.0	3.5	4.0
	2†	0.02	3.66	12.94	4.78	4.20				
Plugged/Choked	1*	0.01	4.38	17.19	6.39	2.06	70.0	70.0	70.0	70.0
	1†	0.02	4.86	18.86	6.98	2.10				
Structural deficiency	1*	0.01	1.88	6.40	2.35	2.06	10.0	20.0	20.0	20.0
	1†	0.02	1.93	6.50	2.39	2.10				
<b>Incipient</b>	1*	0.01	1.88	6.40	2.35	2.06	3.0	3.0	3.0	3.0
	1†	0.02	1.93	6.50	2.39	2.10				
Other	1*	0.01	1.88	6.40	2.35	2.06	3.0	3.0	3.0	3.0
	1†	0.02	1.93	6.50	2.39	2.10				
<b>All modes</b>	8*	8.24	16.52	27.13	5.83	16.48	15.5	3.0	76.1	264.0
	8†	8.45	16.90	27.72	5.94	16.81				
<b>Comments</b>										

**Maintainable item versus failure mode, to be continued**

Item: Vessels - Hydrocyclone

	AIR	ELP	ELU	OTH	PDE
Piping	0.00	25.00	0.00	0.00	0.00
Sand trap system	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	0.00
Valves	0.00	12.50	0.00	37.50	0.00
Total	0.00	37.50	0.00	37.50	0.00

**Maintainable item versus failure mode, continued**

Item: Vessels - Hydrocyclone

	PLU	SER	STD	UNK	Sum
Piping	0.00	0.00	0.00	0.00	25.00
Sand trap system	12.50	0.00	0.00	0.00	12.50
Subunit	0.00	0.00	12.50	0.00	12.50
Valves	0.00	0.00	0.00	0.00	50.00
Total	12.50	0.00	12.50	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Vessels - Hydrocyclone

	AIR	ELP	ELU	OTH	PDE
Combined causes	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	12.50	0.00	12.50	0.00
Mechanical Failure - general	0.00	0.00	0.00	25.00	0.00
Wear	0.00	25.00	0.00	0.00	0.00
Total	0.00	37.50	0.00	37.50	0.00

**Failure descriptor versus failure mode, continued**

Item: Vessels - Hydrocyclone

	PLU	SER	STD	UNK	Sum
Combined causes	12.50	0.00	0.00	0.00	12.50
Leakage	0.00	0.00	0.00	0.00	25.00
Mechanical Failure - general	0.00	0.00	12.50	0.00	37.50
Wear	0.00	0.00	0.00	0.00	25.00
Total	12.50	0.00	12.50	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 3.2.5.1		Item Mechanical Equipment Vessels Hydrocyclone (1-10)m3									
Population 17	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.3803		Operational time † 0.3722							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	3*	0.58	7.02	19.64	6.41	7.89	5.0	5.0	169.7	264.0	
	3†	0.72	7.20	19.45	6.23	8.06					
External leakage - Process medium	3*	0.58	7.02	19.64	6.41	7.89	5.0	5.0	169.7	264.0	
	3†	0.72	7.20	19.45	6.23	8.06					
<b>Degraded</b>	3*	2.00	8.65	19.13	5.46	7.89	27.3	4.0	31.3	70.0	
	3†	1.79	9.06	20.96	6.16	8.06					
Other	1*	0.00	2.64	10.85	4.12	2.63	2.0	4.0	4.0	4.0	
	1†	0.00	2.71	11.06	4.18	2.69					
Plugged/Choked	1*	0.01	4.43	17.56	6.55	2.63	70.0	70.0	70.0	70.0	
	1†	0.01	4.90	19.42	7.25	2.69					
Structural deficiency	1*	0.00	2.64	10.85	4.12	2.63	10.0	20.0	20.0	20.0	
	1†	0.00	2.71	11.06	4.18	2.69					
<b>All modes</b>	6*	6.91	15.82	27.69	6.44	15.78	21.8	4.0	100.5	264.0	
	6†	7.11	16.21	28.34	6.58	16.12					
Comments											

Taxonomy no 3.2.5.2		Item Mechanical Equipment Vessels Hydrocyclone Unknown									
Population 3	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1052		Operational time † 0.1037							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Degraded	1*	0.48	9.51	45.11	9.51	9.51	3.0	3.0	3.0	3.0	
	1†	0.48	9.65	45.77	9.65	9.65					
Other	1*	0.48	9.51	45.11	9.51	9.51	3.0	3.0	3.0	3.0	
	1†	0.48	9.65	45.77	9.65	9.65					
Incipient	1*	0.48	9.51	45.11	9.51	9.51	3.0	3.0	3.0	3.0	
	1†	0.48	9.65	45.77	9.65	9.65					
Other	1*	0.48	9.51	45.11	9.51	9.51	3.0	3.0	3.0	3.0	
	1†	0.48	9.65	45.77	9.65	9.65					
All modes	2*	3.37	19.01	59.84	19.01	19.01	3.0	3.0	3.0	3.0	
	2†	3.42	19.29	60.72	19.29	19.29					
Comments											

Taxonomy no 3.2.6		Item Mechanical Equipment Vessels Mol sieve dryer								
Population 6	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *			Operational time †					
		0.1053					0.1032			
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	7*	31.21	66.50	124.92	66.50	66.50	-	1.0	10.1	37.0
	7†	31.83	67.83	127.42	67.83	67.83				
Abnormal instrument reading	1*	0.47	9.50	45.08	9.50	9.50	-	3.0	3.0	3.0
	1†	0.48	9.69	45.98	9.69	9.69				
External leakage - Process medium	5*	18.71	47.50	99.89	47.50	47.50	-	1.0	6.2	20.0
	5†	19.09	48.45	101.89	48.45	48.45				
Structural deficiency	1*	0.47	9.50	45.08	9.50	9.50	-	37.0	37.0	37.0
	1†	0.48	9.69	45.98	9.69	9.69				
All modes	7*	31.21	66.50	124.92	66.50	66.50	-	1.0	10.1	37.0
	7†	31.83	67.83	127.42	67.83	67.83				
Comments										

**Maintainable item versus failure mode, to be continued**

Item: Vessels - Mol sieve dryer

	AIR	ELP	ELU	OTH	PDE
Other	0.00	14.29	0.00	0.00	0.00
Unknown	14.29	0.00	0.00	0.00	0.00
Valves	0.00	57.14	0.00	0.00	0.00
Total	14.29	71.43	0.00	0.00	0.00

**Maintainable item versus failure mode, continued**

Item: Vessels - Mol sieve dryer

	PLU	SER	STD	UNK	Sum
Other	0.00	0.00	14.29	0.00	28.57
Unknown	0.00	0.00	0.00	0.00	14.29
Valves	0.00	0.00	0.00	0.00	57.14
Total	0.00	0.00	14.29	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Vessels - Mol sieve dryer

	AIR	ELP	ELU	OTH	PDE
Corrosion	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	14.29	0.00	0.00	0.00	0.00
Leakage	0.00	71.43	0.00	0.00	0.00
Total	14.29	71.43	0.00	0.00	0.00

**Failure descriptor versus failure mode, continued**

Item: Vessels - Mol sieve dryer

	PLU	SER	STD	UNK	Sum
Corrosion	0.00	0.00	14.29	0.00	14.29
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	14.29
Leakage	0.00	0.00	0.00	0.00	71.43
Total	0.00	0.00	14.29	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 3.2.6.1		Item Mechanical Equipment Vessels Mol sieve dryer (10-50)m3									
Population 6	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1053			Operational time † 0.1032						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
<b>Incipient</b>	7*	<b>31.21</b>	<b>66.50</b>	<b>124.92</b>	<b>66.50</b>	<b>66.50</b>	-	1.0	10.1	37.0	
	7†	<b>31.83</b>	<b>67.83</b>	<b>127.42</b>	<b>67.83</b>	<b>67.83</b>					
Abnormal instrument reading	1*	0.47	9.50	45.08	9.50	9.50	-	3.0	3.0	3.0	
	1†	0.48	9.69	45.98	9.69	9.69					
External leakage - Process medium	5*	18.71	47.50	99.89	47.50	47.50	-	1.0	6.2	20.0	
	5†	19.09	48.45	101.89	48.45	48.45					
Structural deficiency	1*	0.47	9.50	45.08	9.50	9.50	-	37.0	37.0	37.0	
	1†	0.48	9.69	45.98	9.69	9.69					
<b>All modes</b>	7*	<b>31.21</b>	<b>66.50</b>	<b>124.92</b>	<b>66.50</b>	<b>66.50</b>	-	1.0	10.1	37.0	
	7†	<b>31.83</b>	<b>67.83</b>	<b>127.42</b>	<b>67.83</b>	<b>67.83</b>					
<b>Comments</b>											



Taxonomy no 3.2.7		Item Mechanical Equipment Vessels Scrubber									
Population 25	Installations 7	Aggregated time in service (10 <sup>6</sup> hours)						No of demands			
		Calendar time *			Operational time †						
		0.6545						0.6286			
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	<b>11*</b> <b>11†</b>	<b>0.01</b>	<b>22.98</b>	<b>97.53</b>	<b>37.57</b>	<b>16.81</b>	<b>5.8</b>	<b>2.0</b>	<b>8.8</b>	<b>28.0</b>	
Abnormal instrument reading	1*	0.00	2.13	10.24	4.22	1.53	2.5	5.0	5.0	5.0	
	1†	0.00	2.22	10.68	4.40	1.59					
External leakage - Process medium	1*	0.00	1.34	6.04	2.40	1.53	7.0	9.0	9.0	9.0	
	1†	0.00	1.41	6.51	2.62	1.59					
External leakage - Utility medium	1*	0.00	2.13	10.24	4.22	1.53	2.0	4.0	4.0	4.0	
	1†	0.00	2.22	10.68	4.40	1.59					
Other	3*	0.00	5.70	24.09	9.26	4.58	5.3	6.0	8.7	10.0	
	3†	0.00	5.98	25.22	9.68	4.77					
Parameter deviation	2*	0.20	2.88	8.29	2.74	3.06	-	2.0	3.0	4.0	
	2†	0.37	3.01	7.77	2.43	3.18					
Structural deficiency	2*	0.00	4.97	24.38	10.25	3.06	9.5	10.0	19.0	28.0	
	2†	0.00	5.18	25.41	10.68	3.18					
Unknown	1*	0.00	2.13	10.24	4.22	1.53	-	-	-	-	
	1†	0.00	2.22	10.68	4.40	1.59					
<b>Degraded</b>	<b>17*</b> <b>17†</b>	<b>0.01</b>	<b>19.20</b>	<b>81.74</b>	<b>31.53</b>	<b>25.98</b>	<b>10.8</b>	<b>4.0</b>	<b>8.7</b>	<b>22.0</b>	
Abnormal instrument reading	1*	0.00	1.52	7.97	3.60	1.53	-	20.0	20.0	20.0	
	1†	0.00	1.59	8.36	3.79	1.59					
External leakage - Process medium	6*	2.66	8.54	17.12	4.55	9.17	9.3	4.0	7.5	16.0	
	6†	2.72	8.88	17.94	4.79	9.55					
External leakage - Utility medium	3*	0.00	3.90	16.77	6.49	4.58	-	4.0	10.3	20.0	
	3†	0.00	4.02	16.74	6.38	4.77					
Other	6*	0.00	6.97	36.52	16.43	9.17	-	4.0	5.0	8.0	
	6†	0.00	7.08	36.92	16.50	9.55					
Plugged/Choked	1*	0.00	1.34	6.04	2.40	1.53	15.0	22.0	22.0	22.0	
	1†	0.00	1.41	6.51	2.62	1.59					
<b>Incipient</b>	<b>68*</b> <b>68†</b>	<b>6.53</b>	<b>93.41</b>	<b>268.84</b>	<b>88.64</b>	<b>103.90</b>	<b>10.8</b>	<b>1.0</b>	<b>11.2</b>	<b>53.0</b>	
Abnormal instrument reading	43*	0.79	50.06	157.81	56.54	65.70	11.8	1.0	11.1	39.0	
	43†	0.91	52.15	163.16	58.14	68.41					
External leakage - Utility medium	4*	0.00	8.70	38.98	15.43	6.11	8.3	4.0	13.5	42.0	
	4†	0.00	9.02	40.53	16.06	6.36					
Minor in-service problems	8*	2.10	12.06	28.79	8.61	12.22	13.5	4.0	14.5	53.0	
	8†	2.45	12.50	28.96	8.52	12.73					
Other	3*	0.86	4.91	11.70	3.50	4.58	2.0	4.0	6.0	8.0	
	3†	0.91	5.08	12.02	3.58	4.77					
Parameter deviation	4*	0.25	5.88	17.68	5.97	6.11	-	2.0	8.5	14.0	
	4†	0.40	6.07	17.63	5.83	6.36					
<b>Comments</b>											

(cont.)

Taxonomy no		Item									
3.2.7		Mechanical Equipment Vessels Scrubber									
Population	Installations	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *			Operational time †						
25	7	0.6545			0.6286						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Structural deficiency	5*	0.05	8.15	28.84	10.65	7.64	-	8.0	10.0	14.0	
	5†	0.05	8.37	29.44	10.87	7.95					
Unknown	1*	0.00	2.13	10.24	4.22	1.53	2.0	4.0	4.0	4.0	
	1†	0.00	2.22	10.68	4.40	1.59					
<b>All modes</b>		96*	4.77	134.32	405.92	138.74	146.69	9.7	1.0	10.5	53.0
		96†	5.90	139.21	418.52	141.36	152.73				
<b>Comments</b>											

**Maintainable item versus failure mode, to be continued**

Item: Vessels - Scrubber

	AIR	ELP	ELU	OTH	PDE
Body/shell	0.00	0.00	1.04	1.04	0.00
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00
Control unit	1.04	0.00	0.00	0.00	0.00
Heater	0.00	0.00	0.00	0.00	0.00
Instrument, flow	0.52	0.00	0.00	0.00	0.00
Instrument, level	38.02	2.08	1.04	2.08	6.25
Instrument, pressure	4.17	0.00	1.04	2.08	0.00
Instrument, temperature	2.08	0.00	0.00	0.00	0.00
Monitoring	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	0.00	0.00	0.00
Support	0.00	0.00	0.00	0.00	0.00
Unknown	1.04	1.04	0.00	0.00	0.00
Valves	0.00	4.17	5.21	7.29	0.00
Total	46.88	7.29	8.33	12.50	6.25

**Maintainable item versus failure mode, continued**

Item: Vessels - Scrubber

	PLU	SER	STD	UNK	Sum
Body/shell	0.00	0.00	2.08	0.00	4.17
Cabling & junction boxes	0.00	1.04	1.04	0.00	2.08
Control unit	0.00	0.00	0.00	0.00	1.04
Heater	0.00	1.04	0.00	0.00	1.04
Instrument, flow	0.00	0.00	0.00	0.00	0.52
Instrument, level	0.00	2.08	0.00	0.00	51.56
Instrument, pressure	0.00	1.04	0.00	0.00	8.33
Instrument, temperature	0.00	0.00	0.00	0.00	2.08
Monitoring	0.00	1.04	0.00	0.00	1.04
Piping	0.00	0.00	1.56	0.00	1.56
Support	0.00	0.00	1.04	0.00	1.04
Unknown	0.00	2.08	1.04	0.00	5.21
Valves	1.04	0.00	0.52	2.08	20.31
Total	1.04	8.33	7.29	2.08	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item: Vessels - Scrubber**

	AIR	ELP	ELU	OTH	PDE
Breakage	2.08	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	1.04	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00
Common mode failure	0.00	0.00	0.00	0.00	1.04
Corrosion	1.04	0.00	0.00	1.04	0.00
Deformation	0.00	0.00	0.00	2.08	0.00
Earth/isolation fault	1.04	0.00	0.00	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00
Fatigue	0.00	1.04	0.00	0.00	0.00
Faulty signal/indication/alarm	13.54	0.00	0.00	0.00	1.04
Instrument failure - general	5.21	0.00	1.04	1.04	1.04
Leakage	0.00	0.00	4.17	0.00	0.00
Looseness	0.00	1.04	0.00	0.00	0.00
Mechanical Failure - general	0.00	1.04	1.04	0.00	0.00
No cause found	0.00	1.04	0.00	0.00	0.00
No signal/indication/alarm	6.25	0.00	0.00	1.04	0.00
Other	0.00	0.00	0.00	1.04	0.00
Out of adjustment	16.67	0.00	0.00	1.04	3.12
Unknown	0.00	0.00	1.04	1.04	0.00
Vibration	0.00	0.00	0.00	0.00	0.00
Wear	1.04	3.12	1.04	3.12	0.00
Total	46.88	7.29	8.33	12.50	6.25

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

Item: Vessels - Scrubber

	PLU	SER	STD	UNK	Sum
Breakage	0.00	0.00	0.00	0.00	2.08
Cavitation	0.00	0.00	2.08	0.00	3.12
Clearance/ alignment failure	1.04	0.00	0.00	0.00	1.04
Common mode failure	0.00	0.00	0.00	0.00	1.04
Corrosion	0.00	3.12	3.12	0.00	8.33
Deformation	0.00	0.00	1.04	0.00	3.12
Earth/isolation fault	0.00	0.00	0.00	0.00	1.04
Electrical failure - general	0.00	1.04	0.00	0.00	1.04
External influence - general	0.00	1.04	0.00	0.00	1.04
Fatigue	0.00	0.00	0.00	0.00	1.04
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	14.58
Instrument failure - general	0.00	1.04	0.00	0.00	9.37
Leakage	0.00	0.00	0.00	0.00	4.17
Looseness	0.00	0.00	0.00	0.00	1.04
Mechanical Failure - general	0.00	0.00	1.04	0.00	3.12
No cause found	0.00	0.00	0.00	0.00	1.04
No signal/indication/alarm	0.00	0.00	0.00	1.04	8.33
Other	0.00	1.04	0.00	1.04	3.12
Out of adjustment	0.00	0.00	0.00	0.00	20.83
Unknown	0.00	0.00	0.00	0.00	2.08
Vibration	0.00	1.04	0.00	0.00	1.04
Wear	0.00	0.00	0.00	0.00	8.33
Total	1.04	8.33	7.29	2.08	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 3.2.7.1		Item Mechanical Equipment Vessels Scrubber (1-10)m3									
Population 17	Installations 6	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.4880		Operational time † 0.4675			Active rep.hrs	Repair (manhours)			
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ	Min		Mean	Max	
<b>Critical</b>	<b>11*</b> <b>11†</b>	<b>0.04</b>	<b>27.83</b>	<b>113.35</b>	<b>42.83</b>	<b>22.54</b>	<b>5.8</b>	<b>2.0</b>	<b>8.8</b>	<b>28.0</b>	
Abnormal instrument reading	1*	0.00	2.73	11.90	4.63	2.05	2.5	5.0	5.0	5.0	
	1†	0.00	2.84	12.39	4.82	2.14					
External leakage - Process medium	1*	0.01	1.81	7.01	2.59	2.05	7.0	9.0	9.0	9.0	
	1†	0.00	1.90	7.57	2.83	2.14					
External leakage - Utility medium	1*	0.00	2.73	11.90	4.63	2.05	2.0	4.0	4.0	4.0	
	1†	0.00	2.84	12.39	4.82	2.14					
Other	3*	0.03	7.24	27.47	10.13	6.15	5.3	6.0	8.7	10.0	
	3†	0.03	7.59	28.71	10.59	6.42					
Parameter deviation	2*	0.00	3.45	14.98	5.82	4.10	-	2.0	3.0	4.0	
	2†	0.00	3.55	15.11	5.83	4.28					
Structural deficiency	2*	0.00	6.21	29.09	11.84	4.10	9.5	10.0	19.0	28.0	
	2†	0.00	6.46	30.30	12.33	4.28					
Unknown	1*	0.00	2.73	11.90	4.63	2.05	-	-	-	-	
	1†	0.00	2.84	12.39	4.82	2.14					
<b>Degraded</b>	<b>16*</b> <b>16†</b>	<b>0.03</b>	<b>22.31</b>	<b>90.50</b>	<b>34.14</b>	<b>32.78</b>	<b>10.8</b>	<b>4.0</b>	<b>8.0</b>	<b>22.0</b>	
External leakage - Process medium	6*	0.29	9.93	30.23	10.46	12.29	9.3	4.0	7.5	16.0	
	6†	0.31	10.36	31.51	10.89	12.83					
External leakage - Utility medium	3*	0.06	5.32	17.32	6.30	6.15	-	4.0	10.3	20.0	
	3†	0.14	5.56	17.05	5.96	6.42					
Other	6*	0.00	8.90	43.22	17.94	12.29	-	4.0	5.0	8.0	
	6†	0.00	9.08	43.45	17.87	12.83					
Plugged/Choked	1*	0.01	1.81	7.01	2.59	2.05	15.0	22.0	22.0	22.0	
	1†	0.00	1.90	7.57	2.83	2.14					
<b>Incipient</b>	<b>63*</b> <b>63†</b>	<b>11.76</b>	<b>105.96</b>	<b>279.35</b>	<b>88.32</b>	<b>129.09</b>	<b>10.8</b>	<b>1.0</b>	<b>10.1</b>	<b>53.0</b>	
Abnormal instrument reading	39*	1.60	55.41	168.73	58.44	79.91	11.8	1.0	9.8	36.0	
	39†	2.07	57.76	174.51	59.62	83.43					
External leakage - Utility medium	4*	0.01	10.80	45.74	17.60	8.20	8.3	4.0	13.5	42.0	
	4†	0.01	11.19	47.53	18.31	8.56					
Minor in-service problems	7*	3.17	13.96	31.03	8.89	14.34	13.5	4.0	12.6	53.0	
	7†	3.84	14.50	30.77	8.54	14.97					
Other	3*	0.03	7.35	27.06	10.00	6.15	2.0	4.0	6.0	8.0	
	3†	0.03	7.61	28.24	10.43	6.42					
Parameter deviation	4*	2.56	8.03	15.97	4.22	8.20	-	2.0	8.5	14.0	
	4†	2.74	8.32	16.37	4.28	8.56					
Structural deficiency	5*	0.43	10.50	31.61	10.71	10.25	-	8.0	10.0	14.0	
	5†	0.54	10.80	32.35	10.80	10.70					
<b>Comments</b>											

(cont.)

Taxonomy no 3.2.7.1		Item Mechanical Equipment Vessels Scrubber (1-10)m3									
Population 17	Installations 6	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *			Operational time †						
		0.4880			0.4675						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Unknown	1*	0.00	2.73	11.90	4.63	2.05	2.0	4.0	4.0	4.0	
	1†	0.00	2.84	12.39	4.82	2.14					
All modes	90*	11.49	151.67	431.32	141.58	184.41	9.7	1.0	9.5	53.0	
	90†	13.41	157.17	438.14	142.63	192.52					
Comments											

Taxonomy no 3.2.7.2		Item Mechanical Equipment Vessels Scrubber (10-50)m3									
Population 8	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1664			Operational time † 0.1611						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Degraded</b>	1*	0.05	5.55	18.38	6.73	6.01	-	20.0	20.0	20.0	
	1†	0.05	5.75	19.30	7.08	6.21					
Abnormal instrument reading	1*	0.05	5.55	18.38	6.73	6.01	-	20.0	20.0	20.0	
	1†	0.05	5.75	19.30	7.08	6.21					
<b>Incipient</b>	5*	0.77	25.93	78.87	27.26	30.05	-	8.0	25.0	39.0	
	5†	0.64	27.00	82.96	29.07	31.04					
Abnormal instrument reading	4*	1.39	21.17	61.49	20.34	24.04	-	8.0	24.3	39.0	
	4†	1.17	21.99	65.43	21.81	24.83					
Minor in-service problems	1*	0.05	5.55	18.38	6.73	6.01	-	28.0	28.0	28.0	
	1†	0.05	5.75	19.30	7.08	6.21					
<b>All modes</b>	6*	0.55	30.69	95.84	34.11	36.05	-	8.0	24.2	39.0	
	6†	0.49	32.00	101.10	36.27	37.25					
<b>Comments</b>											



Taxonomy no 3.2.8		Item Mechanical Equipment Vessels Separator								
Population 83	Installations 13	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
		4.6937		1.3051						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>59*</b>	<b>0.22</b>	<b>28.86</b>	<b>98.13</b>	<b>36.11</b>	<b>12.57</b>	<b>5.2</b>	<b>1.0</b>	<b>7.4</b>	<b>45.0</b>
	<b>59†</b>	<b>0.24</b>	<b>35.92</b>	<b>124.00</b>	<b>45.72</b>	<b>45.21</b>				
Abnormal instrument reading	23*	0.00	13.44	65.65	27.46	4.90	4.8	1.0	6.9	20.0
	23†	0.00	14.03	79.08	41.87	17.62				
External leakage - Process medium	21*	0.00	6.92	38.88	20.48	4.47	5.9	1.0	6.1	18.0
	21†	0.00	9.55	55.26	30.03	16.09				
Other	7*	0.00	5.14	26.52	11.58	1.49	6.4	1.0	12.6	45.0
	7†	0.00	5.33	29.57	17.63	5.36				
Parameter deviation	3*	0.10	0.56	1.32	0.39	0.64	2.2	1.0	4.0	8.0
	3†	0.00	2.39	13.26	6.81	2.30				
Plugged/Choked	5*	0.00	3.10	13.59	5.31	1.07	2.5	2.0	9.2	22.0
	5†	0.00	4.05	17.55	6.81	3.83				
<b>Degraded</b>	<b>145*</b>	<b>0.34</b>	<b>68.29</b>	<b>248.96</b>	<b>91.98</b>	<b>30.89</b>	<b>5.1</b>	<b>1.0</b>	<b>7.5</b>	<b>64.0</b>
	<b>145†</b>	<b>0.34</b>	<b>102.44</b>	<b>397.11</b>	<b>146.90</b>	<b>111.10</b>				
Abnormal instrument reading	42*	0.00	22.66	120.19	54.93	8.95	6.3	1.0	9.0	64.0
	42†	0.00	24.96	134.08	86.45	32.18				
External leakage - Process medium	19*	0.05	9.92	35.73	13.20	4.05	5.8	1.5	7.8	25.0
	19†	0.09	15.61	54.85	20.25	14.56				
External leakage - Utility medium	7*	0.01	4.62	17.99	6.67	1.49	8.8	4.0	15.9	40.0
	7†	0.01	5.07	20.62	7.78	5.36				
Other	23*	0.15	12.31	39.62	14.36	4.90	5.3	1.0	9.0	32.0
	23†	0.38	16.77	51.67	18.16	17.62				
Parameter deviation	12*	0.00	4.02	16.91	6.48	2.56	3.8	1.0	6.3	40.0
	12†	0.06	8.92	30.89	11.39	9.19				
Plugged/Choked	37*	0.15	10.81	34.34	12.36	7.88	3.7	1.0	4.3	15.0
	37†	0.02	29.68	124.87	47.88	28.35				
Structural deficiency	5*	0.00	2.87	15.28	7.01	1.07	2.4	1.0	2.4	4.0
	5†	0.00	3.15	18.29	9.96	3.83				
<b>Incipient</b>	<b>623*</b>	<b>0.20</b>	<b>323.16</b>	<b>1371.71</b>	<b>528.35</b>	<b>132.73</b>	<b>5.1</b>	<b>0.5</b>	<b>7.2</b>	<b>104.0</b>
	<b>623†</b>	<b>0.00</b>	<b>385.12</b>	<b>1885.58</b>	<b>790.88</b>	<b>477.37</b>				
Abnormal instrument reading	428*	0.01	217.01	1007.37	407.25	91.19	5.2	1.0	6.8	97.0
	428†	0.00	252.30	1351.08	622.79	327.95				
External leakage - Process medium	31*	0.14	8.65	27.28	9.77	6.60	4.0	1.0	6.9	52.0
	31†	0.00	23.71	107.38	42.70	23.75				
External leakage - Utility medium	9*	0.00	5.90	28.34	11.67	1.92	4.0	4.0	9.3	20.0
	9†	0.00	6.15	33.86	16.93	6.90				
Minor in-service problems	81*	0.01	48.14	219.88	87.70	17.26	4.7	1.0	8.0	95.0
	81†	0.00	49.42	271.94	134.72	62.07				
Other	21*	0.14	14.74	48.51	17.72	4.47	6.2	2.0	9.7	40.0
	21†	0.03	15.30	61.88	23.31	16.09				
<b>Comments</b>										

(cont.)

Taxonomy no 3.2.8		Item Mechanical Equipment Vessels Separator								
Population 83	Installations 13	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
		4.6937		1.3051						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Parameter deviation	25*	0.76	14.80	44.18	14.74	5.33	5.0	0.5	6.4	40.0
	25†	0.68	21.26	64.48	22.18	19.16				
Plugged/Choked	23*	0.00	10.38	49.20	20.15	4.90	5.0	1.0	7.8	104.0
	23†	0.00	15.42	75.08	31.29	17.62				
Structural deficiency	4*	0.00	2.60	10.64	4.03	0.85	2.8	2.0	19.3	56.0
	4†	0.02	2.99	10.62	3.92	3.06				
Unknown	1*	0.00	0.56	2.75	1.16	0.21	11.0	11.0	11.0	11.0
	1†	0.00	0.71	3.93	2.03	0.77				
<b>Unknown</b>	<b>10*</b>	<b>0.00</b>	<b>5.63</b>	<b>25.75</b>	<b>10.28</b>	<b>2.13</b>	<b>4.3</b>	<b>1.0</b>	<b>15.1</b>	<b>52.0</b>
	<b>10†</b>	<b>0.00</b>	<b>6.89</b>	<b>33.95</b>	<b>14.33</b>	<b>7.66</b>				
Other	1*	0.00	0.72	3.58	1.53	0.21	-	52.0	52.0	52.0
	1†	0.01	0.78	2.50	0.90	0.77				
Parameter deviation	1*	0.00	0.19	0.59	0.21	0.21	-	-	-	-
	1†	0.00	0.80	4.30	2.76	0.77				
Unknown	8*	0.00	4.78	23.62	10.00	1.70	4.3	1.0	9.9	31.0
	8†	0.00	5.18	28.59	14.42	6.13				
<b>All modes</b>	<b>837*</b>	<b>0.56</b>	<b>425.07</b>	<b>1739.83</b>	<b>658.73</b>	<b>178.32</b>	<b>5.1</b>	<b>0.5</b>	<b>7.3</b>	<b>104.0</b>
	<b>837†</b>	<b>0.04</b>	<b>526.87</b>	<b>2433.20</b>	<b>979.64</b>	<b>641.34</b>				
Comments										

**Maintainable item versus failure mode, to be continued**

**Item:** Vessels - Separator

	AIR	ELP	ELU	OTH	PDE
Actuating device	0.24	0.06	0.12	0.36	0.12
Body/shell	0.00	0.00	0.12	0.00	0.00
Cabling & junction boxes	0.24	0.00	0.00	0.12	0.00
Control unit	1.31	0.00	0.00	0.36	0.12
Instrument, flow	6.33	0.00	0.00	0.00	0.60
Instrument, general	0.48	0.00	0.00	0.00	0.00
Instrument, level	40.92	0.72	0.36	0.90	2.63
Instrument, pressure	2.27	0.12	0.00	0.12	0.00
Instrument, temperature	0.72	0.00	0.00	0.00	0.00
Monitoring	0.48	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00
Piping	0.06	0.60	0.12	0.00	0.00
Plates, trays, vanes, pads	0.00	0.00	0.00	0.00	0.00
Sand trap system	0.00	0.00	0.00	0.00	0.00
Subunit	0.24	0.00	0.00	0.00	0.00
Support	0.00	0.00	0.00	0.12	0.00
Unknown	0.48	0.12	0.12	0.24	0.12
Valves	5.14	6.87	1.08	4.00	1.31
Total	58.90	8.48	1.91	6.21	4.90

**Maintainable item versus failure mode, continued**

**Item:** Vessels - Separator

	PLU	SER	STD	UNK	Sum
Actuating device	0.00	0.00	0.00	0.00	0.90
Body/shell	0.00	0.24	0.36	0.00	0.72
Cabling & junction boxes	0.00	0.12	0.00	0.00	0.48
Control unit	0.12	0.00	0.00	0.00	1.91
Instrument, flow	0.00	0.36	0.00	0.00	7.29
Instrument, general	0.00	0.36	0.00	0.00	0.84
Instrument, level	0.00	1.67	0.00	0.36	47.55
Instrument, pressure	0.00	0.24	0.00	0.12	2.87
Instrument, temperature	0.00	0.00	0.00	0.00	0.72
Monitoring	0.00	0.00	0.00	0.00	0.48
Other	0.24	0.00	0.00	0.00	0.24
Piping	0.00	1.55	0.24	0.00	2.57
Plates, trays, vanes, pads	0.00	0.24	0.00	0.00	0.24
Sand trap system	0.24	0.00	0.00	0.00	0.24
Subunit	3.46	0.12	0.00	0.00	3.82
Support	0.00	0.12	0.00	0.00	0.24
Unknown	0.24	0.60	0.00	0.24	2.15
Valves	3.46	4.06	0.48	0.36	26.76
Total	7.77	9.68	1.08	1.08	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Vessels - Separator

	AIR	ELP	ELU	OTH	PDE
Blockage/plugged	5.73	0.12	0.00	0.60	0.36
Breakage	0.48	0.12	0.36	0.48	0.24
Clearance/ alignment failure	0.24	0.00	0.00	0.00	0.00
Combined causes	0.12	0.12	0.00	0.00	0.12
Common mode failure	0.12	0.00	0.00	0.00	0.00
Contamination	0.12	0.00	0.00	0.00	0.00
Control failure	0.48	0.00	0.00	0.24	0.12
Corrosion	0.24	0.12	0.12	0.36	0.00
Deformation	0.12	0.00	0.00	0.00	0.00
Earth/isolation fault	0.24	0.00	0.00	0.00	0.00
Electrical failure - general	0.60	0.00	0.00	0.12	0.00
Erosion	0.00	2.51	0.00	0.00	0.24
External influence - general	0.12	0.00	0.00	0.12	0.00
Faulty signal/indication/alarm	5.14	0.00	0.00	0.12	0.00
Instrument failure - general	19.83	0.00	0.00	0.60	1.31
Leakage	0.36	2.27	0.36	0.48	0.00
Looseness	0.24	0.48	0.12	0.00	0.00
Material failure - general	0.00	0.36	0.12	0.60	0.12
Mechanical Failure - general	1.79	0.96	0.12	0.60	0.24
Misc. external influences	1.08	0.00	0.00	0.12	0.00
Miscellaneous - general	0.00	0.00	0.00	0.12	0.00
No cause found	0.12	0.00	0.12	0.12	0.00
No signal/indication/alarm	0.96	0.00	0.00	0.00	0.00
Open circuit	0.24	0.00	0.00	0.00	0.00
Out of adjustment	19.71	0.00	0.12	0.84	1.67
Short circuiting	0.00	0.00	0.00	0.12	0.00
Sticking	0.24	0.00	0.12	0.12	0.00
Unknown	0.12	0.12	0.00	0.00	0.36
Vibration	0.24	0.00	0.00	0.00	0.00
Wear	0.24	1.31	0.36	0.48	0.12
Total	58.90	8.48	1.91	6.21	4.90

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

Item: Vessels - Separator

	PLU	SER	STD	UNK	Sum
Blockage/plugged	5.38	0.96	0.00	0.00	13.14
Breakage	0.12	0.12	0.00	0.00	1.91
Clearance/ alignment failure	0.24	0.12	0.00	0.00	0.60
Combined causes	0.00	0.00	0.00	0.00	0.36
Common mode failure	0.00	0.00	0.00	0.00	0.12
Contamination	0.12	0.12	0.00	0.00	0.36
Control failure	0.12	0.00	0.00	0.00	0.96
Corrosion	0.36	0.84	0.36	0.00	2.39
Deformation	0.00	0.00	0.00	0.00	0.12
Earth/isolation fault	0.00	0.24	0.00	0.00	0.48
Electrical failure - general	0.00	0.12	0.00	0.00	0.84
Erosion	0.00	0.00	0.00	0.00	2.75
External influence - general	0.12	0.72	0.00	0.00	1.08
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	5.26
Instrument failure - general	0.48	1.55	0.12	0.72	24.61
Leakage	0.00	0.12	0.00	0.00	3.58
Looseness	0.00	0.00	0.00	0.00	0.84
Material failure - general	0.00	1.43	0.12	0.00	2.75
Mechanical Failure - general	0.48	0.84	0.24	0.12	5.38
Misc. external influences	0.00	1.67	0.24	0.00	3.11
Miscellaneous - general	0.00	0.00	0.00	0.00	0.12
No cause found	0.00	0.00	0.00	0.00	0.36
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.96
Open circuit	0.00	0.00	0.00	0.00	0.24
Out of adjustment	0.12	0.36	0.00	0.12	22.94
Short circuiting	0.00	0.00	0.00	0.00	0.12
Sticking	0.12	0.00	0.00	0.00	0.60
Unknown	0.00	0.24	0.00	0.12	0.96
Vibration	0.00	0.00	0.00	0.00	0.24
Wear	0.12	0.24	0.00	0.00	2.87
Total	7.77	9.68	1.08	1.08	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 3.2.8.1		Item Mechanical Equipment Vessels Separator (1-10)m3									
Population 50	Installations 5	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *		Operational time †							
		3.7259		0.3552							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	<b>11*</b> <b>11†</b>	<b>1.95</b>	<b>10.69</b>	<b>25.23</b>	<b>7.50</b>	<b>2.95</b>	<b>2.1</b>	<b>1.0</b>	<b>6.0</b>	<b>22.0</b>	
Abnormal instrument reading	1*	0.51	4.50	11.82	3.73	0.27	-	2.0	2.0	2.0	
	1†	0.00	4.18	18.52	7.30	2.82					
External leakage - Process medium	3*	0.07	0.72	1.96	0.63	0.81	1.7	2.0	2.7	4.0	
	3†	0.03	7.40	28.64	10.59	8.45					
Parameter deviation	3*	0.07	0.72	1.96	0.63	0.81	2.2	1.0	4.0	8.0	
	3†	0.03	7.40	28.64	10.59	8.45					
Plugged/Choked	4*	0.34	6.94	20.78	6.95	1.07	3.0	3.0	11.0	22.0	
	4†	1.12	10.74	28.74	9.17	11.26					
<b>Degraded</b>	<b>61*</b> <b>61†</b>	<b>27.86</b>	<b>94.50</b>	<b>193.41</b>	<b>52.23</b>	<b>16.37</b>	<b>3.2</b>	<b>1.0</b>	<b>6.1</b>	<b>40.0</b>	
		<b>28.23</b>	<b>182.94</b>	<b>450.11</b>	<b>137.33</b>	<b>171.74</b>					
Abnormal instrument reading	2*	0.09	0.53	1.27	0.38	0.54	1.0	1.0	1.0	1.0	
	2†	0.16	5.27	16.04	5.54	5.63					
External leakage - Process medium	13*	5.86	32.04	75.51	22.43	3.49	3.1	1.5	6.3	20.0	
	13†	1.02	45.48	140.13	49.26	36.60					
External leakage - Utility medium	2*	1.56	10.06	24.71	7.53	0.54	-	8.0	24.0	40.0	
	2†	0.00	9.75	43.52	17.20	5.63					
Other	12*	9.19	37.22	80.72	22.76	3.22	1.8	1.0	8.9	21.0	
	12†	1.03	46.30	142.75	50.21	33.78					
Parameter deviation	6*	0.37	1.57	3.46	0.98	1.61	2.0	1.0	2.7	8.0	
	6†	6.71	16.25	29.16	6.97	16.89					
Plugged/Choked	26*	1.41	8.50	20.53	6.19	6.98	4.0	3.0	4.5	15.0	
	26†	1.18	62.59	194.82	69.14	73.20					
<b>Incipient</b>	<b>101*</b> <b>101†</b>	<b>38.63</b>	<b>136.00</b>	<b>281.87</b>	<b>76.86</b>	<b>27.11</b>	<b>1.9</b>	<b>0.5</b>	<b>3.2</b>	<b>40.0</b>	
		<b>48.88</b>	<b>285.56</b>	<b>684.35</b>	<b>205.39</b>	<b>284.35</b>					
Abnormal instrument reading	53*	14.23	67.68	153.90	44.78	14.22	1.8	1.0	2.7	15.0	
	53†	11.80	151.28	428.18	140.28	149.21					
External leakage - Process medium	20*	3.30	5.12	7.28	1.22	5.37	1.9	1.0	2.0	4.0	
	20†	0.02	42.92	183.30	70.79	56.31					
External leakage - Utility medium	2*	1.56	10.06	24.71	7.53	0.54	-	12.0	12.5	13.0	
	2†	0.00	9.75	43.52	17.20	5.63					
Minor in-service problems	2*	1.56	10.06	24.71	7.53	0.54	-	3.0	5.0	7.0	
	2†	0.00	9.75	43.52	17.20	5.63					
Other	3*	4.14	14.73	30.63	8.37	0.81	-	8.0	19.3	40.0	
	3†	0.10	13.92	47.62	17.54	8.45					
Parameter deviation	15*	6.08	23.47	50.13	13.98	4.03	1.6	0.5	2.0	4.0	
	15†	25.03	42.23	63.08	11.68	42.23					
Plugged/Choked	6*	0.27	1.46	3.44	1.02	1.61	3.5	1.0	3.5	4.0	
	6†	0.10	14.37	49.45	18.22	16.89					
<b>Comments</b>											

(cont.)

Taxonomy no 3.2.8.1		Item Mechanical Equipment Vessels Separator (1-10)m3								
Population 50	Installations 5	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
		3.7259		0.3552						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Unknown	1*	0.01	0.25	0.77	0.27	0.27	-	-	-	-
	1†	0.00	2.58	11.36	4.45	2.82	-	-	-	-
Parameter deviation	1*	0.01	0.25	0.77	0.27	0.27	-	-	-	-
	1†	0.00	2.58	11.36	4.45	2.82	-	-	-	-
All modes	174*	79.09	250.41	499.99	132.28	46.70	2.4	0.5	4.4	40.0
	174†	85.37	499.14	1196.46	359.14	489.87				
Comments										

Taxonomy no 3.2.8.2		Item Mechanical Equipment Vessels Separator (10-50)m3								
Population 11	Installations 7	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
		0.3440		0.3375						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>6*</b>	<b>0.28</b>	<b>17.87</b>	<b>56.42</b>	<b>20.23</b>	<b>17.44</b>	<b>6.5</b>	<b>1.0</b>	<b>11.0</b>	<b>45.0</b>
	<b>6†</b>	<b>0.29</b>	<b>18.24</b>	<b>57.38</b>	<b>20.53</b>	<b>17.78</b>				
Abnormal instrument reading	3*	0.02	7.60	30.09	11.22	8.72	2.5	1.0	3.7	6.0
	3†	0.02	7.77	31.03	11.61	8.89				
Other	3*	0.00	11.42	57.69	24.79	8.72	9.2	2.0	18.3	45.0
	3†	0.00	11.59	58.49	25.14	8.89				
<b>Degraded</b>	<b>32*</b>	<b>0.22</b>	<b>79.24</b>	<b>310.37</b>	<b>115.33</b>	<b>93.02</b>	<b>5.7</b>	<b>1.0</b>	<b>9.6</b>	<b>47.0</b>
	<b>32†</b>	<b>0.21</b>	<b>81.45</b>	<b>320.78</b>	<b>119.44</b>	<b>94.83</b>				
Abnormal instrument reading	5*	3.15	14.44	32.48	9.38	14.53	8.3	2.0	14.2	47.0
	5†	2.83	14.79	34.49	10.19	14.82				
External leakage - Process medium	1*	0.00	2.61	12.81	5.39	2.91	-	16.0	16.0	16.0
	1†	0.00	2.65	12.92	5.39	2.96				
External leakage - Utility medium	4*	0.09	10.96	36.91	13.56	11.63	11.3	5.0	14.8	35.0
	4†	0.10	11.16	37.27	13.67	11.85				
Other	7*	3.74	19.10	44.27	13.03	20.35	5.4	1.0	8.9	32.0
	7†	3.47	19.48	46.17	13.75	20.74				
Parameter deviation	4*	0.28	11.05	33.88	11.84	11.63	7.8	2.0	14.0	40.0
	4†	0.23	11.33	35.14	12.43	11.85				
Plugged/Choked	10*	0.00	23.64	117.28	49.81	29.07	3.0	1.0	3.8	8.0
	10†	0.00	24.42	121.41	51.64	29.63				
Structural deficiency	1*	0.00	2.61	12.81	5.39	2.91	4.0	4.0	4.0	4.0
	1†	0.00	2.68	13.25	5.61	2.96				
<b>Incipient</b>	<b>146*</b>	<b>0.78</b>	<b>328.25</b>	<b>1301.09</b>	<b>485.49</b>	<b>424.40</b>	<b>5.5</b>	<b>1.0</b>	<b>9.1</b>	<b>95.0</b>
	<b>146†</b>	<b>0.77</b>	<b>336.66</b>	<b>1337.46</b>	<b>499.41</b>	<b>432.65</b>				
Abnormal instrument reading	81*	0.02	183.13	831.43	330.94	235.45	4.6	1.0	7.3	95.0
	81†	0.02	189.04	859.90	342.50	240.03				
External leakage - Process medium	3*	0.04	9.16	34.21	12.63	8.72	2.0	4.0	8.7	12.0
	3†	0.04	9.34	35.28	13.01	8.89				
External leakage - Utility medium	5*	0.00	11.46	59.31	26.06	14.53	-	4.0	10.2	20.0
	5†	0.00	11.57	59.75	26.13	14.82				
Minor in-service problems	32*	0.10	70.67	287.36	108.51	93.02	7.7	1.0	12.3	95.0
	32†	0.10	72.23	294.31	111.23	94.83				
Other	12*	0.29	30.86	101.99	37.30	34.88	10.5	2.0	9.8	30.0
	12†	0.33	31.42	102.51	37.34	35.56				
Parameter deviation	5*	0.06	13.02	48.35	17.85	14.53	20.0	2.0	11.6	40.0
	5†	0.07	13.19	48.01	17.74	14.82				
Plugged/Choked	6*	1.87	15.73	40.83	12.79	17.44	3.0	2.0	5.8	10.0
	6†	1.88	16.05	41.75	13.09	17.78				
Structural deficiency	2*	0.09	5.39	16.89	6.03	5.81	-	12.0	34.0	56.0
	2†	0.15	5.50	16.79	5.84	5.93				
<b>Comments</b>										

(cont.)



Taxonomy no 3.2.8.2		Item Mechanical Equipment Vessels Separator (10-50)m3								
Population 11	Installations 7	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.3440			Operational time † 0.3375					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Unknown	1*	0.00	2.61	12.81	5.39	2.91	4.0	4.0	4.0	4.0
	1†	0.00	2.68	13.25	5.61	2.96				
Unknown	1*	0.00	2.61	12.81	5.39	2.91	4.0	4.0	4.0	4.0
	1†	0.00	2.68	13.25	5.61	2.96				
All modes	185*	1.51	425.82	1644.87	607.44	537.77	5.6	1.0	9.2	95.0
	185†	1.47	436.81	1692.81	626.13	548.23				
Comments										

Taxonomy no 3.2.8.3		Item Mechanical Equipment Vessels Separator (50-100)m <sup>3</sup>								
Population 11	Installations 6	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †			Active rep.hrs	Repair (manhours)		
		0.3031		0.2962						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max
<b>Critical</b>	6*	0.01	17.46	74.56	28.79	19.79	6.7	2.0	6.8	18.0
	6†	0.01	17.66	74.85	28.81	20.26				
Abnormal instrument reading	1*	0.00	2.91	12.62	4.90	3.30	2.0	3.0	3.0	3.0
	1†	0.00	2.97	12.69	4.90	3.38				
External leakage - Process medium	5*	0.00	14.78	73.90	31.57	16.50	7.6	2.0	7.6	18.0
	5†	0.00	14.91	74.40	31.73	16.88				
<b>Degraded</b>	5*	0.01	25.83	111.91	43.45	16.50	5.6	2.0	5.6	10.0
	5†	0.01	26.46	114.77	44.58	16.88				
External leakage - Process medium	4*	0.00	23.47	110.10	44.84	13.20	6.5	2.0	6.5	10.0
	4†	0.00	24.10	113.02	46.01	13.51				
Other	1*	0.00	3.18	15.72	6.66	3.30	2.0	2.0	2.0	2.0
	1†	0.00	3.23	15.85	6.67	3.38				
<b>Incipient</b>	47*	6.92	137.01	409.93	136.83	155.05	10.6	1.0	13.4	52.0
	47†	8.03	139.07	410.19	136.35	158.70				
Abnormal instrument reading	34*	0.71	101.50	348.29	128.32	112.17	10.7	1.0	12.5	50.0
	34†	0.77	102.67	349.42	128.58	114.80				
External leakage - Process medium	8*	0.84	23.53	71.08	24.29	26.39	12.8	2.0	18.6	52.0
	8†	0.91	24.10	72.68	24.74	27.01				
External leakage - Utility medium	1*	0.00	3.18	15.72	6.66	3.30	4.0	4.0	4.0	4.0
	1†	0.00	3.23	15.85	6.67	3.38				
Minor in-service problems	1*	0.00	3.18	15.72	6.66	3.30	3.0	3.0	3.0	3.0
	1†	0.00	3.23	15.85	6.67	3.38				
Other	2*	0.04	6.40	22.79	8.42	6.60	3.0	3.0	6.0	9.0
	2†	0.04	6.57	23.43	8.66	6.75				
Parameter deviation	1*	0.00	2.91	12.62	4.90	3.30	16.0	35.0	35.0	35.0
	1†	0.00	2.97	12.69	4.90	3.38				
<b>Unknown</b>	2*	0.00	7.10	31.32	12.30	6.60	-	27.0	39.5	52.0
	2†	0.00	7.40	32.92	12.99	6.75				
Other	1*	0.21	3.39	9.94	3.30	3.30	-	52.0	52.0	52.0
	1†	0.22	3.49	10.19	3.38	3.38				
Unknown	1*	0.21	3.39	9.94	3.30	3.30	-	27.0	27.0	27.0
	1†	0.22	3.49	10.19	3.38	3.38				
<b>All modes</b>	60*	13.74	185.87	530.58	174.41	197.94	9.6	1.0	12.9	52.0
	60†	15.01	188.84	532.88	174.37	202.59				
<b>Comments</b>										

Taxonomy no 3.2.8.4		Item Mechanical Equipment Vessels Separator (100-300)m3									
Population 8	Installations 5	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.2199			Operational time † 0.2164						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	17*	<b>0.32</b>	<b>60.91</b>	<b>219.34</b>	<b>81.05</b>	<b>77.32</b>	<b>5.8</b>	<b>1.0</b>	<b>7.4</b>	<b>18.0</b>	
	17†	<b>0.34</b>	<b>61.60</b>	<b>219.31</b>	<b>81.02</b>	<b>78.57</b>					
Abnormal instrument reading	1*	0.01	4.12	16.84	6.37	4.55	9.0	18.0	18.0	18.0	
	1†	0.01	4.19	17.06	6.44	4.62					
External leakage - Process medium	12*	0.00	42.42	218.27	94.67	54.58	6.1	1.0	6.2	15.0	
	12†	0.00	42.67	219.42	95.15	55.46					
Other	4*	0.03	14.86	59.63	22.38	18.19	4.3	1.0	8.3	13.0	
	4†	0.03	15.11	60.40	22.61	18.49					
<b>Degraded</b>	5*	<b>1.39</b>	<b>20.94</b>	<b>60.67</b>	<b>20.05</b>	<b>22.74</b>	<b>8.3</b>	<b>3.0</b>	<b>8.8</b>	<b>25.0</b>	
	5†	<b>1.53</b>	<b>21.28</b>	<b>61.00</b>	<b>20.08</b>	<b>23.11</b>					
External leakage - Process medium	1*	0.01	4.12	16.84	6.37	4.55	22.5	25.0	25.0	25.0	
	1†	0.01	4.19	17.06	6.44	4.62					
External leakage - Utility medium	1*	0.00	4.28	18.70	7.30	4.55	4.0	4.0	4.0	4.0	
	1†	0.00	4.34	18.80	7.30	4.62					
Other	2*	0.70	8.74	24.63	8.05	9.10	6.0	4.0	6.0	8.0	
	2†	0.85	8.89	24.23	7.80	9.24					
Plugged/Choked	1*	0.00	4.52	21.03	8.51	4.55	3.0	3.0	3.0	3.0	
	1†	0.00	4.63	21.55	8.73	4.62					
<b>Incipient</b>	44*	<b>9.91</b>	<b>190.24</b>	<b>567.44</b>	<b>189.25</b>	<b>200.12</b>	<b>9.1</b>	<b>1.0</b>	<b>10.8</b>	<b>97.0</b>	
	44†	<b>11.21</b>	<b>193.32</b>	<b>569.92</b>	<b>189.42</b>	<b>203.36</b>					
Abnormal instrument reading	33*	0.90	138.56	481.49	177.63	150.09	11.1	1.0	12.2	97.0	
	33†	0.98	140.63	483.57	178.20	152.52					
External leakage - Utility medium	1*	0.00	4.28	18.70	7.30	4.55	4.0	4.0	4.0	4.0	
	1†	0.00	4.34	18.80	7.30	4.62					
Minor in-service problems	5*	3.14	20.57	50.77	15.51	22.74	3.4	2.0	6.4	11.0	
	5†	3.35	20.94	51.09	15.51	23.11					
Other	2*	0.70	8.74	24.63	8.05	9.10	3.0	3.0	3.0	3.0	
	2†	0.85	8.89	24.23	7.80	9.24					
Parameter deviation	3*	0.01	24.49	108.55	42.74	13.64	5.0	6.0	9.7	13.0	
	3†	0.01	25.28	111.74	43.93	13.87					
<b>All modes</b>	66*	<b>4.61</b>	<b>263.11</b>	<b>823.03</b>	<b>293.23</b>	<b>300.19</b>	<b>8.2</b>	<b>1.0</b>	<b>9.8</b>	<b>97.0</b>	
	66†	<b>5.26</b>	<b>266.83</b>	<b>828.46</b>	<b>293.36</b>	<b>305.04</b>					
<b>Comments</b>											

Taxonomy no 3.2.8.5		Item Mechanical Equipment Vessels Separator (300-1000)m3									
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0701		Operational time † 0.0693							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
<b>Critical</b>	<b>18*</b> <b>18†</b>	<b>165.88</b> <b>167.91</b>	<b>256.67</b> <b>259.82</b>	<b>380.59</b> <b>385.25</b>	<b>256.67</b> <b>259.82</b>	<b>256.67</b> <b>259.82</b>	<b>4.8</b>	<b>1.0</b>	<b>7.0</b>	<b>20.0</b>	
Abnormal instrument reading	17*	154.44	242.41	363.58	242.41	242.41	5.0	1.0	7.3	20.0	
	17†	156.33	245.38	368.03	245.38	245.38					
Plugged/Choked	1*	0.71	14.26	67.66	14.26	14.26	2.0	2.0	2.0	2.0	
	1†	0.72	14.43	68.49	14.43	14.43					
<b>Degraded</b>	<b>41*</b> <b>41†</b>	<b>442.98</b> <b>448.40</b>	<b>584.65</b> <b>591.80</b>	<b>758.57</b> <b>767.86</b>	<b>584.65</b> <b>591.80</b>	<b>584.65</b> <b>591.80</b>	<b>5.7</b>	<b>1.0</b>	<b>7.7</b>	<b>64.0</b>	
Abnormal instrument reading	35*	368.88	499.09	661.70	499.09	499.09	6.4	1.0	8.7	64.0	
	35†	373.39	505.20	669.80	505.20	505.20					
Parameter deviation	2*	5.06	28.52	89.76	28.52	28.52	1.5	1.0	1.5	2.0	
	2†	5.12	28.87	90.86	28.87	28.87					
Structural deficiency	4*	19.46	57.04	130.55	57.04	57.04	2.0	1.0	2.0	3.0	
	4†	19.70	57.74	132.14	57.74	57.74					
<b>Incipient</b>	<b>279*</b> <b>279†</b>	<b>3594.91</b> <b>3638.91</b>	<b>3978.44</b> <b>4027.14</b>	<b>4393.14</b> <b>4446.92</b>	<b>3978.44</b> <b>4027.14</b>	<b>3978.44</b> <b>4027.14</b>	<b>4.3</b>	<b>1.0</b>	<b>6.0</b>	<b>104.0</b>	
Abnormal instrument reading	222*	2824.44	3165.64	3538.10	3165.64	3165.64	4.3	1.0	5.8	78.0	
	222†	2859.01	3204.39	3581.41	3204.39	3204.39					
Minor in-service problems	41*	442.98	584.65	758.57	584.65	584.65	3.7	1.0	5.2	28.0	
	41†	448.40	591.80	767.86	591.80	591.80					
Other	1*	0.71	14.26	67.66	14.26	14.26	3.0	3.0	3.0	3.0	
	1†	0.72	14.43	68.49	14.43	14.43					
Parameter deviation	1*	0.71	14.26	67.66	14.26	14.26	2.5	5.0	5.0	5.0	
	1†	0.72	14.43	68.49	14.43	14.43					
Plugged/Choked	11*	87.98	156.86	259.67	156.86	156.86	6.4	1.0	11.3	104.0	
	11†	89.06	158.78	262.85	158.78	158.78					
Structural deficiency	2*	5.06	28.52	89.76	28.52	28.52	2.8	2.0	4.5	7.0	
	2†	5.12	28.87	90.86	28.87	28.87					
Unknown	1*	0.71	14.26	67.66	14.26	14.26	11.0	11.0	11.0	11.0	
	1†	0.72	14.43	68.49	14.43	14.43					
<b>Unknown</b>	<b>6*</b> <b>6†</b>	<b>37.29</b> <b>37.75</b>	<b>85.56</b> <b>86.61</b>	<b>168.83</b> <b>170.90</b>	<b>85.56</b> <b>86.61</b>	<b>85.56</b> <b>86.61</b>	<b>4.3</b>	<b>1.0</b>	<b>7.6</b>	<b>31.0</b>	
Unknown	6*	37.29	85.56	168.83	85.56	85.56	4.3	1.0	7.6	31.0	
	6†	37.75	86.61	170.90	86.61	86.61					
<b>All modes</b>	<b>344*</b> <b>344†</b>	<b>4478.51</b> <b>4533.33</b>	<b>4905.32</b> <b>4965.36</b>	<b>5363.22</b> <b>5428.87</b>	<b>4905.32</b> <b>4965.36</b>	<b>4905.32</b> <b>4965.36</b>	<b>4.5</b>	<b>1.0</b>	<b>6.3</b>	<b>104.0</b>	
Comments											

Taxonomy no 3.2.8.6		Item Mechanical Equipment Vessels Separator Unknown									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0306		Operational time † 0.0306							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	1*	1.63	32.63	154.82	32.63	32.63	8.0	8.0	8.0	8.0	
	1†	1.63	32.65	154.94	32.65	32.65					
External leakage - Process medium	1*	1.63	32.63	154.82	32.63	32.63	8.0	8.0	8.0	8.0	
	1†	1.63	32.65	154.94	32.65	32.65					
<b>Degraded</b>	1*	1.63	32.63	154.82	32.63	32.63	24.0	24.0	24.0	24.0	
	1†	1.63	32.65	154.94	32.65	32.65					
Other	1*	1.63	32.63	154.82	32.63	32.63	24.0	24.0	24.0	24.0	
	1†	1.63	32.65	154.94	32.65	32.65					
<b>Incipient</b>	6*	85.32	195.77	386.32	195.77	195.77	8.3	2.0	8.3	30.0	
	6†	85.39	195.92	386.62	195.92	195.92					
Abnormal instrument reading	5*	64.28	163.14	343.09	163.14	163.14	8.8	2.0	8.8	30.0	
	5†	64.33	163.27	343.36	163.27	163.27					
Other	1*	1.63	32.63	154.82	32.63	32.63	6.0	6.0	6.0	6.0	
	1†	1.63	32.65	154.94	32.65	32.65					
<b>All modes</b>	8*	129.86	261.03	470.99	261.03	261.03	10.3	2.0	10.3	30.0	
	8†	129.96	261.23	471.36	261.23	261.23					
Comments											

Taxonomy no 3.2.9		Item Mechanical Equipment Vessels Stripper								
Population 2	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *			Operational time †					
		0.0482			0.0471					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max
All modes	0* 0†	0.04 0.04	9.82 10.20	37.71 39.17	13.89 14.43	0.00 0.00	-	-	-	-
Comments										

<b>Taxonomy no</b> 3.2.9.1		<b>Item</b> Mechanical Equipment Vessels Stripper (1-10)m3								
<b>Population</b> 2	<b>Installations</b> 2	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>			
		<b>Calendar time *</b> 0.0482			<b>Operational time †</b> 0.0471					
<b>Failure mode</b>	<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours).</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
		<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/t</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>	0* 0†	0.02 0.02	5.04 5.20	19.37 19.98	7.13 7.36	0.00 0.00	-	-	-	-
<b>Comments</b>										

Taxonomy no 3.2.10		Item Mechanical Equipment Vessels Surge tank								
Population 12	Installations 7	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.3400		Operational time † 0.2770						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	2* 2†	0.47 1.02	5.65 6.76	15.82 16.69	5.16 5.11	5.88 7.22	14.3	24.0	28.5	33.0
Abnormal instrument reading	2* 2†	0.47 1.02	5.65 6.76	15.82 16.69	5.16 5.11	5.88 7.22	14.3	24.0	28.5	33.0
<b>Degraded</b>	4* 4†	0.89 0.20	10.62 13.16	29.67 41.57	9.67 14.91	11.76 14.44	23.8	1.0	25.5	72.0
Other	2* 2†	0.11 0.04	5.29 6.55	16.33 22.62	5.76 8.34	5.88 7.22	36.0	1.0	36.5	72.0
Parameter deviation	1* 1†	0.01 0.00	2.56 3.36	9.75 16.82	3.59 7.19	2.94 3.61	-	6.0	6.0	6.0
Structural deficiency	1* 1†	0.00 0.00	3.17 3.49	16.85 18.13	7.70 8.03	2.94 3.61	11.5	23.0	23.0	23.0
<b>Incipient</b>	26* 26†	8.10 0.84	62.38 79.22	159.28 258.50	49.54 94.16	76.47 93.86	67.2	1.0	67.7	594.0
Abnormal instrument reading	13* 13†	0.00 0.00	23.11 37.61	115.25 198.31	49.15 90.00	38.23 46.93	0.5	1.0	7.6	21.0
External leakage - Utility medium	1* 1†	0.01 0.00	2.56 3.36	9.75 16.82	3.59 7.19	2.94 3.61	-	12.0	12.0	12.0
Minor in-service problems	2* 2†	0.01 0.02	5.41 6.89	21.32 26.65	7.94 9.85	5.88 7.22	108.5	36.0	126.5	217.0
Other	5* 5†	0.08 0.20	14.33 16.10	50.74 51.64	18.74 18.68	14.71 18.05	97.2	13.0	194.4	594.0
Parameter deviation	1* 1†	0.00 0.00	3.17 3.49	16.85 18.13	7.70 8.03	2.94 3.61	5.5	11.0	11.0	11.0
Structural deficiency	4* 4†	0.00 0.00	12.42 13.27	63.65 67.48	27.56 29.12	11.76 14.44	51.5	58.0	103.0	179.0
<b>All modes</b>	32* 32†	12.27 1.67	76.21 95.38	185.56 298.37	56.26 106.31	94.12 115.52	55.2	1.0	59.9	594.0
<b>Comments</b>										



**Maintainable item versus failure mode, to be continued**

Item: Vessels - Surge tank

	AIR	ELP	ELU	OTH	PDE
Body/shell	0.00	0.00	0.00	6.25	0.00
Instrument, level	34.38	0.00	0.00	0.00	3.13
Instrument, pressure	9.38	0.00	0.00	0.00	0.00
Instrument, temperature	3.13	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	3.13	0.00
Subunit	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	3.13
Valves	0.00	0.00	3.13	12.50	0.00
Total	46.88	0.00	3.13	21.88	6.25

**Maintainable item versus failure mode, continued**

Item: Vessels - Surge tank

	PLU	SER	STD	UNK	Sum
Body/shell	0.00	3.13	6.25	0.00	15.63
Instrument, level	0.00	0.00	0.00	0.00	37.50
Instrument, pressure	0.00	0.00	0.00	0.00	9.38
Instrument, temperature	0.00	0.00	0.00	0.00	3.13
Other	0.00	0.00	0.00	0.00	3.13
Subunit	0.00	0.00	3.13	0.00	3.13
Unknown	0.00	0.00	0.00	0.00	3.13
Valves	0.00	3.13	6.25	0.00	25.00
Total	0.00	6.25	15.63	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Vessels - Surge tank

	AIR	ELP	ELU	OTH	PDE
Cavitation	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	3.13	0.00
Control failure	6.25	0.00	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	12.50	0.00
Faulty signal/indication/alarm	6.25	0.00	0.00	0.00	0.00
Instrument failure - general	0.00	0.00	3.13	0.00	3.13
Misc. external influences	0.00	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	3.13
No signal/indication/alarm	9.38	0.00	0.00	0.00	0.00
Out of adjustment	25.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	6.25	0.00
Total	46.88	0.00	3.13	21.88	6.25

**Failure descriptor versus failure mode, continued**

**Item:** Vessels - Surge tank

	PLU	SER	STD	UNK	Sum
Cavitation	0.00	0.00	3.13	0.00	3.13
Clearance/ alignment failure	0.00	0.00	0.00	0.00	3.13
Control failure	0.00	0.00	0.00	0.00	6.25
Corrosion	0.00	0.00	12.50	0.00	25.00
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	6.25
Instrument failure - general	0.00	0.00	0.00	0.00	6.25
Misc. external influences	0.00	3.13	0.00	0.00	3.13
No cause found	0.00	0.00	0.00	0.00	3.13
No signal/indication/alarm	0.00	0.00	0.00	0.00	9.38
Out of adjustment	0.00	0.00	0.00	0.00	25.00
Sticking	0.00	3.13	0.00	0.00	3.13
Unknown	0.00	0.00	0.00	0.00	6.25
Total	0.00	6.25	15.63	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 3.2.10.1		Item Mechanical Equipment Vessels Surge tank (1-10)m3									
Population 5	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1542		Operational time † 0.0976							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	2*	<b>0.09</b>	<b>18.66</b>	<b>68.33</b>	<b>25.24</b>	<b>12.97</b>	14.3	24.0	28.5	33.0	
	2†	<b>0.40</b>	<b>21.45</b>	<b>66.78</b>	<b>23.70</b>	<b>20.48</b>					
Abnormal instrument reading	2*	0.09	18.66	68.33	25.24	12.97	14.3	24.0	28.5	33.0	
	2†	0.40	21.45	66.78	23.70	20.48					
<b>Degraded</b>	2*	<b>0.12</b>	<b>11.30</b>	<b>36.90</b>	<b>13.45</b>	<b>12.97</b>	-	1.0	3.5	6.0	
	2†	<b>1.93</b>	<b>19.87</b>	<b>54.03</b>	<b>17.38</b>	<b>20.48</b>					
Other	1*	0.09	5.93	18.74	6.72	6.48	-	1.0	1.0	1.0	
	1†	0.05	9.90	36.42	13.45	10.24					
Parameter deviation	1*	0.09	5.93	18.74	6.72	6.48	-	6.0	6.0	6.0	
	1†	0.05	9.90	36.42	13.45	10.24					
<b>Incipient</b>	14*	<b>0.58</b>	<b>70.27</b>	<b>235.96</b>	<b>86.62</b>	<b>90.78</b>	-	2.0	10.4	36.0	
	14†	<b>0.66</b>	<b>134.03</b>	<b>488.08</b>	<b>180.33</b>	<b>143.37</b>					
Abnormal instrument reading	12*	0.59	60.76	200.14	73.12	77.81	-	2.0	8.2	21.0	
	12†	0.60	115.00	415.14	153.40	122.89					
External leakage - Utility medium	1*	0.09	5.93	18.74	6.72	6.48	-	12.0	12.0	12.0	
	1†	0.05	9.90	36.42	13.45	10.24					
Minor in-service problems	1*	0.09	5.93	18.74	6.72	6.48	-	36.0	36.0	36.0	
	1†	0.05	9.90	36.42	13.45	10.24					
<b>All modes</b>	18*	<b>22.04</b>	<b>102.15</b>	<b>230.55</b>	<b>66.76</b>	<b>116.71</b>	14.3	1.0	11.7	36.0	
	18†	<b>9.67</b>	<b>175.50</b>	<b>520.38</b>	<b>173.25</b>	<b>184.34</b>					
<b>Comments</b>											

Taxonomy no		Item									
3.2.10.2		Mechanical Equipment Vessels Surge tank (10-50)m3									
Population	Installations	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *			Operational time †						
4	4	0.1122			0.1098						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Incipient	1*	0.59	9.25	26.92	8.91	8.91	297.0	594.0	594.0	594.0	
	1†	0.63	9.50	27.56	9.11	9.11					
Other	1*	0.59	9.25	26.92	8.91	8.91	297.0	594.0	594.0	594.0	
	1†	0.63	9.50	27.56	9.11	9.11					
All modes	1*	0.59	9.25	26.92	8.91	8.91	297.0	594.0	594.0	594.0	
	1†	0.63	9.50	27.56	9.11	9.11					
Comments											

Taxonomy no 3.2.10.3		Item Mechanical Equipment Vessels Surge tank (50-100)m3								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0245		Operational time † 0.0235						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	5*	80.32	203.85	428.69	203.85	203.85	62.9	58.0	125.8	217.0
	5†	83.74	212.55	446.99	212.55	212.55				
Minor in-service problems	1*	2.04	40.77	193.45	40.77	40.77	108.5	217.0	217.0	217.0
	1†	2.13	42.51	201.71	42.51	42.51				
Structural deficiency	4*	55.65	163.08	373.25	163.08	163.08	51.5	58.0	103.0	179.0
	4†	58.03	170.04	389.18	170.04	170.04				
All modes	5*	80.32	203.85	428.69	203.85	203.85	62.9	58.0	125.8	217.0
	5†	83.74	212.55	446.99	212.55	212.55				
Comments										

Taxonomy no		Item								
3.2.10.4		Mechanical Equipment Vessels Surge tank Unknown								
Population	Installations	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
2	2	0.0491		0.0461						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Degraded</b>	2*	7.24	40.77	96.73	28.83	40.77	23.8	23.0	47.5	72.0
	2†	7.71	43.42	103.01	30.70	43.41				
Other	1*	1.02	20.38	61.05	20.38	20.38	36.0	72.0	72.0	72.0
	1†	1.16	21.86	65.12	21.71	21.71				
Structural deficiency	1*	1.02	20.38	61.05	20.38	20.38	11.5	23.0	23.0	23.0
	1†	0.09	21.49	81.53	30.06	21.71				
<b>Incipient</b>	6*	45.25	122.31	229.94	57.66	122.31	32.5	1.0	65.0	180.0
	6†	44.58	130.67	253.35	65.34	130.24				
Abnormal instrument reading	1*	1.02	20.38	61.05	20.38	20.38	0.5	1.0	1.0	1.0
	1†	0.09	21.49	81.53	30.06	21.71				
Other	4*	0.70	81.54	272.35	99.87	81.54	47.3	13.0	94.5	180.0
	4†	0.70	88.26	297.75	109.41	86.83				
Parameter deviation	1*	1.02	20.38	61.05	20.38	20.38	5.5	11.0	11.0	11.0
	1†	0.09	21.49	81.53	30.06	21.71				
<b>All modes</b>	8*	81.13	163.08	268.06	57.66	163.08	30.3	1.0	60.6	180.0
	8†	80.69	174.03	296.09	66.65	173.66				
<b>Comments</b>										

## Heaters and Boilers

### Inventory description

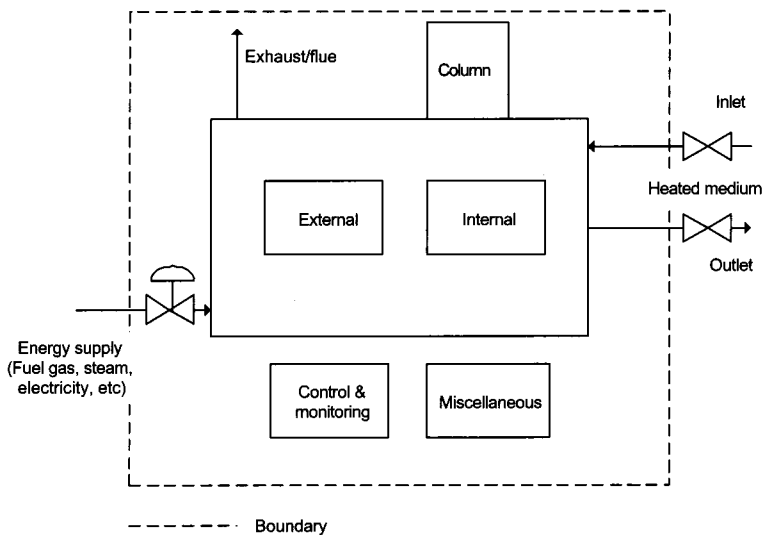
The boundary definition is shown in Figure 19 and corresponding subdivision in Maintainable Items in Table 14.

The boundary definition applies to hydrocarbon (HC) fired heaters and (re)boilers supplying energy to heat or boil a medium. The energy may be supplied through combustion of hydrocarbons, through supply of a high temperature medium (e.g. steam) or by electricity.

The heater and boiler components will typically include a vessel/shell in which the heating process is performed. For heaters and HC-fired boilers, a burner device and exhaust system are included. Unlike most boilers, the heaters contain a tube coil through which the medium to be heated is flowing.

For HC fired heaters and boilers, the fuel control valve is inside the equipment boundary, while fuel conditioning equipment (e.g. scrubbers) and ESD/PSD valves are outside the boundary.

Inlet, outlet, pressure relief and drain valves are specifically excluded. Valves and instruments included are those locally mounted and/or which form a pressure boundary (e.g. block valves, calibration valves, and local indicators/gauges).



**Figure 19-Heaters and boilers, Boundary Definition**

**Table 14 Heaters and Boilers, Subdivision in Maintainable Items**

HEATERS AND BOILERS				
Column	Control & monitoring	External	Internal	Miscellaneous
<ul style="list-style-type: none"> <li>• Body/shell</li> <li>• Packing</li> <li>• Reflux coil/ condenser</li> </ul>	<ul style="list-style-type: none"> <li>• Actuating device</li> <li>• Cabling &amp; junction boxes</li> <li>• Control unit</li> <li>• Instruments</li> <li>• Internal power supply</li> <li>• Monitoring</li> <li>• Valves</li> </ul>	<ul style="list-style-type: none"> <li>• Body/shell</li> <li>• Piping</li> <li>• Support</li> <li>• Valves</li> </ul>	<ul style="list-style-type: none"> <li>• Body/shell</li> <li>• Burner</li> <li>• Exhaust stack</li> <li>• Fire tube</li> <li>• Support</li> <li>• Tube coil</li> </ul>	<ul style="list-style-type: none"> <li>• Fan</li> </ul>

(For all subunits the MIs "Unknown" and "Subunit" are included.)

**List of failure modes**

- AIR Abnormal instrument reading
- ELP External leakage - Process medium
- ELU External leakage - Utility medium
- IHT Insufficient heat transfer
- INL Internal leakage
- SER Minor in-service problems
- OTH Other
- OHE Overheating
- PDE Parameter deviation
- PLU Plugged/Choked
- STD Structural deficiency



Taxonomy no 3.3		Item Mechanical Equipment Heaters and boilers								
Population 9	Installations 6	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.2505			Operational time † 0.2262					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	13*	8.07	47.31	113.47	34.08	51.90	14.0	1.0	22.4	41.0
	13†	8.28	52.89	129.69	39.49	57.48				
Abnormal instrument reading	4*	0.02	12.34	50.67	19.21	15.97	12.4	13.0	24.8	41.0
	4†	0.02	13.57	54.95	20.71	17.69				
Insufficient heat transfer	3*	0.00	11.48	52.32	20.85	11.98	2.8	1.0	2.8	4.0
	3†	0.00	14.31	68.01	27.89	13.26				
Overheating	1*	0.00	3.94	19.57	8.32	3.99	37.5	35.0	35.0	35.0
	1†	0.00	4.32	21.37	9.05	4.42				
Parameter deviation	2*	0.00	6.50	28.42	11.10	7.98	20.5	41.0	41.0	41.0
	2†	0.00	7.14	31.06	12.07	8.84				
Structural deficiency	3*	1.11	12.77	35.44	11.52	11.98	16.0	19.0	22.0	25.0
	3†	1.48	13.92	37.08	11.79	13.26				
<b>Degraded</b>	92*	0.00	316.53	1669.39	757.82	367.28	12.7	0.5	22.3	813.0
	92†	0.00	418.77	2166.48	951.49	406.78				
External leakage - Utility medium	2*	1.67	8.35	19.25	5.65	7.98	98.8	2.0	196.5	391.0
	2†	1.67	9.41	22.33	6.66	8.84				
Insufficient heat transfer	87*	0.00	296.51	1606.25	746.82	347.32	10.8	0.5	18.4	813.0
	87†	0.00	395.94	2076.67	935.85	384.67				
Internal leakage	1*	0.25	4.11	12.04	3.99	3.99	-	-	-	-
	1†	0.00	4.50	23.05	9.98	4.42				
Parameter deviation	1*	0.00	3.51	14.58	5.55	3.99	9.5	19.0	19.0	19.0
	1†	0.00	3.87	15.91	6.04	4.42				
Plugged/Choked	1*	0.00	3.93	19.50	8.29	3.99	8.0	8.0	8.0	8.0
	1†	0.28	4.56	13.34	4.42	4.42				
<b>Incipient</b>	53*	3.17	191.23	600.46	214.53	211.59	5.7	0.5	9.4	113.0
	53†	1.99	229.21	765.18	280.54	234.34				
Abnormal instrument reading	18*	4.81	73.99	215.09	71.17	71.86	5.8	0.5	9.6	44.0
	18†	3.30	85.69	258.32	87.81	79.59				
External leakage - Process medium	2*	0.03	7.88	30.45	11.25	7.98	2.5	2.0	2.5	3.0
	2†	0.00	9.53	41.65	16.25	8.84				
External leakage - Utility medium	1*	0.00	3.94	19.57	8.32	3.99	4.5	9.0	9.0	9.0
	1†	0.00	4.32	21.37	9.05	4.42				
Minor in-service problems	17*	0.03	62.13	266.14	102.91	67.87	7.1	1.5	11.2	113.0
	17†	0.02	76.93	337.98	132.36	75.17				
Other	14*	13.05	51.42	110.57	30.99	55.89	2.6	1.0	4.2	7.0
	14†	7.35	57.49	147.20	45.84	61.90				
Overheating	1*	0.00	3.51	14.58	5.55	3.99	28.5	57.0	57.0	57.0
	1†	0.00	3.87	15.91	6.04	4.42				
<b>Unknown</b>	1*	0.00	8.46	39.70	16.17	3.99	-	12.0	12.0	12.0
	1†	0.00	8.94	42.14	17.21	4.42				
Abnormal instrument reading	1*	0.00	8.46	39.70	16.17	3.99	-	12.0	12.0	12.0
	1†	0.00	8.94	42.14	17.21	4.42				

Comments

(cont.)

Taxonomy no 3.3		Item Mechanical Equipment Heaters and boilers								
Population 9	Installations 6	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.2505			Operational time † 0.2262					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	159* 159†	0.12 0.13	555.60 704.23	2469.51 3141.33	973.80 1240.98	634.76 703.02	10.5	0.5	18.0	813.0
Comments										

**Maintainable item versus failure mode, to be continued**

**Item:** Heaters and boilers

	AIR	ELP	ELU	IHT	INL	OHE
Actuating device	0.00	0.00	0.00	0.63	0.00	0.00
Body/shell	0.00	0.00	0.00	0.00	0.00	0.00
Burner(s)	0.63	0.63	0.63	6.29	0.00	0.00
Cabling & junction boxes	2.52	0.00	0.00	6.60	0.00	0.63
Control unit	0.63	0.00	0.00	0.94	0.00	0.00
Instrument, flame	0.00	0.00	0.00	35.53	0.00	0.00
Instrument, flow	0.63	0.63	0.00	0.00	0.00	0.00
Instrument, general	1.89	0.00	0.00	0.63	0.00	0.00
Instrument, level	1.89	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	1.89	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	2.52	0.00	0.00	0.00	0.00	0.63
Internal power supply	0.63	0.00	0.00	1.26	0.00	0.00
Monitoring	0.63	0.00	0.00	0.31	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	0.63	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	0.00	0.00
Support	0.00	0.00	0.00	0.00	0.00	0.00
Tube coil	0.00	0.00	0.00	0.00	0.63	0.00
Unknown	0.63	0.00	0.00	3.77	0.00	0.00
Valves	0.00	0.00	0.63	0.63	0.00	0.00
Total	14.47	1.26	1.89	56.60	0.63	1.26

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

**Item:** Heaters and boilers

	OTH	PDE	PLU	SER	STD	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	0.63
Body/shell	0.00	0.00	0.00	0.63	0.00	0.63
Burner(s)	0.63	0.00	0.00	1.89	0.00	10.69
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	9.75
Control unit	0.00	0.00	0.00	1.26	0.00	2.83
Instrument, flame	0.00	0.00	0.00	1.26	0.00	36.79
Instrument, flow	0.63	0.63	0.00	0.00	0.00	2.52
Instrument, general	0.00	0.00	0.00	0.63	0.00	3.14
Instrument, level	0.00	0.00	0.00	0.00	0.00	1.89
Instrument, pressure	0.00	0.00	0.00	0.00	0.00	1.89
Instrument, temperature	0.00	1.26	0.00	0.63	0.00	5.03
Internal power supply	0.00	0.00	0.00	0.00	0.00	1.89
Monitoring	0.00	0.00	0.00	0.00	0.00	0.94
Other	3.14	0.00	0.00	0.63	1.26	5.03
Piping	0.00	0.00	0.00	0.63	0.00	1.26
Subunit	0.00	0.00	0.00	0.00	0.63	0.63
Support	0.00	0.00	0.00	0.63	0.00	0.63
Tube coil	0.00	0.00	0.00	0.00	0.00	0.63
Unknown	1.89	0.00	0.63	1.26	0.00	8.18
Valves	2.52	0.00	0.00	1.26	0.00	5.03
Total	8.81	1.89	0.63	10.69	1.89	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Heaters and boilers

	AIR	ELP	ELU	IHT	INL	OHE
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00
Breakage	0.00	0.00	0.00	1.26	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	0.00	0.00	0.00	5.66	0.00	0.00
Control failure	1.26	0.00	0.00	1.26	0.00	0.00
Corrosion	0.63	0.63	0.00	2.52	0.00	0.00
Deformation	0.00	0.00	0.00	0.63	0.00	0.00
Electrical failure - general	1.89	0.00	0.00	1.89	0.00	0.63
Faulty signal/indication/alarm	2.52	0.00	0.00	0.63	0.00	0.00
Instrument failure - general	2.52	0.00	0.63	33.96	0.00	0.63
Leakage	0.00	0.00	1.26	0.00	0.00	0.00
Looseness	0.00	0.63	0.00	0.63	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.00	0.63	0.00
Mechanical Failure - general	0.00	0.00	0.00	4.40	0.00	0.00
Misc. external influences	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.63	0.00	0.00
No power/ voltage	1.26	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	2.52	0.00	0.00	0.00	0.00	0.00
Open circuit	0.00	0.00	0.00	1.26	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	1.26	0.00	0.00	0.63	0.00	0.00
Short circuiting	0.63	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.00	0.00	0.63	0.00	0.00
Unknown	0.00	0.00	0.00	0.63	0.00	0.00
Total	14.47	1.26	1.89	56.60	0.63	1.26

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

**Item:** Heaters and boilers

	OTH	PDE	PLU	SER	STD	Sum
Blockage/plugged	0.63	0.00	0.00	0.63	0.00	1.26
Breakage	1.26	0.00	0.00	0.00	0.00	2.52
Cavitation	0.00	0.00	0.00	0.63	0.63	1.26
Clearance/ alignment failure	0.00	0.00	0.00	0.63	0.00	0.63
Contamination	0.00	0.00	0.00	0.00	0.00	5.66
Control failure	0.00	0.00	0.63	0.00	0.00	3.14
Corrosion	0.63	0.00	0.00	1.26	0.00	5.66
Deformation	0.00	0.00	0.00	0.63	0.00	1.26
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	4.40
Faulty signal/indication/alarm	0.00	0.63	0.00	0.00	0.00	3.77
Instrument failure - general	1.89	1.26	0.00	2.52	0.00	43.40
Leakage	0.63	0.00	0.00	0.00	0.00	1.89
Looseness	0.00	0.00	0.00	0.63	0.00	1.89
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.63
Mechanical Failure - general	0.63	0.00	0.00	0.63	1.26	6.92
Misc. external influences	0.63	0.00	0.00	0.00	0.00	0.63
Miscellaneous - general	0.63	0.00	0.00	0.00	0.00	1.26
No power/ voltage	0.00	0.00	0.00	0.00	0.00	1.26
No signal/indication/alarm	0.00	0.00	0.00	0.63	0.00	3.14
Open circuit	0.00	0.00	0.00	0.00	0.00	1.26
Other	0.63	0.00	0.00	0.00	0.00	0.63
Out of adjustment	0.00	0.00	0.00	2.52	0.00	4.40
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.63
Sticking	0.63	0.00	0.00	0.00	0.00	1.26
Unknown	0.63	0.00	0.00	0.00	0.00	1.26
Total	8.81	1.89	0.63	10.69	1.89	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 3.3.1		Item Mechanical Equipment Heaters and boilers Direct HC fired heater								
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0491		Operational time † 0.0451						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	3*	16.72	61.15	158.08	61.15	61.15	23.5	19.0	27.0	35.0
	3†	18.19	66.54	172.00	66.54	66.54				
Overheating	1*	1.02	20.38	96.73	20.38	20.38	37.5	35.0	35.0	35.0
	1†	1.11	22.18	105.24	22.18	22.18				
Structural deficiency	2*	7.24	40.77	128.32	40.77	40.77	9.5	19.0	19.0	19.0
	2†	7.87	44.36	139.62	44.36	44.36				
<b>Degraded</b>	3*	16.72	61.15	158.08	61.15	61.15	220.2	86.0	440.3	813.0
	3†	18.19	66.54	172.00	66.54	66.54				
Insufficient heat transfer	3*	16.72	61.15	158.08	61.15	61.15	220.2	86.0	440.3	813.0
	3†	18.19	66.54	172.00	66.54	66.54				
<b>Incipient</b>	13*	156.72	265.00	421.27	265.00	265.00	9.5	2.0	19.1	113.0
	13†	170.51	288.33	458.35	288.33	288.33				
Abnormal instrument reading	7*	66.96	142.69	268.06	142.69	142.69	6.5	2.0	13.0	44.0
	7†	72.86	155.25	291.65	155.25	155.25				
External leakage - Utility medium	1*	1.02	20.38	96.73	20.38	20.38	4.5	9.0	9.0	9.0
	1†	1.11	22.18	105.24	22.18	22.18				
Minor in-service problems	2*	7.24	40.77	128.32	40.77	40.77	32.3	16.0	64.5	113.0
	2†	7.87	44.36	139.62	44.36	44.36				
Other	3*	16.72	61.15	158.08	61.15	61.15	2.2	4.0	4.3	5.0
	3†	18.19	66.54	172.00	66.54	66.54				
<b>All modes</b>	19*	253.60	387.31	568.28	387.31	387.31	48.4	2.0	94.4	813.0
	19†	275.92	421.40	618.29	421.40	421.40				
<b>Comments</b>										

**Maintainable item versus failure mode, to be continued**

**Item:** Heaters and boilers - Direct HC fired heater

	AIR	ELP	ELU	IHT	INL	OHE
Body/shell	0.00	0.00	0.00	0.00	0.00	0.00
Burner(s)	0.00	0.00	0.00	10.53	0.00	0.00
Cabling & junction boxes	21.05	0.00	0.00	0.00	0.00	0.00
Instrument, general	5.26	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	5.26
Internal power supply	5.26	0.00	0.00	0.00	0.00	0.00
Monitoring	5.26	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00
Valves	0.00	0.00	5.26	5.26	0.00	0.00
<b>Total</b>	<b>36.84</b>	<b>0.00</b>	<b>5.26</b>	<b>15.79</b>	<b>0.00</b>	<b>5.26</b>

**Maintainable item versus failure mode, continued**

**Item:** Heaters and boilers - Direct HC fired heater

	OTH	PDE	PLU	SER	STD	Sum
Body/shell	0.00	0.00	0.00	5.26	0.00	5.26
Burner(s)	0.00	0.00	0.00	0.00	0.00	10.53
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	21.05
Instrument, general	0.00	0.00	0.00	0.00	0.00	5.26
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	5.26
Internal power supply	0.00	0.00	0.00	0.00	0.00	5.26
Monitoring	0.00	0.00	0.00	0.00	0.00	5.26
Other	5.26	0.00	0.00	0.00	10.53	15.79
Piping	0.00	0.00	0.00	5.26	0.00	5.26
Unknown	10.53	0.00	0.00	0.00	0.00	10.53
Valves	0.00	0.00	0.00	0.00	0.00	10.53
<b>Total</b>	<b>15.79</b>	<b>0.00</b>	<b>0.00</b>	<b>10.53</b>	<b>10.53</b>	<b>100.0</b>

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.



**Failure descriptor versus failure mode, to be continued**

**Item:** Heaters and boilers - Direct HC fired heater

	AIR	ELP	ELU	IHT	INL	OHE
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	5.26	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	15.79	0.00	0.00	5.26	0.00	0.00
Faulty signal/indication/alarm	0.00	0.00	0.00	5.26	0.00	0.00
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	5.26
Leakage	0.00	0.00	5.26	0.00	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	5.26	0.00	0.00
Misc. external influences	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00
No power/ voltage	10.53	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	5.26	0.00	0.00	0.00	0.00	0.00
<b>Total</b>	<b>36.84</b>	<b>0.00</b>	<b>5.26</b>	<b>15.79</b>	<b>0.00</b>	<b>5.26</b>

**Failure descriptor versus failure mode, continued**

**Item:** Heaters and boilers - Direct HC fired heater

	OTH	PDE	PLU	SER	STD	Sum
Cavitation	0.00	0.00	0.00	5.26	0.00	5.26
Corrosion	0.00	0.00	0.00	0.00	0.00	5.26
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	21.05
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	5.26
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	5.26
Leakage	5.26	0.00	0.00	0.00	0.00	10.53
Mechanical Failure - general	0.00	0.00	0.00	0.00	10.53	15.79
Misc. external influences	5.26	0.00	0.00	0.00	0.00	5.26
Miscellaneous - general	5.26	0.00	0.00	0.00	0.00	5.26
No power/ voltage	0.00	0.00	0.00	0.00	0.00	10.53
No signal/indication/alarm	0.00	0.00	0.00	5.26	0.00	10.53
<b>Total</b>	<b>15.79</b>	<b>0.00</b>	<b>0.00</b>	<b>10.53</b>	<b>10.53</b>	<b>100.0</b>

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 3.3.1.1		Item Mechanical Equipment Heaters and boilers Direct HC fired heater Heating medium								
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0491		Operational time † 0.0451						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	3*	16.72	61.15	158.08	61.15	61.15	23.5	19.0	27.0	35.0
	3†	18.19	66.54	172.00	66.54	66.54				
Overheating	1*	1.02	20.38	96.73	20.38	20.38	37.5	35.0	35.0	35.0
	1†	1.11	22.18	105.24	22.18	22.18				
Structural deficiency	2*	7.24	40.77	128.32	40.77	40.77	9.5	19.0	19.0	19.0
	2†	7.87	44.36	139.62	44.36	44.36				
<b>Degraded</b>	3*	16.72	61.15	158.08	61.15	61.15	220.2	86.0	440.3	813.0
	3†	18.19	66.54	172.00	66.54	66.54				
Insufficient heat transfer	3*	16.72	61.15	158.08	61.15	61.15	220.2	86.0	440.3	813.0
	3†	18.19	66.54	172.00	66.54	66.54				
<b>Incipient</b>	13*	156.72	265.00	421.27	265.00	265.00	9.5	2.0	19.1	113.0
	13†	170.51	288.33	458.35	288.33	288.33				
Abnormal instrument reading	7*	66.96	142.69	268.06	142.69	142.69	6.5	2.0	13.0	44.0
	7†	72.86	155.25	291.65	155.25	155.25				
External leakage - Utility medium	1*	1.02	20.38	96.73	20.38	20.38	4.5	9.0	9.0	9.0
	1†	1.11	22.18	105.24	22.18	22.18				
Minor in-service problems	2*	7.24	40.77	128.32	40.77	40.77	32.3	16.0	64.5	113.0
	2†	7.87	44.36	139.62	44.36	44.36				
Other	3*	16.72	61.15	158.08	61.15	61.15	2.2	4.0	4.3	5.0
	3†	18.19	66.54	172.00	66.54	66.54				
<b>All modes</b>	19*	253.60	387.31	568.28	387.31	387.31	48.4	2.0	94.4	813.0
	19†	275.92	421.40	618.29	421.40	421.40				
Comments										

Taxonomy no 3.3.2		Item Mechanical Equipment Heaters and boilers Electric heater/boiler								
Population 2	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
		0.0540		0.0534						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	1*	0.33	16.81	52.23	18.50	18.50	-	-	-	-
	1†	0.33	17.00	52.83	18.72	18.72				
Internal leakage	1*	0.33	16.81	52.23	18.50	18.50	-	-	-	-
	1†	0.33	17.00	52.83	18.72	18.72				
Incipient	2*	0.76	32.09	98.62	34.56	37.00	2.5	4.0	5.0	6.0
	2†	0.87	32.51	99.33	34.56	37.44				
Minor in-service problems	2*	0.76	32.09	98.62	34.56	37.00	2.5	4.0	5.0	6.0
	2†	0.87	32.51	99.33	34.56	37.44				
Unknown	1*	0.13	31.80	120.37	44.39	18.50	-	12.0	12.0	12.0
	1†	0.13	33.50	127.94	47.14	18.72				
Abnormal instrument reading	1*	0.13	31.80	120.37	44.39	18.50	-	12.0	12.0	12.0
	1†	0.13	33.50	127.94	47.14	18.72				
All modes	4*	25.42	74.21	143.66	37.00	74.01	2.5	4.0	7.3	12.0
	4†	25.95	75.35	145.59	37.44	74.88				
Comments										

**Maintainable item versus failure mode, to be continued**

**Item:** Heaters and boilers - Electric heater/boiler

	AIR	ELP	ELU	IHT	INL	OHE
Instrument, pressure	25.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	0.00
Support	0.00	0.00	0.00	0.00	0.00	0.00
Tube coil	0.00	0.00	0.00	0.00	25.00	0.00
Total	25.00	0.00	0.00	0.00	25.00	0.00

**Maintainable item versus failure mode, continued**

**Item:** Heaters and boilers - Electric heater/boiler

	OTH	PDE	PLU	SER	STD	Sum
Instrument, pressure	0.00	0.00	0.00	0.00	0.00	25.00
Instrument, temperature	0.00	0.00	0.00	25.00	0.00	25.00
Support	0.00	0.00	0.00	25.00	0.00	25.00
Tube coil	0.00	0.00	0.00	0.00	0.00	25.00
Total	0.00	0.00	0.00	50.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Heaters and boilers - Electric heater/boiler

	AIR	ELP	ELU	IHT	INL	OHE
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	25.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.00	25.00	0.00
Total	25.00	0.00	0.00	0.00	25.00	0.00

**Failure descriptor versus failure mode, continued**

**Item:** Heaters and boilers - Electric heater/boiler

	OTH	PDE	PLU	SER	STD	Sum
Corrosion	0.00	0.00	0.00	25.00	0.00	25.00
Deformation	0.00	0.00	0.00	25.00	0.00	25.00
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	25.00
Material failure - general	0.00	0.00	0.00	0.00	0.00	25.00
Total	0.00	0.00	0.00	50.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 3.3.2.1		Item Mechanical Equipment Heaters and boilers Electric heater/boiler Gas treatment								
Population 2	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0540		Operational time † 0.0534						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Degraded</b>	1*	0.33	16.81	52.23	18.50	18.50	-	-	-	-
	1†	0.33	17.00	52.83	18.72	18.72	-	-	-	-
Internal leakage	1*	0.33	16.81	52.23	18.50	18.50	-	-	-	-
	1†	0.33	17.00	52.83	18.72	18.72	-	-	-	-
<b>Incipient</b>	2*	0.76	32.09	98.62	34.56	37.00	2.5	4.0	5.0	6.0
	2†	0.87	32.51	99.33	34.56	37.44	-	-	-	-
Minor in-service problems	2*	0.76	32.09	98.62	34.56	37.00	2.5	4.0	5.0	6.0
	2†	0.87	32.51	99.33	34.56	37.44	-	-	-	-
<b>Unknown</b>	1*	0.13	31.80	120.37	44.39	18.50	-	12.0	12.0	12.0
	1†	0.13	33.50	127.94	47.14	18.72	-	-	-	-
Abnormal instrument reading	1*	0.13	31.80	120.37	44.39	18.50	-	12.0	12.0	12.0
	1†	0.13	33.50	127.94	47.14	18.72	-	-	-	-
<b>All modes</b>	4*	25.42	74.21	143.66	37.00	74.01	2.5	4.0	7.3	12.0
	4†	25.95	75.35	145.59	37.44	74.88	-	-	-	-
<b>Comments</b>										

Taxonomy no 3.3.3		Item Mechanical Equipment Heaters and boilers HC fired boiler								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
		0.0493		0.0365						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	3*	16.64	60.89	157.39	60.89	60.89	2.8	1.0	2.8	4.0
	3†	22.46	82.18	212.44	82.18	82.18				
Insufficient heat transfer	3*	16.64	60.89	157.39	60.89	60.89	2.8	1.0	2.8	4.0
	3†	22.46	82.18	212.44	82.18	82.18				
<b>Degraded</b>	86*	1447.77	1745.41	2088.20	1745.41	1745.41	3.2	0.5	3.2	16.0
	86†	1954.16	2355.91	2818.59	2355.91	2355.91				
External leakage - Utility medium	1*	1.01	20.30	96.30	20.30	20.30	2.0	2.0	2.0	2.0
	1†	1.37	27.39	129.99	27.39	27.39				
Insufficient heat transfer	84*	1410.81	1704.82	2044.01	1704.82	1704.82	3.2	0.5	3.2	16.0
	84†	1904.26	2301.12	2758.94	2301.12	2301.12				
Plugged/Choked	1*	1.01	20.30	96.30	20.30	20.30	8.0	8.0	8.0	8.0
	1†	1.37	27.39	129.99	27.39	27.39				
<b>Incipient</b>	29*	421.03	588.57	802.48	588.57	588.57	2.9	0.5	2.9	11.0
	29†	568.30	794.43	1083.17	794.43	794.43				
Abnormal instrument reading	8*	80.78	162.36	292.97	162.36	162.36	1.6	0.5	1.6	3.0
	8†	109.03	219.15	395.44	219.15	219.15				
External leakage - Process medium	2*	7.20	40.59	127.76	40.59	40.59	2.5	2.0	2.5	3.0
	2†	9.72	54.79	172.45	54.79	54.79				
Minor in-service problems	13*	156.03	263.84	419.42	263.84	263.84	4.0	1.5	4.0	11.0
	13†	210.61	356.13	566.13	356.13	356.13				
Other	6*	53.07	121.77	240.30	121.77	121.77	2.3	1.0	2.3	7.0
	6†	71.64	164.37	324.35	164.37	164.37				
<b>All modes</b>	118*	2044.11	2394.87	2790.52	2394.87	2394.87	3.1	0.5	3.1	16.0
	118†	2759.08	3232.52	3766.56	3232.52	3232.52				
<b>Comments</b>										

**Maintainable item versus failure mode, to be continued**

**Item:** Heaters and boilers - HC fired boiler

	AIR	ELP	ELU	IHT	INL	OHE
Actuating device	0.00	0.00	0.00	0.85	0.00	0.00
Burner(s)	0.85	0.85	0.85	6.78	0.00	0.00
Cabling & junction boxes	0.00	0.00	0.00	8.90	0.00	0.00
Control unit	0.00	0.00	0.00	1.27	0.00	0.00
Instrument, flame	0.00	0.00	0.00	47.88	0.00	0.00
Instrument, flow	0.00	0.85	0.00	0.00	0.00	0.00
Instrument, general	1.69	0.00	0.00	0.85	0.00	0.00
Instrument, pressure	1.69	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	1.69	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.00	0.00	0.00	1.69	0.00	0.00
Monitoring	0.00	0.00	0.00	0.42	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.85	0.00	0.00	5.08	0.00	0.00
Valves	0.00	0.00	0.00	0.00	0.00	0.00
Total	6.78	1.69	0.85	73.73	0.00	0.00

**Maintainable item versus failure mode, continued**

**Item:** Heaters and boilers - HC fired boiler

	OTH	PDE	PLU	SER	STD	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	0.85
Burner(s)	0.85	0.00	0.00	2.54	0.00	12.71
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	8.90
Control unit	0.00	0.00	0.00	1.69	0.00	2.97
Instrument, flame	0.00	0.00	0.00	1.69	0.00	49.58
Instrument, flow	0.00	0.00	0.00	0.00	0.00	0.85
Instrument, general	0.00	0.00	0.00	0.85	0.00	3.39
Instrument, pressure	0.00	0.00	0.00	0.00	0.00	1.69
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	1.69
Internal power supply	0.00	0.00	0.00	0.00	0.00	1.69
Monitoring	0.00	0.00	0.00	0.00	0.00	0.42
Other	0.00	0.00	0.00	0.85	0.00	0.85
Unknown	0.85	0.00	0.85	1.69	0.00	9.32
Valves	3.39	0.00	0.00	1.69	0.00	5.08
Total	5.08	0.00	0.85	11.02	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Heaters and boilers - HC fired boiler

	AIR	ELP	ELU	IHT	INL	OHE
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00
Breakage	0.00	0.00	0.00	1.69	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	0.00	0.00	0.00	7.63	0.00	0.00
Control failure	0.85	0.00	0.00	1.69	0.00	0.00
Corrosion	0.00	0.85	0.00	3.39	0.00	0.00
Deformation	0.00	0.00	0.00	0.85	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	1.69	0.00	0.00
Faulty signal/indication/alarm	1.69	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	1.69	0.00	0.85	45.76	0.00	0.00
Looseness	0.00	0.85	0.00	0.85	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	5.08	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.85	0.00	0.00
No signal/indication/alarm	0.85	0.00	0.00	0.00	0.00	0.00
Open circuit	0.00	0.00	0.00	1.69	0.00	0.00
Out of adjustment	1.69	0.00	0.00	0.85	0.00	0.00
Sticking	0.00	0.00	0.00	0.85	0.00	0.00
Unknown	0.00	0.00	0.00	0.85	0.00	0.00
Total	6.78	1.69	0.85	73.73	0.00	0.00

**Failure descriptor versus failure mode, continued**

Item: Heaters and boilers - HC fired boiler

	OTH	PDE	PLU	SER	STD	Sum
Blockage/plugged	0.85	0.00	0.00	0.85	0.00	1.69
Breakage	0.00	0.00	0.00	0.00	0.00	1.69
Clearance/ alignment failure	0.00	0.00	0.00	0.85	0.00	0.85
Contamination	0.00	0.00	0.00	0.00	0.00	7.63
Control failure	0.00	0.00	0.85	0.00	0.00	3.39
Corrosion	0.00	0.00	0.00	0.85	0.00	5.08
Deformation	0.00	0.00	0.00	0.00	0.00	0.85
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	1.69
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	1.69
Instrument failure - general	2.54	0.00	0.00	3.39	0.00	54.24
Looseness	0.00	0.00	0.00	0.85	0.00	2.54
Mechanical Failure - general	0.85	0.00	0.00	0.85	0.00	6.78
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.85
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.85
Open circuit	0.00	0.00	0.00	0.00	0.00	1.69
Out of adjustment	0.00	0.00	0.00	3.39	0.00	5.93
Sticking	0.85	0.00	0.00	0.00	0.00	1.69
Unknown	0.00	0.00	0.00	0.00	0.00	0.85
Total	5.08	0.00	0.85	11.02	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.



Taxonomy no 3.3.3.1		Item Mechanical Equipment Heaters and boilers HC fired boiler Oil processing									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0493		Operational time † 0.0365							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	3*	16.64	60.89	157.39	60.89	60.89	2.8	1.0	2.8	4.0	
	3†	22.46	82.18	212.44	82.18	82.18					
Insufficient heat transfer	3*	16.64	60.89	157.39	60.89	60.89	2.8	1.0	2.8	4.0	
	3†	22.46	82.18	212.44	82.18	82.18					
<b>Degraded</b>	86*	1447.77	1745.41	2088.20	1745.41	1745.41	3.2	0.5	3.2	16.0	
	86†	1954.16	2355.91	2818.59	2355.91	2355.91					
External leakage - Utility medium	1*	1.01	20.30	96.30	20.30	20.30	2.0	2.0	2.0	2.0	
	1†	1.37	27.39	129.99	27.39	27.39					
Insufficient heat transfer	84*	1410.81	1704.82	2044.01	1704.82	1704.82	3.2	0.5	3.2	16.0	
	84†	1904.26	2301.12	2758.94	2301.12	2301.12					
Plugged/Choked	1*	1.01	20.30	96.30	20.30	20.30	8.0	8.0	8.0	8.0	
	1†	1.37	27.39	129.99	27.39	27.39					
<b>Incipient</b>	29*	421.03	588.57	802.48	588.57	588.57	2.9	0.5	2.9	11.0	
	29†	568.30	794.43	1083.17	794.43	794.43					
Abnormal instrument reading	8*	80.78	162.36	292.97	162.36	162.36	1.6	0.5	1.6	3.0	
	8†	109.03	219.15	395.44	219.15	219.15					
External leakage - Process medium	2*	7.20	40.59	127.76	40.59	40.59	2.5	2.0	2.5	3.0	
	2†	9.72	54.79	172.45	54.79	54.79					
Minor in-service problems	13*	156.03	263.84	419.42	263.84	263.84	4.0	1.5	4.0	11.0	
	13†	210.61	356.13	566.13	356.13	356.13					
Other	6*	53.07	121.77	240.30	121.77	121.77	2.3	1.0	2.3	7.0	
	6†	71.64	164.37	324.35	164.37	164.37					
<b>All modes</b>	118*	2044.11	2394.87	2790.52	2394.87	2394.87	3.1	0.5	3.1	16.0	
	118†	2759.08	3232.52	3766.56	3232.52	3232.52					
Comments											

Taxonomy no 3.3.4		Item Mechanical Equipment Heaters and boilers Non-HC fired boiler								
Population 4	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0981		Operational time † 0.0912						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/r		Min	Mean	Max
<b>Critical</b>	7*	28.70	68.29	121.58	28.83	71.35	16.1	13.0	29.4	41.0
	7†	28.86	73.14	133.84	32.67	76.79				
Abnormal instrument reading	4*	11.01	37.06	75.65	20.38	40.77	12.4	13.0	24.8	41.0
	4†	11.62	39.86	81.88	22.18	43.88				
Parameter deviation	2*	0.38	17.67	54.56	19.22	20.38	20.5	41.0	41.0	41.0
	2†	0.37	19.01	59.03	20.91	21.94				
Structural deficiency	1*	0.07	16.99	63.79	23.54	10.19	22.5	25.0	25.0	25.0
	1†	0.08	17.68	65.75	24.27	10.97				
<b>Degraded</b>	2*	2.58	23.10	60.83	19.22	20.38	102.5	19.0	205.0	391.0
	2†	3.09	24.49	62.87	19.60	21.94				
External leakage - Utility medium	1*	0.07	16.99	63.79	23.54	10.19	195.5	391.0	391.0	391.0
	1†	0.08	17.68	65.75	24.27	10.97				
Parameter deviation	1*	0.18	9.27	28.78	10.19	10.19	9.5	19.0	19.0	19.0
	1†	0.20	9.98	30.98	10.97	10.97				
<b>Incipient</b>	9*	50.44	94.51	149.76	30.58	91.73	11.1	2.0	19.6	57.0
	9†	53.93	101.33	160.81	32.91	98.73				
Abnormal instrument reading	3*	0.23	57.76	221.36	81.54	30.58	15.5	2.0	24.3	44.0
	3†	0.24	60.19	230.13	84.79	32.91				
Other	5*	8.46	44.17	102.92	30.39	50.96	3.4	6.0	6.8	7.0
	5†	8.04	47.25	113.42	34.08	54.85				
Overheating	1*	0.18	9.27	28.78	10.19	10.19	28.5	57.0	57.0	57.0
	1†	0.20	9.98	30.98	10.97	10.97				
<b>All modes</b>	18*	120.36	185.32	261.68	43.24	183.46	23.9	2.0	45.5	391.0
	18†	128.93	198.83	281.04	46.54	197.46				
<b>Comments</b>										

**Maintainable item versus failure mode, to be continued**

**Item:** Heaters and boilers - Non-HC fired boiler

	AIR	ELP	ELU	IHT	INL	OHE
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	5.56
Control unit	5.56	0.00	0.00	0.00	0.00	0.00
Instrument, flow	5.56	0.00	0.00	0.00	0.00	0.00
Instrument, level	16.67	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	11.11	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	5.56	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	0.00	0.00
Total	38.89	0.00	5.56	0.00	0.00	5.56

**Maintainable item versus failure mode, continued**

**Item:** Heaters and boilers - Non-HC fired boiler

	OTH	PDE	PLU	SER	STD	Sum
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	5.56
Control unit	0.00	0.00	0.00	0.00	0.00	5.56
Instrument, flow	5.56	5.56	0.00	0.00	0.00	16.67
Instrument, level	0.00	0.00	0.00	0.00	0.00	16.67
Instrument, temperature	0.00	11.11	0.00	0.00	0.00	22.22
Other	22.22	0.00	0.00	0.00	0.00	22.22
Piping	0.00	0.00	0.00	0.00	0.00	5.56
Subunit	0.00	0.00	0.00	0.00	5.56	5.56
Total	27.78	16.67	0.00	0.00	5.56	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Heaters and boilers - Non-HC fired boiler

	AIR	ELP	ELU	IHT	INL	OHE
Breakage	0.00	0.00	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	5.56	0.00	0.00	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	5.56
Faulty signal/indication/alarm	11.11	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	5.56	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	5.56	0.00	0.00	0.00
No signal/indication/alarm	11.11	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	5.56	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00
Total	38.89	0.00	5.56	0.00	0.00	5.56

**Failure descriptor versus failure mode, continued**

**Item:** Heaters and boilers - Non-HC fired boiler

	OTH	PDE	PLU	SER	STD	Sum
Breakage	11.11	0.00	0.00	0.00	0.00	11.11
Cavitation	0.00	0.00	0.00	0.00	5.56	5.56
Control failure	0.00	0.00	0.00	0.00	0.00	5.56
Corrosion	5.56	0.00	0.00	0.00	0.00	5.56
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	5.56
Faulty signal/indication/alarm	0.00	5.56	0.00	0.00	0.00	16.67
Instrument failure - general	0.00	11.11	0.00	0.00	0.00	16.67
Leakage	0.00	0.00	0.00	0.00	0.00	5.56
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	11.11
Other	5.56	0.00	0.00	0.00	0.00	5.56
Short circuiting	0.00	0.00	0.00	0.00	0.00	5.56
Unknown	5.56	0.00	0.00	0.00	0.00	5.56
Total	27.78	16.67	0.00	0.00	5.56	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 3.3.4.1		Item Mechanical Equipment Heaters and boilers Non-HC fired boiler Gas treatment								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0245		Operational time † 0.0235						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	1*	2.04	40.77	193.45	40.77	40.77	22.5	25.0	25.0	25.0
	1†	2.13	42.51	201.71	42.51	42.51				
Structural deficiency	1*	2.04	40.77	193.45	40.77	40.77	22.5	25.0	25.0	25.0
	1†	2.13	42.51	201.71	42.51	42.51				
<b>Degraded</b>	1*	2.04	40.77	193.45	40.77	40.77	195.5	391.0	391.0	391.0
	1†	2.13	42.51	201.71	42.51	42.51				
External leakage - Utility medium	1*	2.04	40.77	193.45	40.77	40.77	195.5	391.0	391.0	391.0
	1†	2.13	42.51	201.71	42.51	42.51				
<b>Incipient</b>	3*	33.43	122.31	316.17	122.31	122.31	15.5	2.0	24.3	44.0
	3†	34.86	127.53	329.66	127.53	127.53				
Abnormal instrument reading	3*	33.43	122.31	316.17	122.31	122.31	15.5	2.0	24.3	44.0
	3†	34.86	127.53	329.66	127.53	127.53				
<b>All modes</b>	5*	80.32	203.85	428.69	203.85	203.85	52.9	2.0	97.8	391.0
	5†	83.74	212.55	446.99	212.55	212.55				
<b>Comments</b>										

Taxonomy no 3.3.4.2		Item Mechanical Equipment Heaters and boilers Non-HC fired boiler Heating medium								
Population 3	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0736			Operational time † 0.0676					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>6*</b>	<b>35.54</b>	<b>81.54</b>	<b>160.90</b>	<b>81.54</b>	<b>81.54</b>	<b>15.1</b>	<b>13.0</b>	<b>30.2</b>	<b>41.0</b>
	<b>6†</b>	<b>38.67</b>	<b>88.72</b>	<b>175.07</b>	<b>88.72</b>	<b>88.72</b>				
Abnormal instrument reading	4*	18.55	54.36	124.42	54.36	54.36	12.4	13.0	24.8	41.0
	4†	20.18	59.14	135.36	59.14	59.14				
Parameter deviation	2*	4.82	27.18	85.55	27.18	27.18	20.5	41.0	41.0	41.0
	2†	5.25	29.57	93.08	29.57	29.57				
<b>Degraded</b>	<b>1*</b>	<b>0.68</b>	<b>13.59</b>	<b>64.48</b>	<b>13.59</b>	<b>13.59</b>	<b>9.5</b>	<b>19.0</b>	<b>19.0</b>	<b>19.0</b>
	<b>1†</b>	<b>0.74</b>	<b>14.79</b>	<b>70.16</b>	<b>14.79</b>	<b>14.79</b>				
Parameter deviation	1*	0.68	13.59	64.48	13.59	13.59	9.5	19.0	19.0	19.0
	1†	0.74	14.79	70.16	14.79	14.79				
<b>Incipient</b>	<b>6*</b>	<b>35.54</b>	<b>81.54</b>	<b>160.90</b>	<b>81.54</b>	<b>81.54</b>	<b>8.4</b>	<b>6.0</b>	<b>16.8</b>	<b>57.0</b>
	<b>6†</b>	<b>38.67</b>	<b>88.72</b>	<b>175.07</b>	<b>88.72</b>	<b>88.72</b>				
Other	5*	26.77	67.95	142.90	67.95	67.95	3.4	6.0	6.8	7.0
	5†	29.13	73.93	155.47	73.93	73.93				
Overheating	1*	0.68	13.59	64.48	13.59	13.59	28.5	57.0	57.0	57.0
	1†	0.74	14.79	70.16	14.79	14.79				
<b>All modes</b>	<b>13*</b>	<b>104.48</b>	<b>176.67</b>	<b>280.85</b>	<b>176.67</b>	<b>176.67</b>	<b>11.8</b>	<b>6.0</b>	<b>23.7</b>	<b>57.0</b>
	<b>13†</b>	<b>113.67</b>	<b>192.22</b>	<b>305.56</b>	<b>192.22</b>	<b>192.22</b>				
<b>Comments</b>										

## CONTROL AND SAFETY EQUIPMENT

### *Fire and Gas Detectors*

#### Inventory description

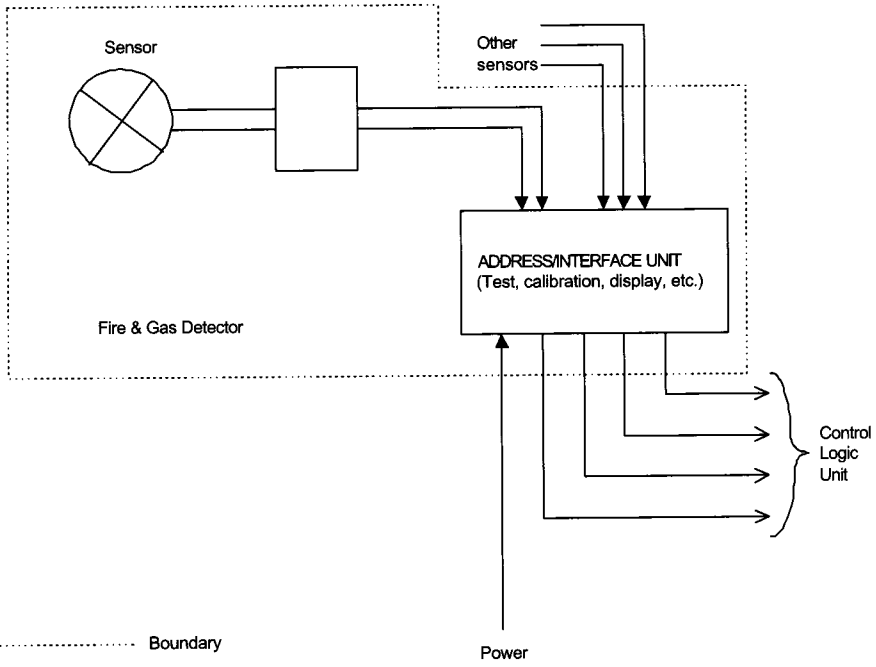
The boundary definition is shown in Figure 20 and corresponding subdivision in Maintainable Items in Table 15.

It has been difficult to obtain a consistent system breakdown covering all relevant technical configurations of F&G systems. Thus, the proposed breakdown is a trade-off between several factors.

The catalytic gas detector contains a sensor part and a separate electronic unit (interface unit) which combined make up a Wheatstone bridge circuit. The sensor contains element(s) which are sensitive to hydrocarbon gas (catalytic oxidation of the element). The change in electrical resistance produces an out-of-balance current in the Wheatstone bridge circuit. The interface unit may be located in control rooms or in the field (transducers). Some vendors of logic control systems have designed separate input cards for gas sensors. Thus, they do not use the interface units provided by the vendor of the gas sensor. In the proposed system breakdown, these *dedicated* gas input cards are considered to be part of the gas detector (interface unit), and not part of the Control Logic Units (CLUs).

Most conventional fire sensors gives a standard output signal which is compatible to a standard input modules of logic control systems. Thus, for these fire detectors, there are no separate interface units. For F&G Detectors there is no subdivision on subunit level, only on Maintainable Item level. One reason for this is that it is common to replace both elements on the sensor part and the interface part during repair.

In the future there will be more use of addressable fire detection systems. In these systems several individual detectors are connected to a dedicated address/interface unit.



**Figure 20 Fire & Gas Detectors, Boundary Definition**



**Table 15 F&G Detectors, Subdivision in Maintainable Items**

FIRE & GAS DETECTORS	
Sensor & Interface unit	Miscellaneous
<ul style="list-style-type: none"> <li>• Mounting socket</li> <li>• Detector head</li> <li>• Cover</li> <li>• Control card</li> <li>• Display</li> <li>• Cabinet</li> <li>• Cabling</li> </ul>	<ul style="list-style-type: none"> <li>• Others</li> </ul>

(For all subunits the MIs "Unknown" and "Subunit" are included.)

**List of failure modes**

- ERO Erratic output
- FTF Fail to function on demand
- HIO High output
- HIU High output, unknown reading
- LOO Low output
- LOU Low output, unknown reading
- SER Minor in-service problems
- NOO No output
- OTH Other
- SHH Spurious high level alarm signal
- SLL Spurious low level alarm signal
- SPO Spurious operation
- UNK Unknown
- VLO Very low output

Taxonomy no 4.1		Item Control and Safety Equipment Fire & Gas Detectors								
Population 858	Installations 18	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 28.5689		Operational time † 26.9668			Active rep.hrs	Repair (manhours)		
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)	
		Lower	Mean	Upper	SD	n/τ	Min		Mean	Max
<b>Critical</b>	47*	0.00	0.97	5.39	2.76	1.65	2.8	0.5	4.4	41.0
	47†	0.00	1.10	6.26	3.35	1.74				
Fail to function on demand	12*	0.00	0.19	1.01	0.66	0.42	3.8	1.0	4.3	10.0
	12†	0.00	0.21	1.11	0.85	0.44				
No output	5*	0.00	0.30	1.64	0.80	0.18	1.8	1.0	3.4	4.0
	5†	0.00	0.30	1.66	0.82	0.19				
Spurious high level alarm signal	9*	0.00	0.16	0.90	0.43	0.32	2.3	1.0	2.3	8.0
	9†	0.00	0.18	0.99	0.59	0.33				
Spurious low level alarm signal	5*	0.06	0.16	0.31	0.08	0.18	3.2	0.5	3.2	6.0
	5†	0.00	0.14	0.57	0.22	0.19				
Spurious operation	16*	0.00	0.38	2.02	0.93	0.56	2.8	2.0	6.4	41.0
	16†	0.00	0.43	2.37	1.13	0.59				
<b>Degraded</b>	232*	2.24	9.19	20.01	5.66	8.12	1.2	1.0	1.5	12.5
	232†	2.03	9.44	21.33	6.18	8.60				
Erratic output	44*	0.00	1.32	5.18	1.93	1.54	2.5	1.0	1.9	11.0
	44†	0.00	1.43	6.00	2.30	1.63				
Fail to function on demand	6*	0.01	0.22	0.66	0.23	0.21	0.5	1.0	1.0	1.0
	6†	0.02	0.22	0.63	0.21	0.22				
High output	10*	0.00	0.36	1.84	0.80	0.35	1.9	2.0	2.2	4.0
	10†	0.00	0.38	1.96	0.86	0.37				
High output, unknown reading	22*	0.00	0.28	0.92	1.37	0.77	3.0	1.0	1.7	3.0
	22†	0.00	0.34	0.97	1.70	0.82				
Low output	4*	0.00	0.16	0.77	0.33	0.14	2.8	1.0	3.8	6.0
	4†	0.00	0.17	0.81	0.34	0.15				
Low output, unknown reading	1*	0.00	0.09	0.52	0.26	0.04	-	10.0	10.0	10.0
	1†	0.00	0.09	0.52	0.26	0.04				
Minor in-service problems	5*	0.06	0.16	0.31	0.08	0.18	2.5	2.0	4.5	12.5
	5†	0.00	0.14	0.57	0.22	0.19				
Other	23*	0.00	1.25	6.01	2.48	0.81	0.5	1.0	1.0	1.0
	23†	0.00	1.25	6.07	2.52	0.85				
Spurious low level alarm signal	1*	0.00	0.03	0.10	0.04	0.04	2.0	2.0	2.0	2.0
	1†	0.00	0.03	0.13	0.05	0.04				
Unknown	4*	0.00	0.10	0.40	0.15	0.14	5.0	2.0	5.3	12.0
	4†	0.02	0.13	0.33	0.10	0.15				
Very low output	112*	0.77	5.43	13.63	4.20	3.92	0.5	1.0	1.0	1.0
	112†	0.80	5.43	13.52	4.15	4.15				
<b>Incipient</b>	76*	0.00	4.29	23.67	11.92	2.66	1.9	1.0	2.6	6.0
	76†	0.00	4.33	23.95	12.20	2.82				
Minor in-service problems	76*	0.00	4.29	23.67	11.92	2.66	1.9	1.0	2.6	6.0
	76†	0.00	4.33	23.95	12.20	2.82				
<b>Unknown</b>	8*	0.05	0.30	0.73	0.22	0.28	1.4	1.0	1.8	6.0
	8†	0.07	0.31	0.67	0.19	0.30				
<b>Comments</b>										

(cont.)

Taxonomy no 4.1		Item Control and Safety Equipment Fire & Gas Detectors								
Population 858	Installations 18	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 28.5689			Operational time † 26.9668					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Unknown	2*	0.00	0.06	0.29	0.12	0.07	4.0	2.0	4.0	6.0
	2†	0.00	0.06	0.30	0.12	0.07				
Very low output	6*	0.00	0.26	0.84	0.31	0.21	0.5	1.0	1.0	1.0
	6†	0.00	0.26	0.82	0.30	0.22				
All modes	363*	1.01	14.72	42.44	14.00	12.71	1.5	0.5	2.1	41.0
	363†	0.81	15.08	44.84	14.94	13.46				
Comments										

**Maintainable item versus failure mode, to be continued**

Item: Fire & Gas Detectors

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
Cabinet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cabling	0.00	0.00	0.00	0.00	0.00	0.00	0.55
Control card	0.00	0.00	0.00	0.00	0.28	0.28	0.00
Detector head	12.12	4.55	2.48	5.79	0.83	0.00	0.83
Other	0.00	0.14	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	0.28	0.28	0.00	0.00	0.00
Unknown	0.00	0.28	0.00	0.00	0.00	0.00	0.00
Total	12.12	4.96	2.75	6.06	1.10	0.28	1.38

**Maintainable item versus failure mode, continued**

Item: Fire & Gas Detectors

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
Cabinet	0.00	0.28	0.00	0.00	0.00	0.28	0.00	0.55
Cabling	0.00	3.03	0.00	0.00	0.00	0.00	0.00	3.58
Control card	0.00	0.00	0.00	0.00	0.55	0.00	0.00	1.10
Detector head	4.13	17.91	2.20	1.65	3.03	0.55	32.51	88.57
Other	1.38	0.00	0.00	0.00	0.83	0.00	0.00	2.34
Subunit	0.00	0.00	0.00	0.00	0.00	0.55	0.00	1.10
Unknown	0.83	1.10	0.28	0.00	0.00	0.28	0.00	2.75
Total	6.34	22.31	2.48	1.65	4.41	1.65	32.51	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Fire & Gas Detectors

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
Clearance/ alignment failure	0.28	0.00	0.00	0.00	0.00	0.00	0.00
Common mode failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	1.38	0.55	0.28	0.00	0.28	0.00	0.28
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.00	1.65	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	4.41	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	0.00	1.10	0.28	0.28	0.83	0.28	0.00
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Looseness	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Misc. external influences	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	1.10
Out of adjustment	4.41	0.83	2.20	5.79	0.00	0.00	0.00
Short circuiting	0.00	0.28	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vibration	1.65	0.55	0.00	0.00	0.00	0.00	0.00
Total	12.12	4.96	2.75	6.06	1.10	0.28	1.38

**Failure descriptor versus failure mode, continued**

Item: Fire & Gas Detectors

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
Clearance/ alignment failure	0.00	1.10	0.00	0.00	0.00	0.00	0.00	1.38
Common mode failure	0.00	3.03	0.00	0.00	0.00	0.00	0.00	3.03
Contamination	0.00	0.55	0.28	0.28	0.83	0.00	0.00	4.68
Corrosion	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.28
External influence - general	4.96	0.00	0.00	0.00	0.83	0.00	0.00	7.44
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.55	0.00	0.00	4.96
Instrument failure - general	0.00	0.00	1.10	0.55	0.28	0.28	0.00	4.96
Leakage	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.28
Looseness	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.28
Misc. external influences	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.28
Miscellaneous - general	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.28
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10
Out of adjustment	1.38	17.36	1.10	0.55	0.55	0.83	32.51	67.49
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28
Unknown	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.55
Vibration	0.00	0.00	0.00	0.00	0.55	0.00	0.00	2.75
Total	6.34	22.31	2.48	1.65	4.41	1.65	32.51	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.1.1		Item Control and Safety Equipment Fire & Gas Detectors Flame								
Population 27	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 1.6861		Operational time † 1.3608						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/r		Min	Mean	Max
<b>Critical</b>	1*	0.03	0.59	2.81	0.59	0.59	-	4.0	4.0	4.0
	1†	0.04	0.73	3.49	0.73	0.73				
Spurious operation	1*	0.03	0.59	2.81	0.59	0.59	-	4.0	4.0	4.0
	1†	0.04	0.73	3.49	0.73	0.73				
<b>Degraded</b>	7*	1.95	4.15	7.80	4.15	4.15	6.5	1.0	1.7	3.0
	7†	2.41	5.14	9.66	5.14	5.14				
Erratic output	5*	1.17	2.97	6.24	2.97	2.97	6.5	1.0	1.6	3.0
	5†	1.45	3.67	7.73	3.67	3.67				
Unknown	2*	0.21	1.19	3.73	1.19	1.19	6.5	2.0	2.0	2.0
	2†	0.26	1.47	4.63	1.47	1.47				
<b>Incipient</b>	1*	0.03	0.59	2.81	0.59	0.59	1.0	1.0	1.0	1.0
	1†	0.04	0.73	3.49	0.73	0.73				
Minor in-service problems	1*	0.03	0.59	2.81	0.59	0.59	1.0	1.0	1.0	1.0
	1†	0.04	0.73	3.49	0.73	0.73				
<b>All modes</b>	9*	2.78	5.34	9.31	5.34	5.34	5.7	1.0	1.9	4.0
	9†	3.45	6.61	11.54	6.61	6.61				
<b>Comments</b>										

**Maintainable item versus failure mode, to be continued**

**Item:** Fire & Gas Detectors - Flame

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
Cabinet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Detector head	55.56	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	55.56	0.00	0.00	0.00	0.00	0.00	0.00

**Maintainable item versus failure mode, continued**

**Item:** Fire & Gas Detectors - Flame

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
Cabinet	0.00	11.11	0.00	0.00	0.00	0.00	0.00	11.11
Detector head	0.00	0.00	0.00	0.00	0.00	22.22	0.00	77.78
Other	0.00	0.00	0.00	0.00	11.11	0.00	0.00	11.11
Total	0.00	11.11	0.00	0.00	11.11	22.22	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Fire & Gas Detectors - Flame

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
Contamination	22.22	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	33.33	0.00	0.00	0.00	0.00	0.00	0.00
Total	55.56	0.00	0.00	0.00	0.00	0.00	0.00

**Failure descriptor versus failure mode, continued**

**Item:** Fire & Gas Detectors - Flame

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.22
Instrument failure - general	0.00	0.00	0.00	0.00	11.11	0.00	0.00	11.11
Leakage	0.00	11.11	0.00	0.00	0.00	0.00	0.00	11.11
Out of adjustment	0.00	0.00	0.00	0.00	0.00	22.22	0.00	55.56
Total	0.00	11.11	0.00	0.00	11.11	22.22	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.1.1.1		Item Control and Safety Equipment Fire & Gas Detectors Flame Infrared									
Population 27	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 1.6861		Operational time † 1.3608							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
<b>Critical</b>	1*	0.03	0.59	2.81	0.59	0.59	-	4.0	4.0	4.0	
	1†	0.04	0.73	3.49	0.73	0.73					
Spurious operation	1*	0.03	0.59	2.81	0.59	0.59	-	4.0	4.0	4.0	
	1†	0.04	0.73	3.49	0.73	0.73					
<b>Degraded</b>	7*	1.95	4.15	7.80	4.15	4.15	6.5	1.0	1.7	3.0	
	7†	2.41	5.14	9.66	5.14	5.14					
Erratic output	5*	1.17	2.97	6.24	2.97	2.97	6.5	1.0	1.6	3.0	
	5†	1.45	3.67	7.73	3.67	3.67					
Unknown	2*	0.21	1.19	3.73	1.19	1.19	6.5	2.0	2.0	2.0	
	2†	0.26	1.47	4.63	1.47	1.47					
<b>Incipient</b>	1*	0.03	0.59	2.81	0.59	0.59	1.0	1.0	1.0	1.0	
	1†	0.04	0.73	3.49	0.73	0.73					
Minor in-service problems	1*	0.03	0.59	2.81	0.59	0.59	1.0	1.0	1.0	1.0	
	1†	0.04	0.73	3.49	0.73	0.73					
<b>All modes</b>	9*	2.78	5.34	9.31	5.34	5.34	5.7	1.0	1.9	4.0	
	9†	3.45	6.61	11.54	6.61	6.61					
<b>Comments</b>											



Taxonomy no 4.1.2		Item Control and Safety Equipment Fire & Gas Detectors H2S gas								
Population 542	Installations 13	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 16.7692		Operational time † 16.7692						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max
<b>Degraded</b>	<b>157*</b>	<b>3.68</b>	<b>11.07</b>	<b>21.69</b>	<b>5.64</b>	<b>9.36</b>	<b>0.5</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>
	<b>157†</b>	<b>3.68</b>	<b>11.07</b>	<b>21.69</b>	<b>5.64</b>	<b>9.36</b>				
Erratic output	16*	0.02	1.38	4.36	1.57	0.95	0.5	1.0	1.0	1.0
	16†	0.02	1.38	4.36	1.57	0.95				
Fail to function on demand	6*	0.00	0.31	1.34	0.52	0.36	0.5	1.0	1.0	1.0
	6†	0.00	0.31	1.34	0.52	0.36				
Other	23*	0.00	1.76	7.85	3.11	1.37	0.5	1.0	1.0	1.0
	23†	0.00	1.76	7.85	3.11	1.37				
Very low output	112*	3.37	7.44	12.80	2.92	6.68	0.5	1.0	1.0	1.0
	112†	3.37	7.44	12.80	2.92	6.68				
<b>Unknown</b>	<b>6*</b>	<b>0.08</b>	<b>0.37</b>	<b>0.82</b>	<b>0.23</b>	<b>0.36</b>	<b>0.5</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>
	<b>6†</b>	<b>0.08</b>	<b>0.37</b>	<b>0.82</b>	<b>0.23</b>	<b>0.36</b>				
Very low output	6*	0.08	0.37	0.82	0.23	0.36	0.5	1.0	1.0	1.0
	6†	0.08	0.37	0.82	0.23	0.36				
<b>All modes</b>	<b>163*</b>	<b>3.82</b>	<b>11.46</b>	<b>22.42</b>	<b>5.83</b>	<b>9.72</b>	<b>0.5</b>	<b>1.0</b>	<b>1.0</b>	<b>1.0</b>
	<b>163†</b>	<b>3.82</b>	<b>11.46</b>	<b>22.42</b>	<b>5.83</b>	<b>9.72</b>				
<b>Comments</b>										

**Maintainable item versus failure mode, to be continued**

**Item:** Fire & Gas Detectors - H2S gas

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
Detector head	9.82	3.68	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	9.82	3.68	0.00	0.00	0.00	0.00	0.00

**Maintainable item versus failure mode, continued**

**Item:** Fire & Gas Detectors - H2S gas

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
Detector head	9.20	0.00	0.00	0.00	0.00	0.00	72.39	95.09
Other	3.07	0.00	0.00	0.00	0.00	0.00	0.00	3.07
Unknown	1.84	0.00	0.00	0.00	0.00	0.00	0.00	1.84
Total	14.11	0.00	0.00	0.00	0.00	0.00	72.39	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Fire & Gas Detectors - H2S gas

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
External influence - general	0.00	3.07	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	9.82	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	0.00	0.61	0.00	0.00	0.00	0.00	0.00
Total	9.82	3.68	0.00	0.00	0.00	0.00	0.00

**Failure descriptor versus failure mode, continued**

**Item:** Fire & Gas Detectors - H2S gas

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
External influence - general	11.04	0.00	0.00	0.00	0.00	0.00	0.00	14.11
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.82
Out of adjustment	3.07	0.00	0.00	0.00	0.00	0.00	72.39	76.07
Total	14.11	0.00	0.00	0.00	0.00	0.00	72.39	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no		Item								
4.1.2.1		Control and Safety Equipment Fire & Gas Detectors H2S gas H2S gas								
Population	Installations	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *			Operational time †					
542	13	16.7692			16.7692					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Degraded</b>	157*	3.68	11.07	21.69	5.64	9.36	0.5	1.0	1.0	1.0
	157†	3.68	11.07	21.69	5.64	9.36				
Erratic output	16*	0.02	1.38	4.36	1.57	0.95	0.5	1.0	1.0	1.0
	16†	0.02	1.38	4.36	1.57	0.95				
Fail to function on demand	6*	0.00	0.31	1.34	0.52	0.36	0.5	1.0	1.0	1.0
	6†	0.00	0.31	1.34	0.52	0.36				
Other	23*	0.00	1.76	7.85	3.11	1.37	0.5	1.0	1.0	1.0
	23†	0.00	1.76	7.85	3.11	1.37				
Very low output	112*	3.37	7.44	12.80	2.92	6.68	0.5	1.0	1.0	1.0
	112†	3.37	7.44	12.80	2.92	6.68				
<b>Unknown</b>	6*	0.08	0.37	0.82	0.23	0.36	0.5	1.0	1.0	1.0
	6†	0.08	0.37	0.82	0.23	0.36				
Very low output	6*	0.08	0.37	0.82	0.23	0.36	0.5	1.0	1.0	1.0
	6†	0.08	0.37	0.82	0.23	0.36				
<b>All modes</b>	163*	3.82	11.46	22.42	5.83	9.72	0.5	1.0	1.0	1.0
	163†	3.82	11.46	22.42	5.83	9.72				
<b>Comments</b>										

Taxonomy no		Item								
4.1.3		Control and Safety Equipment Fire & Gas Detectors Heat								
Population	Installations	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *			Operational time †					
23	1	0.7231			0.7052					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max
All modes	0 <sup>*</sup> 0 <sup>†</sup>	0.00	0.66	2.54	0.93	0.00	-	-	-	-
		0.00	0.68	2.60	0.96	0.00				
Comments										

<b>Taxonomy no</b> 4.1.3.1		<b>Item</b> Control and Safety Equipment Fire & Gas Detectors Heat Rate compensated									
<b>Population</b> 23	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>				
		<b>Calendar time *</b> 0.7231			<b>Operational time †</b> 0.7052						
<b>Failure mode</b>		<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours)</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
			<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/τ</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>		0* 0†	0.00 0.00	0.34 0.35	1.30 1.33	0.48 0.49	0.00 0.00	-	-	-	
<b>Comments</b>											

Taxonomy no 4.1.4		Item Control and Safety Equipment Fire & Gas Detectors Hydrocarbon gas								
Population 163	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
		6.1522		4.9737						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>46*</b>	<b>2.98</b>	<b>6.17</b>	<b>10.28</b>	<b>2.25</b>	<b>7.48</b>	<b>2.8</b>	<b>0.5</b>	<b>4.4</b>	<b>41.0</b>
	<b>46†</b>	<b>1.32</b>	<b>6.53</b>	<b>15.00</b>	<b>4.39</b>	<b>9.25</b>				
Fail to function on demand	12*	0.31	1.43	3.23	0.94	1.95	3.8	1.0	4.3	10.0
	12†	0.05	1.52	4.61	1.59	2.41				
No output	5*	0.00	1.36	5.92	2.30	0.81	1.8	1.0	3.4	4.0
	5†	0.00	1.40	5.86	2.24	1.01				
Spurious high level alarm signal	9*	0.59	1.27	2.16	0.49	1.46	2.3	1.0	2.3	8.0
	9†	0.26	1.35	3.16	0.93	1.81				
Spurious low level alarm signal	5*	0.06	0.62	1.70	0.55	0.81	3.2	0.5	3.2	6.0
	5†	0.04	0.74	2.20	0.74	1.01				
Spurious operation	15*	0.91	2.19	3.91	0.93	2.44	2.8	2.0	6.6	41.0
	15†	0.77	2.55	5.17	1.39	3.02				
<b>Degraded</b>	<b>68*</b>	<b>1.03</b>	<b>7.11</b>	<b>17.74</b>	<b>5.46</b>	<b>11.05</b>	<b>2.9</b>	<b>1.0</b>	<b>2.7</b>	<b>12.5</b>
	<b>68†</b>	<b>0.25</b>	<b>8.00</b>	<b>24.29</b>	<b>8.38</b>	<b>13.67</b>				
Erratic output	23*	0.01	1.92	7.25	2.67	3.74	4.4	1.0	2.7	11.0
	23†	0.00	2.27	9.80	3.80	4.62				
High output	10*	0.16	1.79	4.98	1.62	1.63	1.9	2.0	2.2	4.0
	10†	0.41	2.03	4.65	1.36	2.01				
High output, unknown reading	22*	0.01	1.87	6.83	2.52	3.58	3.0	1.0	1.7	3.0
	22†	0.00	2.20	9.35	3.60	4.42				
Low output	4*	0.07	0.80	2.21	0.72	0.65	2.8	1.0	3.8	6.0
	4†	0.25	0.86	1.78	0.48	0.80				
Low output, unknown reading	1*	0.00	0.49	2.07	0.79	0.16	-	10.0	10.0	10.0
	1†	0.00	0.48	2.04	0.78	0.20				
Minor in-service problems	5*	0.06	0.62	1.70	0.55	0.81	2.5	2.0	4.5	12.5
	5†	0.04	0.74	2.20	0.74	1.01				
Spurious low level alarm signal	1*	0.00	0.14	0.45	0.16	0.16	2.0	2.0	2.0	2.0
	1†	0.00	0.17	0.56	0.20	0.20				
Unknown	2*	0.03	0.28	0.73	0.23	0.33	2.0	2.0	7.0	12.0
	2†	0.04	0.34	0.92	0.29	0.40				
<b>Incipient</b>	<b>64*</b>	<b>0.00</b>	<b>18.45</b>	<b>85.53</b>	<b>34.54</b>	<b>10.40</b>	<b>1.2</b>	<b>1.0</b>	<b>2.1</b>	<b>4.0</b>
	<b>64†</b>	<b>0.00</b>	<b>18.66</b>	<b>86.10</b>	<b>34.64</b>	<b>12.87</b>				
Minor in-service problems	64*	0.00	18.45	85.53	34.54	10.40	1.2	1.0	2.1	4.0
	64†	0.00	18.66	86.10	34.64	12.87				
<b>All modes</b>	<b>178*</b>	<b>0.57</b>	<b>29.16</b>	<b>90.58</b>	<b>32.09</b>	<b>28.93</b>	<b>2.1</b>	<b>0.5</b>	<b>3.0</b>	<b>41.0</b>
	<b>178†</b>	<b>1.82</b>	<b>31.51</b>	<b>92.96</b>	<b>30.90</b>	<b>35.79</b>				
<b>Comments</b>										

**Maintainable item versus failure mode, to be continued**

**Item: Fire & Gas Detectors - Hydrocarbon gas**

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
Cabinet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cabling	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Control card	0.00	0.00	0.00	0.00	0.56	0.56	0.00
Detector head	12.92	5.90	5.06	11.80	1.69	0.00	1.69
Other	0.00	0.28	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	0.56	0.56	0.00	0.00	0.00
Unknown	0.00	0.56	0.00	0.00	0.00	0.00	0.00
Total	12.92	6.74	5.62	12.36	2.25	0.56	2.81

**Maintainable item versus failure mode, continued**

**Item: Fire & Gas Detectors - Hydrocarbon gas**

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
Cabinet	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.56
Cabling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Control card	0.00	0.00	0.00	0.00	1.12	0.00	0.00	2.25
Detector head	0.00	36.52	4.49	3.37	6.18	0.00	0.00	89.61
Other	0.00	0.00	0.00	0.00	1.12	0.00	0.00	1.40
Subunit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Unknown	0.00	2.25	0.56	0.00	0.00	0.56	0.00	3.93
Total	0.00	38.76	5.06	3.37	8.43	1.12	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item: Fire & Gas Detectors - Hydrocarbon gas**

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
Clearance/ alignment failure	0.56	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	1.69	1.12	0.56	0.00	0.56	0.00	0.56
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.00	0.56	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	0.00	2.25	0.56	0.56	1.69	0.56	0.00
Looseness	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Misc. external influences	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	2.25
Out of adjustment	7.30	1.12	4.49	11.80	0.00	0.00	0.00
Short circuiting	0.00	0.56	0.00	0.00	0.00	0.00	0.00
Vibration	3.37	1.12	0.00	0.00	0.00	0.00	0.00
Total	12.92	6.74	5.62	12.36	2.25	0.56	2.81

**Failure descriptor versus failure mode, continued**

**Item: Fire & Gas Detectors - Hydrocarbon gas**

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
Clearance/ alignment failure	0.00	2.25	0.00	0.00	0.00	0.00	0.00	2.81
Contamination	0.00	1.12	0.56	0.56	1.69	0.00	0.00	8.43
Corrosion	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.56
External influence - general	0.00	0.00	0.00	0.00	1.69	0.00	0.00	2.25
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	1.12	0.00	0.00	1.12
Instrument failure - general	0.00	0.00	2.25	1.12	0.00	0.56	0.00	9.55
Looseness	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.56
Misc. external influences	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.56
Miscellaneous - general	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.56
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25
Out of adjustment	0.00	35.39	2.25	1.12	1.12	0.56	0.00	65.17
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
Vibration	0.00	0.00	0.00	0.00	1.12	0.00	0.00	5.62
Total	0.00	38.76	5.06	3.37	8.43	1.12	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.



Taxonomy no 4.1.4.1		Item Control and Safety Equipment Fire & Gas Detectors Hydrocarbon gas Catalytic									
Population 24	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.4205		Operational time † 0.4163							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Degraded  Low output, unknown reading	1*	0.12	2.38	11.28	2.38	2.38	-	10.0	10.0	10.0	
	1†	0.12	2.40	11.40	2.40	2.40	-	10.0	10.0	10.0	
	1*	0.12	2.38	11.28	2.38	2.38	-	10.0	10.0	10.0	
	1†	0.12	2.40	11.40	2.40	2.40	-	10.0	10.0	10.0	
All modes	1*	0.12	2.38	11.28	2.38	2.38	-	10.0	10.0	10.0	
	1†	0.12	2.40	11.40	2.40	2.40	-	10.0	10.0	10.0	
Comments											

Taxonomy no 4.1.4.2		Item Control and Safety Equipment Fire & Gas Detectors Hydrocarbon gas Infrared								
Population 137	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 5.6602			Operational time † 4.4982		Active rep.hrs	Repair (manhours)		
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).						Active rep.hrs	Repair (manhours)	
		Lower	Mean	Upper	SD	n/t	Min		Mean	Max
<b>Critical</b>	<b>43*</b> <b>43†</b>	<b>2.30</b> <b>1.16</b>	<b>6.08</b> <b>6.78</b>	<b>11.33</b> <b>16.27</b>	<b>2.82</b> <b>4.88</b>	<b>7.60</b> <b>9.56</b>	<b>2.9</b>	<b>0.5</b>	<b>4.0</b>	<b>41.0</b>
Fail to function on demand	11*	0.42	1.55	3.25	0.90	1.94	4.0	1.0	3.7	8.0
	11†	0.16	1.73	4.74	1.53	2.45				
No output	5*	0.00	1.77	7.17	2.70	0.88	1.8	1.0	3.4	4.0
	5†	0.01	1.81	7.07	2.63	1.11				
Spurious high level alarm signal	9*	0.67	1.41	2.38	0.53	1.59	2.3	1.0	2.3	8.0
	9†	0.28	1.54	3.65	1.08	2.00				
Spurious low level alarm signal	5*	0.05	0.69	1.95	0.64	0.88	3.2	0.5	3.2	6.0
	5†	0.03	0.84	2.53	0.86	1.11				
Spurious operation	13*	0.26	1.67	4.10	1.25	2.30	2.8	2.0	5.8	41.0
	13†	0.08	1.92	5.78	1.96	2.89				
<b>Degraded</b>	<b>67*</b> <b>67†</b>	<b>2.11</b> <b>1.03</b>	<b>8.56</b> <b>9.81</b>	<b>18.59</b> <b>26.20</b>	<b>5.25</b> <b>8.35</b>	<b>11.84</b> <b>14.90</b>	<b>2.9</b>	<b>1.0</b>	<b>2.6</b>	<b>12.5</b>
Erratic output	23*	0.02	2.38	7.81	2.85	4.06	4.4	1.0	2.7	11.0
	23†	0.01	2.90	10.97	4.05	5.11				
High output	10*	0.24	2.22	5.92	1.88	1.77	1.9	2.0	2.2	4.0
	10†	0.60	2.45	5.34	1.51	2.22				
High output, unknown reading	22*	0.03	2.31	7.43	2.69	3.89	3.0	1.0	1.7	3.0
	22†	0.01	2.80	10.40	3.84	4.89				
Low output	4*	0.07	0.98	2.82	0.93	0.71	2.8	1.0	3.8	6.0
	4†	0.21	1.03	2.37	0.70	0.89				
Minor in-service problems	5*	0.05	0.69	1.95	0.64	0.88	2.5	2.0	4.5	12.5
	5†	0.03	0.84	2.53	0.86	1.11				
Spurious low level alarm signal	1*	0.00	0.16	0.49	0.18	0.18	2.0	2.0	2.0	2.0
	1†	0.00	0.20	0.62	0.22	0.22				
Unknown	2*	0.04	0.31	0.82	0.26	0.35	2.0	2.0	7.0	12.0
	2†	0.03	0.38	1.06	0.34	0.44				
<b>Incipient</b>	<b>64*</b> <b>64†</b>	<b>0.02</b> <b>0.02</b>	<b>24.55</b> <b>24.83</b>	<b>103.70</b> <b>103.83</b>	<b>39.85</b> <b>39.68</b>	<b>11.31</b> <b>14.23</b>	<b>1.2</b>	<b>1.0</b>	<b>2.1</b>	<b>4.0</b>
Minor in-service problems	64*	0.02	24.55	103.70	39.85	11.31	1.2	1.0	2.1	4.0
	64†	0.02	24.83	103.83	39.68	14.23				
<b>All modes</b>	<b>174*</b> <b>174†</b>	<b>2.05</b> <b>4.38</b>	<b>36.40</b> <b>39.47</b>	<b>107.66</b> <b>104.09</b>	<b>35.82</b> <b>32.91</b>	<b>30.74</b> <b>38.68</b>	<b>2.1</b>	<b>0.5</b>	<b>2.8</b>	<b>41.0</b>
Comments										

Taxonomy no 4.1.4.3		Item Control and Safety Equipment Fire & Gas Detectors Hydrocarbon gas Photo-electric beam								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0540		Operational time † 0.0420						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical Fail to function on demand	1*	0.93	18.52	87.87	18.52	18.52	2.0	10.0	10.0	10.0
	1†	1.19	23.84	113.11	23.84	23.84				
	1*	0.93	18.52	87.87	18.52	18.52	2.0	10.0	10.0	10.0
	1†	1.19	23.84	113.11	23.84	23.84				
All modes	1*	0.93	18.52	87.87	18.52	18.52	2.0	10.0	10.0	10.0
	1†	1.19	23.84	113.11	23.84	23.84				
Comments										

Taxonomy no 4.1.4.4		Item Control and Safety Equipment Fire & Gas Detectors Hydrocarbon gas Unknown									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *		Operational time †							
		0.0175		0.0173							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Critical	2*	20.26	114.16	359.30	114.16	114.16	-	4.0	12.0	20.0	
	2†	20.47	115.31	362.93	115.31	115.31	-	4.0	12.0	20.0	
Spurious operation	2*	20.26	114.16	359.30	114.16	114.16	-	4.0	12.0	20.0	
	2†	20.47	115.31	362.93	115.31	115.31	-	4.0	12.0	20.0	
All modes	2*	20.26	114.16	359.30	114.16	114.16	-	4.0	12.0	20.0	
	2†	20.47	115.31	362.93	115.31	115.31	-	4.0	12.0	20.0	
Comments											

Taxonomy no 4.1.5		Item Control and Safety Equipment Fire & Gas Detectors Smoke/Combustion									
Population 103	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *			Operational time †						
		3.2383			3.1580						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Incipient	11*	1.91	3.40	5.62	3.40	3.40	6.0	6.0	6.0	6.0	
	11†	1.95	3.48	5.77	3.48	3.48					
Minor in-service problems	11*	1.91	3.40	5.62	3.40	3.40	6.0	6.0	6.0	6.0	
	11†	1.95	3.48	5.77	3.48	3.48					
Unknown	2*	0.11	0.62	1.94	0.62	0.62	4.0	2.0	4.0	6.0	
	2†	0.11	0.63	1.99	0.63	0.63					
Unknown	2*	0.11	0.62	1.94	0.62	0.62	4.0	2.0	4.0	6.0	
	2†	0.11	0.63	1.99	0.63	0.63					
All modes	13*	2.37	4.01	6.38	4.01	4.01	5.7	2.0	5.7	6.0	
	13†	2.43	4.12	6.54	4.12	4.12					
Comments											

**Maintainable item versus failure mode, to be continued**

**Item:** Fire & Gas Detectors - Smoke/Combustion

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
Cabling	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00

**Maintainable item versus failure mode, continued**

**Item:** Fire & Gas Detectors - Smoke/Combustion

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
Cabling	0.00	84.62	0.00	0.00	0.00	0.00	0.00	84.62
Subunit	0.00	0.00	0.00	0.00	0.00	15.38	0.00	15.38
Total	0.00	84.62	0.00	0.00	0.00	15.38	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Fire & Gas Detectors - Smoke/Combustion

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
Common mode failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00

**Failure descriptor versus failure mode, continued**

**Item:** Fire & Gas Detectors - Smoke/Combustion

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
Common mode failure	0.00	84.62	0.00	0.00	0.00	0.00	0.00	84.62
Unknown	0.00	0.00	0.00	0.00	0.00	15.38	0.00	15.38
Total	0.00	84.62	0.00	0.00	0.00	15.38	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.1.5.1		Item Control and Safety Equipment Fire & Gas Detectors Smoke/Combustion Photo-electric									
Population 103	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 3.2383		Operational time † 3.1580							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Incipient</b>	11*	1.91	3.40	5.62	3.40	3.40	6.0	6.0	6.0	6.0	
	11†	1.95	3.48	5.77	3.48	3.48					
Minor in-service problems	11*	1.91	3.40	5.62	3.40	3.40	6.0	6.0	6.0	6.0	
	11†	1.95	3.48	5.77	3.48	3.48					
<b>Unknown</b>	2*	0.11	0.62	1.94	0.62	0.62	4.0	2.0	4.0	6.0	
	2†	0.11	0.63	1.99	0.63	0.63					
Unknown	2*	0.11	0.62	1.94	0.62	0.62	4.0	2.0	4.0	6.0	
	2†	0.11	0.63	1.99	0.63	0.63					
<b>All modes</b>	13*	2.37	4.01	6.38	4.01	4.01	5.7	2.0	5.7	6.0	
	13†	2.43	4.12	6.54	4.12	4.12					
<b>Comments</b>											

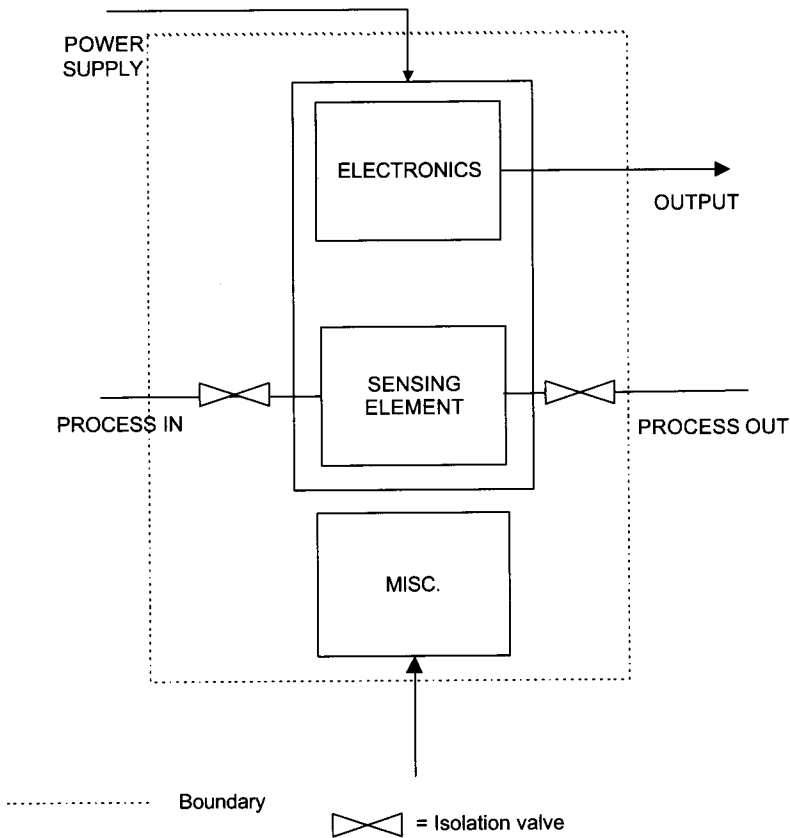
### Process Sensors

#### Inventory description

The boundary definition shown in Figure 21 comprises the sensing element and the (local) electronics for signal conversion and transmission. The sensing element measures some process parameter (e.g. pressure, level, temperature, flow, etc.) and the electronics converts the measurement to a standard electric signal that is transmitted to a computer, a solid state controller or a PLC. Some sensors may be calibrated by adjusting a screw at the electronic housing.

Isolation valves (block valves) and associated pipework are also included.

The subdivision in Subunits and Maintainable Items is similar to the F&G detectors, and is shown in Table 16.



**Figure 21 Process Sensors, Boundary Definition**



**Table 16 Prosess Sensors, Subdivision in Maintainable Items**

PROCESS SENSOR	
Sensor & electronics	Miscellaneous
<ul style="list-style-type: none"> <li>• Sensing element</li> <li>• Electronics</li> </ul>	<ul style="list-style-type: none"> <li>• Isolation valve</li> <li>• Piping</li> </ul>

(For all subunits the MIs "Unknown" and "Subunit" are included.

**List of failure modes**

- ERO Erratic output
- FTF Fail to function on demand
- HIO High output
- LOO Low output
- SER Minor in-service problems
- OTH Other
- SPO Spurious operation

Taxonomy no 4.2		Item Control and Safety Equipment Process sensors								
Population 209	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 7.0700			Operational time † 6.0635					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>18*</b> <b>18†</b>	<b>0.50</b>	<b>2.81</b>	<b>6.68</b>	<b>1.99</b>	<b>2.55</b>	<b>4.4</b>	<b>1.0</b>	<b>6.6</b>	<b>24.0</b>
Erratic output	4*	0.02	1.90	6.16	2.24	0.57	7.0	2.0	8.5	12.0
Fail to function on demand	4†	0.02	1.91	6.42	2.36	0.66				
	7*	0.27	0.90	1.84	0.50	0.99	4.2	2.0	6.7	22.0
Low output	7†	0.06	1.02	3.01	1.00	1.15				
	1*	0.00	0.13	0.41	0.15	0.14	4.0	4.0	4.0	4.0
Spurious operation	1†	0.00	0.16	0.56	0.21	0.16				
	6*	0.33	0.80	1.44	0.35	0.85	2.8	1.0	5.8	24.0
<b>Degraded</b>	6†	0.14	0.92	2.27	0.69	0.99				
	<b>23*</b> <b>23†</b>	<b>0.58</b>	<b>6.18</b>	<b>16.94</b>	<b>5.47</b>	<b>3.25</b>	<b>3.7</b>	<b>2.0</b>	<b>7.5</b>	<b>26.0</b>
Erratic output	5*	0.06	0.84	2.41	0.79	0.71	3.4	2.0	5.0	8.0
	5†	0.11	0.86	2.20	0.68	0.82				
High output	4*	0.01	1.66	5.53	2.03	0.57	2.0	2.0	13.5	26.0
	4†	0.01	1.73	5.96	2.20	0.66				
Low output	6*	0.00	0.72	2.87	1.07	0.85	3.3	2.0	5.3	8.0
	6†	0.01	0.77	2.69	0.99	0.99				
Other	8*	0.04	2.94	9.33	3.36	1.13	5.3	2.0	7.7	16.0
	8†	0.04	3.11	10.01	3.63	1.32				
<b>Incipient</b>	<b>21*</b> <b>21†</b>	<b>0.00</b>	<b>2.17</b>	<b>8.64</b>	<b>3.23</b>	<b>2.97</b>	<b>9.6</b>	<b>1.0</b>	<b>11.6</b>	<b>135.0</b>
Erratic output	10*	0.00	1.09	4.95	1.97	1.41	4.4	2.0	7.0	24.0
	10†	0.00	1.15	4.92	1.90	1.65				
High output	1*	0.00	0.14	0.47	0.17	0.14	1.5	3.0	3.0	3.0
	1†	0.00	0.15	0.48	0.17	0.16				
Minor in-service problems	8*	0.11	1.00	2.64	0.83	1.13	18.8	1.0	20.0	135.0
	8†	0.16	1.15	2.87	0.88	1.32				
Other	2*	0.00	0.27	0.94	0.35	0.28	3.3	3.0	5.0	7.0
	2†	0.00	0.29	0.95	0.35	0.33				
<b>Unknown</b>	<b>1*</b> <b>1†</b>	<b>0.00</b>	<b>0.45</b>	<b>1.75</b>	<b>0.65</b>	<b>0.14</b>	-	<b>28.0</b>	<b>28.0</b>	<b>28.0</b>
Erratic output	1*	0.00	0.45	1.75	0.65	0.14	-	28.0	28.0	28.0
	1†	0.00	0.47	1.87	0.70	0.16				
<b>All modes</b>	<b>63*</b> <b>63†</b>	<b>4.10</b>	<b>11.26</b>	<b>21.29</b>	<b>5.37</b>	<b>8.91</b>	<b>6.2</b>	<b>1.0</b>	<b>9.0</b>	<b>135.0</b>
			<b>5.75</b>	<b>11.70</b>	<b>19.36</b>	<b>4.20</b>	<b>10.39</b>			
Comments										

**Maintainable item versus failure mode**

Item: Process sensors

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Electronics	11.11	1.59	1.59	0.00	0.00	1.59	3.17	19.05
Isolation valve	1.59	1.59	0.00	0.00	0.00	0.00	0.00	3.17
Other	7.94	3.17	1.59	7.94	6.35	4.76	3.17	34.92
Piping	0.00	0.00	0.00	0.00	3.17	0.00	0.00	3.17
Sensing element	6.35	3.17	4.76	1.59	0.00	3.17	3.17	22.22
Subunit	1.59	1.59	0.00	0.00	0.00	0.00	0.00	3.17
Unknown	3.17	0.00	0.00	1.59	6.35	3.17	0.00	14.29
Total	31.75	11.11	7.94	11.11	15.87	12.70	9.52	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode**

Item: Process sensors

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Blockage/plugged	0.00	1.59	0.00	0.00	1.59	0.00	1.59	4.76
Breakage	0.00	0.00	0.00	0.00	1.59	0.00	0.00	1.59
Clearance/ alignment failure	4.76	0.00	0.00	4.76	0.00	4.76	0.00	14.29
Corrosion	0.00	0.00	0.00	0.00	1.59	0.00	0.00	1.59
Electrical failure - general	1.59	1.59	0.00	0.00	0.00	0.00	0.00	3.17
Faulty signal/indication/alarm	22.22	3.17	6.35	3.17	0.00	1.59	1.59	38.10
Instrument failure - general	0.00	1.59	0.00	0.00	0.00	0.00	1.59	3.17
Leakage	0.00	0.00	0.00	0.00	7.94	4.76	0.00	12.70
Mechanical Failure - general	0.00	1.59	0.00	0.00	0.00	0.00	1.59	3.17
Misc. external influences	0.00	0.00	0.00	0.00	1.59	0.00	0.00	1.59
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	1.59	1.59
No signal/indication/alarm	0.00	1.59	0.00	0.00	0.00	0.00	1.59	3.17
Out of adjustment	3.17	0.00	1.59	1.59	0.00	0.00	0.00	6.35
Vibration	0.00	0.00	0.00	1.59	0.00	0.00	0.00	1.59
Wear	0.00	0.00	0.00	0.00	1.59	1.59	0.00	3.17
Total	31.75	11.11	7.94	11.11	15.87	12.70	9.52	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.2.1		Item Control and Safety Equipment Process sensors Flow																																																																																																																																																																																								
Population 35	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands																																																																																																																																																																																			
		Calendar time * 1.3416		Operational time † 1.2266																																																																																																																																																																																						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)																																																																																																																																																																																		
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max																																																																																																																																																																																
<b>Critical</b>	4*	0.73	3.26	7.28	2.10	2.98	4.5	2.0	9.8	22.0																																																																																																																																																																																
	4†	1.00	3.81	8.08	2.25	3.26					Erratic output	1*	0.01	0.68	2.11	0.75	0.75	6.0	12.0	12.0	12.0	1†	0.01	0.74	2.30	0.82	0.82	Fail to function on demand	3*	0.40	2.65	6.57	2.01	2.24	4.0	2.0	9.0	22.0	3†	0.18	3.59	10.72	3.58	2.45	<b>Degraded</b>	6*	0.27	3.69	10.54	3.47	4.47	4.3	2.0	6.3	16.0	6†	0.71	4.14	9.90	2.97	4.89	Erratic output	3*	0.47	2.04	4.52	1.29	2.24	3.3	2.0	4.0	6.0	3†	0.04	2.04	6.33	2.24	2.45	High output	1*	0.01	0.68	2.11	0.75	0.75	2.0	2.0	2.0	2.0	1†	0.01	0.74	2.30	0.82	0.82	Other	2*	0.02	1.29	4.13	1.49	1.49	7.0	8.0	12.0	16.0	2†	0.04	1.42	4.32	1.49	1.63	<b>Incipient</b>	6*	1.99	4.52	7.88	1.83	4.47	2.3	1.0	4.2	8.0	6†	2.26	5.11	8.88	2.05	4.89	Minor in-service problems	5*	1.57	3.84	6.93	1.67	3.73	2.1	1.0	3.6	8.0	5†	1.12	4.56	9.92	2.80	4.08	Other	1*	0.01	0.68	2.11	0.75	0.75	3.5	7.0	7.0	7.0	1†	0.01	0.74	2.30	0.82	0.82	<b>All modes</b>	16*	7.33	11.77	17.07	2.98	11.93	3.6	1.0	6.4	22.0	16†	8.29	13.16	18.94	3.26	13.04	<b>Comments</b>					
Erratic output	1*	0.01	0.68	2.11	0.75	0.75	6.0	12.0	12.0	12.0																																																																																																																																																																																
	1†	0.01	0.74	2.30	0.82	0.82					Fail to function on demand	3*	0.40	2.65	6.57	2.01	2.24	4.0	2.0	9.0	22.0	3†	0.18	3.59	10.72	3.58	2.45	<b>Degraded</b>	6*	0.27	3.69	10.54	3.47	4.47	4.3	2.0	6.3	16.0	6†	0.71	4.14	9.90	2.97	4.89	Erratic output	3*	0.47	2.04	4.52	1.29	2.24	3.3	2.0	4.0	6.0	3†	0.04	2.04	6.33	2.24	2.45	High output	1*	0.01	0.68	2.11	0.75	0.75	2.0	2.0	2.0	2.0	1†	0.01	0.74	2.30	0.82	0.82	Other	2*	0.02	1.29	4.13	1.49	1.49	7.0	8.0	12.0	16.0	2†	0.04	1.42	4.32	1.49	1.63	<b>Incipient</b>	6*	1.99	4.52	7.88	1.83	4.47	2.3	1.0	4.2	8.0	6†	2.26	5.11	8.88	2.05	4.89	Minor in-service problems	5*	1.57	3.84	6.93	1.67	3.73	2.1	1.0	3.6	8.0	5†	1.12	4.56	9.92	2.80	4.08	Other	1*	0.01	0.68	2.11	0.75	0.75	3.5	7.0	7.0	7.0	1†	0.01	0.74	2.30	0.82	0.82	<b>All modes</b>	16*	7.33	11.77	17.07	2.98	11.93	3.6	1.0	6.4	22.0	16†	8.29	13.16	18.94	3.26	13.04	<b>Comments</b>																						
Fail to function on demand	3*	0.40	2.65	6.57	2.01	2.24	4.0	2.0	9.0	22.0																																																																																																																																																																																
	3†	0.18	3.59	10.72	3.58	2.45					<b>Degraded</b>	6*	0.27	3.69	10.54	3.47	4.47	4.3	2.0	6.3	16.0	6†	0.71	4.14	9.90	2.97	4.89	Erratic output	3*	0.47	2.04	4.52	1.29	2.24	3.3	2.0	4.0	6.0	3†	0.04	2.04	6.33	2.24	2.45	High output	1*	0.01	0.68	2.11	0.75	0.75	2.0	2.0	2.0	2.0	1†	0.01	0.74	2.30	0.82	0.82	Other	2*	0.02	1.29	4.13	1.49	1.49	7.0	8.0	12.0	16.0	2†	0.04	1.42	4.32	1.49	1.63	<b>Incipient</b>	6*	1.99	4.52	7.88	1.83	4.47	2.3	1.0	4.2	8.0	6†	2.26	5.11	8.88	2.05	4.89	Minor in-service problems	5*	1.57	3.84	6.93	1.67	3.73	2.1	1.0	3.6	8.0	5†	1.12	4.56	9.92	2.80	4.08	Other	1*	0.01	0.68	2.11	0.75	0.75	3.5	7.0	7.0	7.0	1†	0.01	0.74	2.30	0.82	0.82	<b>All modes</b>	16*	7.33	11.77	17.07	2.98	11.93	3.6	1.0	6.4	22.0	16†	8.29	13.16	18.94	3.26	13.04	<b>Comments</b>																																							
<b>Degraded</b>	6*	0.27	3.69	10.54	3.47	4.47	4.3	2.0	6.3	16.0																																																																																																																																																																																
	6†	0.71	4.14	9.90	2.97	4.89					Erratic output	3*	0.47	2.04	4.52	1.29	2.24	3.3	2.0	4.0	6.0	3†	0.04	2.04	6.33	2.24	2.45	High output	1*	0.01	0.68	2.11	0.75	0.75	2.0	2.0	2.0	2.0	1†	0.01	0.74	2.30	0.82	0.82	Other	2*	0.02	1.29	4.13	1.49	1.49	7.0	8.0	12.0	16.0	2†	0.04	1.42	4.32	1.49	1.63	<b>Incipient</b>	6*	1.99	4.52	7.88	1.83	4.47	2.3	1.0	4.2	8.0	6†	2.26	5.11	8.88	2.05	4.89	Minor in-service problems	5*	1.57	3.84	6.93	1.67	3.73	2.1	1.0	3.6	8.0	5†	1.12	4.56	9.92	2.80	4.08	Other	1*	0.01	0.68	2.11	0.75	0.75	3.5	7.0	7.0	7.0	1†	0.01	0.74	2.30	0.82	0.82	<b>All modes</b>	16*	7.33	11.77	17.07	2.98	11.93	3.6	1.0	6.4	22.0	16†	8.29	13.16	18.94	3.26	13.04	<b>Comments</b>																																																								
Erratic output	3*	0.47	2.04	4.52	1.29	2.24	3.3	2.0	4.0	6.0																																																																																																																																																																																
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High output	1*	0.01	0.68	2.11	0.75	0.75	2.0	2.0	2.0	2.0																																																																																																																																																																																
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Other	2*	0.02	1.29	4.13	1.49	1.49	7.0	8.0	12.0	16.0																																																																																																																																																																																
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Other	1*	0.01	0.68	2.11	0.75	0.75	3.5	7.0	7.0	7.0																																																																																																																																																																																
	1†	0.01	0.74	2.30	0.82	0.82					<b>All modes</b>	16*	7.33	11.77	17.07	2.98	11.93	3.6	1.0	6.4	22.0	16†	8.29	13.16	18.94	3.26	13.04	<b>Comments</b>																																																																																																																																																														
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	16†	8.29	13.16	18.94	3.26	13.04																																																																																																																																																																																				
<b>Comments</b>																																																																																																																																																																																										

**Maintainable item versus failure mode**

**Item:** Process sensors - Flow

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Electronics	18.75	0.00	6.25	0.00	0.00	6.25	0.00	31.25
Isolation valve	0.00	6.25	0.00	0.00	0.00	0.00	0.00	6.25
Other	0.00	6.25	0.00	0.00	0.00	6.25	0.00	12.50
Piping	0.00	0.00	0.00	0.00	6.25	0.00	0.00	6.25
Sensing element	0.00	0.00	0.00	0.00	0.00	6.25	0.00	6.25
Subunit	0.00	6.25	0.00	0.00	0.00	0.00	0.00	6.25
Unknown	6.25	0.00	0.00	0.00	12.50	12.50	0.00	31.25
Total	25.00	18.75	6.25	0.00	18.75	31.25	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode**

**Item:** Process sensors - Flow

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Breakage	0.00	0.00	0.00	0.00	6.25	0.00	0.00	6.25
Clearance/ alignment failure	6.25	0.00	0.00	0.00	0.00	18.75	0.00	25.00
Corrosion	0.00	0.00	0.00	0.00	6.25	0.00	0.00	6.25
Electrical failure - general	6.25	6.25	0.00	0.00	0.00	0.00	0.00	12.50
Faulty signal/indication/alarm	12.50	6.25	6.25	0.00	0.00	0.00	0.00	25.00
Leakage	0.00	0.00	0.00	0.00	0.00	12.50	0.00	12.50
Mechanical Failure - general	0.00	6.25	0.00	0.00	0.00	0.00	0.00	6.25
Misc. external influences	0.00	0.00	0.00	0.00	6.25	0.00	0.00	6.25
Total	25.00	18.75	6.25	0.00	18.75	31.25	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

<b>Taxonomy no</b> 4.2.1.1		<b>Item</b> Control and Safety Equipment Process sensors Flow Electro-mechanical									
<b>Population</b> 2	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>				
		<b>Calendar time *</b> 0.0985			<b>Operational time †</b> 0.0701						
<b>Failure mode</b>		<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours)</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
			<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/τ</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>		0 <sup>*</sup> 0 <sup>†</sup>	0.01 0.02	3.55 4.62	13.62 17.76	5.01 6.54	0.00 0.00	-	-	-	
<b>Comments</b>											

Taxonomy no 4.2.1.2		Item Control and Safety Equipment Process sensors Flow Unknown								
Population 33	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 1.2430		Operational time † 1.1565						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	<b>4*</b> <b>4†</b>	<b>1.15</b> <b>0.54</b>	<b>3.63</b> <b>4.95</b>	<b>7.26</b> <b>13.11</b>	<b>1.92</b> <b>4.16</b>	<b>3.22</b> <b>3.46</b>	<b>4.5</b>	<b>2.0</b>	<b>9.8</b>	<b>22.0</b>
Erratic output	1* 1†	0.01 0.02	0.73 0.79	2.27 2.44	0.80 0.86	0.80 0.86	6.0	12.0	12.0	12.0
Fail to function on demand	3* 3†	0.21 0.08	3.42 4.71	9.98 14.83	3.31 5.31	2.41 2.59	4.0	2.0	9.0	22.0
<b>Degraded</b>	<b>6*</b> <b>6†</b>	<b>0.62</b> <b>1.70</b>	<b>4.05</b> <b>4.68</b>	<b>10.00</b> <b>8.88</b>	<b>3.06</b> <b>2.24</b>	<b>4.83</b> <b>5.19</b>	<b>4.3</b>	<b>2.0</b>	<b>6.3</b>	<b>16.0</b>
Erratic output	3* 3†	0.04 0.09	2.01 2.19	6.29 6.60	2.24 2.24	2.41 2.59	3.3	2.0	4.0	6.0
High output	1* 1†	0.01 0.02	0.73 0.79	2.27 2.44	0.80 0.86	0.80 0.86	2.0	2.0	2.0	2.0
Other	2* 2†	0.04 0.09	1.40 1.52	4.28 4.50	1.49 1.49	1.61 1.73	7.0	8.0	12.0	16.0
<b>Incipient</b>	<b>6*</b> <b>6†</b>	<b>2.26</b> <b>1.43</b>	<b>5.00</b> <b>5.99</b>	<b>8.62</b> <b>13.14</b>	<b>1.97</b> <b>3.73</b>	<b>4.83</b> <b>5.19</b>	<b>2.3</b>	<b>1.0</b>	<b>4.2</b>	<b>8.0</b>
Minor in-service problems	5* 5†	1.21 1.55	4.42 5.08	9.26 10.26	2.54 2.74	4.02 4.32	2.1	1.0	3.6	8.0
Other	1* 1†	0.01 0.02	0.73 0.79	2.27 2.44	0.80 0.86	0.80 0.86	3.5	7.0	7.0	7.0
<b>All modes</b>	<b>16*</b> <b>16†</b>	<b>8.13</b> <b>8.01</b>	<b>12.93</b> <b>14.50</b>	<b>18.64</b> <b>22.56</b>	<b>3.22</b> <b>4.48</b>	<b>12.87</b> <b>13.84</b>	<b>3.6</b>	<b>1.0</b>	<b>6.4</b>	<b>22.0</b>
<b>Comments</b>										

Taxonomy no 4.2.2		Item Control and Safety Equipment Process sensors Level								
Population 76	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 2.0952		Operational time † 1.8624						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	8*	1.62	3.99	7.23	1.75	3.82	5.0	1.0	7.6	24.0
	8†	1.48	4.65	9.26	2.44	4.30				
Erratic output	3*	0.00	2.17	9.03	3.44	1.43	7.3	2.0	7.3	10.0
	3†	0.00	2.22	9.27	3.54	1.61				
Fail to function on demand	1*	0.00	0.46	1.72	0.63	0.48	-	-	-	-
	1†	0.00	0.56	2.33	0.89	0.54				
Low output	1*	0.00	0.46	1.72	0.63	0.48	4.0	4.0	4.0	4.0
	1†	0.00	0.56	2.33	0.89	0.54				
Spurious operation	3*	0.12	1.33	3.71	1.20	1.43	3.0	1.0	9.0	24.0
	3†	0.03	1.55	4.77	1.68	1.61				
<b>Degraded</b>	13*	1.46	14.24	38.26	12.23	6.20	3.2	2.0	8.5	26.0
	13†	1.43	14.86	40.45	13.02	6.98				
Erratic output	2*	0.01	1.05	3.54	1.30	0.95	3.5	5.0	6.5	8.0
	2†	0.01	1.11	3.59	1.30	1.07				
High output	3*	0.59	9.93	29.21	9.70	1.43	-	12.0	17.3	26.0
	3†	0.47	10.44	31.34	10.54	1.61				
Low output	6*	0.01	2.28	8.98	3.34	2.86	3.3	2.0	5.3	8.0
	6†	0.01	2.43	8.57	3.16	3.22				
Other	2*	0.02	2.33	7.96	2.93	0.95	2.0	2.0	7.0	12.0
	2†	0.02	2.59	8.73	3.20	1.07				
<b>Incipient</b>	15*	0.00	5.22	21.89	8.38	7.16	12.5	2.0	14.5	135.0
	15†	0.01	5.55	21.91	8.16	8.05				
Erratic output	10*	0.00	3.53	15.66	6.17	4.77	4.4	2.0	7.0	24.0
	10†	0.00	3.67	15.69	6.06	5.37				
High output	1*	0.00	0.44	1.54	0.57	0.48	1.5	3.0	3.0	3.0
	1†	0.01	0.48	1.57	0.57	0.54				
Minor in-service problems	3*	0.15	1.33	3.49	1.10	1.43	46.5	3.0	47.3	135.0
	3†	0.19	1.49	3.82	1.19	1.61				
Other	1*	0.00	0.44	1.54	0.57	0.48	3.0	3.0	3.0	3.0
	1†	0.01	0.48	1.57	0.57	0.54				
<b>Unknown</b>	1*	0.03	2.61	8.56	3.12	0.48	-	28.0	28.0	28.0
	1†	0.02	2.75	9.22	3.39	0.54				
Erratic output	1*	0.03	2.61	8.56	3.12	0.48	-	28.0	28.0	28.0
	1†	0.02	2.75	9.22	3.39	0.54				
<b>All modes</b>	37*	5.38	23.81	53.01	15.21	17.66	8.1	1.0	11.4	135.0
	37†	6.31	24.70	53.01	14.84	19.87				
<b>Comments</b>										



**Maintainable item versus failure mode**

Item: Process sensors - Level

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Electronics	10.81	0.00	0.00	0.00	0.00	0.00	0.00	10.81
Isolation valve	2.70	0.00	0.00	0.00	0.00	0.00	0.00	2.70
Other	13.51	0.00	2.70	13.51	2.70	5.41	5.41	43.24
Piping	0.00	0.00	0.00	0.00	2.70	0.00	0.00	2.70
Sensing element	10.81	2.70	8.11	2.70	0.00	2.70	2.70	29.73
Subunit	2.70	0.00	0.00	0.00	0.00	0.00	0.00	2.70
Unknown	2.70	0.00	0.00	2.70	2.70	0.00	0.00	8.11
Total	43.24	2.70	10.81	18.92	8.11	8.11	8.11	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode**

Item: Process sensors - Level

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Blockage/plugged	0.00	2.70	0.00	0.00	2.70	0.00	2.70	8.11
Clearance/ alignment failure	5.41	0.00	0.00	8.11	0.00	0.00	0.00	13.51
Faulty signal/indication/alarm	32.43	0.00	8.11	5.41	0.00	2.70	0.00	48.65
Leakage	0.00	0.00	0.00	0.00	2.70	2.70	0.00	5.41
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00	2.70	2.70
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	2.70	2.70
Out of adjustment	5.41	0.00	2.70	2.70	0.00	0.00	0.00	10.81
Vibration	0.00	0.00	0.00	2.70	0.00	0.00	0.00	2.70
Wear	0.00	0.00	0.00	0.00	2.70	2.70	0.00	5.41
Total	43.24	2.70	10.81	18.92	8.11	8.11	8.11	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.2.2.1		Item Control and Safety Equipment Process sensors Level Capacitance									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0351		Operational time † 0.0350							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Degraded	2*	10.12	57.00	179.41	57.00	57.00	3.0	4.0	6.0	8.0	
	2†	10.13	57.08	179.65	57.08	57.08					
Low output	2*	10.12	57.00	179.41	57.00	57.00	3.0	4.0	6.0	8.0	
	2†	10.13	57.08	179.65	57.08	57.08					
Incipient	1*	1.42	28.50	135.23	28.50	28.50	3.0	3.0	3.0	3.0	
	1†	1.43	28.54	135.42	28.54	28.54					
Other	1*	1.42	28.50	135.23	28.50	28.50	3.0	3.0	3.0	3.0	
	1†	1.43	28.54	135.42	28.54	28.54					
All modes	3*	23.37	85.50	221.02	85.50	85.50	3.0	3.0	5.0	8.0	
	3†	23.40	85.62	221.32	85.62	85.62					
Comments											

Taxonomy no 4.2.2.2		Item Control and Safety Equipment Process sensors Level Conductivity									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0351		Operational time † 0.0350			Active rep.hrs	Repair (manhours)			
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ	Min		Mean	Max	
Incipient	2*	10.12	57.00	179.41	57.00	57.00	68.3	4.0	69.5	135.0	
	2†	10.13	57.08	179.65	57.08	57.08					
Minor in-service problems	2*	10.12	57.00	179.41	57.00	57.00	68.3	4.0	69.5	135.0	
	2†	10.13	57.08	179.65	57.08	57.08					
All modes	2*	10.12	57.00	179.41	57.00	57.00	68.3	4.0	69.5	135.0	
	2†	10.13	57.08	179.65	57.08	57.08					
Comments											

Taxonomy no 4.2.2.3		Item Control and Safety Equipment Process sensors Level Displacement						No of demands			
Population 36	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Calendar time * 1.2810		Operational time † 1.1490				Min	Mean	Max	
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					n/r	Active rep.hrs	Min	Mean	Max
		Lower	Mean	Upper	SD	n/r					
<b>Critical</b>	4*	0.77	3.31	7.30	2.08	3.12	3.7	1.0	9.7	24.0	
	4†	0.25	4.16	12.23	4.06	3.48					
Fail to function on demand	1*	0.00	0.89	3.50	1.30	0.78					
	1†	0.07	1.05	3.07	1.01	0.87					
Low output	1*	0.00	0.89	3.50	1.30	0.78	4.0	4.0	4.0	4.1	
	1†	0.07	1.05	3.07	1.01	0.87					
Spurious operation	2*	0.26	1.56	3.76	1.13	1.56	3.5	1.0	12.5	24.1	
	2†	0.17	1.82	4.95	1.59	1.74					
<b>Degraded</b>	9*	1.69	19.28	53.48	17.37	7.03	3.2	2.0	10.2	26	
	9†	1.43	20.39	58.63	19.32	7.83					
Erratic output	1*	0.01	0.71	2.21	0.78	0.78	2.0	8.0	8.0	8	
	1†	0.01	0.78	2.44	0.87	0.87					
High output	3*	0.66	13.75	41.21	13.79	2.34		12.0	17.3	24	
	3†	0.38	14.59	44.62	15.55	2.61					
Low output	4*	0.68	2.81	6.14	1.74	3.12	3.5	2.0	5.0		
	4†	0.06	2.76	8.51	3.00	3.48		12.0	12.0	1	
Other	1*	0.05	3.80	12.22	4.42	0.78					
	1†	0.04	4.10	13.59	4.97	0.87					
<b>Incipient</b>	11*	0.03	6.18	22.39	8.27	8.59	4.1	2.0	6.6		
	11†	0.08	6.66	21.40	7.75	9.57					
Erratic output	10*	0.04	5.71	19.99	7.38	7.81	4.4	2.0	7.0		
	10†	0.12	6.20	19.27	6.83	8.70					
High output	1*	0.01	0.71	2.21	0.78	0.78	1.5	3.0	3.0		
	1†	0.01	0.78	2.44	0.87	0.87					
<b>Unknown</b>	1*	0.05	3.80	12.22	4.42	0.78		28.0	28.0		
	1†	0.04	4.10	13.59	4.97	0.87					
Erratic output	1*	0.05	3.80	12.22	4.42	0.78		28.0	28.0		
	1†	0.04	4.10	13.59	4.97	0.87					
<b>All modes</b>	25*	5.91	28.97	66.42	19.42	19.52	19.52	3.8	1.0	9.3	
	25†	6.74	30.77	69.15	19.97	21.76					
Comments											

Taxonomy no 4.2.2.4		Item Control and Safety Equipment Process sensors Level Magnetic								
Population 7	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.3449		Operational time † 0.2454						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	1*	0.14	2.90	13.76	2.90	2.90	2.0	2.0	2.0	2.0
	1†	0.20	4.07	19.33	4.07	4.07				
Spurious operation	1*	0.14	2.90	13.76	2.90	2.90	2.0	2.0	2.0	2.0
	1†	0.20	4.07	19.33	4.07	4.07				
<b>Degraded</b>	1*	0.14	2.90	13.76	2.90	2.90	2.0	2.0	2.0	2.0
	1†	0.20	4.07	19.33	4.07	4.07				
Other	1*	0.14	2.90	13.76	2.90	2.90	2.0	2.0	2.0	2.0
	1†	0.20	4.07	19.33	4.07	4.07				
<b>Incipient</b>	1*	0.14	2.90	13.76	2.90	2.90	3.0	3.0	3.0	3.0
	1†	0.20	4.07	19.33	4.07	4.07				
Minor in-service problems	1*	0.14	2.90	13.76	2.90	2.90	3.0	3.0	3.0	3.0
	1†	0.20	4.07	19.33	4.07	4.07				
<b>All modes</b>	3*	2.38	8.70	22.48	8.70	8.70	2.3	2.0	2.3	3.0
	3†	3.34	12.22	31.60	12.22	12.22				
<b>Comments</b>										

Taxonomy no 4.2.2.5		Item Control and Safety Equipment Process sensors Level Other								
Population 4	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0556		Operational time † 0.0554						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max
Degraded	1*	0.90	17.99	85.37	17.99	17.99	5.0	5.0	5.0	5.0
	1†	0.90	18.04	85.62	18.04	18.04				
Erratic output	1*	0.90	17.99	85.37	17.99	17.99	5.0	5.0	5.0	5.0
	1†	0.90	18.04	85.62	18.04	18.04				
All modes	1*	0.90	17.99	85.37	17.99	17.99	5.0	5.0	5.0	5.0
	1†	0.90	18.04	85.62	18.04	18.04				
Comments										

<b>Taxonomy no</b> 4.2.2.6		<b>Item</b> Control and Safety Equipment Process sensors Level Sonic									
<b>Population</b> 26	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>				
		<b>Calendar time *</b> 0.3084			<b>Operational time †</b> 0.3074						
<b>Failure mode</b>		<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours)</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
			<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/c</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
Critical		3*	2.66	9.73	25.15	9.73	9.73	7.3	2.0	7.3	10.0
		3†	2.67	9.76	25.22	9.76	9.76				
Erratic output		3*	2.66	9.73	25.15	9.73	9.73	7.3	2.0	7.3	10.0
		3†	2.67	9.76	25.22	9.76	9.76				
All modes		3*	2.66	9.73	25.15	9.73	9.73	7.3	2.0	7.3	10.0
		3†	2.67	9.76	25.22	9.76	9.76				
<b>Comments</b>											

Taxonomy no 4.2.2.7		Item Control and Safety Equipment Process sensors Level Unknown								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
		0.0351		0.0350						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
All modes	0 <sup>*</sup> 0 <sup>†</sup>	0.03 0.04	8.91 9.04	34.23 34.73	12.61 12.79	0.00 0.00	-	-	-	-
Comments										



Taxonomy no 4.2.3		Item Control and Safety Equipment Process sensors Pressure								
Population 55	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 1.9401		Operational time † 1.4675						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	4*	0.02	5.30	20.47	7.55	2.06	-	2.0	5.3	12.0
	4†	0.02	5.55	21.35	7.87	2.73				
Other	4*	0.02	5.30	20.47	7.55	2.06	-	2.0	5.3	12.0
	4†	0.02	5.55	21.35	7.87	2.73				
All modes	4*	0.02	5.30	20.47	7.55	2.06	-	2.0	5.3	12.0
	4†	0.02	5.55	21.35	7.87	2.73				
Comments										

**Maintainable item versus failure mode**

**Item:** Process sensors - Pressure

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Other	0.00	0.00	0.00	0.00	75.00	0.00	0.00	75.00
Unknown	0.00	0.00	0.00	0.00	25.00	0.00	0.00	25.00
Total	0.00	0.00	0.00	0.00	100.0	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode**

**Item:** Process sensors - Pressure

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Leakage	0.00	0.00	0.00	0.00	100.0	0.00	0.00	100.0
Total	0.00	0.00	0.00	0.00	100.0	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.2.3.1		Item Control and Safety Equipment Process sensors Pressure Capacitance									
Population 7	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.3449			Operational time † 0.2454						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
All modes		0 <sup>*</sup> 0 <sup>†</sup>	0.00 0.01	1.14 1.49	4.37 5.72	1.61 2.11	0.00 0.00	-	-	-	-
Comments											

Taxonomy no 4.2.3.2		Item Control and Safety Equipment Process sensors Pressure Electro-mechanical								
Population 45	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 1.4836		Operational time † 1.1394						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	4*	0.02	5.48	21.05	7.76	2.70	-	2.0	5.3	12.0
	4†	0.02	5.75	21.82	8.04	3.51				
Other	4*	0.02	5.48	21.05	7.76	2.70		2.0	5.3	12.0
	4†	0.02	5.75	21.82	8.04	3.51				
All modes	4*	0.02	5.48	21.05	7.76	2.70	-	2.0	5.3	12.0
	4†	0.02	5.75	21.82	8.04	3.51				
Comments										

Taxonomy no 4.2.3.3		Item Control and Safety Equipment Process sensors Pressure Piezo-electric									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0493		Operational time † 0.0351							
Failure mode		No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
			Lower	Mean	Upper	SD	n/t		Min	Mean	Max
All modes		0* 0†	0.01 0.02	3.48 4.00	13.38 15.35	4.93 5.65	0.00 0.00	-	-	-	-
Comments											

<b>Taxonomy no</b> 4.2.3.4		<b>Item</b> Control and Safety Equipment Process sensors Pressure Semiconductor strain									
<b>Population</b> 1	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>				
		<b>Calendar time *</b> 0.0493			<b>Operational time †</b> 0.0351						
<b>Failure mode</b>		<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours)</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
			<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/t</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>		0* 0†	0.01 0.02	3.48 4.00	13.38 15.35	4.93 5.65	0.00 0.00	-	-	-	
<b>Comments</b>											

<b>Taxonomy no</b> 4.2.3.5		<b>Item</b> Control and Safety Equipment Process sensors Pressure Unknown								
<b>Population</b> 1	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>			
		<b>Calendar time *</b> 0.0131		<b>Operational time †</b> 0.0125						
<b>Failure mode</b>	<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours).</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
		<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/τ</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>	0* 0†	0.02 0.02	4.66 4.88	17.88 18.73	6.58 6.90	0.00 0.00	-	-	-	-
<b>Comments</b>										

Taxonomy no 4.2.4		Item Control and Safety Equipment Process sensors Temperature								
Population 43	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 1.6932		Operational time † 1.5070						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	6*	0.02	4.57	17.01	6.28	3.54	3.5	2.0	3.5	8.0
	6†	0.03	6.39	24.32	8.96	3.98				
Fail to function on demand	3*	0.01	2.23	8.00	2.96	1.77	4.3	2.5	4.3	8.0
	3†	0.01	3.10	11.67	4.30	1.99				
Spurious operation	3*	0.01	2.23	8.00	2.96	1.77	2.7	2.0	2.7	3.0
	3†	0.01	3.10	11.67	4.30	1.99				
<b>All modes</b>	6*	0.02	4.57	17.01	6.28	3.54	3.5	2.0	3.5	8.0
	6†	0.03	6.39	24.32	8.96	3.98				
<b>Comments</b>										



**Maintainable item versus failure mode**

**Item:** Process sensors - Temperature

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Electronics	0.00	16.67	0.00	0.00	0.00	0.00	33.33	50.00
Other	0.00	16.67	0.00	0.00	0.00	0.00	0.00	16.67
Sensing element	0.00	16.67	0.00	0.00	0.00	0.00	16.67	33.33
Total	0.00	50.00	0.00	0.00	0.00	0.00	50.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode**

**Item:** Process sensors - Temperature

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Faulty signal/indication/alarm	0.00	16.67	0.00	0.00	0.00	0.00	16.67	33.33
Instrument failure - general	0.00	16.67	0.00	0.00	0.00	0.00	16.67	33.33
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	16.67	16.67
No signal/indication/alarm	0.00	16.67	0.00	0.00	0.00	0.00	0.00	16.67
Total	0.00	50.00	0.00	0.00	0.00	0.00	50.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.2.4.1		Item Control and Safety Equipment Process sensors Temperature Capillary								
Population 8	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.2949		Operational time † 0.2803						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.00 0.01	1.24 1.39	4.75 5.35	1.75 1.97	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 4.2.4.2		Item Control and Safety Equipment Process sensors Temperature Resistance									
Population 19	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.6950		Operational time † 0.6658							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Critical	3*	0.05	14.62	56.60	20.93	4.32	4.7	3.0	4.7	8.0	
	3†	0.07	20.73	80.21	29.65	4.51					
Fail to function on demand	1*	0.01	4.47	17.61	6.56	1.44	8.0	8.0	8.0	8.0	
	1†	0.02	6.47	25.45	9.47	1.50					
Spurious operation	2*	0.03	9.55	37.11	13.75	2.88	3.0	3.0	3.0	3.0	
	2†	0.04	13.60	52.83	19.56	3.00					
All modes	3*	0.05	14.62	56.60	20.93	4.32	4.7	3.0	4.7	8.0	
	3†	0.07	20.73	80.21	29.65	4.51					
Comments											

Taxonomy no 4.2.4.3		Item Control and Safety Equipment Process sensors Temperature Thermocouple									
Population 10	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *		Operational time †							
		0.4927		0.3506							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Critical	3*	1.66	6.09	15.74	6.09	6.09	2.3	2.0	2.3	2.5	
	3†	2.34	8.56	22.12	8.56	8.56					
Fail to function on demand	2*	0.72	4.06	12.78	4.06	4.06	2.5	2.5	2.5	2.5	
	2†	1.01	5.70	17.95	5.70	5.70					
Spurious operation	1*	0.10	2.03	9.63	2.03	2.03	2.0	2.0	2.0	2.0	
	1†	0.14	2.85	13.53	2.85	2.85					
All modes	3*	1.66	6.09	15.74	6.09	6.09	2.3	2.0	2.3	2.5	
	3†	2.34	8.56	22.12	8.56	8.56					
Comments											

Taxonomy no 4.2.4.4		Item Control and Safety Equipment Process sensors Temperature Unknown									
Population 6	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.2105			Operational time † 0.2102						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n / r		Min	Mean	Max	
All modes		0* 0†	0.01 0.01	1.56 1.73	6.00 6.66	2.21 2.45	0.00 0.00	-	-	-	-
Comments											

### Valves

#### Inventory description

The boundary definition is shown in Figure 22 and subdivision in. Maintainable Items are shown in Table 17.

The valve consists of the valve with housing, and the actuator. A valve includes the complete assembly of connector (i.e. inlet, outlet, and seals) connected to the piping. The pilot (solenoid) valve for hydraulically/ pneumatically operated valves is included as a separate Maintainable Item within the subunit "Actuator". Hydraulic accumulators are not included within the boundary.

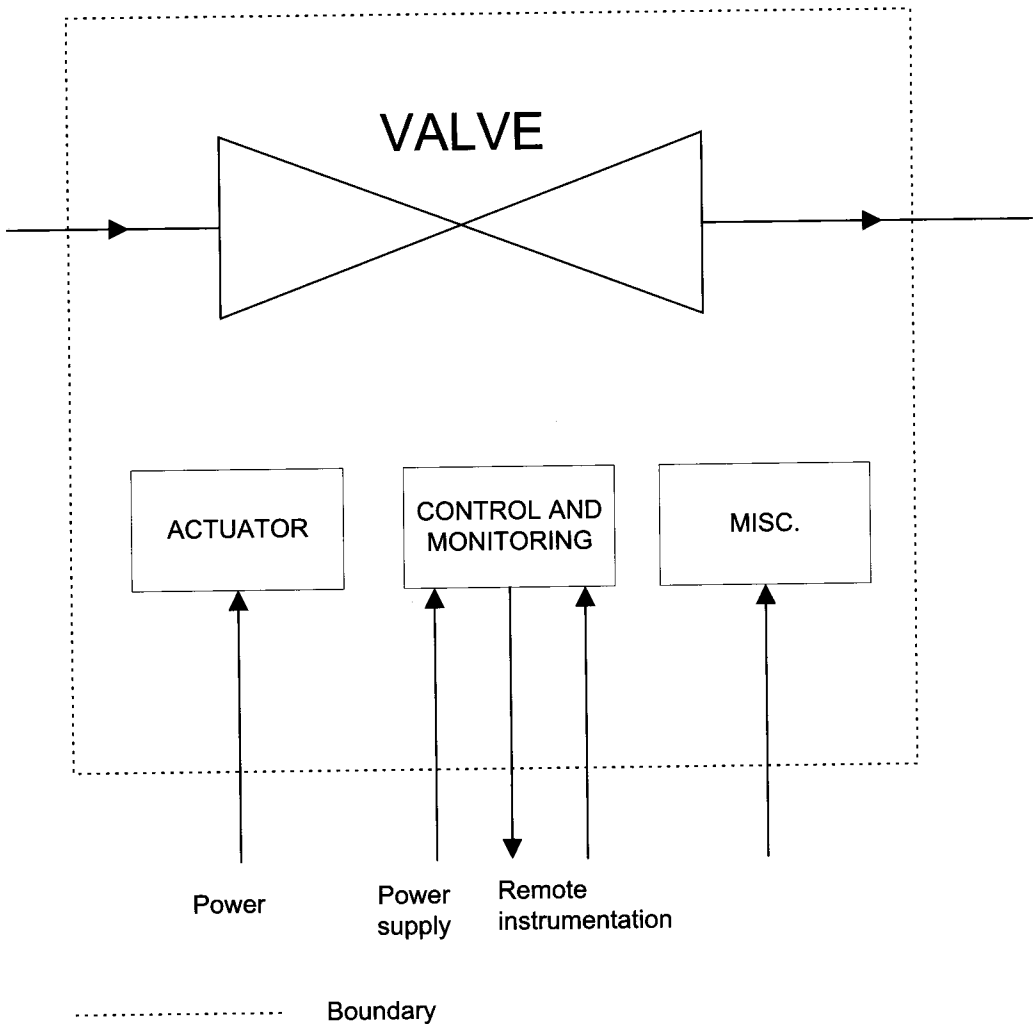


Figure 22 Valves, Boundary Definition

**Table 17 Valves, Subdivision in Maintainable Items**

VALVES			
Valve	Actuator	Control and Monitoring	Miscellaneous
<ul style="list-style-type: none"> <li>• Bonnet</li> <li>• Closure member<sup>7</sup></li> <li>• Flange</li> <li>• Other valve components</li> <li>• Packing</li> <li>• Seals</li> <li>• Seat rings</li> <li>• Valve body w/internals</li> </ul>	<ul style="list-style-type: none"> <li>• Case</li> <li>• Diaphragm</li> <li>• Electric motor</li> <li>• Gear</li> <li>• Indicator</li> <li>• Instrument, position</li> <li>• Other actuator components</li> <li>• Pilot valve</li> <li>• Piston</li> <li>• Positioner</li> <li>• Seals (gaskets)</li> <li>• Spring</li> <li>• Stem</li> </ul>	<ul style="list-style-type: none"> <li>• Actuating device</li> <li>• Cabling &amp; junction boxes</li> <li>• Control unit</li> <li>• Instrument</li> <li>• Monitoring</li> <li>• Internal power supply</li> <li>• Valves</li> </ul>	<ul style="list-style-type: none"> <li>• Other</li> </ul>

(For all subunits the MIs "Unknown" and "Subunit" are included.)

**List of failure modes**

- AIR Abnormal instrument reading
- DOP Delayed operation
- ELP External leakage - Process medium
- ELU External leakage - Utility medium
- FTC Fail to close on demand
- FTO Fail to open on demand
- FTR Fail to regulate
- HIO High output
- INL Internal leakage
- LOO Low output
- SER Minor in-service problems
- OTH Other
- PLU Plugged/Choked
- SPO Spurious operation
- STD Structural deficiency
- UNK Unknown
- LCP Valve leakage in closed position

<sup>7</sup> That part of the valve that is positioned in the flow stream to permit, obstruct or regulate flow (API Spec. 6D)

Taxonomy no 4.3		Item Control and Safety Equipment Valves								
Population 1170	Installations 40	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 36.6612		Operational time † 31.6175						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	358*	0.01	6.79	28.28	10.78	9.77	9.1	0.5	12.0	113.0
	358†	3.00	25.97	67.80	21.31	11.32				
Delayed operation	3*	0.00	0.11	0.55	0.24	0.08	32.0	28.0	64.0	113.0
	3†	0.00	0.15	0.71	0.29	0.09				
External leakage - Process medium	11*	0.00	0.24	0.82	0.30	0.30	11.0	1.0	13.5	54.0
	11†	0.00	0.29	1.16	0.44	0.35				
External leakage - Utility medium	2*	0.00	0.06	0.19	0.07	0.05	9.8	17.0	19.5	22.0
	2†	0.00	0.08	0.25	0.09	0.06				
Fail to close on demand	134*	0.00	2.31	13.11	7.48	3.66	8.2	1.0	11.3	78.0
	134†	0.00	5.09	22.77	9.01	4.24				
Fail to open on demand	84*	0.02	2.81	9.37	3.43	2.29	7.6	1.0	10.4	78.0
	84†	7.06	29.13	63.54	17.98	2.66				
Fail to regulate	72*	0.00	0.55	1.09	3.05	1.96	11.5	0.5	13.3	93.0
	72†	0.00	0.90	4.75	3.23	2.28				
High output	1*	0.00	0.03	0.08	0.03	0.03	6.0	6.0	6.0	6.0
	1†	0.00	0.03	0.09	0.03	0.03				
Internal leakage	3*	0.01	0.07	0.20	0.07	0.08	26.3	6.0	34.0	48.0
	3†	0.01	0.08	0.22	0.07	0.09				
Low output	1*	0.00	0.03	0.09	0.04	0.03	2.0	3.0	3.0	3.0
	1†	0.00	0.03	0.10	0.04	0.03				
Other	4*	0.00	0.13	0.45	0.17	0.11	8.3	1.0	16.7	37.0
	4†	0.00	0.16	0.54	0.20	0.13				
Spurious operation	23*	0.00	0.61	2.98	1.25	0.63	3.2	1.0	4.9	24.0
	23†	0.00	1.17	5.39	2.17	0.73				
Structural deficiency	7*	0.00	0.20	0.88	0.35	0.19	5.2	2.0	6.0	16.0
	7†	0.00	0.25	0.85	0.31	0.22				
Unknown	2*	0.00	0.05	0.14	0.04	0.05	62.0	36.0	65.0	94.0
	2†	0.01	0.06	0.15	0.05	0.06				
Valve leakage in closed position	11*	0.03	0.25	0.66	0.21	0.30	8.6	6.0	10.2	35.0
	11†	0.05	0.30	0.74	0.22	0.35				
<b>Degraded</b>	<b>302*</b>	<b>1.08</b>	<b>8.47</b>	<b>21.73</b>	<b>6.77</b>	<b>8.24</b>	<b>8.0</b>	<b>0.5</b>	<b>9.8</b>	<b>92.0</b>
	<b>302†</b>	<b>3.87</b>	<b>19.74</b>	<b>45.72</b>	<b>13.45</b>	<b>9.55</b>				
Abnormal instrument reading	6*	0.00	0.24	0.99	0.38	0.16	3.8	2.0	4.5	6.0
	6†	0.00	0.31	1.00	0.36	0.19				
Delayed operation	27*	0.01	1.00	3.34	1.23	0.74	5.8	1.0	10.5	36.0
	27†	0.13	1.59	4.47	1.46	0.85				
External leakage - Process medium	33*	0.02	2.13	7.17	2.63	0.90	8.7	1.0	10.8	45.0
	33†	5.52	20.42	43.00	11.87	1.04				
External leakage - Utility medium	38*	0.00	1.16	4.54	1.69	1.04	9.1	1.0	13.4	92.0
	38†	0.08	1.76	5.29	1.78	1.20				
Fail to open on demand	2*	0.00	0.06	0.18	0.07	0.05	3.3	0.5	3.3	6.0
	2†	0.00	0.07	0.22	0.08	0.06				
<b>Comments</b>										

(cont.)



Taxonomy no 4.3		Item Control and Safety Equipment Valves								
Population 1170	Installations 40	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
		36.6612		31.6175						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
High output	4*	0.00	0.10	0.32	0.11	0.11	4.1	2.0	4.4	9.0
	4†	0.00	0.13	0.41	0.15	0.13				
Internal leakage	18*	0.00	0.67	3.33	1.42	0.49	15.3	4.0	20.6	48.0
	18†	0.00	1.02	4.03	1.50	0.57				
Low output	14*	0.00	0.26	1.48	0.77	0.38	5.3	1.0	5.3	13.0
	14†	0.00	0.43	2.30	1.06	0.44				
Minor in-service problems	4*	0.00	0.10	0.38	0.14	0.11	4.0	4.0	4.0	4.0
	4†	0.00	0.12	0.38	0.14	0.13				
Other	44*	0.00	1.47	6.79	2.74	1.20	6.0	2.0	7.6	61.0
	44†	0.02	2.41	8.13	2.98	1.39				
Plugged/Choked	4*	0.00	0.15	0.77	0.35	0.11	2.0	2.0	2.0	2.0
	4†	0.00	0.21	0.93	0.36	0.13				
Spurious operation	74*	0.00	0.68	0.96	4.34	2.02	7.2	4.0	7.4	35.0
	74†	0.00	1.22	6.29	4.78	2.34				
Structural deficiency	3*	0.00	0.35	1.89	0.88	0.08	6.0	6.0	6.0	6.0
	3†	0.00	0.59	2.53	0.98	0.09				
Unknown	2*	0.00	0.05	0.14	0.04	0.05	6.0	2.0	6.0	10.0
	2†	0.01	0.06	0.15	0.05	0.06				
Valve leakage in closed position	29*	0.00	0.47	1.99	0.77	0.79	12.6	2.0	13.0	70.0
	29†	0.01	0.66	2.05	0.73	0.92				
<b>Incipient</b>	339*	<b>3.53</b>	<b>14.93</b>	<b>32.80</b>	<b>9.32</b>	<b>9.25</b>	<b>4.9</b>	<b>1.0</b>	<b>6.3</b>	<b>80.0</b>
	339†	<b>86.84</b>	<b>143.70</b>	<b>212.14</b>	<b>38.42</b>	<b>10.72</b>				
Abnormal instrument reading	111*	1.85	9.73	22.72	6.71	3.03	4.1	1.0	5.6	80.0
	111†	105.90	160.11	223.45	35.95	3.51				
Delayed operation	4*	0.00	0.34	1.50	0.59	0.11	2.5	1.0	4.3	8.0
	4†	0.43	3.58	9.25	2.89	0.13				
External leakage - Process medium	4*	0.00	0.18	0.74	0.28	0.11	4.0	1.0	3.7	7.0
	4†	0.00	0.22	0.76	0.28	0.13				
External leakage - Utility medium	30*	0.00	0.88	4.43	1.90	0.82	3.5	1.0	6.5	20.0
	30†	0.36	7.39	22.13	7.41	0.95				
Fail to regulate	1*	0.00	0.03	0.09	0.04	0.03	3.0	3.0	3.0	3.0
	1†	0.00	0.03	0.10	0.04	0.03				
Internal leakage	3*	0.00	0.12	0.47	0.17	0.08	18.0	4.0	15.3	30.0
	3†	0.00	0.13	0.39	0.14	0.09				
Low output	2*	0.00	0.06	0.27	0.11	0.05	3.5	1.0	6.5	12.0
	2†	0.00	0.08	0.34	0.13	0.06				
Minor in-service problems	42*	0.00	2.02	8.34	3.17	1.15	3.0	1.0	3.7	10.0
	42†	0.13	3.34	10.05	3.41	1.33				
Other	28*	0.00	0.60	3.11	2.72	0.76	4.7	1.0	9.6	28.0
	28†	0.00	1.12	6.24	3.22	0.89				
Spurious operation	7*	0.00	0.32	1.45	0.58	0.19	4.8	1.0	8.7	16.0
	7†	0.00	0.61	2.33	0.86	0.22				

Comments

(cont.)

Taxonomy no 4.3		Item Control and Safety Equipment Valves								
Population 1170	Installations 40	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
		36.6612		31.6175						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Structural deficiency	3*	0.00	0.35	1.90	0.88	0.08	9.0	13.0	15.5	18.0
	3†	0.00	0.58	2.47	0.96	0.09				
Unknown	1*	0.00	0.03	0.09	0.04	0.03	3.0	3.0	3.0	3.0
	1†	0.00	0.03	0.10	0.04	0.03				
Valve leakage in closed position	103*	0.00	0.74	0.81	6.85	2.81	6.5	2.0	6.5	14.0
	103†	0.00	1.26	2.07	7.57	3.26				
Unknown	18*	<b>0.00</b>	<b>0.35</b>	<b>1.80</b>	<b>1.47</b>	<b>0.49</b>	15.6	1.0	23.2	119.0
	18†	<b>0.00</b>	<b>0.54</b>	<b>3.02</b>	<b>1.56</b>	<b>0.57</b>				
Unknown	18*	0.00	0.35	1.80	1.47	0.49	15.6	1.0	23.2	119.0
	18†	0.00	0.54	3.02	1.56	0.57				
<b>All modes</b>	1017*	<b>7.74</b>	<b>31.05</b>	<b>67.14</b>	<b>18.89</b>	<b>27.74</b>	7.5	0.5	9.7	119.0
	1017†	<b>110.16</b>	<b>190.63</b>	<b>289.04</b>	<b>54.91</b>	<b>32.17</b>				
<b>Comments</b>										

**Maintainable item versus failure mode, to be continued**

**Item:** Valves described by taxonomy code

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	0.79	0.10	0.00	0.00	0.20	0.20	0.10	0.00	0.00
Bonnet	0.00	0.00	0.00	0.10	0.00	0.49	0.00	0.00	0.00
Cabling & junction boxes	0.39	0.10	0.00	0.00	0.00	0.39	0.00	0.00	0.00
Case	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
Closure member (Ball/gate/disc/etc.)	0.00	0.10	0.00	0.00	0.20	0.10	0.00	0.00	0.00
Control unit	1.38	0.10	0.00	0.10	0.20	0.10	0.69	0.00	0.00
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.00	0.00
Electric motor (electric actuator)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Flange	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
Gear	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
Indicator	0.10	0.00	0.00	0.00	0.15	0.00	0.20	0.00	0.00
Instrument, general	0.88	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00
Instrument, position	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.20	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
Monitoring	4.52	0.20	0.00	0.00	0.10	0.00	0.10	0.00	0.00
Other	0.10	0.00	0.20	0.10	0.00	0.00	0.00	0.00	0.10
Other actuator components	0.00	0.29	0.00	1.08	0.39	0.10	0.10	0.00	0.00
Other valve components	0.00	0.00	0.59	0.20	0.20	0.44	0.20	0.00	0.20
Packing	0.00	0.00	0.44	0.29	0.21	0.00	0.00	0.00	0.10
Pilot valve	0.10	0.00	0.00	0.49	2.16	0.49	0.00	0.00	0.20
Piston(s)	0.00	0.00	0.00	0.20	0.29	0.29	0.33	0.00	0.00
Positioner	0.39	0.00	0.00	0.10	0.15	0.10	0.88	0.10	0.00
Seals	0.00	0.00	0.84	0.00	0.41	0.00	0.10	0.05	0.29
Seals (gaskets)	0.00	0.00	0.29	2.26	0.00	0.00	0.00	0.00	0.39
Seat rings	0.00	0.00	0.98	0.00	0.56	0.34	0.00	0.05	0.39
Spring	0.00	0.00	0.00	0.00	0.10	0.10	0.03	0.00	0.00
Stem	0.00	0.39	0.20	0.20	0.20	0.20	0.23	0.00	0.00
Subunit	0.10	0.59	0.20	0.49	2.26	1.47	2.36	0.10	0.49
Unknown	0.88	0.79	0.20	0.69	4.82	3.34	1.18	0.00	0.10
Valve body w/internals	0.00	0.69	0.59	0.10	0.59	0.10	0.39	0.20	0.10
Valves	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Total	11.50	3.34	4.72	6.88	13.18	8.46	7.18	0.49	2.36

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

Item: Valves described by taxonomy code

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.20	0.69	0.00	0.10	1.08	0.00	0.00	3.44
Bonnet	0.00	0.00	0.00	0.00	0.10	0.00	0.15	0.00	0.84
Cabling & junction boxes	0.00	0.00	0.59	0.00	0.20	0.00	0.10	0.00	1.77
Case	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0.00	0.59
Control unit	0.00	0.00	0.00	0.00	0.29	0.29	0.00	0.10	3.24
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Electric motor (electric actuator)	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.10
Flange	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Gear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Indicator	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.54
Instrument, general	0.00	0.10	0.20	0.00	0.20	0.20	0.00	0.00	1.97
Instrument, position	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.39
Monitoring	0.00	0.00	0.20	0.00	0.10	0.00	0.00	0.00	5.21
Other	0.10	0.00	1.08	0.00	0.10	0.00	0.00	0.00	1.77
Other actuator components	0.00	0.00	0.39	0.00	0.29	0.10	0.00	0.00	2.75
Other valve components	0.10	0.00	0.20	0.00	0.20	0.20	0.00	0.00	2.51
Packing	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34
Pilot valve	0.00	0.00	0.00	0.00	0.79	0.10	0.20	0.29	4.82
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	1.16
Positioner	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	1.92
Seals	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.79
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	3.00
Seat rings	1.08	0.00	0.10	0.00	0.10	0.10	0.00	0.00	3.70
Spring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Stem	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	1.70
Subunit	1.77	0.00	3.05	0.00	0.39	0.39	0.10	0.79	14.55
Unknown	10.52	0.59	0.49	0.29	1.28	6.69	0.39	0.98	33.24
Valve body w/internals	0.10	0.79	0.00	0.00	0.00	0.88	0.25	0.00	4.77
Valves	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.39
Total	14.06	1.67	7.47	0.39	4.52	10.23	1.28	2.26	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Valves described by taxonomy code

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.29	0.00	0.00	0.00	1.87	1.57	0.49	0.20	0.10
Breakage	0.20	0.00	0.29	0.20	0.20	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.29	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.10
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Control failure	0.20	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Corrosion	0.39	0.20	0.10	0.20	0.20	0.20	0.39	0.00	0.00
Deformation	0.00	0.00	0.29	0.10	0.10	0.20	0.20	0.10	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Electrical failure - general	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Erosion	0.00	0.00	0.10	0.00	0.10	0.00	0.20	0.00	0.10
External influence - general	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	1.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	2.95	0.59	0.00	0.20	3.05	1.28	0.10	0.10	0.00
Leakage	0.00	0.20	2.06	4.23	0.39	0.10	0.10	0.00	0.49
Looseness	0.00	0.10	0.20	0.20	0.10	0.00	0.10	0.00	0.20
Material failure - general	0.10	0.00	0.29	0.49	0.39	1.57	0.00	0.00	0.20
Mechanical Failure - general	0.20	1.08	0.00	0.49	2.46	1.38	1.08	0.00	0.29
Misc. external influences	0.20	0.10	0.00	0.10	0.20	0.20	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.29	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
Open circuit	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	4.52	0.29	0.00	0.20	0.98	0.29	3.05	0.00	0.10
Short circuiting	0.10	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.49	0.00	0.00	0.29	0.29	0.00	0.00	0.00
Unknown	0.00	0.29	0.29	0.10	0.69	0.49	0.20	0.10	0.10
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.00
Wear	0.00	0.00	1.08	0.29	1.67	0.29	0.79	0.00	0.59
Total	11.50	3.34	4.72	6.88	13.18	8.46	7.18	0.49	2.36

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

Item: Valves described by taxonomy code

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	1.18	0.10	0.29	0.10	0.10	0.00	0.00	6.29
Breakage	0.00	0.00	0.10	0.00	0.00	0.20	0.00	0.00	1.18
Cavitation	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.20
Clearance/ alignment failure	0.20	0.00	0.00	0.00	0.00	0.10	0.00	0.10	1.38
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29
Corrosion	0.10	0.00	1.28	0.00	0.69	0.10	0.29	0.10	4.23
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Electrical failure - general	0.00	0.00	0.10	0.00	0.10	0.00	0.00	0.00	0.29
Erosion	0.20	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.79
External influence - general	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.39
Faulty signal/indication/alarm	0.00	0.10	0.29	0.00	0.10	0.59	0.00	0.00	2.56
Instrument failure - general	0.10	0.00	0.39	0.00	0.69	0.88	0.20	0.59	11.11
Leakage	2.56	0.10	0.00	0.00	0.10	0.29	0.00	0.00	10.62
Looseness	0.20	0.00	0.20	0.00	0.69	0.10	0.00	0.00	2.06
Material failure - general	10.32	0.00	0.20	0.00	0.00	6.39	0.10	0.00	20.06
Mechanical Failure - general	0.20	0.10	0.29	0.00	0.39	0.49	0.29	0.39	9.14
Misc. external influences	0.00	0.00	0.29	0.00	0.49	0.00	0.10	0.00	1.67
Miscellaneous - general	0.00	0.00	0.10	0.00	0.10	0.29	0.00	0.00	0.59
No cause found	0.00	0.00	0.10	0.00	0.00	0.10	0.00	0.00	0.20
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39
Open circuit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Other	0.00	0.00	0.00	0.00	0.10	0.00	0.10	0.00	0.20
Out of adjustment	0.00	0.20	3.05	0.00	0.20	0.20	0.00	0.10	13.18
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.29
Software failure	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.20
Sticking	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	1.38
Unknown	0.10	0.00	0.29	0.10	0.29	0.29	0.00	0.98	4.33
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.49
Wear	0.10	0.00	0.20	0.00	0.00	0.00	0.10	0.00	5.11
Total	14.06	1.67	7.47	0.39	4.52	10.23	1.28	2.26	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.3.1		Item Control and Safety Equipment Valves Ball									
Population 316	Installations 18	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 9.7170		Operational time † 9.3247							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
<b>Critical</b>	123*	0.00	10.06	43.64	16.95	12.66	6.3	1.0	10.7	113.0	
	123†	0.00	10.47	45.13	17.49	13.19					
Delayed operation	3*	0.00	0.28	1.13	0.43	0.31	32.0	28.0	64.0	113.0	
	3†	0.00	0.30	1.30	0.50	0.32					
External leakage - Utility medium	2*	0.00	0.19	0.76	0.28	0.21	9.8	17.0	19.5	22.0	
	2†	0.00	0.21	0.88	0.34	0.21					
Fail to close on demand	61*	0.00	5.73	30.99	14.39	6.28	6.3	1.0	9.9	60.0	
	61†	0.00	5.85	31.72	14.76	6.54					
Fail to open on demand	35*	0.59	3.31	7.86	2.34	3.60	5.7	1.0	9.9	78.0	
	35†	0.73	3.46	7.85	2.28	3.75					
Other	3*	0.00	0.28	1.13	0.43	0.31	8.3	1.0	16.7	37.0	
	3†	0.00	0.30	1.30	0.50	0.32					
Spurious operation	17*	0.01	1.32	4.39	1.61	1.75	2.2	1.0	4.2	24.0	
	17†	0.00	1.36	5.41	2.02	1.82					
Structural deficiency	2*	0.00	0.22	0.84	0.31	0.21	2.0	2.0	2.0	2.0	
	2†	0.00	0.23	0.85	0.31	0.21					
<b>Degraded</b>	85*	2.70	16.37	39.61	11.96	8.75	9.3	1.0	14.2	92.0	
	85†	2.79	17.00	41.22	12.47	9.12					
Abnormal instrument reading	3*	0.00	0.50	2.05	0.78	0.31	3.5	2.0	4.3	6.0	
	3†	0.00	0.51	2.07	0.78	0.32					
Delayed operation	18*	0.32	2.06	5.05	1.54	1.85	5.9	1.0	10.9	36.0	
	18†	0.36	2.13	5.13	1.54	1.93					
External leakage - Process medium	10*	0.00	2.48	10.33	3.93	1.03	10.8	1.0	13.6	36.0	
	10†	0.00	2.62	10.90	4.16	1.07					
External leakage - Utility medium	26*	0.18	2.82	8.24	2.73	2.68	8.4	1.0	14.7	92.0	
	26†	0.21	2.94	8.44	2.78	2.79					
Fail to open on demand	1*	0.00	0.10	0.40	0.15	0.10	6.0	6.0	6.0	6.0	
	1†	0.00	0.11	0.41	0.15	0.11					
Internal leakage	10*	0.01	1.96	7.59	2.81	1.03	12.8	4.0	24.6	48.0	
	10†	0.01	1.98	7.69	2.85	1.07					
Other	11*	0.01	3.48	13.69	5.10	1.13	13.5	2.0	12.2	61.0	
	11†	0.01	3.66	14.44	5.38	1.18					
Plugged/Choked	1*	0.00	0.37	1.87	0.81	0.10	-	-	-	-	
	1†	0.00	0.37	1.90	0.82	0.11					
Spurious operation	1*	0.00	0.12	0.58	0.25	0.10	14.0	14.0	14.0	14.0	
	1†	0.00	0.12	0.60	0.25	0.11					
Structural deficiency	2*	0.00	0.94	4.55	1.88	0.21	-	6.0	6.0	6.0	
	2†	0.00	1.00	4.82	1.99	0.21					
Unknown	1*	0.00	0.12	0.58	0.25	0.10	2.0	2.0	2.0	2.0	
	1†	0.00	0.12	0.60	0.25	0.11					

Comments

(cont.)

Taxonomy no 4.3.1		Item Control and Safety Equipment Valves Ball								
Population 316	Installations 18	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 9.7170			Operational time † 9.3247		Active rep.hrs	Repair (manhours)		
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)	
		Lower	Mean	Upper	SD	n/τ	Min		Mean	Max
Valve leakage in closed position	1* 1†	0.00 0.00	0.12 0.12	0.58 0.60	0.25 0.25	0.10 0.11	58.0	70.0	70.0	70.0
Incipient	112* 112†	2.79 2.86	13.86 14.65	31.90 33.97	9.35 10.00	11.53 12.01	5.2	1.0	8.5	67.0
Abnormal instrument reading	29* 29†	0.27 0.30	4.61 4.91	13.60 14.36	4.52 4.76	2.98 3.11	6.9	1.0	10.1	67.0
External leakage - Process medium	3* 3†	0.00 0.00	0.39 0.41	1.66 1.75	0.64 0.68	0.31 0.32	4.0	1.0	4.0	7.0
External leakage - Utility medium	23* 23†	0.00 0.00	1.04 1.10	5.73 5.84	2.68 2.66	2.37 2.47	3.8	2.0	7.7	20.0
Internal leakage	2* 2†	0.00 0.00	0.22 0.23	1.18 1.24	0.54 0.57	0.21 0.21	18.0	12.0	21.0	30.0
Low output	1* 1†	0.00 0.00	0.10 0.11	0.39 0.44	0.14 0.17	0.10 0.11	6.0	12.0	12.0	12.0
Minor in-service problems	26* 26†	0.12 0.12	5.48 5.57	16.91 17.21	5.95 6.06	2.68 2.79	2.6	1.0	3.6	10.0
Other	24* 24†	0.00 0.00	1.65 1.83	9.13 10.21	4.64 5.31	2.47 2.57	4.9	1.0	9.6	28.0
Structural deficiency	3* 3†	0.00 0.00	0.85 0.87	4.08 4.17	1.68 1.72	0.31 0.32	9.0	13.0	15.5	18.0
Valve leakage in closed position	1* 1†	0.00 0.00	0.14 0.15	0.60 0.64	0.23 0.25	0.10 0.11	7.0	7.0	7.0	7.0
Unknown	8* 8†	0.00 0.00	0.84 0.86	4.84 4.96	2.62 2.68	0.82 0.86	2.0	1.0	2.7	8.0
Unknown	8* 8†	0.00 0.00	0.84 0.86	4.84 4.96	2.62 2.68	0.82 0.86	2.0	1.0	2.7	8.0
<b>All modes</b>	<b>328* 328†</b>	<b>8.45 8.80</b>	<b>42.01 43.70</b>	<b>96.67 100.54</b>	<b>28.34 29.47</b>	<b>33.76 35.18</b>	<b>6.4</b>	<b>1.0</b>	<b>10.7</b>	<b>113.0</b>
Comments										



**Maintainable item versus failure mode, to be continued**

Item: Valves described by taxonomy code - Ball

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	2.13	0.00	0.00	0.00	0.61	0.30	0.00	0.00	0.00
Bonnet	0.00	0.00	0.00	0.00	0.00	1.52	0.00	0.00	0.00
Cabling & junction boxes	0.00	0.30	0.00	0.00	0.00	0.91	0.00	0.00	0.00
Case	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00
Closure member (Ball/gate/disc/etc.)	0.00	0.30	0.00	0.00	0.30	0.30	0.00	0.00	0.00
Control unit	1.52	0.30	0.00	0.30	0.30	0.00	0.00	0.00	0.00
Electric motor (electric actuator)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Indicator	0.30	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00
Instrument, general	2.13	0.00	0.00	1.22	0.00	0.00	0.00	0.00	0.00
Instrument, position	1.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.61	0.30	0.00	0.00	0.00	0.00	0.30
Other actuator components	0.00	0.30	0.00	1.83	0.61	0.30	0.00	0.00	0.00
Other valve components	0.00	0.00	0.91	0.00	0.00	0.30	0.00	0.00	0.61
Packing	0.00	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00
Pilot valve	0.00	0.00	0.00	1.22	3.05	1.52	0.00	0.00	0.61
Piston(s)	0.00	0.00	0.00	0.30	0.30	0.00	0.00	0.00	0.00
Positioner	0.91	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00
Seals	0.00	0.00	0.91	0.00	0.00	0.00	0.00	0.00	0.00
Seals (gaskets)	0.00	0.00	0.30	6.71	0.00	0.00	0.00	0.00	1.22
Seat rings	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.61
Stem	0.00	1.22	0.30	0.61	0.61	0.61	0.00	0.00	0.00
Subunit	0.00	0.91	0.00	0.00	2.44	2.13	0.00	0.00	0.00
Unknown	0.91	1.83	0.30	1.52	9.45	2.44	0.00	0.00	0.30
Valve body w/internals	0.00	0.61	0.30	0.30	0.61	0.30	0.00	0.00	0.00
Valves	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00
Total	9.76	6.40	3.96	15.55	18.60	10.98	0.00	0.00	3.66

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

**Item:** Valves described by taxonomy code - Ball

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.30	1.52	0.00	0.30	3.35	0.00	0.00	8.54
Bonnet	0.00	0.00	0.00	0.00	0.30	0.00	0.46	0.00	2.29
Cabling & junction boxes	0.00	0.00	1.83	0.00	0.30	0.00	0.00	0.00	3.35
Case	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91
Control unit	0.00	0.00	0.00	0.00	0.30	0.30	0.00	0.00	3.05
Electric motor (electric actuator)	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.30
Indicator	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.91
Instrument, general	0.00	0.00	0.61	0.00	0.30	0.61	0.00	0.00	4.88
Instrument, position	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.83
Monitoring	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00	1.22
Other	0.30	0.00	3.05	0.00	0.30	0.00	0.00	0.00	4.88
Other actuator components	0.00	0.00	1.22	0.00	0.91	0.00	0.00	0.00	5.18
Other valve components	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	2.13
Packing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61
Pilot valve	0.00	0.00	0.00	0.00	0.91	0.30	0.00	0.61	8.23
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61
Positioner	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.22
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.23
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91
Stem	0.00	0.00	0.00	0.00	0.30	0.30	0.30	0.00	4.27
Subunit	0.30	0.00	0.91	0.00	1.22	0.00	0.00	0.30	8.23
Unknown	0.00	0.00	0.61	0.30	2.13	0.61	1.22	1.83	23.48
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	2.29
Valves	0.00	0.00	0.91	0.00	0.00	0.00	0.00	0.00	1.22
Total	0.61	0.30	11.59	0.30	7.93	5.49	2.13	2.74	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Valves described by taxonomy code - Ball

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.61	0.00	0.00	0.00	2.13	0.30	0.00	0.00	0.30
Breakage	0.00	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	1.52	0.00	0.00	0.00
Control failure	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00
Corrosion	0.91	0.61	0.30	0.00	0.61	0.61	0.00	0.00	0.00
Deformation	0.00	0.00	0.00	0.30	0.30	0.00	0.00	0.00	0.00
Electrical failure - general	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	2.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	3.66	1.83	0.00	0.61	6.10	3.35	0.00	0.00	0.00
Leakage	0.00	0.30	2.74	10.98	0.30	0.00	0.00	0.00	1.52
Looseness	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.30	0.00	0.91	1.22	0.30	0.00	0.00	0.00	0.61
Mechanical Failure - general	0.30	1.52	0.00	0.61	4.88	3.05	0.00	0.00	0.91
Misc. external influences	0.00	0.00	0.00	0.30	0.61	0.30	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	1.22	0.30	0.00	0.00	0.30	0.30	0.00	0.00	0.00
Short circuiting	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00
Sticking	0.00	1.22	0.00	0.00	0.91	0.61	0.00	0.00	0.00
Unknown	0.00	0.61	0.00	0.30	1.22	0.61	0.00	0.00	0.30
Wear	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00
Total	9.76	6.40	3.96	15.55	18.60	10.98	0.00	0.00	3.66

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

Item: Valves described by taxonomy code - Ball

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	3.66
Breakage	0.00	0.00	0.30	0.00	0.00	0.30	0.00	0.00	1.22
Cavitation	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.61
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.52
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
Corrosion	0.00	0.00	3.66	0.00	0.61	0.00	0.91	0.00	8.23
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61
Electrical failure - general	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.61
External influence - general	0.00	0.00	0.91	0.00	0.00	0.00	0.00	0.00	1.22
Faulty signal/indication/alarm	0.00	0.30	0.91	0.00	0.00	1.52	0.00	0.00	4.88
Instrument failure - general	0.00	0.00	1.22	0.00	0.61	2.74	0.00	1.52	21.65
Leakage	0.61	0.00	0.00	0.00	0.30	0.00	0.00	0.00	16.77
Looseness	0.00	0.00	0.30	0.00	2.13	0.30	0.00	0.00	3.05
Material failure - general	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	3.66
Mechanical Failure - general	0.00	0.00	0.61	0.00	0.91	0.00	0.61	0.30	13.72
Misc. external influences	0.00	0.00	0.91	0.00	0.91	0.00	0.00	0.00	3.05
Miscellaneous - general	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.30
No cause found	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.30
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
Other	0.00	0.00	0.00	0.00	0.30	0.00	0.30	0.00	0.61
Out of adjustment	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	2.44
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
Sticking	0.00	0.00	0.00	0.00	0.91	0.00	0.00	0.00	3.66
Unknown	0.00	0.00	0.91	0.30	0.91	0.61	0.00	0.91	6.71
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.61
Total	0.61	0.30	11.59	0.30	7.93	5.49	2.13	2.74	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.3.1.1		Item Control and Safety Equipment Valves Ball Emergency shutdown (ESD)								
Population 25	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.5504			Operational time † 0.5554					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max
<b>Critical</b>	21*	25.56	38.15	54.94	38.15	38.15	6.8	1.0	14.6	55.0
	21†	25.34	37.81	54.45	37.81	37.81				
Delayed operation	2*	0.64	3.63	11.44	3.63	3.63	19.8	28.0	39.5	51.0
	2†	0.64	3.60	11.33	3.60	3.60				
External leakage - Utility medium	1*	0.09	1.82	8.62	1.82	1.82	8.5	17.0	17.0	17.0
	1†	0.09	1.80	8.54	1.80	1.80				
Fail to close on demand	3*	1.49	5.45	14.09	5.45	5.45	18.2	34.0	43.0	55.0
	3†	1.48	5.40	13.96	5.40	5.40				
Fail to open on demand	1*	0.09	1.82	8.62	1.82	1.82	3.5	7.0	7.0	7.0
	1†	0.09	1.80	8.54	1.80	1.80				
Other	3*	1.49	5.45	14.09	5.45	5.45	8.3	1.0	16.7	37.0
	3†	1.48	5.40	13.96	5.40	5.40				
Spurious operation	11*	11.21	19.98	33.08	19.98	19.98	1.1	1.0	2.2	14.0
	11†	11.11	19.81	32.79	19.81	19.81				
<b>Degraded</b>	5*	3.58	9.08	19.10	9.08	9.08	14.8	11.0	29.6	61.0
	5†	3.55	9.00	18.93	9.00	9.00				
External leakage - Utility medium	1*	0.09	1.82	8.62	1.82	1.82	20.0	40.0	40.0	40.0
	1†	0.09	1.80	8.54	1.80	1.80				
Other	4*	2.48	7.27	16.63	7.27	7.27	13.5	11.0	27.0	61.0
	4†	2.46	7.20	16.48	7.20	7.20				
<b>Incipient</b>	24*	30.06	43.60	61.32	43.60	43.60	5.4	1.0	10.7	29.0
	24†	29.80	43.21	60.77	43.21	43.21				
Abnormal instrument reading	2*	0.64	3.63	11.44	3.63	3.63	12.0	19.0	24.0	29.0
	2†	0.64	3.60	11.33	3.60	3.60				
External leakage - Utility medium	1*	0.09	1.82	8.62	1.82	1.82	3.0	6.5	6.5	6.5
	1†	0.09	1.80	8.54	1.80	1.80				
Low output	1*	0.09	1.82	8.62	1.82	1.82	6.0	12.0	12.0	12.0
	1†	0.09	1.80	8.54	1.80	1.80				
Other	19*	22.60	34.52	50.65	34.52	34.52	4.5	1.0	8.9	28.0
	19†	22.40	34.21	50.20	34.21	34.21				
Structural deficiency	1*	0.09	1.82	8.62	1.82	1.82	9.0	18.0	18.0	18.0
	1†	0.09	1.80	8.54	1.80	1.80				
<b>All modes</b>	50*	70.79	90.84	114.98	90.84	90.84	7.0	1.0	14.4	61.0
	50†	70.16	90.03	113.95	90.03	90.03				
<b>Comments</b>										

Taxonomy no 4.3.1.2		Item Control and Safety Equipment Valves Ball Flare, vent & blow-down									
Population 3	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1462		Operational time † 0.1461							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max	
Critical	2*	2.43	13.68	43.06	13.68	13.68	6.0	4.0	16.5	29.0	
	2†	2.43	13.69	43.08	13.69	13.69					
Fail to open on demand	2*	2.43	13.68	43.06	13.68	13.68	6.0	4.0	16.5	29.0	
	2†	2.43	13.69	43.08	13.69	13.69					
Degraded	2*	2.43	13.68	43.06	13.68	13.68	8.0	10.0	17.5	25.0	
	2†	2.43	13.69	43.08	13.69	13.69					
Delayed operation	2*	2.43	13.68	43.06	13.68	13.68	8.0	10.0	17.5	25.0	
	2†	2.43	13.69	43.08	13.69	13.69					
All modes	4*	9.34	27.36	62.62	27.36	27.36	7.0	4.0	17.0	29.0	
	4†	9.34	27.37	62.65	27.37	27.37					
Comments											

Taxonomy no 4.3.1.3		Item Control and Safety Equipment Valves Ball Gas systems									
Population 224	Installations 17	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *			Operational time †						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	87*	0.00	10.40	50.64	21.10	13.27	5.8	1.0	9.0	113.0	
	87†	0.00	10.90	52.34	21.57	13.71					
Delayed operation	1*	0.00	0.18	0.93	0.42	0.15	56.5	113.0	113.0	113.0	
	1†	0.00	0.21	1.16	0.54	0.16					
Fail to close on demand	52*	0.00	5.86	33.01	17.44	7.93	5.2	1.0	7.1	46.0	
	52†	0.00	6.00	33.78	17.83	8.19					
Fail to open on demand	26*	0.48	3.83	9.84	3.07	3.97	5.3	1.0	9.2	78.0	
	26†	0.46	3.98	10.36	3.25	4.10					
Spurious operation	6*	0.09	0.78	2.05	0.65	0.92	4.3	2.0	7.8	24.0	
	6†	0.10	0.81	2.08	0.65	0.95					
Structural deficiency	2*	0.00	0.29	0.95	0.35	0.31	2.0	2.0	2.0	2.0	
	2†	0.00	0.30	0.97	0.35	0.32					
<b>Degraded</b>	65*	2.48	18.42	46.72	14.48	9.92	9.7	1.0	13.6	92.0	
	65†	2.63	19.29	48.76	15.09	10.24					
Abnormal instrument reading	3*	0.00	0.57	1.94	0.71	0.46	3.5	2.0	4.3	6.0	
	3†	0.01	0.58	1.92	0.70	0.47					
Delayed operation	14*	0.22	2.34	6.40	2.06	2.14	5.5	1.0	9.5	36.0	
	14†	0.16	2.45	7.11	2.35	2.21					
External leakage - Process medium	10*	0.00	2.80	11.82	4.54	1.53	10.8	1.0	13.6	36.0	
	10†	0.00	2.96	12.48	4.79	1.58					
External leakage - Utility medium	17*	0.10	3.33	10.13	3.51	2.59	9.0	1.0	15.2	92.0	
	17†	0.13	3.52	10.62	3.63	2.68					
Internal leakage	10*	0.01	2.27	8.52	3.14	1.53	12.8	4.0	24.6	48.0	
	10†	0.01	2.31	8.59	3.17	1.58					
Other	7*	0.00	3.66	15.78	6.12	1.07	-	2.0	2.3	4.0	
	7†	0.00	3.83	16.55	6.42	1.10					
Plugged/Choked	1*	0.00	0.40	2.07	0.90	0.15	-	-	-	-	
	1†	0.00	0.41	2.10	0.91	0.16					
Structural deficiency	2*	0.00	1.04	5.18	2.21	0.31	-	6.0	6.0	6.0	
	2†	0.00	1.10	5.48	2.33	0.32					
Valve leakage in closed position	1*	0.00	0.17	0.88	0.38	0.15	58.0	70.0	70.0	70.0	
	1†	0.00	0.18	0.91	0.39	0.16					
<b>Incipient</b>	69*	1.35	12.18	32.12	10.16	10.53	5.3	1.0	7.8	67.0	
	69†	1.50	12.62	32.78	10.27	10.87					
Abnormal instrument reading	19*	0.11	3.31	10.01	3.43	2.90	8.1	1.0	11.5	67.0	
	19†	0.13	3.51	10.59	3.61	2.99					
External leakage - Process medium	2*	0.00	0.42	1.98	0.81	0.31	4.0	1.0	4.0	7.0	
	2†	0.00	0.44	2.09	0.86	0.32					
External leakage - Utility medium	18*	0.00	1.37	7.55	3.81	2.75	3.7	2.0	7.4	20.0	
	18†	0.00	1.44	7.90	3.82	2.84					
<b>Comments</b>											

(cont.)

Taxonomy no 4.3.1.3		Item Control and Safety Equipment Valves Ball Gas systems								
Population 224	Installations 17	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 6.5555		Operational time † 6.3474						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Internal leakage	1*	0.00	0.21	1.14	0.55	0.15	30.0	30.0	30.0	30.0
	1†	0.00	0.22	1.20	0.58	0.16				
Minor in-service problems	25*	0.12	6.20	19.25	6.82	3.81	2.6	1.0	3.6	10.0
	25†	0.13	6.31	19.56	6.91	3.94				
Other	1*	0.00	0.14	0.43	0.15	0.15	2.0	3.0	3.0	3.0
	1†	0.00	0.14	0.45	0.16	0.16				
Structural deficiency	2*	0.00	0.93	4.74	2.04	0.31	-	13.0	13.0	13.0
	2†	0.00	0.95	4.81	2.07	0.32				
Valve leakage in closed position	1*	0.00	0.21	1.14	0.55	0.15	7.0	7.0	7.0	7.0
	1†	0.00	0.22	1.20	0.58	0.16				
<b>Unknown</b>	6*	<b>0.00</b>	<b>0.82</b>	<b>4.52</b>	<b>2.19</b>	<b>0.92</b>	<b>2.2</b>	<b>1.0</b>	<b>2.8</b>	<b>8.0</b>
	6†	<b>0.00</b>	<b>0.85</b>	<b>4.65</b>	<b>2.23</b>	<b>0.95</b>				
Unknown	6*	0.00	0.82	4.52	2.19	0.92	2.2	1.0	2.8	8.0
	6†	0.00	0.85	4.65	2.23	0.95				
<b>All modes</b>	227*	<b>4.96</b>	<b>42.23</b>	<b>109.81</b>	<b>34.42</b>	<b>34.63</b>	<b>6.3</b>	<b>1.0</b>	<b>9.7</b>	<b>113.0</b>
	227†	<b>5.62</b>	<b>43.97</b>	<b>112.62</b>	<b>35.07</b>	<b>35.76</b>				
<b>Comments</b>										



Taxonomy no 4.3.1.4		Item Control and Safety Equipment Valves Ball Main power								
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0526		Operational time † 0.0512						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.03 0.03	7.76 7.98	29.79 30.64	10.97 11.29	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 4.3.1.5		Item Control and Safety Equipment Valves Ball Oil systems																																																																																																																																																																																																																																																																																																															
Population 48	Installations 6	Aggregated time in service (10 <sup>6</sup> hours)						No of demands																																																																																																																																																																																																																																																																																																									
		Calendar time * 1.7460			Operational time † 1.5593																																																																																																																																																																																																																																																																																																												
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)																																																																																																																																																																																																																																																																																																								
		Lower	Mean	Upper	SD	n/τ	Min		Mean	Max																																																																																																																																																																																																																																																																																																							
<b>Critical</b>	10*	3.22	5.85	9.11	1.81	5.73	9.1	3.0	15.9	60.0																																																																																																																																																																																																																																																																																																							
	10†	0.75	6.78	17.89	5.66	6.41					External leakage - Utility medium	1*	0.00	0.52	2.09	0.78	0.57	11.0	22.0	22.0	22.0	1†	0.00	0.61	2.63	1.02	0.64	Fail to close on demand	3*	0.08	2.86	8.71	3.02	1.72	11.8	3.0	22.7	60.0	3†	0.12	2.98	8.98	3.05	1.92	Fail to open on demand	6*	0.65	3.26	7.53	2.21	3.44	7.5	3.0	11.5	16.0	6†	1.53	3.68	6.59	1.57	3.85	<b>Degraded</b>	11*	2.72	6.35	11.22	2.64	6.30	6.5	2.0	10.1	16.0	11†	3.95	7.05	10.87	2.13	7.05	Delayed operation	2*	0.19	1.19	2.90	0.88	1.15	6.5	10.0	13.0	16.0	2†	0.24	1.31	3.06	0.91	1.28	External leakage - Utility medium	7*	0.23	3.64	10.63	3.52	4.01	6.0	4.0	9.8	13.0	7†	0.35	4.06	11.31	3.68	4.49	Spurious operation	1*	0.01	0.65	2.12	0.77	0.57	14.0	14.0	14.0	14.0	1†	0.05	0.69	1.97	0.65	0.64	Unknown	1*	0.01	0.65	2.12	0.77	0.57	2.0	2.0	2.0	2.0	1†	0.05	0.69	1.97	0.65	0.64	<b>Incipient</b>	16*	2.04	10.75	25.09	7.41	9.16	4.8	2.0	8.0	28.0	16†	2.63	11.88	26.61	7.66	10.26	Abnormal instrument reading	8*	0.13	7.56	23.71	8.47	4.58	3.4	2.0	3.8	8.0	8†	0.16	8.35	25.97	9.21	5.13	External leakage - Process medium	1*	0.00	0.51	1.89	0.70	0.57	-	-	-	-	1†	0.00	0.57	1.90	0.70	0.64	External leakage - Utility medium	2*	0.00	0.95	3.75	1.40	1.15	7.0	12.0	14.0	16.0	2†	0.01	1.04	3.78	1.40	1.28	Minor in-service problems	1*	0.00	0.52	2.09	0.78	0.57	2.5	5.0	5.0	5.0	1†	0.00	0.61	2.63	1.02	0.64	Other	4*	0.01	2.22	8.01	2.96	2.29	7.1	4.0	14.3	28.0	4†	0.02	2.53	8.69	3.20	2.57	<b>Unknown</b>	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	Unknown	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	<b>All modes</b>	39*	10.07	25.94	47.80	11.76	22.34	6.4	2.0	10.6	60.0	39†	13.50	27.59	45.74	9.95	25.01	<b>Comments</b>					
External leakage - Utility medium	1*	0.00	0.52	2.09	0.78	0.57	11.0	22.0	22.0	22.0																																																																																																																																																																																																																																																																																																							
	1†	0.00	0.61	2.63	1.02	0.64					Fail to close on demand	3*	0.08	2.86	8.71	3.02	1.72	11.8	3.0	22.7	60.0	3†	0.12	2.98	8.98	3.05	1.92	Fail to open on demand	6*	0.65	3.26	7.53	2.21	3.44	7.5	3.0	11.5	16.0	6†	1.53	3.68	6.59	1.57	3.85	<b>Degraded</b>	11*	2.72	6.35	11.22	2.64	6.30	6.5	2.0	10.1	16.0	11†	3.95	7.05	10.87	2.13	7.05	Delayed operation	2*	0.19	1.19	2.90	0.88	1.15	6.5	10.0	13.0	16.0	2†	0.24	1.31	3.06	0.91	1.28	External leakage - Utility medium	7*	0.23	3.64	10.63	3.52	4.01	6.0	4.0	9.8	13.0	7†	0.35	4.06	11.31	3.68	4.49	Spurious operation	1*	0.01	0.65	2.12	0.77	0.57	14.0	14.0	14.0	14.0	1†	0.05	0.69	1.97	0.65	0.64	Unknown	1*	0.01	0.65	2.12	0.77	0.57	2.0	2.0	2.0	2.0	1†	0.05	0.69	1.97	0.65	0.64	<b>Incipient</b>	16*	2.04	10.75	25.09	7.41	9.16	4.8	2.0	8.0	28.0	16†	2.63	11.88	26.61	7.66	10.26	Abnormal instrument reading	8*	0.13	7.56	23.71	8.47	4.58	3.4	2.0	3.8	8.0	8†	0.16	8.35	25.97	9.21	5.13	External leakage - Process medium	1*	0.00	0.51	1.89	0.70	0.57	-	-	-	-	1†	0.00	0.57	1.90	0.70	0.64	External leakage - Utility medium	2*	0.00	0.95	3.75	1.40	1.15	7.0	12.0	14.0	16.0	2†	0.01	1.04	3.78	1.40	1.28	Minor in-service problems	1*	0.00	0.52	2.09	0.78	0.57	2.5	5.0	5.0	5.0	1†	0.00	0.61	2.63	1.02	0.64	Other	4*	0.01	2.22	8.01	2.96	2.29	7.1	4.0	14.3	28.0	4†	0.02	2.53	8.69	3.20	2.57	<b>Unknown</b>	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	Unknown	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	<b>All modes</b>	39*	10.07	25.94	47.80	11.76	22.34	6.4	2.0	10.6	60.0	39†	13.50	27.59	45.74	9.95	25.01	<b>Comments</b>																						
Fail to close on demand	3*	0.08	2.86	8.71	3.02	1.72	11.8	3.0	22.7	60.0																																																																																																																																																																																																																																																																																																							
	3†	0.12	2.98	8.98	3.05	1.92					Fail to open on demand	6*	0.65	3.26	7.53	2.21	3.44	7.5	3.0	11.5	16.0	6†	1.53	3.68	6.59	1.57	3.85	<b>Degraded</b>	11*	2.72	6.35	11.22	2.64	6.30	6.5	2.0	10.1	16.0	11†	3.95	7.05	10.87	2.13	7.05	Delayed operation	2*	0.19	1.19	2.90	0.88	1.15	6.5	10.0	13.0	16.0	2†	0.24	1.31	3.06	0.91	1.28	External leakage - Utility medium	7*	0.23	3.64	10.63	3.52	4.01	6.0	4.0	9.8	13.0	7†	0.35	4.06	11.31	3.68	4.49	Spurious operation	1*	0.01	0.65	2.12	0.77	0.57	14.0	14.0	14.0	14.0	1†	0.05	0.69	1.97	0.65	0.64	Unknown	1*	0.01	0.65	2.12	0.77	0.57	2.0	2.0	2.0	2.0	1†	0.05	0.69	1.97	0.65	0.64	<b>Incipient</b>	16*	2.04	10.75	25.09	7.41	9.16	4.8	2.0	8.0	28.0	16†	2.63	11.88	26.61	7.66	10.26	Abnormal instrument reading	8*	0.13	7.56	23.71	8.47	4.58	3.4	2.0	3.8	8.0	8†	0.16	8.35	25.97	9.21	5.13	External leakage - Process medium	1*	0.00	0.51	1.89	0.70	0.57	-	-	-	-	1†	0.00	0.57	1.90	0.70	0.64	External leakage - Utility medium	2*	0.00	0.95	3.75	1.40	1.15	7.0	12.0	14.0	16.0	2†	0.01	1.04	3.78	1.40	1.28	Minor in-service problems	1*	0.00	0.52	2.09	0.78	0.57	2.5	5.0	5.0	5.0	1†	0.00	0.61	2.63	1.02	0.64	Other	4*	0.01	2.22	8.01	2.96	2.29	7.1	4.0	14.3	28.0	4†	0.02	2.53	8.69	3.20	2.57	<b>Unknown</b>	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	Unknown	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	<b>All modes</b>	39*	10.07	25.94	47.80	11.76	22.34	6.4	2.0	10.6	60.0	39†	13.50	27.59	45.74	9.95	25.01	<b>Comments</b>																																							
Fail to open on demand	6*	0.65	3.26	7.53	2.21	3.44	7.5	3.0	11.5	16.0																																																																																																																																																																																																																																																																																																							
	6†	1.53	3.68	6.59	1.57	3.85					<b>Degraded</b>	11*	2.72	6.35	11.22	2.64	6.30	6.5	2.0	10.1	16.0	11†	3.95	7.05	10.87	2.13	7.05	Delayed operation	2*	0.19	1.19	2.90	0.88	1.15	6.5	10.0	13.0	16.0	2†	0.24	1.31	3.06	0.91	1.28	External leakage - Utility medium	7*	0.23	3.64	10.63	3.52	4.01	6.0	4.0	9.8	13.0	7†	0.35	4.06	11.31	3.68	4.49	Spurious operation	1*	0.01	0.65	2.12	0.77	0.57	14.0	14.0	14.0	14.0	1†	0.05	0.69	1.97	0.65	0.64	Unknown	1*	0.01	0.65	2.12	0.77	0.57	2.0	2.0	2.0	2.0	1†	0.05	0.69	1.97	0.65	0.64	<b>Incipient</b>	16*	2.04	10.75	25.09	7.41	9.16	4.8	2.0	8.0	28.0	16†	2.63	11.88	26.61	7.66	10.26	Abnormal instrument reading	8*	0.13	7.56	23.71	8.47	4.58	3.4	2.0	3.8	8.0	8†	0.16	8.35	25.97	9.21	5.13	External leakage - Process medium	1*	0.00	0.51	1.89	0.70	0.57	-	-	-	-	1†	0.00	0.57	1.90	0.70	0.64	External leakage - Utility medium	2*	0.00	0.95	3.75	1.40	1.15	7.0	12.0	14.0	16.0	2†	0.01	1.04	3.78	1.40	1.28	Minor in-service problems	1*	0.00	0.52	2.09	0.78	0.57	2.5	5.0	5.0	5.0	1†	0.00	0.61	2.63	1.02	0.64	Other	4*	0.01	2.22	8.01	2.96	2.29	7.1	4.0	14.3	28.0	4†	0.02	2.53	8.69	3.20	2.57	<b>Unknown</b>	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	Unknown	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	<b>All modes</b>	39*	10.07	25.94	47.80	11.76	22.34	6.4	2.0	10.6	60.0	39†	13.50	27.59	45.74	9.95	25.01	<b>Comments</b>																																																								
<b>Degraded</b>	11*	2.72	6.35	11.22	2.64	6.30	6.5	2.0	10.1	16.0																																																																																																																																																																																																																																																																																																							
	11†	3.95	7.05	10.87	2.13	7.05					Delayed operation	2*	0.19	1.19	2.90	0.88	1.15	6.5	10.0	13.0	16.0	2†	0.24	1.31	3.06	0.91	1.28	External leakage - Utility medium	7*	0.23	3.64	10.63	3.52	4.01	6.0	4.0	9.8	13.0	7†	0.35	4.06	11.31	3.68	4.49	Spurious operation	1*	0.01	0.65	2.12	0.77	0.57	14.0	14.0	14.0	14.0	1†	0.05	0.69	1.97	0.65	0.64	Unknown	1*	0.01	0.65	2.12	0.77	0.57	2.0	2.0	2.0	2.0	1†	0.05	0.69	1.97	0.65	0.64	<b>Incipient</b>	16*	2.04	10.75	25.09	7.41	9.16	4.8	2.0	8.0	28.0	16†	2.63	11.88	26.61	7.66	10.26	Abnormal instrument reading	8*	0.13	7.56	23.71	8.47	4.58	3.4	2.0	3.8	8.0	8†	0.16	8.35	25.97	9.21	5.13	External leakage - Process medium	1*	0.00	0.51	1.89	0.70	0.57	-	-	-	-	1†	0.00	0.57	1.90	0.70	0.64	External leakage - Utility medium	2*	0.00	0.95	3.75	1.40	1.15	7.0	12.0	14.0	16.0	2†	0.01	1.04	3.78	1.40	1.28	Minor in-service problems	1*	0.00	0.52	2.09	0.78	0.57	2.5	5.0	5.0	5.0	1†	0.00	0.61	2.63	1.02	0.64	Other	4*	0.01	2.22	8.01	2.96	2.29	7.1	4.0	14.3	28.0	4†	0.02	2.53	8.69	3.20	2.57	<b>Unknown</b>	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	Unknown	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	<b>All modes</b>	39*	10.07	25.94	47.80	11.76	22.34	6.4	2.0	10.6	60.0	39†	13.50	27.59	45.74	9.95	25.01	<b>Comments</b>																																																																									
Delayed operation	2*	0.19	1.19	2.90	0.88	1.15	6.5	10.0	13.0	16.0																																																																																																																																																																																																																																																																																																							
	2†	0.24	1.31	3.06	0.91	1.28					External leakage - Utility medium	7*	0.23	3.64	10.63	3.52	4.01	6.0	4.0	9.8	13.0	7†	0.35	4.06	11.31	3.68	4.49	Spurious operation	1*	0.01	0.65	2.12	0.77	0.57	14.0	14.0	14.0	14.0	1†	0.05	0.69	1.97	0.65	0.64	Unknown	1*	0.01	0.65	2.12	0.77	0.57	2.0	2.0	2.0	2.0	1†	0.05	0.69	1.97	0.65	0.64	<b>Incipient</b>	16*	2.04	10.75	25.09	7.41	9.16	4.8	2.0	8.0	28.0	16†	2.63	11.88	26.61	7.66	10.26	Abnormal instrument reading	8*	0.13	7.56	23.71	8.47	4.58	3.4	2.0	3.8	8.0	8†	0.16	8.35	25.97	9.21	5.13	External leakage - Process medium	1*	0.00	0.51	1.89	0.70	0.57	-	-	-	-	1†	0.00	0.57	1.90	0.70	0.64	External leakage - Utility medium	2*	0.00	0.95	3.75	1.40	1.15	7.0	12.0	14.0	16.0	2†	0.01	1.04	3.78	1.40	1.28	Minor in-service problems	1*	0.00	0.52	2.09	0.78	0.57	2.5	5.0	5.0	5.0	1†	0.00	0.61	2.63	1.02	0.64	Other	4*	0.01	2.22	8.01	2.96	2.29	7.1	4.0	14.3	28.0	4†	0.02	2.53	8.69	3.20	2.57	<b>Unknown</b>	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	Unknown	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	<b>All modes</b>	39*	10.07	25.94	47.80	11.76	22.34	6.4	2.0	10.6	60.0	39†	13.50	27.59	45.74	9.95	25.01	<b>Comments</b>																																																																																										
External leakage - Utility medium	7*	0.23	3.64	10.63	3.52	4.01	6.0	4.0	9.8	13.0																																																																																																																																																																																																																																																																																																							
	7†	0.35	4.06	11.31	3.68	4.49					Spurious operation	1*	0.01	0.65	2.12	0.77	0.57	14.0	14.0	14.0	14.0	1†	0.05	0.69	1.97	0.65	0.64	Unknown	1*	0.01	0.65	2.12	0.77	0.57	2.0	2.0	2.0	2.0	1†	0.05	0.69	1.97	0.65	0.64	<b>Incipient</b>	16*	2.04	10.75	25.09	7.41	9.16	4.8	2.0	8.0	28.0	16†	2.63	11.88	26.61	7.66	10.26	Abnormal instrument reading	8*	0.13	7.56	23.71	8.47	4.58	3.4	2.0	3.8	8.0	8†	0.16	8.35	25.97	9.21	5.13	External leakage - Process medium	1*	0.00	0.51	1.89	0.70	0.57	-	-	-	-	1†	0.00	0.57	1.90	0.70	0.64	External leakage - Utility medium	2*	0.00	0.95	3.75	1.40	1.15	7.0	12.0	14.0	16.0	2†	0.01	1.04	3.78	1.40	1.28	Minor in-service problems	1*	0.00	0.52	2.09	0.78	0.57	2.5	5.0	5.0	5.0	1†	0.00	0.61	2.63	1.02	0.64	Other	4*	0.01	2.22	8.01	2.96	2.29	7.1	4.0	14.3	28.0	4†	0.02	2.53	8.69	3.20	2.57	<b>Unknown</b>	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	Unknown	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	<b>All modes</b>	39*	10.07	25.94	47.80	11.76	22.34	6.4	2.0	10.6	60.0	39†	13.50	27.59	45.74	9.95	25.01	<b>Comments</b>																																																																																																											
Spurious operation	1*	0.01	0.65	2.12	0.77	0.57	14.0	14.0	14.0	14.0																																																																																																																																																																																																																																																																																																							
	1†	0.05	0.69	1.97	0.65	0.64					Unknown	1*	0.01	0.65	2.12	0.77	0.57	2.0	2.0	2.0	2.0	1†	0.05	0.69	1.97	0.65	0.64	<b>Incipient</b>	16*	2.04	10.75	25.09	7.41	9.16	4.8	2.0	8.0	28.0	16†	2.63	11.88	26.61	7.66	10.26	Abnormal instrument reading	8*	0.13	7.56	23.71	8.47	4.58	3.4	2.0	3.8	8.0	8†	0.16	8.35	25.97	9.21	5.13	External leakage - Process medium	1*	0.00	0.51	1.89	0.70	0.57	-	-	-	-	1†	0.00	0.57	1.90	0.70	0.64	External leakage - Utility medium	2*	0.00	0.95	3.75	1.40	1.15	7.0	12.0	14.0	16.0	2†	0.01	1.04	3.78	1.40	1.28	Minor in-service problems	1*	0.00	0.52	2.09	0.78	0.57	2.5	5.0	5.0	5.0	1†	0.00	0.61	2.63	1.02	0.64	Other	4*	0.01	2.22	8.01	2.96	2.29	7.1	4.0	14.3	28.0	4†	0.02	2.53	8.69	3.20	2.57	<b>Unknown</b>	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	Unknown	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	<b>All modes</b>	39*	10.07	25.94	47.80	11.76	22.34	6.4	2.0	10.6	60.0	39†	13.50	27.59	45.74	9.95	25.01	<b>Comments</b>																																																																																																																												
Unknown	1*	0.01	0.65	2.12	0.77	0.57	2.0	2.0	2.0	2.0																																																																																																																																																																																																																																																																																																							
	1†	0.05	0.69	1.97	0.65	0.64					<b>Incipient</b>	16*	2.04	10.75	25.09	7.41	9.16	4.8	2.0	8.0	28.0	16†	2.63	11.88	26.61	7.66	10.26	Abnormal instrument reading	8*	0.13	7.56	23.71	8.47	4.58	3.4	2.0	3.8	8.0	8†	0.16	8.35	25.97	9.21	5.13	External leakage - Process medium	1*	0.00	0.51	1.89	0.70	0.57	-	-	-	-	1†	0.00	0.57	1.90	0.70	0.64	External leakage - Utility medium	2*	0.00	0.95	3.75	1.40	1.15	7.0	12.0	14.0	16.0	2†	0.01	1.04	3.78	1.40	1.28	Minor in-service problems	1*	0.00	0.52	2.09	0.78	0.57	2.5	5.0	5.0	5.0	1†	0.00	0.61	2.63	1.02	0.64	Other	4*	0.01	2.22	8.01	2.96	2.29	7.1	4.0	14.3	28.0	4†	0.02	2.53	8.69	3.20	2.57	<b>Unknown</b>	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	Unknown	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	<b>All modes</b>	39*	10.07	25.94	47.80	11.76	22.34	6.4	2.0	10.6	60.0	39†	13.50	27.59	45.74	9.95	25.01	<b>Comments</b>																																																																																																																																													
<b>Incipient</b>	16*	2.04	10.75	25.09	7.41	9.16	4.8	2.0	8.0	28.0																																																																																																																																																																																																																																																																																																							
	16†	2.63	11.88	26.61	7.66	10.26					Abnormal instrument reading	8*	0.13	7.56	23.71	8.47	4.58	3.4	2.0	3.8	8.0	8†	0.16	8.35	25.97	9.21	5.13	External leakage - Process medium	1*	0.00	0.51	1.89	0.70	0.57	-	-	-	-	1†	0.00	0.57	1.90	0.70	0.64	External leakage - Utility medium	2*	0.00	0.95	3.75	1.40	1.15	7.0	12.0	14.0	16.0	2†	0.01	1.04	3.78	1.40	1.28	Minor in-service problems	1*	0.00	0.52	2.09	0.78	0.57	2.5	5.0	5.0	5.0	1†	0.00	0.61	2.63	1.02	0.64	Other	4*	0.01	2.22	8.01	2.96	2.29	7.1	4.0	14.3	28.0	4†	0.02	2.53	8.69	3.20	2.57	<b>Unknown</b>	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	Unknown	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	<b>All modes</b>	39*	10.07	25.94	47.80	11.76	22.34	6.4	2.0	10.6	60.0	39†	13.50	27.59	45.74	9.95	25.01	<b>Comments</b>																																																																																																																																																														
Abnormal instrument reading	8*	0.13	7.56	23.71	8.47	4.58	3.4	2.0	3.8	8.0																																																																																																																																																																																																																																																																																																							
	8†	0.16	8.35	25.97	9.21	5.13					External leakage - Process medium	1*	0.00	0.51	1.89	0.70	0.57	-	-	-	-	1†	0.00	0.57	1.90	0.70	0.64	External leakage - Utility medium	2*	0.00	0.95	3.75	1.40	1.15	7.0	12.0	14.0	16.0	2†	0.01	1.04	3.78	1.40	1.28	Minor in-service problems	1*	0.00	0.52	2.09	0.78	0.57	2.5	5.0	5.0	5.0	1†	0.00	0.61	2.63	1.02	0.64	Other	4*	0.01	2.22	8.01	2.96	2.29	7.1	4.0	14.3	28.0	4†	0.02	2.53	8.69	3.20	2.57	<b>Unknown</b>	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	Unknown	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	<b>All modes</b>	39*	10.07	25.94	47.80	11.76	22.34	6.4	2.0	10.6	60.0	39†	13.50	27.59	45.74	9.95	25.01	<b>Comments</b>																																																																																																																																																																															
External leakage - Process medium	1*	0.00	0.51	1.89	0.70	0.57	-	-	-	-																																																																																																																																																																																																																																																																																																							
	1†	0.00	0.57	1.90	0.70	0.64					External leakage - Utility medium	2*	0.00	0.95	3.75	1.40	1.15	7.0	12.0	14.0	16.0	2†	0.01	1.04	3.78	1.40	1.28	Minor in-service problems	1*	0.00	0.52	2.09	0.78	0.57	2.5	5.0	5.0	5.0	1†	0.00	0.61	2.63	1.02	0.64	Other	4*	0.01	2.22	8.01	2.96	2.29	7.1	4.0	14.3	28.0	4†	0.02	2.53	8.69	3.20	2.57	<b>Unknown</b>	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	Unknown	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	<b>All modes</b>	39*	10.07	25.94	47.80	11.76	22.34	6.4	2.0	10.6	60.0	39†	13.50	27.59	45.74	9.95	25.01	<b>Comments</b>																																																																																																																																																																																																
External leakage - Utility medium	2*	0.00	0.95	3.75	1.40	1.15	7.0	12.0	14.0	16.0																																																																																																																																																																																																																																																																																																							
	2†	0.01	1.04	3.78	1.40	1.28					Minor in-service problems	1*	0.00	0.52	2.09	0.78	0.57	2.5	5.0	5.0	5.0	1†	0.00	0.61	2.63	1.02	0.64	Other	4*	0.01	2.22	8.01	2.96	2.29	7.1	4.0	14.3	28.0	4†	0.02	2.53	8.69	3.20	2.57	<b>Unknown</b>	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	Unknown	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	<b>All modes</b>	39*	10.07	25.94	47.80	11.76	22.34	6.4	2.0	10.6	60.0	39†	13.50	27.59	45.74	9.95	25.01	<b>Comments</b>																																																																																																																																																																																																																	
Minor in-service problems	1*	0.00	0.52	2.09	0.78	0.57	2.5	5.0	5.0	5.0																																																																																																																																																																																																																																																																																																							
	1†	0.00	0.61	2.63	1.02	0.64					Other	4*	0.01	2.22	8.01	2.96	2.29	7.1	4.0	14.3	28.0	4†	0.02	2.53	8.69	3.20	2.57	<b>Unknown</b>	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	Unknown	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	<b>All modes</b>	39*	10.07	25.94	47.80	11.76	22.34	6.4	2.0	10.6	60.0	39†	13.50	27.59	45.74	9.95	25.01	<b>Comments</b>																																																																																																																																																																																																																																		
Other	4*	0.01	2.22	8.01	2.96	2.29	7.1	4.0	14.3	28.0																																																																																																																																																																																																																																																																																																							
	4†	0.02	2.53	8.69	3.20	2.57					<b>Unknown</b>	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	Unknown	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	<b>All modes</b>	39*	10.07	25.94	47.80	11.76	22.34	6.4	2.0	10.6	60.0	39†	13.50	27.59	45.74	9.95	25.01	<b>Comments</b>																																																																																																																																																																																																																																																			
<b>Unknown</b>	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0																																																																																																																																																																																																																																																																																																							
	2†	0.00	3.93	16.70	6.44	1.28					Unknown	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0	2†	0.00	3.93	16.70	6.44	1.28	<b>All modes</b>	39*	10.07	25.94	47.80	11.76	22.34	6.4	2.0	10.6	60.0	39†	13.50	27.59	45.74	9.95	25.01	<b>Comments</b>																																																																																																																																																																																																																																																																				
Unknown	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0																																																																																																																																																																																																																																																																																																							
	2†	0.00	3.93	16.70	6.44	1.28					<b>All modes</b>	39*	10.07	25.94	47.80	11.76	22.34	6.4	2.0	10.6	60.0	39†	13.50	27.59	45.74	9.95	25.01	<b>Comments</b>																																																																																																																																																																																																																																																																																					
<b>All modes</b>	39*	10.07	25.94	47.80	11.76	22.34	6.4	2.0	10.6	60.0																																																																																																																																																																																																																																																																																																							
	39†	13.50	27.59	45.74	9.95	25.01																																																																																																																																																																																																																																																																																																											
<b>Comments</b>																																																																																																																																																																																																																																																																																																																	

Taxonomy no 4.3.1.6		Item Control and Safety Equipment Valves Ball Oily water treatment								
Population 13	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.6356		Operational time † 0.6347						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / τ		Min	Mean	Max
<b>Critical</b>	3*	0.24	5.46	16.39	5.51	4.72	6.0	2.0	11.3	20.0
	3†	0.25	5.47	16.43	5.52	4.73				
Fail to close on demand	3*	0.24	5.46	16.39	5.51	4.72	6.0	2.0	11.3	20.0
	3†	0.25	5.47	16.43	5.52	4.73				
<b>Degraded</b>	2*	0.90	3.65	7.90	2.22	3.15	6.0	6.0	9.0	12.0
	2†	0.91	3.65	7.91	2.23	3.15				
External leakage - Utility medium	1*	0.02	1.41	4.41	1.57	1.57	6.0	12.0	12.0	12.0
	1†	0.02	1.41	4.42	1.58	1.58				
Fail to open on demand	1*	0.01	3.69	14.80	5.55	1.57	6.0	6.0	6.0	6.0
	1†	0.01	3.71	14.85	5.56	1.58				
<b>Incipient</b>	3*	0.46	4.05	10.62	3.35	4.72	3.7	4.0	7.3	12.0
	3†	0.46	4.06	10.63	3.35	4.73				
External leakage - Utility medium	2*	0.37	2.82	7.18	2.23	3.15	2.5	4.0	5.0	6.0
	2†	0.37	2.83	7.19	2.23	3.15				
Internal leakage	1*	0.02	1.41	4.41	1.57	1.57	6.0	12.0	12.0	12.0
	1†	0.02	1.41	4.42	1.58	1.58				
<b>All modes</b>	8*	1.51	13.21	34.58	10.88	12.59	5.1	2.0	9.3	20.0
	8†	1.52	13.26	34.64	10.89	12.60				
<b>Comments</b>										

Taxonomy no 4.3.1.7		Item Control and Safety Equipment Valves Ball Water injection								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0306		Operational time † 0.0306						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
All modes	0* 0†	0.05 0.05	11.75 11.89	45.12 45.64	16.62 16.81	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 4.3.2		Item Control and Safety Equipment Valves Butterfly									
Population 25	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.6974		Operational time † 0.6451							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	7*	4.02	9.26	16.25	3.79	10.04	4.6	2.0	4.6	8.0	
	7†	1.22	9.27	23.59	7.32	10.85					
External leakage - Process medium	1*	0.02	1.26	3.99	1.43	1.43	2.0	2.0	2.0	2.0	
	1†	0.02	1.36	4.31	1.55	1.55					
Fail to close on demand	2*	0.03	2.36	7.51	2.70	2.87	5.0	4.0	5.0	6.0	
	2†	0.06	2.57	7.91	2.78	3.10					
Fail to regulate	4*	0.82	5.32	13.06	3.98	5.74	5.0	2.0	5.0	8.0	
	4†	0.64	5.84	15.43	4.89	6.20					
<b>Degraded</b>	8*	4.62	10.47	18.22	4.21	11.47	7.3	1.0	7.3	28.0	
	8†	5.29	11.43	19.46	4.38	12.40					
External leakage - Process medium	5*	0.70	5.77	14.93	4.67	7.17	9.0	1.0	9.0	28.0	
	5†	1.43	6.50	14.58	4.21	7.75					
External leakage - Utility medium	1*	0.01	1.91	6.86	2.54	1.43	4.0	4.0	4.0	4.0	
	1†	0.01	2.53	9.99	3.72	1.55					
Internal leakage	1*	0.02	1.26	3.99	1.43	1.43	5.0	5.0	5.0	5.0	
	1†	0.02	1.36	4.31	1.55	1.55					
Low output	1*	0.02	1.26	3.99	1.43	1.43	4.0	4.0	4.0	4.0	
	1†	0.02	1.36	4.31	1.55	1.55					
<b>Unknown</b>	1*	0.02	1.26	3.99	1.43	1.43	67.0	114.0	114.0	114.0	
	1†	0.02	1.36	4.31	1.55	1.55					
Unknown	1*	0.02	1.26	3.99	1.43	1.43	67.0	114.0	114.0	114.0	
	1†	0.02	1.36	4.31	1.55	1.55					
<b>All modes</b>	16*	2.61	17.99	44.92	13.81	22.94	9.8	1.0	12.8	114.0	
	16†	3.97	20.11	46.49	13.66	24.80					
<b>Comments</b>											

**Maintainable item versus failure mode, to be continued**

Item: Valves described by taxonomy code - Butterfly

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	0.00	0.00	0.00	0.00	6.25	0.00	0.00	0.00	0.00
Other actuator components	0.00	0.00	0.00	0.00	0.00	0.00	6.25	0.00	0.00
Packing	0.00	0.00	3.13	0.00	0.00	0.00	0.00	0.00	6.25
Seat rings	0.00	0.00	9.38	0.00	0.00	0.00	0.00	0.00	0.00
Spring	0.00	0.00	0.00	0.00	6.25	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	6.25	0.00	0.00	12.50	0.00	0.00
Valve body w/internals	0.00	0.00	25.00	0.00	0.00	0.00	6.25	0.00	0.00
Total	0.00	0.00	37.50	6.25	12.50	0.00	25.00	0.00	6.25

**Maintainable item versus failure mode, continued**

Item: Valves described by taxonomy code - Butterfly

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	6.25	0.00	0.00	0.00	0.00	0.00	0.00	6.25
Monitoring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.25
Other actuator components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.25
Packing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.38
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.38
Spring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.25
Subunit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.25	25.00
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.25
Total	0.00	6.25	0.00	0.00	0.00	0.00	0.00	6.25	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Valves described by taxonomy code - Butterfly

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	12.50	0.00	0.00
Looseness	0.00	0.00	0.00	0.00	0.00	0.00	6.25	0.00	6.25
Mechanical Failure - general	0.00	0.00	0.00	6.25	0.00	0.00	0.00	0.00	0.00
Out of adjustment	0.00	0.00	0.00	0.00	6.25	0.00	6.25	0.00	0.00
Unknown	0.00	0.00	6.25	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	31.25	0.00	6.25	0.00	0.00	0.00	0.00
Total	0.00	0.00	37.50	6.25	12.50	0.00	25.00	0.00	6.25

**Failure descriptor versus failure mode, continued**

Item: Valves described by taxonomy code - Butterfly

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.50
Looseness	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.50
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.25
Out of adjustment	0.00	6.25	0.00	0.00	0.00	0.00	0.00	0.00	18.75
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.25	12.50
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.50
Total	0.00	6.25	0.00	0.00	0.00	0.00	0.00	6.25	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.3.2.1		Item Control and Safety Equipment Valves Butterfly Cooling systems								
Population 7	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1840		Operational time † 0.1793						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / r		Min	Mean	Max
Critical	1*	0.27	5.44	25.79	5.44	5.44	4.0	4.0	4.0	4.0
	1†	0.28	5.58	26.47	5.58	5.58				
Fail to regulate	1*	0.27	5.44	25.79	5.44	5.44	4.0	4.0	4.0	4.0
	1†	0.28	5.58	26.47	5.58	5.58				
Degraded	1*	0.27	5.44	25.79	5.44	5.44	5.0	5.0	5.0	5.0
	1†	0.28	5.58	26.47	5.58	5.58				
Internal leakage	1*	0.27	5.44	25.79	5.44	5.44	5.0	5.0	5.0	5.0
	1†	0.28	5.58	26.47	5.58	5.58				
All modes	2*	1.93	10.87	34.22	10.87	10.87	4.5	4.0	4.5	5.0
	2†	1.98	11.16	35.12	11.16	11.16				
Comments										



Taxonomy no 4.3.2.2		Item Control and Safety Equipment Valves Butterfly Gas systems									
Population 5	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1719			Operational time † 0.1583						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n / τ		Min	Mean	Max	
All modes		0* 0†	0.01 0.01	2.50 2.73	9.62 10.48	3.54 3.86	0.00 0.00	-	-	-	-
Comments											

Taxonomy no 4.3.2.3		Item Control and Safety Equipment Valves Butterfly Oil systems									
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0985		Operational time † 0.0716			Active rep.hrs	Repair (manhours)			
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ	Min		Mean	Max	
Critical	1*	0.51	10.15	48.15	10.15	10.15	2.0	2.0	2.0	2.0	
	1†	0.70	13.96	66.26	13.96	13.96					
Fail to regulate	1*	0.51	10.15	48.15	10.15	10.15	2.0	2.0	2.0	2.0	
	1†	0.70	13.96	66.26	13.96	13.96					
Degraded	1*	0.51	10.15	48.15	10.15	10.15	4.0	4.0	4.0	4.0	
	1†	0.70	13.96	66.26	13.96	13.96					
External leakage - Utility medium	1*	0.51	10.15	48.15	10.15	10.15	4.0	4.0	4.0	4.0	
	1†	0.70	13.96	66.26	13.96	13.96					
All modes	2*	3.60	20.30	63.88	20.30	20.30	3.0	2.0	3.0	4.0	
	2†	4.96	27.93	87.90	27.93	27.93					
Comments											

Taxonomy no 4.3.2.4		Item Control and Safety Equipment Valves Butterfly Oily water treatment								
Population 5	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0854		Operational time † 0.0823						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Unknown	1*	0.59	11.71	55.57	11.71	11.71	67.0	114.0	114.0	114.0
	1†	0.61	12.15	57.66	12.15	12.15				
Unknown	1*	0.59	11.71	55.57	11.71	11.71	67.0	114.0	114.0	114.0
	1†	0.61	12.15	57.66	12.15	12.15				
All modes	1*	0.59	11.71	55.57	11.71	11.71	67.0	114.0	114.0	114.0
	1†	0.61	12.15	57.66	12.15	12.15				
Comments										

Taxonomy no 4.3.2.5		Item Control and Safety Equipment Valves Butterfly Sea water lift									
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0526		Operational time † 0.0512							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/r		Min	Mean	Max	
Critical	2*	6.75	38.05	119.77	38.05	38.05	5.0	4.0	5.0	6.0	
	2†	6.93	39.05	122.91	39.05	39.05					
Fail to close on demand	2*	6.75	38.05	119.77	38.05	38.05	5.0	4.0	5.0	6.0	
	2†	6.93	39.05	122.91	39.05	39.05					
All modes	2*	6.75	38.05	119.77	38.05	38.05	5.0	4.0	5.0	6.0	
	2†	6.93	39.05	122.91	39.05	39.05					
Comments											

Taxonomy no 4.3.2.6		Item Control and Safety Equipment Valves Butterfly Water injection								
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0526		Operational time † 0.0512						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max
<b>Critical</b>	3*	15.60	57.08	147.55	57.08	57.08	5.3	2.0	5.3	8.0
	3†	16.01	58.58	151.42	58.58	58.58				
External leakage - Process medium	1*	0.95	19.03	90.28	19.03	19.03	2.0	2.0	2.0	2.0
	1†	0.98	19.53	92.65	19.53	19.53				
Fail to regulate	2*	6.75	38.05	119.77	38.05	38.05	7.0	6.0	7.0	8.0
	2†	6.93	39.05	122.91	39.05	39.05				
<b>Degraded</b>	3*	15.60	57.08	147.55	57.08	57.08	5.0	1.0	5.0	13.0
	3†	16.01	58.58	151.42	58.58	58.58				
External leakage - Process medium	3*	15.60	57.08	147.55	57.08	57.08	5.0	1.0	5.0	13.0
	3†	16.01	58.58	151.42	58.58	58.58				
<b>All modes</b>	6*	49.75	114.16	225.27	114.16	114.16	5.2	1.0	5.2	13.0
	6†	51.06	117.15	231.18	117.15	117.15				
<b>Comments</b>										

Taxonomy no 4.3.2.7		Item Control and Safety Equipment Valves Butterfly Well servicing								
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0526		Operational time † 0.0512			Active rep.hrs	Repair (manhours)		
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).						Active rep.hrs	Repair (manhours)	
		Lower	Mean	Upper	SD	n/τ	Min		Mean	Max
Degraded	3*	15.60	57.08	147.55	57.08	57.08	11.3	2.0	11.3	28.0
	3†	16.01	58.58	151.42	58.58	58.58				
External leakage - Process medium	2*	6.75	38.05	119.77	38.05	38.05	15.0	2.0	15.0	28.0
	2†	6.93	39.05	122.91	39.05	39.05				
Low output	1*	0.95	19.03	90.28	19.03	19.03	4.0	4.0	4.0	4.0
	1†	0.98	19.53	92.65	19.53	19.53				
All modes	3*	15.60	57.08	147.55	57.08	57.08	11.3	2.0	11.3	28.0
	3†	16.01	58.58	151.42	58.58	58.58				
Comments										

Taxonomy no 4.3.3		Item Control and Safety Equipment Valves Check								
Population 46	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 1.3664		Operational time † 1.3115						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.00 0.00	0.36 0.38	1.39 1.46	0.51 0.54	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 4.3.3.1		Item Control and Safety Equipment Valves Check Chemical injection									
Population 15	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.4176			Operational time † 0.4172						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max	
All modes		0* 0†	0.00 0.00	0.28 0.29	1.07 1.11	0.39 0.41	0.00 0.00	-	-	-	-
Comments											



Taxonomy no 4.3.3.2		Item Control and Safety Equipment Valves Check Gas systems								
Population 16	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.4883			Operational time † 0.4610					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max
All modes	0* 0†	0.00	0.27	1.03	0.38	0.00	-	-	-	-
		0.00	0.28	1.08	0.40	0.00				
Comments										

Taxonomy no 4.3.3.3		Item Control and Safety Equipment Valves Check Oil systems									
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0985		Operational time † 0.0716							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max	
All modes	0* 0†	0.00 0.00	0.34 0.36	1.30 1.39	0.48 0.51	0.00 0.00	-	-	-	-	
Comments											

Taxonomy no 4.3.3.4		Item Control and Safety Equipment Valves Check Unknown								
Population 13	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.3619			Operational time † 0.3616		Active rep.hrs	Repair (manhours)		
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).						Active rep.hrs	Repair (manhours)	
		Lower	Mean	Upper	SD	n/τ	Min		Mean	Max
All modes	0* 0†	0.00	0.29	1.10	0.41	0.00	-	-	-	-
		0.00	0.30	1.15	0.42	0.00				
Comments										

Taxonomy no 4.3.4		Item Control and Safety Equipment Valves Diaphragm									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0263		Operational time † 0.0256							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Critical	1*	1.90	38.05	180.56	38.05	38.05	36.0	36.0	36.0	36.0	
	1†	1.95	39.05	185.29	39.05	39.05					
Unknown	1*	1.90	38.05	180.56	38.05	38.05	36.0	36.0	36.0	36.0	
	1†	1.95	39.05	185.29	39.05	39.05					
Degraded	2*	13.51	76.10	239.54	76.10	76.10	7.0	5.0	7.0	9.0	
	2†	13.86	78.10	245.82	78.10	78.10					
External leakage - Utility medium	1*	1.90	38.05	180.56	38.05	38.05	5.0	5.0	5.0	5.0	
	1†	1.95	39.05	185.29	39.05	39.05					
High output	1*	1.90	38.05	180.56	38.05	38.05	9.0	9.0	9.0	9.0	
	1†	1.95	39.05	185.29	39.05	39.05					
All modes	3*	31.20	114.16	295.09	114.16	114.16	16.7	5.0	16.7	36.0	
	3†	32.02	117.15	302.84	117.15	117.15					
Comments											

**Maintainable item versus failure mode, to be continued**

**Item:** Valves described by taxonomy code - Diaphragm

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67	0.00
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67	0.00
Subunit	0.00	0.00	0.00	33.33	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	33.33	0.00	0.00	0.00	33.33	0.00

**Maintainable item versus failure mode, continued**

**Item:** Valves described by taxonomy code - Diaphragm

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67
Subunit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	66.67
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Valves described by taxonomy code - Diaphragm

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	0.00	33.33	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	33.33	0.00	0.00	0.00	33.33	0.00

**Failure descriptor versus failure mode, continued**

**Item:** Valves described by taxonomy code - Diaphragm

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	33.33
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.3.4.1		Item Control and Safety Equipment Valves Diaphragm Well servicing								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0263		Operational time † 0.0256						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	1*	1.90	38.05	180.56	38.05	38.05	36.0	36.0	36.0	36.0
	1†	1.95	39.05	185.29	39.05	39.05				
Unknown	1*	1.90	38.05	180.56	38.05	38.05	36.0	36.0	36.0	36.0
	1†	1.95	39.05	185.29	39.05	39.05				
Degraded	2*	13.51	76.10	239.54	76.10	76.10	7.0	5.0	7.0	9.0
	2†	13.86	78.10	245.82	78.10	78.10				
External leakage - Utility medium	1*	1.90	38.05	180.56	38.05	38.05	5.0	5.0	5.0	5.0
	1†	1.95	39.05	185.29	39.05	39.05				
High output	1*	1.90	38.05	180.56	38.05	38.05	9.0	9.0	9.0	9.0
	1†	1.95	39.05	185.29	39.05	39.05				
All modes	3*	31.20	114.16	295.09	114.16	114.16	16.7	5.0	16.7	36.0
	3†	32.02	117.15	302.84	117.15	117.15				
Comments										

Taxonomy no 4.3.5		Item Control and Safety Equipment Valves Gate									
Population 177	Installations 28	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 6.6856			Operational time † 3.8523		Active rep.hrs	Repair (manhours)			
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / τ	Min		Mean	Max	
<b>Critical</b>	70*	0.01	7.67	31.30	11.84	10.47	6.9	1.0	9.9	66.0	
	70†	8.46	69.57	179.79	56.22	18.17					
External leakage - Process medium	1*	0.00	0.14	0.42	0.15	0.15	2.0	2.0	2.0	2.0	
	1†	0.01	0.24	0.74	0.26	0.26					
Fail to close on demand	34*	0.00	3.03	15.85	7.10	5.09	5.7	1.0	9.7	66.0	
	34†	0.03	9.62	37.19	13.74	8.83					
Fail to open on demand	24*	0.00	3.81	16.47	6.39	3.59	8.8	1.0	12.0	60.0	
	24†	7.51	66.05	173.11	54.53	6.23					
Other	1*	0.00	0.21	1.16	0.55	0.15	-	-	-	-	
	1†	0.00	0.56	2.73	1.13	0.26					
Spurious operation	4*	0.00	0.52	2.29	0.89	0.60	6.3	3.0	6.3	8.0	
	4†	0.00	2.17	10.47	4.32	1.04					
Structural deficiency	4*	0.00	0.45	1.72	0.63	0.60	4.3	2.0	4.5	9.0	
	4†	0.19	0.95	2.19	0.64	1.04					
Valve leakage in closed position	2*	0.00	0.25	0.83	0.30	0.30	12.5	10.0	12.5	15.0	
	2†	0.07	0.48	1.20	0.37	0.52					
<b>Degraded</b>	76*	0.00	6.52	34.27	15.48	11.37	7.5	1.0	8.1	62.0	
	76†	0.41	33.00	106.11	38.43	19.73					
Abnormal instrument reading	3*	0.00	0.41	2.12	0.92	0.45	4.0	4.0	4.7	6.0	
	3†	0.00	1.20	6.51	3.03	0.78					
Delayed operation	4*	0.00	0.61	3.36	1.62	0.60	8.0	12.0	13.5	15.0	
	4†	0.02	1.44	4.53	1.62	1.04					
External leakage - Process medium	8*	0.00	2.06	10.10	4.24	1.20	7.3	3.0	8.3	30.0	
	8†	4.55	42.37	112.63	35.78	2.08					
External leakage - Utility medium	6*	0.00	0.71	4.08	2.27	0.90	13.8	1.0	15.8	62.0	
	6†	0.01	1.79	6.17	2.27	1.56					
Minor in-service problems	1*	0.00	0.21	1.16	0.55	0.15	4.0	4.0	4.0	4.0	
	1†	0.00	0.56	2.73	1.13	0.26					
Other	31*	0.00	1.68	5.59	8.24	4.64	4.5	2.0	5.4	23.0	
	31†	0.00	4.55	21.68	8.90	8.05					
Spurious operation	2*	0.00	0.25	0.83	0.30	0.30	21.0	7.0	21.0	35.0	
	2†	0.07	0.48	1.20	0.37	0.52					
Structural deficiency	1*	0.00	0.14	0.44	0.16	0.15	6.0	6.0	6.0	6.0	
	1†	0.01	0.24	0.75	0.26	0.26					
Valve leakage in closed position	20*	0.00	0.93	1.64	5.40	2.99	9.4	2.0	9.4	24.0	
	20†	0.00	2.84	13.14	5.30	5.19					
<b>Incipient</b>	86*	3.31	17.93	42.16	12.50	12.86	2.3	1.0	3.2	80.0	
	86†	130.23	288.98	498.36	114.01	22.32					
Abnormal instrument reading	66*	1.46	14.25	38.28	12.23	9.87	2.3	1.0	3.4	80.0	
	66†	112.64	262.36	462.84	108.65	17.13					
<b>Comments</b>											

(cont.)

Taxonomy no 4.3.5		Item Control and Safety Equipment Valves Gate								
Population 177	Installations 28	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 6.6856			Operational time † 3.8523					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Delayed operation	2*	0.00	0.35	1.15	0.42	0.30	1.0	1.0	1.0	1.0
	2†	0.06	6.97	23.22	8.51	0.52				
External leakage - Process medium	1*	0.00	0.22	1.20	0.60	0.15	-	3.0	3.0	3.0
	1†	0.00	0.59	2.86	1.20	0.26				
External leakage - Utility medium	7*	0.00	1.59	7.90	3.36	1.05	2.0	1.0	2.6	4.0
	7†	0.26	19.29	61.56	22.21	1.82				
Internal leakage	1*	0.00	0.22	1.20	0.60	0.15	-	4.0	4.0	4.0
	1†	0.00	0.59	2.86	1.20	0.26				
Minor in-service problems	7*	0.44	0.99	1.72	0.40	1.05	2.8	2.0	2.8	3.0
	7†	0.17	1.68	4.55	1.46	1.82				
Other	2*	0.00	0.99	5.45	2.67	0.30	3.0	3.0	3.0	3.0
	2†	0.00	2.20	9.25	3.54	0.52				
<b>Unknown</b>	8*	<b>0.01</b>	<b>0.86</b>	<b>2.73</b>	<b>0.99</b>	<b>1.20</b>	<b>12.2</b>	<b>1.0</b>	<b>17.8</b>	<b>64.0</b>
	8†	<b>0.58</b>	<b>1.87</b>	<b>3.76</b>	<b>1.00</b>	<b>2.08</b>				
Unknown	8*	0.01	0.86	2.73	0.99	1.20	12.2	1.0	17.8	64.0
	8†	0.58	1.87	3.76	1.00	2.08				
<b>All modes</b>	240*	<b>7.46</b>	<b>32.77</b>	<b>72.77</b>	<b>20.84</b>	<b>35.90</b>	<b>5.7</b>	<b>1.0</b>	<b>7.2</b>	<b>80.0</b>
	240†	<b>185.60</b>	<b>401.99</b>	<b>685.32</b>	<b>154.65</b>	<b>62.30</b>				
<b>Comments</b>										



**Maintainable item versus failure mode, to be continued**

**Item:** Valves described by taxonomy code - Gate

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bonnet	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	1.67	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00
Control unit	1.25	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00
Instrument, general	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, position	4.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other actuator components	0.00	0.83	0.00	2.08	0.83	0.00	0.00	0.00	0.00
Other valve components	0.00	0.00	0.42	0.83	0.42	1.46	0.00	0.00	0.00
Packing	0.00	0.00	0.00	0.42	0.42	0.00	0.00	0.00	0.00
Pilot valve	0.42	0.00	0.00	0.42	5.00	0.00	0.00	0.00	0.00
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Seals (gaskets)	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00
Seat rings	0.00	0.00	2.92	0.00	0.42	1.46	0.00	0.00	0.00
Subunit	0.00	0.42	0.42	0.00	0.83	2.92	0.00	0.00	0.00
Unknown	1.67	0.83	0.42	0.83	5.42	2.92	0.00	0.00	0.00
Valve body w/internals	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00
Total	28.75	2.50	4.17	5.42	14.17	10.00	0.00	0.00	0.42

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

Item: Valves described by taxonomy code - Gate

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	1.25
Bonnet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.42	0.00	0.42	0.00	2.92
Control unit	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	2.50
Instrument, general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83
Instrument, position	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.58
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.83
Monitoring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.50
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Other actuator components	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	4.17
Other valve components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.12
Packing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83
Pilot valve	0.00	0.00	0.00	0.00	2.08	0.00	0.83	0.42	9.17
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83
Seals	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Seat rings	3.75	0.00	0.42	0.00	0.00	0.00	0.00	0.00	8.96
Subunit	5.00	0.00	11.67	0.00	0.00	0.83	0.42	1.67	24.17
Unknown	0.00	0.00	1.25	0.00	0.83	0.00	0.00	1.25	15.42
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.83
Total	9.17	0.00	14.17	0.00	3.33	2.50	2.08	3.33	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Valves described by taxonomy code - Gate

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.42	0.00	0.00	0.00	2.92	5.83	0.00	0.00	0.00
Breakage	0.83	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00
Clearance/ alignment failure	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	6.67	0.00	0.00	0.00	4.58	0.42	0.00	0.00	0.00
Leakage	0.00	0.42	4.17	2.92	0.42	0.00	0.00	0.00	0.00
Looseness	0.00	0.00	0.00	0.42	0.42	0.00	0.00	0.00	0.42
Material failure - general	0.00	0.00	0.00	0.42	0.00	0.42	0.00	0.00	0.00
Mechanical Failure - general	0.42	0.42	0.00	0.83	3.75	1.67	0.00	0.00	0.00
Misc. external influences	0.83	0.42	0.00	0.00	0.00	0.42	0.00	0.00	0.00
Open circuit	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	14.17	0.42	0.00	0.00	0.00	0.42	0.00	0.00	0.00
Short circuiting	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.42	0.00	0.00	0.83	0.42	0.00	0.00	0.00
Wear	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00
<b>Total</b>	<b>28.75</b>	<b>2.50</b>	<b>4.17</b>	<b>5.42</b>	<b>14.17</b>	<b>10.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.42</b>

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

Item: Valves described by taxonomy code - Gate

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.17
Breakage	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	2.08
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	1.67
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Corrosion	0.00	0.00	0.42	0.00	1.25	0.42	0.00	0.00	2.92
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Electrical failure - general	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.42
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	2.92
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.42	12.92
Leakage	9.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.08
Looseness	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	1.67
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.00	1.25
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.42	0.00	0.42	0.83	8.75
Misc. external influences	0.00	0.00	0.00	0.00	0.83	0.00	0.42	0.00	2.92
Open circuit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83
Out of adjustment	0.00	0.00	12.50	0.00	0.42	0.83	0.00	0.00	28.75
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.83
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67	3.33
Wear	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	1.25
Total	9.17	0.00	14.17	0.00	3.33	2.50	2.08	3.33	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.3.5.1		Item Control and Safety Equipment Valves Gate Chemical injection								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0263		Operational time † 0.0256						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max
All modes	0* 0†	0.05 0.07	12.04 18.62	46.22 71.50	17.02 26.33	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 4.3.5.2		Item Control and Safety Equipment Valves Gate Emergency shutdown (ESD)									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0219		Operational time † 0.0219							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Incipient	1*	2.28	45.64	216.55	45.64	45.64	-	-	-	-	
	1†	2.28	45.69	216.79	45.69	45.69	-	-	-	-	
Other	1*	2.28	45.64	216.55	45.64	45.64	-	-	-	-	
	1†	2.28	45.69	216.79	45.69	45.69	-	-	-	-	
All modes	1*	2.28	45.64	216.55	45.64	45.64	-	-	-	-	
	1†	2.28	45.69	216.79	45.69	45.69	-	-	-	-	
Comments											

Taxonomy no 4.3.5.3		Item Control and Safety Equipment Valves Gate Flare, vent & blow-down								
Population 42	Installations 19	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 2.9787		Operational time † 0.1988			Active rep.hrs	Repair (manhours)		
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)	
		Lower	Mean	Upper	SD	n/τ	Min		Mean	Max
<b>Critical</b>	13*	0.00	5.40	22.91	8.82	4.36	9.8	1.0	14.2	60.0
	13†	0.17	134.65	552.13	209.19	65.41				
Fail to close on demand	2*	0.00	0.71	2.66	0.98	0.67	1.5	2.0	2.0	2.0
	2†	0.00	18.50	94.35	40.76	10.06				
Fail to open on demand	10*	0.00	4.49	22.02	9.26	3.36	11.6	1.0	17.2	60.0
	10†	0.00	110.09	516.04	210.03	50.31				
Spurious operation	1*	0.00	0.29	1.51	0.68	0.34	8.0	8.0	8.0	8.0
	1†	0.00	5.52	31.87	17.29	5.03				
<b>Degraded</b>	7*	0.00	2.59	12.95	5.53	2.35	7.3	3.0	9.0	30.0
	7†	0.00	65.22	316.42	131.21	35.22				
External leakage - Process medium	7*	0.00	2.59	12.95	5.53	2.35	7.3	3.0	9.0	30.0
	7†	0.00	65.22	316.42	131.21	35.22				
<b>Incipient</b>	54*	4.28	19.77	44.57	12.89	18.13	2.1	1.0	3.3	80.0
	54†	60.05	441.15	1115.90	345.50	271.70				
Abnormal instrument reading	48*	2.70	18.26	45.39	13.93	16.11	2.2	1.0	3.5	80.0
	48†	41.79	400.92	1073.00	342.26	241.51				
Delayed operation	2*	0.00	0.63	3.38	1.56	0.67	1.0	1.0	1.0	1.0
	2†	0.37	11.68	35.43	12.20	10.06				
External leakage - Utility medium	4*	0.00	1.21	5.31	2.07	1.34	1.5	1.0	1.5	3.0
	4†	0.00	29.96	163.71	76.52	20.13				
<b>All modes</b>	74*	6.31	27.84	61.91	17.74	24.84	4.0	1.0	5.8	80.0
	74†	93.03	652.14	1633.42	503.23	372.32				
<b>Comments</b>										

Taxonomy no 4.3.5.4		Item Control and Safety Equipment Valves Gate Gas systems								
Population 92	Installations 8	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 2.5419		Operational time † 2.5059						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	51*	1.23	14.97	42.02	13.72	20.06	5.8	1.0	8.8	66.0
	51†	1.27	15.17	42.42	13.83	20.35				
Fail to close on demand	29*	0.11	8.52	27.20	9.82	11.41	5.3	1.0	10.0	66.0
	29†	0.12	8.63	27.51	9.92	11.57				
Fail to open on demand	14*	0.49	4.29	11.23	3.53	5.51	6.6	1.0	7.6	30.0
	14†	0.50	4.35	11.37	3.57	5.59				
Other	1*	0.00	0.74	3.23	1.26	0.39	-	-	-	-
	1†	0.00	0.74	3.23	1.26	0.40				
Spurious operation	2*	0.00	1.19	5.20	2.03	0.79	4.5	3.0	4.5	6.0
	2†	0.00	1.19	5.21	2.03	0.80				
Structural deficiency	4*	0.04	1.22	3.68	1.26	1.57	4.3	2.0	4.5	9.0
	4†	0.04	1.23	3.73	1.28	1.60				
Valve leakage in closed position	1*	0.00	0.39	1.35	0.50	0.39	15.0	15.0	15.0	15.0
	1†	0.00	0.39	1.39	0.51	0.40				
<b>Degraded</b>	50*	0.17	18.06	59.62	21.79	19.67	7.4	1.0	7.9	62.0
	50†	0.16	18.34	61.00	22.35	19.95				
Abnormal instrument reading	3*	0.00	1.38	5.34	1.97	1.18	4.0	4.0	4.7	6.0
	3†	0.00	1.42	5.58	2.08	1.20				
Delayed operation	3*	0.29	1.35	3.06	0.89	1.18	-	15.0	15.0	15.0
	3†	0.32	1.35	2.97	0.84	1.20				
External leakage - Process medium	1*	0.00	0.77	3.40	1.33	0.39	-	3.0	3.0	3.0
	1†	0.00	0.78	3.41	1.33	0.40				
External leakage - Utility medium	6*	0.85	2.64	5.24	1.38	2.36	13.8	1.0	15.8	62.0
	6†	0.90	2.66	5.17	1.34	2.39				
Minor in-service problems	1*	0.00	0.74	3.23	1.26	0.39	4.0	4.0	4.0	4.0
	1†	0.00	0.74	3.23	1.26	0.40				
Other	24*	0.00	6.91	34.84	14.96	9.44	4.3	2.0	5.2	23.0
	24†	0.00	7.03	35.60	15.32	9.58				
Spurious operation	2*	0.00	0.75	2.70	1.00	0.79	21.0	7.0	21.0	35.0
	2†	0.00	0.76	2.77	1.02	0.80				
Structural deficiency	1*	0.01	0.35	1.10	0.39	0.39	6.0	6.0	6.0	6.0
	1†	0.01	0.35	1.11	0.40	0.40				
Valve leakage in closed position	9*	0.00	2.50	12.94	5.66	3.54	9.3	2.0	9.3	22.0
	9†	0.00	2.56	13.22	5.81	3.59				
<b>Incipient</b>	29*	1.65	12.06	30.46	9.42	11.41	2.7	1.0	3.1	12.0
	29†	1.67	12.20	30.82	9.54	11.57				
Abnormal instrument reading	17*	0.44	5.42	15.23	4.98	6.69	2.6	1.0	3.1	12.0
	17†	0.46	5.48	15.34	5.00	6.78				
External leakage - Process medium	1*	0.00	0.77	3.40	1.33	0.39	-	3.0	3.0	3.0
	1†	0.00	0.78	3.41	1.33	0.40				

Comments

(cont.)



Taxonomy no 4.3.5.4		Item Control and Safety Equipment Valves Gate Gas systems								
Population 92	Installations 8	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 2.5419		Operational time † 2.5059						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max
External leakage - Utility medium	2* 2†	0.00 0.01	3.52 3.67	14.44 14.97	5.48 5.66	0.79 0.80	-	4.0	4.0	4.0
Internal leakage	1* 1†	0.00 0.00	0.77 0.78	3.40 3.41	1.33 1.33	0.39 0.40	-	4.0	4.0	4.0
Minor in-service problems	7* 7†	0.02 0.02	2.19 2.21	7.20 7.25	2.63 2.64	2.75 2.79	2.8	2.0	2.8	3.0
Other	1* 1†	0.00 0.00	0.74 0.74	3.23 3.23	1.26 1.26	0.39 0.40	3.0	3.0	3.0	3.0
<b>Unknown</b>	7* 7†	<b>0.19</b> <b>0.20</b>	<b>2.12</b> <b>2.15</b>	<b>5.83</b> <b>5.90</b>	<b>1.89</b> <b>1.91</b>	<b>2.75</b> <b>2.79</b>	<b>8.9</b>	<b>1.0</b>	<b>11.1</b>	<b>51.0</b>
Unknown	7* 7†	0.19 0.20	2.12 2.15	5.83 5.90	1.89 1.91	2.75 2.79	8.9	1.0	11.1	51.0
<b>All modes</b>	<b>137*</b> <b>137†</b>	<b>24.33</b> <b>24.44</b>	<b>48.73</b> <b>49.37</b>	<b>79.97</b> <b>81.37</b>	<b>17.16</b> <b>17.57</b>	<b>53.90</b> <b>54.67</b>	<b>6.0</b>	<b>1.0</b>	<b>7.5</b>	<b>66.0</b>
Comments										

Taxonomy no 4.3.5.5		Item Control and Safety Equipment Valves Gate Oil systems								
Population 24	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.6175		Operational time † 0.6066						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max
<b>Critical</b>	4*	2.23	6.50	12.58	3.24	6.48	7.5	2.0	7.5	10.0
	4†	2.27	6.61	12.80	3.30	6.59				
External leakage - Process medium	1*	0.01	1.55	5.60	2.07	1.62	2.0	2.0	2.0	2.0
	1†	0.01	1.59	5.78	2.14	1.65				
Fail to close on demand	1*	0.11	1.68	4.89	1.62	1.62	10.0	10.0	10.0	10.0
	1†	0.11	1.70	4.98	1.65	1.65				
Spurious operation	1*	0.11	1.68	4.89	1.62	1.62	8.0	8.0	8.0	8.0
	1†	0.11	1.70	4.98	1.65	1.65				
Valve leakage in closed position	1*	0.01	1.55	5.60	2.07	1.62	10.0	10.0	10.0	10.0
	1†	0.01	1.59	5.78	2.14	1.65				
<b>Degraded</b>	7*	0.08	10.44	35.69	13.14	11.34	3.7	2.0	4.4	13.0
	7†	0.07	10.74	36.94	13.61	11.54				
Other	4*	0.09	6.05	19.15	6.88	6.48	4.0	2.0	5.3	13.0
	4†	0.08	6.21	19.81	7.15	6.59				
Valve leakage in closed position	3*	0.16	4.58	13.87	4.76	4.86	3.3	2.0	3.3	5.0
	3†	0.13	4.70	14.32	4.96	4.95				
<b>Unknown</b>	1*	0.01	1.55	5.60	2.07	1.62	35.0	64.0	64.0	64.0
	1†	0.01	1.59	5.78	2.14	1.65				
Unknown	1*	0.01	1.55	5.60	2.07	1.62	35.0	64.0	64.0	64.0
	1†	0.01	1.59	5.78	2.14	1.65				
<b>All modes</b>	12*	3.17	18.57	44.52	13.37	19.43	7.6	2.0	10.4	64.0
	12†	3.04	19.00	46.34	14.06	19.78				
<b>Comments</b>										

Taxonomy no 4.3.5.6		Item Control and Safety Equipment Valves Gate Oily water treatment								
Population 11	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.3416		Operational time † 0.3399						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Critical	2*	0.11	6.58	20.60	7.34	5.85	12.5	1.0	12.5	24.0
	2†	0.11	6.64	20.84	7.44	5.88				
Fail to close on demand	2*	0.11	6.58	20.60	7.34	5.85	12.5	1.0	12.5	24.0
	2†	0.11	6.64	20.84	7.44	5.88				
Degraded	1*	0.04	2.58	8.16	2.93	2.93	8.0	12.0	12.0	12.0
	1†	0.04	2.60	8.20	2.94	2.94				
Delayed operation	1*	0.04	2.58	8.16	2.93	2.93	8.0	12.0	12.0	12.0
	1†	0.04	2.60	8.20	2.94	2.94				
Incipient	2*	0.11	6.58	20.60	7.34	5.85	3.0	2.0	3.0	4.0
	2†	0.11	6.64	20.84	7.44	5.88				
Abnormal instrument reading	1*	0.02	4.54	16.40	6.06	2.93	2.0	2.0	2.0	2.0
	1†	0.02	4.60	16.70	6.17	2.94				
External leakage - Utility medium	1*	0.04	2.58	8.16	2.93	2.93	4.0	4.0	4.0	4.0
	1†	0.04	2.60	8.20	2.94	2.94				
All modes	5*	1.17	15.34	43.60	14.31	14.64	7.8	1.0	8.6	24.0
	5†	1.16	15.48	44.11	14.49	14.71				
Comments										

Taxonomy no 4.3.5.7		Item Control and Safety Equipment Valves Gate Sea water lift									
Population 6	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1577			Operational time † 0.1536						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Degraded	11*	39.13	69.76	115.49	69.76	69.76	10.5	2.0	10.5	24.0	
	11†	40.16	71.59	118.52	71.59	71.59					
Other	3*	5.20	19.03	49.18	19.03	19.03	6.7	2.0	6.7	14.0	
	3†	5.34	19.53	50.47	19.53	19.53					
Valve leakage in closed position	8*	25.24	50.74	91.55	50.74	50.74	11.9	4.0	11.9	24.0	
	8†	25.90	52.07	93.95	52.07	52.07					
All modes	11*	39.13	69.76	115.49	69.76	69.76	10.5	2.0	10.5	24.0	
	11†	40.16	71.59	118.52	71.59	71.59					
Comments											

Taxonomy no 4.3.6		Item Control and Safety Equipment Valves Globe									
Population 255	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)						No of demands			
		Calendar time * 8.0172			Operational time † 7.1701						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	115* 115†	0.09 0.13	10.52 11.11	35.34 35.83	12.97 12.99	14.34 16.04	14.2	1.0	15.8	94.0	
External leakage - Process medium	7* 7†	0.17 0.30	0.91 0.97	2.11 1.94	0.62 0.52	0.87 0.98	13.0	1.0	15.1	54.0	
Fail to close on demand	31* 31†	0.00 0.00	2.51 2.68	10.45 10.81	3.99 4.07	3.87 4.32	15.0	2.0	15.2	78.0	
Fail to open on demand	8* 8†	0.23 0.33	1.20 1.27	2.80 2.71	0.83 0.76	1.00 1.12	14.9	1.5	15.9	48.0	
Fail to regulate	59* 59†	0.00 0.00	4.64 4.93	19.98 20.73	7.74 7.94	7.36 8.23	12.5	2.0	14.3	93.0	
High output	1* 1†	0.00 0.00	0.11 0.12	0.36 0.39	0.13 0.14	0.12 0.14	6.0	6.0	6.0	6.0	
Internal leakage	3* 3†	0.08 0.00	0.34 0.33	0.75 1.09	0.22 0.40	0.37 0.42	26.3	6.0	34.0	48.0	
Spurious operation	1* 1†	0.00 0.00	0.25 0.26	1.01 1.05	0.38 0.39	0.12 0.14	8.0	8.0	8.0	8.0	
Structural deficiency	1* 1†	0.00 0.00	0.11 0.12	0.36 0.39	0.13 0.14	0.12 0.14	12.0	16.0	16.0	16.0	
Unknown	1* 1†	0.00 0.00	0.11 0.12	0.36 0.39	0.13 0.14	0.12 0.14	88.0	94.0	94.0	94.0	
Valve leakage in closed position	3* 3†	0.07 0.07	0.36 0.40	0.83 0.97	0.24 0.29	0.37 0.42	11.3	6.0	17.0	35.0	
<b>Degraded</b>	48* 48†	2.90 2.78	7.22 8.38	13.11 16.43	3.18 4.28	5.99 6.69	10.3	0.5	11.4	46.0	
Delayed operation	1* 1†	0.00 0.00	0.25 0.26	1.01 1.05	0.38 0.39	0.12 0.14	4.0	8.0	8.0	8.0	
External leakage - Process medium	9* 9†	0.10 0.11	1.86 1.94	5.53 5.73	1.84 1.91	1.12 1.26	9.3	1.0	12.7	45.0	
External leakage - Utility medium	4* 4†	0.05 0.13	0.42 0.49	1.11 1.05	0.35 0.29	0.50 0.56	7.8	2.0	7.8	14.0	
Fail to open on demand	1* 1†	0.01 0.00	0.13 0.16	0.38 0.51	0.12 0.18	0.12 0.14	0.5	0.5	0.5	0.5	
High output	3* 3†	0.05 0.05	0.48 0.59	1.27 1.63	0.40 0.53	0.37 0.42	2.5	2.0	2.8	3.5	
Internal leakage	7* 7†	0.19 0.41	0.81 0.92	1.77 1.60	0.50 0.37	0.87 0.98	18.1	4.0	18.1	42.0	
Low output	11* 11†	0.00 0.00	1.49 2.00	6.54 8.74	2.56 3.41	1.37 1.53	6.1	1.5	6.1	13.0	
Other	2* 2†	0.03 0.02	0.25 0.28	0.63 0.82	0.20 0.27	0.25 0.28	20.0	32.0	32.0	32.0	
<b>Comments</b>											

(cont.)

Taxonomy no 4.3.6		Item Control and Safety Equipment Valves Globe									
Population 255	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 8.0172			Operational time † 7.1701						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Plugged/Choked	2*	0.00	0.28	0.97	0.36	0.25	-	-	-	-	
	2†	0.00	0.36	1.40	0.52	0.28					
Spurious operation	1*	0.00	0.11	0.36	0.13	0.12	11.0	11.0	11.0	11.0	
	1†	0.00	0.12	0.39	0.14	0.14					
Unknown	1*	0.00	0.11	0.36	0.13	0.12	10.0	10.0	10.0	10.0	
	1†	0.00	0.12	0.39	0.14	0.14					
Valve leakage in closed position	6*	0.10	1.16	3.22	1.04	0.75	17.0	4.0	17.0	46.0	
	6†	0.13	1.28	3.47	1.11	0.84					
<b>Incipient</b>	<b>26*</b>	<b>2.28</b>	<b>3.25</b>	<b>4.36</b>	<b>0.64</b>	<b>3.24</b>	<b>5.4</b>	<b>1.0</b>	<b>5.6</b>	<b>19.0</b>	
	<b>26†</b>	<b>2.21</b>	<b>3.70</b>	<b>5.50</b>	<b>1.01</b>	<b>3.63</b>					
Abnormal instrument reading	14*	0.02	1.27	4.08	1.48	1.75	7.2	3.0	7.2	19.0	
	14†	0.06	1.41	4.25	1.44	1.95					
Low output	1*	0.01	0.13	0.38	0.12	0.12	1.0	1.0	1.0	1.0	
	1†	0.00	0.16	0.51	0.18	0.14					
Minor in-service problems	9*	0.17	1.44	3.72	1.16	1.12	3.8	2.0	4.2	8.0	
	9†	0.15	1.76	4.90	1.60	1.26					
Other	1*	0.00	0.25	1.01	0.38	0.12	3.0	3.0	3.0	3.0	
	1†	0.00	0.26	1.05	0.39	0.14					
Valve leakage in closed position	1*	0.01	0.13	0.38	0.12	0.12	2.0	2.0	2.0	2.0	
	1†	0.00	0.16	0.51	0.18	0.14					
<b>Unknown</b>	<b>1*</b>	<b>0.00</b>	<b>0.11</b>	<b>0.36</b>	<b>0.13</b>	<b>0.12</b>	<b>87.0</b>	<b>119.0</b>	<b>119.0</b>	<b>119.0</b>	
	<b>1†</b>	<b>0.00</b>	<b>0.12</b>	<b>0.39</b>	<b>0.14</b>	<b>0.14</b>					
Unknown	1*	0.00	0.11	0.36	0.13	0.12	87.0	119.0	119.0	119.0	
	1†	0.00	0.12	0.39	0.14	0.14					
<b>All modes</b>	<b>190*</b>	<b>8.51</b>	<b>21.50</b>	<b>39.29</b>	<b>9.58</b>	<b>23.70</b>	<b>12.5</b>	<b>0.5</b>	<b>13.9</b>	<b>119.0</b>	
	<b>190†</b>	<b>13.43</b>	<b>23.91</b>	<b>36.85</b>	<b>7.20</b>	<b>26.50</b>					
<b>Comments</b>											

**Maintainable item versus failure mode, to be continued**

Item: Valves described by taxonomy code - Globe

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	0.53	0.00	0.00	0.00	0.00	0.53	0.53	0.00	0.00
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.00
Control unit	3.16	0.00	0.00	0.00	0.00	0.53	3.68	0.00	0.00
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.53	0.53	0.00	0.00
Flange	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00
Gear	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00
Indicator	0.00	0.00	0.00	0.00	0.26	0.00	1.05	0.00	0.00
Instrument, general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.53	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00
Monitoring	2.11	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other valve components	0.00	0.00	0.53	0.00	0.53	0.00	1.05	0.00	0.00
Packing	0.00	0.00	2.11	0.00	0.61	0.00	0.00	0.00	0.00
Piston(s)	0.00	0.00	0.00	0.53	1.05	0.53	1.75	0.00	0.00
Positioner	0.53	0.00	0.00	0.00	0.79	0.53	4.74	0.53	0.00
Seals	0.00	0.00	2.37	0.00	2.19	0.00	0.53	0.00	1.05
Seals (gaskets)	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00
Seat rings	0.00	0.00	0.26	0.00	2.46	0.00	0.00	0.00	1.05
Spring	0.00	0.00	0.00	0.00	0.00	0.53	0.18	0.00	0.00
Stem	0.00	0.00	0.53	0.00	0.00	0.00	1.23	0.00	0.00
Subunit	0.53	0.53	0.53	1.58	6.32	0.53	11.58	0.53	2.63
Unknown	0.00	0.00	0.00	0.00	0.00	1.05	1.05	0.00	0.00
Valve body w/internals	0.00	0.00	0.00	0.00	1.58	0.00	1.58	1.05	0.53
Total	7.37	0.53	8.42	2.11	16.32	4.74	31.05	2.11	5.26

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

Item: Valves described by taxonomy code - Globe

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.58
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.53	0.53	0.00	0.00	0.00	0.00	1.58
Control unit	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.53	8.95
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05
Flange	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05
Gear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53
Indicator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32
Instrument, general	0.00	0.53	0.00	0.00	0.53	0.00	0.00	0.00	1.05
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05
Monitoring	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00	3.16
Other	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.53
Other valve components	0.00	0.00	0.53	0.00	0.53	0.00	0.00	0.00	3.16
Packing	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.30
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	4.12
Positioner	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.00	8.16
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.14
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	1.32
Seat rings	1.05	0.00	0.00	0.00	0.53	0.00	0.00	0.00	5.35
Spring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70
Stem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.75
Subunit	1.58	0.00	0.00	0.00	0.00	0.53	0.00	0.53	27.37
Unknown	1.05	1.58	0.00	0.53	0.53	0.53	0.00	0.00	6.32
Valve body w/internals	0.00	4.21	0.00	0.00	0.00	0.00	0.53	0.00	9.47
Total	5.26	6.32	1.58	1.05	4.74	1.05	0.53	1.58	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.



**Failure descriptor versus failure mode, to be continued**

Item: Valves described by taxonomy code - Globe

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.00	0.00	0.00	0.00	2.11	0.00	1.58	1.05	0.00
Breakage	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.53
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53
Control failure	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	0.53	0.00	0.00	0.00	0.00	0.00	2.11	0.00	0.00
Deformation	0.00	0.00	1.58	0.00	0.00	1.05	1.05	0.00	0.00
Erosion	0.00	0.00	0.53	0.00	0.53	0.00	1.05	0.00	0.53
Faulty signal/indication/alarm	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	0.53	0.53	0.53	0.00
Leakage	0.00	0.00	0.00	0.00	0.53	0.53	0.53	0.00	0.00
Looseness	0.00	0.53	1.05	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	1.05	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00
Out of adjustment	4.21	0.00	0.00	1.05	4.21	0.53	15.79	0.00	0.53
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00
Unknown	0.00	0.00	1.05	0.00	0.53	0.00	1.05	0.53	0.00
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	2.11	0.00	0.00
Wear	0.00	0.00	3.16	1.05	8.42	0.53	4.21	0.00	3.16
Total	7.37	0.53	8.42	2.11	16.32	4.74	31.05	2.11	5.26

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

Item: Valves described by taxonomy code - Globe

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	6.32	0.00	1.05	0.53	0.53	0.00	0.00	13.16
Breakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05
Clearance/ alignment failure	1.05	0.00	0.00	0.00	0.00	0.53	0.00	0.00	2.63
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53
Corrosion	0.53	0.00	0.00	0.00	1.05	0.00	0.00	0.53	4.74
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.68
Erosion	1.05	0.00	0.53	0.00	0.00	0.00	0.00	0.00	4.21
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00	1.58
Instrument failure - general	0.53	0.00	0.00	0.00	1.05	0.00	0.00	0.00	3.16
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.58
Looseness	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Material failure - general	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	1.05
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53
Miscellaneous - general	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.53
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.58
Out of adjustment	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.53	27.37
Software failure	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.00	1.05
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53
Unknown	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.53	4.21
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	2.63
Wear	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.05
Total	5.26	6.32	1.58	1.05	4.74	1.05	0.53	1.58	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.3.6.1		Item Control and Safety Equipment Valves Globe Chemical injection									
Population 11	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.3581		Operational time † 0.3123							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max	
Critical	8*	0.15	19.62	66.37	24.40	22.34	14.3	5.0	14.3	28.0	
	8†	0.29	20.98	66.84	24.10	25.62					
External leakage - Process medium	2*	0.84	5.31	12.99	3.95	5.59	6.5	6.0	6.5	7.0	
	2†	0.87	5.93	14.75	4.53	6.40					
Fail to close on demand	6*	0.16	14.86	48.42	17.63	16.76	16.8	5.0	16.8	28.0	
	6†	0.43	16.10	49.17	17.10	19.21					
Degraded	3*	1.53	8.72	20.76	6.20	8.38	11.3	3.5	11.3	19.0	
	3†	3.14	10.27	20.76	5.55	9.61					
High output	1*	0.22	2.99	8.50	2.79	2.79	3.5	3.5	3.5	3.5	
	1†	0.05	3.89	12.53	4.54	3.20					
Internal leakage	1*	0.02	2.62	9.12	3.36	2.79	19.0	19.0	19.0	19.0	
	1†	0.03	2.94	9.51	3.45	3.20					
Other	1*	0.22	2.99	8.50	2.79	2.79	-	-	-	-	
	1†	0.05	3.89	12.53	4.54	3.20					
Incipient	1*	0.22	2.99	8.50	2.79	2.79	3.0	3.0	3.0	3.0	
	1†	0.05	3.89	12.53	4.54	3.20					
Minor in-service problems	1*	0.22	2.99	8.50	2.79	2.79	3.0	3.0	3.0	3.0	
	1†	0.05	3.89	12.53	4.54	3.20					
All modes	12*	18.73	32.87	50.23	9.67	33.51	12.7	3.0	12.7	28.0	
	12†	21.14	37.63	57.96	11.32	38.43					
Comments											

Taxonomy no 4.3.6.2		Item Control and Safety Equipment Valves Globe Combined function								
Population 4	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1051			Operational time † 0.1024					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max
All modes	0* 0†	0.02	3.89	14.96	5.51	0.00	-	-	-	-
		0.02	4.05	15.57	5.73	0.00				
Comments										

Taxonomy no 4.3.6.3		Item Control and Safety Equipment Valves Globe Compressed air								
Population 34	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.8935		Operational time † 0.8707						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	15*	10.35	16.79	25.85	16.79	16.79	10.5	2.0	10.5	24.0
	15†	10.62	17.23	26.53	17.23	17.23				
Fail to close on demand	2*	0.40	2.24	7.05	2.24	2.24	10.5	9.0	10.5	12.0
	2†	0.41	2.30	7.23	2.30	2.30				
Fail to regulate	12*	7.75	13.43	21.76	13.43	13.43	10.8	2.0	10.8	24.0
	12†	7.95	13.78	22.33	13.78	13.78				
Valve leakage in closed position	1*	0.06	1.12	5.31	1.12	1.12	6.0	6.0	6.0	6.0
	1†	0.06	1.15	5.45	1.15	1.15				
<b>Degraded</b>	4*	1.53	4.48	10.25	4.48	4.48	7.8	2.0	7.8	14.0
	4†	1.57	4.59	10.51	4.59	4.59				
External leakage - Utility medium	4*	1.53	4.48	10.25	4.48	4.48	7.8	2.0	7.8	14.0
	4†	1.57	4.59	10.51	4.59	4.59				
<b>Incipient</b>	7*	3.68	7.83	14.72	7.83	7.83	5.7	4.0	5.7	8.0
	7†	3.77	8.04	15.10	8.04	8.04				
Abnormal instrument reading	7*	3.68	7.83	14.72	7.83	7.83	5.7	4.0	5.7	8.0
	7†	3.77	8.04	15.10	8.04	8.04				
<b>All modes</b>	26*	20.39	29.10	40.37	29.10	29.10	8.8	2.0	8.8	24.0
	26†	20.92	29.86	41.43	29.86	29.86				
<b>Comments</b>										

Taxonomy no 4.3.6.4		Item Control and Safety Equipment Valves Globe Condensate processing								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0263		Operational time † 0.0256						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	2*	13.51	76.10	239.54	76.10	76.10	9.0	9.0	9.0	9.0
	2†	13.86	78.10	245.82	78.10	78.10				
Fail to close on demand	1*	1.90	38.05	180.56	38.05	38.05	9.0	9.0	9.0	9.0
	1†	1.95	39.05	185.29	39.05	39.05				
Fail to regulate	1*	1.90	38.05	180.56	38.05	38.05	9.0	9.0	9.0	9.0
	1†	1.95	39.05	185.29	39.05	39.05				
All modes	2*	13.51	76.10	239.54	76.10	76.10	9.0	9.0	9.0	9.0
	2†	13.86	78.10	245.82	78.10	78.10				
Comments										

<b>Taxonomy no</b> 4.3.6.5		<b>Item</b> Control and Safety Equipment Valves Globe Cooling systems									
<b>Population</b> 19	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>				
		<b>Calendar time *</b> 0.4993			<b>Operational time †</b> 0.4866						
<b>Failure mode</b>		<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours)</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
			<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n / τ</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>Critical</b>		1*	0.10	2.00	9.50	2.00	2.00	7.0	7.0	7.0	7.0
		‡†	0.10	2.06	9.75	2.06	2.06				
<b>Fail to regulate</b>		1*	0.10	2.00	9.50	2.00	2.00	7.0	7.0	7.0	7.0
		‡†	0.10	2.06	9.75	2.06	2.06				
<b>All modes</b>		1*	0.10	2.00	9.50	2.00	2.00	7.0	7.0	7.0	7.0
		‡†	0.10	2.06	9.75	2.06	2.06				
<b>Comments</b>											

Taxonomy no 4.3.6.6		Item Control and Safety Equipment Valves Globe Essential power									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0263			Operational time † 0.0256						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
All modes		0* 0†	0.04 0.04	10.09 10.75	38.76 41.28	14.27 15.20	0.00 0.00	-	-	-	-
Comments											



Taxonomy no 4.3.6.7		Item Control and Safety Equipment Valves Globe Flare, vent & blow-down									
Population 14	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)						No of demands			
		Calendar time * 0.3679			Operational time † 0.3585						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ	Min		Mean	Max	
Critical	3*	2.23	8.15	21.08	8.15	8.15	11.7	6.0	11.7	20.0	
	3†	2.29	8.37	21.63	8.37	8.37					
Fail to close on demand	2*	0.96	5.44	17.11	5.44	5.44	7.5	6.0	7.5	9.0	
	2†	0.99	5.58	17.56	5.58	5.58					
Fail to open on demand	1*	0.14	2.72	12.90	2.72	2.72	20.0	20.0	20.0	20.0	
	1†	0.14	2.79	13.24	2.79	2.79					
Degraded	1*	0.14	2.72	12.90	2.72	2.72	11.0	11.0	11.0	11.0	
	1†	0.14	2.79	13.24	2.79	2.79					
Spurious operation	1*	0.14	2.72	12.90	2.72	2.72	11.0	11.0	11.0	11.0	
	1†	0.14	2.79	13.24	2.79	2.79					
Incipient	1*	0.14	2.72	12.90	2.72	2.72	8.0	8.0	8.0	8.0	
	1†	0.14	2.79	13.24	2.79	2.79					
Abnormal instrument reading	1*	0.14	2.72	12.90	2.72	2.72	8.0	8.0	8.0	8.0	
	1†	0.14	2.79	13.24	2.79	2.79					
All modes	5*	5.35	13.59	28.58	13.59	13.59	10.8	6.0	10.8	20.0	
	5†	5.49	13.95	29.33	13.95	13.95					
Comments											

Taxonomy no 4.3.6.8		Item Control and Safety Equipment Valves Globe Gas systems								
Population 85	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 3.1270		Operational time † 2.6771			Active rep.hrs	Repair (manhours)		
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).						Min	Mean	Max
		Lower	Mean	Upper	SD	n/τ				
<b>Critical</b>	39*	0.14	16.46	55.28	20.30	12.47	11.1	1.0	12.0	54.0
	39†	0.15	16.99	56.51	20.70	14.57				
External leakage - Process medium	4*	0.22	1.54	3.86	1.19	1.28	17.5	1.0	21.3	54.0
	4†	0.41	1.60	3.43	0.96	1.49				
Fail to close on demand	12*	0.00	5.18	21.79	8.35	3.84	9.2	4.0	9.5	18.0
	12†	0.00	5.33	22.56	8.67	4.48				
Fail to open on demand	6*	0.26	2.41	6.43	2.05	1.92	16.3	2.0	17.7	48.0
	6†	0.40	2.48	6.05	1.83	2.24				
Fail to regulate	15*	0.01	6.27	25.32	9.53	4.80	9.1	3.0	9.6	29.0
	15†	0.01	6.51	26.23	9.86	5.60				
Spurious operation	1*	0.01	0.36	1.16	0.42	0.32	8.0	8.0	8.0	8.0
	1†	0.03	0.39	1.13	0.37	0.37				
Valve leakage in closed position	1*	0.00	0.28	0.98	0.36	0.32	10.0	10.0	10.0	10.0
	1†	0.00	0.34	1.33	0.50	0.37				
<b>Degraded</b>	22*	1.07	6.87	16.85	5.13	7.04	6.4	1.0	8.1	45.0
	22†	1.33	7.86	18.89	5.68	8.22				
Delayed operation	1*	0.01	0.36	1.16	0.42	0.32	4.0	8.0	8.0	8.0
	1†	0.03	0.39	1.13	0.37	0.37				
External leakage - Process medium	6*	0.01	2.30	8.17	3.02	1.92	6.9	1.0	12.0	45.0
	6†	0.02	2.41	8.09	2.97	2.24				
High output	2*	0.03	0.64	1.92	0.65	0.64	2.0	2.0	2.5	3.0
	2†	0.07	0.74	2.04	0.66	0.75				
Low output	7*	0.01	1.66	6.35	2.34	2.24	4.1	1.5	4.1	8.0
	7†	0.00	2.13	8.65	3.26	2.61				
Plugged/Choked	1*	0.00	0.28	0.98	0.36	0.32	-	-	-	-
	1†	0.00	0.34	1.33	0.50	0.37				
Valve leakage in closed position	5*	0.26	1.66	4.07	1.24	1.60	11.2	4.0	11.2	24.0
	5†	0.51	1.87	3.93	1.08	1.87				
<b>Incipient</b>	8*	1.19	2.64	4.56	1.04	2.56	6.9	1.0	6.9	19.0
	8†	1.51	3.01	4.93	1.06	2.99				
Abnormal instrument reading	4*	0.03	1.45	4.46	1.57	1.28	10.4	6.0	10.4	19.0
	4†	0.10	1.58	4.58	1.52	1.49				
Low output	1*	0.00	0.28	0.98	0.36	0.32	1.0	1.0	1.0	1.0
	1†	0.00	0.34	1.33	0.50	0.37				
Minor in-service problems	2*	0.03	0.64	1.92	0.65	0.64	5.0	2.0	5.0	8.0
	2†	0.07	0.74	2.04	0.66	0.75				
Other	1*	0.01	0.36	1.16	0.42	0.32	3.0	3.0	3.0	3.0
	1†	0.03	0.39	1.13	0.37	0.37				
<b>All modes</b>	69*	5.66	25.94	58.36	16.86	22.07	9.2	1.0	10.2	54.0
	69†	8.37	27.69	56.17	15.06	25.77				
<b>Comments</b>										

Taxonomy no 4.3.6.9		Item Control and Safety Equipment Valves Globe Main power								
Population 3	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0788			Operational time † 0.0768					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.02 0.02	4.90 5.12	18.81 19.65	6.93 7.24	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 4.3.6.10		Item Control and Safety Equipment Valves Globe Oil systems								
Population 33	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 1.1979		Operational time † 0.9880						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	13*	0.07	14.61	53.17	19.64	10.85	17.2	1.5	21.0	93.0
	13†	0.10	15.57	53.99	19.91	13.16				
Fail to close on demand	1*	0.01	0.73	2.32	0.83	0.83	2.0	2.0	2.0	2.0
	1†	0.01	0.90	2.94	1.07	1.01				
Fail to open on demand	1*	0.01	0.73	2.32	0.83	0.83	1.5	1.5	1.5	1.5
	1†	0.01	0.90	2.94	1.07	1.01				
Fail to regulate	10*	0.02	12.37	49.69	18.66	8.35	20.8	2.0	25.3	93.0
	10†	0.03	12.93	51.28	19.14	10.12				
Structural deficiency	1*	0.01	1.13	4.13	1.53	0.83	12.0	16.0	16.0	16.0
	1†	0.01	1.18	3.79	1.37	1.01				
<b>Degraded</b>	9*	3.80	7.39	11.93	2.50	7.51	17.3	0.5	18.8	42.0
	9†	4.28	8.82	14.68	3.21	9.11				
Fail to open on demand	1*	0.01	0.73	2.32	0.83	0.83	0.5	0.5	0.5	0.5
	1†	0.01	0.90	2.94	1.07	1.01				
Internal leakage	2*	0.28	2.23	5.74	1.79	1.67	39.5	37.0	39.5	42.0
	2†	0.53	2.28	5.02	1.43	2.02				
Low output	4*	0.83	2.94	6.11	1.67	3.34	9.8	6.0	9.8	13.0
	4†	0.28	3.33	9.34	3.05	4.05				
Other	1*	0.01	1.13	4.13	1.53	0.83	20.0	32.0	32.0	32.0
	1†	0.01	1.18	3.79	1.37	1.01				
Plugged/Choked	1*	0.01	0.73	2.32	0.83	0.83	-	-	-	-
	1†	0.01	0.90	2.94	1.07	1.01				
<b>Incipient</b>	6*	0.58	4.39	11.18	3.47	5.01	2.5	2.0	3.2	8.0
	6†	2.31	5.69	10.28	2.48	6.07				
Minor in-service problems	5*	0.52	3.78	9.54	2.95	4.17	2.6	2.0	3.4	8.0
	5†	0.51	4.54	11.94	3.77	5.06				
Valve leakage in closed position	1*	0.01	0.73	2.32	0.83	0.83	2.0	2.0	2.0	2.0
	1†	0.01	0.90	2.94	1.07	1.01				
<b>Unknown</b>	1*	0.01	1.13	4.13	1.53	0.83	87.0	119.0	119.0	119.0
	1†	0.01	1.18	3.79	1.37	1.01				
Unknown	1*	0.01	1.13	4.13	1.53	0.83	87.0	119.0	119.0	119.0
	1†	0.01	1.18	3.79	1.37	1.01				
<b>All modes</b>	29*	5.29	26.70	61.66	18.11	24.21	16.6	0.5	20.0	119.0
	29†	8.18	29.90	62.72	17.25	29.35				
<b>Comments</b>										

Taxonomy no 4.3.6.11		Item Control and Safety Equipment Valves Globe Oily water treatment								
Population 13	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.3646		Operational time † 0.2991						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	13*	4.47	28.02	68.39	20.77	35.65	11.8	4.0	15.1	48.0
	13†	7.66	35.31	79.57	23.02	43.47				
Fail to close on demand	3*	0.51	7.12	20.43	6.73	8.23	9.3	4.0	9.3	16.0
	3†	0.71	8.78	24.67	8.06	10.03				
Fail to regulate	7*	7.65	17.66	31.04	7.26	19.20	11.0	5.0	11.3	20.0
	7†	0.76	18.47	55.58	18.80	23.41				
High output	1*	0.06	2.52	7.79	2.74	2.74	6.0	6.0	6.0	6.0
	1†	0.07	3.09	9.52	3.34	3.34				
Internal leakage	1*	0.06	2.52	7.79	2.74	2.74	25.0	48.0	48.0	48.0
	1†	0.07	3.09	9.52	3.34	3.34				
Valve leakage in closed position	1*	0.06	2.52	7.79	2.74	2.74	18.0	35.0	35.0	35.0
	1†	0.07	3.09	9.52	3.34	3.34				
<b>Degraded</b>	1*	<b>0.06</b>	<b>2.52</b>	<b>7.79</b>	<b>2.74</b>	<b>2.74</b>	<b>46.0</b>	<b>46.0</b>	<b>46.0</b>	<b>46.0</b>
	1†	<b>0.07</b>	<b>3.09</b>	<b>9.52</b>	<b>3.34</b>	<b>3.34</b>				
Valve leakage in closed position	1*	0.06	2.52	7.79	2.74	2.74	46.0	46.0	46.0	46.0
	1†	0.07	3.09	9.52	3.34	3.34				
<b>Incipient</b>	3*	<b>0.51</b>	<b>7.12</b>	<b>20.43</b>	<b>6.73</b>	<b>8.23</b>	<b>6.3</b>	<b>3.0</b>	<b>6.3</b>	<b>8.0</b>
	3†	<b>0.71</b>	<b>8.78</b>	<b>24.67</b>	<b>8.06</b>	<b>10.03</b>				
Abnormal instrument reading	2*	0.42	4.93	13.77	4.48	5.48	5.5	3.0	5.5	8.0
	2†	0.57	6.07	16.63	5.37	6.69				
Minor in-service problems	1*	0.06	2.52	7.79	2.74	2.74	8.0	8.0	8.0	8.0
	1†	0.07	3.09	9.52	3.34	3.34				
<b>All modes</b>	17*	<b>3.32</b>	<b>34.36</b>	<b>93.51</b>	<b>30.10</b>	<b>46.62</b>	<b>12.9</b>	<b>3.0</b>	<b>15.4</b>	<b>48.0</b>
	17†	<b>5.38</b>	<b>42.91</b>	<b>110.28</b>	<b>34.40</b>	<b>56.84</b>				
<b>Comments</b>										

Taxonomy no 4.3.6.12		Item Control and Safety Equipment Valves Globe Sea water lift									
Population 12	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.3154		Operational time † 0.3073							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	8*	12.62	25.37	45.77	25.37	25.37	20.9	3.0	20.9	78.0	
	8†	12.95	26.03	46.97	26.03	26.03					
External leakage - Process medium	1*	0.16	3.17	15.05	3.17	3.17	8.0	8.0	8.0	8.0	
	1†	0.16	3.25	15.44	3.25	3.25					
Fail to close on demand	1*	0.16	3.17	15.05	3.17	3.17	78.0	78.0	78.0	78.0	
	1†	0.16	3.25	15.44	3.25	3.25					
Fail to regulate	4*	4.33	12.68	29.03	12.68	12.68	6.8	3.0	6.8	17.0	
	4†	4.44	13.02	29.79	13.02	13.02					
Internal leakage	2*	1.13	6.34	19.96	6.34	6.34	27.0	6.0	27.0	48.0	
	2†	1.16	6.51	20.49	6.51	6.51					
<b>Degraded</b>	7*	10.42	22.20	41.70	22.20	22.20	10.1	3.0	10.1	36.0	
	7†	10.69	22.78	42.79	22.78	22.78					
External leakage - Process medium	3*	2.60	9.51	24.59	9.51	9.51	14.0	3.0	14.0	36.0	
	3†	2.67	9.76	25.24	9.76	9.76					
Internal leakage	4*	4.33	12.68	29.03	12.68	12.68	7.3	4.0	7.3	11.0	
	4†	4.44	13.02	29.79	13.02	13.02					
<b>All modes</b>	15*	29.32	47.56	73.23	47.56	47.56	15.9	3.0	15.9	78.0	
	15†	30.08	48.81	75.15	48.81	48.81					
<b>Comments</b>											

Taxonomy no 4.3.6.13		Item Control and Safety Equipment Valves Globe Water injection								
Population 5	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1314		Operational time † 0.1280						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	6*	19.90	45.66	90.11	45.66	45.66	40.7	10.0	50.5	94.0
	6†	20.42	46.86	92.47	46.86	46.86				
Fail to close on demand	1*	0.38	7.61	36.11	7.61	7.61	47.0	47.0	47.0	47.0
	1†	0.39	7.81	37.06	7.81	7.81				
Fail to regulate	4*	10.39	30.44	69.67	30.44	30.44	27.3	10.0	40.5	69.0
	4†	10.66	31.24	71.50	31.24	31.24				
Unknown	1*	0.38	7.61	36.11	7.61	7.61	88.0	94.0	94.0	94.0
	1†	0.39	7.81	37.06	7.81	7.81				
All modes	6*	19.90	45.66	90.11	45.66	45.66	40.7	10.0	50.5	94.0
	6†	20.42	46.86	92.47	46.86	46.86				
Comments										

Taxonomy no 4.3.6.14		Item Control and Safety Equipment Valves Globe Well servicing								
Population 20	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.5256		Operational time † 0.5122						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/r		Min	Mean	Max
Critical	7*	6.25	13.32	25.02	13.32	13.32	12.1	4.0	12.3	49.0
	7†	6.41	13.67	25.68	13.67	13.67				
Fail to close on demand	2*	0.68	3.81	11.98	3.81	3.81	27.0	6.0	27.5	49.0
	2†	0.69	3.91	12.29	3.91	3.91				
Fail to regulate	5*	3.75	9.51	20.01	9.51	9.51	6.2	4.0	6.2	9.0
	5†	3.85	9.76	20.53	9.76	9.76				
Degraded	1*	0.10	1.90	9.03	1.90	1.90	10.0	10.0	10.0	10.0
	1†	0.10	1.95	9.26	1.95	1.95				
Unknown	1*	0.10	1.90	9.03	1.90	1.90	10.0	10.0	10.0	10.0
	1†	0.10	1.95	9.26	1.95	1.95				
All modes	8*	7.57	15.22	27.46	15.22	15.22	11.9	4.0	12.0	49.0
	8†	7.77	15.62	28.18	15.62	15.62				
Comments										



Taxonomy no 4.3.7		Item Control and Safety Equipment Valves PSV - Conventional								
Population 170	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 5.1485			Operational time † 4.8847					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	23*	0.42	3.84	10.15	3.21	4.47	6.3	5.0	6.3	11.0
	23†	0.45	4.05	10.70	3.39	4.71				
Fail to close on demand	3*	0.09	0.57	1.38	0.42	0.58	6.0	6.0	6.0	6.0
	3†	0.10	0.60	1.46	0.44	0.61				
Fail to open on demand	14*	0.32	2.46	6.29	1.96	2.72	6.5	5.0	6.5	11.0
	14†	0.33	2.59	6.63	2.06	2.87				
Valve leakage in closed position	6*	0.17	1.11	2.74	0.84	1.17	6.0	6.0	6.0	6.0
	6†	0.18	1.17	2.89	0.88	1.23				
<b>Degraded</b>	65*	7.43	11.94	17.31	3.03	12.63	6.6	4.0	6.6	16.0
	65†	7.80	12.57	18.27	3.21	13.31				
Spurious operation	65*	7.43	11.94	17.31	3.03	12.63	6.6	4.0	6.6	16.0
	65†	7.80	12.57	18.27	3.21	13.31				
<b>Incipient</b>	99*	4.11	15.29	32.29	8.93	19.23	6.6	2.0	6.6	14.0
	99†	4.32	16.11	34.04	9.42	20.27				
Valve leakage in closed position	99*	4.11	15.29	32.29	8.93	19.23	6.6	2.0	6.6	14.0
	99†	4.32	16.11	34.04	9.42	20.27				
<b>All modes</b>	187*	2.06	23.99	66.77	21.72	36.32	6.5	2.0	6.5	16.0
	187†	2.17	25.28	70.38	22.90	38.28				
<b>Comments</b>										

**Maintainable item versus failure mode, to be continued**

**Item:** Valves described by taxonomy code - PSV - Conventional

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Unknown	0.00	0.00	0.00	0.00	1.60	7.49	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	1.60	7.49	0.00	0.00	0.00

**Maintainable item versus failure mode, continued**

**Item:** Valves described by taxonomy code - PSV - Conventional

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Unknown	56.15	0.00	0.00	0.00	0.00	34.76	0.00	0.00	100.0
Total	56.15	0.00	0.00	0.00	0.00	34.76	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Valves described by taxonomy code - PSV - Conventional

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Material failure - general	0.00	0.00	0.00	0.00	1.60	7.49	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	1.60	7.49	0.00	0.00	0.00

**Failure descriptor versus failure mode, continued**

**Item:** Valves described by taxonomy code - PSV - Conventional

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Material failure - general	56.15	0.00	0.00	0.00	0.00	34.76	0.00	0.00	100.0
Total	56.15	0.00	0.00	0.00	0.00	34.76	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.3.7.1		Item Control and Safety Equipment Valves PSV - Conventional Crude oil handling									
Population 13	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.3987		Operational time † 0.3783							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	4*	3.42	10.03	22.96	10.03	10.03	6.8	6.0	6.8	8.0	
	4†	3.61	10.57	24.20	10.57	10.57					
Fail to open on demand	3*	2.06	7.52	19.45	7.52	7.52	7.0	6.0	7.0	8.0	
	3†	2.17	7.93	20.50	7.93	7.93					
Valve leakage in closed position	1*	0.13	2.51	11.90	2.51	2.51	6.0	6.0	6.0	6.0	
	1†	0.13	2.64	12.54	2.64	2.64					
<b>Degraded</b>	2*	0.89	5.02	15.79	5.02	5.02	9.5	7.0	9.5	12.0	
	2†	0.94	5.29	16.64	5.29	5.29					
Spurious operation	2*	0.89	5.02	15.79	5.02	5.02	9.5	7.0	9.5	12.0	
	2†	0.94	5.29	16.64	5.29	5.29					
<b>Incipient</b>	2*	0.89	5.02	15.79	5.02	5.02	9.0	6.0	9.0	12.0	
	2†	0.94	5.29	16.64	5.29	5.29					
Valve leakage in closed position	2*	0.89	5.02	15.79	5.02	5.02	9.0	6.0	9.0	12.0	
	2†	0.94	5.29	16.64	5.29	5.29					
<b>All modes</b>	8*	9.98	20.06	36.20	20.06	20.06	8.0	6.0	8.0	12.0	
	8†	10.52	21.15	38.16	21.15	21.15					
<b>Comments</b>											

Taxonomy no 4.3.7.2		Item Control and Safety Equipment Valves PSV - Conventional Gas systems								
Population 83	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 2.4800		Operational time † 2.3530						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	5*	0.24	1.87	4.76	1.48	2.02	7.0	6.0	7.0	11.0
	5†	0.26	1.97	5.01	1.56	2.12				
Fail to open on demand	2*	0.12	0.78	1.93	0.59	0.81	8.5	6.0	8.5	11.0
	2†	0.12	0.82	2.04	0.62	0.85				
Valve leakage in closed position	3*	0.17	1.15	2.88	0.89	1.21	6.0	6.0	6.0	6.0
	3†	0.17	1.21	3.04	0.93	1.27				
Degraded	36*	5.60	12.83	22.46	5.23	14.52	6.7	4.0	6.7	16.0
	36†	5.89	13.51	23.69	5.52	15.30				
Spurious operation	36*	5.60	12.83	22.46	5.23	14.52	6.7	4.0	6.7	16.0
	36†	5.89	13.51	23.69	5.52	15.30				
Incipient	50*	3.63	15.75	34.86	9.96	20.16	6.7	4.0	6.7	14.0
	50†	3.82	16.60	36.75	10.50	21.25				
Valve leakage in closed position	50*	3.63	15.75	34.86	9.96	20.16	6.7	4.0	6.7	14.0
	50†	3.82	16.60	36.75	10.50	21.25				
All modes	91*	1.92	24.32	68.73	22.50	36.69	6.7	4.0	6.7	16.0
	91†	2.02	25.63	72.45	23.72	38.67				
Comments										

Taxonomy no 4.3.7.3		Item Control and Safety Equipment Valves PSV - Conventional Main power																																																																																																																																																						
Population 51	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands																																																																																																																																																	
		Calendar time * 1.5643		Operational time † 1.4841																																																																																																																																																				
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)																																																																																																																																																
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max																																																																																																																																														
<b>Critical</b>	11*	3.94	7.03	11.64	7.03	7.03	5.9	5.0	5.9	6.0																																																																																																																																														
	11†	4.16	7.41	12.27	7.41	7.41					Fail to close on demand	3*	0.52	1.92	4.96	1.92	1.92	6.0	6.0	6.0	6.0	3†	0.55	2.02	5.23	2.02	2.02	Fail to open on demand	7*	2.10	4.47	8.41	4.47	4.47	5.9	5.0	5.9	6.0	7†	2.21	4.72	8.86	4.72	4.72	Valve leakage in closed position	1*	0.03	0.64	3.03	0.64	0.64	6.0	6.0	6.0	6.0	1†	0.03	0.67	3.20	0.67	0.67	<b>Degraded</b>	21*	9.00	13.42	19.33	13.42	13.42	6.2	4.0	6.2	10.0	21†	9.48	14.15	20.38	14.15	14.15	Spurious operation	21*	9.00	13.42	19.33	13.42	13.42	6.2	4.0	6.2	10.0	21†	9.48	14.15	20.38	14.15	14.15	<b>Incipient</b>	34*	15.99	21.74	28.94	21.74	21.74	5.9	2.0	5.9	7.0	34†	16.85	22.91	30.50	22.91	22.91	Valve leakage in closed position	34*	15.99	21.74	28.94	21.74	21.74	5.9	2.0	5.9	7.0	34†	16.85	22.91	30.50	22.91	22.91	<b>All modes</b>	66*	34.03	42.19	51.79	42.19	42.19	6.0	2.0	6.0	10.0	66†	35.87	44.47	54.58	44.47	44.47	<b>Comments</b>					
Fail to close on demand	3*	0.52	1.92	4.96	1.92	1.92	6.0	6.0	6.0	6.0																																																																																																																																														
	3†	0.55	2.02	5.23	2.02	2.02					Fail to open on demand	7*	2.10	4.47	8.41	4.47	4.47	5.9	5.0	5.9	6.0	7†	2.21	4.72	8.86	4.72	4.72	Valve leakage in closed position	1*	0.03	0.64	3.03	0.64	0.64	6.0	6.0	6.0	6.0	1†	0.03	0.67	3.20	0.67	0.67	<b>Degraded</b>	21*	9.00	13.42	19.33	13.42	13.42	6.2	4.0	6.2	10.0	21†	9.48	14.15	20.38	14.15	14.15	Spurious operation	21*	9.00	13.42	19.33	13.42	13.42	6.2	4.0	6.2	10.0	21†	9.48	14.15	20.38	14.15	14.15	<b>Incipient</b>	34*	15.99	21.74	28.94	21.74	21.74	5.9	2.0	5.9	7.0	34†	16.85	22.91	30.50	22.91	22.91	Valve leakage in closed position	34*	15.99	21.74	28.94	21.74	21.74	5.9	2.0	5.9	7.0	34†	16.85	22.91	30.50	22.91	22.91	<b>All modes</b>	66*	34.03	42.19	51.79	42.19	42.19	6.0	2.0	6.0	10.0	66†	35.87	44.47	54.58	44.47	44.47	<b>Comments</b>																						
Fail to open on demand	7*	2.10	4.47	8.41	4.47	4.47	5.9	5.0	5.9	6.0																																																																																																																																														
	7†	2.21	4.72	8.86	4.72	4.72					Valve leakage in closed position	1*	0.03	0.64	3.03	0.64	0.64	6.0	6.0	6.0	6.0	1†	0.03	0.67	3.20	0.67	0.67	<b>Degraded</b>	21*	9.00	13.42	19.33	13.42	13.42	6.2	4.0	6.2	10.0	21†	9.48	14.15	20.38	14.15	14.15	Spurious operation	21*	9.00	13.42	19.33	13.42	13.42	6.2	4.0	6.2	10.0	21†	9.48	14.15	20.38	14.15	14.15	<b>Incipient</b>	34*	15.99	21.74	28.94	21.74	21.74	5.9	2.0	5.9	7.0	34†	16.85	22.91	30.50	22.91	22.91	Valve leakage in closed position	34*	15.99	21.74	28.94	21.74	21.74	5.9	2.0	5.9	7.0	34†	16.85	22.91	30.50	22.91	22.91	<b>All modes</b>	66*	34.03	42.19	51.79	42.19	42.19	6.0	2.0	6.0	10.0	66†	35.87	44.47	54.58	44.47	44.47	<b>Comments</b>																																							
Valve leakage in closed position	1*	0.03	0.64	3.03	0.64	0.64	6.0	6.0	6.0	6.0																																																																																																																																														
	1†	0.03	0.67	3.20	0.67	0.67					<b>Degraded</b>	21*	9.00	13.42	19.33	13.42	13.42	6.2	4.0	6.2	10.0	21†	9.48	14.15	20.38	14.15	14.15	Spurious operation	21*	9.00	13.42	19.33	13.42	13.42	6.2	4.0	6.2	10.0	21†	9.48	14.15	20.38	14.15	14.15	<b>Incipient</b>	34*	15.99	21.74	28.94	21.74	21.74	5.9	2.0	5.9	7.0	34†	16.85	22.91	30.50	22.91	22.91	Valve leakage in closed position	34*	15.99	21.74	28.94	21.74	21.74	5.9	2.0	5.9	7.0	34†	16.85	22.91	30.50	22.91	22.91	<b>All modes</b>	66*	34.03	42.19	51.79	42.19	42.19	6.0	2.0	6.0	10.0	66†	35.87	44.47	54.58	44.47	44.47	<b>Comments</b>																																																								
<b>Degraded</b>	21*	9.00	13.42	19.33	13.42	13.42	6.2	4.0	6.2	10.0																																																																																																																																														
	21†	9.48	14.15	20.38	14.15	14.15					Spurious operation	21*	9.00	13.42	19.33	13.42	13.42	6.2	4.0	6.2	10.0	21†	9.48	14.15	20.38	14.15	14.15	<b>Incipient</b>	34*	15.99	21.74	28.94	21.74	21.74	5.9	2.0	5.9	7.0	34†	16.85	22.91	30.50	22.91	22.91	Valve leakage in closed position	34*	15.99	21.74	28.94	21.74	21.74	5.9	2.0	5.9	7.0	34†	16.85	22.91	30.50	22.91	22.91	<b>All modes</b>	66*	34.03	42.19	51.79	42.19	42.19	6.0	2.0	6.0	10.0	66†	35.87	44.47	54.58	44.47	44.47	<b>Comments</b>																																																																									
Spurious operation	21*	9.00	13.42	19.33	13.42	13.42	6.2	4.0	6.2	10.0																																																																																																																																														
	21†	9.48	14.15	20.38	14.15	14.15					<b>Incipient</b>	34*	15.99	21.74	28.94	21.74	21.74	5.9	2.0	5.9	7.0	34†	16.85	22.91	30.50	22.91	22.91	Valve leakage in closed position	34*	15.99	21.74	28.94	21.74	21.74	5.9	2.0	5.9	7.0	34†	16.85	22.91	30.50	22.91	22.91	<b>All modes</b>	66*	34.03	42.19	51.79	42.19	42.19	6.0	2.0	6.0	10.0	66†	35.87	44.47	54.58	44.47	44.47	<b>Comments</b>																																																																																										
<b>Incipient</b>	34*	15.99	21.74	28.94	21.74	21.74	5.9	2.0	5.9	7.0																																																																																																																																														
	34†	16.85	22.91	30.50	22.91	22.91					Valve leakage in closed position	34*	15.99	21.74	28.94	21.74	21.74	5.9	2.0	5.9	7.0	34†	16.85	22.91	30.50	22.91	22.91	<b>All modes</b>	66*	34.03	42.19	51.79	42.19	42.19	6.0	2.0	6.0	10.0	66†	35.87	44.47	54.58	44.47	44.47	<b>Comments</b>																																																																																																											
Valve leakage in closed position	34*	15.99	21.74	28.94	21.74	21.74	5.9	2.0	5.9	7.0																																																																																																																																														
	34†	16.85	22.91	30.50	22.91	22.91					<b>All modes</b>	66*	34.03	42.19	51.79	42.19	42.19	6.0	2.0	6.0	10.0	66†	35.87	44.47	54.58	44.47	44.47	<b>Comments</b>																																																																																																																												
<b>All modes</b>	66*	34.03	42.19	51.79	42.19	42.19	6.0	2.0	6.0	10.0																																																																																																																																														
	66†	35.87	44.47	54.58	44.47	44.47																																																																																																																																																		
<b>Comments</b>																																																																																																																																																								

Taxonomy no 4.3.7.4		Item Control and Safety Equipment Valves PSV - Conventional Water fire fighting								
Population 11	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.3374		Operational time † 0.3201						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	2*	1.05	5.93	18.66	5.93	5.93	6.0	6.0	6.0	6.0
	2†	1.11	6.25	19.67	6.25	6.25				
Fail to open on demand	2*	1.05	5.93	18.66	5.93	5.93	6.0	6.0	6.0	6.0
	2†	1.11	6.25	19.67	6.25	6.25				
<b>Degraded</b>	1*	0.15	2.96	14.06	2.96	2.96	6.0	6.0	6.0	6.0
	1†	0.16	3.12	14.82	3.12	3.12				
Spurious operation	1*	0.15	2.96	14.06	2.96	2.96	6.0	6.0	6.0	6.0
	1†	0.16	3.12	14.82	3.12	3.12				
<b>Incipient</b>	5*	5.84	14.82	31.17	14.82	14.82	7.4	6.0	7.4	9.0
	5†	6.15	15.62	32.85	15.62	15.62				
Valve leakage in closed position	5*	5.84	14.82	31.17	14.82	14.82	7.4	6.0	7.4	9.0
	5†	6.15	15.62	32.85	15.62	15.62				
<b>All modes</b>	8*	11.80	23.71	42.78	23.71	23.71	6.9	6.0	6.9	9.0
	8†	12.43	24.99	45.10	24.99	24.99				
<b>Comments</b>										

Taxonomy no 4.3.7.5		Item Control and Safety Equipment Valves PSV - Conventional Water injection								
Population 12	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *		Operational time †						
		0.3681		0.3492						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / τ		Min	Mean	Max
<b>Critical</b>	1*	0.14	2.72	12.89	2.72	2.72	6.0	6.0	6.0	6.0
	1†	0.14	2.86	13.59	2.86	2.86				
Valve leakage in closed position	1*	0.14	2.72	12.89	2.72	2.72	6.0	6.0	6.0	6.0
	1†	0.14	2.86	13.59	2.86	2.86				
<b>Degraded</b>	5*	5.35	13.58	28.57	13.58	13.58	6.0	6.0	6.0	6.0
	5†	5.64	14.32	30.11	14.32	14.32				
Spurious operation	5*	5.35	13.58	28.57	13.58	13.58	6.0	6.0	6.0	6.0
	5†	5.64	14.32	30.11	14.32	14.32				
<b>Incipient</b>	8*	10.81	21.74	39.22	21.74	21.74	7.4	6.0	7.4	12.0
	8†	11.40	22.91	41.34	22.91	22.91				
Valve leakage in closed position	8*	10.81	21.74	39.22	21.74	21.74	7.4	6.0	7.4	12.0
	8†	11.40	22.91	41.34	22.91	22.91				
<b>All modes</b>	14*	22.99	38.04	59.46	38.04	38.04	6.8	6.0	6.8	12.0
	14†	24.23	40.09	62.67	40.09	40.09				
<b>Comments</b>										

Taxonomy no 4.3.8		Item Control and Safety Equipment Valves PSV - Conventional w/bellows								
Population 32	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.6747		Operational time † 0.4284						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
<b>Critical</b>	1*	0.03	1.35	4.19	1.48	1.48	15.0	30.0	30.0	30.0
	1†	0.02	2.17	7.34	2.70	2.33				
External leakage - Process medium	1*	0.03	1.35	4.19	1.48	1.48	15.0	30.0	30.0	30.0
	1†	0.02	2.17	7.34	2.70	2.33				
<b>Degraded</b>	7*	0.71	8.38	23.41	7.63	10.38	5.4	2.0	10.6	30.0
	7†	0.15	14.03	45.69	16.63	16.34				
Delayed operation	3*	0.92	4.05	8.97	2.57	4.45	4.7	5.0	9.0	14.0
	3†	0.62	6.40	17.36	5.58	7.00				
External leakage - Process medium	1*	0.03	1.35	4.19	1.48	1.48	1.0	2.0	2.0	2.0
	1†	0.02	2.17	7.34	2.70	2.33				
Spurious operation	2*	0.05	2.57	7.98	2.83	2.96	9.5	7.0	18.5	30.0
	2†	0.68	4.39	10.82	3.30	4.67				
Valve leakage in closed position	1*	0.03	1.35	4.19	1.48	1.48	4.0	8.0	8.0	8.0
	1†	0.02	2.17	7.34	2.70	2.33				
<b>Incipient</b>	5*	1.06	6.38	15.39	4.64	7.41	5.2	6.0	10.2	16.0
	5†	0.21	10.21	31.62	11.17	11.67				
Delayed operation	2*	0.05	2.57	7.98	2.83	2.96	4.0	7.0	7.5	8.0
	2†	0.68	4.39	10.82	3.30	4.67				
Spurious operation	3*	0.92	4.05	8.97	2.57	4.45	6.0	6.0	12.0	16.0
	3†	0.62	6.40	17.36	5.58	7.00				
<b>All modes</b>	13*	0.22	14.39	45.37	16.26	19.27	6.1	2.0	11.9	30.0
	13†	0.16	25.48	89.11	32.89	30.35				
<b>Comments</b>										



**Maintainable item versus failure mode, to be continued**

Item: Valves described by taxonomy code - PSV - Conventional w/bellows

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Seals	0.00	0.00	7.69	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Valve body w/internals	0.00	38.46	7.69	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	38.46	15.38	0.00	0.00	0.00	0.00	0.00	0.00

**Maintainable item versus failure mode, continued**

Item: Valves described by taxonomy code - PSV - Conventional w/bellows

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.69
Subunit	7.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.69
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	38.46	0.00	0.00	84.62
Total	7.69	0.00	0.00	0.00	0.00	38.46	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Valves described by taxonomy code - PSV - Conventional w/bellows

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Leakage	0.00	0.00	15.38	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	30.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	0.00	7.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	38.46	15.38	0.00	0.00	0.00	0.00	0.00	0.00

**Failure descriptor versus failure mode, continued**

Item: Valves described by taxonomy code - PSV - Conventional w/bellows

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Leakage	7.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.08
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	30.77	0.00	0.00	61.54
Out of adjustment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.69
Unknown	0.00	0.00	0.00	0.00	0.00	7.69	0.00	0.00	7.69
Total	7.69	0.00	0.00	0.00	0.00	38.46	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.3.8.1		Item Control and Safety Equipment Valves PSV - Conventional w/bellows Condensate processing									
Population 4	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time † 0.0701			Operational time † 0.0666						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n / τ		Min	Mean	Max	
All modes		0* 0†	0.02 0.02	4.77 5.80	18.31 22.28	6.74 8.20	0.00 0.00	-	-	-	-
Comments											

Taxonomy no 4.3.8.2		Item Control and Safety Equipment Valves PSV - Conventional w/bellows Gas systems								
Population 21	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.4457			Operational time † 0.2728					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Degraded	4*	2.42	8.15	16.65	4.49	8.98	4.5	5.0	8.5	14.0
	4†	0.88	12.90	37.28	12.31	14.66				
Delayed operation	3*	0.10	5.61	17.52	6.23	6.73	4.7	5.0	9.0	14.0
	3†	1.29	10.01	25.61	7.97	11.00				
Spurious operation	1*	0.04	2.04	6.33	2.24	2.24	4.0	7.0	7.0	7.0
	1†	0.03	3.38	11.18	4.09	3.67				
Incipient	4*	2.42	8.15	16.65	4.49	8.98	5.5	6.0	11.0	16.0
	4†	0.88	12.90	37.28	12.31	14.66				
Delayed operation	1*	0.04	2.04	6.33	2.24	2.24	4.0	8.0	8.0	8.0
	1†	0.03	3.38	11.18	4.09	3.67				
Spurious operation	3*	0.10	5.61	17.52	6.23	6.73	6.0	6.0	12.0	16.0
	3†	1.29	10.01	25.61	7.97	11.00				
All modes	8*	1.26	14.26	39.48	12.81	17.95	5.0	5.0	9.8	16.0
	8†	0.27	24.46	79.55	28.94	29.32				
Comments										

Taxonomy no 4.3.8.3		Item Control and Safety Equipment Valves PSV - Conventional w/bellows Oil systems								
Population 7	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1589		Operational time † 0.0890						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	1*	0.31	6.29	29.86	6.29	6.29	15.0	30.0	30.0	30.0
	1†	0.56	11.24	53.31	11.24	11.24				
External leakage - Process medium	1*	0.31	6.29	29.86	6.29	6.29	15.0	30.0	30.0	30.0
	1†	0.56	11.24	53.31	11.24	11.24				
<b>Degraded</b>	3*	5.16	18.88	48.80	18.88	18.88	6.7	2.0	13.3	30.0
	3†	9.21	33.71	87.13	33.71	33.71				
External leakage - Process medium	1*	0.31	6.29	29.86	6.29	6.29	1.0	2.0	2.0	2.0
	1†	0.56	11.24	53.31	11.24	11.24				
Spurious operation	1*	0.31	6.29	29.86	6.29	6.29	15.0	30.0	30.0	30.0
	1†	0.56	11.24	53.31	11.24	11.24				
Valve leakage in closed position	1*	0.31	6.29	29.86	6.29	6.29	4.0	8.0	8.0	8.0
	1†	0.56	11.24	53.31	11.24	11.24				
<b>Incipient</b>	1*	0.31	6.29	29.86	6.29	6.29	4.0	7.0	7.0	7.0
	1†	0.56	11.24	53.31	11.24	11.24				
Delayed operation	1*	0.31	6.29	29.86	6.29	6.29	4.0	7.0	7.0	7.0
	1†	0.56	11.24	53.31	11.24	11.24				
<b>All modes</b>	5*	12.40	31.46	66.16	31.46	31.46	7.8	2.0	15.4	30.0
	5†	22.13	56.18	118.15	56.18	56.18				
<b>Comments</b>										

Taxonomy no 4.3.9		Item Control and Safety Equipment Valves PSV - Pilot operated									
Population 34	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 1.1545			Operational time † 0.8041						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	3*	0.19	2.27	6.35	2.07	2.60	-	4.0	6.7	8.0	
	3†	0.07	3.28	10.16	3.60	3.73					
External leakage - Process medium	1*	0.00	0.77	2.80	1.03	0.87	-	8.0	8.0	8.0	
	1†	0.00	1.13	4.39	1.63	1.24					
Fail to close on demand	1*	0.00	0.77	2.80	1.03	0.87	-	4.0	4.0	4.0	
	1†	0.00	1.13	4.39	1.63	1.24					
Spurious operation	1*	0.00	0.77	2.80	1.03	0.87	-	8.0	8.0	8.0	
	1†	0.00	1.13	4.39	1.63	1.24					
<b>Degraded</b>	5*	0.02	3.44	12.07	4.46	4.33	3.0	4.0	6.6	10.0	
	5†	0.02	5.15	19.53	7.20	6.22					
Delayed operation	1*	0.00	0.77	2.80	1.03	0.87	-	6.0	6.0	6.0	
	1†	0.00	1.13	4.39	1.63	1.24					
Spurious operation	3*	0.19	2.27	6.35	2.07	2.60	3.0	4.0	6.3	10.0	
	3†	0.07	3.28	10.16	3.60	3.73					
Valve leakage in closed position	1*	0.00	0.77	2.80	1.03	0.87	-	8.0	8.0	8.0	
	1†	0.00	1.13	4.39	1.63	1.24					
<b>Incipient</b>	7*	0.66	5.26	13.50	4.21	6.06	2.0	1.0	8.0	24.0	
	7†	0.56	7.79	22.35	7.36	8.71					
Other	1*	0.00	0.77	2.80	1.03	0.87	-	24.0	24.0	24.0	
	1†	0.00	1.13	4.39	1.63	1.24					
Spurious operation	4*	0.33	3.16	8.45	2.69	3.46	1.0	1.0	6.3	14.0	
	4†	1.59	4.83	9.51	2.49	4.97					
Valve leakage in closed position	2*	0.23	1.59	3.98	1.22	1.73	3.0	2.0	3.5	5.0	
	2†	0.35	2.33	5.75	1.76	2.49					
<b>All modes</b>	15*	0.05	9.89	36.61	13.52	12.99	2.3	1.0	7.3	24.0	
	15†	0.06	15.29	58.36	21.51	18.65					
<b>Comments</b>											

**Maintainable item versus failure mode, to be continued**

**Item:** Valves described by taxonomy code - PSV - Pilot operated

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Other valve components	0.00	0.00	6.67	0.00	0.00	0.00	0.00	0.00	0.00
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	6.67	0.00	0.00	6.67	0.00	0.00	0.00	0.00
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	6.67	6.67	0.00	6.67	0.00	0.00	0.00	0.00

**Maintainable item versus failure mode, continued**

**Item:** Valves described by taxonomy code - PSV - Pilot operated

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Other valve components	6.67	0.00	6.67	0.00	0.00	13.33	0.00	0.00	33.33
Seat rings	0.00	0.00	0.00	0.00	0.00	6.67	0.00	0.00	6.67
Subunit	6.67	0.00	0.00	0.00	0.00	6.67	0.00	0.00	26.67
Valve body w/internals	6.67	0.00	0.00	0.00	0.00	26.67	0.00	0.00	33.33
Total	20.00	0.00	6.67	0.00	0.00	53.33	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Valves described by taxonomy code - PSV - Pilot operated

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Breakage	0.00	0.00	6.67	0.00	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	0.00	0.00	6.67	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	6.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	6.67	6.67	0.00	6.67	0.00	0.00	0.00	0.00

**Failure descriptor versus failure mode, continued**

**Item:** Valves described by taxonomy code - PSV - Pilot operated

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Breakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.67
Leakage	6.67	0.00	0.00	0.00	0.00	20.00	0.00	0.00	33.33
Mechanical Failure - general	13.33	0.00	6.67	0.00	0.00	6.67	0.00	0.00	33.33
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	20.00
No cause found	0.00	0.00	0.00	0.00	0.00	6.67	0.00	0.00	6.67
Total	20.00	0.00	6.67	0.00	0.00	53.33	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.3.9.1		Item Control and Safety Equipment Valves PSV - Pilot operated Condensate processing									
Population 8	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1402		Operational time † 0.1331							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max	
All modes	0* 0†	0.01 0.01	2.62 3.02	10.07 11.58	3.71 4.26	0.00 0.00	-	-	-	-	
Comments											

Taxonomy no 4.3.9.2		Item Control and Safety Equipment Valves PSV - Pilot operated Gas systems									
Population 7	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)						No of demands			
		Calendar time * 0.1226			Operational time † 0.1165						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
All modes	0* 0†	0.01 0.01	2.89 3.35	11.09 12.87	4.08 4.74	0.00 0.00	-	-	-	-	
Comments											



Taxonomy no 4.3.9.3		Item Control and Safety Equipment Valves PSV - Pilot operated Oil systems									
Population 19	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.8917		Operational time † 0.5545							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Critical	3*	0.35	3.07	8.02	2.52	3.36	-	4.0	6.7	8.0	
	3†	0.69	4.93	12.40	3.83	5.41					
External leakage - Process medium	1*	0.01	1.04	3.46	1.27	1.12	-	8.0	8.0	8.0	
	1†	0.02	1.66	5.46	1.99	1.80					
Fail to close on demand	1*	0.01	1.04	3.46	1.27	1.12	-	4.0	4.0	4.0	
	1†	0.02	1.66	5.46	1.99	1.80					
Spurious operation	1*	0.01	1.04	3.46	1.27	1.12	-	8.0	8.0	8.0	
	1†	0.02	1.66	5.46	1.99	1.80					
Degraded	5*	0.13	4.86	14.84	5.16	5.61	3.0	4.0	6.6	10.0	
	5†	0.27	7.75	23.43	8.01	9.02					
Delayed operation	1*	0.01	1.04	3.46	1.27	1.12	-	6.0	6.0	6.0	
	1†	0.02	1.66	5.46	1.99	1.80					
Spurious operation	3*	0.35	3.07	8.02	2.52	3.36	3.0	4.0	6.3	10.0	
	3†	0.69	4.93	12.40	3.83	5.41					
Valve leakage in closed position	1*	0.01	1.04	3.46	1.27	1.12	-	8.0	8.0	8.0	
	1†	0.02	1.66	5.46	1.99	1.80					
Incipient	7*	2.95	7.49	13.70	3.35	7.85	2.0	1.0	8.0	24.0	
	7†	5.46	12.10	20.86	4.77	12.62					
Other	1*	0.01	1.04	3.46	1.27	1.12	-	24.0	24.0	24.0	
	1†	0.02	1.66	5.46	1.99	1.80					
Spurious operation	4*	1.46	4.39	8.61	2.24	4.49	1.0	1.0	6.3	14.0	
	4†	2.34	7.06	13.84	3.61	7.21					
Valve leakage in closed position	2*	0.32	2.10	5.19	1.59	2.24	3.0	2.0	3.5	5.0	
	2†	0.50	3.36	8.33	2.55	3.61					
All modes	15*	0.82	14.50	42.86	14.26	16.82	2.3	1.0	7.3	24.0	
	15†	1.54	23.10	66.92	22.12	27.05					
Comments											

Taxonomy no 4.3.10		Item Control and Safety Equipment Valves Unknown									
Population 114	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 3.1738		Operational time † 3.1710							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	15*	2.91	4.73	7.28	4.73	4.73	2.7	0.5	12.1	50.0	
	15†	2.92	4.73	7.28	4.73	4.73					
Fail to close on demand	2*	0.11	0.63	1.98	0.63	0.63	4.0	50.0	50.0	50.0	
	2†	0.11	0.63	1.99	0.63	0.63					
Fail to open on demand	3*	0.26	0.95	2.44	0.95	0.95	4.0	4.0	4.0	4.0	
	3†	0.26	0.95	2.45	0.95	0.95					
Fail to regulate	9*	1.48	2.84	4.95	2.84	2.84	1.7	0.5	1.8	3.0	
	9†	1.48	2.84	4.95	2.84	2.84					
Low output	1*	0.02	0.32	1.50	0.32	0.32	2.0	3.0	3.0	3.0	
	1†	0.02	0.32	1.50	0.32	0.32					
<b>Degraded</b>	6*	0.82	1.89	3.73	1.89	1.89	1.3	1.0	1.3	2.0	
	6†	0.82	1.89	3.73	1.89	1.89					
Low output	2*	0.11	0.63	1.98	0.63	0.63	1.0	1.0	1.0	1.0	
	2†	0.11	0.63	1.99	0.63	0.63					
Minor in-service problems	3*	0.26	0.95	2.44	0.95	0.95	-	-	-	-	
	3†	0.26	0.95	2.45	0.95	0.95					
Plugged/Choked	1*	0.02	0.32	1.50	0.32	0.32	2.0	2.0	2.0	2.0	
	1†	0.02	0.32	1.50	0.32	0.32					
<b>Incipient</b>	4*	0.43	1.26	2.88	1.26	1.26	3.0	3.0	3.0	3.0	
	4†	0.43	1.26	2.89	1.26	1.26					
Abnormal instrument reading	2*	0.11	0.63	1.98	0.63	0.63	-	-	-	-	
	2†	0.11	0.63	1.99	0.63	0.63					
Fail to regulate	1*	0.02	0.32	1.50	0.32	0.32	3.0	3.0	3.0	3.0	
	1†	0.02	0.32	1.50	0.32	0.32					
Unknown	1*	0.02	0.32	1.50	0.32	0.32	3.0	3.0	3.0	3.0	
	1†	0.02	0.32	1.50	0.32	0.32					
<b>All modes</b>	25*	5.48	7.88	11.00	7.88	7.88	2.4	0.5	7.1	50.0	
	25†	5.48	7.88	11.01	7.88	7.88					
<b>Comments</b>											

**Maintainable item versus failure mode, to be continued**

Item: Valves described by taxonomy code - Unknown

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Unknown	8.00	0.00	0.00	0.00	8.00	12.00	40.00	0.00	0.00
Total	8.00	0.00	0.00	0.00	8.00	12.00	40.00	0.00	0.00

**Maintainable item versus failure mode, continued**

Item: Valves described by taxonomy code - Unknown

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Unknown	0.00	12.00	0.00	4.00	12.00	0.00	0.00	4.00	100.0
Total	0.00	12.00	0.00	4.00	12.00	0.00	0.00	4.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Valves described by taxonomy code - Unknown

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.00	0.00	0.00	0.00	4.00	4.00	0.00	0.00	0.00
Instrument failure - general	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00	40.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	4.00	0.00	0.00	0.00	0.00
Out of adjustment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	8.00	0.00	0.00	0.00
Total	8.00	0.00	0.00	0.00	8.00	12.00	40.00	0.00	0.00

**Failure descriptor versus failure mode, continued**

Item: Valves described by taxonomy code - Unknown

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.00	4.00	0.00	0.00	0.00	0.00	12.00
Instrument failure - general	0.00	0.00	0.00	0.00	12.00	0.00	0.00	0.00	20.00
Leakage	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00
Mechanical Failure - general	0.00	4.00	0.00	0.00	0.00	0.00	0.00	4.00	48.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00
Out of adjustment	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00
Total	0.00	12.00	0.00	4.00	12.00	0.00	0.00	4.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.4		Item Control and Safety Equipment Valves								
Population 1170	Installations 40	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 36.6612		Operational time † 31.6175						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	358*	0.01	6.79	28.28	10.78	9.77	9.1	0.5	12.0	113.0
	358†	3.00	25.97	67.80	21.31	11.32				
Delayed operation	3*	0.00	0.11	0.55	0.24	0.08	32.0	28.0	64.0	113.0
	3†	0.00	0.15	0.71	0.29	0.09				
External leakage - Process medium	11*	0.00	0.24	0.82	0.30	0.30	11.0	1.0	13.5	54.0
	11†	0.00	0.29	1.16	0.44	0.35				
External leakage - Utility medium	2*	0.00	0.06	0.19	0.07	0.05	9.8	17.0	19.5	22.0
	2†	0.00	0.08	0.25	0.09	0.06				
Fail to close on demand	134*	0.00	2.31	13.11	7.48	3.66	8.2	1.0	11.3	78.0
	134†	0.00	5.09	22.77	9.01	4.24				
Fail to open on demand	84*	0.02	2.81	9.37	3.43	2.29	7.6	1.0	10.4	78.0
	84†	7.06	29.13	63.54	17.98	2.66				
Fail to regulate	72*	0.00	0.55	1.09	3.05	1.96	11.5	0.5	13.3	93.0
	72†	0.00	0.90	4.75	3.23	2.28				
High output	1*	0.00	0.03	0.08	0.03	0.03	6.0	6.0	6.0	6.0
	1†	0.00	0.03	0.09	0.03	0.03				
Internal leakage	3*	0.01	0.07	0.20	0.07	0.08	26.3	6.0	34.0	48.0
	3†	0.01	0.08	0.22	0.07	0.09				
Low output	1*	0.00	0.03	0.09	0.04	0.03	2.0	3.0	3.0	3.0
	1†	0.00	0.03	0.10	0.04	0.03				
Other	4*	0.00	0.13	0.45	0.17	0.11	8.3	1.0	16.7	37.0
	4†	0.00	0.16	0.54	0.20	0.13				
Spurious operation	23*	0.00	0.61	2.98	1.25	0.63	3.2	1.0	4.9	24.0
	23†	0.00	1.17	5.39	2.17	0.73				
Structural deficiency	7*	0.00	0.20	0.88	0.35	0.19	5.2	2.0	6.0	16.0
	7†	0.00	0.25	0.85	0.31	0.22				
Unknown	2*	0.00	0.05	0.14	0.04	0.05	62.0	36.0	65.0	94.0
	2†	0.01	0.06	0.15	0.05	0.06				
Valve leakage in closed position	11*	0.03	0.25	0.66	0.21	0.30	8.6	6.0	10.2	35.0
	11†	0.05	0.30	0.74	0.22	0.35				
<b>Degraded</b>	302*	1.08	8.47	21.73	6.77	8.24	8.0	0.5	9.8	92.0
	302†	3.87	19.74	45.72	13.45	9.55				
Abnormal instrument reading	6*	0.00	0.24	0.99	0.38	0.16	3.8	2.0	4.5	6.0
	6†	0.00	0.31	1.00	0.36	0.19				
Delayed operation	27*	0.01	1.00	3.34	1.23	0.74	5.8	1.0	10.5	36.0
	27†	0.13	1.59	4.47	1.46	0.85				
External leakage - Process medium	33*	0.02	2.13	7.17	2.63	0.90	8.7	1.0	10.8	45.0
	33†	5.52	20.42	43.00	11.87	1.04				
External leakage - Utility medium	38*	0.00	1.16	4.54	1.69	1.04	9.1	1.0	13.4	92.0
	38†	0.08	1.76	5.29	1.78	1.20				
Fail to open on demand	2*	0.00	0.06	0.18	0.07	0.05	3.3	0.5	3.3	6.0
	2†	0.00	0.07	0.22	0.08	0.06				
<b>Comments</b>										

(cont.)

Taxonomy no 4.4		Item Control and Safety Equipment Valves									
Population 1170	Installations 40	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 36.6612		Operational time † 31.6175							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
High output	4*	0.00	0.10	0.32	0.11	0.11	4.1	2.0	4.4	9.0	
	4†	0.00	0.13	0.41	0.15	0.13					
Internal leakage	18*	0.00	0.67	3.33	1.42	0.49	15.3	4.0	20.6	48.0	
	18†	0.00	1.02	4.03	1.50	0.57					
Low output	14*	0.00	0.26	1.48	0.77	0.38	5.3	1.0	5.3	13.0	
	14†	0.00	0.43	2.30	1.06	0.44					
Minor in-service problems	4*	0.00	0.10	0.38	0.14	0.11	4.0	4.0	4.0	4.0	
	4†	0.00	0.12	0.38	0.14	0.13					
Other	44*	0.00	1.47	6.79	2.74	1.20	6.0	2.0	7.6	61.0	
	44†	0.02	2.41	8.13	2.98	1.39					
Plugged/Choked	4*	0.00	0.15	0.77	0.35	0.11	2.0	2.0	2.0	2.0	
	4†	0.00	0.21	0.93	0.36	0.13					
Spurious operation	74*	0.00	0.68	0.96	4.34	2.02	7.2	4.0	7.4	35.0	
	74†	0.00	1.22	6.29	4.78	2.34					
Structural deficiency	3*	0.00	0.35	1.89	0.88	0.08	6.0	6.0	6.0	6.0	
	3†	0.00	0.59	2.53	0.98	0.09					
Unknown	2*	0.00	0.05	0.14	0.04	0.05	6.0	2.0	6.0	10.0	
	2†	0.01	0.06	0.15	0.05	0.06					
Valve leakage in closed position	29*	0.00	0.47	1.99	0.77	0.79	12.6	2.0	13.0	70.0	
	29†	0.01	0.66	2.05	0.73	0.92					
<b>Incipient</b>	<b>339*</b>	<b>3.53</b>	<b>14.93</b>	<b>32.80</b>	<b>9.32</b>	<b>9.25</b>	<b>4.9</b>	<b>1.0</b>	<b>6.3</b>	<b>80.0</b>	
	<b>339†</b>	<b>86.84</b>	<b>143.70</b>	<b>212.14</b>	<b>38.42</b>	<b>10.72</b>					
Abnormal instrument reading	111*	1.85	9.73	22.72	6.71	3.03	4.1	1.0	5.6	80.0	
	111†	105.90	160.11	223.45	35.95	3.51					
Delayed operation	4*	0.00	0.34	1.50	0.59	0.11	2.5	1.0	4.3	8.0	
	4†	0.43	3.58	9.25	2.89	0.13					
External leakage - Process medium	4*	0.00	0.18	0.74	0.28	0.11	4.0	1.0	3.7	7.0	
	4†	0.00	0.22	0.76	0.28	0.13					
External leakage - Utility medium	30*	0.00	0.88	4.43	1.90	0.82	3.5	1.0	6.5	20.0	
	30†	0.36	7.39	22.13	7.41	0.95					
Fail to regulate	1*	0.00	0.03	0.09	0.04	0.03	3.0	3.0	3.0	3.0	
	1†	0.00	0.03	0.10	0.04	0.03					
Internal leakage	3*	0.00	0.12	0.47	0.17	0.08	18.0	4.0	15.3	30.0	
	3†	0.00	0.13	0.39	0.14	0.09					
Low output	2*	0.00	0.06	0.27	0.11	0.05	3.5	1.0	6.5	12.0	
	2†	0.00	0.08	0.34	0.13	0.06					
Minor in-service problems	42*	0.00	2.02	8.34	3.17	1.15	3.0	1.0	3.7	10.0	
	42†	0.13	3.34	10.05	3.41	1.33					
Other	28*	0.00	0.60	3.11	2.72	0.76	4.7	1.0	9.6	28.0	
	28†	0.00	1.12	6.24	3.22	0.89					
Spurious operation	7*	0.00	0.32	1.45	0.58	0.19	4.8	1.0	8.7	16.0	
	7†	0.00	0.61	2.33	0.86	0.22					

Comments

(cont.)

Taxonomy no 4.4		Item Control and Safety Equipment Valves								
Population 1170	Installations 40	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *			Operational time †					
		36.6612			31.6175					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Structural deficiency	3*	0.00	0.35	1.90	0.88	0.08	9.0	13.0	15.5	18.0
	3†	0.00	0.58	2.47	0.96	0.09				
Unknown	1*	0.00	0.03	0.09	0.04	0.03	3.0	3.0	3.0	3.0
	1†	0.00	0.03	0.10	0.04	0.03				
Valve leakage in closed position	103*	0.00	0.74	0.81	6.85	2.81	6.5	2.0	6.5	14.0
	103†	0.00	1.26	2.07	7.57	3.26				
Unknown	18*	<b>0.00</b>	<b>0.35</b>	<b>1.80</b>	<b>1.47</b>	<b>0.49</b>	15.6	1.0	23.2	119.0
	18†	<b>0.00</b>	<b>0.54</b>	<b>3.02</b>	<b>1.56</b>	<b>0.57</b>				
Unknown	18*	0.00	0.35	1.80	1.47	0.49	15.6	1.0	23.2	119.0
	18†	0.00	0.54	3.02	1.56	0.57				
All modes	1017*	7.74	31.05	67.14	18.89	27.74	7.5	0.5	9.7	119.0
	1017†	110.16	190.63	289.04	54.91	32.17				
Comments										

**Maintainable item versus failure mode, to be continued**

Item: Valves described by application

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	0.79	0.10	0.00	0.00	0.20	0.20	0.10	0.00	0.00
Bonnet	0.00	0.00	0.00	0.10	0.00	0.49	0.00	0.00	0.00
Cabling & junction boxes	0.39	0.10	0.00	0.00	0.00	0.39	0.00	0.00	0.00
Case	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
Closure member (Ball/gate/disc/etc.)	0.00	0.10	0.00	0.00	0.20	0.10	0.00	0.00	0.00
Control unit	1.38	0.10	0.00	0.10	0.20	0.10	0.69	0.00	0.00
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.00	0.00
Electric motor (electric actuator)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Flange	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
Gear	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
Indicator	0.10	0.00	0.00	0.00	0.15	0.00	0.20	0.00	0.00
Instrument, general	0.88	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00
Instrument, position	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.20	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
Monitoring	4.52	0.20	0.00	0.00	0.10	0.00	0.10	0.00	0.00
Other	0.10	0.00	0.20	0.10	0.00	0.00	0.00	0.00	0.10
Other actuator components	0.00	0.29	0.00	1.08	0.39	0.10	0.10	0.00	0.00
Other valve components	0.00	0.00	0.59	0.20	0.20	0.44	0.20	0.00	0.20
Packing	0.00	0.00	0.44	0.29	0.21	0.00	0.00	0.00	0.10
Pilot valve	0.10	0.00	0.00	0.49	2.16	0.49	0.00	0.00	0.20
Piston(s)	0.00	0.00	0.00	0.20	0.29	0.29	0.33	0.00	0.00
Positioner	0.39	0.00	0.00	0.10	0.15	0.10	0.88	0.10	0.00
Seals	0.00	0.00	0.84	0.00	0.41	0.00	0.10	0.05	0.29
Seals (gaskets)	0.00	0.00	0.29	2.26	0.00	0.00	0.00	0.00	0.39
Seat rings	0.00	0.00	0.98	0.00	0.56	0.34	0.00	0.05	0.39
Spring	0.00	0.00	0.00	0.00	0.10	0.10	0.03	0.00	0.00
Stem	0.00	0.39	0.20	0.20	0.20	0.20	0.23	0.00	0.00
Subunit	0.10	0.59	0.20	0.49	2.26	1.47	2.36	0.10	0.49
Unknown	0.88	0.79	0.20	0.69	4.82	3.34	1.18	0.00	0.10
Valve body w/internals	0.00	0.69	0.59	0.10	0.59	0.10	0.39	0.20	0.10
Valves	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Total	11.50	3.34	4.72	6.88	13.18	8.46	7.18	0.49	2.36

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

Item: Valves described by application

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.20	0.69	0.00	0.10	1.08	0.00	0.00	3.44
Bonnet	0.00	0.00	0.00	0.00	0.10	0.00	0.15	0.00	0.84
Cabling & junction boxes	0.00	0.00	0.59	0.00	0.20	0.00	0.10	0.00	1.77
Case	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0.00	0.59
Control unit	0.00	0.00	0.00	0.00	0.29	0.29	0.00	0.10	3.24
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Electric motor (electric actuator)	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.10
Flange	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Gear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Indicator	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.54
Instrument, general	0.00	0.10	0.20	0.00	0.20	0.20	0.00	0.00	1.97
Instrument, position	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.39
Monitoring	0.00	0.00	0.20	0.00	0.10	0.00	0.00	0.00	5.21
Other	0.10	0.00	1.08	0.00	0.10	0.00	0.00	0.00	1.77
Other actuator components	0.00	0.00	0.39	0.00	0.29	0.10	0.00	0.00	2.75
Other valve components	0.10	0.00	0.20	0.00	0.20	0.20	0.00	0.00	2.51
Packing	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34
Pilot valve	0.00	0.00	0.00	0.00	0.79	0.10	0.20	0.29	4.82
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	1.16
Positioner	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	1.92
Seals	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.79
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	3.00
Seat rings	1.08	0.00	0.10	0.00	0.10	0.10	0.00	0.00	3.70
Spring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Stem	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	1.70
Subunit	1.77	0.00	3.05	0.00	0.39	0.39	0.10	0.79	14.55
Unknown	10.52	0.59	0.49	0.29	1.28	6.69	0.39	0.98	33.24
Valve body w/internals	0.10	0.79	0.00	0.00	0.00	0.88	0.25	0.00	4.77
Valves	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.39
Total	14.06	1.67	7.47	0.39	4.52	10.23	1.28	2.26	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.



**Failure descriptor versus failure mode, to be continued**

Item: Valves described by application

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.29	0.00	0.00	0.00	1.87	1.57	0.49	0.20	0.10
Breakage	0.20	0.00	0.29	0.20	0.20	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.29	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.10
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Control failure	0.20	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Corrosion	0.39	0.20	0.10	0.20	0.20	0.20	0.39	0.00	0.00
Deformation	0.00	0.00	0.29	0.10	0.10	0.20	0.20	0.10	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Electrical failure - general	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Erosion	0.00	0.00	0.10	0.00	0.10	0.00	0.20	0.00	0.10
External influence - general	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	1.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	2.95	0.59	0.00	0.20	3.05	1.28	0.10	0.10	0.00
Leakage	0.00	0.20	2.06	4.23	0.39	0.10	0.10	0.00	0.49
Looseness	0.00	0.10	0.20	0.20	0.10	0.00	0.10	0.00	0.20
Material failure - general	0.10	0.00	0.29	0.49	0.39	1.57	0.00	0.00	0.20
Mechanical Failure - general	0.20	1.08	0.00	0.49	2.46	1.38	1.08	0.00	0.29
Misc. external influences	0.20	0.10	0.00	0.10	0.20	0.20	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.29	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
Open circuit	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	4.52	0.29	0.00	0.20	0.98	0.29	3.05	0.00	0.10
Short circuiting	0.10	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.49	0.00	0.00	0.29	0.29	0.00	0.00	0.00
Unknown	0.00	0.29	0.29	0.10	0.69	0.49	0.20	0.10	0.10
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.00
Wear	0.00	0.00	1.08	0.29	1.67	0.29	0.79	0.00	0.59
Total	11.50	3.34	4.72	6.88	13.18	8.46	7.18	0.49	2.36

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**Failure descriptor versus failure mode, continued**

**Item:** Valves described by application

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	1.18	0.10	0.29	0.10	0.10	0.00	0.00	6.29
Breakage	0.00	0.00	0.10	0.00	0.00	0.20	0.00	0.00	1.18
Cavitation	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.20
Clearance/ alignment failure	0.20	0.00	0.00	0.00	0.00	0.10	0.00	0.10	1.38
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29
Corrosion	0.10	0.00	1.28	0.00	0.69	0.10	0.29	0.10	4.23
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Electrical failure - general	0.00	0.00	0.10	0.00	0.10	0.00	0.00	0.00	0.29
Erosion	0.20	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.79
External influence - general	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.39
Faulty signal/indication/alarm	0.00	0.10	0.29	0.00	0.10	0.59	0.00	0.00	2.56
Instrument failure - general	0.10	0.00	0.39	0.00	0.69	0.88	0.20	0.59	11.11
Leakage	2.56	0.10	0.00	0.00	0.10	0.29	0.00	0.00	10.62
Looseness	0.20	0.00	0.20	0.00	0.69	0.10	0.00	0.00	2.06
Material failure - general	10.32	0.00	0.20	0.00	0.00	6.39	0.10	0.00	20.06
Mechanical Failure - general	0.20	0.10	0.29	0.00	0.39	0.49	0.29	0.39	9.14
Misc. external influences	0.00	0.00	0.29	0.00	0.49	0.00	0.10	0.00	1.67
Miscellaneous - general	0.00	0.00	0.10	0.00	0.10	0.29	0.00	0.00	0.59
No cause found	0.00	0.00	0.10	0.00	0.00	0.10	0.00	0.00	0.20
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39
Open circuit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Other	0.00	0.00	0.00	0.00	0.10	0.00	0.10	0.00	0.20
Out of adjustment	0.00	0.20	3.05	0.00	0.20	0.20	0.00	0.10	13.18
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.29
Software failure	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.20
Sticking	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	1.38
Unknown	0.10	0.00	0.29	0.10	0.29	0.29	0.00	0.98	4.33
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.49
Wear	0.10	0.00	0.20	0.00	0.00	0.00	0.10	0.00	5.11
Total	14.06	1.67	7.47	0.39	4.52	10.23	1.28	2.26	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.4.1		Item Control and Safety Equipment Valves Blowdown									
Population 94	Installations 24	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 4.5502		Operational time † 1.7378							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	<b>29*</b> <b>29†</b>	<b>0.01</b> <b>9.83</b>	<b>5.61</b> <b>97.36</b>	<b>23.25</b> <b>262.40</b>	<b>8.84</b> <b>84.03</b>	<b>6.37</b> <b>16.69</b>	<b>6.5</b>	<b>1.0</b>	<b>10.9</b>	<b>60.0</b>	
Fail to close on demand	3* 3†	0.05 0.06	0.69 13.70	2.00 50.67	0.66 18.71	0.66 1.73	2.0	2.0	2.3	3.0	
Fail to open on demand	25* 25†	0.00 2.69	4.66 79.21	22.67 239.75	9.43 82.19	5.49 14.39	7.0	1.0	12.1	60.0	
Spurious operation	1* 1†	0.00 0.00	0.20 3.41	1.15 16.67	0.61 6.98	0.22 0.58	8.0	8.0	8.0	8.0	
<b>Degraded</b>	<b>20*</b> <b>20†</b>	<b>0.02</b> <b>0.70</b>	<b>3.73</b> <b>46.23</b>	<b>13.69</b> <b>146.10</b>	<b>5.06</b> <b>52.42</b>	<b>4.40</b> <b>11.51</b>	<b>7.8</b>	<b>1.0</b>	<b>12.2</b>	<b>36.0</b>	
Delayed operation	8* 8†	0.00 0.02	1.14 3.60	6.15 13.42	2.86 4.96	1.76 4.60	7.0	6.0	16.0	36.0	
External leakage - Process medium	10* 10†	0.00 1.08	2.44 49.44	11.44 152.55	4.66 53.70	2.20 5.75	9.3	1.0	10.5	36.0	
External leakage - Utility medium	2* 2†	0.00 0.13	0.35 1.02	1.46 2.61	0.56 0.81	0.44 1.15	3.0	1.0	5.5	10.0	
<b>Incipient</b>	<b>68*</b> <b>68†</b>	<b>3.96</b> <b>122.85</b>	<b>18.07</b> <b>348.03</b>	<b>40.61</b> <b>666.40</b>	<b>11.72</b> <b>170.02</b>	<b>14.94</b> <b>39.13</b>	<b>2.9</b>	<b>1.0</b>	<b>3.9</b>	<b>80.0</b>	
Abnormal instrument reading	51* 51†	1.47 104.93	15.59 318.45	42.64 625.94	13.76 163.45	11.21 29.35	2.4	1.0	3.6	80.0	
Delayed operation	2* 2†	0.00 0.03	0.48 8.69	2.67 33.80	1.40 12.52	0.44 1.15	1.0	1.0	1.0	1.0	
External leakage - Process medium	2* 2†	0.00 0.13	0.36 1.17	1.98 3.09	0.93 0.98	0.44 1.15	4.0	1.0	4.0	7.0	
External leakage - Utility medium	4* 4†	0.00 0.06	0.90 22.50	4.67 88.67	2.05 33.02	0.88 2.30	1.5	1.0	1.5	3.0	
Internal leakage	1* 1†	0.00 0.03	0.20 0.58	1.03 1.73	0.47 0.58	0.22 0.58	30.0	30.0	30.0	30.0	
Minor in-service problems	6* 6†	0.00 1.05	0.96 3.22	4.12 6.35	1.60 1.66	1.32 3.45	3.7	2.0	4.0	6.0	
Other	1* 1†	0.00 0.00	0.59 1.61	3.22 6.88	1.99 2.66	0.22 0.58	2.0	4.0	4.0	4.0	
Valve leakage in closed position	1* 1†	0.00 0.03	0.20 0.58	1.03 1.73	0.47 0.58	0.22 0.58	7.0	7.0	7.0	7.0	
<b>All modes</b>	<b>117*</b> <b>117†</b>	<b>8.36</b> <b>194.65</b>	<b>27.30</b> <b>509.72</b>	<b>55.13</b> <b>945.93</b>	<b>14.72</b> <b>234.27</b>	<b>25.71</b> <b>67.33</b>	<b>4.6</b>	<b>1.0</b>	<b>7.1</b>	<b>80.0</b>	
<b>Comments</b>											

**Maintainable item versus failure mode, to be continued**

**Item:** Valves described by application - Blowdown

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bonnet	0.00	0.00	0.00	0.00	0.00	4.27	0.00	0.00	0.00
Cabling & junction boxes	1.71	0.85	0.00	0.00	0.00	1.71	0.00	0.00	0.00
Control unit	3.42	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Indicator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	1.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	35.04	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	1.71	0.00	0.00	0.00	0.00	0.00	0.85
Other actuator components	0.00	1.71	0.00	2.56	1.71	0.00	0.00	0.00	0.00
Other valve components	0.00	0.00	0.00	0.00	0.00	3.85	0.00	0.00	0.00
Piston(s)	0.00	0.00	0.00	0.00	0.00	1.71	0.00	0.00	0.00
Seals	0.00	0.00	2.56	0.00	0.00	0.00	0.00	0.00	0.00
Seals (gaskets)	0.00	0.00	0.00	2.56	0.00	0.00	0.00	0.00	0.00
Seat rings	0.00	0.00	5.98	0.00	0.00	2.99	0.00	0.00	0.00
Stem	0.00	1.71	0.00	0.00	0.00	1.71	0.00	0.00	0.00
Subunit	0.00	1.71	0.00	0.00	0.00	1.71	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.85	2.56	0.00	0.00	0.00
Valve body w/internals	0.00	0.85	0.00	0.00	0.00	0.85	0.00	0.00	0.00
Valves	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>Total</b>	<b>43.59</b>	<b>8.55</b>	<b>10.26</b>	<b>5.13</b>	<b>2.56</b>	<b>21.37</b>	<b>0.00</b>	<b>0.00</b>	<b>0.85</b>

**Maintainable item versus failure mode, continued**

**Item:** Valves described by application - Blowdown

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	1.71
Bonnet	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	5.13
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.27
Control unit	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	5.13
Indicator	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.85
Instrument, general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.71
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85
Monitoring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.90
Other	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.42
Other actuator components	0.00	0.00	0.00	0.00	1.71	0.85	0.00	0.00	8.55
Other valve components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.85
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.71
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.56
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.56
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.97
Stem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.42
Subunit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.42
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.42
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.71
Valves	0.00	0.00	0.85	0.00	0.00	0.00	0.00	0.00	0.85
<b>Total</b>	<b>0.85</b>	<b>0.00</b>	<b>0.85</b>	<b>0.00</b>	<b>5.13</b>	<b>0.85</b>	<b>0.00</b>	<b>0.00</b>	<b>100.0</b>

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Valves described by application - Blowdown

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	7.69	0.00	0.00	0.00
Breakage	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	4.27	0.00	0.00	0.00
Faulty signal/indication/alarm	5.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	8.55	1.71	0.00	0.00	0.00	1.71	0.00	0.00	0.00
Leakage	0.00	0.85	10.26	5.13	1.71	0.00	0.00	0.00	0.85
Looseness	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00
Mechanical Failure - general	0.00	1.71	0.00	0.00	0.00	5.98	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open circuit	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	29.06	1.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	1.71	0.00	0.00	0.00	0.85	0.00	0.00	0.00
Unknown	0.00	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	43.59	8.55	10.26	5.13	2.56	21.37	0.00	0.00	0.85

**Failure descriptor versus failure mode, continued**

Item: Valves described by application - Blowdown

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.69
Breakage	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.00	1.71
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.27
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.13
Instrument failure - general	0.00	0.00	0.85	0.00	0.00	0.00	0.00	0.00	12.82
Leakage	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.66
Looseness	0.00	0.00	0.00	0.00	2.56	0.00	0.00	0.00	2.56
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.69
Miscellaneous - general	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.85
Open circuit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85
Out of adjustment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.77
Sticking	0.00	0.00	0.00	0.00	1.71	0.00	0.00	0.00	4.27
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85
Total	0.85	0.00	0.85	0.00	5.13	0.85	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.4.1.1		Item Control and Safety Equipment Valves Blowdown Ball									
Population 58	Installations 6	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 1.5890		Operational time † 1.5556							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	16*	0.01	6.36	25.63	9.64	10.07	3.7	2.0	8.3	29.0	
	16†	0.02	6.47	25.62	9.56	10.29					
Fail to close on demand	1*	0.00	0.78	3.48	1.38	0.63	3.0	3.0	3.0	3.0	
	1†	0.00	0.80	3.60	1.43	0.64					
Fail to open on demand	15*	0.00	5.33	25.58	10.53	9.44	3.8	2.0	8.7	29.0	
	15†	0.00	5.40	25.61	10.50	9.64					
<b>Degraded</b>	13*	4.32	7.79	12.09	2.39	8.18	8.0	1.0	13.9	36.0	
	13†	4.59	7.98	12.13	2.32	8.36					
Delayed operation	8*	0.15	4.50	13.65	4.69	5.03	7.0	6.0	16.0	36.0	
	8†	0.17	4.55	13.75	4.69	5.14					
External leakage - Process medium	3*	0.02	1.91	6.19	2.25	1.89	14.0	1.0	14.0	36.0	
	3†	0.02	1.97	6.64	2.44	1.93					
External leakage - Utility medium	2*	0.04	1.08	3.26	1.12	1.26	3.0	1.0	5.5	10.0	
	2†	0.05	1.10	3.30	1.12	1.29					
<b>Incipient</b>	14*	5.19	9.32	14.42	2.84	8.81	5.9	1.0	6.2	30.0	
	14†	4.86	9.71	15.91	3.41	9.00					
Abnormal instrument reading	3*	0.05	3.26	10.32	3.71	1.89	4.7	4.0	4.7	6.0	
	3†	0.05	3.33	10.52	3.77	1.93					
External leakage - Process medium	2*	0.25	1.29	3.01	0.89	1.26	4.0	1.0	4.0	7.0	
	2†	0.26	1.33	3.09	0.91	1.29					
Internal leakage	1*	0.00	0.65	2.52	0.93	0.63	30.0	30.0	30.0	30.0	
	1†	0.00	0.67	2.64	0.98	0.64					
Minor in-service problems	6*	0.32	3.35	9.17	2.96	3.78	3.7	2.0	4.0	6.0	
	6†	0.30	3.43	9.50	3.08	3.86					
Other	1*	0.01	2.85	11.12	4.12	0.63	2.0	4.0	4.0	4.0	
	1†	0.01	2.94	11.46	4.25	0.64					
Valve leakage in closed position	1*	0.00	0.65	2.52	0.93	0.63	7.0	7.0	7.0	7.0	
	1†	0.00	0.67	2.64	0.98	0.64					
<b>All modes</b>	43*	14.12	25.15	38.76	7.57	27.06	5.8	1.0	9.3	36.0	
	43†	15.65	25.89	38.22	6.92	27.64					
<b>Comments</b>											

Taxonomy no 4.4.1.1.1		Item Control and Safety Equipment Valves Blowdown Ball (1.1-5.0) inch									
Population 55	Installations 6	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 1.5181			Operational time † 1.4863						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max	
<b>Critical</b>	16*	0.03	7.02	25.78	9.52	10.54	3.7	2.0	8.3	29.0	
	16†	0.04	7.15	25.48	9.41	10.76					
Fail to close on demand	1*	0.00	0.83	3.56	1.38	0.66	3.0	3.0	3.0	3.0	
	1†	0.00	0.85	3.68	1.43	0.67					
Fail to open on demand	15*	0.00	5.88	26.55	10.55	9.88	3.8	2.0	8.7	29.0	
	15†	0.00	5.95	26.56	10.49	10.09					
<b>Degraded</b>	12*	0.72	6.38	16.75	5.28	7.90	8.3	1.0	14.3	36.0	
	12†	0.75	6.52	17.00	5.34	8.07					
Delayed operation	7*	0.21	3.52	10.35	3.44	4.61	7.3	6.0	16.9	36.0	
	7†	0.30	3.62	10.15	3.31	4.71					
External leakage - Process medium	3*	0.03	2.08	6.61	2.38	1.98	14.0	1.0	14.0	36.0	
	3†	0.02	2.16	7.07	2.57	2.02					
External leakage - Utility medium	2*	0.07	1.14	3.36	1.12	1.32	3.0	1.0	5.5	10.0	
	2†	0.08	1.17	3.38	1.12	1.35					
<b>Incipient</b>	13*	2.47	9.57	20.45	5.71	8.56	5.9	1.0	6.2	30.0	
	13†	2.35	9.93	21.81	6.20	8.75					
Abnormal instrument reading	2*	0.01	1.67	5.66	2.08	1.32	4.0	4.0	4.0	4.0	
	2†	0.01	1.72	5.90	2.17	1.35					
External leakage - Process medium	2*	0.27	1.37	3.17	0.93	1.32	4.0	1.0	4.0	7.0	
	2†	0.29	1.42	3.25	0.95	1.35					
Internal leakage	1*	0.00	0.70	2.63	0.97	0.66	30.0	30.0	30.0	30.0	
	1†	0.00	0.72	2.78	1.02	0.67					
Minor in-service problems	6*	0.39	3.62	9.62	3.06	3.95	3.7	2.0	4.0	6.0	
	6†	0.38	3.71	9.97	3.19	4.04					
Other	1*	0.07	5.53	17.63	6.36	0.66	2.0	4.0	4.0	4.0	
	1†	0.08	5.69	18.17	6.56	0.67					
Valve leakage in closed position	1*	0.00	0.70	2.63	0.97	0.66	7.0	7.0	7.0	7.0	
	1†	0.00	0.72	2.78	1.02	0.67					
<b>All modes</b>		41*	12.60	24.40	39.35	8.24	27.01	5.8	1.0	9.4	36.0
		41†	14.07	25.19	38.92	7.64	27.58				
Comments											

Taxonomy no 4.4.1.1.2		Item Control and Safety Equipment Valves Blowdown Ball (5.1-10) inch								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0227			Operational time † 0.0220					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	1*	2.20	44.05	208.99	44.05	44.05	5.0	10.0	10.0	10.0
	1†	2.27	45.45	215.68	45.45	45.45				
Delayed operation	1*	2.20	44.05	208.99	44.05	44.05	5.0	10.0	10.0	10.0
	1†	2.27	45.45	215.68	45.45	45.45				
All modes	1*	2.20	44.05	208.99	44.05	44.05	5.0	10.0	10.0	10.0
	1†	2.27	45.45	215.68	45.45	45.45				
Comments										



Taxonomy no 4.4.1.1.3		Item Control and Safety Equipment Valves Blowdown Ball Unknown								
Population 2	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0482		Operational time † 0.0473						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	1*	0.18	19.14	63.13	23.07	20.76	6.0	6.0	6.0	6.0
	1†	0.21	19.46	63.42	23.09	21.16				
Abnormal instrument reading	1*	0.18	19.14	63.13	23.07	20.76	6.0	6.0	6.0	6.0
	1†	0.21	19.46	63.42	23.09	21.16				
All modes	1*	0.18	19.14	63.13	23.07	20.76	6.0	6.0	6.0	6.0
	1†	0.21	19.46	63.42	23.09	21.16				
Comments										

Taxonomy no 4.4.1.2		Item Control and Safety Equipment Valves Blowdown Gate									
Population 36	Installations 19	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 2.9612		Operational time † 0.1822							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	13*	0.00	5.43	22.97	8.83	4.39	9.8	1.0	14.2	60.0	
	13†	0.14	134.04	556.78	211.86	71.35					
Fail to close on demand	2*	0.00	0.72	2.63	0.97	0.68	1.5	2.0	2.0	2.0	
	2†	0.00	18.23	93.39	40.43	10.98					
Fail to open on demand	10*	0.00	4.51	22.10	9.28	3.38	11.6	1.0	17.2	60.0	
	10†	0.00	109.71	520.95	213.55	54.89					
Spurious operation	1*	0.00	0.29	1.52	0.68	0.34	8.0	8.0	8.0	8.0	
	1†	0.00	5.60	32.07	17.29	5.49					
<b>Degraded</b>	7*	0.00	2.60	12.99	5.54	2.36	7.3	3.0	9.0	30.0	
	7†	0.00	64.94	317.24	132.71	38.42					
External leakage - Process medium	7*	0.00	2.60	12.99	5.54	2.36	7.3	3.0	9.0	30.0	
	7†	0.00	64.94	317.24	132.71	38.42					
<b>Incipient</b>	54*	4.41	19.89	44.53	12.83	18.24	2.1	1.0	3.3	80.0	
	54†	62.42	438.33	1098.32	338.44	296.39					
Abnormal instrument reading	48*	2.78	18.37	45.40	13.89	16.21	2.2	1.0	3.5	80.0	
	48†	42.30	398.52	1062.14	338.00	263.46					
Delayed operation	2*	0.00	0.63	3.39	1.56	0.68	1.0	1.0	1.0	1.0	
	2†	2.32	11.51	26.49	7.76	10.98					
External leakage - Utility medium	4*	0.00	1.22	5.31	2.07	1.35	1.5	1.0	1.5	3.0	
	4†	0.00	29.96	164.20	76.87	21.95					
<b>All modes</b>	74*	6.47	27.99	61.88	17.66	24.99	4.0	1.0	5.8	80.0	
	74†	94.42	648.55	1617.21	497.07	406.16					
<b>Comments</b>											

Taxonomy no 4.4.1.2.1		Item Control and Safety Equipment Valves Blowdown Gate (1.1-5.0) inch								
Population 36	Installations 19	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 2.9612			Operational time † 0.1822					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	13*	0.00	5.43	22.97	8.83	4.39	9.8	1.0	14.2	60.0
	13†	0.14	134.04	556.78	211.86	71.35				
Fail to close on demand	2*	0.00	0.72	2.63	0.97	0.68	1.5	2.0	2.0	2.0
	2†	0.00	18.23	93.39	40.43	10.98				
Fail to open on demand	10*	0.00	4.51	22.10	9.28	3.38	11.6	1.0	17.2	60.0
	10†	0.00	109.71	520.95	213.55	54.89				
Spurious operation	1*	0.00	0.29	1.52	0.68	0.34	8.0	8.0	8.0	8.0
	1†	0.00	5.60	32.07	17.29	5.49				
<b>Degraded</b>	7*	0.00	2.60	12.99	5.54	2.36	7.3	3.0	9.0	30.0
	7†	0.00	64.94	317.24	132.71	38.42				
External leakage - Process medium	7*	0.00	2.60	12.99	5.54	2.36	7.3	3.0	9.0	30.0
	7†	0.00	64.94	317.24	132.71	38.42				
<b>Incipient</b>	54*	4.41	19.89	44.53	12.83	18.24	2.1	1.0	3.3	80.0
	54†	62.42	438.33	1098.32	338.44	296.39				
Abnormal instrument reading	48*	2.78	18.37	45.40	13.89	16.21	2.2	1.0	3.5	80.0
	48†	42.30	398.52	1062.14	338.00	263.46				
Delayed operation	2*	0.00	0.63	3.39	1.56	0.68	1.0	1.0	1.0	1.0
	2†	2.32	11.51	26.49	7.76	10.98				
External leakage - Utility medium	4*	0.00	1.22	5.31	2.07	1.35	1.5	1.0	1.5	3.0
	4†	0.00	29.96	164.20	76.87	21.95				
<b>All modes</b>	74*	6.47	27.99	61.88	17.66	24.99	4.0	1.0	5.8	80.0
	74†	94.42	648.55	1617.21	497.07	406.16				
<b>Comments</b>										

Taxonomy no 4.4.2		Item Control and Safety Equipment Valves By-pass									
Population 4	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1373		Operational time † 0.1353							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Degraded</b>	2*	0.17	16.16	52.69	19.19	14.57	10.5	2.0	20.0	38.0	
	2†	0.19	16.23	52.48	19.05	14.79					
External leakage - Utility medium	1*	0.55	7.70	22.11	7.28	7.28	2.0	2.0	2.0	2.0	
	1†	0.54	7.78	22.41	7.39	7.39					
Internal leakage	1*	0.55	7.70	22.11	7.28	7.28	19.0	38.0	38.0	38.0	
	1†	0.54	7.78	22.41	7.39	7.39					
<b>Incipient</b>	1*	0.04	6.88	24.29	8.97	7.28	8.0	8.0	8.0	8.0	
	1†	0.04	7.01	24.92	9.20	7.39					
Abnormal instrument reading	1*	0.04	6.88	24.29	8.97	7.28	8.0	8.0	8.0	8.0	
	1†	0.04	7.01	24.92	9.20	7.39					
<b>All modes</b>	3*	4.50	22.51	51.88	15.22	21.85	9.7	2.0	16.0	38.0	
	3†	4.83	22.76	51.62	15.00	22.18					
<b>Comments</b>											

**Maintainable item versus failure mode, to be continued**

**Item:** Valves described by application - By-pass

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Control unit	33.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.00	0.00	0.00	33.33	0.00	0.00	0.00	0.00	0.00
Pilot valve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
Total	33.33	0.00	0.00	33.33	0.00	0.00	0.00	0.00	33.33

**Maintainable item versus failure mode, continued**

**Item:** Valves described by application - By-pass

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Control unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
Instrument, general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
Pilot valve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Valves described by application - By-pass

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Instrument failure - general	33.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	0.00	33.33	0.00	0.00	0.00	0.00	33.33
Total	33.33	0.00	0.00	33.33	0.00	0.00	0.00	0.00	33.33

**Failure descriptor versus failure mode, continued**

**Item:** Valves described by application - By-pass

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	66.67
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.4.2.1		Item Control and Safety Equipment Valves By-pass Ball									
Population 4	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1373			Operational time † 0.1353						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Degraded	2* 2†	0.17 0.19	16.16 16.23	52.69 52.48	19.19 19.05	14.57 14.79	10.5	2.0	20.0	38.0	
External leakage - Utility medium	1* 1†	0.55 0.54	7.70 7.78	22.11 22.41	7.28 7.39	7.28 7.39	2.0	2.0	2.0	2.0	
Internal leakage	1* 1†	0.55 0.54	7.70 7.78	22.11 22.41	7.28 7.39	7.28 7.39	19.0	38.0	38.0	38.0	
Incipient	1* 1†	0.04 0.04	6.88 7.01	24.29 24.92	8.97 9.20	7.28 7.39	8.0	8.0	8.0	8.0	
Abnormal instrument reading	1* 1†	0.04 0.04	6.88 7.01	24.29 24.92	8.97 9.20	7.28 7.39	8.0	8.0	8.0	8.0	
All modes	3* 3†	4.50 4.83	22.51 22.76	51.88 51.62	15.22 15.00	21.85 22.18	9.7	2.0	16.0	38.0	
Comments											

Taxonomy no 4.4.2.1.1		Item Control and Safety Equipment Valves By-pass Ball (1.1-5.0) inch									
Population 3	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1110		Operational time † 0.1097							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n / τ		Min	Mean	Max	
Degraded	2*	1.45	17.61	49.38	16.12	18.01	10.5	2.0	20.0	38.0	
	2†	1.61	17.75	48.96	15.86	18.24					
External leakage - Utility medium	1*	0.04	8.79	32.76	12.09	9.01	2.0	2.0	2.0	2.0	
	1†	0.04	8.86	32.76	12.10	9.12					
Internal leakage	1*	0.04	8.79	32.76	12.09	9.01	19.0	38.0	38.0	38.0	
	1†	0.04	8.86	32.76	12.10	9.12					
Incipient	1*	0.53	9.18	27.09	9.01	9.01	8.0	8.0	8.0	8.0	
	1†	0.55	9.33	27.46	9.12	9.12					
Abnormal instrument reading	1*	0.53	9.18	27.09	9.01	9.01	8.0	8.0	8.0	8.0	
	1†	0.55	9.33	27.46	9.12	9.12					
All modes	3*	7.29	26.89	56.57	15.60	27.02	9.7	2.0	16.0	38.0	
	3†	7.36	27.20	57.26	15.80	27.36					
Comments											

Taxonomy no 4.4.2.1.2		Item Control and Safety Equipment Valves By-pass Ball (5.1-10) inch								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0263			Operational time † 0.0256					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.04 0.04	10.31 10.51	39.60 40.35	14.58 14.86	0.00 0.00	-	-	-	-
Comments										



Taxonomy no 4.4.3		Item Control and Safety Equipment Valves Combined								
Population 4	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1608		Operational time † 0.1589						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.01 0.01	2.83 3.10	10.85 11.89	4.00 4.38	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 4.4.3.1		Item Control and Safety Equipment Valves Combined Ball									
Population 4	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1608			Operational time † 0.1589						
Failure mode		No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
			Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes		0* 0†	0.01 0.01	1.48 1.56	5.69 5.99	2.09 2.21	0.00 0.00	-	-	-	-
Comments											

Taxonomy no 4.4.3.1.1		Item Control and Safety Equipment Valves Combined Ball (1.1-5.0) inch								
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1169		Operational time † 0.1169						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0 <sup>*</sup> 0 <sup>†</sup>	0.00 0.00	1.10 1.14	4.22 4.39	1.56 1.62	0.00 0.00	-	-	-	-
Comments										

<b>Taxonomy no</b> 4.4.3.1.2		<b>Item</b> Control and Safety Equipment Valves Combined Ball (20.1-30) inch									
<b>Population</b> 2	<b>Installations</b> 2	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>				
		<b>Calendar time *</b> 0.0438			<b>Operational time †</b> 0.0420						
<b>Failure mode</b>		<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours)</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
			<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	$n/\tau$		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>		0* 0†	0.01 0.01	1.31 1.38	5.03 5.30	1.85 1.95	0.00 0.00	-	-	-	-
<b>Comments</b>											

Taxonomy no 4.4.4		Item Control and Safety Equipment Valves ESD								
Population 59	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 1.9199		Operational time † 1.8970			Active rep.hrs	Repair (manhours)		
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)	
		Lower	Mean	Upper	SD	n/τ	Min		Mean	Max
<b>Critical</b>	<b>84*</b> <b>84†</b>	<b>0.04</b>	<b>18.82</b>	<b>75.56</b>	<b>28.35</b>	<b>43.75</b>	<b>3.5</b>	<b>1.0</b>	<b>5.1</b>	<b>45.0</b>
Fail to close on demand	63*	0.13	15.92	53.52	19.65	32.81	3.8	1.0	5.7	45.0
	63†	0.13	16.14	54.23	19.91	33.21				
Fail to open on demand	15*	0.88	5.79	14.28	4.37	7.81	2.4	1.0	3.1	6.0
	15†	0.89	5.86	14.46	4.42	7.91				
Spurious operation	1*	0.01	0.48	1.48	0.52	0.52	2.0	2.0	2.0	2.0
	1†	0.01	0.49	1.50	0.53	0.53				
Structural deficiency	5*	0.53	2.30	5.10	1.46	2.60	4.3	2.0	4.5	9.0
	5†	0.54	2.33	5.16	1.47	2.64				
<b>Degraded</b>	<b>23*</b> <b>23†</b>	<b>8.40</b>	<b>55.59</b>	<b>137.43</b>	<b>42.05</b>	<b>11.98</b>	<b>3.3</b>	<b>1.0</b>	<b>8.7</b>	<b>41.0</b>
Abnormal instrument reading	4*	0.46	1.88	4.11	1.16	2.08	3.8	2.0	3.8	5.0
	4†	0.46	1.91	4.16	1.18	2.11				
Delayed operation	6*	1.11	5.43	12.44	3.64	3.13	2.6	1.0	6.0	15.0
	6†	1.15	5.43	12.33	3.58	3.16				
External leakage - Process medium	3*	1.31	21.13	61.80	20.49	1.56	-	1.0	2.0	3.0
	3†	1.55	22.44	64.66	21.33	1.58				
External leakage - Utility medium	2*	0.14	0.96	2.40	0.74	1.04	2.5	1.0	2.5	4.0
	2†	0.14	0.97	2.42	0.75	1.05				
Internal leakage	4*	0.00	7.61	34.71	13.84	2.08	-	8.0	27.7	41.0
	4†	0.00	7.65	34.88	13.90	2.11				
Other	2*	0.75	11.64	33.89	11.22	1.04	-	2.0	12.5	23.0
	2†	0.85	12.22	35.21	11.61	1.05				
Structural deficiency	2*	0.07	7.81	25.83	9.45	1.04	6.0	6.0	6.0	6.0
	2†	0.09	8.36	27.19	9.89	1.05				
<b>Incipient</b>	<b>28*</b> <b>28†</b>	<b>6.32</b>	<b>16.39</b>	<b>30.31</b>	<b>7.48</b>	<b>14.58</b>	<b>2.4</b>	<b>1.0</b>	<b>2.6</b>	<b>5.0</b>
Abnormal instrument reading	14*	0.16	6.40	19.63	6.86	7.29	2.5	1.0	2.7	5.0
	14†	0.18	6.48	19.80	6.88	7.38				
External leakage - Process medium	1*	0.00	3.52	14.86	5.71	0.52	-	3.0	3.0	3.0
	1†	0.00	3.54	14.94	5.74	0.53				
Internal leakage	1*	0.00	3.52	14.86	5.71	0.52	-	4.0	4.0	4.0
	1†	0.00	3.54	14.94	5.74	0.53				
Minor in-service problems	12*	0.63	5.70	15.05	4.76	6.25	2.1	1.0	2.1	4.0
	12†	0.65	5.77	15.16	4.78	6.33				
<b>Unknown</b>	<b>14*</b> <b>14†</b>	<b>0.87</b>	<b>5.48</b>	<b>13.40</b>	<b>4.07</b>	<b>7.29</b>	<b>2.4</b>	<b>1.0</b>	<b>3.5</b>	<b>8.0</b>
Unknown	14*	0.87	5.48	13.40	4.07	7.29	2.4	1.0	3.5	8.0
	14†	0.88	5.55	13.57	4.12	7.38				

Comments

(cont.)

Taxonomy no 4.4.4		Item Control and Safety Equipment Valves ESD								
Population 59	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 1.9199		Operational time † 1.8970						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max
All modes	149* 149†	67.28 61.01	77.44 78.29	88.18 97.35	6.36 11.07	77.61 78.54	3.2	1.0	5.1	45.0
Comments										

**Maintainable item versus failure mode, to be continued**

**Item:** Valves described by application - ESD

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bonnet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Closure member (Ball/gate/disc/etc.)	0.00	0.67	0.00	0.00	0.67	0.00	0.00	0.00	0.00
Control unit	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, position	8.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other actuator components	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00
Other valve components	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00
Pilot valve	0.00	0.00	0.00	0.67	12.75	2.68	0.00	0.00	0.00
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.01
Seat rings	0.00	0.00	0.67	0.00	0.67	0.00	0.00	0.00	0.67
Stem	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	2.68	2.68	0.00	0.00	0.00
Unknown	1.34	2.68	1.34	0.00	23.49	4.70	0.00	0.00	0.00
Valve body w/internals	0.00	0.00	0.00	0.00	1.34	0.00	0.00	0.00	0.00
Total	12.08	4.03	2.68	1.34	42.28	10.07	0.00	0.00	3.36

**Maintainable item versus failure mode, continued**

**Item:** Valves described by application - ESD

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	1.34
Bonnet	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.67
Cabling & junction boxes	0.00	0.00	0.67	0.00	1.34	0.00	0.67	0.00	4.03
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34
Control unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Instrument, position	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.72
Other	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.67
Other actuator components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Other valve components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Pilot valve	0.00	0.00	0.00	0.00	3.36	0.00	1.34	2.01	22.82
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.01
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.01
Stem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Subunit	0.00	0.00	0.00	0.00	2.01	0.00	0.67	2.01	10.07
Unknown	0.00	0.00	0.00	0.00	0.67	0.67	0.67	5.37	40.94
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	2.01
Total	0.00	0.00	1.34	0.00	8.05	0.67	4.70	9.40	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Valves described by application - ESD

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.67	0.00	0.00	0.00	8.05	2.68	0.00	0.00	0.67
Breakage	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	0.67	0.00	0.67	0.00	1.34	0.00	0.00	0.00	0.00
Electrical failure - general	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	4.03	1.34	0.00	0.00	19.46	3.36	0.00	0.00	0.00
Leakage	0.00	0.00	2.01	0.67	0.00	0.00	0.00	0.00	0.00
Looseness	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Mechanical Failure - general	0.67	2.01	0.00	0.00	10.07	0.67	0.00	0.00	1.34
Misc. external influences	0.67	0.00	0.00	0.67	1.34	0.67	0.00	0.00	0.00
Open circuit	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	0.67	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00
Short circuiting	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.67	0.00	0.00	2.01	2.01	0.00	0.00	0.00
Total	12.08	4.03	2.68	1.34	42.28	10.07	0.00	0.00	3.36

**Failure descriptor versus failure mode, continued**

Item: Valves described by application - ESD

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.08
Breakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	2.01
Corrosion	0.00	0.00	0.67	0.00	2.01	0.00	0.67	0.00	6.04
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	0.67	1.34	3.36	33.56
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.68
Looseness	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	1.34
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	1.34
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.67	0.00	1.34	1.34	18.12
Misc. external influences	0.00	0.00	0.00	0.00	2.68	0.00	0.67	0.00	6.71
Open circuit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Out of adjustment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Sticking	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.67
Unknown	0.00	0.00	0.00	0.00	2.01	0.00	0.00	4.03	10.74
Total	0.00	0.00	1.34	0.00	8.05	0.67	4.70	9.40	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.



Taxonomy no 4.4.4.1		Item Control and Safety Equipment Valves ESD Ball									
Population 30	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.9731			Operational time † 0.9610						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	53*	0.14	28.56	103.69	38.31	54.47	3.3	1.0	4.7	36.0	
	53†	0.15	29.08	104.96	38.78	55.15					
Fail to close on demand	42*	0.23	24.06	79.49	29.07	43.16	3.5	1.0	5.1	36.0	
	42†	0.24	24.49	80.56	29.42	43.71					
Fail to open on demand	9*	0.68	7.06	19.19	6.17	9.25	2.6	1.0	3.2	6.0	
	9†	0.70	7.16	19.44	6.25	9.37					
Spurious operation	1*	0.02	0.94	2.91	1.03	1.03	2.0	2.0	2.0	2.0	
	1†	0.02	0.95	2.94	1.04	1.04					
Structural deficiency	1*	0.02	0.94	2.91	1.03	1.03	-	-	-	-	
	1†	0.02	0.95	2.94	1.04	1.04					
<b>Degraded</b>	16*	7.90	60.64	154.75	48.11	16.44	3.1	1.0	9.1	41.0	
	16†	8.56	64.01	162.49	50.39	16.65					
Abnormal instrument reading	2*	0.26	1.88	4.71	1.45	2.06	3.5	2.0	3.5	5.0	
	2†	0.27	1.90	4.77	1.47	2.08					
Delayed operation	5*	0.59	5.59	14.92	4.75	5.14	2.6	1.0	3.8	9.0	
	5†	0.62	5.66	15.00	4.76	5.20					
External leakage - Process medium	2*	0.71	23.63	71.85	24.82	2.06	-	1.0	1.0	1.0	
	2†	1.00	25.41	76.55	25.99	2.08					
External leakage - Utility medium	1*	0.02	0.94	2.91	1.03	1.03	4.0	4.0	4.0	4.0	
	1†	0.02	0.95	2.94	1.04	1.04					
Internal leakage	4*	0.01	10.48	43.03	16.31	4.11	-	8.0	27.7	41.0	
	4†	0.01	10.57	43.32	16.41	4.16					
Other	1*	0.21	11.06	34.45	12.23	1.03	-	2.0	2.0	2.0	
	1†	0.28	11.89	36.55	12.82	1.04					
Structural deficiency	1*	0.21	11.06	34.45	12.23	1.03	-	6.0	6.0	6.0	
	1†	0.28	11.89	36.55	12.82	1.04					
<b>Incipient</b>	13*	2.95	11.89	25.77	7.26	13.36	2.1	1.0	2.1	5.0	
	13†	3.01	12.06	26.08	7.34	13.53					
Abnormal instrument reading	4*	0.50	3.54	8.89	2.74	4.11	2.7	1.0	2.7	5.0	
	4†	0.51	3.59	9.01	2.78	4.16					
Minor in-service problems	9*	2.09	8.80	19.32	5.49	9.25	1.8	1.0	1.8	4.0	
	9†	2.15	8.93	19.50	5.52	9.37					
<b>Unknown</b>	8*	0.66	6.40	17.18	5.49	8.22	2.0	1.0	2.7	8.0	
	8†	0.67	6.49	17.40	5.56	8.33					
Unknown	8*	0.66	6.40	17.18	5.49	8.22	2.0	1.0	2.7	8.0	
	8†	0.67	6.49	17.40	5.56	8.33					
<b>All modes</b>	90*	52.70	87.94	130.48	23.86	92.49	3.0	1.0	5.0	41.0	
	90†	50.12	89.38	137.84	26.96	93.66					
<b>Comments</b>											

Taxonomy no 4.4.4.1.1		Item Control and Safety Equipment Valves ESD Ball (1.1-5.0) inch								
Population 12	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.4208			Operational time † 0.4157					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	17*	25.74	40.40	60.60	40.40	40.40	3.0	1.0	3.7	9.0
	17†	26.06	40.90	61.34	40.90	40.90				
Fail to close on demand	8*	9.46	19.01	34.31	19.01	19.01	3.3	2.0	3.9	9.0
	8†	9.57	19.25	34.73	19.25	19.25				
Fail to open on demand	8*	9.46	19.01	34.31	19.01	19.01	2.8	1.0	3.5	6.0
	8†	9.57	19.25	34.73	19.25	19.25				
Structural deficiency	1*	0.12	2.38	11.28	2.38	2.38	-	-	-	-
	1†	0.12	2.41	11.42	2.41	2.41				
<b>Incipient</b>	3*	1.95	7.13	18.43	7.13	7.13	1.0	1.0	1.0	1.0
	3†	1.97	7.22	18.66	7.22	7.22				
Abnormal instrument reading	1*	0.12	2.38	11.28	2.38	2.38	1.0	1.0	1.0	1.0
	1†	0.12	2.41	11.42	2.41	2.41				
Minor in-service problems	2*	0.84	4.75	14.96	4.75	4.75	1.0	1.0	1.0	1.0
	2†	0.85	4.81	15.14	4.81	4.81				
<b>Unknown</b>	1*	0.12	2.38	11.28	2.38	2.38	3.0	3.0	3.0	3.0
	1†	0.12	2.41	11.42	2.41	2.41				
Unknown	1*	0.12	2.38	11.28	2.38	2.38	3.0	3.0	3.0	3.0
	1†	0.12	2.41	11.42	2.41	2.41				
<b>All modes</b>	21*	33.44	49.91	71.87	49.91	49.91	2.8	1.0	3.4	9.0
	21†	33.85	50.52	72.75	50.52	50.52				
<b>Comments</b>										

Taxonomy no 4.4.4.1.2		Item Control and Safety Equipment Valves ESD Ball (5.1-10) inch								
Population 8	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.2805			Operational time † 0.2771					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	19*	44.35	67.73	99.38	67.73	67.73	4.1	1.0	7.0	36.0
	19†	44.89	68.56	100.60	68.56	68.56				
Fail to close on demand	18*	41.47	64.17	95.15	64.17	64.17	4.3	1.0	7.4	36.0
	18†	41.98	64.95	96.31	64.95	64.95				
Fail to open on demand	1*	0.18	3.56	16.92	3.56	3.56	1.0	1.0	1.0	1.0
	1†	0.18	3.61	17.12	3.61	3.61				
<b>Degraded</b>	5*	7.02	17.82	37.49	17.82	17.82	3.3	1.0	4.2	9.0
	5†	7.11	18.04	37.94	18.04	18.04				
Abnormal instrument reading	2*	1.27	7.13	22.44	7.13	7.13	3.5	2.0	3.5	5.0
	2†	1.28	7.22	22.72	7.22	7.22				
Delayed operation	2*	1.27	7.13	22.44	7.13	7.13	2.8	1.0	5.0	9.0
	2†	1.28	7.22	22.72	7.22	7.22				
External leakage - Utility medium	1*	0.18	3.56	16.92	3.56	3.56	4.0	4.0	4.0	4.0
	1†	0.18	3.61	17.12	3.61	3.61				
<b>Incipient</b>	6*	9.32	21.39	42.21	21.39	21.39	2.7	2.0	2.7	4.0
	6†	9.44	21.65	42.73	21.65	21.65				
Abnormal instrument reading	2*	1.27	7.13	22.44	7.13	7.13	2.0	2.0	2.0	2.0
	2†	1.28	7.22	22.72	7.22	7.22				
Minor in-service problems	4*	4.87	14.26	32.64	14.26	14.26	3.0	2.0	3.0	4.0
	4†	4.93	14.43	33.04	14.43	14.43				
<b>Unknown</b>	6*	9.32	21.39	42.21	21.39	21.39	1.6	1.0	2.6	8.0
	6†	9.44	21.65	42.73	21.65	21.65				
Unknown	6*	9.32	21.39	42.21	21.39	21.39	1.6	1.0	2.6	8.0
	6†	9.44	21.65	42.73	21.65	21.65				
<b>All modes</b>	36*	95.29	128.34	169.48	128.34	128.34	3.4	1.0	5.4	36.0
	36†	96.46	129.91	171.55	129.91	129.91				
<b>Comments</b>										

Taxonomy no 4.4.4.1.3		Item Control and Safety Equipment Valves ESD Ball (10.1-20) inch								
Population 4	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1403		Operational time † 0.1386						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours):					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	17*	77.22	121.21	181.79	121.21	121.21	2.7	1.0	3.2	11.0
	17†	78.17	122.69	184.02	122.69	122.69				
Fail to close on demand	16*	71.54	114.08	173.25	114.08	114.08	2.7	1.0	3.3	11.0
	16†	72.42	115.47	175.37	115.47	115.47				
Spurious operation	1*	0.36	7.13	33.83	7.13	7.13	2.0	2.0	2.0	2.0
	1†	0.36	7.22	34.25	7.22	7.22				
Degraded	3*	5.85	21.39	55.29	21.39	21.39	2.5	2.0	2.5	3.0
	3†	5.92	21.65	55.97	21.65	21.65				
Delayed operation	2*	2.53	14.26	44.88	14.26	14.26	2.5	2.0	2.5	3.0
	2†	2.56	14.43	45.43	14.43	14.43				
Internal leakage	1*	0.36	7.13	33.83	7.13	7.13	-	-	-	-
	1†	0.36	7.22	34.25	7.22	7.22				
Incipient	3*	5.85	21.39	55.29	21.39	21.39	2.3	1.0	2.3	5.0
	3†	5.92	21.65	55.97	21.65	21.65				
Abnormal instrument reading	1*	0.36	7.13	33.83	7.13	7.13	5.0	5.0	5.0	5.0
	1†	0.36	7.22	34.25	7.22	7.22				
Minor in-service problems	2*	2.53	14.26	44.88	14.26	14.26	1.0	1.0	1.0	1.0
	2†	2.56	14.43	45.43	14.43	14.43				
Unknown	1*	0.36	7.13	33.83	7.13	7.13	3.0	3.0	3.0	3.0
	1†	0.36	7.22	34.25	7.22	7.22				
Unknown	1*	0.36	7.13	33.83	7.13	7.13	3.0	3.0	3.0	3.0
	1†	0.36	7.22	34.25	7.22	7.22				
All modes	24*	117.98	171.12	240.64	171.12	171.12	2.6	1.0	3.0	11.0
	24†	119.43	173.21	243.58	173.21	173.21				
Comments										

Taxonomy no 4.4.4.1.4		Item Control and Safety Equipment Valves ESD Ball (20.1-30) inch								
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0526		Operational time † 0.0526						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	<i>n</i> / <i>τ</i>		Min	Mean	Max
Degraded	2*	6.75	38.02	119.66	38.02	38.02	-	8.0	8.0	8.0
	2†	6.75	38.05	119.77	38.05	38.05	-	-	-	-
Delayed operation	1*	0.95	19.01	90.20	19.01	19.01	-	-	-	-
	1†	0.95	19.03	90.28	19.03	19.03	-	-	-	-
Internal leakage	1*	0.95	19.01	90.20	19.01	19.01	-	8.0	8.0	8.0
	1†	0.95	19.03	90.28	19.03	19.03	-	-	-	-
All modes	2*	6.75	38.02	119.66	38.02	38.02	-	8.0	8.0	8.0
	2†	6.75	38.05	119.77	38.05	38.05	-	-	-	-
Comments										

Taxonomy no 4.4.4.1.5		Item Control and Safety Equipment Valves ESD Ball (30.1-40) inch								
Population 4	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0789		Operational time † 0.0770						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	6*	14.11	88.64	216.45	65.74	76.01	-	1.0	16.8	41.0
	6†	12.36	93.95	239.27	74.33	77.88	-			
External leakage - Process medium	2*	0.18	34.82	125.88	46.51	25.34	-	1.0	1.0	1.0
	2†	0.18	37.38	136.96	50.60	25.96	-			
Internal leakage	2*	3.41	23.39	58.30	17.92	25.34	-	34.0	37.5	41.0
	2†	0.24	22.62	73.85	26.91	25.96	-			
Other	1*	0.16	15.83	52.00	18.98	12.67	-	2.0	2.0	2.0
	1†	0.13	16.96	57.42	21.11	12.98	-			
Structural deficiency	1*	0.16	15.83	52.00	18.98	12.67	-	6.0	6.0	6.0
	1†	0.13	16.96	57.42	21.11	12.98	-			
Incipient	1*	0.15	11.61	37.19	13.44	12.67	-	-	-	-
	1†	0.18	11.88	37.51	13.45	12.98	-			
Minor in-service problems	1*	0.15	11.61	37.19	13.44	12.67	-	-	-	-
	1†	0.18	11.88	37.51	13.45	12.98	-			
All modes	7*	36.00	95.61	178.48	44.46	88.68	-	1.0	16.8	41.0
	7†	31.11	100.91	203.25	54.15	90.86	-			
Comments										

Taxonomy no 4.4.4.2		Item Control and Safety Equipment Valves ESD Gate									
Population 29	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.9468		Operational time † 0.9361							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	31*	2.81	23.75	61.67	19.32	32.74	3.8	1.0	5.7	45.0	
	31†	2.78	23.96	62.51	19.63	33.12					
Fail to close on demand	21*	4.66	18.05	38.61	10.78	22.18	4.2	1.0	6.8	45.0	
	21†	4.59	18.19	39.19	11.00	22.43					
Fail to open on demand	6*	0.48	5.39	14.92	4.84	6.34	2.1	1.0	2.8	6.0	
	6†	0.48	5.45	15.09	4.90	6.41					
Structural deficiency	4*	0.38	3.75	10.09	3.23	4.22	4.3	2.0	4.5	9.0	
	4†	0.39	3.79	10.21	3.27	4.27					
<b>Degraded</b>	7*	0.29	22.39	71.72	25.93	7.39	3.8	1.0	8.0	23.0	
	7†	0.29	22.43	71.74	25.91	7.48					
Abnormal instrument reading	2*	0.23	1.98	5.15	1.61	2.11	4.0	4.0	4.0	4.0	
	2†	0.23	2.00	5.21	1.63	2.14					
Delayed operation	1*	0.02	6.64	26.01	9.66	1.06	-	15.0	15.0	15.0	
	1†	0.02	6.64	26.03	9.67	1.07					
External leakage - Process medium	1*	0.02	6.64	26.01	9.66	1.06	-	3.0	3.0	3.0	
	1†	0.02	6.64	26.03	9.67	1.07					
External leakage - Utility medium	1*	0.03	1.00	3.04	1.06	1.06	1.0	1.0	1.0	1.0	
	1†	0.03	1.01	3.08	1.07	1.07					
Other	1*	0.02	6.64	26.01	9.66	1.06	-	23.0	23.0	23.0	
	1†	0.02	6.64	26.03	9.67	1.07					
Structural deficiency	1*	0.03	1.00	3.04	1.06	1.06	6.0	6.0	6.0	6.0	
	1†	0.03	1.01	3.08	1.07	1.07					
<b>Incipient</b>	15*	4.45	24.65	58.26	17.33	15.84	2.5	1.0	2.9	5.0	
	15†	4.59	24.70	57.99	17.19	16.02					
Abnormal instrument reading	10*	5.92	10.77	16.78	3.34	10.56	2.4	1.0	2.7	5.0	
	10†	5.98	10.88	16.97	3.38	10.68					
External leakage - Process medium	1*	0.02	6.64	26.01	9.66	1.06	-	3.0	3.0	3.0	
	1†	0.02	6.64	26.03	9.67	1.07					
Internal leakage	1*	0.02	6.64	26.01	9.66	1.06	-	4.0	4.0	4.0	
	1†	0.02	6.64	26.03	9.67	1.07					
Minor in-service problems	3*	0.32	2.89	7.64	2.42	3.17	3.0	3.0	3.0	3.0	
	3†	0.32	2.92	7.73	2.45	3.20					
<b>Unknown</b>	6*	0.48	5.39	14.92	4.84	6.34	2.9	1.0	4.5	8.0	
	6†	0.48	5.45	15.09	4.90	6.41					
Unknown	6*	0.48	5.39	14.92	4.84	6.34	2.9	1.0	4.5	8.0	
	6†	0.48	5.45	15.09	4.90	6.41					
<b>All modes</b>	59*	40.32	66.53	98.06	17.70	62.32	3.4	1.0	5.2	45.0	
	59†	41.32	66.97	97.66	17.26	63.03					
<b>Comments</b>											

Taxonomy no 4.4.4.2.1		Item Control and Safety Equipment Valves ESD Gate (1.1-5.0) inch										
Population 10	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)						No of demands				
		Calendar time * 0.3506			Operational time † 0.3464							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/t	Min		Mean	Max		
Critical	3*	2.34	8.56	22.12	8.56	8.56	2.7	1.0	5.0	12.0		
	3†	2.37	8.66	22.39	8.66	8.66						
Fail to close on demand	2*	1.01	5.70	17.95	5.70	5.70	3.5	1.0	6.5	12.0		
	2†	1.02	5.77	18.17	5.77	5.77						
Structural deficiency	1*	0.14	2.85	13.53	2.85	2.85	1.0	2.0	2.0	2.0		
	1†	0.14	2.89	13.70	2.89	2.89						
Degraded	1*	0.14	2.85	13.53	2.85	2.85	6.0	6.0	6.0	6.0		
	1†	0.14	2.89	13.70	2.89	2.89						
Structural deficiency	1*	0.14	2.85	13.53	2.85	2.85	6.0	6.0	6.0	6.0		
	1†	0.14	2.89	13.70	2.89	2.89						
Incipient	3*	2.34	8.56	22.12	8.56	8.56	3.0	3.0	3.0	3.0		
	3†	2.37	8.66	22.39	8.66	8.66						
Minor in-service problems	3*	2.34	8.56	22.12	8.56	8.56	3.0	3.0	3.0	3.0		
	3†	2.37	8.66	22.39	8.66	8.66						
All modes	7*	9.37	19.96	37.50	19.96	19.96	3.3	1.0	4.5	12.0		
	7†	9.48	20.21	37.96	20.21	20.21						
Comments												



Taxonomy no 4.4.4.2.2		Item Control and Safety Equipment Valves ESD Gate (5.1-10) inch																																																																																																																																																						
Population 12	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands																																																																																																																																																	
		Calendar time * 0.4208		Operational time † 0.4157																																																																																																																																																				
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)																																																																																																																																																
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max																																																																																																																																														
<b>Critical</b>	21*	33.44	49.91	71.87	49.91	49.91	4.0	1.0	6.1	45.0																																																																																																																																														
	21†	33.85	50.52	72.75	50.52	50.52					Fail to close on demand	15*	21.97	35.65	54.89	35.65	35.65	4.3	1.0	7.1	45.0	15†	22.24	36.09	55.56	36.09	36.09	Fail to open on demand	3*	1.95	7.13	18.43	7.13	7.13	1.2	1.0	1.7	3.0	3†	1.97	7.22	18.66	7.22	7.22	Structural deficiency	3*	1.95	7.13	18.43	7.13	7.13	5.3	2.0	5.3	9.0	3†	1.97	7.22	18.66	7.22	7.22	<b>Incipient</b>	7*	7.81	16.64	31.25	16.64	16.64	2.3	1.0	2.3	5.0	7†	7.90	16.84	31.63	16.84	16.84	Abnormal instrument reading	7*	7.81	16.64	31.25	16.64	16.64	2.3	1.0	2.3	5.0	7†	7.90	16.84	31.63	16.84	16.84	<b>Unknown</b>	3*	1.95	7.13	18.43	7.13	7.13	3.0	2.0	5.3	8.0	3†	1.97	7.22	18.66	7.22	7.22	Unknown	3*	1.95	7.13	18.43	7.13	7.13	3.0	2.0	5.3	8.0	3†	1.97	7.22	18.66	7.22	7.22	<b>All modes</b>	31*	53.34	73.67	99.43	73.67	73.67	3.5	1.0	5.2	45.0	31†	53.99	74.58	100.65	74.58	74.58	Comments					
Fail to close on demand	15*	21.97	35.65	54.89	35.65	35.65	4.3	1.0	7.1	45.0																																																																																																																																														
	15†	22.24	36.09	55.56	36.09	36.09					Fail to open on demand	3*	1.95	7.13	18.43	7.13	7.13	1.2	1.0	1.7	3.0	3†	1.97	7.22	18.66	7.22	7.22	Structural deficiency	3*	1.95	7.13	18.43	7.13	7.13	5.3	2.0	5.3	9.0	3†	1.97	7.22	18.66	7.22	7.22	<b>Incipient</b>	7*	7.81	16.64	31.25	16.64	16.64	2.3	1.0	2.3	5.0	7†	7.90	16.84	31.63	16.84	16.84	Abnormal instrument reading	7*	7.81	16.64	31.25	16.64	16.64	2.3	1.0	2.3	5.0	7†	7.90	16.84	31.63	16.84	16.84	<b>Unknown</b>	3*	1.95	7.13	18.43	7.13	7.13	3.0	2.0	5.3	8.0	3†	1.97	7.22	18.66	7.22	7.22	Unknown	3*	1.95	7.13	18.43	7.13	7.13	3.0	2.0	5.3	8.0	3†	1.97	7.22	18.66	7.22	7.22	<b>All modes</b>	31*	53.34	73.67	99.43	73.67	73.67	3.5	1.0	5.2	45.0	31†	53.99	74.58	100.65	74.58	74.58	Comments																						
Fail to open on demand	3*	1.95	7.13	18.43	7.13	7.13	1.2	1.0	1.7	3.0																																																																																																																																														
	3†	1.97	7.22	18.66	7.22	7.22					Structural deficiency	3*	1.95	7.13	18.43	7.13	7.13	5.3	2.0	5.3	9.0	3†	1.97	7.22	18.66	7.22	7.22	<b>Incipient</b>	7*	7.81	16.64	31.25	16.64	16.64	2.3	1.0	2.3	5.0	7†	7.90	16.84	31.63	16.84	16.84	Abnormal instrument reading	7*	7.81	16.64	31.25	16.64	16.64	2.3	1.0	2.3	5.0	7†	7.90	16.84	31.63	16.84	16.84	<b>Unknown</b>	3*	1.95	7.13	18.43	7.13	7.13	3.0	2.0	5.3	8.0	3†	1.97	7.22	18.66	7.22	7.22	Unknown	3*	1.95	7.13	18.43	7.13	7.13	3.0	2.0	5.3	8.0	3†	1.97	7.22	18.66	7.22	7.22	<b>All modes</b>	31*	53.34	73.67	99.43	73.67	73.67	3.5	1.0	5.2	45.0	31†	53.99	74.58	100.65	74.58	74.58	Comments																																							
Structural deficiency	3*	1.95	7.13	18.43	7.13	7.13	5.3	2.0	5.3	9.0																																																																																																																																														
	3†	1.97	7.22	18.66	7.22	7.22					<b>Incipient</b>	7*	7.81	16.64	31.25	16.64	16.64	2.3	1.0	2.3	5.0	7†	7.90	16.84	31.63	16.84	16.84	Abnormal instrument reading	7*	7.81	16.64	31.25	16.64	16.64	2.3	1.0	2.3	5.0	7†	7.90	16.84	31.63	16.84	16.84	<b>Unknown</b>	3*	1.95	7.13	18.43	7.13	7.13	3.0	2.0	5.3	8.0	3†	1.97	7.22	18.66	7.22	7.22	Unknown	3*	1.95	7.13	18.43	7.13	7.13	3.0	2.0	5.3	8.0	3†	1.97	7.22	18.66	7.22	7.22	<b>All modes</b>	31*	53.34	73.67	99.43	73.67	73.67	3.5	1.0	5.2	45.0	31†	53.99	74.58	100.65	74.58	74.58	Comments																																																								
<b>Incipient</b>	7*	7.81	16.64	31.25	16.64	16.64	2.3	1.0	2.3	5.0																																																																																																																																														
	7†	7.90	16.84	31.63	16.84	16.84					Abnormal instrument reading	7*	7.81	16.64	31.25	16.64	16.64	2.3	1.0	2.3	5.0	7†	7.90	16.84	31.63	16.84	16.84	<b>Unknown</b>	3*	1.95	7.13	18.43	7.13	7.13	3.0	2.0	5.3	8.0	3†	1.97	7.22	18.66	7.22	7.22	Unknown	3*	1.95	7.13	18.43	7.13	7.13	3.0	2.0	5.3	8.0	3†	1.97	7.22	18.66	7.22	7.22	<b>All modes</b>	31*	53.34	73.67	99.43	73.67	73.67	3.5	1.0	5.2	45.0	31†	53.99	74.58	100.65	74.58	74.58	Comments																																																																									
Abnormal instrument reading	7*	7.81	16.64	31.25	16.64	16.64	2.3	1.0	2.3	5.0																																																																																																																																														
	7†	7.90	16.84	31.63	16.84	16.84					<b>Unknown</b>	3*	1.95	7.13	18.43	7.13	7.13	3.0	2.0	5.3	8.0	3†	1.97	7.22	18.66	7.22	7.22	Unknown	3*	1.95	7.13	18.43	7.13	7.13	3.0	2.0	5.3	8.0	3†	1.97	7.22	18.66	7.22	7.22	<b>All modes</b>	31*	53.34	73.67	99.43	73.67	73.67	3.5	1.0	5.2	45.0	31†	53.99	74.58	100.65	74.58	74.58	Comments																																																																																										
<b>Unknown</b>	3*	1.95	7.13	18.43	7.13	7.13	3.0	2.0	5.3	8.0																																																																																																																																														
	3†	1.97	7.22	18.66	7.22	7.22					Unknown	3*	1.95	7.13	18.43	7.13	7.13	3.0	2.0	5.3	8.0	3†	1.97	7.22	18.66	7.22	7.22	<b>All modes</b>	31*	53.34	73.67	99.43	73.67	73.67	3.5	1.0	5.2	45.0	31†	53.99	74.58	100.65	74.58	74.58	Comments																																																																																																											
Unknown	3*	1.95	7.13	18.43	7.13	7.13	3.0	2.0	5.3	8.0																																																																																																																																														
	3†	1.97	7.22	18.66	7.22	7.22					<b>All modes</b>	31*	53.34	73.67	99.43	73.67	73.67	3.5	1.0	5.2	45.0	31†	53.99	74.58	100.65	74.58	74.58	Comments																																																																																																																												
<b>All modes</b>	31*	53.34	73.67	99.43	73.67	73.67	3.5	1.0	5.2	45.0																																																																																																																																														
	31†	53.99	74.58	100.65	74.58	74.58																																																																																																																																																		
Comments																																																																																																																																																								

Taxonomy no 4.4.4.2.3		Item Control and Safety Equipment Valves ESD Gate (10.1-20) inch								
Population 3	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *			Operational time †					
		0.1052					0.1039			
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	7*	31.23	66.54	125.01	66.54	66.54	3.9	2.0	5.0	10.0
	7†	31.61	67.36	126.54	67.36	67.36				
Fail to close on demand	4*	12.98	38.03	87.03	38.03	38.03	4.5	4.0	5.8	10.0
	4†	13.14	38.49	88.10	38.49	38.49				
Fail to open on demand	3*	7.80	28.52	73.72	28.52	28.52	3.0	2.0	4.0	6.0
	3†	7.89	28.87	74.62	28.87	28.87				
<b>Degraded</b>	3*	7.80	28.52	73.72	28.52	28.52	3.0	1.0	3.0	4.0
	3†	7.89	28.87	74.62	28.87	28.87				
Abnormal instrument reading	2*	3.37	19.01	59.84	19.01	19.01	4.0	4.0	4.0	4.0
	2†	3.42	19.25	60.58	19.25	19.25				
External leakage - Utility medium	1*	0.48	9.51	45.11	9.51	9.51	1.0	1.0	1.0	1.0
	1†	0.48	9.62	45.66	9.62	9.62				
<b>Incipient</b>	2*	3.37	19.01	59.84	19.01	19.01	3.0	2.0	3.0	4.0
	2†	3.42	19.25	60.58	19.25	19.25				
Abnormal instrument reading	2*	3.37	19.01	59.84	19.01	19.01	3.0	2.0	3.0	4.0
	2†	3.42	19.25	60.58	19.25	19.25				
<b>Unknown</b>	3*	7.80	28.52	73.72	28.52	28.52	2.8	1.0	3.7	5.0
	3†	7.89	28.87	74.62	28.87	28.87				
Unknown	3*	7.80	28.52	73.72	28.52	28.52	2.8	1.0	3.7	5.0
	3†	7.89	28.87	74.62	28.87	28.87				
<b>All modes</b>	15*	87.89	142.60	219.55	142.60	142.60	3.4	1.0	4.1	10.0
	15†	88.96	144.34	222.24	144.34	144.34				
<b>Comments</b>										

Taxonomy no 4.4.4.2.4		Item Control and Safety Equipment Valves ESD Gate (20.1-30) inch									
Population 4	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0702			Operational time † 0.0701						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Degraded</b>	3*	11.68	42.75	110.51	42.75	42.75	-	3.0	13.7	23.0	
	3†	11.70	42.81	110.66	42.81	42.81	-				
Delayed operation	1*	0.71	14.25	67.62	14.25	14.25	-	15.0	15.0	15.0	
	1†	0.71	14.27	67.71	14.27	14.27	-				
External leakage - Process medium	1*	0.71	14.25	67.62	14.25	14.25	-	3.0	3.0	3.0	
	1†	0.71	14.27	67.71	14.27	14.27	-				
Other	1*	0.71	14.25	67.62	14.25	14.25	-	23.0	23.0	23.0	
	1†	0.71	14.27	67.71	14.27	14.27	-				
<b>Incipient</b>	3*	11.68	42.75	110.51	42.75	42.75	-	3.0	4.0	5.0	
	3†	11.70	42.81	110.66	42.81	42.81	-				
Abnormal instrument reading	1*	0.71	14.25	67.62	14.25	14.25	-	5.0	5.0	5.0	
	1†	0.71	14.27	67.71	14.27	14.27	-				
External leakage - Process medium	1*	0.71	14.25	67.62	14.25	14.25	-	3.0	3.0	3.0	
	1†	0.71	14.27	67.71	14.27	14.27	-				
Internal leakage	1*	0.71	14.25	67.62	14.25	14.25	-	4.0	4.0	4.0	
	1†	0.71	14.27	67.71	14.27	14.27	-				
<b>All modes</b>	6*	37.26	85.50	168.72	85.50	85.50	-	3.0	8.8	23.0	
	6†	37.31	85.62	168.95	85.62	85.62	-				
<b>Comments</b>											

Taxonomy no 4.4.5		Item Control and Safety Equipment Valves ESD/PSD								
Population 161	Installations 7	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 5.5206		Operational time † 5.5161						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	52*	2.25	16.29	41.07	12.70	9.42	6.6	1.0	12.6	66.0
	52†	2.31	16.37	41.08	12.67	9.43				
Delayed operation	2*	0.00	0.66	2.77	1.06	0.36	19.8	28.0	39.5	51.0
	2†	0.00	0.66	2.76	1.05	0.36				
External leakage - Utility medium	1*	0.00	0.28	0.98	0.36	0.18	8.5	17.0	17.0	17.0
	1†	0.00	0.28	0.97	0.36	0.18				
Fail to close on demand	18*	1.46	5.37	11.28	3.11	3.26	10.9	2.0	21.6	66.0
	18†	1.46	5.43	11.45	3.16	3.26				
Fail to open on demand	8*	0.20	3.67	10.87	3.62	1.45	3.4	2.0	5.6	12.0
	8†	0.21	3.70	10.95	3.64	1.45				
Other	3*	0.00	0.99	4.39	1.73	0.54	8.3	1.0	16.7	37.0
	3†	0.00	0.99	4.37	1.72	0.54				
Spurious operation	19*	0.01	4.24	16.66	6.20	3.44	2.8	1.0	4.5	24.0
	19†	0.01	4.23	16.58	6.16	3.44				
Structural deficiency	1*	0.00	0.17	0.51	0.18	0.18	2.0	2.0	2.0	2.0
	1†	0.00	0.17	0.52	0.18	0.18				
<b>Degraded</b>	35*	3.17	15.92	36.73	10.78	6.34	8.3	2.0	14.9	61.0
	35†	3.22	16.01	36.84	10.80	6.35				
Abnormal instrument reading	1*	0.02	1.66	5.39	1.96	0.18	-	6.0	6.0	6.0
	1†	0.02	1.74	5.57	2.01	0.18				
Delayed operation	6*	0.11	2.39	7.16	2.41	1.09	9.3	4.0	10.2	14.0
	6†	0.11	2.40	7.20	2.42	1.09				
External leakage - Process medium	3*	0.08	0.51	1.25	0.38	0.54	6.0	10.0	21.3	35.0
	3†	0.08	0.51	1.25	0.38	0.54				
External leakage - Utility medium	14*	0.15	3.82	11.50	3.91	2.54	6.5	2.0	11.3	40.0
	14†	0.15	3.83	11.53	3.91	2.54				
Fail to open on demand	1*	0.00	0.17	0.51	0.18	0.18	6.0	6.0	6.0	6.0
	1†	0.00	0.17	0.52	0.18	0.18				
Internal leakage	3*	0.07	3.51	10.89	3.86	0.54	10.0	9.0	28.5	48.0
	3†	0.07	3.52	10.91	3.86	0.54				
Other	6*	0.06	3.11	9.70	3.45	1.09	13.5	4.0	22.4	61.0
	6†	0.06	3.10	9.69	3.45	1.09				
Plugged/Choked	1*	0.00	0.88	3.42	1.27	0.18	-	-	-	-
	1†	0.00	0.88	3.43	1.27	0.18				
<b>Incipient</b>	74*	5.22	27.22	63.41	18.72	13.40	4.3	1.0	8.2	29.0
	74†	5.34	27.38	63.51	18.70	13.42				
Abnormal instrument reading	10*	0.41	5.50	15.65	5.14	1.81	5.0	2.0	8.8	29.0
	10†	0.42	5.54	15.75	5.17	1.81				
External leakage - Process medium	1*	0.00	0.18	0.54	0.19	0.18	-	-	-	-
	1†	0.00	0.18	0.54	0.19	0.18				

Comments

(cont.)

Taxonomy no 4.4.5		Item Control and Safety Equipment Valves ESD/PSD									
Population 161	Installations 7	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 5.5206		Operational time † 5.5161							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
External leakage - Utility medium	25* 25†	0.04 0.04	5.06 5.13	16.94 17.14	6.22 6.29	4.53 4.53	3.6	2.0	6.9	20.0	
Internal leakage	1* 1†	0.00 0.00	0.18 0.18	0.54 0.54	0.19 0.19	0.18 0.18	6.0	12.0	12.0	12.0	
Low output	1* 1†	0.00 0.00	0.28 0.28	0.98 0.97	0.36 0.36	0.18 0.18	6.0	12.0	12.0	12.0	
Minor in-service problems	11* 11†	0.35 0.37	7.02 7.06	21.00 21.06	7.01 7.02	1.99 1.99	2.0	2.0	4.3	10.0	
Other	22* 22†	0.00 0.00	5.89 5.86	29.66 29.52	12.72 12.67	3.99 3.99	4.9	1.0	9.6	28.0	
Structural deficiency	3* 3†	0.02 0.02	2.19 2.20	7.23 7.23	2.64 2.64	0.54 0.54	9.0	13.0	15.5	18.0	
<b>All modes</b>	<b>161* 161†</b>	<b>15.30 15.61</b>	<b>61.20 61.59</b>	<b>132.25 132.52</b>	<b>37.20 37.16</b>	<b>29.16 29.19</b>	<b>5.9</b>	<b>1.0</b>	<b>11.1</b>	<b>66.0</b>	
<b>Comments</b>											

**Maintainable item versus failure mode, to be continued**

**Item:** Valves described by application - ESD/PSD

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	0.00	0.00	0.00	0.00	0.62	0.62	0.00	0.00	0.00
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	1.24	0.00	0.00	0.00
Control unit	0.62	0.00	0.00	0.62	1.24	0.00	0.00	0.00	0.00
Electric motor (electric actuator)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Indicator	0.62	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00
Instrument, general	0.62	0.00	0.00	1.86	0.00	0.00	0.00	0.00	0.00
Instrument, position	1.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	0.62	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other actuator components	0.00	0.62	0.00	3.11	0.62	0.00	0.00	0.00	0.00
Other valve components	0.00	0.00	1.24	1.24	0.62	0.00	0.00	0.00	0.00
Packing	0.00	0.00	0.00	0.62	0.62	0.00	0.00	0.00	0.00
Pilot valve	0.62	0.00	0.00	2.48	1.86	0.62	0.00	0.00	0.62
Piston(s)	0.00	0.00	0.00	0.62	0.62	0.00	0.00	0.00	0.00
Seals (gaskets)	0.00	0.00	0.62	11.80	0.00	0.00	0.00	0.00	0.62
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Stem	0.00	0.62	0.62	0.00	0.62	0.00	0.00	0.00	0.00
Subunit	0.00	0.62	0.00	0.00	0.62	0.62	0.00	0.00	0.00
Unknown	1.24	1.86	0.00	1.86	3.11	2.48	0.00	0.00	0.62
Valve body w/internals	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Valves	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00
<b>Total</b>	<b>6.83</b>	<b>4.97</b>	<b>2.48</b>	<b>24.84</b>	<b>11.18</b>	<b>5.59</b>	<b>0.00</b>	<b>0.00</b>	<b>2.48</b>

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**

**Item:** Valves described by application - ESD/PSD

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.62	3.73	0.00	0.00	6.21	0.00	0.00	11.80
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.24
Control unit	0.00	0.00	0.00	0.00	0.00	1.86	0.00	0.00	4.35
Electric motor (electric actuator)	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.62
Indicator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.24
Instrument, general	0.00	0.00	0.62	0.00	0.62	1.24	0.00	0.00	4.97
Instrument, position	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.86
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.62
Monitoring	0.00	0.00	1.24	0.00	0.00	0.00	0.00	0.00	2.48
Other	0.00	0.00	6.21	0.00	0.00	0.00	0.00	0.00	6.83
Other actuator components	0.00	0.00	2.48	0.00	0.62	0.00	0.00	0.00	7.45
Other valve components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.11
Packing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.24
Pilot valve	0.00	0.00	0.00	0.00	1.86	0.62	0.00	0.00	8.70
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.24
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.04
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Stem	0.00	0.00	0.00	0.00	0.62	0.62	0.62	0.00	3.73
Subunit	0.00	0.00	1.86	0.00	0.00	0.00	0.00	0.00	3.73
Unknown	0.00	0.00	1.24	0.62	3.11	0.62	1.86	0.00	18.63
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Valves	0.00	0.00	1.24	0.00	0.00	0.00	0.00	0.00	1.86
Total	0.00	0.62	19.25	0.62	6.83	11.80	2.48	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Valves described by application - ESD/PSD

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.00	0.00	0.00	0.00	0.62	0.62	0.00	0.00	0.00
Breakage	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	0.00	0.62	0.00	1.24	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	1.86	1.24	0.00	1.24	1.24	2.48	0.00	0.00	0.00
Leakage	0.00	0.62	1.86	18.01	0.00	0.00	0.00	0.00	1.24
Looseness	0.00	0.00	0.00	0.62	0.62	0.00	0.00	0.00	0.00
Material failure - general	0.62	0.00	0.62	2.48	0.62	0.00	0.00	0.00	0.62
Mechanical Failure - general	0.62	0.62	0.00	0.62	1.86	1.24	0.00	0.00	0.62
Misc. external influences	0.62	0.62	0.00	0.00	0.00	0.62	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	1.24	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00
Short circuiting	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00
Sticking	0.00	1.24	0.00	0.00	1.86	0.62	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.62	1.24	0.00	0.00	0.00	0.00
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	6.83	4.97	2.48	24.84	11.18	5.59	0.00	0.00	2.48

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.



**Failure descriptor versus failure mode, continued**

Item: Valves described by application - ESD/PSD

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	1.86
Breakage	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	1.24
Cavitation	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	1.24
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Corrosion	0.00	0.00	4.35	0.00	0.00	0.62	0.62	0.00	7.45
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Electrical failure - general	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.62
External influence - general	0.00	0.00	1.86	0.00	0.00	0.00	0.00	0.00	1.86
Faulty signal/indication/alarm	0.00	0.62	1.86	0.00	0.00	3.73	0.00	0.00	6.83
Instrument failure - general	0.00	0.00	1.86	0.00	0.62	4.35	0.00	0.00	14.91
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.74
Looseness	0.00	0.00	0.62	0.00	2.48	0.62	0.00	0.00	4.97
Material failure - general	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	5.59
Mechanical Failure - general	0.00	0.00	1.24	0.00	1.86	0.00	0.62	0.00	9.32
Misc. external influences	0.00	0.00	1.86	0.00	0.62	0.00	0.00	0.00	4.35
No cause found	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.62
Other	0.00	0.00	0.00	0.00	0.62	0.00	0.62	0.00	1.24
Out of adjustment	0.00	0.00	1.24	0.00	0.00	0.00	0.00	0.00	3.11
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	1.24
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.73
Unknown	0.00	0.00	1.86	0.62	0.00	1.24	0.00	0.00	5.59
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.62
Total	0.00	0.62	19.25	0.62	6.83	11.80	2.48	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.4.5.1		Item Control and Safety Equipment Valves ESD/PSD Ball									
Population 117	Installations 5	Aggregated time in service (10 <sup>6</sup> hours)						No of demands			
		Calendar time * 4.2331			Operational time † 4.2359						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ	Min		Mean	Max	
Critical	38*	0.63	13.85	41.57	13.97	8.98	6.8	1.0	12.9	55.0	
	38†	0.64	13.78	41.34	13.87	8.97					
Delayed operation	2*	0.00	0.87	3.46	1.29	0.47	19.8	28.0	39.5	51.0	
	2†	0.00	0.86	3.43	1.28	0.47					
External leakage - Utility medium	1*	0.00	0.37	1.32	0.49	0.24	8.5	17.0	17.0	17.0	
	1†	0.00	0.36	1.31	0.48	0.24					
Fail to close on demand	11*	0.34	3.36	9.06	2.90	2.60	12.3	2.0	23.4	55.0	
	11†	0.34	3.35	9.03	2.89	2.60					
Fail to open on demand	4*	0.13	1.31	3.52	1.13	0.94	3.8	4.0	6.8	12.0	
	4†	0.13	1.30	3.51	1.12	0.94					
Other	3*	0.00	1.33	5.46	2.07	0.71	8.3	1.0	16.7	37.0	
	3†	0.00	1.32	5.42	2.06	0.71					
Spurious operation	16*	0.02	5.50	20.55	7.58	3.78	2.3	1.0	4.3	24.0	
	16†	0.02	5.46	20.40	7.53	3.78					
Structural deficiency	1*	0.00	0.24	0.81	0.30	0.24	2.0	2.0	2.0	2.0	
	1†	0.00	0.24	0.81	0.30	0.24					
Degraded	31*	4.34	19.29	43.01	12.35	7.32	8.4	2.0	15.7	61.0	
	31†	4.33	19.27	42.98	12.34	7.32					
Delayed operation	4*	0.06	2.64	8.18	2.89	0.94	10.0	4.0	9.8	14.0	
	4†	0.06	2.64	8.18	2.88	0.94					
External leakage - Process medium	3*	0.12	0.66	1.57	0.47	0.71	6.0	10.0	21.3	35.0	
	3†	0.12	0.66	1.57	0.47	0.71					
External leakage - Utility medium	13*	0.41	4.94	13.81	4.50	3.07	6.5	2.0	11.8	40.0	
	13†	0.41	4.94	13.80	4.50	3.07					
Fail to open on demand	1*	0.00	0.24	0.81	0.30	0.24	6.0	6.0	6.0	6.0	
	1†	0.00	0.24	0.81	0.30	0.24					
Internal leakage	3*	0.43	4.97	13.86	4.51	0.71	10.0	9.0	28.5	48.0	
	3†	0.43	4.97	13.85	4.51	0.71					
Other	6*	0.29	4.25	12.25	4.04	1.42	13.5	4.0	22.4	61.0	
	6†	0.29	4.23	12.20	4.03	1.42					
Plugged/Choked	1*	0.01	1.18	4.06	1.50	0.24	-	-	-	-	
	1†	0.01	1.18	4.06	1.50	0.24					
Incipient	62*	4.07	26.42	65.01	19.84	14.65	4.5	1.0	9.0	29.0	
	62†	4.08	26.34	64.74	19.74	14.64					
Abnormal instrument reading	5*	0.24	3.30	9.45	3.11	1.18	9.0	6.0	15.5	29.0	
	5†	0.24	3.30	9.43	3.10	1.18					
External leakage - Process medium	1*	0.00	0.22	0.67	0.24	0.24	-	-	-	-	
	1†	0.00	0.22	0.67	0.24	0.24					
External leakage - Utility medium	22*	0.00	3.49	14.70	5.64	5.20	3.6	2.0	7.3	20.0	
	22†	0.00	3.48	14.70	5.65	5.19					
Comments											

(cont.)

Taxonomy no 4.4.5.1		Item Control and Safety Equipment Valves ESD/PSD Ball								
Population 117	Installations 5	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 4.2331		Operational time † 4.2359						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/t		Min	Mean	Max
Internal leakage	1*	0.00	0.22	0.67	0.24	0.24	6.0	12.0	12.0	12.0
	1†	0.00	0.22	0.67	0.24	0.24				
Low output	1*	0.00	0.37	1.32	0.49	0.24	6.0	12.0	12.0	12.0
	1†	0.00	0.36	1.31	0.48	0.24				
Minor in-service problems	8*	0.29	7.52	22.68	7.72	1.89	2.0	2.0	4.8	10.0
	8†	0.29	7.53	22.69	7.71	1.89				
Other	21*	0.00	8.11	35.98	14.17	4.96	4.9	1.0	9.6	28.0
	21†	0.00	8.05	35.74	14.09	4.96				
Structural deficiency	3*	0.11	3.00	9.06	3.09	0.71	9.0	13.0	15.5	18.0
	3†	0.11	3.00	9.05	3.09	0.71				
All modes	131*	13.15	61.78	139.95	40.63	30.95	6.1	1.0	11.7	61.0
	131†	13.18	61.60	139.39	40.43	30.93				
Comments										

Taxonomy no 4.4.5.1.1		Item Control and Safety Equipment Valves ESD/PSD Ball (1.1-5.0) inch										
Population 37	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)						No of demands				
		Calendar time * 1.3554			Operational time † 1.3594							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)				
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max		
<b>Critical</b>	6*	0.52	4.27	11.00	3.44	4.43	4.0	2.0	7.2	14.0		
	6†	0.51	4.24	10.98	3.44	4.41						
Fail to close on demand	4*	0.65	2.88	6.39	1.83	2.95	4.0	2.0	6.8	14.0		
	4†	0.64	2.86	6.38	1.83	2.94						
Fail to open on demand	2*	0.23	1.50	3.70	1.13	1.48	4.0	4.0	8.0	12.0		
	2†	0.22	1.49	3.71	1.14	1.47						
<b>Degraded</b>	13*	0.04	8.56	32.26	11.90	9.59	6.2	2.0	15.8	48.0		
	13†	0.03	8.49	32.22	11.88	9.56						
Delayed operation	1*	0.00	0.75	2.67	0.99	0.74	7.0	14.0	14.0	14.0		
	1†	0.00	0.74	2.67	0.99	0.74						
External leakage - Process medium	2*	0.23	1.50	3.70	1.13	1.48	2.0	19.0	27.0	35.0		
	2†	0.22	1.49	3.71	1.14	1.47						
External leakage - Utility medium	8*	0.01	5.43	22.00	8.29	5.90	5.4	2.0	10.5	40.0		
	8†	0.01	5.39	21.92	8.28	5.88						
Fail to open on demand	1*	0.01	0.70	2.26	0.82	0.74	6.0	6.0	6.0	6.0		
	1†	0.01	0.69	2.25	0.82	0.74						
Internal leakage	1*	0.00	0.75	2.67	0.99	0.74	16.0	48.0	48.0	48.0		
	1†	0.00	0.74	2.67	0.99	0.74						
<b>Incipient</b>	5*	0.02	3.55	13.01	4.81	3.69	3.2	3.0	6.2	12.0		
	5†	0.02	3.52	12.99	4.80	3.68						
External leakage - Utility medium	4*	0.02	2.89	9.86	3.63	2.95	3.5	4.0	7.0	12.0		
	4†	0.02	2.87	9.84	3.63	2.94						
Other	1*	0.00	0.75	2.67	0.99	0.74	2.0	3.0	3.0	3.0		
	1†	0.00	0.74	2.67	0.99	0.74						
<b>All modes</b>	24*	0.07	15.10	55.35	20.45	17.71	5.0	2.0	11.7	48.0		
	24†	0.07	15.00	55.28	20.42	17.65						
<b>Comments</b>												

Taxonomy no 4.4.5.1.2		Item Control and Safety Equipment Valves ESD/PSD Ball (5.1-10) inch									
Population 26	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.9684			Operational time † 0.9695						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	4*	0.88	3.98	8.93	2.57	4.13	14.0	4.0	20.5	46.0	
	4†	0.87	3.98	8.93	2.58	4.13					
Fail to close on demand	3*	0.52	2.98	7.08	2.12	3.10	17.3	12.0	26.0	46.0	
	3†	0.52	2.97	7.08	2.12	3.09					
Spurious operation	1*	0.01	1.01	3.64	1.35	1.03	4.0	4.0	4.0	4.0	
	1†	0.01	1.01	3.64	1.35	1.03					
<b>Degraded</b>	3*	0.60	3.74	9.13	2.77	3.10	8.5	9.0	13.0	17.0	
	3†	0.63	3.69	8.84	2.65	3.09					
Delayed operation	1*	0.01	1.01	3.64	1.35	1.03	13.0	13.0	13.0	13.0	
	1†	0.01	1.01	3.64	1.35	1.03					
Internal leakage	1*	0.01	0.98	3.32	1.22	1.03	4.0	9.0	9.0	9.0	
	1†	0.01	0.98	3.32	1.22	1.03					
Other	1*	0.03	3.72	12.82	4.73	1.03	8.5	17.0	17.0	17.0	
	1†	0.02	3.63	12.61	4.65	1.03					
<b>Incipient</b>	5*	2.22	5.38	9.66	2.31	5.16	3.6	4.0	6.4	12.0	
	5†	2.22	5.37	9.64	2.31	5.16					
External leakage - Utility medium	2*	0.32	1.98	4.82	1.46	2.07	2.5	4.0	5.0	6.0	
	2†	0.32	1.98	4.82	1.46	2.06					
Internal leakage	1*	0.01	0.98	3.32	1.22	1.03	6.0	12.0	12.0	12.0	
	1†	0.01	0.98	3.32	1.22	1.03					
Minor in-service problems	1*	0.01	1.01	3.64	1.35	1.03	4.0	4.0	4.0	4.0	
	1†	0.01	1.01	3.64	1.35	1.03					
Other	1*	0.03	3.72	12.82	4.73	1.03	3.0	6.0	6.0	6.0	
	1†	0.02	3.63	12.61	4.65	1.03					
<b>All modes</b>	12*	7.55	12.81	19.20	3.58	12.39	8.3	4.0	12.8	46.0	
	12†	2.30	14.66	35.93	10.93	12.38					
<b>Comments</b>											

Taxonomy no 4.4.5.1.3		Item Control and Safety Equipment Valves ESD/PSD Ball (10.1-20) inch								
Population 38	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)						No of demands		
		Calendar time * 1.4991			Operational time † 1.4982					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max
<b>Critical</b>	13*	0.32	15.19	47.02	16.60	8.67	8.1	1.0	16.2	51.0
	13†	0.32	15.21	47.07	16.62	8.68				
Delayed operation	2*	0.01	3.00	11.79	4.39	1.33	19.8	28.0	39.5	51.0
	2†	0.01	3.00	11.80	4.39	1.33				
Fail to close on demand	1*	0.00	1.33	5.31	1.99	0.67	17.0	34.0	34.0	34.0
	1†	0.00	1.33	5.32	1.99	0.67				
Other	2*	0.01	3.00	11.79	4.39	1.33	9.5	1.0	19.0	37.0
	2†	0.01	3.00	11.80	4.39	1.33				
Spurious operation	7*	0.50	5.68	15.71	5.10	4.67	4.0	1.0	8.1	24.0
	7†	0.50	5.68	15.73	5.11	4.67				
Structural deficiency	1*	0.01	0.88	3.03	1.11	0.67	2.0	2.0	2.0	2.0
	1†	0.01	0.88	3.03	1.12	0.67				
<b>Degraded</b>	3*	0.29	2.47	6.43	2.02	2.00	7.2	2.0	10.3	19.0
	3†	0.29	2.47	6.44	2.02	2.00				
External leakage - Process medium	1*	0.01	0.88	3.03	1.11	0.67	10.0	10.0	10.0	10.0
	1†	0.01	0.88	3.03	1.12	0.67				
External leakage - Utility medium	1*	0.01	0.59	1.86	0.67	0.67	2.0	2.0	2.0	2.0
	1†	0.01	0.59	1.86	0.67	0.67				
Other	1*	0.00	1.33	5.31	1.99	0.67	9.5	19.0	19.0	19.0
	1†	0.00	1.33	5.32	1.99	0.67				
<b>Incipient</b>	28*	2.79	19.64	49.23	15.17	18.68	4.4	1.0	8.8	28.0
	28†	2.79	19.66	49.28	15.19	18.69				
Abnormal instrument reading	2*	0.28	1.45	3.38	1.00	1.33	6.3	6.0	12.5	19.0
	2†	0.28	1.45	3.38	1.00	1.33				
External leakage - Process medium	1*	0.01	0.59	1.86	0.67	0.67	-	-	-	-
	1†	0.01	0.59	1.86	0.67	0.67				
External leakage - Utility medium	16*	0.43	7.81	23.16	7.71	10.67	3.8	2.0	7.6	20.0
	16†	0.43	7.81	23.17	7.71	10.68				
Minor in-service problems	2*	0.03	1.11	3.41	1.20	1.33	1.0	2.0	2.0	2.0
	2†	0.03	1.11	3.42	1.20	1.33				
Other	7*	0.05	10.02	36.55	13.50	4.67	6.1	1.0	12.1	28.0
	7†	0.05	10.03	36.58	13.52	4.67				
<b>All modes</b>	44*	4.35	38.26	100.29	31.59	29.35	5.7	1.0	11.2	51.0
	44†	4.35	38.30	100.39	31.63	29.37				
<b>Comments</b>										

Taxonomy no 4.4.5.1.4		Item Control and Safety Equipment Valves ESD/PSD Ball (20.1-30) inch								
Population 10	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.2542		Operational time † 0.2540						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	8*	3.69	27.71	70.40	21.84	31.47	2.1	1.0	4.1	17.0
	8†	3.69	27.73	70.48	21.87	31.50				
External leakage - Utility medium	1*	0.04	3.67	12.04	4.39	3.93	8.5	17.0	17.0	17.0
	1†	0.04	3.68	12.05	4.40	3.94				
Fail to open on demand	2*	1.30	7.70	18.50	5.56	7.87	3.5	4.0	5.5	7.0
	2†	1.31	7.71	18.52	5.57	7.88				
Spurious operation	5*	0.22	16.67	53.32	19.26	19.67	0.5	1.0	1.0	1.0
	5†	0.22	16.68	53.38	19.28	19.69				
Degraded	9*	5.30	39.99	101.71	31.58	35.41	20.0	4.0	12.0	40.0
	9†	5.30	40.01	101.76	31.59	35.44				
Delayed operation	2*	0.83	7.97	21.34	6.81	7.87	-	4.0	6.0	8.0
	2†	0.83	7.98	21.35	6.81	7.88				
External leakage - Utility medium	3*	1.29	11.53	30.32	9.57	11.80	20.0	4.0	22.0	40.0
	3†	1.30	11.54	30.34	9.58	11.81				
Internal leakage	1*	0.09	13.99	48.51	17.89	3.93	-	-	-	-
	1†	0.09	13.99	48.52	17.90	3.94				
Other	2*	0.83	7.97	21.34	6.81	7.87	-	4.0	4.0	4.0
	2†	0.83	7.98	21.35	6.81	7.88				
Plugged/Choked	1*	0.02	3.98	14.87	5.49	3.93	-	-	-	-
	1†	0.02	3.98	14.88	5.49	3.94				
Incipient	13*	8.50	45.91	107.87	31.99	51.14	4.6	1.0	8.6	17.0
	13†	8.51	45.95	107.97	32.02	51.19				
Abnormal instrument reading	2*	0.83	7.97	21.34	6.81	7.87	-	8.0	8.0	8.0
	2†	0.83	7.98	21.35	6.81	7.88				
Low output	1*	0.04	3.67	12.04	4.39	3.93	6.0	12.0	12.0	12.0
	1†	0.04	3.68	12.05	4.40	3.94				
Minor in-service problems	3*	0.14	11.74	37.81	13.70	11.80	-	6.0	6.0	6.0
	3†	0.14	11.75	37.83	13.71	11.81				
Other	7*	0.11	22.19	80.41	29.71	27.54	4.4	1.0	8.6	17.0
	7†	0.11	22.21	80.50	29.74	27.56				
All modes	30*	59.72	114.09	182.66	37.86	118.02	4.5	1.0	7.8	40.0
	30†	59.73	114.18	182.86	37.93	118.13				
Comments										

Taxonomy no 4.4.5.1.5		Item Control and Safety Equipment Valves ESD/PSD Ball (30.1-40) inch									
Population 5	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1253		Operational time † 0.1242							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n / τ		Min	Mean	Max	
<b>Critical</b>	7*	<b>17.44</b>	<b>52.56</b>	<b>103.02</b>	<b>26.84</b>	<b>55.85</b>	7.5	1.0	18.3	55.0	
	7†	<b>17.26</b>	<b>52.96</b>	<b>104.52</b>	<b>27.39</b>	<b>56.35</b>					
Fail to close on demand	3*	6.86	24.34	50.58	13.82	23.94	18.8	40.0	47.5	55.0	
	3†	6.90	24.53	51.01	13.94	24.15					
Other	1*	0.15	7.28	22.56	7.98	7.98	6.0	12.0	12.0	12.0	
	1†	0.15	7.35	22.77	8.05	8.05					
Spurious operation	3*	5.01	21.83	48.36	13.82	23.94	0.5	1.0	1.0	1.0	
	3†	5.06	22.04	48.80	13.94	24.15					
<b>Degraded</b>	3*	<b>6.86</b>	<b>24.34</b>	<b>50.58</b>	<b>13.82</b>	<b>23.94</b>	<b>18.0</b>	<b>11.0</b>	<b>36.0</b>	<b>61.0</b>	
	3†	<b>6.90</b>	<b>24.53</b>	<b>51.01</b>	<b>13.94</b>	<b>24.15</b>					
External leakage - Utility medium	1*	0.06	11.82	42.68	15.77	7.98	-	-	-	-	
	1†	0.06	11.83	42.55	15.72	8.05					
Other	2*	0.21	13.82	43.68	15.67	15.96	18.0	11.0	36.0	61.0	
	2†	0.21	13.95	44.15	15.86	16.10					
<b>Incipient</b>	11*	<b>51.40</b>	<b>90.08</b>	<b>137.56</b>	<b>26.46</b>	<b>87.77</b>	<b>7.5</b>	<b>4.0</b>	<b>14.0</b>	<b>29.0</b>	
	11†	<b>51.77</b>	<b>90.79</b>	<b>138.69</b>	<b>26.70</b>	<b>88.55</b>					
Abnormal instrument reading	1*	0.15	7.28	22.56	7.98	7.98	14.5	29.0	29.0	29.0	
	1†	0.15	7.35	22.77	8.05	8.05					
Minor in-service problems	2*	0.11	26.08	98.13	36.20	15.96	-	10.0	10.0	10.0	
	2†	0.11	26.10	98.06	36.18	16.10					
Other	5*	4.24	33.98	87.42	27.28	39.90	4.7	4.0	9.3	20.0	
	5†	4.11	34.25	88.74	27.78	40.25					
Structural deficiency	3*	3.43	29.52	76.90	24.13	23.94	9.0	13.0	15.5	18.0	
	3†	3.59	29.58	76.47	23.91	24.15					
<b>All modes</b>	21*	<b>112.58</b>	<b>167.87</b>	<b>232.18</b>	<b>36.56</b>	<b>167.56</b>	<b>9.1</b>	<b>1.0</b>	<b>18.7</b>	<b>61.0</b>	
	21†	<b>113.45</b>	<b>169.24</b>	<b>234.11</b>	<b>36.89</b>	<b>169.04</b>					
Comments											



Taxonomy no 4.4.5.1.6		Item Control and Safety Equipment Valves ESD/PSD Ball Unknown								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0306		Operational time † 0.0306						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	<i>n/t</i>		Min	Mean	Max
All modes	0* 0†	0.05 0.05	12.91 12.91	49.56 49.56	18.25 18.25	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 4.4.5.2		Item Control and Safety Equipment Valves ESD/PSD Butterfly								
Population 4	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1226		Operational time † 0.1225						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.01 0.01	3.82 3.83	14.68 14.70	5.41 5.41	0.00 0.00	-	-	-	-
Comments										

<b>Taxonomy no</b> 4.4.5.2.1		<b>Item</b> Control and Safety Equipment Valves ESD/PSD Butterfly (5.1-10) inch									
<b>Population</b> 3	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>				
		<b>Calendar time *</b> 0.0919			<b>Operational time †</b> 0.0919						
<b>Failure mode</b>		<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours)</b>				<b>Active rep.hrs</b>	<b>Repair (manhours)</b>			
			<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>		<b>n / τ</b>	<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>		0* 0†	0.01 0.01	2.25 2.25	8.62 8.63	3.18 3.18	0.00 0.00	-	-	-	-
<b>Comments</b>											

<b>Taxonomy no</b> 4.4.5.2.2		<b>Item</b> Control and Safety Equipment Valves ESD/PSD Butterfly (10.1-20) inch								
<b>Population</b> 1	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>			
		<b>Calendar time *</b> 0.0306			<b>Operational time †</b> 0.0306					
<b>Failure mode</b>	<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours)</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
		<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n / τ</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>	0* 0†	0.01 0.01	3.10 3.10	11.90 11.91	4.38 4.39	0.00 0.00	-	-	-	-
<b>Comments</b>										

Taxonomy no 4.4.5.3		Item Control and Safety Equipment Valves ESD/PSD Gate								
Population 40	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 1.1649		Operational time † 1.1577						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	14*	2.17	14.81	36.90	11.34	12.02	6.1	2.0	11.7	66.0
	14†	2.15	15.05	37.68	11.61	12.09				
Fail to close on demand	7*	1.59	8.18	19.01	5.60	6.01	8.3	2.0	18.5	66.0
	7†	1.55	8.35	19.63	5.82	6.05				
Fail to open on demand	4*	0.00	4.60	19.97	7.76	3.43	3.0	2.0	4.0	6.0
	4†	0.00	4.66	20.27	7.88	3.46				
Spurious operation	3*	0.21	2.16	5.85	1.88	2.58	5.7	3.0	5.7	8.0
	3†	0.22	2.17	5.87	1.88	2.59				
<b>Degraded</b>	4*	0.03	5.10	18.33	6.77	3.43	7.0	6.0	8.0	12.0
	4†	1.46	3.79	7.00	1.73	3.46				
Abnormal instrument reading	1*	0.02	3.38	12.57	4.64	0.86	-	6.0	6.0	6.0
	1†	0.02	3.54	13.05	4.82	0.86				
Delayed operation	2*	0.14	1.81	5.13	1.68	1.72	8.0	12.0	12.0	12.0
	2†	0.14	1.83	5.19	1.70	1.73				
External leakage - Utility medium	1*	0.01	0.76	2.39	0.86	0.86	6.0	6.0	6.0	6.0
	1†	0.01	0.76	2.41	0.86	0.86				
<b>Incipient</b>	12*	2.72	22.48	58.16	18.19	10.30	2.3	2.0	2.8	4.0
	12†	2.80	23.00	59.42	18.58	10.37				
Abnormal instrument reading	5*	0.00	5.60	25.21	10.00	4.29	2.0	2.0	2.0	2.0
	5†	0.00	5.68	25.58	10.15	4.32				
External leakage - Utility medium	3*	0.06	7.43	25.12	9.23	2.58	4.0	4.0	4.0	4.0
	3†	0.06	7.76	26.12	9.59	2.59				
Minor in-service problems	3*	0.00	3.55	14.54	5.51	2.58	2.0	2.0	2.0	2.0
	3†	0.00	3.60	14.77	5.60	2.59				
Other	1*	0.41	8.73	26.17	8.77	0.86	-	-	-	-
	1†	0.40	8.77	26.32	8.84	0.86				
<b>All modes</b>	30*	6.65	42.45	104.06	31.68	25.75	5.0	2.0	8.1	66.0
	30†	6.75	43.40	106.58	32.48	25.91				
<b>Comments</b>										

Taxonomy no 4.4.5.3.1		Item Control and Safety Equipment Valves ESD/PSD Gate (1.1-5.0) inch								
Population 21	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.6789			Operational time † 0.6752					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	10*	1.29	16.44	46.46	15.21	14.73	3.2	2.0	4.0	7.0
	10†	1.27	16.61	47.13	15.46	14.81				
Fail to close on demand	4*	0.04	6.91	24.77	9.15	5.89	2.5	2.0	3.7	7.0
	4†	0.04	6.99	25.10	9.28	5.92				
Fail to open on demand	4*	0.04	6.91	24.77	9.15	5.89	3.0	2.0	4.0	6.0
	4†	0.04	6.99	25.10	9.28	5.92				
Spurious operation	2*	0.44	2.80	6.85	2.08	2.95	4.5	3.0	4.5	6.0
	2†	0.44	2.82	6.89	2.09	2.96				
<b>Degraded</b>	3*	1.18	4.38	9.23	2.55	4.42	7.0	6.0	9.0	12.0
	3†	1.19	4.40	9.28	2.57	4.44				
Delayed operation	2*	0.54	2.98	7.01	2.08	2.95	8.0	12.0	12.0	12.0
	2†	0.55	2.99	7.05	2.09	2.96				
External leakage - Utility medium	1*	0.01	1.38	4.81	1.77	1.47	6.0	6.0	6.0	6.0
	1†	0.01	1.39	4.82	1.78	1.48				
<b>Incipient</b>	8*	0.06	14.04	52.16	19.26	11.78	2.0	2.0	2.0	2.0
	8†	0.06	14.21	52.83	19.50	11.85				
Abnormal instrument reading	5*	0.04	8.69	31.62	11.68	7.36	2.0	2.0	2.0	2.0
	5†	0.04	8.80	32.04	11.84	7.40				
Minor in-service problems	3*	0.03	5.13	17.92	6.62	4.42	2.0	2.0	2.0	2.0
	3†	0.03	5.19	18.17	6.71	4.44				
<b>All modes</b>	21*	1.98	35.00	103.46	34.42	30.93	3.3	2.0	4.0	12.0
	21†	1.94	35.36	104.92	34.94	31.10				
<b>Comments</b>										

Taxonomy no 4.4.5.3.2		Item Control and Safety Equipment Valves ESD/PSD Gate (5.1-10) inch								
Population 3	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0744		Operational time † 0.0737						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	1*	0.25	12.25	37.98	13.44	13.44	24.0	24.0	24.0	24.0
	1†	0.25	12.37	38.35	13.56	13.56				
Fail to close on demand	1*	0.25	12.25	37.98	13.44	13.44	24.0	24.0	24.0	24.0
	1†	0.25	12.37	38.35	13.56	13.56				
All modes	1*	0.25	12.25	37.98	13.44	13.44	24.0	24.0	24.0	24.0
	1†	0.25	12.37	38.35	13.56	13.56				
Comments										

Taxonomy no 4.4.5.3.3		Item Control and Safety Equipment Valves ESD/PSD Gate (10.1-20) inch									
Population 7	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1357			Operational time † 0.1331						
Failure mode		No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
			Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical		2*	2.35	14.25	34.49	10.42	14.74	10.0	10.0	38.0	66.0
		2†	2.39	14.54	35.22	10.65	15.02				
Fail to close on demand		2*	2.35	14.25	34.49	10.42	14.74	10.0	10.0	38.0	66.0
		2†	2.39	14.54	35.22	10.65	15.02				
Degraded		1*	0.01	7.17	29.13	10.99	7.37	-	6.0	6.0	6.0
		1†	0.01	7.40	30.44	11.55	7.51				
Abnormal instrument reading		1*	0.01	7.17	29.13	10.99	7.37	-	6.0	6.0	6.0
		1†	0.01	7.40	30.44	11.55	7.51				
Incipient		3*	6.95	23.27	47.43	12.76	22.10	-	4.0	4.0	4.0
		3†	7.15	23.82	48.43	13.01	22.53				
External leakage - Utility medium		2*	0.76	14.41	42.91	14.31	14.74	-	4.0	4.0	4.0
		2†	0.46	14.83	45.03	15.53	15.02				
Other		1*	0.03	11.39	44.89	16.72	7.37	-	-	-	-
		1†	0.03	11.44	44.99	16.74	7.51				
All modes		6*	19.80	44.81	78.02	18.05	44.21	10.0	4.0	18.0	66.0
		6†	20.33	45.85	79.69	18.40	45.07				
Comments											



Taxonomy no 4.4.5.3.4		Item Control and Safety Equipment Valves ESD/PSD Gate Unknown								
Population 9	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.2758			Operational time † 0.2756					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	1*	0.18	3.63	17.20	3.63	3.63	8.0	8.0	8.0	8.0
	1†	0.18	3.63	17.22	3.63	3.63				
Spurious operation	1*	0.18	3.63	17.20	3.63	3.63	8.0	8.0	8.0	8.0
	1†	0.18	3.63	17.22	3.63	3.63				
Incipient	1*	0.18	3.63	17.20	3.63	3.63	4.0	4.0	4.0	4.0
	1†	0.18	3.63	17.22	3.63	3.63				
External leakage - Utility medium	1*	0.18	3.63	17.20	3.63	3.63	4.0	4.0	4.0	4.0
	1†	0.18	3.63	17.22	3.63	3.63				
All modes	2*	1.29	7.25	22.82	7.25	7.25	6.0	4.0	6.0	8.0
	2†	1.29	7.26	22.84	7.26	7.26				
Comments										

Taxonomy no 4.4.6		Item Control and Safety Equipment Valves Monitoring									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0175		Operational time † 0.0175							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Degraded  External leakage - Utility medium	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-	
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-	
	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-	
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-	
All modes	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-	
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-	
Comments											

**Maintainable item versus failure mode, to be continued**

**Item:** Valves described by application - Monitoring

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Unknown	0.00	0.00	0.00	100.0	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	100.0	0.00	0.00	0.00	0.00	0.00

**Maintainable item versus failure mode, continued**

**Item:** Valves described by application - Monitoring

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Valves described by application - Monitoring

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
External influence - general	0.00	0.00	0.00	100.0	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	100.0	0.00	0.00	0.00	0.00	0.00

**Failure descriptor versus failure mode, continued**

**Item:** Valves described by application - Monitoring

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.4.6.1		Item Control and Safety Equipment Valves Monitoring Ball									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0175		Operational time † 0.0175							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Degraded	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-	
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-	
External leakage - Utility medium	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-	
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-	
All modes	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-	
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-	
Comments											

Taxonomy no 4.4.6.1.1		Item Control and Safety Equipment Valves Monitoring Ball (20.1-30) inch								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0175			Operational time † 0.0175					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-
External leakage - Utility medium	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-
All modes	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-
	1†	2.85	57.08	270.83	57.08	57.08	-	-	-	-
Comments										

Taxonomy no 4.4.7		Item Control and Safety Equipment Valves Press. red									
Population 14	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.6349			Operational time † 0.4749						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Degraded	2*	0.56	3.15	9.91	3.15	3.15	3.5	3.5	3.5	3.5	
	2†	0.75	4.21	13.26	4.21	4.21					
High output	1*	0.08	1.57	7.47	1.57	1.57	3.5	3.5	3.5	3.5	
	1†	0.11	2.11	9.99	2.11	2.11					
Other	1*	0.08	1.57	7.47	1.57	1.57	-	-	-	-	
	1†	0.11	2.11	9.99	2.11	2.11					
Incipient	1*	0.08	1.57	7.47	1.57	1.57	3.0	3.0	3.0	3.0	
	1†	0.11	2.11	9.99	2.11	2.11					
Minor in-service problems	1*	0.08	1.57	7.47	1.57	1.57	3.0	3.0	3.0	3.0	
	1†	0.11	2.11	9.99	2.11	2.11					
All modes	3*	1.29	4.72	12.21	4.72	4.72	3.3	3.0	3.3	3.5	
	3†	1.73	6.32	16.33	6.32	6.32					
Comments											

**Maintainable item versus failure mode, to be continued**

Item: Valves described by application - Press. red

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other valve components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	0.00

**Maintainable item versus failure mode, continued**

Item: Valves described by application - Press. red

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Closure member (Ball/gate/disc/etc.)	0.00	0.00	33.33	0.00	0.00	0.00	0.00	0.00	33.33
Other valve components	0.00	0.00	0.00	0.00	33.33	0.00	0.00	0.00	33.33
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
Total	0.00	0.00	33.33	0.00	33.33	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Valves described by application - Press. red

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Erosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	0.00

**Failure descriptor versus failure mode, continued**

Item: Valves described by application - Press. red

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Erosion	0.00	0.00	33.33	0.00	0.00	0.00	0.00	0.00	33.33
Instrument failure - general	0.00	0.00	0.00	0.00	33.33	0.00	0.00	0.00	66.67
Total	0.00	0.00	33.33	0.00	33.33	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.4.7.1		Item Control and Safety Equipment Valves Press. red Check									
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0985		Operational time † 0.0716							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max	
All modes	0* 0†	0.01 0.01	2.45 3.32	9.39 12.74	3.46 4.69	0.00 0.00	-	-	-	-	
Comments											



<b>Taxonomy no</b> 4.4.7.1.1		<b>Item</b> Control and Safety Equipment Valves Press. red Check Unknown								
<b>Population</b> 2	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>			
		<b>Calendar time *</b> 0.0985			<b>Operational time †</b> 0.0716					
<b>Failure mode</b>	<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours)</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
		<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/t</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>	0 <sup>+</sup> 0 <sup>†</sup>	0.01 0.01	1.65 2.25	6.34 8.63	2.33 3.18	0.00 0.00	-	-	-	-
<b>Comments</b>										

Taxonomy no 4.4.7.2		Item Control and Safety Equipment Valves Press. red Globe									
Population 12	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)						No of demands			
		Calendar time * 0.5364			Operational time † 0.4032						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / τ	Min		Mean	Max	
Degraded	2*	0.66	3.73	11.74	3.73	3.73	3.5	3.5	3.5	3.5	
	2†	0.88	4.96	15.61	4.96	4.96					
High output	1*	0.09	1.86	8.85	1.86	1.86	3.5	3.5	3.5	3.5	
	1†	0.12	2.48	11.77	2.48	2.48					
Other	1*	0.09	1.86	8.85	1.86	1.86	-	-	-	-	
	1†	0.12	2.48	11.77	2.48	2.48					
Incipient	1*	0.09	1.86	8.85	1.86	1.86	3.0	3.0	3.0	3.0	
	1†	0.12	2.48	11.77	2.48	2.48					
Minor in-service problems	1*	0.09	1.86	8.85	1.86	1.86	3.0	3.0	3.0	3.0	
	1†	0.12	2.48	11.77	2.48	2.48					
All modes	3*	1.53	5.59	14.46	5.59	5.59	3.3	3.0	3.3	3.5	
	3†	2.03	7.44	19.23	7.44	7.44					
Comments											

Taxonomy no 4.4.7.2.1		Item Control and Safety Equipment Valves Press. red Globe (1.1-5.0) inch									
Population 12	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.5364			Operational time † 0.4032						
Failure mode		No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
			Lower	Mean	Upper	SD	n / τ		Min	Mean	Max
Degraded		2*	0.66	3.73	11.74	3.73	3.73	3.5	3.5	3.5	3.5
		2†	0.88	4.96	15.61	4.96	4.96				
High output		1*	0.09	1.86	8.85	1.86	1.86	3.5	3.5	3.5	3.5
		1†	0.12	2.48	11.77	2.48	2.48				
Other		1*	0.09	1.86	8.85	1.86	1.86	-	-	-	-
		1†	0.12	2.48	11.77	2.48	2.48				
Incipient		1*	0.09	1.86	8.85	1.86	1.86	3.0	3.0	3.0	3.0
		1†	0.12	2.48	11.77	2.48	2.48				
Minor in-service problems		1*	0.09	1.86	8.85	1.86	1.86	3.0	3.0	3.0	3.0
		1†	0.12	2.48	11.77	2.48	2.48				
All modes		3*	1.53	5.59	14.46	5.59	5.59	3.3	3.0	3.3	3.5
		3†	2.03	7.44	19.23	7.44	7.44				
Comments											

Taxonomy no 4.4.8		Item Control and Safety Equipment Valves Process control								
Population 319	Installations 11	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 9.5848			Operational time † 8.5060					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	<b>128*</b> <b>128†</b>	<b>0.01</b> <b>0.04</b>	<b>6.91</b> <b>7.76</b>	<b>28.15</b> <b>28.17</b>	<b>10.64</b> <b>10.41</b>	<b>13.35</b> <b>15.05</b>	<b>14.2</b>	<b>1.0</b>	<b>16.5</b>	<b>113.0</b>
Delayed operation	1* 1†	0.00 0.00	0.17 0.21	0.71 0.92	0.27 0.36	0.10 0.12	56.5	113.0	113.0	113.0
External leakage - Process medium	8* 8†	0.07 0.09	0.75 0.83	2.09 2.18	0.68 0.69	0.83 0.94	11.6	1.0	13.5	54.0
External leakage - Utility medium	1* 1†	0.00 0.00	0.17 0.21	0.71 0.92	0.27 0.36	0.10 0.12	11.0	22.0	22.0	22.0
Fail to close on demand	34* 34†	0.01 0.02	1.95 2.23	7.68 7.41	2.86 2.72	3.55 4.00	14.1	2.0	14.5	78.0
Fail to open on demand	10* 10†	0.16 0.23	1.19 1.35	3.01 3.22	0.93 0.96	1.04 1.18	16.0	1.5	20.8	78.0
Fail to regulate	63* 63†	0.00 0.00	2.88 3.16	14.62 15.35	6.30 6.37	6.57 7.41	12.0	2.0	13.7	93.0
High output	1* 1†	0.00 0.00	0.09 0.10	0.29 0.32	0.10 0.12	0.10 0.12	6.0	6.0	6.0	6.0
Internal leakage	3* 3†	0.06 0.06	0.27 0.30	0.62 0.70	0.18 0.20	0.31 0.35	26.3	6.0	34.0	48.0
Spurious operation	1* 1†	0.00 0.00	0.18 0.19	0.79 0.80	0.31 0.31	0.10 0.12	8.0	8.0	8.0	8.0
Structural deficiency	1* 1†	0.00 0.00	0.09 0.10	0.29 0.32	0.10 0.12	0.10 0.12	12.0	16.0	16.0	16.0
Unknown	2* 2†	0.02 0.02	0.18 0.20	0.47 0.53	0.15 0.17	0.21 0.24	62.0	36.0	65.0	94.0
Valve leakage in closed position	3* 3†	0.07 0.08	0.29 0.33	0.64 0.73	0.18 0.21	0.31 0.35	11.3	6.0	17.0	35.0
<b>Degraded</b>	<b>62*</b> <b>62†</b>	<b>1.48</b> <b>6.05</b>	<b>6.46</b> <b>7.58</b>	<b>14.31</b> <b>9.26</b>	<b>4.09</b> <b>0.98</b>	<b>6.47</b> <b>7.29</b>	<b>10.3</b>	<b>0.5</b>	<b>12.3</b>	<b>92.0</b>
Delayed operation	2* 2†	0.00 0.01	0.28 0.32	0.89 0.98	0.32 0.34	0.21 0.24	3.3	2.5	5.3	8.0
External leakage - Process medium	14* 14†	0.50 0.12	1.50 1.64	2.95 4.72	0.77 1.55	1.46 1.65	9.2	1.0	11.4	45.0
External leakage - Utility medium	11* 11†	0.29 0.19	1.27 1.54	2.81 3.98	0.80 1.25	1.15 1.29	11.1	2.0	18.1	92.0
Fail to open on demand	1* 1†	0.00 0.00	0.11 0.14	0.36 0.48	0.13 0.18	0.10 0.12	0.5	0.5	0.5	0.5
High output	3* 3†	0.03 0.04	0.34 0.39	0.97 1.05	0.32 0.34	0.31 0.35	4.3	2.0	4.7	9.0
Internal leakage	8* 8†	0.12 0.17	0.70 0.78	1.66 1.76	0.50 0.51	0.83 0.94	16.5	4.0	16.5	42.0
<b>Comments</b>										

(cont.)

Taxonomy no 4.4.8		Item Control and Safety Equipment Valves Process control									
Population 319	Installations 11	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 9.5848		Operational time † 8.5060							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Low output	12*	0.00	1.13	5.03	1.99	1.25	6.0	1.5	6.0	13.0	
	12†	0.00	1.41	6.76	2.78	1.41					
Other	1*	0.00	0.09	0.29	0.10	0.10	20.0	32.0	32.0	32.0	
	1†	0.00	0.10	0.32	0.12	0.12					
Plugged/Choked	2*	0.00	0.23	0.72	0.26	0.21	-	-	-	-	
	2†	0.00	0.29	0.97	0.36	0.24					
Spurious operation	1*	0.00	0.09	0.29	0.10	0.10	11.0	11.0	11.0	11.0	
	1†	0.00	0.10	0.32	0.12	0.12					
Unknown	1*	0.00	0.09	0.29	0.10	0.10	10.0	10.0	10.0	10.0	
	1†	0.00	0.10	0.32	0.12	0.12					
Valve leakage in closed position	6*	0.22	0.75	1.53	0.41	0.63	17.0	4.0	17.0	46.0	
	6†	0.38	0.80	1.34	0.30	0.71					
<b>Incipient</b>	<b>36*</b>	<b>0.55</b>	<b>6.18</b>	<b>17.12</b>	<b>5.56</b>	<b>3.76</b>	<b>6.5</b>	<b>1.0</b>	<b>8.9</b>	<b>67.0</b>	
	<b>36†</b>	<b>0.67</b>	<b>7.02</b>	<b>19.17</b>	<b>6.18</b>	<b>4.23</b>					
Abnormal instrument reading	19*	0.39	1.72	3.81	1.09	1.98	8.4	2.0	11.3	67.0	
	19†	0.40	1.96	4.49	1.31	2.23					
External leakage - Utility medium	1*	0.00	0.17	0.71	0.27	0.10	8.5	17.0	17.0	17.0	
	1†	0.00	0.21	0.92	0.36	0.12					
Low output	1*	0.00	0.11	0.36	0.13	0.10	1.0	1.0	1.0	1.0	
	1†	0.00	0.14	0.48	0.18	0.12					
Minor in-service problems	11*	0.73	6.98	18.68	5.96	1.15	3.7	2.0	4.4	8.0	
	11†	0.66	7.28	20.06	6.49	1.29					
Other	3*	0.08	0.44	1.03	0.30	0.31	5.2	3.0	9.3	13.0	
	3†	0.07	0.57	1.50	0.47	0.35					
Valve leakage in closed position	1*	0.00	0.11	0.36	0.13	0.10	2.0	2.0	2.0	2.0	
	1†	0.00	0.14	0.48	0.18	0.12					
<b>Unknown</b>	<b>2*</b>	<b>0.02</b>	<b>0.18</b>	<b>0.47</b>	<b>0.15</b>	<b>0.21</b>	<b>77.0</b>	<b>114.0</b>	<b>116.5</b>	<b>119.0</b>	
	<b>2†</b>	<b>0.02</b>	<b>0.20</b>	<b>0.53</b>	<b>0.17</b>	<b>0.24</b>					
Unknown	2*	0.02	0.18	0.47	0.15	0.21	77.0	114.0	116.5	119.0	
	2†	0.02	0.20	0.53	0.17	0.24					
<b>All modes</b>	<b>228*</b>	<b>7.63</b>	<b>19.61</b>	<b>36.10</b>	<b>8.87</b>	<b>23.79</b>	<b>12.6</b>	<b>0.5</b>	<b>15.1</b>	<b>119.0</b>	
	<b>228†</b>	<b>13.23</b>	<b>23.00</b>	<b>34.95</b>	<b>6.67</b>	<b>26.80</b>					
<b>Comments</b>											

**Maintainable item versus failure mode, to be continued**

Item: Valves described by application - Process control

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	0.44	0.00	0.00	0.00	0.00	0.44	0.44	0.00	0.00
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Case	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00
Control unit	2.63	0.00	0.00	0.00	0.00	0.44	3.07	0.00	0.00
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.44	0.44	0.00	0.00
Flange	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.00	0.00
Gear	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00
Indicator	0.00	0.00	0.00	0.00	0.22	0.00	0.88	0.00	0.00
Instrument, general	2.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.44	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00
Monitoring	1.75	0.00	0.00	0.00	0.44	0.00	0.44	0.00	0.00
Other	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00
Other actuator components	0.00	0.00	0.00	0.44	0.44	0.00	0.44	0.00	0.00
Other valve components	0.00	0.00	0.44	0.00	0.44	0.00	0.88	0.00	0.00
Packing	0.00	0.00	1.97	0.00	0.51	0.00	0.00	0.00	0.44
Piston(s)	0.00	0.00	0.00	0.44	0.88	0.44	1.46	0.00	0.00
Positioner	0.44	0.00	0.00	0.44	0.66	0.44	3.95	0.44	0.00
Seals	0.00	0.00	1.97	0.00	1.83	0.00	0.44	0.22	0.88
Seals (gaskets)	0.00	0.00	0.88	0.44	0.00	0.00	0.00	0.00	0.00
Seat rings	0.00	0.00	0.88	0.00	2.05	0.00	0.00	0.22	0.88
Spring	0.00	0.00	0.00	0.00	0.44	0.44	0.15	0.00	0.00
Stem	0.00	0.44	0.44	0.88	0.00	0.00	1.02	0.00	0.00
Subunit	0.44	0.88	0.44	2.19	5.26	0.88	10.53	0.44	2.19
Unknown	0.00	0.00	0.00	0.00	0.00	0.88	0.88	0.00	0.00
Valve body w/internals	0.00	0.00	1.75	0.44	1.32	0.00	1.75	0.44	0.44
<b>Total</b>	<b>8.33</b>	<b>1.32</b>	<b>9.65</b>	<b>5.70</b>	<b>14.91</b>	<b>4.82</b>	<b>27.63</b>	<b>1.75</b>	<b>4.82</b>

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Maintainable item versus failure mode, continued**  
**Item: Valves described by application - Process control**

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.00	1.75
Cabling & junction boxes	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.44
Case	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.88
Control unit	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.44	7.46
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88
Flange	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88
Gear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
Indicator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10
Instrument, general	0.00	0.44	0.44	0.00	0.44	0.00	0.00	0.00	3.51
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88
Monitoring	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	3.07
Other	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.88
Other actuator components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32
Other valve components	0.00	0.00	0.44	0.00	0.44	0.00	0.00	0.00	2.63
Packing	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.24
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	3.44
Positioner	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.00	7.24
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.34
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	1.54
Seat rings	0.88	0.00	0.00	0.00	0.44	0.00	0.00	0.00	5.34
Spring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.02
Stem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78
Subunit	1.32	0.00	0.00	0.00	0.44	0.44	0.00	1.32	26.75
Unknown	0.88	1.32	0.00	0.44	0.88	0.44	0.00	0.00	5.70
Valve body w/internals	0.00	3.51	0.00	0.00	0.00	0.00	0.44	0.00	10.09
Total	4.39	5.70	1.75	0.88	4.82	0.88	0.44	2.19	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Valves described by application - Process control

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.88	0.00	0.00	0.00	1.75	0.00	2.19	0.88	0.00
Breakage	0.00	0.00	0.88	0.88	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.44
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
Control failure	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	1.32	0.44	0.00	0.00	0.00	0.44	1.75	0.00	0.00
Deformation	0.00	0.00	1.32	0.44	0.44	0.88	0.88	0.44	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Erosion	0.00	0.00	0.44	0.00	0.44	0.00	0.88	0.00	0.44
Faulty signal/indication/alarm	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	0.88	0.44	0.00	0.00
Leakage	0.00	0.00	0.00	0.88	0.44	0.44	0.44	0.00	0.00
Looseness	0.00	0.44	0.88	0.44	0.00	0.00	0.44	0.00	0.44
Material failure - general	0.00	0.00	0.00	0.44	0.00	0.44	0.00	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	0.44	0.00	0.00	0.44	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.88	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00
Out of adjustment	3.51	0.00	0.00	0.88	3.95	0.44	13.60	0.00	0.44
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.44	0.00	0.00	0.00	0.44	0.00	0.00	0.00
Unknown	0.00	0.00	1.32	0.00	0.44	0.00	0.88	0.44	0.00
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	1.75	0.00	0.00
Wear	0.00	0.00	4.82	1.32	7.46	0.44	3.51	0.00	2.63
<b>Total</b>	<b>8.33</b>	<b>1.32</b>	<b>9.65</b>	<b>5.70</b>	<b>14.91</b>	<b>4.82</b>	<b>27.63</b>	<b>1.75</b>	<b>4.82</b>

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.



**Failure descriptor versus failure mode, continued**

Item: Valves described by application - Process control

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	5.26	0.00	0.88	0.44	0.44	0.00	0.00	12.72
Breakage	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	2.19
Clearance/ alignment failure	0.88	0.00	0.00	0.00	0.00	0.44	0.00	0.00	2.19
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
Corrosion	0.44	0.00	0.00	0.00	1.32	0.00	0.00	0.44	6.14
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.39
Electrical failure - general	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.44
Erosion	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.07
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	1.75
Instrument failure - general	0.44	0.00	0.00	0.00	0.88	0.00	0.00	0.00	2.63
Leakage	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	2.63
Looseness	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.51
Material failure - general	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	1.32
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88
Miscellaneous - general	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.44
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32
Out of adjustment	0.00	0.44	0.00	0.00	0.44	0.00	0.00	0.44	24.12
Software failure	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.00	0.88
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88
Unknown	0.44	0.00	0.00	0.00	0.00	0.00	0.00	1.32	4.82
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.00	2.19
Wear	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.61
Total	4.39	5.70	1.75	0.88	4.82	0.88	0.44	2.19	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.4.8.1		Item Control and Safety Equipment Valves Process control Ball									
Population 53	Installations 9	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 1.5170		Operational time † 1.1917			Active rep.hrs	Repair (manhours)			
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Min	Mean	Max	
		Lower	Mean	Upper	SD	n/τ					
<b>Critical</b>	5*	0.92	3.09	6.30	1.70	3.30	22.9	2.0	45.4	113.0	
	5†	1.01	3.85	8.20	2.28	4.20					
Delayed operation	1*	0.01	0.57	1.83	0.66	0.66	56.5	113.0	113.0	113.0	
	1†	0.01	0.72	2.32	0.84	0.84					
External leakage - Utility medium	1*	0.01	0.57	1.83	0.66	0.66	11.0	22.0	22.0	22.0	
	1†	0.01	0.72	2.32	0.84	0.84					
Fail to close on demand	1*	0.01	0.57	1.83	0.66	0.66	6.0	12.0	12.0	12.0	
	1†	0.01	0.72	2.32	0.84	0.84					
Fail to open on demand	2*	0.12	1.46	4.12	1.35	1.32	20.5	2.0	40.0	78.0	
	2†	0.08	1.84	5.52	1.85	1.68					
<b>Degraded</b>	6*	1.16	3.62	7.20	1.90	3.96	14.6	2.5	28.7	92.0	
	6†	1.30	4.52	9.32	2.53	5.03					
Delayed operation	1*	0.01	1.04	3.66	1.35	0.66	2.5	2.5	2.5	2.5	
	1†	0.01	1.31	5.05	1.86	0.84					
External leakage - Utility medium	5*	0.89	2.84	5.69	1.51	3.30	17.6	13.0	35.3	92.0	
	5†	1.04	3.55	7.28	1.97	4.20					
<b>Incipient</b>	11*	0.08	11.70	40.72	15.02	7.25	9.2	2.0	17.9	67.0	
	11†	0.10	12.48	42.03	15.44	9.23					
Abnormal instrument reading	5*	0.42	3.40	8.78	2.74	3.30	11.8	2.0	22.8	67.0	
	5†	0.38	4.21	11.61	3.76	4.20					
External leakage - Utility medium	1*	0.01	0.57	1.83	0.66	0.66	8.5	17.0	17.0	17.0	
	1†	0.01	0.72	2.32	0.84	0.84					
Minor in-service problems	3*	0.03	11.85	47.13	17.60	1.98	2.5	5.0	5.0	5.0	
	3†	0.01	11.83	49.65	19.01	2.52					
Other	2*	0.13	1.14	2.97	0.93	1.32	6.3	12.0	12.5	13.0	
	2†	0.16	1.44	3.77	1.19	1.68					
<b>All modes</b>	22*	1.79	14.42	37.14	11.59	14.50	14.2	2.0	28.0	113.0	
	22†	4.11	17.41	38.27	10.88	18.46					
<b>Comments</b>											

Taxonomy no 4.4.8.1.1		Item Control and Safety Equipment Valves Process control Ball (1.1-5.0) inch									
Population 11	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *		Operational time †							
		0.2759		0.2214							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	1*	0.04	3.13	10.02	3.62	3.62	2.0	2.0	2.0	2.0	
	1†	0.05	3.88	12.48	4.52	4.52					
Fail to open on demand	1*	0.04	3.13	10.02	3.62	3.62	2.0	2.0	2.0	2.0	
	1†	0.05	3.88	12.48	4.52	4.52					
<b>Degraded</b>	1*	0.04	3.13	10.02	3.62	3.62	2.5	2.5	2.5	2.5	
	1†	0.05	3.88	12.48	4.52	4.52					
Delayed operation	1*	0.04	3.13	10.02	3.62	3.62	2.5	2.5	2.5	2.5	
	1†	0.05	3.88	12.48	4.52	4.52					
<b>Incipient</b>	2*	0.72	6.25	16.32	5.13	7.25	2.0	2.0	2.0	2.0	
	2†	0.61	7.58	21.35	6.98	9.03					
Abnormal instrument reading	2*	0.72	6.25	16.32	5.13	7.25	2.0	2.0	2.0	2.0	
	2†	0.61	7.58	21.35	6.98	9.03					
<b>All modes</b>	4*	0.99	11.27	31.25	10.15	14.50	2.1	2.0	2.1	2.5	
	4†	0.47	13.49	40.79	13.96	18.07					
<b>Comments</b>											

Taxonomy no 4.4.8.1.2		Item Control and Safety Equipment Valves Process control Ball (5.1-10) inch									
Population 14	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.4042		Operational time † 0.3121							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n / τ		Min	Mean	Max	
Critical	1*	0.04	2.23	6.95	2.47	2.47	39.0	78.0	78.0	78.0	
	1†	0.05	2.87	8.98	3.20	3.20					
Fail to open on demand	1*	0.04	2.23	6.95	2.47	2.47	39.0	78.0	78.0	78.0	
	1†	0.05	2.87	8.98	3.20	3.20					
Degraded	2*	0.60	4.45	11.29	3.50	4.95	6.5	13.0	13.0	13.0	
	2†	0.76	5.74	14.59	4.53	6.41					
External leakage - Utility medium	2*	0.60	4.45	11.29	3.50	4.95	6.5	13.0	13.0	13.0	
	2†	0.76	5.74	14.59	4.53	6.41					
Incipient	2*	0.60	4.45	11.29	3.50	4.95	24.5	31.0	49.0	67.0	
	2†	0.76	5.74	14.59	4.53	6.41					
Abnormal instrument reading	2*	0.60	4.45	11.29	3.50	4.95	24.5	31.0	49.0	67.0	
	2†	0.76	5.74	14.59	4.53	6.41					
All modes	5*	1.82	10.41	24.79	7.41	12.37	20.2	13.0	40.4	78.0	
	5†	2.25	13.34	32.10	9.66	16.02					
Comments											

Taxonomy no 4.4.8.1.3		Item Control and Safety Equipment Valves Process control Ball (10.1-20) inch								
Population 20	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.6134		Operational time † 0.4705						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	3*	1.34	4.89	12.64	4.89	4.89	24.5	12.0	49.0	113.0
	3†	1.74	6.38	16.48	6.38	6.38				
Delayed operation	1*	0.08	1.63	7.74	1.63	1.63	56.5	113.0	113.0	113.0
	1†	0.11	2.13	10.09	2.13	2.13				
External leakage - Utility medium	1*	0.08	1.63	7.74	1.63	1.63	11.0	22.0	22.0	22.0
	1†	0.11	2.13	10.09	2.13	2.13				
Fail to close on demand	1*	0.08	1.63	7.74	1.63	1.63	6.0	12.0	12.0	12.0
	1†	0.11	2.13	10.09	2.13	2.13				
<b>Degraded</b>	3*	1.34	4.89	12.64	4.89	4.89	28.8	23.0	57.5	92.0
	3†	1.74	6.38	16.48	6.38	6.38				
External leakage - Utility medium	3*	1.34	4.89	12.64	4.89	4.89	28.8	23.0	57.5	92.0
	3†	1.74	6.38	16.48	6.38	6.38				
<b>Incipient</b>	4*	2.23	6.52	14.92	6.52	6.52	5.8	5.0	11.5	17.0
	4†	2.90	8.50	19.46	8.50	8.50				
Abnormal instrument reading	1*	0.08	1.63	7.74	1.63	1.63	6.0	12.0	12.0	12.0
	1†	0.11	2.13	10.09	2.13	2.13				
External leakage - Utility medium	1*	0.08	1.63	7.74	1.63	1.63	8.5	17.0	17.0	17.0
	1†	0.11	2.13	10.09	2.13	2.13				
Minor in-service problems	1*	0.08	1.63	7.74	1.63	1.63	2.5	5.0	5.0	5.0
	1†	0.11	2.13	10.09	2.13	2.13				
Other	1*	0.08	1.63	7.74	1.63	1.63	6.0	12.0	12.0	12.0
	1†	0.11	2.13	10.09	2.13	2.13				
<b>All modes</b>	10*	8.84	16.30	27.65	16.30	16.30	17.1	5.0	34.2	113.0
	10†	11.53	21.25	36.05	21.25	21.25				
<b>Comments</b>										

Taxonomy no 4.4.8.1.4		Item Control and Safety Equipment Valves Process control Ball (20.1-30) inch								
Population 8	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.2235		Operational time † 0.1877						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	3*	0.34	33.54	109.85	40.06	13.42	6.5	13.0	13.0	13.0
	3†	0.35	33.60	109.94	40.09	15.98				
Minor in-service problems	2*	0.22	33.50	116.35	42.92	8.95	-	-	-	-
	2†	0.18	33.06	118.03	43.61	10.66				
Other	1*	0.06	3.96	12.49	4.47	4.47	6.5	13.0	13.0	13.0
	1†	0.08	4.75	14.91	5.33	5.33				
All modes	3*	0.34	33.54	109.85	40.06	13.42	6.5	13.0	13.0	13.0
	3†	0.35	33.60	109.94	40.09	15.98				
Comments										

Taxonomy no 4.4.8.2		Item Control and Safety Equipment Valves Process control Butterfly									
Population 21	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.5748		Operational time † 0.5226							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n / r		Min	Mean	Max	
<b>Critical</b>	7*	4.61	11.60	21.17	5.15	12.18	4.6	2.0	4.6	8.0	
	7†	5.95	13.02	22.31	5.06	13.39					
External leakage - Process medium	1*	0.03	1.58	4.91	1.74	1.74	2.0	2.0	2.0	2.0	
	1†	0.03	1.74	5.40	1.91	1.91					
Fail to close on demand	2*	0.06	3.01	9.35	3.31	3.48	5.0	4.0	5.0	6.0	
	2†	0.14	3.34	10.06	3.41	3.83					
Fail to regulate	4*	2.36	6.94	13.47	3.48	6.96	5.0	2.0	5.0	8.0	
	4†	2.74	7.80	14.97	3.83	7.65					
<b>Degraded</b>	8*	4.10	12.93	25.77	6.81	13.92	7.3	1.0	7.3	28.0	
	8†	7.12	14.76	24.64	5.41	15.31					
External leakage - Process medium	5*	1.29	7.50	17.94	5.38	8.70	9.0	1.0	9.0	28.0	
	5†	3.04	8.69	16.71	4.28	9.57					
External leakage - Utility medium	1*	0.01	2.81	10.48	3.87	1.74	4.0	4.0	4.0	4.0	
	1†	0.01	3.95	15.31	5.67	1.91					
Internal leakage	1*	0.03	1.58	4.91	1.74	1.74	5.0	5.0	5.0	5.0	
	1†	0.03	1.74	5.40	1.91	1.91					
Low output	1*	0.03	1.58	4.91	1.74	1.74	4.0	4.0	4.0	4.0	
	1†	0.03	1.74	5.40	1.91	1.91					
<b>Unknown</b>	1*	0.03	1.58	4.91	1.74	1.74	67.0	114.0	114.0	114.0	
	1†	0.03	1.74	5.40	1.91	1.91					
Unknown	1*	0.03	1.58	4.91	1.74	1.74	67.0	114.0	114.0	114.0	
	1†	0.03	1.74	5.40	1.91	1.91					
<b>All modes</b>	16*	15.15	26.35	40.08	7.66	27.83	9.8	1.0	12.8	114.0	
	16†	13.83	28.89	48.39	10.68	30.61					
<b>Comments</b>											

Taxonomy no 4.4.8.2.1		Item Control and Safety Equipment Valves Process control Butterfly (1.1-5.0) inch								
Population 4	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1051		Operational time † 0.1024						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical Fail to close on demand	2*	3.38	19.03	59.88	19.03	19.03	5.0	4.0	5.0	6.0
	2†	3.47	19.53	61.46	19.53	19.53				
	2*	3.38	19.03	59.88	19.03	19.03	5.0	4.0	5.0	6.0
	2†	3.47	19.53	61.46	19.53	19.53				
All modes	2*	3.38	19.03	59.88	19.03	19.03	5.0	4.0	5.0	6.0
	2†	3.47	19.53	61.46	19.53	19.53				
Comments										



Taxonomy no 4.4.8.2.2		Item Control and Safety Equipment Valves Process control Butterfly (5.1-10) inch								
Population 9	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.3055		Operational time † 0.2611						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	1*	0.18	3.31	9.83	3.27	3.27	2.0	2.0	2.0	2.0
	1†	0.31	4.10	11.67	3.83	3.83				
Fail to regulate	1*	0.18	3.31	9.83	3.27	3.27	2.0	2.0	2.0	2.0
	1†	0.31	4.10	11.67	3.83	3.83				
Degraded	4*	2.69	13.00	29.70	8.67	13.09	9.5	2.0	9.5	28.0
	4†	5.00	15.03	29.43	7.66	15.32				
External leakage - Process medium	2*	0.45	6.45	18.58	6.13	6.55	15.0	2.0	15.0	28.0
	2†	1.15	7.28	17.82	5.42	7.66				
External leakage - Utility medium	1*	0.18	3.31	9.83	3.27	3.27	4.0	4.0	4.0	4.0
	1†	0.31	4.10	11.67	3.83	3.83				
Low output	1*	0.01	3.22	12.16	4.48	3.27	4.0	4.0	4.0	4.0
	1†	0.02	3.59	12.48	4.60	3.83				
All modes	5*	6.42	16.34	29.94	7.32	16.37	8.0	2.0	8.0	28.0
	5†	7.52	19.13	35.04	8.56	19.15				
Comments										

Taxonomy no 4.4.8.2.3		Item Control and Safety Equipment Valves Process control Butterfly (10.1-20) inch								
Population 8	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *			Operational time †					
		0.1642			0.1591					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	4*	8.31	24.36	55.74	24.36	24.36	5.0	2.0	5.0	8.0
	4†	8.58	25.14	57.54	25.14	25.14				
External leakage - Process medium	1*	0.30	6.09	28.89	6.09	6.09	2.0	2.0	2.0	2.0
	1†	0.31	6.28	29.82	6.28	6.28				
Fail to regulate	3*	4.99	18.27	47.22	18.27	18.27	6.0	4.0	6.0	8.0
	3†	5.15	18.85	48.74	18.85	18.85				
<b>Degraded</b>	4*	8.31	24.36	55.74	24.36	24.36	5.0	1.0	5.0	13.0
	4†	8.58	25.14	57.54	25.14	25.14				
External leakage - Process medium	3*	4.99	18.27	47.22	18.27	18.27	5.0	1.0	5.0	13.0
	3†	5.15	18.85	48.74	18.85	18.85				
Internal leakage	1*	0.30	6.09	28.89	6.09	6.09	5.0	5.0	5.0	5.0
	1†	0.31	6.28	29.82	6.28	6.28				
<b>Unknown</b>	1*	0.30	6.09	28.89	6.09	6.09	67.0	114.0	114.0	114.0
	1†	0.31	6.28	29.82	6.28	6.28				
Unknown	1*	0.30	6.09	28.89	6.09	6.09	67.0	114.0	114.0	114.0
	1†	0.31	6.28	29.82	6.28	6.28				
<b>All modes</b>	9*	28.59	54.80	95.63	54.80	54.80	11.9	1.0	17.1	114.0
	9†	29.51	56.56	98.70	56.56	56.56				
<b>Comments</b>										

Taxonomy no 4.4.8.3		Item Control and Safety Equipment Valves Process control Check								
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0985			Operational time † 0.0716					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.02 0.02	4.03 5.36	15.48 20.57	5.70 7.57	0.00 0.00	-	-	-	-
Comments										

<b>Taxonomy no</b> 4.4.8.3.1		<b>Item</b> Control and Safety Equipment Valves Process control Check (1.1-5.0) inch									
<b>Population</b> 2	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>				
		<b>Calendar time *</b> 0.0985			<b>Operational time †</b> 0.0716						
<b>Failure mode</b>		<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours).</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
			<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<i>n / t</i>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>		0* 0†	0.01 0.01	2.25 3.03	8.63 11.64	3.18 4.29	0.00 0.00	-	-	-	-
<b>Comments</b>											

Taxonomy no 4.4.8.4		Item Control and Safety Equipment Valves Process control Diaphragm								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0263		Operational time † 0.0256						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max
Critical	1*	1.90	38.05	180.56	38.05	38.05	36.0	36.0	36.0	36.0
	1†	1.95	39.05	185.29	39.05	39.05				
Unknown	1*	1.90	38.05	180.56	38.05	38.05	36.0	36.0	36.0	36.0
	1†	1.95	39.05	185.29	39.05	39.05				
Degraded	2*	13.51	76.10	239.54	76.10	76.10	7.0	5.0	7.0	9.0
	2†	13.86	78.10	245.82	78.10	78.10				
External leakage - Utility medium	1*	1.90	38.05	180.56	38.05	38.05	5.0	5.0	5.0	5.0
	1†	1.95	39.05	185.29	39.05	39.05				
High output	1*	1.90	38.05	180.56	38.05	38.05	9.0	9.0	9.0	9.0
	1†	1.95	39.05	185.29	39.05	39.05				
All modes	3*	31.20	114.16	295.09	114.16	114.16	16.7	5.0	16.7	36.0
	3†	32.02	117.15	302.84	117.15	117.15				
Comments										

Taxonomy no 4.4.8.4.1		Item Control and Safety Equipment Valves Process control Diaphragm (5.1-10) inch									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0263		Operational time † 0.0256							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Critical	1*	1.90	38.05	180.56	38.05	38.05	36.0	36.0	36.0	36.0	
	1†	1.95	39.05	185.29	39.05	39.05					
Unknown	1*	1.90	38.05	180.56	38.05	38.05	36.0	36.0	36.0	36.0	
	1†	1.95	39.05	185.29	39.05	39.05					
Degraded	2*	13.51	76.10	239.54	76.10	76.10	7.0	5.0	7.0	9.0	
	2†	13.86	78.10	245.82	78.10	78.10					
External leakage - Utility medium	1*	1.90	38.05	180.56	38.05	38.05	5.0	5.0	5.0	5.0	
	1†	1.95	39.05	185.29	39.05	39.05					
High output	1*	1.90	38.05	180.56	38.05	38.05	9.0	9.0	9.0	9.0	
	1†	1.95	39.05	185.29	39.05	39.05					
All modes	3*	31.20	114.16	295.09	114.16	114.16	16.7	5.0	16.7	36.0	
	3†	32.02	117.15	302.84	117.15	117.15					
Comments											

Taxonomy no 4.4.8.5		Item Control and Safety Equipment Valves Process control Gate								
Population 2	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0351			Operational time † 0.0350					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / r		Min	Mean	Max
All modes	0* 0†	0.03	8.25	31.69	11.67	0.00	-	-	-	-
		0.03	8.81	33.81	12.45	0.00				
Comments										

<b>Taxonomy no</b> 4.4.8.5.1		<b>Item</b> Control and Safety Equipment Valves Process control Gate (20.1-30) inch								
<b>Population</b> 2	<b>Installations</b> 2	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>			
		<b>Calendar time *</b> 0.0351			<b>Operational time †</b> 0.0350					
<b>Failure mode</b>	<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours).</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
		<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n / <math>\tau</math></b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>	0 <sup>+</sup> 0 <sup>†</sup>	0.02 0.02	5.23 5.45	20.07 20.91	7.39 7.70	0.00 0.00	-	-	-	-
<b>Comments</b>										



Taxonomy no 4.4.8.6		Item Control and Safety Equipment Valves Process control Globe									
Population 240	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 7.3330		Operational time † 6.6594							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Critical	115*	0.15	10.83	34.54	12.46	15.68	14.2	1.0	15.8	94.0	
	115†	0.28	11.55	35.44	12.39	17.27					
External leakage - Process medium	7*	0.29	0.95	1.91	0.51	0.95	13.0	1.0	15.1	54.0	
	7†	0.48	1.04	1.77	0.40	1.05					
Fail to close on demand	31*	0.01	2.60	10.43	3.91	4.23	15.0	2.0	15.2	78.0	
	31†	0.01	2.80	10.81	3.99	4.66					
Fail to open on demand	8*	0.31	1.26	2.73	0.77	1.09	14.9	1.5	15.9	48.0	
	8†	0.45	1.35	2.63	0.68	1.20					
Fail to regulate	59*	0.00	4.78	20.02	7.65	8.05	12.5	2.0	14.3	93.0	
	59†	0.01	5.12	20.80	7.85	8.86					
High output	1*	0.00	0.12	0.38	0.14	0.14	6.0	6.0	6.0	6.0	
	1†	0.00	0.13	0.42	0.15	0.15					
Internal leakage	3*	0.00	0.32	1.05	0.38	0.41	26.3	6.0	34.0	48.0	
	3†	0.01	0.35	1.11	0.40	0.45					
Spurious operation	1*	0.00	0.26	1.05	0.39	0.14	8.0	8.0	8.0	8.0	
	1†	0.00	0.27	1.09	0.41	0.15					
Structural deficiency	1*	0.00	0.12	0.38	0.14	0.14	12.0	16.0	16.0	16.0	
	1†	0.00	0.13	0.42	0.15	0.15					
Unknown	1*	0.00	0.12	0.38	0.14	0.14	88.0	94.0	94.0	94.0	
	1†	0.00	0.13	0.42	0.15	0.15					
Valve leakage in closed position	3*	0.06	0.39	0.95	0.29	0.41	11.3	6.0	17.0	35.0	
	3†	0.04	0.44	1.18	0.38	0.45					
<b>Degraded</b>	46*	2.73	7.93	15.34	3.95	6.27	10.5	0.5	11.5	46.0	
	46†	2.48	9.30	19.68	5.45	6.91					
Delayed operation	1*	0.00	0.26	1.05	0.39	0.14	4.0	8.0	8.0	8.0	
	1†	0.00	0.27	1.09	0.41	0.15					
External leakage - Process medium	9*	0.10	1.93	5.74	1.91	1.23	9.3	1.0	12.7	45.0	
	9†	0.12	2.03	5.98	1.98	1.35					
External leakage - Utility medium	4*	0.14	0.48	1.00	0.27	0.55	7.8	2.0	7.8	14.0	
	4†	0.15	0.53	1.10	0.30	0.60					
Fail to open on demand	1*	0.00	0.16	0.51	0.18	0.14	0.5	0.5	0.5	0.5	
	1†	0.00	0.22	0.80	0.30	0.15					
High output	2*	0.04	0.39	1.06	0.34	0.27	2.0	2.0	2.5	3.0	
	2†	0.04	0.46	1.26	0.41	0.30					
Internal leakage	7*	0.40	0.90	1.56	0.36	0.95	18.1	4.0	18.1	42.0	
	7†	0.12	0.91	2.31	0.72	1.05					
Low output	11*	0.00	2.00	8.73	3.41	1.50	6.1	1.5	6.1	13.0	
	11†	0.00	2.73	11.67	4.51	1.65					
Other	1*	0.00	0.12	0.38	0.14	0.14	20.0	32.0	32.0	32.0	
	1†	0.00	0.13	0.42	0.15	0.15					

Comments

(cont.)

Taxonomy no 4.4.8.6		Item Control and Safety Equipment Valves Process control Globe									
Population 240	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *		Operational time †							
		7.3330		6.6594							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Plugged/Choked	2*	0.00	0.36	1.40	0.52	0.27	-	-	-	-	
	2†	0.00	0.47	1.92	0.73	0.30					
Spurious operation	1*	0.00	0.12	0.38	0.14	0.14	11.0	11.0	11.0	11.0	
	1†	0.00	0.13	0.42	0.15	0.15					
Unknown	1*	0.00	0.12	0.38	0.14	0.14	10.0	10.0	10.0	10.0	
	1†	0.00	0.13	0.42	0.15	0.15					
Valve leakage in closed position	6*	0.12	1.28	3.49	1.12	0.82	17.0	4.0	17.0	46.0	
	6†	0.15	1.43	3.86	1.23	0.90					
Incipient	25*	2.35	3.45	4.73	0.73	3.41	5.5	1.0	5.7	19.0	
	25†	2.72	3.86	5.18	0.75	3.75					
Abnormal instrument reading	14*	0.07	1.38	4.12	1.38	1.91	7.2	3.0	7.2	19.0	
	14†	0.16	1.56	4.16	1.33	2.10					
Low output	1*	0.00	0.16	0.51	0.18	0.14	1.0	1.0	1.0	1.0	
	1†	0.00	0.22	0.80	0.30	0.15					
Minor in-service problems	8*	0.16	1.55	4.14	1.32	1.09	3.9	2.0	4.4	8.0	
	8†	0.14	1.90	5.46	1.80	1.20					
Other	1*	0.00	0.26	1.05	0.39	0.14	3.0	3.0	3.0	3.0	
	1†	0.00	0.27	1.09	0.41	0.15					
Valve leakage in closed position	1*	0.00	0.16	0.51	0.18	0.14	2.0	2.0	2.0	2.0	
	1†	0.00	0.22	0.80	0.30	0.15					
Unknown	1*	0.00	0.12	0.38	0.14	0.14	87.0	119.0	119.0	119.0	
	1†	0.00	0.13	0.42	0.15	0.15					
Unknown	1*	0.00	0.12	0.38	0.14	0.14	87.0	119.0	119.0	119.0	
	1†	0.00	0.13	0.42	0.15	0.15					
All modes	187*	12.32	22.91	36.15	7.33	25.50	12.6	0.5	14.0	119.0	
	187†	18.78	26.12	34.45	4.78	28.08					
Comments											

Taxonomy no 4.4.8.6.1		Item Control and Safety Equipment Valves Process control Globe (1.1-5.0) inch									
Population 152	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *			Operational time †						
		4.6798					4.1811				
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max	
<b>Critical</b>	72*	0.32	12.17	37.20	12.95	15.39	9.1	1.0	9.3	28.0	
	72†	0.90	13.10	37.82	12.48	17.22					
External leakage - Process medium	4*	0.09	0.75	1.95	0.61	0.85	5.5	1.0	5.5	8.0	
	4†	0.25	0.87	1.79	0.49	0.96					
Fail to close on demand	25*	0.02	4.05	14.40	5.32	5.34	10.8	4.0	11.0	28.0	
	25†	0.03	4.26	14.58	5.37	5.98					
Fail to open on demand	4*	0.28	0.84	1.64	0.43	0.85	14.4	1.5	15.4	24.0	
	4†	0.32	0.95	1.85	0.48	0.96					
Fail to regulate	36*	0.23	6.16	18.58	6.33	7.69	7.9	2.0	8.1	24.0	
	36†	0.59	6.69	18.55	6.02	8.61					
Internal leakage	1*	0.00	0.20	0.62	0.22	0.21	6.0	6.0	6.0	6.0	
	1†	0.00	0.22	0.68	0.24	0.24					
Valve leakage in closed position	2*	0.09	0.45	1.03	0.30	0.43	8.0	6.0	8.0	10.0	
	2†	0.07	0.53	1.36	0.42	0.48					
<b>Degraded</b>	31*	2.02	7.70	16.38	4.56	6.62	7.8	0.5	7.8	36.0	
	31†	1.43	9.91	24.75	7.61	7.41					
External leakage - Process medium	4*	0.28	0.84	1.64	0.43	0.85	11.0	2.0	11.0	36.0	
	4†	0.32	0.95	1.85	0.48	0.96					
External leakage - Utility medium	4*	0.09	0.75	1.95	0.61	0.85	7.8	2.0	7.8	14.0	
	4†	0.25	0.87	1.79	0.49	0.96					
Fail to open on demand	1*	0.00	0.28	0.93	0.34	0.21	0.5	0.5	0.5	0.5	
	1†	0.00	0.38	1.43	0.53	0.24					
High output	1*	0.00	0.28	0.93	0.34	0.21	3.0	3.0	3.0	3.0	
	1†	0.00	0.38	1.43	0.53	0.24					
Internal leakage	5*	0.07	0.91	2.57	0.84	1.07	9.6	4.0	9.6	19.0	
	5†	0.17	1.03	2.48	0.75	1.20					
Low output	10*	0.01	3.28	12.49	4.60	2.14	6.2	1.5	6.2	13.0	
	10†	0.02	4.54	17.42	6.42	2.39					
Plugged/Choked	2*	0.00	0.61	2.23	0.82	0.43	-	-	-	-	
	2†	0.00	0.85	3.22	1.19	0.48					
Spurious operation	1*	0.00	0.20	0.62	0.22	0.21	11.0	11.0	11.0	11.0	
	1†	0.00	0.22	0.68	0.24	0.24					
Unknown	1*	0.00	0.20	0.62	0.22	0.21	10.0	10.0	10.0	10.0	
	1†	0.00	0.22	0.68	0.24	0.24					
Valve leakage in closed position	2*	0.00	0.61	2.23	0.82	0.43	9.0	6.0	9.0	12.0	
	2†	0.00	0.85	3.22	1.19	0.48					
<b>Incipient</b>	17*	2.34	3.66	5.22	0.88	3.63	5.6	1.0	5.6	19.0	
	17†	2.25	4.28	6.83	1.41	4.07					
Abnormal instrument reading	11*	0.43	2.07	4.74	1.38	2.35	7.0	3.0	7.0	19.0	
	11†	1.03	2.42	4.28	1.01	2.63					

Comments

(cont.)

Taxonomy no 4.4.8.6.1		Item Control and Safety Equipment Valves Process control Globe (1.1-5.0) inch								
Population 152	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 4.6798			Operational time † 4.1811					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Low output	1*	0.00	0.28	0.93	0.34	0.21	1.0	1.0	1.0	1.0
	1†	0.00	0.38	1.43	0.53	0.24				
Minor in-service problems	4*	0.08	1.07	3.05	1.00	0.85	3.8	2.0	3.8	8.0
	4†	0.03	1.43	4.41	1.55	0.96				
Valve leakage in closed position	1*	0.00	0.28	0.93	0.34	0.21	2.0	2.0	2.0	2.0
	1†	0.00	0.38	1.43	0.53	0.24				
All modes	120*	13.63	24.03	36.80	7.12	25.64	8.3	0.5	8.4	36.0
	120†	22.56	28.19	34.34	3.59	28.70				
Comments										

Taxonomy no 4.4.8.6.2		Item Control and Safety Equipment Valves Process control Globe (5.1-10) inch									
Population 40	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time *			Operational time †						
		1.1662					1.0489				
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	17*	3.35	12.35	26.00	7.17	14.58	18.1	2.0	19.3	54.0	
	17†	7.35	14.80	24.34	5.24	16.21					
External leakage - Process medium	1*	0.02	0.78	2.42	0.86	0.86	54.0	54.0	54.0	54.0	
	1†	0.02	0.87	2.70	0.95	0.95					
Fail to close on demand	5*	1.67	4.27	7.83	1.92	4.29	23.4	2.0	23.6	49.0	
	5†	1.94	4.84	8.79	2.13	4.77					
Fail to open on demand	1*	0.02	0.78	2.42	0.86	0.86	6.0	6.0	6.0	6.0	
	1†	0.02	0.87	2.70	0.95	0.95					
Fail to regulate	8*	0.65	5.52	14.34	4.49	6.86	13.4	4.0	13.6	29.0	
	8†	1.48	6.44	14.26	4.08	7.63					
High output	1*	0.02	0.78	2.42	0.86	0.86	6.0	6.0	6.0	6.0	
	1†	0.02	0.87	2.70	0.95	0.95					
Valve leakage in closed position	1*	0.02	0.78	2.42	0.86	0.86	18.0	35.0	35.0	35.0	
	1†	0.02	0.87	2.70	0.95	0.95					
<b>Degraded</b>	3*	0.81	2.71	5.52	1.49	2.57	29.7	6.0	29.7	46.0	
	3†	0.56	3.25	7.76	2.32	2.86					
Internal leakage	1*	0.02	0.78	2.42	0.86	0.86	37.0	37.0	37.0	37.0	
	1†	0.02	0.87	2.70	0.95	0.95					
Low output	1*	0.01	1.72	6.64	2.46	0.86	6.0	6.0	6.0	6.0	
	1†	0.01	2.41	9.47	3.52	0.95					
Valve leakage in closed position	1*	0.02	0.78	2.42	0.86	0.86	46.0	46.0	46.0	46.0	
	1†	0.02	0.87	2.70	0.95	0.95					
<b>Incipient</b>	4*	1.22	3.49	6.70	1.72	3.43	6.3	2.0	6.3	9.0	
	4†	1.43	3.97	7.53	1.91	3.81					
Abnormal instrument reading	3*	0.05	2.15	6.60	2.31	2.57	7.7	6.0	7.7	9.0	
	3†	0.11	2.43	7.28	2.44	2.86					
Minor in-service problems	1*	0.01	1.72	6.64	2.46	0.86	2.0	2.0	2.0	2.0	
	1†	0.01	2.41	9.47	3.52	0.95					
<b>All modes</b>		24*	13.44	19.81	27.19	4.20	20.58	17.6	2.0	18.4	54.0
		24†	14.40	22.25	31.47	5.22	22.88				
Comments											

Taxonomy no 4.4.8.6.3		Item Control and Safety Equipment Valves Process control Globe (10.1-20) inch									
Population 10	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1957			Operational time † 0.1718						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	20*	67.72	102.19	148.48	102.19	102.19	29.8	3.0	36.3	94.0	
	20†	77.16	116.44	169.18	116.44	116.44					
Fail to close on demand	1*	0.26	5.11	24.24	5.11	5.11	78.0	78.0	78.0	78.0	
	1†	0.29	5.82	27.62	5.82	5.82					
Fail to regulate	15*	47.24	76.64	118.00	76.64	76.64	23.0	3.0	29.5	93.0	
	15†	53.82	87.33	134.45	87.33	87.33					
Internal leakage	2*	1.81	10.22	32.16	10.22	10.22	36.5	48.0	48.0	48.0	
	2†	2.07	11.64	36.65	11.64	11.64					
Structural deficiency	1*	0.26	5.11	24.24	5.11	5.11	12.0	16.0	16.0	16.0	
	1†	0.29	5.82	27.62	5.82	5.82					
Unknown	1*	0.26	5.11	24.24	5.11	5.11	88.0	94.0	94.0	94.0	
	1†	0.29	5.82	27.62	5.82	5.82					
<b>Degraded</b>	1*	0.26	5.11	24.24	5.11	5.11	20.0	32.0	32.0	32.0	
	1†	0.29	5.82	27.62	5.82	5.82					
Other	1*	0.26	5.11	24.24	5.11	5.11	20.0	32.0	32.0	32.0	
	1†	0.29	5.82	27.62	5.82	5.82					
<b>Unknown</b>	1*	0.26	5.11	24.24	5.11	5.11	87.0	119.0	119.0	119.0	
	1†	0.29	5.82	27.62	5.82	5.82					
Unknown	1*	0.26	5.11	24.24	5.11	5.11	87.0	119.0	119.0	119.0	
	1†	0.29	5.82	27.62	5.82	5.82					
<b>All modes</b>	22*	76.09	112.41	160.50	112.41	112.41	32.0	3.0	39.9	119.0	
	22†	86.70	128.08	182.88	128.08	128.08					
<b>Comments</b>											

Taxonomy no 4.4.8.6.4		Item Control and Safety Equipment Valves Process control Globe Unknown									
Population 38	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 1.2912		Operational time † 1.2576							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max	
<b>Critical</b>	6*	0.12	3.42	10.33	3.53	4.65	13.2	2.0	16.3	48.0	
	6†	0.20	3.59	10.61	3.53	4.77					
External leakage - Process medium	2*	0.13	1.35	3.66	1.18	1.55	7.5	6.0	15.0	24.0	
	2†	0.15	1.40	3.71	1.18	1.59					
Fail to open on demand	3*	0.16	1.92	5.40	1.76	2.32	18.7	2.0	20.0	48.0	
	3†	0.19	2.00	5.47	1.77	2.39					
Spurious operation	1*	0.01	0.68	2.16	0.77	0.77	8.0	8.0	8.0	8.0	
	1†	0.01	0.71	2.22	0.80	0.80					
<b>Degraded</b>	11*	0.76	6.18	15.92	4.97	8.52	11.3	1.0	14.5	45.0	
	11†	1.27	6.67	15.57	4.60	8.75					
Delayed operation	1*	0.01	0.68	2.16	0.77	0.77	4.0	8.0	8.0	8.0	
	1†	0.01	0.71	2.22	0.80	0.80					
External leakage - Process medium	5*	0.15	2.95	8.81	2.94	3.87	7.9	1.0	14.0	45.0	
	5†	0.21	3.09	8.91	2.94	3.98					
High output	1*	0.01	0.68	2.16	0.77	0.77	1.0	2.0	2.0	2.0	
	1†	0.01	0.71	2.22	0.80	0.80					
Internal leakage	1*	0.01	0.68	2.16	0.77	0.77	42.0	42.0	42.0	42.0	
	1†	0.01	0.71	2.22	0.80	0.80					
Valve leakage in closed position	3*	0.16	1.92	5.40	1.76	2.32	12.7	4.0	12.7	24.0	
	3†	0.19	2.00	5.47	1.77	2.39					
<b>Incipient</b>	4*	1.12	3.17	6.07	1.55	3.10	4.3	2.0	5.3	8.0	
	4†	0.41	3.62	9.48	2.99	3.18					
Minor in-service problems	3*	0.30	2.72	7.19	2.28	2.32	4.7	2.0	6.0	8.0	
	3†	0.09	3.44	10.52	3.67	2.39					
Other	1*	0.01	0.68	2.16	0.77	0.77	3.0	3.0	3.0	3.0	
	1†	0.01	0.71	2.22	0.80	0.80					
<b>All modes</b>	21*	1.72	12.03	30.13	9.28	16.26	10.5	1.0	13.3	48.0	
	21†	2.31	12.89	30.54	9.09	16.70					
<b>Comments</b>											

Taxonomy no 4.4.9		Item Control and Safety Equipment Valves PSD								
Population 7	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1610			Operational time † 0.1577					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	1*	0.07	5.50	17.60	6.36	6.21	30.0	60.0	60.0	60.0
	1†	0.07	5.62	18.10	6.56	6.34				
Fail to close on demand	1*	0.07	5.50	17.60	6.36	6.21	30.0	60.0	60.0	60.0
	1†	0.07	5.62	18.10	6.56	6.34				
Incipient	5*	3.40	27.71	71.49	22.34	31.06	2.8	1.0	3.4	8.0
	5†	3.35	28.28	73.42	23.00	31.71				
Abnormal instrument reading	5*	3.40	27.71	71.49	22.34	31.06	2.8	1.0	3.4	8.0
	5†	3.35	28.28	73.42	23.00	31.71				
All modes	6*	14.02	34.74	62.96	15.22	37.27	7.3	1.0	12.8	60.0
	6†	14.33	35.48	64.29	15.53	38.05				
Comments										



**Maintainable item versus failure mode, to be continued**

Item: Valves described by application - PSD

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Instrument, general	16.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, position	16.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Positioner	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	16.67	0.00	0.00	0.00	0.00
Total	83.33	0.00	0.00	0.00	16.67	0.00	0.00	0.00	0.00

**Maintainable item versus failure mode, continued**

Item: Valves described by application - PSD

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Instrument, general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67
Instrument, position	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67
Positioner	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00
Subunit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Valves described by application - PSD

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Faulty signal/indication/alarm	33.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	0.00	16.67	0.00	0.00	0.00	0.00
Total	83.33	0.00	0.00	0.00	16.67	0.00	0.00	0.00	0.00

**Failure descriptor versus failure mode, continued**

Item: Valves described by application - PSD

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.4.9.1		Item Control and Safety Equipment Valves PSD Ball									
Population 5	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.1084		Operational time † 0.1055							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Critical	1*	0.17	8.43	26.12	9.23	9.23	30.0	60.0	60.0	60.0	
	1†	0.18	8.65	26.81	9.48	9.48					
Fail to close on demand	1*	0.17	8.43	26.12	9.23	9.23	30.0	60.0	60.0	60.0	
	1†	0.18	8.65	26.81	9.48	9.48					
Incipient	4*	1.18	30.42	91.68	31.14	36.91	3.3	2.0	4.0	8.0	
	4†	1.13	31.18	94.16	32.14	37.91					
Abnormal instrument reading	4*	1.18	30.42	91.68	31.14	36.91	3.3	2.0	4.0	8.0	
	4†	1.13	31.18	94.16	32.14	37.91					
All modes	5*	1.09	37.00	112.56	38.93	46.14	8.6	2.0	15.2	60.0	
	5†	1.05	37.92	115.69	40.18	47.38					
Comments											

Taxonomy no 4.4.9.1.1		Item Control and Safety Equipment Valves PSD Ball (1.1-5.0) inch									
Population 2	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0454			Operational time † 0.0440						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
All modes		0* 0†	0.03 0.03	8.49 8.74	32.59 33.57	12.00 12.36	0.00 0.00	-	-	-	-
Comments											

Taxonomy no 4.4.9.1.2		Item Control and Safety Equipment Valves PSD Ball (5.1-10) inch								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0227			Operational time † 0.0220					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	4*	60.12	176.18	403.23	176.18	176.18	3.3	2.0	4.0	8.0
	4†	62.05	181.82	416.14	181.82	181.82				
Abnormal instrument reading	4*	60.12	176.18	403.23	176.18	176.18	3.3	2.0	4.0	8.0
	4†	62.05	181.82	416.14	181.82	181.82				
All modes	4*	60.12	176.18	403.23	176.18	176.18	3.3	2.0	4.0	8.0
	4†	62.05	181.82	416.14	181.82	181.82				
Comments										

Taxonomy no 4.4.9.1.3		Item Control and Safety Equipment Valves PSD Ball (10.1-20) inch									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0227		Operational time † 0.0220							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
Critical	1*	2.20	44.05	208.99	44.05	44.05	30.0	60.0	60.0	60.0	
	1†	2.27	45.45	215.68	45.45	45.45					
Fail to close on demand	1*	2.20	44.05	208.99	44.05	44.05	30.0	60.0	60.0	60.0	
	1†	2.27	45.45	215.68	45.45	45.45					
All modes	1*	2.20	44.05	208.99	44.05	44.05	30.0	60.0	60.0	60.0	
	1†	2.27	45.45	215.68	45.45	45.45					
Comments											

Taxonomy no 4.4.9.1.4		Item Control and Safety Equipment Valves PSD Ball (20.1-30) inch									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0175			Operational time † 0.0175						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
All modes		0* 0†	0.06 0.06	16.10 16.28	61.82 62.53	22.77 23.03	0.00 0.00	-	-	-	-
Comments											

Taxonomy no 4.4.9.2		Item Control and Safety Equipment Valves PSD Gate								
Population 2	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0526		Operational time † 0.0522						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / τ		Min	Mean	Max
Incipient	1*	0.23	17.42	55.80	20.17	19.01	1.0	1.0	1.0	1.0
	1†	0.22	17.58	56.42	20.41	19.17				
Abnormal instrument reading	1*	0.23	17.42	55.80	20.17	19.01	1.0	1.0	1.0	1.0
	1†	0.22	17.58	56.42	20.41	19.17				
All modes	1*	0.23	17.42	55.80	20.17	19.01	1.0	1.0	1.0	1.0
	1†	0.22	17.58	56.42	20.41	19.17				
Comments										

Taxonomy no 4.4.9.2.1		Item Control and Safety Equipment Valves PSD Gate (10.1-20) inch								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.0351			Operational time † 0.0346					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	1*	1.43	28.52	135.32	28.52	28.52	1.0	1.0	1.0	1.0
	1†	1.44	28.87	136.98	28.87	28.87				
Abnormal instrument reading	1*	1.43	28.52	135.32	28.52	28.52	1.0	1.0	1.0	1.0
	1†	1.44	28.87	136.98	28.87	28.87				
All modes	1*	1.43	28.52	135.32	28.52	28.52	1.0	1.0	1.0	1.0
	1†	1.44	28.87	136.98	28.87	28.87				
Comments										



Taxonomy no 4.4.9.2.2		Item Control and Safety Equipment Valves PSD Gate (20.1-30) inch									
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.0175			Operational time † 0.0175						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max	
All modes		0* 0†	0.04 0.04	10.81 10.88	41.52 41.77	15.29 15.39	0.00 0.00	-	-	-	-
Comments											

Taxonomy no 4.4.10		Item Control and Safety Equipment Valves Relief								
Population 278	Installations 7	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 8.0979		Operational time † 7.1698						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	33*	2.83	3.92	5.15	0.71	4.08	8.3	2.0	8.6	30.0
	33†	0.40	3.99	10.75	3.44	4.60				
External leakage - Process medium	3*	0.06	0.65	1.75	0.56	0.37	8.5	2.0	13.3	30.0
	3†	0.04	1.00	3.00	1.02	0.42				
Fail to close on demand	4*	0.00	0.42	1.76	0.68	0.49	6.0	4.0	5.5	6.0
	4†	0.00	0.53	2.55	1.05	0.56				
Fail to open on demand	17*	0.06	1.40	4.22	1.43	2.10	9.0	5.0	9.0	30.0
	17†	0.16	1.68	4.61	1.49	2.37				
Spurious operation	1*	0.00	0.25	1.12	0.44	0.12	-	8.0	8.0	8.0
	1†	0.00	0.38	1.76	0.70	0.14				
Valve leakage in closed position	8*	0.02	0.77	2.37	0.83	0.99	7.6	6.0	7.6	15.0
	8†	0.07	0.92	2.62	0.86	1.12				
<b>Degraded</b>	128*	0.06	13.25	48.93	18.07	15.81	6.7	2.0	7.1	35.0
	128†	0.15	16.36	54.46	19.95	17.85				
Delayed operation	4*	0.00	1.12	4.67	1.78	0.49	4.7	5.0	8.3	14.0
	4†	0.01	1.98	7.79	2.90	0.56				
External leakage - Process medium	1*	0.00	0.27	1.23	0.49	0.12	1.0	2.0	2.0	2.0
	1†	0.00	0.48	2.18	0.87	0.14				
Other	29*	0.00	4.38	24.34	12.55	3.58	4.5	2.0	4.8	14.0
	29†	0.00	4.58	26.20	14.11	4.04				
Spurious operation	72*	0.02	4.28	16.30	6.01	8.89	7.0	4.0	7.3	35.0
	72†	0.10	5.55	17.28	6.13	10.04				
Valve leakage in closed position	22*	0.00	3.62	18.93	8.50	2.72	9.2	2.0	9.3	24.0
	22†	0.00	4.18	21.67	9.56	3.07				
<b>Incipient</b>	111*	0.03	6.92	26.59	9.79	13.71	6.4	1.0	6.8	24.0
	111†	0.15	9.47	29.89	10.72	15.48				
Delayed operation	2*	0.00	0.57	2.75	1.13	0.25	4.0	7.0	7.5	8.0
	2†	0.00	1.04	4.69	1.86	0.28				
Other	1*	0.00	0.25	1.12	0.44	0.12	-	24.0	24.0	24.0
	1†	0.00	0.38	1.76	0.70	0.14				
Spurious operation	7*	0.03	2.04	6.50	2.35	0.86	4.8	1.0	8.7	16.0
	7†	0.08	3.44	10.58	3.72	0.98				
Valve leakage in closed position	101*	0.00	3.83	21.56	11.39	12.47	6.5	2.0	6.5	14.0
	101†	0.00	4.53	24.90	12.04	14.09				
<b>All modes</b>	272*	3.03	23.29	59.45	18.49	33.59	6.8	1.0	7.2	35.0
	272†	6.90	30.17	66.90	19.13	37.94				
<b>Comments</b>										

**Maintainable item versus failure mode, to be continued**

**Item:** Valves described by application - Relief

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Other valve components	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00
Seals	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	0.37	0.37	0.00	0.37	1.10	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	1.10	5.15	0.00	0.00	0.00
Valve body w/internals	0.00	1.84	0.37	0.00	0.00	0.00	0.00	0.00	0.00
<b>Total</b>	<b>0.00</b>	<b>2.21</b>	<b>1.47</b>	<b>0.00</b>	<b>1.47</b>	<b>6.25</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>

**Maintainable item versus failure mode, continued**

**Item:** Valves described by application - Relief

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Other valve components	0.37	0.00	0.37	0.00	0.00	0.74	0.00	0.00	1.84
Seals	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74
Seat rings	3.31	0.00	0.37	0.00	0.00	0.37	0.00	0.00	4.04
Subunit	5.15	0.00	10.29	0.00	0.00	1.10	0.00	0.00	18.75
Unknown	38.60	0.00	0.00	0.00	0.00	23.90	0.00	0.00	68.75
Valve body w/internals	0.37	0.00	0.00	0.00	0.00	3.31	0.00	0.00	5.88
<b>Total</b>	<b>48.16</b>	<b>0.00</b>	<b>11.03</b>	<b>0.00</b>	<b>0.00</b>	<b>29.41</b>	<b>0.00</b>	<b>0.00</b>	<b>100.0</b>

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

**Item:** Valves described by application - Relief

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Breakage	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	1.10	0.00	0.37	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.00	1.10	5.15	0.00	0.00	0.00
Mechanical Failure - general	0.00	1.84	0.00	0.00	0.00	0.37	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	0.00	0.37	0.00	0.00	0.00	0.37	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.00
Total	0.00	2.21	1.47	0.00	1.47	6.25	0.00	0.00	0.00

**Failure descriptor versus failure mode, continued**

**Item:** Valves described by application - Relief

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Breakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37
Leakage	8.82	0.00	0.00	0.00	0.00	1.10	0.00	0.00	11.40
Material failure - general	38.60	0.00	0.00	0.00	0.00	23.90	0.00	0.00	68.75
Mechanical Failure - general	0.74	0.00	0.37	0.00	0.00	1.84	0.00	0.00	5.15
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	1.10	0.00	0.00	1.10
No cause found	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.37
Out of adjustment	0.00	0.00	10.29	0.00	0.00	0.74	0.00	0.00	11.76
Unknown	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.37
Wear	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.74
Total	48.16	0.00	11.03	0.00	0.00	29.41	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.4.10.1		Item Control and Safety Equipment Valves Relief Gate								
Population 39	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.9724		Operational time † 0.9452						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	6*	2.69	6.17	12.18	6.17	6.17	14.8	2.0	14.8	30.0
	6†	2.77	6.35	12.53	6.35	6.35				
External leakage - Process medium	1*	0.05	1.03	4.88	1.03	1.03	2.0	2.0	2.0	2.0
	1†	0.05	1.06	5.02	1.06	1.06				
Fail to open on demand	3*	0.84	3.09	7.98	3.09	3.09	20.7	5.0	20.7	30.0
	3†	0.87	3.17	8.20	3.17	3.17				
Valve leakage in closed position	2*	0.37	2.06	6.47	2.06	2.06	12.5	10.0	12.5	15.0
	2†	0.38	2.12	6.66	2.12	2.12				
Degraded	51*	40.98	52.45	66.23	52.45	52.45	7.1	2.0	7.3	35.0
	51†	42.16	53.96	68.14	53.96	53.96				
Other	29*	21.33	29.82	40.66	29.82	29.82	4.5	2.0	4.8	14.0
	29†	21.95	30.68	41.83	30.68	30.68				
Spurious operation	2*	0.37	2.06	6.47	2.06	2.06	21.0	7.0	21.0	35.0
	2†	0.38	2.12	6.66	2.12	2.12				
Valve leakage in closed position	20*	13.63	20.57	29.88	20.57	20.57	9.4	2.0	9.4	24.0
	20†	14.02	21.16	30.75	21.16	21.16				
All modes	57*	46.46	58.62	73.09	58.62	58.62	7.9	2.0	8.1	35.0
	57†	47.79	60.31	75.19	60.31	60.31				
Comments										

Taxonomy no 4.4.10.1.1		Item Control and Safety Equipment Valves Relief Gate (1.1-5.0) inch								
Population 36	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.8936			Operational time † 0.8684					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	6*	2.93	6.71	13.25	6.71	6.71	14.8	2.0	14.8	30.0
	6†	3.01	6.91	13.63	6.91	6.91				
External leakage - Process medium	1*	0.06	1.12	5.31	1.12	1.12	2.0	2.0	2.0	2.0
	1†	0.06	1.15	5.46	1.15	1.15				
Fail to open on demand	3*	0.92	3.36	8.68	3.36	3.36	20.7	5.0	20.7	30.0
	3†	0.94	3.45	8.93	3.45	3.45				
Valve leakage in closed position	2*	0.40	2.24	7.04	2.24	2.24	12.5	10.0	12.5	15.0
	2†	0.41	2.30	7.25	2.30	2.30				
<b>Degraded</b>	44*	37.70	49.24	63.31	49.24	49.24	7.3	2.0	7.5	35.0
	44†	38.79	50.67	65.15	50.67	50.67				
Other	27*	21.33	30.22	41.67	30.22	30.22	4.6	2.0	4.9	14.0
	27†	21.95	31.09	42.88	31.09	31.09				
Spurious operation	2*	0.40	2.24	7.04	2.24	2.24	21.0	7.0	21.0	35.0
	2†	0.41	2.30	7.25	2.30	2.30				
Valve leakage in closed position	15*	10.35	16.79	25.85	16.79	16.79	10.4	2.0	10.4	24.0
	15†	10.65	17.27	26.60	17.27	17.27				
<b>All modes</b>	50*	43.60	55.96	70.83	55.96	55.96	8.2	2.0	8.4	35.0
	50†	44.87	57.58	72.88	57.58	57.58				
<b>Comments</b>										

<b>Taxonomy no</b> 4.4.10.1.2		<b>Item</b> Control and Safety Equipment Valves Relief Gate (5.1-10) inch									
<b>Population</b> 3	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>				
		<b>Calendar time *</b> 0.0788			<b>Operational time †</b> 0.0768						
<b>Failure mode</b>		<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours).</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
			<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/τ</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
Degraded		7*	41.67	88.79	166.79	88.79	88.79	5.7	2.0	5.7	16.0
		7†	42.76	91.12	171.17	91.12	91.12				
Other		2*	4.50	25.37	79.85	25.37	25.37	3.5	3.0	3.5	4.0
		2†	4.62	26.03	81.94	26.03	26.03				
Valve leakage in closed position		5*	24.99	63.42	133.37	63.42	63.42	6.6	2.0	6.6	16.0
		5†	25.64	65.08	136.87	65.08	65.08				
<b>All modes</b>		7*	41.67	88.79	166.79	88.79	88.79	5.7	2.0	5.7	16.0
		7†	42.76	91.12	171.17	91.12	91.12				
<b>Comments</b>											

Taxonomy no 4.4.10.2		Item Control and Safety Equipment Valves Relief Globe								
Population 3	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1478		Operational time † 0.1074						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.01 0.02	2.95 4.03	11.34 15.48	4.18 5.70	0.00 0.00	-	-	-	-
Comments										



<b>Taxonomy no</b> 4.4.10.2.1		<b>Item</b> Control and Safety Equipment Valves Relief Globe (1.1-5.0) inch								
<b>Population</b> 3	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>			
		<b>Calendar time *</b> 0.1478			<b>Operational time †</b> 0.1074					
<b>Failure mode</b>	<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours).</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
		<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/τ</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>	0* 0†	0.01 0.01	1.58 2.16	6.05 8.30	2.23 3.06	0.00 0.00	-	-	-	-
<b>Comments</b>										

Taxonomy no 4.4.10.3		Item Control and Safety Equipment Valves Relief PSV - Conventional									
Population 170	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 5.1485		Operational time † 4.8847							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n / τ		Min	Mean	Max	
<b>Critical</b>	23*	0.42	3.84	10.15	3.21	4.47	6.3	5.0	6.3	11.0	
	23†	0.45	4.05	10.70	3.39	4.71					
Fail to close on demand	3*	0.09	0.57	1.38	0.42	0.58	6.0	6.0	6.0	6.0	
	3†	0.10	0.60	1.46	0.44	0.61					
Fail to open on demand	14*	0.32	2.46	6.29	1.96	2.72	6.5	5.0	6.5	11.0	
	14†	0.33	2.59	6.63	2.06	2.87					
Valve leakage in closed position	6*	0.17	1.11	2.74	0.84	1.17	6.0	6.0	6.0	6.0	
	6†	0.18	1.17	2.89	0.88	1.23					
<b>Degraded</b>	65*	7.43	11.94	17.31	3.03	12.63	6.6	4.0	6.6	16.0	
	65†	7.80	12.57	18.27	3.21	13.31					
Spurious operation	65*	7.43	11.94	17.31	3.03	12.63	6.6	4.0	6.6	16.0	
	65†	7.80	12.57	18.27	3.21	13.31					
<b>Incipient</b>	99*	4.11	15.29	32.29	8.93	19.23	6.6	2.0	6.6	14.0	
	99†	4.32	16.11	34.04	9.42	20.27					
Valve leakage in closed position	99*	4.11	15.29	32.29	8.93	19.23	6.6	2.0	6.6	14.0	
	99†	4.32	16.11	34.04	9.42	20.27					
<b>All modes</b>	187*	2.06	23.99	66.77	21.72	36.32	6.5	2.0	6.5	16.0	
	187†	2.17	25.28	70.38	22.90	38.28					
<b>Comments</b>											

Taxonomy no 4.4.10.3.1		Item Control and Safety Equipment Valves Relief PSV - Conventional (1.1-5.0) inch								
Population 148	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 4.4737			Operational time † 4.2445					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / t		Min	Mean	Max
<b>Critical</b>	22*	0.44	4.18	11.15	3.55	4.92	6.3	5.0	6.3	11.0
	22†	0.47	4.41	11.75	3.74	5.18				
Fail to close on demand	3*	0.10	0.65	1.59	0.48	0.67	6.0	6.0	6.0	6.0
	3†	0.11	0.69	1.68	0.51	0.71				
Fail to open on demand	14*	0.34	2.79	7.22	2.26	3.13	6.5	5.0	6.5	11.0
	14†	0.36	2.94	7.61	2.38	3.30				
Valve leakage in closed position	5*	0.16	1.07	2.64	0.81	1.12	6.0	6.0	6.0	6.0
	5†	0.17	1.13	2.78	0.85	1.18				
<b>Degraded</b>	58*	7.02	12.10	18.29	3.46	12.96	6.4	4.0	6.4	12.0
	58†	7.38	12.74	19.29	3.66	13.66				
Spurious operation	58*	7.02	12.10	18.29	3.46	12.96	6.4	4.0	6.4	12.0
	58†	7.38	12.74	19.29	3.66	13.66				
<b>Incipient</b>	97*	3.52	16.54	37.47	10.88	21.68	6.4	2.0	6.4	13.0
	97†	3.70	17.43	39.51	11.47	22.85				
Valve leakage in closed position	97*	3.52	16.54	37.47	10.88	21.68	6.4	2.0	6.4	13.0
	97†	3.70	17.43	39.51	11.47	22.85				
<b>All modes</b>	177*	1.86	25.66	73.44	24.16	39.56	6.4	2.0	6.4	13.0
	177†	1.96	27.04	77.42	25.48	41.70				
<b>Comments</b>										

Taxonomy no 4.4.10.3.2		Item Control and Safety Equipment Valves Relief PSV - Conventional (5.1-10) inch								
Population 8	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.2454			Operational time † 0.2328					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	1*	0.20	4.08	19.34	4.08	4.08	6.0	6.0	6.0	6.0
	1†	0.21	4.30	20.38	4.30	4.30				
Valve leakage in closed position	1*	0.20	4.08	19.34	4.08	4.08	6.0	6.0	6.0	6.0
	1†	0.21	4.30	20.38	4.30	4.30				
<b>Degraded</b>	7*	13.39	28.53	53.59	28.53	28.53	8.0	6.0	8.0	16.0
	7†	14.11	30.07	56.49	30.07	30.07				
Spurious operation	7*	13.39	28.53	53.59	28.53	28.53	8.0	6.0	8.0	16.0
	7†	14.11	30.07	56.49	30.07	30.07				
<b>Incipient</b>	2*	1.45	8.15	25.65	8.15	8.15	13.5	13.0	13.5	14.0
	2†	1.52	8.59	27.04	8.59	8.59				
Valve leakage in closed position	2*	1.45	8.15	25.65	8.15	8.15	13.5	13.0	13.5	14.0
	2†	1.52	8.59	27.04	8.59	8.59				
<b>All modes</b>	10*	22.11	40.75	69.12	40.75	40.75	8.9	6.0	8.9	16.0
	10†	23.30	42.96	72.85	42.96	42.96				
<b>Comments</b>										

Taxonomy no 4.4.10.3.3		Item Control and Safety Equipment Valves Relief PSV - Conventional Unknown								
Population 14	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.4294		Operational time † 0.4074						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.00 0.00	1.11 1.17	4.26 4.49	1.57 1.66	0.00 0.00	-	-	-	-
Comments										

Taxonomy no 4.4.10.4		Item Control and Safety Equipment Valves Relief PSV - Conventional w/bellows								
Population 32	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.6747		Operational time † 0.4284						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	1*	0.03	1.35	4.19	1.48	1.48	15.0	30.0	30.0	30.0
	1†	0.02	2.17	7.34	2.70	2.33				
External leakage - Process medium	1*	0.03	1.35	4.19	1.48	1.48	15.0	30.0	30.0	30.0
	1†	0.02	2.17	7.34	2.70	2.33				
<b>Degraded</b>	7*	0.71	8.38	23.41	7.63	10.38	5.4	2.0	10.6	30.0
	7†	0.15	14.03	45.69	16.63	16.34				
Delayed operation	3*	0.92	4.05	8.97	2.57	4.45	4.7	5.0	9.0	14.0
	3†	0.62	6.40	17.36	5.58	7.00				
External leakage - Process medium	1*	0.03	1.35	4.19	1.48	1.48	1.0	2.0	2.0	2.0
	1†	0.02	2.17	7.34	2.70	2.33				
Spurious operation	2*	0.05	2.57	7.98	2.83	2.96	9.5	7.0	18.5	30.0
	2†	0.68	4.39	10.82	3.30	4.67				
Valve leakage in closed position	1*	0.03	1.35	4.19	1.48	1.48	4.0	8.0	8.0	8.0
	1†	0.02	2.17	7.34	2.70	2.33				
<b>Incipient</b>	5*	1.06	6.38	15.39	4.64	7.41	5.2	6.0	10.2	16.0
	5†	0.21	10.21	31.62	11.17	11.67				
Delayed operation	2*	0.05	2.57	7.98	2.83	2.96	4.0	7.0	7.5	8.0
	2†	0.68	4.39	10.82	3.30	4.67				
Spurious operation	3*	0.92	4.05	8.97	2.57	4.45	6.0	6.0	12.0	16.0
	3†	0.62	6.40	17.36	5.58	7.00				
<b>All modes</b>	13*	0.22	14.39	45.37	16.26	19.27	6.1	2.0	11.9	30.0
	13†	0.16	25.48	89.11	32.89	30.35				
<b>Comments</b>										

Taxonomy no 4.4.10.4.1		Item Control and Safety Equipment Valves Relief PSV - Conventional w/bellows (1.1-5.0) inch								
Population 25	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *			Operational time †					
		0.5158					0.3394			
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	5*	0.47	8.26	24.40	8.12	9.69	4.4	5.0	8.4	14.0
	5†	0.11	14.51	49.42	18.19	14.73				
Delayed operation	3*	0.99	5.32	12.47	3.70	5.82	4.7	5.0	9.0	14.0
	3†	0.13	8.73	27.61	9.91	8.84				
Spurious operation	1*	0.02	1.78	5.73	2.08	1.94	4.0	7.0	7.0	7.0
	1†	0.01	2.92	11.09	4.09	2.95				
Valve leakage in closed position	1*	0.02	1.78	5.73	2.08	1.94	4.0	8.0	8.0	8.0
	1†	0.01	2.92	11.09	4.09	2.95				
Incipient	5*	0.47	8.26	24.40	8.12	9.69	5.2	6.0	10.2	16.0
	5†	0.11	14.51	49.42	18.19	14.73				
Delayed operation	2*	0.53	3.59	8.93	2.74	3.88	4.0	7.0	7.5	8.0
	2†	0.36	5.84	17.08	5.66	5.89				
Spurious operation	3*	0.99	5.32	12.47	3.70	5.82	6.0	6.0	12.0	16.0
	3†	0.13	8.73	27.61	9.91	8.84				
All modes	10*	0.16	15.60	51.09	18.64	19.39	4.8	5.0	9.3	16.0
	10†	0.15	28.96	104.71	38.69	29.46				
Comments										

Taxonomy no 4.4.10.4.2		Item Control and Safety Equipment Valves Relief PSV - Conventional w/bellows (5.1-10) inch								
Population 7	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1589			Operational time † 0.0890					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	1*	0.31	6.29	29.86	6.29	6.29	15.0	30.0	30.0	30.0
	1†	0.56	11.24	53.31	11.24	11.24				
External leakage - Process medium	1*	0.31	6.29	29.86	6.29	6.29	15.0	30.0	30.0	30.0
	1†	0.56	11.24	53.31	11.24	11.24				
Degraded	2*	2.23	12.58	39.61	12.58	12.58	8.0	2.0	16.0	30.0
	2†	3.99	22.47	70.73	22.47	22.47				
External leakage - Process medium	1*	0.31	6.29	29.86	6.29	6.29	1.0	2.0	2.0	2.0
	1†	0.56	11.24	53.31	11.24	11.24				
Spurious operation	1*	0.31	6.29	29.86	6.29	6.29	15.0	30.0	30.0	30.0
	1†	0.56	11.24	53.31	11.24	11.24				
All modes	3*	5.16	18.88	48.80	18.88	18.88	10.3	2.0	20.7	30.0
	3†	9.21	33.71	87.13	33.71	33.71				
Comments										



Taxonomy no 4.4.10.5		Item Control and Safety Equipment Valves Relief PSV - Pilot operated									
Population 34	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 1.1545		Operational time † 0.8041							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n / τ		Min	Mean	Max	
Critical	3*	0.19	2.27	6.35	2.07	2.60	-	4.0	6.7	8.0	
	3†	0.07	3.28	10.16	3.60	3.73					
External leakage - Process medium	1*	0.00	0.77	2.80	1.03	0.87	-	8.0	8.0	8.0	
	1†	0.00	1.13	4.39	1.63	1.24					
Fail to close on demand	1*	0.00	0.77	2.80	1.03	0.87	-	4.0	4.0	4.0	
	1†	0.00	1.13	4.39	1.63	1.24					
Spurious operation	1*	0.00	0.77	2.80	1.03	0.87	-	8.0	8.0	8.0	
	1†	0.00	1.13	4.39	1.63	1.24					
Degraded	5*	0.02	3.44	12.07	4.46	4.33	3.0	4.0	6.6	10.0	
	5†	0.02	5.15	19.53	7.20	6.22					
Delayed operation	1*	0.00	0.77	2.80	1.03	0.87	-	6.0	6.0	6.0	
	1†	0.00	1.13	4.39	1.63	1.24					
Spurious operation	3*	0.19	2.27	6.35	2.07	2.60	3.0	4.0	6.3	10.0	
	3†	0.07	3.28	10.16	3.60	3.73					
Valve leakage in closed position	1*	0.00	0.77	2.80	1.03	0.87	-	8.0	8.0	8.0	
	1†	0.00	1.13	4.39	1.63	1.24					
Incipient	7*	0.66	5.26	13.50	4.21	6.06	2.0	1.0	8.0	24.0	
	7†	0.56	7.79	22.35	7.36	8.71					
Other	1*	0.00	0.77	2.80	1.03	0.87	-	24.0	24.0	24.0	
	1†	0.00	1.13	4.39	1.63	1.24					
Spurious operation	4*	0.33	3.16	8.45	2.69	3.46	1.0	1.0	6.3	14.0	
	4†	1.59	4.83	9.51	2.49	4.97					
Valve leakage in closed position	2*	0.23	1.59	3.98	1.22	1.73	3.0	2.0	3.5	5.0	
	2†	0.35	2.33	5.75	1.76	2.49					
All modes	15*	0.05	9.89	36.61	13.52	12.99	2.3	1.0	7.3	24.0	
	15†	0.06	15.29	58.36	21.51	18.65					
Comments											

<b>Taxonomy no</b> 4.4.10.5.1		<b>Item</b> Control and Safety Equipment Valves Relief PSV - Pilot operated (1.1-5.0) inch									
<b>Population</b> 17	<b>Installations</b> 2	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>				
		<b>Calendar time *</b> 0.3461			<b>Operational time †</b> 0.2896						
<b>Failure mode</b>		<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours)</b>				<b>Active rep.hrs</b>	<b>Repair (manhours)</b>			
			<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>		<b>n/τ</b>	<b>Min</b>	<b>Mean</b>	<b>Max</b>
Incipient		1*	0.02	5.01	19.02	7.01	2.89	1.0	1.0	1.0	1.0
		1†	0.03	11.05	43.51	16.20	3.45				
Spurious operation		1*	0.02	5.01	19.02	7.01	2.89	1.0	1.0	1.0	1.0
		1†	0.03	11.05	43.51	16.20	3.45				
<b>All modes</b>		1*	0.02	5.01	19.02	7.01	2.89	1.0	1.0	1.0	1.0
		1†	0.03	11.05	43.51	16.20	3.45				
<b>Comments</b>											

Taxonomy no 4.4.10.5.2		Item Control and Safety Equipment Valves Relief PSV - Pilot operated (5.1-10) inch								
Population 17	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.8083			Operational time † 0.5145					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	3*	0.79	3.40	7.51	2.14	3.71	-	4.0	6.7	8.0
	3†	1.25	5.35	11.81	3.37	5.83				
External leakage - Process medium	1*	0.02	1.13	3.55	1.27	1.24	-	8.0	8.0	8.0
	1†	0.03	1.78	5.58	1.99	1.94				
Fail to close on demand	1*	0.02	1.13	3.55	1.27	1.24	-	4.0	4.0	4.0
	1†	0.03	1.78	5.58	1.99	1.94				
Spurious operation	1*	0.02	1.13	3.55	1.27	1.24	-	8.0	8.0	8.0
	1†	0.03	1.78	5.58	1.99	1.94				
<b>Degraded</b>	5*	0.46	5.24	14.51	4.71	6.19	3.0	4.0	6.6	10.0
	5†	0.71	8.23	22.89	7.44	9.72				
Delayed operation	1*	0.02	1.13	3.55	1.27	1.24	-	6.0	6.0	6.0
	1†	0.03	1.78	5.58	1.99	1.94				
Spurious operation	3*	0.79	3.40	7.51	2.14	3.71	3.0	4.0	6.3	10.0
	3†	1.25	5.35	11.81	3.37	5.83				
Valve leakage in closed position	1*	0.02	1.13	3.55	1.27	1.24	-	8.0	8.0	8.0
	1†	0.03	1.78	5.58	1.99	1.94				
<b>Incipient</b>	6*	0.35	6.14	18.11	6.02	7.42	3.0	2.0	9.2	24.0
	6†	0.54	9.64	28.56	9.51	11.66				
Other	1*	0.02	1.13	3.55	1.27	1.24	-	24.0	24.0	24.0
	1†	0.03	1.78	5.58	1.99	1.94				
Spurious operation	3*	0.79	3.40	7.51	2.14	3.71	-	4.0	8.0	14.0
	3†	1.25	5.35	11.81	3.37	5.83				
Valve leakage in closed position	2*	0.02	2.15	6.97	2.53	2.47	3.0	2.0	3.5	5.0
	2†	0.04	3.38	10.97	3.99	3.89				
<b>All modes</b>	14*	0.12	13.30	44.34	16.25	17.32	3.0	2.0	7.7	24.0
	14†	0.18	20.93	69.88	25.62	27.21				
<b>Comments</b>										

Taxonomy no 4.4.11		Item Control and Safety Equipment Valves Shut-off								
Population 67	Installations 5	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 1.3664		Operational time † 1.3404						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	11*	3.86	7.34	11.74	2.43	8.05	14.0	2.0	14.5	37.0
	11†	3.93	7.49	11.96	2.47	8.21				
Fail to close on demand	6*	0.35	3.54	9.62	3.09	4.39	14.2	2.0	13.2	37.0
	6†	0.36	3.61	9.80	3.15	4.48				
Fail to open on demand	5*	0.29	3.06	8.36	2.69	3.66	13.8	10.0	16.2	26.0
	5†	0.30	3.12	8.49	2.73	3.73				
<b>Degraded</b>	18*	0.39	19.70	61.13	21.63	13.17	24.0	2.0	13.6	70.0
	18†	0.40	20.38	63.26	22.39	13.43				
Abnormal instrument reading	1*	0.01	0.94	3.12	1.14	0.73	-	6.0	6.0	6.0
	1†	0.01	0.95	3.07	1.11	0.75				
External leakage - Process medium	2*	0.00	4.04	17.18	6.62	1.46	-	2.0	2.0	2.0
	2†	0.00	4.21	17.80	6.84	1.49				
External leakage - Utility medium	5*	0.29	3.06	8.36	2.69	3.66	27.3	7.0	22.5	62.0
	5†	0.30	3.12	8.49	2.73	3.73				
Internal leakage	2*	0.01	1.47	5.58	2.06	1.46	12.0	4.0	9.5	15.0
	2†	0.01	1.49	5.58	2.06	1.49				
Other	4*	0.01	8.58	35.97	13.76	2.93	-	2.0	2.0	2.0
	4†	0.01	8.96	37.28	14.21	2.98				
Spurious operation	1*	0.01	0.63	2.02	0.73	0.73	14.0	14.0	14.0	14.0
	1†	0.01	0.64	2.06	0.75	0.75				
Structural deficiency	1*	0.00	1.78	7.79	3.04	0.73	-	6.0	6.0	6.0
	1†	0.00	1.85	8.08	3.15	0.75				
Unknown	1*	0.01	0.63	2.02	0.73	0.73	2.0	2.0	2.0	2.0
	1†	0.01	0.64	2.06	0.75	0.75				
Valve leakage in closed position	1*	0.01	0.63	2.02	0.73	0.73	58.0	70.0	70.0	70.0
	1†	0.01	0.64	2.06	0.75	0.75				
<b>Incipient</b>	7*	0.82	3.97	9.07	2.64	5.12	7.3	2.0	7.3	29.0
	7†	0.76	4.02	9.38	2.77	5.22				
Abnormal instrument reading	7*	0.82	3.97	9.07	2.64	5.12	7.3	2.0	7.3	29.0
	7†	0.76	4.02	9.38	2.77	5.22				
<b>Unknown</b>	2*	0.09	1.22	3.46	1.14	1.46	40.0	51.0	57.5	64.0
	2†	0.09	1.24	3.54	1.16	1.49				
Unknown	2*	0.09	1.22	3.46	1.14	1.46	40.0	51.0	57.5	64.0
	2†	0.09	1.24	3.54	1.16	1.49				
<b>All modes</b>	38*	3.60	26.65	67.54	20.93	27.81	17.0	2.0	15.1	70.0
	38†	3.54	27.39	70.00	21.78	28.35				
<b>Comments</b>										

**Maintainable item versus failure mode, to be continued**

**Item:** Valves described by application - Shut-off

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	15.79	0.00	0.00	0.00	2.63	0.00	0.00	0.00	0.00
Bonnet	0.00	0.00	0.00	2.63	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.00	0.00	0.00	2.63	0.00	0.00	0.00
Control unit	2.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other actuator components	0.00	0.00	0.00	2.63	0.00	2.63	0.00	0.00	0.00
Other valve components	0.00	0.00	2.63	0.00	0.00	0.00	0.00	0.00	5.26
Packing	0.00	0.00	0.00	5.26	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	10.53	7.89	0.00	0.00	0.00
Unknown	2.63	0.00	0.00	2.63	0.00	0.00	0.00	0.00	0.00
Valve body w/internals	0.00	0.00	2.63	0.00	2.63	0.00	0.00	0.00	0.00
Total	21.05	0.00	5.26	13.16	15.79	13.16	0.00	0.00	5.26

**Maintainable item versus failure mode, continued**

**Item:** Valves described by application - Shut-off

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	2.63	0.00	0.00	21.05
Bonnet	0.00	0.00	0.00	0.00	0.00	0.00	1.32	0.00	3.95
Cabling & junction boxes	0.00	0.00	10.53	0.00	0.00	0.00	0.00	0.00	10.53
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Control unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Other actuator components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.26
Other valve components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.89
Packing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.26
Subunit	2.63	0.00	0.00	0.00	0.00	0.00	0.00	5.26	26.32
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63	7.89
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	1.32	0.00	6.58
Total	2.63	0.00	10.53	0.00	0.00	2.63	2.63	7.89	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Valves described by application - Shut-off

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	2.63	0.00	0.00	0.00
Control failure	0.00	0.00	0.00	0.00	2.63	0.00	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.00	0.00	2.63	0.00	0.00	0.00
Faulty signal/indication/alarm	7.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	7.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	0.00	10.53	0.00	0.00	0.00	0.00	2.63
Material failure - general	0.00	0.00	5.26	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	2.63	13.16	5.26	0.00	0.00	0.00
No signal/indication/alarm	2.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	2.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Wear	0.00	0.00	0.00	0.00	0.00	2.63	0.00	0.00	0.00
Total	21.05	0.00	5.26	13.16	15.79	13.16	0.00	0.00	5.26

**Failure descriptor versus failure mode, continued**

Item: Valves described by application - Shut-off

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Corrosion	0.00	0.00	10.53	0.00	0.00	0.00	2.63	0.00	15.79
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.89
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	2.63	0.00	2.63	13.16
Leakage	2.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.79
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.26
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63	23.68
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Out of adjustment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63	5.26
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Total	2.63	0.00	10.53	0.00	0.00	2.63	2.63	7.89	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

Taxonomy no 4.4.11.1		Item Control and Safety Equipment Valves Shut-off Ball									
Population 44	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 0.9808		Operational time † 0.9634							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	10*	3.19	9.13	17.55	4.49	10.20	13.8	2.0	14.4	37.0	
	10†	3.20	9.29	17.96	4.62	10.38					
Fail to close on demand	5*	0.31	4.39	12.60	4.15	5.10	13.8	2.0	12.6	37.0	
	5†	0.33	4.47	12.79	4.21	5.19					
Fail to open on demand	5*	0.31	4.39	12.60	4.15	5.10	13.8	10.0	16.2	26.0	
	5†	0.33	4.47	12.79	4.21	5.19					
<b>Degraded</b>	16*	1.74	27.94	81.69	27.08	16.31	19.8	2.0	10.6	70.0	
	16†	1.79	28.97	84.76	28.10	16.61					
Abnormal instrument reading	1*	0.00	1.51	6.03	2.25	1.02	-	6.0	6.0	6.0	
	1†	0.00	1.52	6.02	2.25	1.04					
External leakage - Process medium	2*	0.01	5.44	21.86	8.21	2.04	-	2.0	2.0	2.0	
	2†	0.01	5.69	22.73	8.51	2.08					
External leakage - Utility medium	3*	0.03	2.90	9.41	3.42	3.06	13.0	8.0	10.5	13.0	
	3†	0.04	2.95	9.48	3.43	3.11					
Internal leakage	2*	0.00	2.21	8.94	3.37	2.04	12.0	4.0	9.5	15.0	
	2†	0.00	2.23	8.98	3.37	2.08					
Other	4*	0.03	11.71	45.85	17.03	4.08	-	2.0	2.0	2.0	
	4†	0.04	12.27	47.62	17.62	4.15					
Spurious operation	1*	0.01	0.89	2.83	1.02	1.02	14.0	14.0	14.0	14.0	
	1†	0.01	0.90	2.88	1.04	1.04					
Structural deficiency	1*	0.00	2.36	9.88	3.78	1.02	-	6.0	6.0	6.0	
	1†	0.00	2.46	10.29	3.93	1.04					
Unknown	1*	0.01	0.89	2.83	1.02	1.02	2.0	2.0	2.0	2.0	
	1†	0.01	0.90	2.88	1.04	1.04					
Valve leakage in closed position	1*	0.01	0.89	2.83	1.02	1.02	58.0	70.0	70.0	70.0	
	1†	0.01	0.90	2.88	1.04	1.04					
<b>Incipient</b>	7*	0.11	4.99	15.38	5.41	7.14	7.3	2.0	7.3	29.0	
	7†	0.10	5.07	15.76	5.59	7.27					
Abnormal instrument reading	7*	0.11	4.99	15.38	5.41	7.14	7.3	2.0	7.3	29.0	
	7†	0.10	5.07	15.76	5.59	7.27					
<b>All modes</b>	33*	7.44	37.48	86.54	25.42	33.65	13.0	2.0	11.1	70.0	
	33†	7.39	38.59	89.91	26.55	34.25					
<b>Comments</b>											

<b>Taxonomy no</b> 4.4.11.1.1		<b>Item</b> Control and Safety Equipment Valves Shut-off Ball (1.1-5.0) inch								
<b>Population</b> 8	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>			
		<b>Calendar time *</b> 0.2098			<b>Operational time †</b> 0.2049					
<b>Failure mode</b>	<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours).</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
		<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/τ</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>Critical</b>	2*	1.69	9.53	30.00	9.53	9.53	10.5	10.0	11.5	13.0
	2†	1.73	9.76	30.73	9.76	9.76				
Fail to close on demand	1*	0.24	4.77	22.62	4.77	4.77	13.0	13.0	13.0	13.0
	1†	0.24	4.88	23.16	4.88	4.88				
Fail to open on demand	1*	0.24	4.77	22.62	4.77	4.77	8.0	10.0	10.0	10.0
	1†	0.24	4.88	23.16	4.88	4.88				
<b>Incipient</b>	4*	6.51	19.07	43.64	19.07	19.07	2.5	2.0	2.5	3.0
	4†	6.66	19.53	44.69	19.53	19.53				
Abnormal instrument reading	4*	6.51	19.07	43.64	19.07	19.07	2.5	2.0	2.5	3.0
	4†	6.66	19.53	44.69	19.53	19.53				
<b>All modes</b>	6*	12.46	28.60	56.43	28.60	28.60	5.2	2.0	5.5	13.0
	6†	12.76	29.29	57.79	29.29	29.29				
<b>Comments</b>										



Taxonomy no 4.4.11.1.2		Item Control and Safety Equipment Valves Shut-off Ball (5.1-10) inch								
Population 12	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.3149			Operational time † 0.3073					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
<b>Critical</b>	6*	8.30	19.05	37.60	19.05	19.05	14.8	2.0	15.7	37.0
	6†	8.51	19.53	38.53	19.53	19.53				
Fail to close on demand	3*	2.60	9.53	24.62	9.53	9.53	14.0	2.0	14.0	37.0
	3†	2.67	9.76	25.24	9.76	9.76				
Fail to open on demand	3*	2.60	9.53	24.62	9.53	9.53	15.7	10.0	17.3	26.0
	3†	2.67	9.76	25.24	9.76	9.76				
<b>Degraded</b>	5*	6.26	15.88	33.39	15.88	15.88	21.3	2.0	25.0	70.0
	5†	6.41	16.27	34.22	16.27	16.27				
External leakage - Utility medium	2*	1.13	6.35	19.99	6.35	6.35	13.0	13.0	13.0	13.0
	2†	1.16	6.51	20.49	6.51	6.51				
Internal leakage	1*	0.16	3.18	15.07	3.18	3.18	12.0	15.0	15.0	15.0
	1†	0.16	3.25	15.44	3.25	3.25				
Unknown	1*	0.16	3.18	15.07	3.18	3.18	2.0	2.0	2.0	2.0
	1†	0.16	3.25	15.44	3.25	3.25				
Valve leakage in closed position	1*	0.16	3.18	15.07	3.18	3.18	58.0	70.0	70.0	70.0
	1†	0.16	3.25	15.44	3.25	3.25				
<b>Incipient</b>	3*	2.60	9.53	24.62	9.53	9.53	13.7	4.0	13.7	29.0
	3†	2.67	9.76	25.24	9.76	9.76				
Abnormal instrument reading	3*	2.60	9.53	24.62	9.53	9.53	13.7	4.0	13.7	29.0
	3†	2.67	9.76	25.24	9.76	9.76				
<b>All modes</b>	14*	26.87	44.45	69.49	44.45	44.45	16.5	2.0	18.1	70.0
	14†	27.54	45.56	71.21	45.56	45.56				
<b>Comments</b>										

Taxonomy no 4.4.11.1.3		Item Control and Safety Equipment Valves Shut-off Ball (10.1-20) inch								
Population 1	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *			Operational time †					
		0.0263			0.0256					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n / τ		Min	Mean	Max
Degraded	1*	1.90	38.05	180.56	38.05	38.05	14.0	14.0	14.0	14.0
	1†	1.95	39.05	185.29	39.05	39.05				
Spurious operation	1*	1.90	38.05	180.56	38.05	38.05	14.0	14.0	14.0	14.0
	1†	1.95	39.05	185.29	39.05	39.05				
All modes	1*	1.90	38.05	180.56	38.05	38.05	14.0	14.0	14.0	14.0
	1†	1.95	39.05	185.29	39.05	39.05				
Comments										

Taxonomy no 4.4.11.1.4		Item Control and Safety Equipment Valves Shut-off Ball (20.1-30) inch								
Population 15	Installations 3	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.2719			Operational time † 0.2716					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	2*	0.04	6.42	22.30	8.23	7.36	-	8.0	13.5	19.0
	2†	0.04	6.43	22.33	8.24	7.36	-			
Fail to close on demand	1*	0.03	3.38	11.23	4.11	3.68	-	8.0	8.0	8.0
	1†	0.03	3.39	11.25	4.12	3.68	-			
Fail to open on demand	1*	0.03	3.38	11.23	4.11	3.68	-	19.0	19.0	19.0
	1†	0.03	3.39	11.25	4.12	3.68	-			
Degraded	6*	1.75	38.01	114.04	38.30	22.07	-	2.0	4.0	8.0
	6†	1.75	38.10	114.32	38.39	22.09	-			
Abnormal instrument reading	1*	0.03	3.38	11.23	4.11	3.68	-	6.0	6.0	6.0
	1†	0.03	3.39	11.25	4.12	3.68	-			
External leakage - Process medium	1*	0.04	9.31	35.63	13.13	3.68	-	2.0	2.0	2.0
	1†	0.04	9.34	35.71	13.16	3.68	-			
External leakage - Utility medium	1*	0.03	3.38	11.23	4.11	3.68	-	8.0	8.0	8.0
	1†	0.03	3.39	11.25	4.12	3.68	-			
Internal leakage	1*	0.03	3.38	11.23	4.11	3.68	-	4.0	4.0	4.0
	1†	0.03	3.39	11.25	4.12	3.68	-			
Other	2*	0.13	21.58	75.81	27.99	7.36	-	2.0	2.0	2.0
	2†	0.13	21.64	75.98	28.05	7.36	-			
All modes	8*	3.58	41.89	116.72	37.99	29.42	-	2.0	6.4	19.0
	8†	3.59	41.99	117.01	38.08	29.46	-			
Comments										

Taxonomy no 4.4.11.1.5		Item Control and Safety Equipment Valves Shut-off Ball (30.1-40) inch								
Population 8	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1579			Operational time † 0.1541					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	4*	0.16	36.40	136.13	50.24	25.34	-	2.0	3.3	6.0
	4†	0.17	39.12	147.19	54.30	25.96				
External leakage - Process medium	1*	0.08	7.91	26.00	9.49	6.33	-	-	-	-
	1†	0.07	8.48	28.71	10.56	6.49				
Other	2*	0.09	17.41	62.94	23.26	12.67	-	2.0	2.0	2.0
	2†	0.09	18.69	68.48	25.30	12.98				
Structural deficiency	1*	0.08	7.91	26.00	9.49	6.33	-	6.0	6.0	6.0
	1†	0.07	8.48	28.71	10.56	6.49				
All modes	4*	0.16	36.40	136.13	50.24	25.34	-	2.0	3.3	6.0
	4†	0.17	39.12	147.19	54.30	25.96				
Comments										

Taxonomy no 4.4.11.2		Item Control and Safety Equipment Valves Shut-off Gate										
Population 23	Installations 4	Aggregated time in service (10 <sup>6</sup> hours)						No of demands				
		Calendar time * 0.3856			Operational time † 0.3770							
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)						Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/c	Min		Mean	Max		
Critical	1*	0.03	2.26	7.20	2.59	2.59	16.0	16.0	16.0	16.0		
	1†	0.03	2.32	7.36	2.65	2.65						
Fail to close on demand	1*	0.03	2.26	7.20	2.59	2.59	16.0	16.0	16.0	16.0		
	1†	0.03	2.32	7.36	2.65	2.65						
Degraded	2*	0.28	4.38	12.76	4.23	5.19	34.5	7.0	34.5	62.0		
	2†	0.28	4.47	13.09	4.34	5.31						
External leakage - Utility medium	2*	0.28	4.38	12.76	4.23	5.19	34.5	7.0	34.5	62.0		
	2†	0.28	4.47	13.09	4.34	5.31						
Unknown	2*	0.28	4.38	12.76	4.23	5.19	40.0	51.0	57.5	64.0		
	2†	0.28	4.47	13.09	4.34	5.31						
Unknown	2*	0.28	4.38	12.76	4.23	5.19	40.0	51.0	57.5	64.0		
	2†	0.28	4.47	13.09	4.34	5.31						
All modes	5*	3.74	11.32	22.22	5.80	12.97	33.0	7.0	40.0	64.0		
	5†	3.82	11.58	22.73	5.93	13.26						
Comments												

<b>Taxonomy no</b> 4.4.11.2.1		<b>Item</b> Control and Safety Equipment Valves Shut-off Gate (1.1-5.0) inch								
<b>Population</b> 1	<b>Installations</b> 1	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>			
		<b>Calendar time *</b> 0.0263			<b>Operational time †</b> 0.0256					
<b>Failure mode</b>	<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours).</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
		<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/τ</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>	0*	0.03	7.10	27.25	10.03	0.00	-	-	-	-
	0†	0.03	7.27	27.91	10.28	0.00	-	-	-	-
<b>Comments</b>										

Taxonomy no 4.4.11.2.2		Item Control and Safety Equipment Valves Shut-off Gate (5.1-10) inch								
Population 7	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time * 0.1314			Operational time † 0.1278					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max
Critical	1*	0.14	6.92	21.49	7.61	7.61	16.0	16.0	16.0	16.0
	1†	0.14	7.11	22.08	7.82	7.82				
Fail to close on demand	1*	0.14	6.92	21.49	7.61	7.61	16.0	16.0	16.0	16.0
	1†	0.14	7.11	22.08	7.82	7.82				
Degraded	2*	0.60	13.32	39.98	13.45	15.22	34.5	7.0	34.5	62.0
	2†	0.63	13.69	41.09	13.81	15.64				
External leakage - Utility medium	2*	0.60	13.32	39.98	13.45	15.22	34.5	7.0	34.5	62.0
	2†	0.63	13.69	41.09	13.81	15.64				
Unknown	1*	0.14	6.92	21.49	7.61	7.61	45.0	51.0	51.0	51.0
	1†	0.14	7.11	22.08	7.82	7.82				
Unknown	1*	0.14	6.92	21.49	7.61	7.61	45.0	51.0	51.0	51.0
	1†	0.14	7.11	22.08	7.82	7.82				
All modes	4*	8.22	27.67	56.49	15.22	30.44	32.5	7.0	34.0	62.0
	4†	0.56	25.43	78.45	27.61	31.29				
Comments										

Taxonomy no 4.4.11.2.3		Item Control and Safety Equipment Valves Shut-off Gate (10.1-20) inch								
Population 10	Installations 2	Aggregated time in service (10 <sup>6</sup> hours)					No of demands			
		Calendar time *			Operational time †					
		0.1489			0.1447					
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/c		Min	Mean	Max
Unknown	1*	0.12	6.14	19.02	6.73	6.71	35.0	64.0	64.0	64.0
	1†	0.13	6.32	19.56	6.91	6.91				
Unknown	1*	0.12	6.14	19.02	6.73	6.71	35.0	64.0	64.0	64.0
	1†	0.13	6.32	19.56	6.91	6.91				
All modes	1*	0.12	6.14	19.02	6.73	6.71	35.0	64.0	64.0	64.0
	1†	0.13	6.32	19.56	6.91	6.91				
Comments										



<b>Taxonomy no</b> 4.4.11.2.4		<b>Item</b> Control and Safety Equipment Valves Shut-off Gate (20.1-30) inch									
<b>Population</b> 5	<b>Installations</b> 2	<b>Aggregated time in service (10<sup>6</sup> hours)</b>					<b>No of demands</b>				
		<b>Calendar time *</b> 0.0790			<b>Operational time †</b> 0.0788						
<b>Failure mode</b>		<b>No of failures</b>	<b>Failure rate (per 10<sup>6</sup> hours).</b>					<b>Active rep.hrs</b>	<b>Repair (manhours)</b>		
			<b>Lower</b>	<b>Mean</b>	<b>Upper</b>	<b>SD</b>	<b>n/τ</b>		<b>Min</b>	<b>Mean</b>	<b>Max</b>
<b>All modes</b>		0* 0†	0.02 0.02	4.06 4.10	15.59 15.73	5.74 5.79	0.00 0.00	-	-	-	-
<b>Comments</b>											

Taxonomy no 4.4.12		Item Control and Safety Equipment Valves Unknown									
Population 162	Installations 1	Aggregated time in service (10 <sup>6</sup> hours)					No of demands				
		Calendar time * 4.5101			Operational time † 4.5062						
Failure mode	No of failures	Failure rate (per 10 <sup>6</sup> hours)					Active rep.hrs	Repair (manhours)			
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max	
<b>Critical</b>	20*	2.94	4.43	6.44	4.43	4.43	4.8	0.5	14.4	50.0	
	20†	2.94	4.44	6.45	4.44	4.44					
Fail to close on demand	5*	0.44	1.11	2.33	1.11	1.11	10.3	26.0	38.0	50.0	
	5†	0.44	1.11	2.33	1.11	1.11					
Fail to open on demand	4*	0.30	0.89	2.03	0.89	0.89	3.3	4.0	4.0	4.0	
	4†	0.30	0.89	2.03	0.89	0.89					
Fail to regulate	9*	1.04	2.00	3.48	2.00	2.00	1.7	0.5	1.8	3.0	
	9†	1.04	2.00	3.49	2.00	2.00					
Low output	1*	0.01	0.22	1.05	0.22	0.22	2.0	3.0	3.0	3.0	
	1†	0.01	0.22	1.05	0.22	0.22					
Other	1*	0.01	0.22	1.05	0.22	0.22	-	-	-	-	
	1†	0.01	0.22	1.05	0.22	0.22					
<b>Degraded</b>	11*	1.37	2.44	4.04	2.44	2.44	2.7	1.0	2.5	4.0	
	11†	1.37	2.44	4.04	2.44	2.44					
Delayed operation	1*	0.01	0.22	1.05	0.22	0.22	-	-	-	-	
	1†	0.01	0.22	1.05	0.22	0.22					
External leakage - Utility medium	2*	0.08	0.44	1.40	0.44	0.44	3.5	3.0	3.0	3.0	
	2†	0.08	0.44	1.40	0.44	0.44					
Low output	2*	0.08	0.44	1.40	0.44	0.44	1.0	1.0	1.0	1.0	
	2†	0.08	0.44	1.40	0.44	0.44					
Minor in-service problems	4*	0.30	0.89	2.03	0.89	0.89	4.0	4.0	4.0	4.0	
	4†	0.30	0.89	2.03	0.89	0.89					
Other	1*	0.01	0.22	1.05	0.22	0.22	4.0	4.0	4.0	4.0	
	1†	0.01	0.22	1.05	0.22	0.22					
Plugged/Choked	1*	0.01	0.22	1.05	0.22	0.22	2.0	2.0	2.0	2.0	
	1†	0.01	0.22	1.05	0.22	0.22					
<b>Incipient</b>	8*	0.88	1.77	3.20	1.77	1.77	3.7	3.0	4.8	12.0	
	8†	0.88	1.78	3.20	1.78	1.78					
Abnormal instrument reading	4*	0.30	0.89	2.03	0.89	0.89	5.0	12.0	12.0	12.0	
	4†	0.30	0.89	2.03	0.89	0.89					
Fail to regulate	1*	0.01	0.22	1.05	0.22	0.22	3.0	3.0	3.0	3.0	
	1†	0.01	0.22	1.05	0.22	0.22					
Minor in-service problems	1*	0.01	0.22	1.05	0.22	0.22	3.0	3.0	3.0	3.0	
	1†	0.01	0.22	1.05	0.22	0.22					
Other	1*	0.01	0.22	1.05	0.22	0.22	3.0	3.0	3.0	3.0	
	1†	0.01	0.22	1.05	0.22	0.22					
Unknown	1*	0.01	0.22	1.05	0.22	0.22	3.0	3.0	3.0	3.0	
	1†	0.01	0.22	1.05	0.22	0.22					
<b>All modes</b>	39*	6.50	8.65	11.29	8.65	8.65	3.9	0.5	7.4	50.0	
	39†	6.51	8.65	11.30	8.65	8.65					
<b>Comments</b>											

**Maintainable item versus failure mode, to be continued**

Item: Valves described by application - Unknown

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Unknown	10.26	2.56	0.00	5.13	12.82	10.26	25.64	0.00	0.00
Total	10.26	2.56	0.00	5.13	12.82	10.26	25.64	0.00	0.00

**Maintainable item versus failure mode, continued**

Item: Valves described by application - Unknown

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Unknown	0.00	7.69	7.69	2.56	12.82	0.00	0.00	2.56	100.0
Total	0.00	7.69	7.69	2.56	12.82	0.00	0.00	2.56	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

**Failure descriptor versus failure mode, to be continued**

Item: Valves described by application - Unknown

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.00	0.00	0.00	0.00	5.13	2.56	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	10.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	5.13	2.56	2.56	25.64	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	2.56	0.00	0.00	0.00	0.00
Out of adjustment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	2.56	0.00	0.00	2.56	5.13	0.00	0.00	0.00
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	10.26	2.56	0.00	5.13	12.82	10.26	25.64	0.00	0.00

**Failure descriptor versus failure mode, continued**

Item: Valves described by application - Unknown

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.00	2.56	0.00	0.00	0.00	0.00	10.26
Corrosion	0.00	0.00	2.56	0.00	2.56	0.00	0.00	0.00	5.13
Instrument failure - general	0.00	0.00	0.00	0.00	7.69	0.00	0.00	0.00	17.95
Leakage	0.00	2.56	0.00	0.00	0.00	0.00	0.00	0.00	2.56
Mechanical Failure - general	0.00	2.56	0.00	0.00	0.00	0.00	0.00	2.56	41.03
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.56
Out of adjustment	0.00	2.56	2.56	0.00	2.56	0.00	0.00	0.00	7.69
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.26
Wear	0.00	0.00	2.56	0.00	0.00	0.00	0.00	0.00	2.56
Total	0.00	7.69	7.69	2.56	12.82	0.00	0.00	2.56	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

**SUBSEA EQUIPMENT**

**Common Components**

There are several components that are being used on more than one equipment unit as shown in Table 18. The following tables present reliability data for those components.

**List of failure modes**

- ELP External leakage - process medium
- ELU External leakage - utility medium
- FTC Fail to close/lock
- FTF Fail to function on demand
- FTO Fail to open/unlock
- ILU Internal leakage - utility medium
- LCP Leakage in closed position
- OTH Other
- PLU Plugged/choked
- SPO Spurious operation
- TRF Transmission failure
- UNK Unknown

**Table 18 Failure data for common components**

Taxonomy no		Item										
		Common components										
Component	No of units	Severity class					Failure rate (per 10 <sup>6</sup> hours).					Active repair time (hours)
		#	C	D	I	U	Lower	Mean	Upper	SD	n/τ	Mean
Accumulator - subsea	59	1		1			0.00003	0.8279	3.9222	1.5981	0.9336	
Chemical injection coupling	347	8		8			0.0008	0.3900	1.5604	0.5842	0.6068	12
Coating - external	39						0.0006	0.1589	0.6036	0.2247	-	
Connector	606	3	1		2		0.0003	0.2535	1.0438	0.3957	0.1188	19
Hydraulic coupling	2816	9	6	3			0.0076	0.0827	0.2258	0.0724	0.0904	12.33
Piping (hard pipe)	88	1	1				0.0002	0.3704	1.5971	0.6183	0.3196	
Power/signal coupler	407	10	7	2	1		0.0374	0.6061	1.7671	0.5832	0.6560	9
Valve, check	91						0.0002	0.0610	0.2319	0.0863	-	
Valve, control	176						0.0001	0.0334	0.1269	0.0472	-	
Valve, process isolation	898	18	13	4	1		0.1555	0.5652	1.1823	0.3245	0.5040	35.67
Valve, utility isolation	334	3	3				0.0037	0.4335	1.5707	0.5651	0.2729	10

**Comments**

For components with no failures, n is set to 0.5 based on a non-informative prior.

**Table 19 No. of Components versus Equipment unit**

Component	Control system	Flowline	Manifold	Riser	Running tool	Wellhead & X-mas tree
Accumulator - subsea	58				1	
Chemical injection coupling	198		19			130
Coating - external		38		1		
Connector		91	216	81	6	212
Hydraulic coupling	1359		87			1370
Piping (hard pipe)			39			49
Power/signal coupler	366					41
Valve, check			14			77
Valve, control			13			163
Valve, process isolation		17	309		4	568
Valve, utility isolation			148			186

**Component versus failure mode**

Component	FTC	ELP	ELU	FTO	SPO	UNK	ILU	LCP	OTH	PLU	TRF	Total
Accumulator - subsea							1					1
Chemical injection coupling			8									8
Connector		2							1			3
Hydraulic coupling			6			1		2				9
Piping (hard pipe)										1		1
Power/signal coupler											10	10
Valve, process isolation	3	1	1	4	1			2	6			18
Valve, utility isolation	1			1				1				3
<b>Total</b>	<b>4</b>	<b>3</b>	<b>15</b>	<b>5</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>3</b>	<b>9</b>	<b>1</b>	<b>10</b>	<b>53</b>

**Failure descriptor versus failure mode**

Component	Descriptor	UNK	ELP	ELU	FTC	FTO	ILU	LCP	OTH	PLU	SPO	TRF	Total
Accumulator - subsea	Leakage						1						1
Chemical injection coupling	Leakage			8									8
Connector	Leakage		2										2
	Other								1				1
Hydraulic coupling	Clearance/ alignment failure		1										1
	Corrosion			1									1
	Leakage			1									1
	Material failure - general			1									1
	Miscellaneous - general								2				2
	Unknown				3								
Piping (hard pipe)	Blockage									1			1
Power/signal coupler	Earth/isolation fault											3	3
	Electrical failure - general											5	5
	Other											2	2
Valve, process isolation	Blockage				1	1							2
	Clearance/ alignment failure				2								2
	External influence - general					1					1		2
	Leakage		1	1		1		2	5				10
	Material failure - general					1							1
	Mechanical Failure - general								1				1
Valve, utility isolation	Leakage				1			1					2
	Sticking						1						1
<b>Total</b>			<b>1</b>	<b>3</b>	<b>15</b>	<b>4</b>	<b>5</b>	<b>1</b>	<b>3</b>	<b>9</b>	<b>1</b>	<b>1</b>	<b>10</b>

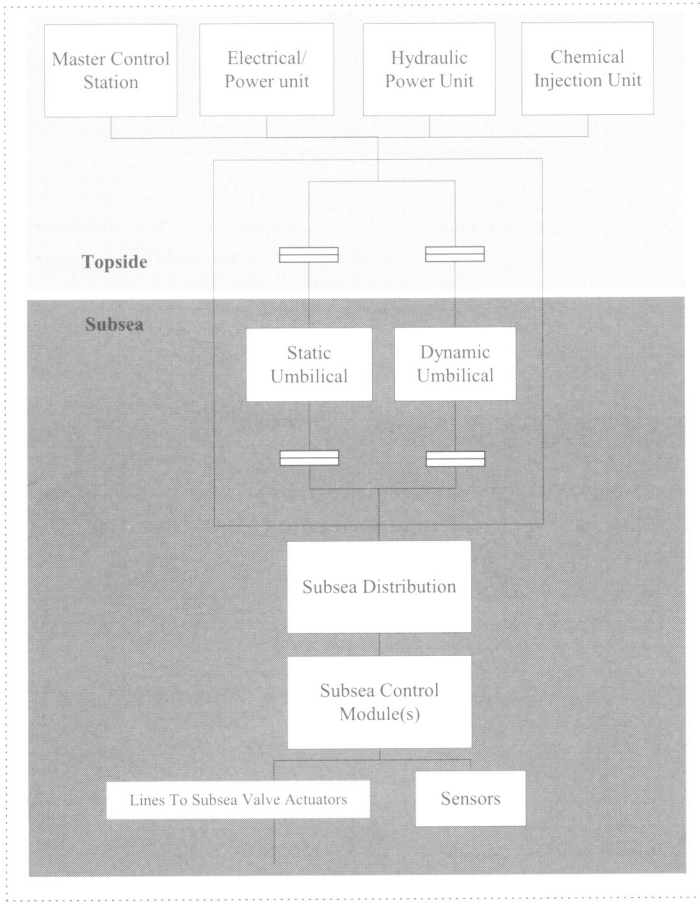
## **Control Systems**

The boundary definition is shown in Figure 23 and subdivision in subunits and components is shown in Table 21. The boundary definition applies to subsea production/injection control systems, controlling both single satellite wells and more complex subsea production facilities such as multi-well manifold template systems.

The subsea control system comprises the surface installed master control station and hydraulic/electric power units, as well as the umbilical(s) and the control equipment installed subsea on the tree or the template (e.g. SDU and SCM).

### **Note:**

- Installation/workover control systems are not included.
- Downhole sensors are not included.
- Hydraulic or electric lines to the various actuators are considered as a part of the control system, not as part of the valves. The actuators, however, are considered part of the valves, which again can be part of the wellhead and X-mas tree or Manifold equipment class.
- The hydraulic couplings in the tree cap are regarded as part of the X-mas tree, not the control system.
- Electric couplers on the X-mas tree are regarded as part of the control system



----- Boundary

**Figure 23 - Control Systems, Boundary definition**



**Table 21 Control System, Subdivision into Subunits and Components**

CONTROL SYSTEM								
Chemical injection unit (topside)	Electrical power unit (topside)	Hydraulic power unit (topside)	Master control station (topside)	Dynamic umbilical	Static umbilical	Sensors	Subsea control module	Subsea distribution module
Subunit	Power supply unit Subunit	Hydraulic power unit Subunit	Subunit	Hydr./ chemical line Power/ signal line Sheath/ armour Subsea umbilical termination unit Topside umbilical termination unit Unknown	Hydr./ chemical line Power/ signal line Sheath/ armour Subsea umbilical termination unit Topside umbilical termination unit Unknown	Comb. pressure and temperature sensor Flow sensor Pressure sensor Sand detection sensor Temperature sensor Valve position sensor	Accumulator – subsea Chemical injection coupling Filter Hydraulic coupling Module base plate Other Power supply unit Power/ signal coupler Solenoid control valve Subsea electronic module Unknown	Accumulator – subsea Chemical injection coupling Hydraulic coupling Hydr./ chemical coupling Hydr./ chemical jumper Power/ signal coupler Power/ signal jumper Unknown

### List of failure modes

AIR	Abnormal instrument reading
ELU	External leakage - utility medium
ERO	Erratic output
FTF	Fail to function on demand
FWR	Fail while running
ILU	Internal leakage - utility medium
LOR	Loss of redundancy
NON	No immediate effect
OTH	Other
SCI	Short circuit
SPO	Spurious operation
TRF	Transmission failure
UNK	Unknown

Taxonomy no		Item										
		Control system										
Population	Installations	Failure data					Aggregated time in service (10 <sup>6</sup> hours)					Active repair time (hours)
							Calendar time					
17	13						0.8531					
Component	No of units	Severity class					Failure rate (per 10 <sup>6</sup> hours).					Mean
		#	C	D	I	U	Lower	Mean	Upper	SD	n/t	
<b>Chemical injection unit (topside)</b>	<b>9</b>						<b>0.0019</b>	<b>0.4854</b>	<b>1.8444</b>	<b>0.6864</b>	-	
Subunit	8						0.0022	0.5419	2.0594	0.7664	-	
<b>Electrical power unit (topside)</b>	<b>10</b>	<b>6</b>	<b>5</b>	<b>1</b>			<b>0.4923</b>	<b>11.9261</b>	<b>36.7995</b>	<b>12.4335</b>	<b>10.9766</b>	<b>10.2</b>
Power supply unit	2	4	4				5.2490	21.6396	47.1058	13.3025	20.0541	9.75
Subunit	8	2	2				0.3144	4.9412	14.3384	4.7225	4.6232	12
<b>Hydraulic power unit (topside)</b>	<b>10</b>	<b>6</b>		<b>2</b>	<b>4</b>		<b>1.4211</b>	<b>13.8661</b>	<b>37.0874</b>	<b>11.7749</b>	<b>10.9766</b>	<b>7</b>
Hydraulic Power Unit	2	5		3	2		13.6340	25.4930	40.3496	8.2222	25.0677	7
Subunit	7	1			1		0.0277	12.7661	50.9176	19.0370	3.4082	
<b>Master control station (topside)</b>	<b>9</b>	<b>21</b>	<b>6</b>	<b>5</b>	<b>10</b>		<b>2.4870</b>	<b>59.3623</b>	<b>182.813</b>	<b>61.7183</b>	<b>40.7693</b>	<b>7.88</b>
Subunit	8	21	13	5	3		6.0807	73.9949	205.964	66.6081	45.5186	7.88
<b>Dynamic umbilical</b>	<b>9</b>	<b>2</b>		<b>1</b>	<b>1</b>		<b>0.1081</b>	<b>4.2669</b>	<b>13.9614</b>	<b>4.8281</b>	<b>5.1013</b>	
Hydraulic/chemical line	49						0.0005	0.1149	0.4367	0.1625	-	
Power/signal line	22	1		1			0.0836	0.9179	2.5089	0.8047	0.9994	
Sheath/armour	2						0.0220	5.5056	20.9214	7.7861	-	
Subsea umbilical termination unit	7						0.0035	0.8785	3.3384	1.2424	-	
Topside umbilical termination unit	5	1		1			0.2145	4.1813	12.5260	4.1813	4.1813	
Unknown	2						0.0220	5.5056	20.9214	7.7861	-	
<b>Static umbilical</b>	<b>40</b>	<b>10</b>	<b>0</b>	<b>2</b>	<b>8</b>		<b>0.0000</b>	<b>4.4905</b>	<b>23.6400</b>	<b>10.4782</b>	<b>6.1930</b>	<b>24.44</b>
Hydraulic/chemical line	248	1		1			0.0000	0.4435	2.0446	0.8196	0.1007	2
Power/signal line	63	8	8				0.2785	2.4052	6.2814	1.9714	3.4281	24
Sheath/armour	12						0.0024	0.6108	2.3210	0.8638	-	
Subsea umbilical termination unit	13	1		1			0.0003	1.9223	8.6998	3.4519	2.1704	50
Topside umbilical termination unit	10						0.0025	0.6248	2.3743	0.8836	-	
Unknown	5						0.0088	2.2023	8.3686	3.1145	-	
<b>Sensors</b>	<b>57</b>	<b>18</b>	<b>1</b>	<b>5</b>	<b>12</b>		<b>0.5749</b>	<b>9.1973</b>	<b>26.7621</b>	<b>8.8247</b>	<b>7.9969</b>	<b>10.8</b>
Combined pressure and temperature sensor	30	1	1				0.0000	0.9210	4.6702	1.9983	0.8984	12
Flow sensor	35						0.0007	0.1758	0.6679	0.2485	-	
Pressure sensor	294	14	14				0.1316	1.7656	4.9961	1.6276	1.2016	10.5
Sand detection sensor	5						0.0088	2.2023	8.3686	3.1145	-	
Temperature sensor	179	2	2				0.0957	0.2563	0.4797	0.1198	0.2687	
Valve position sensor	8	1	1				0.1926	4.5779	14.0908	4.7561	4.9980	
<b>Subsea control module</b>	<b>88</b>	<b>206</b>	<b>23</b>	<b>73</b>	<b>110</b>		<b>3.8233</b>	<b>49.5976</b>	<b>139.558</b>	<b>45.3520</b>	<b>71.1444</b>	<b>7.17</b>
Accumulator - subsea	45	1		1			0.0564	2.4156	7.9758	2.7680	2.7002	
Chemical injection coupling	142	8		8			0.0115	1.4074	5.1224	1.8459	1.6708	12
Filter	103						0.0003	0.0745	0.2832	0.1054	-	
Hydraulic coupling	1090	3		3			0.0005	0.0587	0.2132	0.0768	0.0798	12
Module base plate	72						0.0004	0.1100	0.4179	0.1555	-	
Other	5	3	2		1		17.4951	20.3726	23.4321	1.8064	20.3719	24.1
Power supply unit	23						0.0011	0.2674	1.0160	0.3781	-	
Power/signal coupler	284	2		2			0.0002	0.1587	0.6579	0.2501	0.1939	12
Solenoid control valve	1429	63	10	53			0.0000	1.1628	5.6028	2.3078	1.2589	11.64
Subsea electronic module	107	120	117	3			0.0003	12.7556	61.3365	25.2314	32.3840	3.39
Unknown	16	6	1	1	1		22.2084	50.9948	89.3517	20.819	50.9948	20.5
<b>Subsea distribution module</b>	<b>16</b>	<b>18</b>	<b>2</b>	<b>15</b>	<b>1</b>		<b>0.5300</b>	<b>35.4531</b>	<b>122.438</b>	<b>43.2359</b>	<b>26.4808</b>	<b>24.35</b>
Accumulator - subsea	13*						0.0016	0.3925	1.4913	0.5550	-	

Taxonomy no		Item										
17		Control system										
Population	Installations	Failure data					Aggregated time in service (10 <sup>6</sup> hours)					Active repair time (hours)
17	13						Calendar time					
							0.8531					
Component	No of units	Severity class				Failure rate (per 10 <sup>6</sup> hours).					Active repair time (hours)	
		#	C	D	I	U	Lower	Mean	Upper	SD	n / $\tau$	Mean
Chemical injection coupling	56*						0.0005	0.1310	0.4979	0.1853	-	
Hydraulic coupling	269	3	3				0.0035	0.2743	0.9602	0.3408	0.3036	3
Hydraulic/chemical coupling	32	2	2				0.0092	2.3023	8.8341	3.2507	1.2227	16
Hydraulic/chemical jumper	104	2	2				0.0001	0.5856	2.5995	1.0209	0.4822	104
Power/signal coupler	82	8	7		1		0.3846	7.7878	23.4546	7.8465	2.3599	8.25
Power/signal jumper	46	2	2				0.0003	3.4682	16.0250	6.4322	1.1655	43
Unknown	1	1	0	1			2.4204	47.1876	141.362	47.1876	47.1876	
<b>Equipment unit level</b>	<b>17</b>	<b>287</b>	<b>14</b>	<b>123</b>	<b>150</b>		<b>5.9259</b>	<b>293.274</b>	<b>983.143</b>	<b>343.205</b>	<b>336.422</b>	<b>9.15</b>
<b>Comments</b>												
For components with no failures, n is set to 0.5 based on a non-informative prior.												
* Mean failure for the common component is used in the estimator.												

**Component versus failure mode, Control System**

Subunit	Component	ELU	UNK	FTF	SPO	OTH	ERO	FWR	ILU	SCI	TRF	Total	
Dynamic umbilical	Power/signal line										1	1	
	Topside umbilical termination unit	1										1	
Electric power unit	Power supply unit					2	2					4	
	Subunit					2						2	
Hydraulic power unit	Hydraulic power unit		5									5	
	Subunit					1						1	
Master control station	Subunit		1	4	6	2	4	3		1		21	
Subsea control module	Accumulator – subsea								1			1	
	Chemical injection coupling	8										8	
	Hydraulic coupling	3										3	
	Other			2			1					3	
	Power/signal coupler										2	2	
	Subsea electronic module			6	5	109							120
	Solenoid control valve	50		9						4			63
	Unkonown	2	2						2				6
Subsea distribution module	Hydraulic/chemical coupling					2						2	
	Hydraulic/chemical jumper	2										2	
	Hydraulic coupling		1			2						3	
	Power/signal coupler										8	8	
	Power/signal jumper										2	2	
	Unknown									1			1
Sensors	Valve position sensor			1								1	
	Pressure sensor			1	1	3	9					14	
	Combined pressure and temperature sensor						1					1	
	Temperature sensor					1	1					2	
Static umbilical	Hydraulic/chemical line	1										1	
	Power/signal line										8	8	
	Subsea umbilical termination unit	1										1	
<b>Total</b>		<b>68</b>	<b>9</b>	<b>23</b>	<b>12</b>	<b>124</b>	<b>18</b>	<b>3</b>	<b>7</b>	<b>2</b>	<b>21</b>	<b>287</b>	

**Subunit versus failure mode, Control System**

Subunit	ELU	ILU	LOR	NON	OTH	SPO	ERO	FTF	UNK	Total
Dynamic umbilical	1				1					2
Electric power unit						2	2	2		6
Hydraulic power unit	1			2	2				1	6
Master control station				9	2	6	2	1	1	21
Subsea control module	62	9	108	1	5	7	1	11	2	206
Subsea distribution module	2		7		1	4		4		18
Sensors				12		1	5			18
Static umbilical	2			8						10
<b>Total</b>	<b>68</b>	<b>9</b>	<b>115</b>	<b>32</b>	<b>11</b>	<b>20</b>	<b>10</b>	<b>18</b>	<b>4</b>	<b>287</b>

**Equipment unit versus failure mode, Control System**

Equipment unit	ELP	ILP	SPO	ELU	ILU	NON	OTH	AIR	FTF	LOR	Total
Control system	2	1	24	66	7	18	7	6	18	138	287

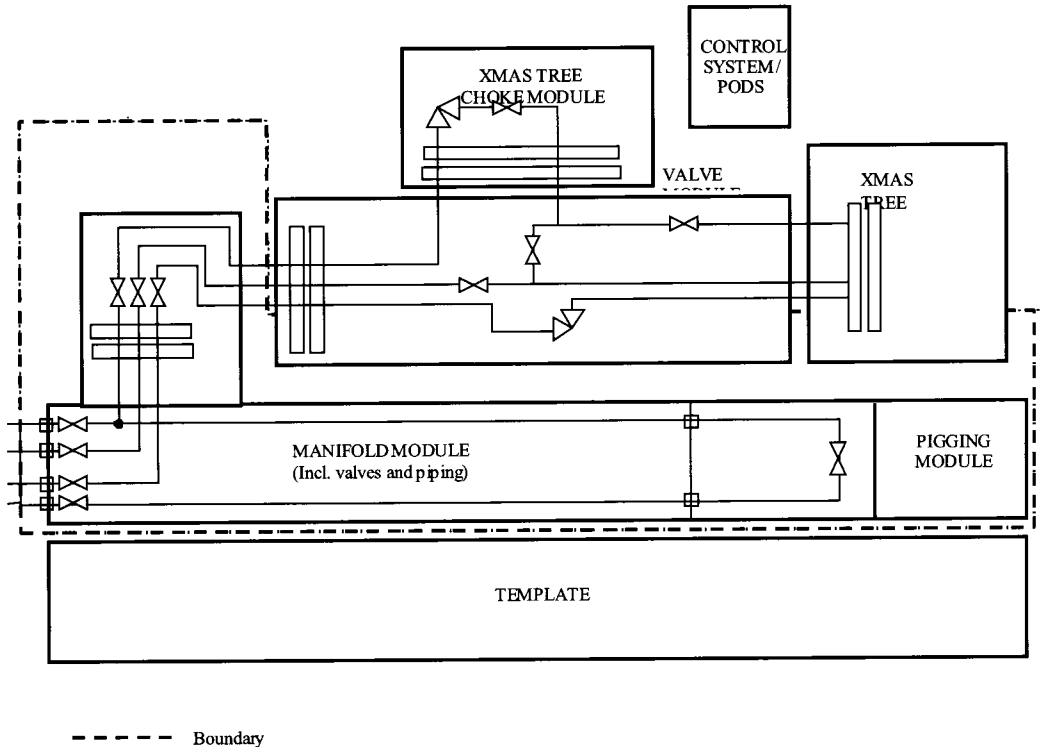
**Failure descriptor versus failure mode, Control System**

Component	Descriptor	ELU	FTF	OTH	ERO	FWR	ILU	SCI	SPO	TRF	UNK	Total
Accumulator - subsea	Leakage						1					1
Chemical injection coupling	Leakage	8										8
Hydraulic power unit	Control failure										2	2
	Faulty signal/indication/alarm										2	2
	Material failure - general										1	1
Hydraulic/chemical coupling	Miscellaneous - general			2								2
Hydraulic/chemical jumper	Burst	1										1
	Material failure - general	1										1
Hydraulic/chemical line	Leakage	1										1
Hydraulic coupling	Clearance/ alignment failure										1	1
	Miscellaneous - general			2								2
	Unknown	3										3
Other	Blockage		2									2
	Earth/isolation fault				1							1
Valve position sensor	Instrument failure - general		1									1
Power supply unit	Electrical failure - general			2	2							4
Combined pressure and temperature sensor	No signal/indication/alarm					1						1
Pressure sensor	Blockage				1							1
	Faulty signal/indication/alarm				2				1			3
	Instrument failure - general			3	4							7
	No signal/indication/alarm		1		1							2
	Software failure				1							1
Power/signal coupler	Earth/isolation fault									3		3
	Electrical failure - general									5		5
	Other									2		2
Power/signal jumper	Electrical failure - general								2			2
Power/signal line	Earth/isolation fault									9		9
Subsea electronic module	Contamination			1								1
	Control failure		2	106								108
	Earth/isolation fault			2								2
	Faulty signal/indication/alarm		1						5			6
	Leakage		1									1
	No signal/indication/alarm		1									1
Solenoid control valve	Short circuiting		1									1
	Contamination						1					1
	Control failure		2									2
	Faulty signal/indication/alarm		7									7
Subunit	Leakage	50					3					53
	Combined causes		1									1
	Contamination			1								1
	Control failure			2	3	2			1		1	9
	Earth/isolation fault							1				1
	Electrical failure - general		1	1								2
	Faulty signal/indication/alarm						1		2			3
	Instrument failure - general			1								1
Software failure		2		1				2			5	
Subsea umbilical termination unit	Unknown								1			1
	Erosion	1										1
Temperature sensor	Instrument failure - general			1	1							2
Topside umbilical termination unit	Leakage	1										1
Unknown	Burst						2					2
	Earth/isolation fault							1				1

Component	Descriptor	ELU	FTF	OTH	ERO	FWR	ILU	SCI	SPO	TRF	UNK	Total	
	Leakage	2										2	
	No cause found										1	1	
	Unknown										1	1	
<b>Total</b>		<b>287</b>	<b>68</b>	<b>23</b>	<b>124</b>	<b>18</b>	<b>3</b>	<b>7</b>	<b>2</b>	<b>12</b>	<b>21</b>	<b>9</b>	<b>287</b>

**Manifold**

The boundary definition is shown in Figure 24 and subdivision in subunits and components is shown in Table 22. The boundary definition applies to manifolds and associated equipment to commingle produced fluids, or distribute fluids or chemicals, to template wells or satellites. Note that the trees and control system are outside the boundary. The manifolds may vary considerably in design from large and complex multi-well template manifolds to simpler free standing manifolds. Note that the template is covered as a separate equipment class in OREDA.



**Figure 24 – Manifold, Boundary Definition**



**Table 22 Manifold, Subdivision into Subunits and Components**

MANIFOLD	
Manifold module	Pigging module
<ul style="list-style-type: none"> <li>• Chemical injection coupling</li> <li>• Connector</li> <li>• Control valve</li> <li>• Hydraulic coupling</li> <li>• Piping (hard pipe)</li> <li>• Structure - protective</li> <li>• Structure - support</li> <li>• Valve, check</li> <li>• Valve, control</li> <li>• Valve, process isolation</li> <li>• Valve, utility isolation</li> </ul>	<ul style="list-style-type: none"> <li>• Connector</li> <li>• Piping (hard pipe)</li> <li>• Valve, process isolation</li> </ul>

**List of failure modes**

- ELP External leakage - process medium
- FTC Fail to close/lock
- FTO Fail to open/unlock
- ILP Internal leakage - process medium
- ILU Internal leakage - utility medium
- LCP Leakage in closed position
- NON No immediate effect
- OTH Other
- SPO Spurious operation

Taxonomy no		Item Manifold										
Population	Installations	Aggregated time in service (10 <sup>6</sup> hours)									Active repair time (hours)	
29	11	Failure data				Calendar time 1.3342						
Component	No of units	Severity class					Failure rate (per 10 <sup>6</sup> hours).					Mean
		#	C	D	I	U	Lower	Mean	Upper	SD	n/τ	
<b>Manifold module</b>	<b>29</b>	<b>10</b>	<b>2</b>	<b>7</b>	<b>1</b>		<b>0.4756</b>	<b>7.7643</b>	<b>22.6621</b>	<b>7.4826</b>	<b>7.4950</b>	<b>7</b>
Chemical injection coupling	19*						0.0010	0.2570	0.9767	0.3635	-	
Connector	214	1	1				0.0001	0.1093	0.4653	0.1791	0.0993	2
Hydraulic coupling	87						0.0002	0.0591	0.2246	0.0836	-	
Piping (hard pipe)	38*						0.0007	0.1792	0.6808	0.2534	-	
Structure - protective	15						0.0017	0.4128	1.5687	0.5838	-	
Structure - support	6						0.0047	1.1738	4.4605	1.6600	-	
Valve, check	14						0.0018	0.4534	1.7228	0.6412	-	
Valve, control	13						0.0014	0.3419	1.2992	0.4835	-	
Valve, process isolation	298	9	8	1			0.0185	0.8313	2.7588	0.9593	0.6708	7.71
Valve, utility isolation	148*						0.0003	0.0849	0.3227	0.1201	-	
<b>Pigging module</b>	<b>8</b>						<b>0.0033</b>	<b>0.8347</b>	<b>3.1720</b>	<b>1.1805</b>		
Connector	2*						0.0010	0.2478	0.9418	0.3505	-	
Piping (hard pipe)	1*						0.0015	0.3643	1.3845	0.5152	-	
Valve, process isolation	11*						0.0017	0.4184	1.5900	0.5917	-	
<b>Equipment level</b>	<b>29</b>	<b>10</b>	<b>2</b>	<b>7</b>	<b>1</b>		<b>0.4756</b>	<b>7.7643</b>	<b>22.6621</b>	<b>7.4826</b>	<b>7.4950</b>	<b>7</b>

**Comments**

For components with no failures, n is set to 0.5 based on a non-informative prior.  
 \* Mean failure for the common component is used in the estimator.

**Component versus failure mode, Manifold**

Component	ELP	FTO	FTC	OTH	LCP	SPO	Total
Connector	1						1
Valve, process isolation	1	2	1	2	2	1	9
<b>Total</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>10</b>

**Subunit versus failure mode, Manifold**

Subunit	ELP	ILP	NON	OTH	ILU	Total
Manifold module	2	3	1	1	3	10

**Equipment unit versus failure mode, Manifold**

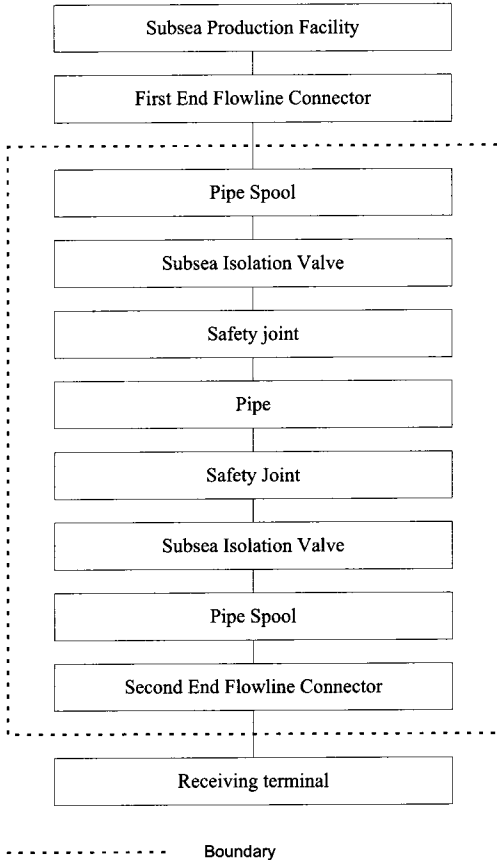
Equipment unit	ELP	ILP	SPO	ILU	NON	Total
Manifold	2	3	1	3	1	10

**Failure descriptor versus failure mode, Manifold**

Component	Descriptor	ELP	FTC	FTO	LCP	SPO	OTH	Total
Connector	Leakage	1						1
Valve, process isolation	Blockage		1					1
	External influence - general			1		1		2
	Leakage	1		1	2		2	6
<b>Total</b>		<b>2</b>	<b>1</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>10</b>

**Flowline**

The boundary definition is shown in Figure 25 and subdivision in subunits and components is shown in Table 23. The boundary definition applies to all subsea flowlines from a subsea production facility to a receiving terminal, e.g. another subsea production facility or a topside production facility (floating or fixed). Flexible or rigid pipes from the sea floor up to and including the hang-off on the receiving installation belong to the riser equipment class. The connector at the subsea facility is excluded from the boundary.



**Figure 25 – Flowline, Boundary Definition**

**Table 23 Flowline, Subdivision into Subunits and Components**

FLOWLINE	
Pipe	Subsea isolation system
<ul style="list-style-type: none"> <li>• Coating - external</li> <li>• Connector</li> <li>• Flexible pipe spool</li> <li>• Rigid pipe spool</li> <li>• Sealine</li> </ul>	<ul style="list-style-type: none"> <li>• Valve, process isolation</li> <li>• Structure - protective</li> <li>• Structure - support</li> </ul>

**List of failure modes**

ELP      External leakage - process medium

Taxonomy no		Item Flowline										
Population	Installations	Failure data					Aggregated time in service (10 <sup>6</sup> hours)					Active repair time (hours)
59	11	Severity class					Calendar time 2.0850					
Component	No of units	#	Severity class				Failure rate (per 10 <sup>6</sup> hours)					Mean
			C	D	I	U	Lower	Mean	Upper	SD	n/τ	
Pipe	60	1		1			0.0000	0.4402	2.2342	0.9568	0.4803	2
Coating - external	38						0.0006	0.1624	0.6172	0.2297	-	
Connector	91*						0.0004	0.0876	0.3330	0.1239	-	
Flexible pipe spool	26	1	1				0.0059	1.1956	4.5224	1.6546	0.7209	2
Rigid pipe spool	74						0.0003	0.0800	0.3041	0.1132	-	
Sealine	55						0.0005	0.1374	0.5222	0.1943	-	
Subsea isolation system	16						0.0011	0.2835	1.0774	0.4010	-	
Valve, process isolation	17*						0.0011	0.2727	1.0361	0.3856	-	
<b>Equipment level</b>	<b>59</b>	<b>1</b>	<b>1</b>				<b>0.0000</b>	<b>0.4346</b>	<b>2.0982</b>	<b>0.8654</b>	<b>0.4796</b>	<b>2</b>
<b>Comments</b>												
For components with no failures, n is set to 0.5 based on a non-informative prior.												
* Mean failure for the common component used in the estimator.												

**Component versus failure mode, Flowline**

Component	ELP
Flexible pipe spool	1

**Subunit versus failure mode, Flowline**

Subunit	ELP
Pipe	1

**Equipment unit versus failure mode, Flowline**

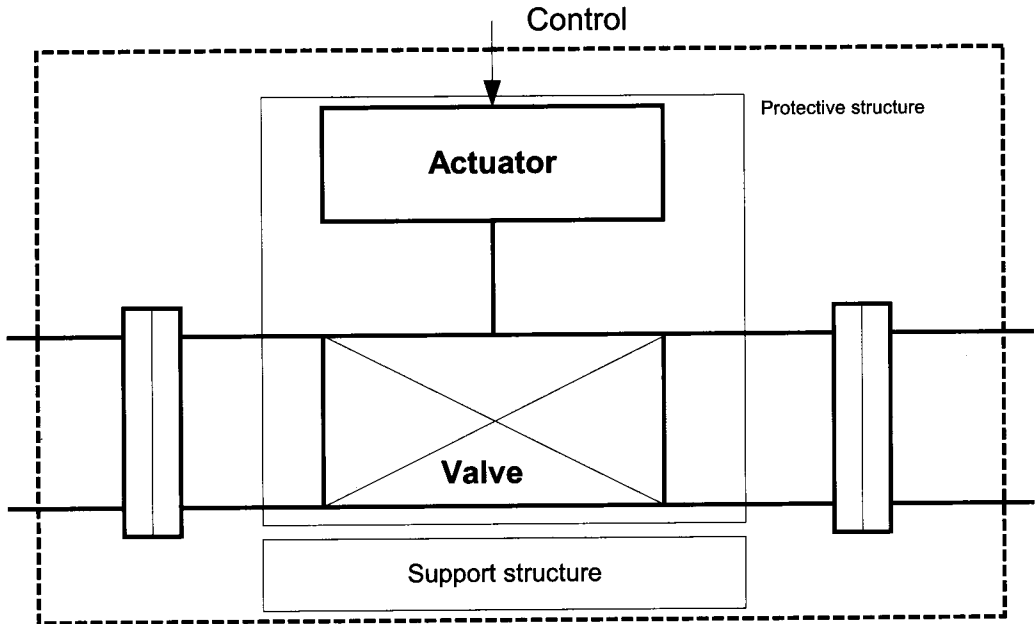
Equipment unit	ELP
Flowline	1

**Failure descriptor versus failure mode, Flowline**

Descriptor	ELP
Leakage	1

**Subsea Isolation System**

The boundary definition is shown in Figure 26 and subdivision in subunits and components is shown in Table 24. The subunit that defines the Subsea Isolation Valve (SSIV) configuration is the ‘Subsea Isolation System’ (SSIS). SSIV includes local accessories e.g. the actuator. The SSIV control system uses the same equipment taxonomy as the current subsea control systems. A SSIS for an installation can consist of several valves e.g. single valve with bypass or two serial valves.



**Figure 26 - Subsea Isolation System, Boundary Definition**

**Table 24 SSIS, Subdivision into Subunits and Components**

Subsea isolation system
<ul style="list-style-type: none"> <li>• Valve, subsea isolation</li> <li>• Structure – protective</li> <li>• Structure - support</li> </ul>

**List of failure modes**

- DOP     Delayed operation
- ELP     External leakage - process medium
- INS     Control/signal failure
- NON     No immediate effect

Taxonomy no		Item Pipeline – SSIV										
Population 85	Installations 32						Aggregated time in service (10 <sup>6</sup> hours)					
		Failure data					Calendar time 2.3683					
Component	No of units	#	Severity class				Failure rate (per 10 <sup>6</sup> hours).					Active repair time (hours)
			C	D	I	U	Lower	Mean	Upper	SD	n/τ	Mean
Subsea isolation system	85	9		5	4		0.0000	3.0865	17.8947	9.6702	3.8001	29
Valve, subsea isolation	146	9		5	4		0.0003	2.0040	9.0202	3.5684	2.5014	36
Equipment level	85	9		2	6		0.0000	3.0865	17.8947	9.6702	3.8001	29
Comments												

**Component versus failure mode, Pipeline**

Component	ELP	DOP	INS	Total
Valve, subsea isolation	6	1	2	9

**Subunit versus failure mode, Pipeline**

Subunit	ELP	NON	DOP	Total
Subsea isolation system	6	2	1	9

**Equipment unit versus failure mode, Pipeline**

Equipment unit	ELP	NON	Total
Pipeline	5	4	9

**Failure descriptor versus failure mode - Valve, subsea isolation**

Descriptor	ELP	DOP	INS	Total
Corrosion	1			1
External influence - general	1			1
Instrument failure - general			1	1
Leakage	2			2
Material failure - general	1			1
Mechanical Failure - general	1	1	1	3
<b>Total</b>	<b>6</b>	<b>1</b>	<b>2</b>	<b>9</b>

### Risers

The boundary definition is shown in Figure 27 and subdivision in subunits and components is shown in Table 25. The boundary definition applies to fixed and flexible production risers from riser base/manifold on sea bottom to the installation surface tree. The riser components may vary significantly but will mainly include riser joints for rigid risers or single pipe length(s) for flexible risers, connectors and various accessories.

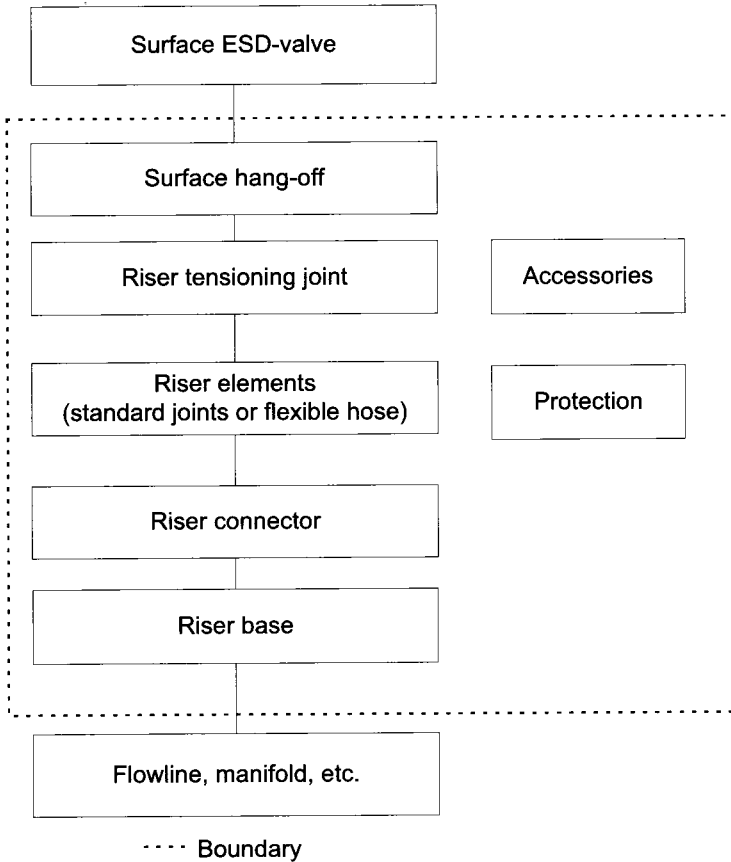


Figure 27 – Risers, Boundary Definition



**Table 25 Riser, Subdivision into Subunits and Components**

RISER			
Accessories	Protection	Riser base	Riser elements
<ul style="list-style-type: none"> <li>• Bend restrictor</li> <li>• Buoyancy device</li> <li>• J/I-tube seal</li> <li>• Stabilizing &amp; guidance equipment</li> <li>• Tension &amp; motion compensation equipment</li> </ul>	<ul style="list-style-type: none"> <li>• Anode</li> <li>• Coating - external</li> </ul>	<ul style="list-style-type: none"> <li>• Gas lift system</li> <li>• Structure</li> <li>• Valve, process isolation</li> <li>• Valve, utility isolation</li> </ul>	<ul style="list-style-type: none"> <li>• Connector</li> <li>• Pipe</li> </ul>

**List of failure modes**

- ELP External leakage - process medium
- NON No immediate effect
- STD Structural failure

Taxonomy no		Item Riser										
Population 42	Installations 8	Failure data					Aggregated time in service (10 <sup>6</sup> hours) Calendar time 2.0633					Active repair time (hours) Mean
		#	C	D	I	U	Lower	Mean	Upper	SD	n/τ	
<b>Accessories</b>	1						0.0332	8.3103	31.5793	11.7526	-	
No comp.												
<b>Protection</b>	1						0.0290	7.2466	27.5370	10.2482	-	
Anode	1						0.0290	7.2466	27.5370	10.2482	-	
Coating - external	1						0.0290	7.2466	27.5370	10.2482	-	
<b>Riser elements</b>	44	5	4	1			0.0000	3.0420	15.3341	6.5293	2.3543	75.5
Connector	81*						0.0003	0.0857	0.3257	0.1212	-	
Pipe	44	5	4	1			0.0000	3.3088	16.9069	7.2821	2.3597	75.5
<b>Equipment level</b>	42	5	4	1			0.0000	3.1408	15.7109	6.6488	2.4233	75.5

**Comments**  
 For components with no failures, n is set to 0.5 based on a non-informative prior.  
 \* Mean failure for the common component is used in the estimator.

**Component versus failure mode, Riser**

Component	ELP	STD	Total
Pipe	1	4	5

**Subunit versus failure mode, Riser**

Subunit	ELP	STD	Total
Riser elements	1	4	5

**Equipment unit versus failure mode, Riser**

Equipment unit	ELP	NON	STD	Total
Riser	1	1	3	5

**Failure descriptor versus failure mode, Riser**

Component	Descriptor	ELP	STD	Total
Pipe	Combined causes		4	4
	Fatigue	1		1
<b>Total</b>		1	4	5

### Running Tool

The boundary definition is shown in Figure 28 and subdivision in subunits and components is shown in Table 26. The boundary applies to the running tool itself including the valve block, connectors, soft landing system and the local control and monitoring. The surface HPU and the surface controls are *not* included. The control system items to be included, end with the umbilical topside termination.

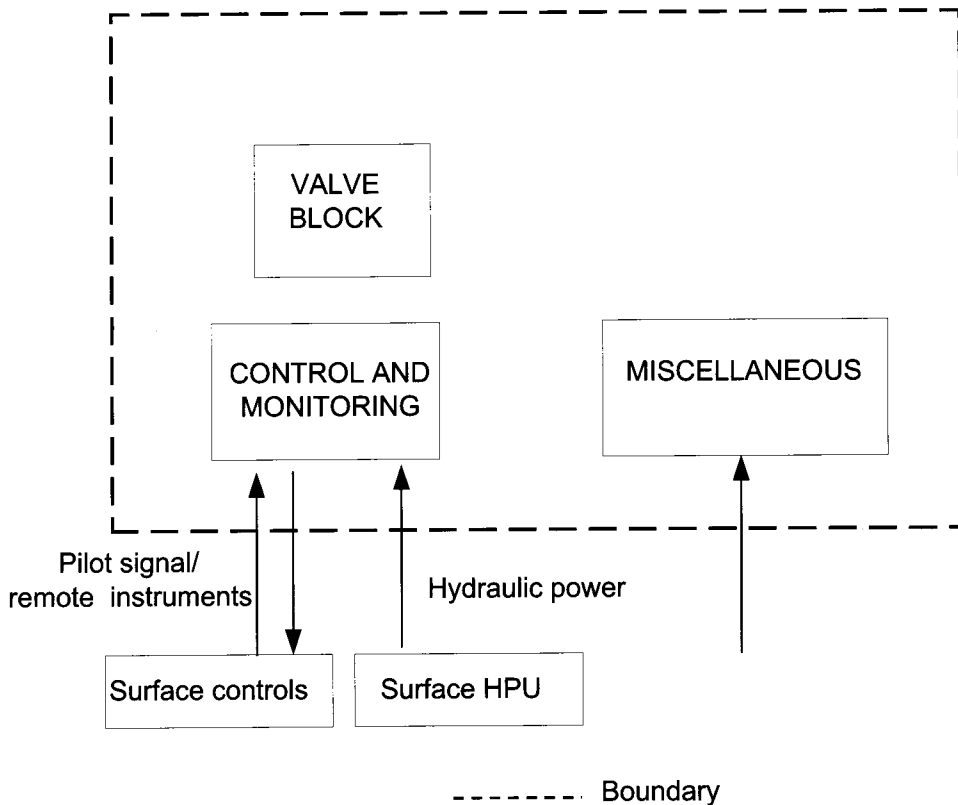


Figure 28 – Running Tool, Boundary Definition

**Table 26 Running tool, Subdivision into Subunits and Components**

RUNNING TOOL		
Control & monitoring	Valve block	Miscellaneous
<ul style="list-style-type: none"> <li>• Accumulator – subsea</li> <li>• Junction plate w/couplers</li> <li>• Pilot control valve</li> <li>• Solenoid control valve</li> <li>• Umbilical</li> </ul>	<ul style="list-style-type: none"> <li>• Ram preventer</li> <li>• Main block</li> <li>• Valve, process isolation</li> <li>• Valve, shear</li> </ul>	<ul style="list-style-type: none"> <li>• Connector</li> <li>• Soft landing system</li> </ul>

**List of failure modes**

- ELU External leakage - utility medium
- ILU Internal leakage - utility medium
- NON No immediate effect
- OTH Other
- UNK Unknown

Taxonomy no		Item									
Population		Installations		Failure data		Aggregated time in service (10 <sup>6</sup> hours)					Active repair time (hours)
6		2				Calendar time					
						0.3032					
Component	No of units	Severity class				Failure rate (per 10 <sup>6</sup> hours).					Mean
		#	C	D	I	U	Lower	Mean	Upper	SD	
<b>Control &amp; monitoring</b>	<b>6</b>	<b>2</b>			<b>2</b>	<b>0.5495</b>	<b>6.0086</b>	<b>16.4134</b>	<b>5.2628</b>	<b>6.5959</b>	<b>40</b>
Accumulator – subsea	1*					0.0031	0.7785	2.9583	1.1010	-	
Junction plate w/couplers	7	2			2	0.2438	5.1754	15.6890	5.2628	5.9221	40
Pilot control valve	1					0.0290	7.2466	27.5370	10.2482	-	
Umbilical	1					0.0290	7.2466	27.5370	10.2482	-	
Other	1					0.0290	7.2466	27.5370	10.2482	-	
<b>Valve block</b>	<b>2</b>	<b>1</b>			<b>1</b>	<b>0.1312</b>	<b>10.5391</b>	<b>37.0168</b>	<b>13.1569</b>	<b>11.3323</b>	
Main block	1					0.0290	7.2466	27.5370	10.2482	-	
Valve, process isolation	4*					0.0019	0.4628	1.7587	0.6545	-	
Valve, shear	5	1			1	0.1174	3.9712	12.7690	4.3856	4.3435	
Other	1					0.0290	7.2466	27.5370	10.2482	-	
<b>Miscellaneous</b>	<b>6</b>	<b>1</b>			<b>1</b>	<b>0.3345</b>	<b>3.1344</b>	<b>8.3189</b>	<b>2.6314</b>	<b>3.2979</b>	<b>36</b>
Connector	6	1			1	0.3345	3.1344	8.3189	2.6314	3.2979	36
Soft landing system	3					0.0070	1.7607	6.6908	2.4900	-	
Other	1					0.0290	7.2466	27.5370	10.2482	-	
<b>Equipment level</b>	<b>6</b>	<b>4</b>			<b>4</b>	<b>0.7835</b>	<b>11.2412</b>	<b>32.1558</b>	<b>10.5256</b>	<b>13.1918</b>	<b>38</b>

**Comments**  
 For components with no failures, n is set to 0.5 based on a non-informative prior.  
 \* Mean failure for the common component is used in the estimator.

**Component versus failure mode, Running Tool**

Component	ELU	UNK	OTH	Total
Junction plate w/couplers			2	2
Connector			1	1
Valve, shear	1			1
<b>Total</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>4</b>

**Subunit versus failure mode, Running Tool**

Subunit	ELU	NON	OTH	Total
Control & monitoring	1	1		2
Miscellaneous			1	1
Valve block	1			1
<b>Total</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>4</b>

**Equipment unit versus failure mode, Running Tool**

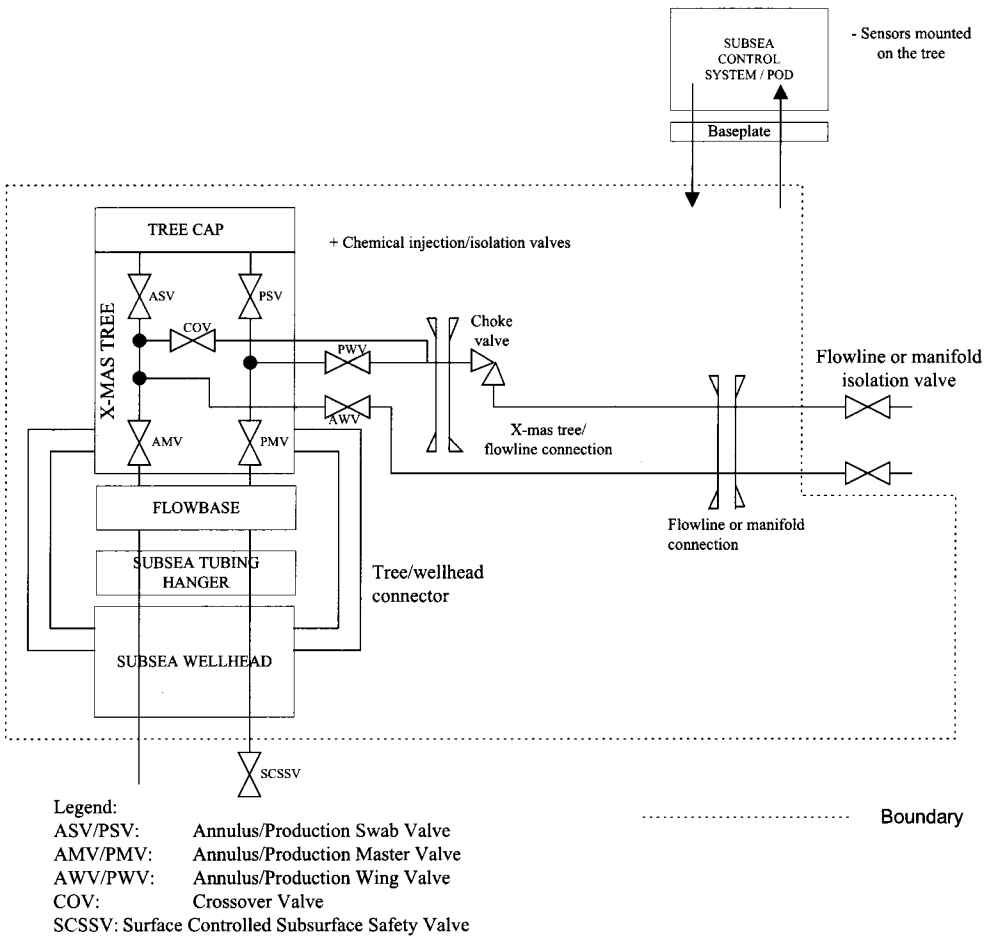
Equipment unit	UNK	ILU	OTH	Total
Running tool	1	2	1	4

**Failure descriptor versus failure mode, Running Tool**

Component	Descriptor	ELU	OTH	UNK	Total
Connector	Other		1		1
Junction plate w/couplers	Leakage			1	1
	Unknown			1	1
Valve, shear	Erosion		1		1
<b>Total</b>		<b>1</b>	<b>1</b>	<b>2</b>	<b>4</b>

### Wellhead and X-mas Tree

The boundary definition is shown in Figure 29 and subdivision in subunits and components is shown in Table 27. The boundary definition applies to both single satellite wells and multiple wells on templates. The equipment boundary includes the subsea wellhead and the tree. Included in the tree are all tree valves and the tree/flowline or tree/manifold connector. The subsea control system is outside the boundary i.e. valves found in the subsea control pod are outside. All control connectors are outside the boundary. Pressure and temperature sensors, and any other detectors mounted on the tree, are outside the boundary.



**Figure 29 Wellhead and X-mas Tree, Boundary Definition**

**Table 27 Wellhead and X-mas Tree, Subdivision into Subunits and Components**

WELLHEAD AND X-MAS TREE			
Flowbase	Subsea wellhead	Subsea X-mas tree	Tubing hanger
<ul style="list-style-type: none"> <li>• Frame</li> <li>• Hub/mandrel</li> <li>• Valve, check</li> <li>• Valve, process isolation</li> <li>• Valve, utility isolation</li> </ul>	<ul style="list-style-type: none"> <li>• Annulus seal assemblies (packoffs)</li> <li>• Casing hangers</li> <li>• Conductor housing</li> <li>• Permanent guidebase (PGB)</li> <li>• Temporary guidebase (TGB)</li> <li>• Wellhead housing (high pressure housing)</li> </ul>	<ul style="list-style-type: none"> <li>• Chemical injection coupling</li> <li>• Connector</li> <li>• Debris cap</li> <li>• Flowspool</li> <li>• Hose (flexible piping)</li> <li>• Hydraulic coupling</li> <li>• Piping (hard pipe)</li> <li>• Tree cap</li> <li>• Tree guide frame</li> <li>• Unknown</li> <li>• Valve, check</li> <li>• Valve, choke</li> <li>• Valve, control</li> <li>• Valve, other</li> <li>• Valve, process isolation</li> <li>• Valve, utility isolation</li> </ul>	<ul style="list-style-type: none"> <li>• Chemical injection coupling</li> <li>• Hydraulic coupling</li> <li>• Power/signal coupler</li> <li>• Tubing hanger body</li> <li>• Tubing hanger isolation plug (H)</li> </ul>

Valves are sorted according to functional features, i.e. process isolation, utility isolation, check, choke and control. The following connectors are included within the boundary of the wellhead and X-mas tree:

- Tree to wellhead connector
- Flowspool to sealine/manifold connector
- Tree to flowbase connector (if applicable)

### List of failure modes

ELP	External leakage - process medium
ELU	External leakage - utility medium
FTC	Fail to close/lock
FTF	Fail to function on demand
FTO	Fail to open/unlock
ILP	Internal leakage - process medium
ILU	Internal leakage - utility medium
LCP	Leakage in closed position
LOB	Loss of barrier
LOR	Loss of redundancy
NON	No immediate effect
OTH	Other
PLU	Plugged/choked
SPO	Spurious operation
STD	Structural failure



Taxonomy no		Item											
83		13		Wellhead & Xmas tree				Aggregated time in service (10 <sup>6</sup> hours)					
				Failure data				Calendar time					
								3.0208					
Component	No of units	Severity class					Failure rate (per 10 <sup>6</sup> hours).					Active repair time (hours)	
		#	C	D	I	U	Lower	Mean	Upper	SD	n/t	Mean	
<b>Flowbase</b>	<b>38</b>	<b>6</b>		<b>6</b>			<b>0.0002</b>	<b>4.7434</b>	<b>22.5348</b>	<b>9.1977</b>	<b>4.9220</b>	<b>7.3</b>	
Frame	38	5		5			0.0000	3.6968	20.3459	9.5439	4.1016	7.6	
Hub/mandrel	47						0.0007	0.1751	0.6654	0.2476	-		
Valve, check	2						0.0088	2.1961	8.3450	3.1057	-		
Valve, process isolation	18	1	1				0.1272	1.6114	4.5161	1.4650	1.7954	6	
Valve, utility isolation	5*						0.0014	0.3479	1.3219	0.4920	-		
<b>Subsea wellhead</b>	<b>82</b>						<b>0.0003</b>	<b>0.0839</b>	<b>0.3190</b>	<b>0.1187</b>	-		
Annulus seal assemblies (packoffs)	130						0.0002	0.0490	0.1862	0.0693	-		
Casing hangers	106						0.0002	0.0590	0.2240	0.0834	-		
Conductor housing	74						0.0004	0.0889	0.3377	0.1257	-		
Other	10						0.0024	0.5900	2.2420	0.8344	-		
Permanent guidebase (PGB)	49						0.0006	0.1524	0.5790	0.2155	-		
Temporary guidebase (TGB)	13						0.0029	0.7206	2.7381	1.0190	-		
Unknown	5						0.0134	3.3613	12.7729	4.7536	-		
Wellhead housing (high pressure housing)	72						0.0004	0.0907	0.3447	0.1283	-		
<b>Subsea X-mas tree</b>	<b>78</b>	<b>50</b>	<b>11</b>	<b>26</b>	<b>13</b>		<b>3.2334</b>	<b>22.2059</b>	<b>55.2296</b>	<b>16.9050</b>	<b>17.2633</b>	<b>32.71</b>	
Chemical injection coupling	124*						0.0003	0.0782	0.2973	0.1106	-		
Connector	212	1			1		0.0000	0.6193	3.1483	1.3502	0.1381	-	
Debris cap	44						0.0006	0.1504	0.5716	0.2127	-		
Flowspool	77	1		1			0.0000	0.4525	2.0788	0.8316	0.3594	72	
Hose (flexible piping)	20						0.0015	0.3692	1.4031	0.5222	-		
Hydraulic coupling	1266	3	3				0.0001	0.0678	0.2806	0.1066	0.0692	9	
Other	25						0.0009	0.2368	0.8998	0.3349	-		
Piping (hard pipe)	49	1	1				0.0000	0.6033	3.4115	1.6847	0.6005	-	
Tree cap	76	8		8			0.0005	2.7429	12.2721	4.8396	2.8281	16.875	
Tree guide frame	42	2			2		0.1395	1.3889	3.7293	1.1862	1.4530	6	
Unknown	6						0.0098	2.4527	9.3203	3.4687	-		
Valve, check	75						0.0003	0.0729	0.2769	0.1031	-		
Valve, choke	75	22	7	15			2.5064	11.3278	25.3340	7.2845	9.0909	34.97	
Valve, control	163						0.0001	0.0370	0.1406	0.0523	-		
Valve, other	24	1			1		0.0509	0.9924	2.9730	0.9924	0.9924		
Valve, process isolation	550	8	4	3	1		0.1112	0.4085	0.8577	0.2360	0.3903	92.00	
Valve, utility isolation	181	3	3				0.0094	1.0345	3.7338	1.3412	0.5020	10.00	
<b>Tubing hanger</b>	<b>75</b>	<b>2</b>	<b>2</b>				<b>0.0000</b>	<b>0.6806</b>	<b>3.7118</b>	<b>1.7175</b>	<b>0.7265</b>		
Chemical injection coupling	6*						0.0015	0.3647	1.3858	0.5157	-		
Hydraulic coupling	104*						0.0004	0.1124	0.4273	0.1590	-		
Power/signal coupler	41*						0.0008	0.2109	0.8016	0.2983	-		
Tubing hanger body	75	2	2				0.0000	0.6806	3.7118	1.7175	0.7265		
Tubing hanger isolation plug (H)	23						0.0010	0.2605	0.9901	0.3685	-		
<b>Equipment level</b>	<b>83</b>	<b>58</b>	<b>10</b>	<b>34</b>	<b>14</b>		<b>3.5222</b>	<b>23.0976</b>	<b>56.8441</b>	<b>17.3006</b>	<b>19.2000</b>	<b>29.4</b>	
<b>Comments</b>													
For components with no failures, n is set to 0.5 based on a non-informative prior.													
* Mean failure for the common component is used in the estimator.													

**Component versus failure mode, Wellhead & Xmas tree**

Subunit	Component	ELP	FTF	FTC	OTH	ILP	LCP	PLU	STD	ELU	FTO	Total	
Flowbase	Frame								4	1		5	
	Valve, process isolation									1		1	
Tubing hanger	Tubing hanger body	1				1						2	
Subsea X-mas tree	Connector	1										1	
	Flowspool							1				1	
	Hydraulic coupling									3		3	
	Piping (hard pipe)							1				1	
	Tree cap				2					6		8	
	Tree guide frame				2							2	
	Valve, choke		12	5	3			1			1	22	
	Valve, process isolation			2	4							2	8
	Valve, utility isolation			1				1				1	3
	Valve, other			1									1
<b>Total</b>		<b>2</b>	<b>12</b>	<b>9</b>	<b>11</b>	<b>1</b>	<b>1</b>	<b>3</b>	<b>4</b>	<b>11</b>	<b>4</b>	<b>58</b>	

**Subunit versus failure mode, Wellhead & Xmas tree**

Subunit	ELP	ILP	LOR	NON	LOB	SPO	PLU	ELU	ILU	OTH	STD	Total
Flowbase								2			4	6
Tubing hanger	1	1										2
Subsea X-mas tree	1	8	1	17	1	4	3	9	2	3	1	50
<b>Total</b>	<b>2</b>	<b>9</b>	<b>1</b>	<b>17</b>	<b>1</b>	<b>4</b>	<b>3</b>	<b>11</b>	<b>2</b>	<b>3</b>	<b>5</b>	<b>58</b>

**Equipment unit versus failure mode, Wellhead & Xmas tree**

Equipment unit	ELP	ILP	SPO	ELU	ILU	LOB	OTH	PLU	STD	NON	Total
Wellhead & Xmas tree	2	8	4	10	1	1	5	3	2	22	58

**Failure descriptor versus failure mode, Wellhead & Xmas tree**

Component	Descriptor	ELP	FTF	FTC	FTO	ILP	LCP	PLU	STD	ELU	OTH	Total
Connector	Leakage	1										1
Flowspool	Blockage							1				1
Frame	Corrosion									1		1
	Deformation								1			1
	Material failure - general								2			2
	Vibration								1			1
Hydraulic coupling	Corrosion									1		1
	Leakage									1		1
	Material failure - general									1		1
Piping	Blockage						1					1
Tubing hanger body	Control failure	1										1
	Leakage					1						1
Tree cap	Erosion									6		6
	Looseness										2	2
Tree guide frame	Trawlboard impact										2	2
Valve, choke	Blockage							1				1
	Breakage				1							1
	Clearance/ alignment failure										3	3
	Contamination		2									2
	Control failure		4	4								8
	Leakage		6									6
	Mechanical Failure - general			1								1
Valve, process isolation	Blockage				1							1
	Clearance/ alignment failure			2								2
	Leakage								1	3		4
	Material failure - general				1							1
	Mechanical Failure - general										1	1
Valve, utility isolation	Leakage			1			1					2
	Sticking				1							1
Valve, other	Sticking			1								1
<b>Total</b>		<b>2</b>	<b>12</b>	<b>9</b>	<b>4</b>	<b>1</b>	<b>1</b>	<b>3</b>	<b>4</b>	<b>11</b>	<b>11</b>	<b>58</b>