ENGINEERING STANDARD

FOR

HAZARDOUS AREA

CONTENTS :

PAGE No.

APPENDICES :

PART 2

TABLES :

APPENDICES :

0. INTRODUCTION

This standard specifies the requirement of Electrical Area Classification in Part 1 and Outlines the Method of Safeguarding of Electrical Installation in Part 2.

Part 1 : ELECTRICAL AREA CLASSIFICATION AND EXTENT

In plants where flammable gases, vapors, liquids or dusts are present, a flammable atmosphere may be formed if they are released.

The flammable atmosphere may also exist inside plant equipment if air or oxygen is present together with a flammable material.

The primary step in recognition of danger is the classification of plant into zones in which the probability of the existence of a flammable atmosphere is broadly assessed. This procedure known as area classification is dealt with in Part 1.

Part 2 : METHOD OF SAFEGUARDING OF ELECTRICAL INSTALLATIONS

Electrical apparatus, including electrically operated process instruments, shall not be installed in a hazardous area when it is practical and economic to site it elsewhere.

Electrical installations in hazardous areas involve high initial capital expenditure on methods of safeguarding and continuing high inspection and maintenance costs relative to comparable installations in non hazardous areas.

Where the installation of electrical apparatus in hazardous areas is unavoidable special methods of safeguarding must be adopted to avoid danger.

Part 2 elaborate on method of safeguarding of electrical apparatus in classified hazardous areas.

PART 1

ELECTRICAL AREA CLASSIFICATION

AND

EXTENT

1. SCOPE

This Standard provides guidance on the classification of areas where flammable gas or vapor risks may arise in order to permit the proper selection of electrical apparatus for use in such areas.

By using the following procedure an area classification map could be sketched for each plant (see Note 1). It is intended to be applied in oil industries, where there may be a risk due to presence of flammable gas or vapor, mixed with air under normal atmospheric conditions (see Note 2) and covers the following areas:

- Petroleum refineries;
- petroleum and gas pipeline transportation facilities;
- natural gas liquid processing plants;
- drilling rigs, production facilities on land and marine fixed or mobile platforms;
- chemical process areas.

It does not apply to:

- Mining;
- processing and manufacture of explosives;
- areas where risks may arise due to the presence of ignitable dusts or fibers;
- catastrophic failures, which are beyond the concept of abnormality dealt with this standard(see Note 3);
- ignition sources other than those associated with electrical apparatus (see Note 4).

This standard does not take into account the effects of consequential damages. Definitions and explanations of terms are given together with the main principles and procedures relating to area classification.

However this standard is applicable for new plants, previous procedures will be retained temporarily as a reference guide for the many existing plants installed according to the earlier code or standard.

Notes:

1) For the purpose of this standard an area is a three dimensional region or space.

2) Normal atmospheric conditions include variations above and below reference levels of 101.3 kPa. (1013 m bar) and 20°C provided the variations have a negligible effect on the explosion properties of the flammable materials.

3) Catastrophic failure in this context is applied for example to rupture of a process vessel or pipeline.

4) In any plant installation irrespective of size, there may be numerous sources of ignition apart from those associated with electrical apparatus. Additional precautions may be necessary to ensure safety in this aspect but these are outside the scope of this part, however some reference is made to them in Part 2.

2. REFERENCE CODES AND STANDARD

IEC (INTERNATIONAL ELECTROTECHNICAL COMMITTEE)

IEC-79-10 "Classification of Hazardous Areas" (1986)

BSI (BRITISH STANDARD INSTITUTE)

BS 5345 Part 1 "General Recommendation" (1989)
BS 5345 Part 2 "Classification of Hazardous Areas" (1983) And 5754 (1989)

NFC (NATIONAL FIRE CODES)

NFC 30, 1987	"Flammable and Combustible Liquids" Code (NFC Vol. 1-1989)
NFC 70	"Articles 500 Through 503 Hazardous Classified Location". (NFC Vol. 3-1989), (National Electric Code 1987)
NFC 497 M Ed, 1986	"Classification of Gases Vapors and Dusts for Electrical Equipment in Hazardous Locations" (NFC Vol. 11-1989).

API (AMERICAN PETROLUME INSTITUTE)

API RP 500 A	"Recommended Practice for Classification of Areas for Electrical Installation in Petroleum Refineries". (1982)
API RP 500 B	"Recommended Practice for Classification of Locations for Electrical Installations at Drilling Rigs and Production Facilities on Land and on Marine Fixed and Mobile Platform" (1987)
API RP 500 C	"Recommended Practice for Classification of Locations for Electrical Installations at Pipeline Transportation Facilities" (1984).

IP (INSTITUTE OF PETROLEUM)

"Area Classification Code. Part 15 of the IP Model Code of Safe Practice in the Petroleum Industry March 1990"

3. DEFINITIONS AND TERMINOLOGY

3.1 Explosive Gas Atmosphere

A mixture with air under normal atmospheric conditions, of flammable materials in the form of gas, vapor or mist, in which, after ignition, combustion spreads throughout the unconsumed mixture.

3.2 Hazardous Area

An area in which an explosive gas atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of electrical apparatus.

3.3 Non Hazardous Area

An area in which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of electrical apparatus.

3.4 Zones

Hazardous areas are classified in zones based upon the frequency of the appearance and the duration of an explosive gas atmosphere as follows:

3.4.1 Zone 0

An area in which an explosive gas atmosphere is present continuously or is present for long periods.

3.4.2 Zone 1

An area in which an explosive gas atmosphere is likely to occur in normal operation*.

3.4.3 Zone 2

An area in which an explosive gas atmosphere is not likely to occur in normal operation* and if does occur it will exist for a short period only.

3.5 Source of Release

A point or location from which a gas, vapor, mist or liquid may be released into the atmosphere so that an explosive gas atmosphere could be formed.

3.6 Grades of Sources of Release (See Appendix A)

There are three basic grades of sources of release as listed below in order of decreasing likelihood of the release occurring:

- Continuous grade
- Primary grade
- Secondary grade

A source of release may be one of the above three grades or may be a combination of two or three, in which case it is regarded as a multi-grade source of release.

3.6.1 Continuous grade source of release

A source which will release continuously or is expected to release for long periods or for short periods which occur frequently.

3.6.2 Primary grade source of release

A source which can be expected to release periodically or occasionally during normal operation*.

3.6.3 Secondary grade source of release

A source which is not expected to release in normal operation* and if it releases is likely to do so only infrequently and for short periods.

3.6.4 Multigrade source of release

A source of release which is a combination of two or three of the above mentioned grades; and

*** See sub clause 3.7.**

a) Is basically graded continuous or primary, and;

b) gives rise to a release under different conditions which create a larger zone but less frequently and/or for a shorter duration than as determined for the basic grade.

Note:

Different conditions mean, for example, different release rate of flammable material but under the same ventilation conditions.

A source of release which is basically graded continuous may in addition be graded primary if the rate of release of flammable material, for the primary grade frequency and/or duration, exceeds that for the continuous grade.

It may, additionally or alternatively to the primary grade, also be graded secondary if the rate of release of flammable material, for the secondary grade frequency and/or duration, exceeds that for continuous and, if applicable, the primary grade.

Similarly a source of release which is basically graded primary may in addition be graded secondary if the rate of release of flammable material for the secondary grade frequency and/or duration exceeds that for the primary grade.

3.7 Normal Operation

The situation when the plant equipment is operating within its design parameters.

Minor releases of flammable material may be part of normal operation. For example, releases from seals which rely on wetting by the fluid being pumped are considered to be minor releases.

Failures (such as the breakdown of pump seals, flange gaskets or spillages caused by accidents) which involve repair or shut down are not considered to be part of normal operation.

3.8 Ventilation

3.8.1 Natural ventilation

Movement of air and its replacement with fresh air due to the effects of wind and/or temperature gradients.

3.8.2 General artificial ventilation

Movement of air and its replacement with fresh air by artificial means (e.g., fans) and applied to a general area.

3.8.3 Local artificial ventilation

Movement of air and its replacement with fresh air by artificial means (usually extraction) applied to a particular source of release or local area.

3.8.4 No ventilation

No ventilation exists where no arrangements have been made to cause air replacement with fresh air.

3.9 Explosive Limits

3.9.1 Lower explosive limit (LEL)

The concentration of flammable gas, vapor or mist in air, below which an explosive gas atmosphere will not be formed.

3.9.2 Upper explosive limit (UEL)

The concentration of flammable gas, vapor or mist in air, above which an explosive gas atmosphere will not be formed.

3.10 Relative Density of a Gas or a Vapor

The density of a gas or a vapor relative to the density of air at the same pressure and at the same temperature. (Air is equal to 1.0.)

3.11 Flammable Material

Material consisting of flammable gas, vapor, liquid and/or mist. (see also Appendix C).

3.12 Flammable Gas or Vapor

Gas or vapor which, when mixed with air in certain proportions, will form an explosive gas atmosphere.

3.13 Flammable Liquid

A liquid capable of producing a flammable vapor or mist under any foreseeable operating conditions.

3.14 Flammable Mist

Droplets of flammable liquid, dispersed in air, so as to form an explosive atmosphere.

3.15 Flash Point

The lowest liquid temperature at which, under certain standardized conditions, a liquid gives off vapors in quantity such as to be capable of forming an ignitable vapor/air mixture.

3.16 Boiling Point

The temperature of a liquid boiling at an ambient pressure of 101.3 kPa (1013 mbar).

Note:

For mixtures the initial boiling point should be used.

"Initial boiling point" is used for liquid mixtures to indicate the lowest value of the boiling point for the range of liquids present.

4. GENERAL

Area classification is a method of analyzing and classifying the environment where explosive gas atmosphere may occur to allow the proper selection of electrical apparatus to be installed in that environment.

The object of the classification procedure is to enable electrical apparatus to be operated safely in that environment.

Once an area has been classified, there is little difficulty in understanding the equipment requirements and associated wiring method because those can be determined from applicable publications.

Where it is necessary to use electrical apparatus in an environment in which there may be an explosive gas atmosphere and it is not possible to:

a) Eliminate the likelihood of an explosive gas atmosphere occurring around the source of ignition, or,
b) eliminate the source of ignition;

Then measures should aim at reducing the likelihood of the occurrence of either or both of the above factors so that the likelihood of coincidence is so small as to be acceptable.

Therefore in situations where an explosive gas atmosphere has a high likelihood of occurrence, reliance is placed on using electrical apparatus which has an extremely low likelihood of creating a source of ignition. Conversely where the likelihood of an explosive gas atmosphere occurring is reduced, electrical apparatus which has an increased likelihood of becoming a source of ignition may be used.

To apply this approach the first step is to assess the likelihood of an explosive gas atmosphere occurring in accordance with the definitions of Zone 0, Zone 1 and Zone 2. The following clauses give guidance on the classification of area in which there may be an explosive gas atmosphere into Zones 0, 1 and 2.

5. BASIC PRINCIPLES

5.1 Fundamental Safety Concepts

It is recommended that plant and installation in which flammable materials are handled, stored or processed be so designed that hazardous areas are kept to a minimum, in particular that Zone 0 and Zone 1 areas should be a minimum in both number and extent. In other words the hazardous areas should be mainly Zone 2.

Where release of flammable material is unavoidable, plant equipment items should be mainly limited to secondary grade sources of release, or failing this (that is where primary or continuous sources of release are unavoidable) the source of release should be such as to have a very limited quantity or rate of release to atmosphere. In carrying out area classification, these principles should receive prime consideration and where necessary, the design, operation or location of process equipment should be modified to meet these requirements.

Similarly, consideration should be given to the design and operation of process equipment to ensure that even when it is operating abnormally the amount of flammable material released to atmosphere is minimized in order to reduce the extent of the area (Zone 2) made hazardous.

Once a plant has been classified and any necessary records made, it is important that no modification to equipment or operating procedures is made without discussion with those responsible for the area classification.

Determination may require inputs from various disciplines before the location classification drawing can be developed (see Clause 10 for task force).

It should be noted that the opening of parts of closed process systems (e.g. filter changing, batch filling) should also be considered as source of release in developing area classification.

5.2 Factors Which Determine Type and Extent of Zones

5.2.1 Type of zone

The likelihood of the presence of an explosive gas atmosphere and hence type of zone depends mainly on the grade of source of release. In some cases the ventilation and other factors may also affect the type of zone.

To facilitate the classification of areas this standard give some typical and specific examples (see Figs. 5 & 6 in Appendix A) which may be used where they are applicable to the situation under consideration.

Where the examples do not strictly apply, a classification may be arrived at by adjusting those examples to the actual condition and using the logic typified in Fig. 1.

Where the actual conditions are not related to the examples, additional consideration should be introduced in the classification procedure which at any case needs sound engineering judgment.

For open air unrestricted ventilated situations, Fig. 1 may be used. Depending on conditions of release and subsequent propagation, it may be necessary in some cases to require a less hazardous zone surrounding a more hazardous zone.

5.2.2 Extent of zone (see Appendix B)

The extent of zones depend mainly on the following parameters:

a) Release rate of flammable material

The extent may increase with increasing release rate (see release velocity).

b) Release velocity

Due to an improved dilution for release of flammable gases, vapors and/or mists in air, the extent of a hazardous area may decrease if, with constant release rate, the release velocity increases that which causes turbulent flow.

c) Concentration of flammable gases vapors and/or mists in the released mixture

The extent may increase with increasing concentration at the release source.

d) Ventilation

With an increased rate of ventilation, the extent of a hazardous area may be reduced. The extent may also be reduced by an improved arrangement of the ventilation system.

e) Obstacles

Obstacles may impede the ventilation and thus may enlarge the extent of the zone. On the other hand some obstacles, for example dikes and walls, may limit the movement of a cloud of an explosive gas atmosphere and thus may reduce the extent.

f) Boiling point of flammable liquids (initial boiling point for liquid mixtures)

For flammable liquids, the concentration of the released vapor is related to the vapor pressure at the relevant maximum liquid temperature. The lower the initial boiling point, the greater the vapor pressure for a given liquid temperature and hence the greater the extent of the hazardous area.

g) Lower explosive limit (LEL)

The lower the LEL, the larger may be the extent of the hazardous area.

h) Flash point

An explosive gas atmosphere can not exist if the flash point is significantly above the relevant maximum temperature of the flammable liquid. The lower the flash point, the larger may be the extent of the hazardous area. Some liquids (such as certain halogenated hydrocarbons) do not possess a flash-point although they are capable of producing an explosive gas atmosphere; in these cases, the equilibrium liquid temperature corresponding to saturated concentration at LEL should be compared with the relevant maximum liquid temperature.

Note:

In special conditions the mist of a flammable liquid may be released at a temperature below the flash point and may therefore produce an explosive gas atmosphere.

i) Relative density

The horizontal extent of a hazardous area may increase with increasing relative density. Where the relative density is less than unity, the vertical extent may increase with a decrease in relative density.

j) Liquid temperature

The extent of a hazardous area may increase with increasing temperature of process liquid provided the temperature is above the flash point. It should be noted that the liquid or vapor temperature after the release may be increased or decreased by the ambient temperature or other factors (e.g., a hot surface).

5.3 Grading of Source of Release (see also Appendix A)

Each item of process equipment (e.g., tank, pump, pipeline, vessel etc.) should be considered as a potential source of release of flammable material. If the item can not contain flammable material it will clearly not give rise to a hazardous area round it.

The same will apply if the item contains a flammable material but can not release it to atmosphere (e.g., an all welded pipeline is not a source of release).

If it is established that the item may release flammable material to the atmosphere (as will be the case with most items) it is necessary, first of all, to determine the grade of the source of release in accordance with the definitions, by establishing the likely frequency and duration of release.

By means of this procedure each item will be graded either "Continuous", "Primary", "Secondary", or "Multi-grade".

The source grade should be estimated by considering operational openings to atmosphere and the possibility of releases under all (normal and abnormal) operating conditions of the plant, installation or process.

6. PROCEDURE FOR DETERMINATION OF THE TYPE AND EXTENT OF ZONES

Having established the grade of the release source it is necessary to determine the release rate from the item and, furthermore, the other necessary factors which may influence the type and extent of the hazardous area, as mentioned in sub Clauses 5.2 (and illustrated in Figs. 5 and 6, Appendix A).

(For consideration of ventilation see Clause 7.)

6.1 General

It is rarely possible by cursory examination of a plant or plant design to decide which parts of the plant can be equated to the three zonal definitions (Zones 0,1 and 2). A more objective approach is therefore necessary and involves the analysis of the basic possibility of an explosive gas atmosphere occurring. Since an explosive gas atmosphere can exist only if a flammable gas, vapor or mist is present with air, it is necessary to decide if any of these flammable materials can exist in the area concerned. Generally speaking such materials (and also flammable liquids and solids which may give rise to them) are contained within process equipment which may or may not provide a totally enclosed containment. To discover the cause of an explosive gas atmosphere existing in an area it is necessary therefore to determine how the items of process equipment containing flammable materials can release them to atmosphere.

Once the likely frequency and duration of release (and hence the grade of source of release), the release rate, concentration, velocity, ventilation and other factors which affect the type of zone and/or extent of the hazardous area have been determined, there is then a firm basis on which to determine the likely presence of an explosive gas atmosphere in the surrounding areas. This approach therefore requires detailed consideration to be given to each item of process equipment which contains a flammable material, and which could therefore be a source of release.

In some cases there may be other considerations (e.g., consequential damage) which may call for a different classification but these considerations are outside the scope of this standard.

It is often convenient to carry out an area classification study in tabular form. An example of such a table is shown in Fig. 2, Appendix A, which should also include details of apparatus group and temperature classification. When the extent of each zone surrounding each source of release has been determined, the composite area classification drawing can be produced. An example of such a drawing is shown in Fig. 3, Appendix A. The preferred way of indicating the zones is shown in Fig. 4, Appendix A.

Note:

Consideration should be given to the possibility that an explosive gas atmosphere may flow into areas in the soil below ground level such as cavities, pits and depressions.

6.2 Open Air Unrestricted Ventilated Situations

6.2.1 A procedure which may be adopted in determining the type and extent of zones around a particular process equipment item is illustrated in Fig. 1, Appendix A.

6.3 Situations Other Than Those in the Open Air

A similar procedure to that described in sub Clause 6.2 may be used for determining the type and extent of zones in other than open air situations. It is not considered practical to include standard figures to cover these situations but it is suggested that for particular situations Fig. 1, Appendix A can be used as a basis provided modifications are introduced to cover special features such as differing degrees of natural or artificial ventilation, and the presence of obstructions. Reference should be made to sub Clause 5.2 and Clause 7.

7. VENTILATION

7.1 General

Gas or vapor released to the atmosphere can be diluted by dispersion or diffusion in the air until its concentration is below the lower explosive limit. Ventilation, that is air movement, will promote dispersion. The degree of ventilation, for example number of air changes per hour, may affect the type and/or extent of zones. The most important factor is that the design of ventilation is related to the source of release in order to achieve optimal ventilation conditions in the hazardous area. In considering the effect of ventilation, the relative density of the gases or vapors is important and should receive special consideration in determining the ventilation arrangements.

The following main types of ventilation are recognized:

a) Natural ventilation.
b) general artificial ventilation.
c) local artificial ventilation.

Note:

It should be noted that the above terms are related to the type and not to the degree of ventilation.

It is also necessary to recognize:

d) no ventilation.

7.2 Natural Ventilation

Examples are:

7.2.1 Open air situations typical of those in the chemical and petroleum industries which comprise open structures, pipe racks, pump bays and the like.

7.2.2 An open building which, having regard to the relative density of the gases and/or vapors involved has opening in the wall and/or roof so dimensioned and located that the ventilation inside the building for the purpose of area classification, can be regarded as equivalent to that in an open air situation.

7.2.3 A building which is not an open building but which has natural ventilation (generally less than that of an open building) provided by permanent openings made for ventilation purposes.

7.3 General Artificial Ventilation

Examples are:

7.3.1 A building which is provided with fans in the walls and/or the roof to improve the general ventilation in the building.

7.3.2 An open air situation provided with suitably located fans to improve the general ventilation of the area.

7.4 Local Artificial Ventilation

Examples are:

7.4.1 An air/vapor extraction system applied to a process machine or vessel which continuously or periodically releases flammable vapor.

7.4.2 A forced or extract ventilation system applied to a small in-adequately ventilated local area where it is expected that an explosive atmosphere may otherwise occur.

7.5 No Ventilation

An example of an area with no ventilation is an enclosure or room having no permanent opening.

Note:

In a large building, the volume of which is large compared with the hazardous area around the source of release, that area need not necessarily be considered to have "no ventilation".

7.6 Relationships Between Grades of Source of Release, Ventilation and Type and Extent of Zone

7.6.1 Natural and general artificial ventilation

A continuous grade source of release may lead to a Zone 0, a primary grade to a Zone 1 and a secondary grade to a Zone 2. In some cases, however, the degree of ventilation may be so good that the extent of the zone may be so small as to be negligible or the zone may have a higher number or in the limit may become non hazardous. On the other hand, the degree of ventilation may be so poor that the zonal classification will have a larger extent and in some cases a lower zone number (see sub Clause 7.6.5). In any case wind direction shall not be overlooked.

Note:

For air situations, the zone number and extent can be determined from Fig. 1: Appendix A.

7.6.2 Local artificial ventilation

Local artificial ventilation will usually be more effective than natural and general artificial ventilation in diluting explosive gas air mixtures. As a consequence, the extent of the zones will be reduced and in some cases will be so small as to be negligible or the zone will have a higher number or may become non hazardous (see sub Clause 7.6.5).

7.6.3 No ventilation

Where a source of release is within an area with no ventilation, a continuous grade will, and a primary grade may, lead to a Zone 0 and a secondary grade to a Zone 1.

Where there are special factors, for example very infrequent release and/or monitoring of the release, higher zone number may apply.

7.6.4 Ventilation restricted by obstacles

Some obstacles which exist in the area may impede the ventilation local to the obstacles and may thus require a larger extent and/or a lesser zone number in the local area. In considering the effect of obstacles, especially in the case of pits and pockets some of which may be inverted, particular attention should be paid to the relative density of the gases and vapors involved (see Item "e" of sub Clause 5.2.2).

7.6.5 Consequences of artificial ventilation failure

The area classification should be established assuming that the ventilation is in operation since this will be the normal condition. The risk of ventilation failure should then be established. If the risk of failure is negligible (e.g., because an automatic independent stand by system is provided) the area classification determined with the ventilation operating will not need modification. However should there be a risk of failure of the ventilation, the likely frequency and duration should be established together with the extent of spread of explosive gas atmosphere in the absence of artificial ventilation. This extent of spread may be greater (see Note) than that of the area classification extent already determined with the ventilation operating. The zone number(s) of the whole area under consideration with ventilation off will depend on the likely frequency and duration of ventilation failure and on the classification determined with the ventilation on.

Where the ventilation is likely to fail infrequently and for short periods, the additional area (see Notes) due to ventilation failure need have a zone number no less than 2.

If provision is made to prevent release of flammable material when the ventilation has failed (e.g., by automatically closing down the process) the classification determined with the ventilation operating need not be modified.

Notes:

1) The electrical installation in the additional area need not be suitable for the zone of this area if provision is made to switch off such electrical installation on ventilation failure.

2) For detailed information about variation in ventilation conditions covering ventilation check for the classification of open sheltered or enclosed areas with released of heavier or lighter than air gases or vapors see chapter 6 of I.P. Model Code of Safe Practice part 15 (1990).

3) While assessing ventilation condition, consideration shall be given to abnormal topographical and or meteorological limitations (example: hollows, major unevenness and sloping ground down where heavier than air gas/vapors or condensated vapor might accumulate).

4) Natural ventilation is characterized by wind speed not less than 0.5 meters/second and frequently over 2 meters/second.

5) Steady state twelve fresh air changes per hour is referred to as adequate ventilation.

8. QUANTIFICATION OF HAZARD DISTANCE

The quantification of hazard distance from source of release has always proven to be one of the most difficult problems to resolve.

Institute of Petroleum has overcome this difficulty by introducing a large number of very useful examples applicable to more common types of facilities such as: drilling, workover and wellhead operation, bulk storage, tankage, road, rail, and marine loading and discharge, container storage and filling and the service stations forecourt. (for more and detailed information see Institute of Petroleum Model Code of Safe Practice Part 15 Area Classification Code for Petroleum Installations 1990).

For less uniform types of plant e.g. processing plant, and crude oil/gas separation an alternative "point source" procedure is recommended which defines petroleum products in four fluid categories. Tables can then be used to asses the radius for different size of equipment source of release. Example of extent of hazard for a few type of point of source release selected from above mentioned Model Code of Safe Practice are shown in Tables 1 to 8 in Appendix B in point source procedure the hazard radius and fluid categorization are obtained as follows:

8.1 Hazard Radius

The hazard radius of a source of release is the longest horizontal extent of the hazardous extent of the hazardous area that is generated by the source when situated in an open area under unrestricted natural ventilation.

From a knowledge of hazardous radius and information given in above mentioned tables, the three dimensional form and extent of the hazard zone envelope will be obtained.

It should be noted that the extent and dimensions of the hazardous zone generated from the release are unaffected by the grade of release. The sizing of the hazard zone will be the same irrespective of its zone number.

8.2 Petroleum Fluid Categorization

Where the petroleum fluid is a liquid its volatility in relation to the conditions of temperature and pressure at which a potential release might take place is an essential factor, since this will determine the extent of rapid vapor formation from that release. Thus for carrying out area classification of a facility a knowledge of the vaporization potential of the petroleum materials to be handled is required.

For the purpose of the area classification of flammable petroleum fluids by the point source procedure they are categorized to Groups A, B, C and G according to their potential for rapid production of flammable vapor release to the environment.

They are defined as follows:

Fluid Category "A"

A flammable liquid that on release would vaporize rapidly and substantially. This category includes:

I) Any liquefied petroleum gases or lighter flammable liquids whether under pressure or refrigerated.
II) Any flammable liquid at a temperature sufficient to produce on release more than about 40% vaporization with no heat input other than surrounding.

Fluid Category "B"

A flammable liquid not in Category "A" but at a temperature sufficient for boiling to occur on release .

Crude oil flashing and crude oil distillation (low pressure processing) is typical example for Category "B".

Fluid Category "C"

A flammable liquid not in Categories "A" or "B" but which can on release be at a temperature above its flash point or form a flammable mist.

Typical examples are crude oil (at ambient temperature) and hot kerosene.

Fluid Category "G"

Any flammable gas or vapor comes under this Category.

Note:

Non hazardous (N.H.) fluids.

These fluids must be below their flash point. It should be established that this is also true upon release under abnormal conditions.

Typically these fluids include kerosene and heavier products, provided they are not heated or can not be heated to their flash point.

Caution: Although non hazardous fluids seems without danger; when spreadout as a thin film under ground spill condition or spilled onto clothing, they can be ignited even at temperatures below their flash point.

8.3 Classification of Petroleum

Since the classification of petroleum material made by the Institute of Petroleum is a very useful source of information for flash point and boiling point of commonly encountered petroleum materials it has been included in Appendix "C" of this part.

The information is normally used with fluid category in assessing the hazard radius in area classification.

9. DATA FOR FLAMMABLE MATERIALS FOR USE WITH ELECTRICAL EQUIPMENT

9.1 Available data, such as names of flammable material including their individual formula, melting point, boiling point relative vapor density, flash point flammable limits LFL and UFL expressed as percentage of the material mixed with air by volume (also as milligrams of material per liter of air), ignition temperature, minimum ignition current, "T" class of suitable apparatus and apparatus grouping where appropriate are shown in tables of Appendix "D".

9.2 Apparatus group shown in above mentioned tables may be applicable to type of protection 'i', 'd', 's' and 'p' some are determined by Minimum Ignition Current (MIC) and/or Maximum Experimental Safe Gap (MESG) determinations and others by chemical similarity.

Notes:

1) For flameproof enclosures, gases and vapors are classified according to the group or sub-group of apparatus required for use in the particular gas or vapor atmosphere.

The general principle used to establish the lists of gases and vapor are given below:

a) Classification according to the Maximum Experimental Safe Gap (MESG). MESG determination is described in IEC publication 79.1A.

b) Classification according to the Minimum Ignition Current (MIC).

For intrinsic safety, gases and vapors are classified according to the ratio of their Minimum Ignition Current (MIC) with that of a laboratory methane. The standard method of determining "MIC" ratio is described in IEC 79-3.

10. TASK FORCE FOR AREA CLASSIFICATION

Which disciplines should be represented in an area classification task force depends on structure of organization and the circumstances of location to be classified, however a task force may consist of authorized persons from following functions, where concerned:

I) Process
II) Electrical
III) Instrumentation
IV) Safety and Fire
V) Plant Operation
VI) Plant Maintenance
VII) Heating Ventilation and Air Conditioning (HVAC)
VIII) Project Management

APPENDICES

APPENDIX A
EXAMPLES OF SOURCE OF RELEASE
AND
APPROACH TO THE DETERMINATION OF TYPE
AND
EXTENT OF ZONES IN OPEN AIR

LIST OF FIGURES IN APPENDIX A

The following are examples of the grading of some sources of release. The examples are not intended to be rigidly applied and may need to be varied to suit particular equipment, situations and practices:

A.1 Continuous Grades of Release (see Sub-Clause 3.6.1 for definition).

a) The surface of a flammable liquid in a non-inerted fixed-roof tank.
b) The surface of a flammable liquid which is open to the atmosphere. (May apply to oil-water separators.)
c) Free vents and other openings which release flammable gas or vapor to atmosphere frequently or for long periods.

A.2 Primary Grades of Release (see Sub-Clause 3.6.2 for definition).

a) Seals of pumps, compressors and valves if release during normal operation of the equipment is expected.

b) Process equipment water drains located on tanks containing flammable liquids which may release flammable material to atmosphere when draining off water during normal operation.

c) Sample points which are expected to release flammable material to atmosphere during normal operation.

A.3 Secondary Grades of Release (see Sub-Clause 3.6.3 for definition).

a) Seals of pumps, compressors and valves where release during normal operation of the equipment is not expected to occur.

b) Flanges, connections and pipe fittings.

(to be continued)

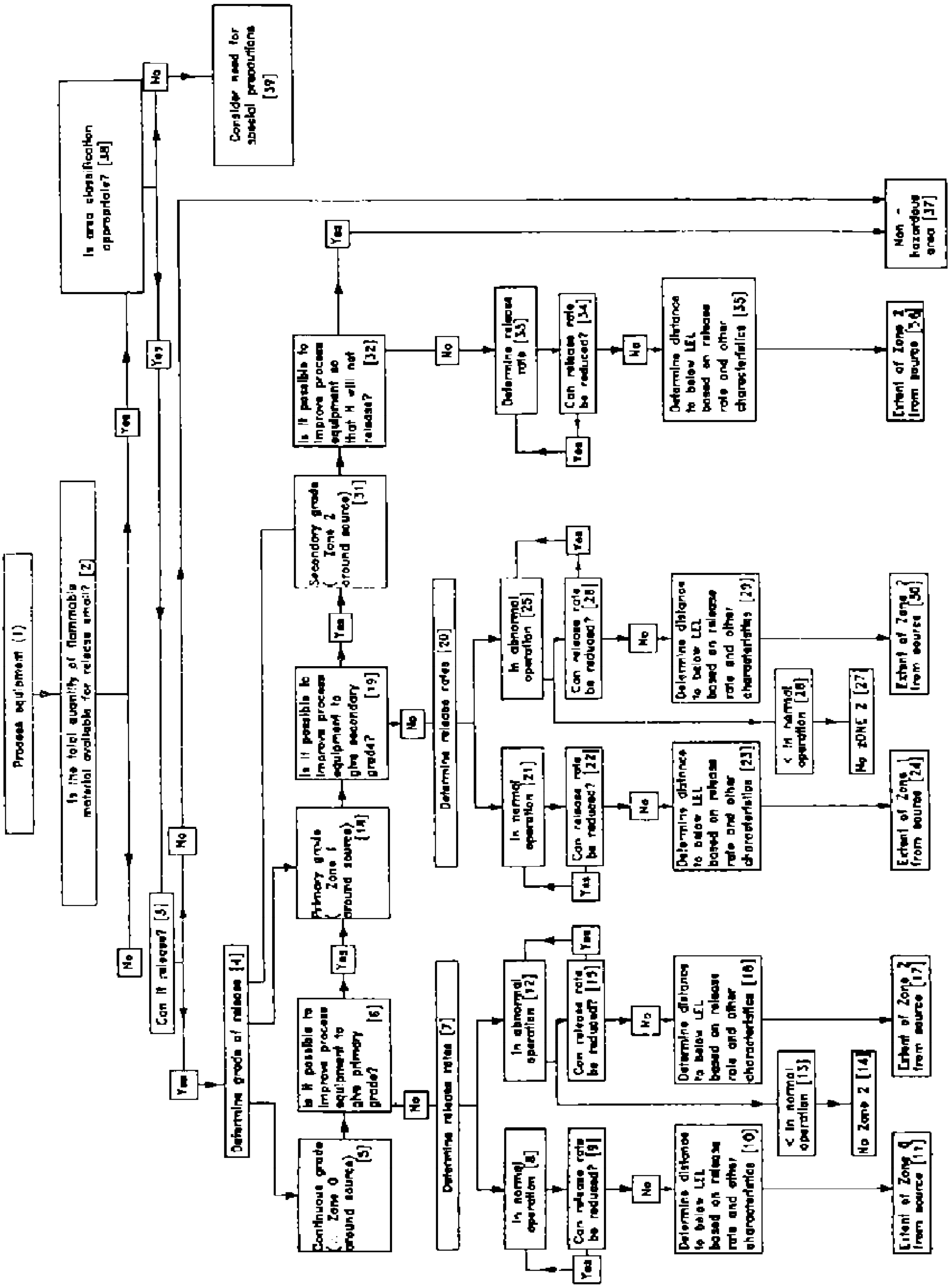
APPENDIX A (continued)

c) Relief valves, vents and other openings which are not expected to release flammable gas or vapor to atmosphere during normal operation.

d) Sample points which are not expected to release flammable material to atmosphere during normal operation.

(to be continued)

APPENDIX A (continued)



DETERMINATION OF TYPE AND EXTENT OF ZONE
Fig. 1

(to be continued)

APPENDIX A (continued)

Process equipment item			Flammable material	Process temperature and pressure	Description of flammable material containment	Ventilation	Source of release		Horizontal distance from source to *			Code reference	Remarks
No.	Description	Item					Description	Grade	Boundary of Zone 0	Boundary of Zone 1	Boundary of Zone 2		
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14
C 57	Hydrogen vessel	Area 2 in open air	Hydrogen	30 C 2300 kPa	Closed system with valves: relief valve to flare	Natural (open air)	Flanges and valve seals (see col. 14)	Secondary	—	—	— m	XYZ National Code, page XY	Release due to flange gasket or valve seal failures (abnormal)
J 29	Xylene pump	Area 5 in open air	Xylene	80 C 300 kPa	Closed system with valves and drains Mechanical seals and throttle bush	Natural (open air)	Flanges and valve seals (see col. 14)	Secondary	—	—	— m	XYZ National Code, page XX	Release due to flange gasket or valve seal failures (abnormal)
							Mechanical seal (see col. 14)	Primary/ secondary (multigrade)	—	— m	— m	XYZ National Code, page YX	Small release in normal operation, Larger release on seals failure (abnormal)
J 84	Ethylene compressor (reciprocating)	Area 4 in open building	Ethylene	70 C 2000 kPa	Closed system with glands, vents and cooler drain points	Natural (equivalent to open air)	Flanges glands and valve seals (see col. 14)	Secondary	—	—	— m	XYZ National Code, page XZ	Release due to flange gasket, gland or valve seal failures (abnormal)
							Vents and drain points (see col. 14)	Primary/ secondary (multigrade)	—	— m	— m	XYZ National Code, page ZX	Small release in normal operation, Larger release may occurs due to incorrect operation (abnormal)
J 32	Fixed roof tank	Area 3 in open air	Gasoline	Ambient	Closed system except for pressure/vacuum valve	Natural (open air)	Tank vent (see col. 14)	Continuous/ primary/ secondary (multigrade)	Zone 0 in vapour space	— m	— m	XYZ National Code, page XZ	Vapour vented during normal filling. Possibility of overfilling (abnormal)

* Vertical distances may also be recorded.

Note: Other information such as temperature class and apparatus group may need to be included.

* Vertical distances may also be recorded.

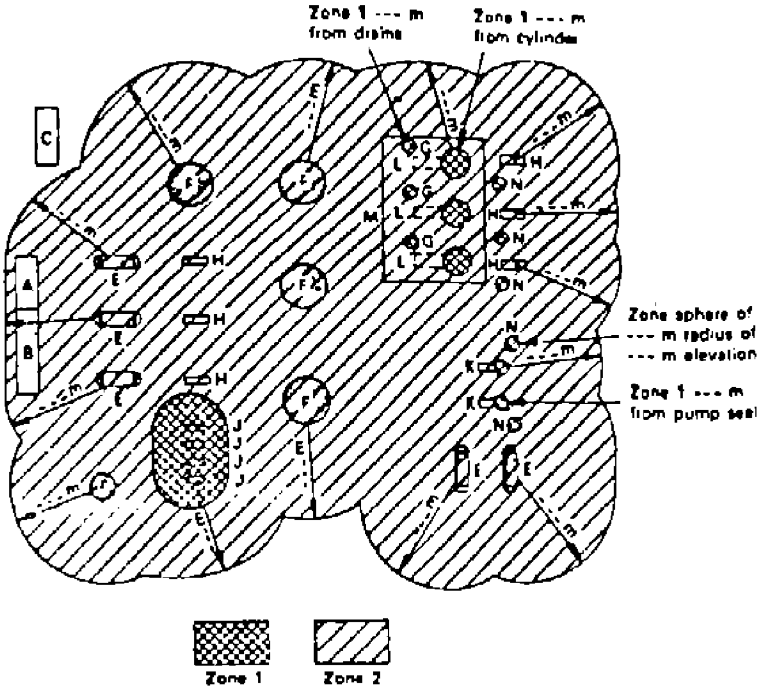
Note:

Other information such as temperature class and apparatus group may need to be included.

EXAMPLE OF TABLE FOR USE DURING AREA CLASSIFICATION STUDY
Fig. 2

(to be continued)

APPENDIX A (continued)



Notes 1 - All dimensions are measured from sources of release. (See examples in Appendix B)

2 - In some cases it may be more practical to establish the actual boundary of a classified area at more convenient geographical limits

Details to be added where necessary regarding

a) Localized Zones 0 or 1.

b) Vertical distances to draw sections to clarify vertical distances.

c) The title of the code which has been used as a basis for extent of areas.

d) Apparatus group and temperature class for selection of electrical apparatus.

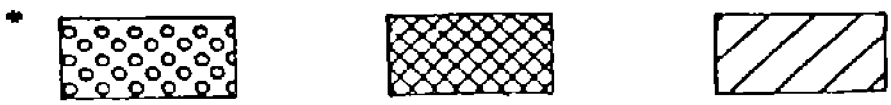
Symbol	Description
A	Control room, pressurized
B	Switch house, pressurized
C	workshop
E	Vessel
F	Distillation column
G	Drain
H	Pump (seals unlikely to release in normal operation)
J	Pump (seals likely to release in normal operation)
K	Pump (seals likely to release in normal operation)
L	Reciprocating compressor
M	Compressor house (open building)
N	Vents (high or low level)

Note. - The above table is given for explanation of this drawing only. It will not appear on the completed area classification drawing.

EXAMPLE OF AN AREA CLASSIFICATION DRAWING
Fig. 3

(to be continued)

APPENDIX A (continued)

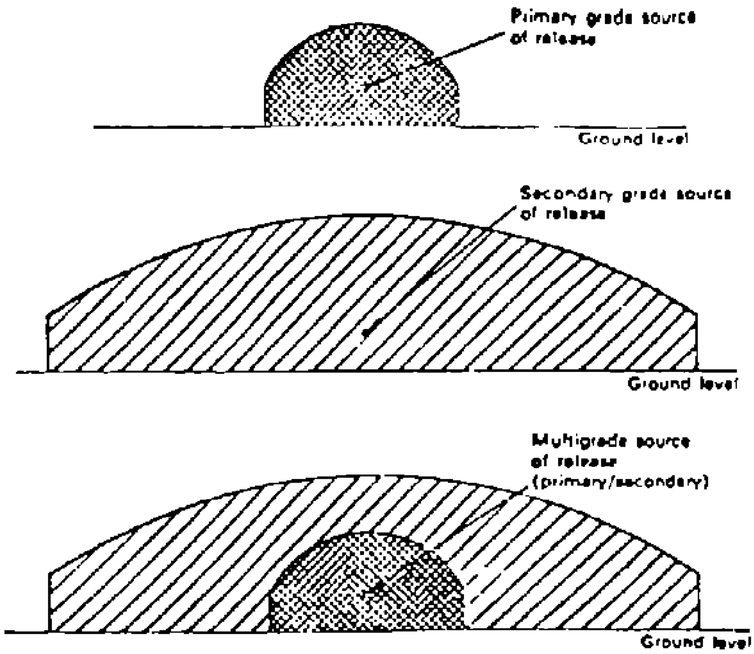


PREFERRED SYMBOLS FOR THE ZONES OF A HAZARDOUS AREA
Fig. 4

Note:

According to IEC standard 79.10

* IP use symbol for Zone '0'



Notes:

1. The diagrams relate to:

a)open air situations,

b)sources of release near to ground level.

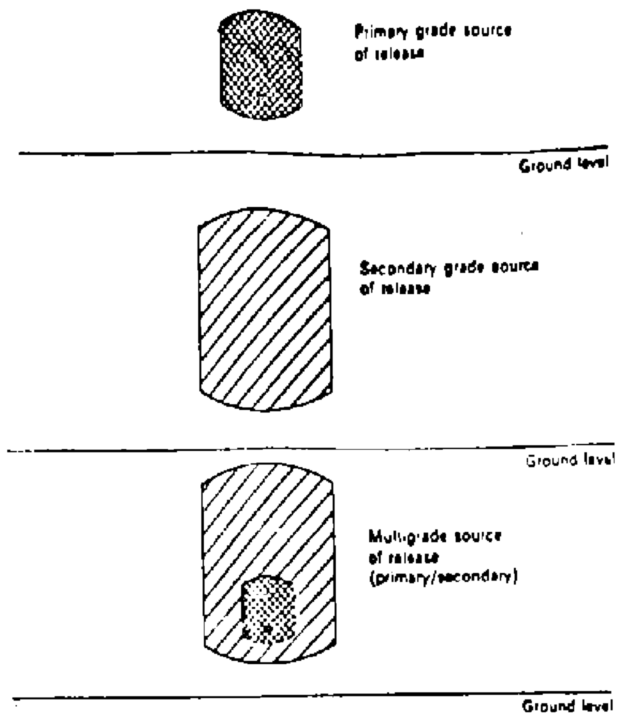
2. The shapes and sizes of the zones will depend on many factors (See sub-clause 5.2)

3. Zone 1 Zone 2

EXAMPLE ILLUSTRATING AREA CLASSIFICATION AROUND VARIOUS SOURCES OF RELEASE FOR HEAVIER-THAN-AIR GASES OR VAPORS
Fig. 5

(to be continued)

APPENDIX A (continued)



Notes:

1. The diagrams relate to:

a)open air situations,
b)sources of release above ground level,
c)gases which are significantly lighter than air.

2. The shapes and sizes of the zones will depend on many factors (see Sub-clause 5.2).

3. Zone 1 Zone 2

EXAMPLE ILLUSTRATING AREA CLASSIFICATION AROUND VARIOUS SOURCES OF RELEASE FOR LIGHTER-THAN-AIR GASES
Fig. 6

APPENDIX B
EXAMPLES OF EXTENT OF HAZARD
GENERAL NOTES FOR SECTIONS 1 AND 2
SECTION 1: EXAMPLES FROM IP
SECTION 2: EXAMPLES FROM API & NFC

General Notes for Sections 1 and 2

The following points to be considered in applying the examples:

1) Since the values indicated herein as criteria for determining the extent of hazardous areas are all minimum, it is desirable that they be modified to safe side values when planning and determinating the extent of hazardous areas.

2) The examples given in the figures should be understood to be merely examples. For instance, in a case where two sources of hazard exist adjacent to each other, there may be only a very small non hazardous area between them. In such a case, the non hazardous area should be included in the hazardous area.

3) In the figures, all sources of release are shown as ⊕ where applicable, but it is desirable that the outside surface of the sources of release be taken up as a basis for determining the extent of the hazardous areas, depending on the nature and the shape of the sources of hazard.

4) All dimensions are in meter and/or decimal fraction of meter.

5) This Appendix is divided into two sections:

Section 1: Are examples from Institute of Petroleum (IP) Model Code of safe practice (part 15).

Section 2: Are examples from American Petroleum Institute Recommended Practice (API-RP) and the National Fire Code (NFC).

6) For more details about each example reference shall be made to following sources as applicable:

a) IP Model Code of Safe Practice (part 15).
b) API-RP 500 (A,B,C).
c) NFC 30.

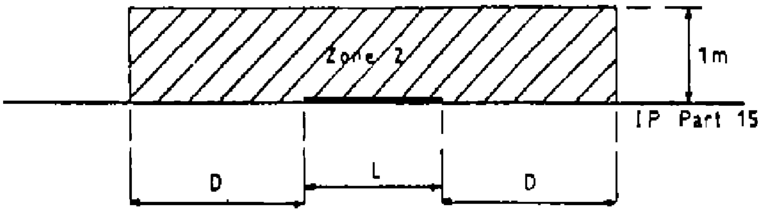
(to be continued)

APPENDIX B (continued)
SECTION 1
EXAMPLES OF EXTENT OF HAZARD
EXTRACT FROM IP

LIST OF TABLES AND FIGURES

(to be continued)

APPENDIX B (continued)
EXAMPLES OF EXTENT OF HAZARD
LIQUID SPILLS



HEIGHT OF ZONE 1 (METER)
ELEVATION
Fig. 7

TABLE 1

L (METERS)	D (METERS)
LESS THAN 5	3
5 TO LESS THAN 10	7.5
10 OR GREATER	15

Notes:

1) In an open area the resulting hazardous area due to spills should be classified as zone 2, because plant design should not allow spillage to occur in normal operation.

2) The size of hazard shall be determined from Fig. 7 and Table 1 shown above and applicable to category C liquids.

3) D1 is the extent of the hazardous area from the edge of the pool.

4) For gases or category A and B liquids the size of hazardous area will often be determined by that of the initiating release rather than on ground accumulation.

TABLE 2 - INSTRUMENT VENTS

FLUID CATEGORY	HAZARD RADIUS (METERS)		
	DIAMETER* 6 mm	DIAMETER* 12 mm	DIAMETER* 25 mm
A	7.5	15	30
B	3	7.5	15
C	0.3	1.5	3
G	3	7.5	15

IP part 15

Note:

*** This is the diameter of the smallest item on the vent line i.e. line, valve level glasses on vessels and restriction orifices.**

(to be continued)

APPENDIX B (continued)

TABLE 3 - PROCESS VENTS

VENT RATE AT AMBIENT CONDITION (m^3/HOUR)	HAZARDOUS RADIUS (METERS)
LESS THAN 10	3
10-100	7.5
100-200	15

IP part 15

Notes:

1) This Table applies only to velocities upto 150 meters/second. It applies to heavier than air gases and vapors with unrestricted upward discharge and dispersion of vapors without condensation.

2) Direct venting to atmosphere of material which could condense should be particularly avoided.

3) For lighter than air gases discharged upward a 5 meters hazard radius may be used or alternatively the radius may be obtained by calculation.

TABLE 4 - DRAINS AND LIQUID SAMPLE POINTS

FLUID CATEGORY	HAZARD RADIUS (METERS)			
	DIAMETER* 3 mm	DIAMETER* 6 mm	DIAMETER* 12 mm	DIAMETER* 25 mm
A	7.5	15	30	+
B	3	7.5	15	30
C	0.3	1.5	1.5	3

IP part 15

Notes:

*** This is the diameter of the smallest item on drain or sample line i.e. line, valve, or restriction orifice.**

+ For this diameter the hazardous radius exceed 30 meters, the size of potential release is greater than that normally considered for area classification, and should be avoided. For the case of release as tabulated which would results in hazard radii of 30 or 15 meters it may be chosen to use a limiter or restriction orifice to reduce these figure if a closed system is not to be provided.

TABLE 5 - FLANGES AND VALVES

FLUID CATEGORY	HAZARD RADIUS (METERS)
A	3
B	3
C	1.5
G	3

IP part 15

Note:

This Table assumes pipework construction to recognized codes and standards. For this reason the possibility of the blowout of part of a gasket has not been considered.

(to be continued)

APPENDIX B (continued)

TABLE 6 - COMPRESSORS +

GAS BUOYANCY	HAZARD RADIUS (METERS)
HEAVIER THAN AIR	15*
LIGHTER THAN AIR	5

IP part 15

Notes:

*** The radius may be reduced to 7.5 meters for pressures below 20 bar (absolute) and shaft diameters of 50 mm or less.**

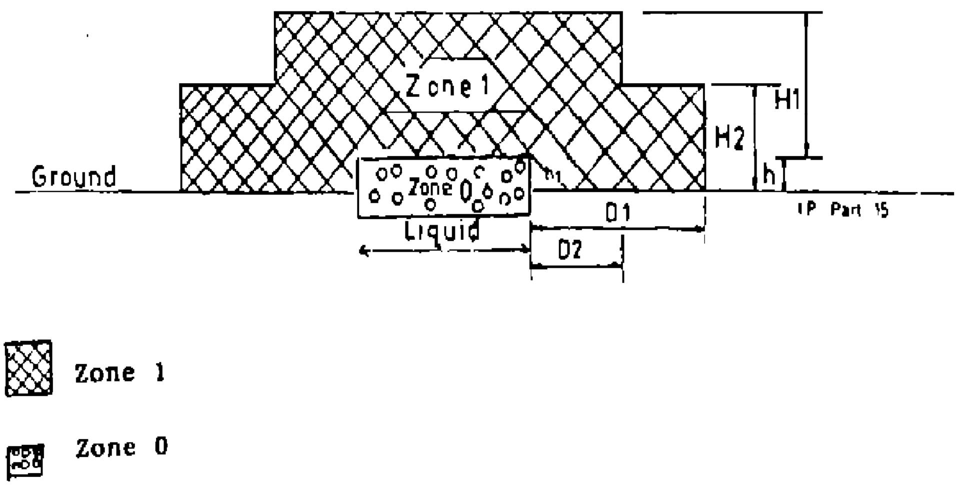
+ For diaphragm compressors the hazard radius may be reduced to 3 meters provided there are no vents or drains to atmosphere at the compressor (if any application).W

TABLE 7 - PUMPS

FLUID CATEGORY	HAZARD RADIUS (METERS)	
	STANDARD PUMP	HIGH INTEGRITY PUMP
A	30	7.5
B	15	3
C	7.5*	3

Note:

*** For clean liquids e.g. finished products which are pumped from atmospheric storage at rates not exceeding 100 m^3/hour the hazard radius may be reduced to 3 meters.**



OPEN SUMP ZONING SHOWN FOR PRIMARY GRADE
Fig. 8

(to be continued)

APPENDIX B (continued)

TABLE 8 - OPEN SUMPS INTERCEPTORS AND SEPARATORS (ALL DISTANCES IN METERS)

*L	D1	D2	H1	H2
LESS THAN 5	3	3	3	3 + h
5 TO LESS THAN 10	7.5	7.5	3	3 + h
10 OR GREATER	15	7.5	7.5	7.5

IP Part 15

Note:

This Table should be used only for Category "C" liquids.

***L: Is the width of the Sump.**

The hazardous area should extend from the edge of the pool in the same direction.

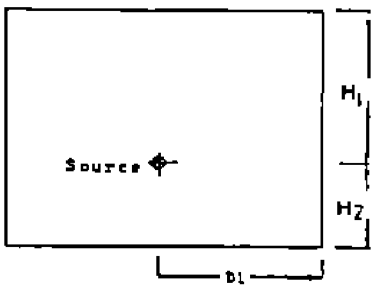


Fig. 9

All dimensions are in meter.

TABLE 9

HAZARD RADIUS	H1	D1	H2
5	7.5	5	3
3	5	3	3
1.5	1.5	1.5	1.5

Hazardous Area from Point Source
Open Area
Release lighter than air

Area should be classified as zone 1 or 2 depending on the grade of release.

(to be continued)

APPENDIX B (continued)

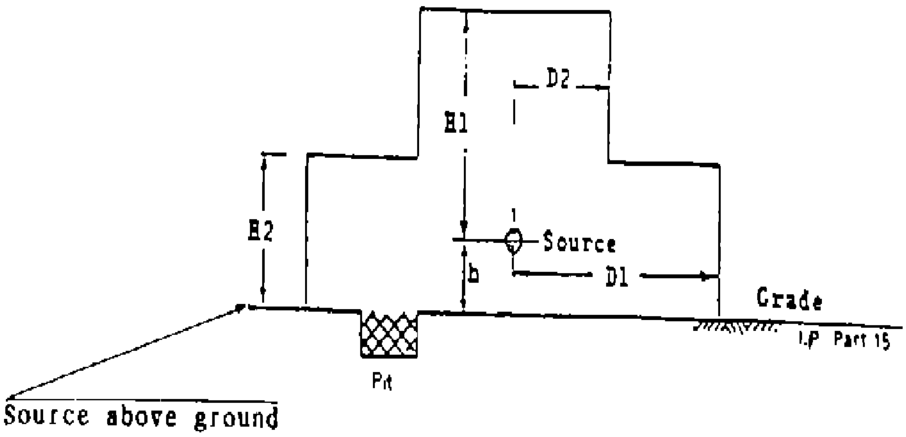
Notes:

1) Hazard radius is determined from Tables 2, 3, 4, 5, 6 and 7 as applicable.

2) Hazard radius in zone 1 or 2 depending on grade of release.

3) For lighter than air release, height of source above ground is not relevant (unless <H2).

4) For mixed and heavier releases as in hydroprocessing plant buoyancy of the mixture shall be determined i.e. either the density of release to atmosphere would be less than 0.75 relative to the ambient air (buoyant) or not.



Source above ground

Fig. 10

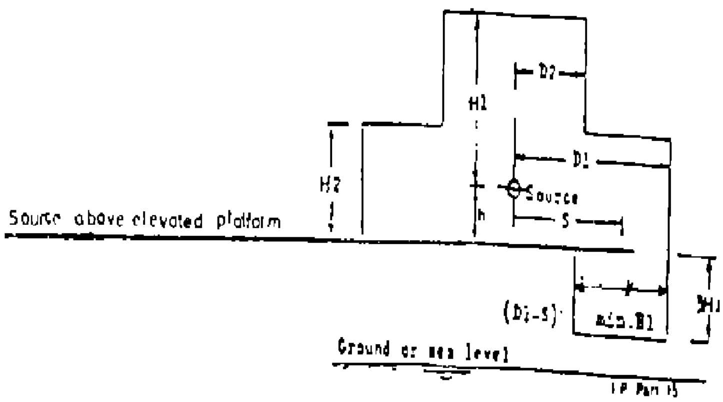


Fig. 11

All dimensions are in meter.

(to be continued)

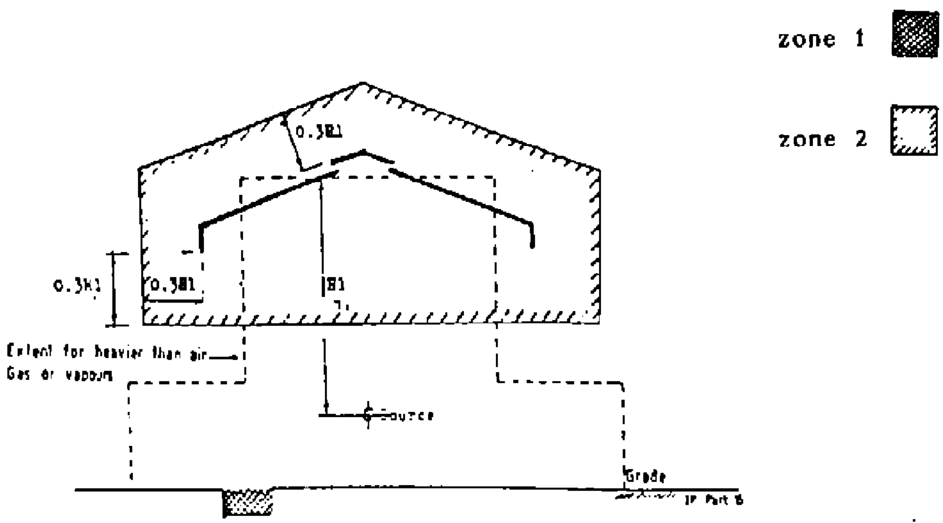
APPENDIX B (continued)

TABLE 10

HAZARD RADIUS	D1	D2	H1	H2
30	30	15	7.5	3
15	15	7.5	7.5	7.5
7.5	7.5	7.5	3	H1+h
3	3	3	3	H1+h
1.5	1.5	1.5	1.5	H1+h
0.3	0.3	0.3	0.3	H1+h

Notes:

1) All pits and depressions in hazardous areas need special consideration. Often they are classified zone 1.
2) Area above ground should be classified as zone 1 or 2 depending on the grade of release.
3) h is height of source above ground level on solid platform floor.
4) D1 for open area by definition is equal to the hazardous radious.
5) Hazardous radious is determined from preceding tables in Appendix B Section 1 (Table 1 to Table 7).
6) Hazardous areas shown should be classified as Zone 1 or 2 depending on grade of release (see Clause 3.6).
7) All pits and depressions in hazardous areas without artifitial ventilation should be regarded as inadequately ventilated rather than a sheltered area, and should be given a more severe zone number than the surrounding area.
8) S is distance from source to edge of solid platform.



SHELTERED AREAS
Fig. 12

Extent of hazardous area around roof producing sheltered area (applicable to lighter and heavier than air gas or vapor)

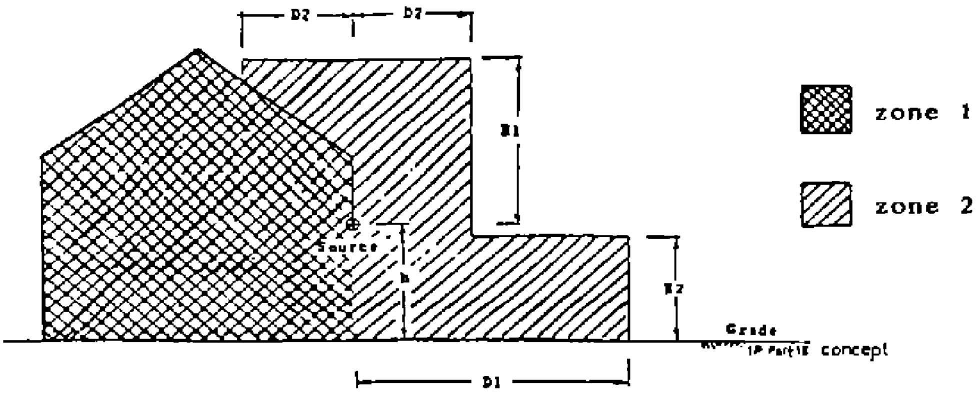
(to be continued)

APPENDIX B (continued)

Notes:

1) The area shown around the roof should be classified as hazardous and take the same zone classification when the hazardous area from a source outside or below the area impinges upon it.
2) When the two areas do not directly impinge, it is prudent to infill the intermediate space. Where the underlying hazard zone is zone 1 then the intermediate space, upto and including the roof area may be classified zone 2 for heavier than air gases or vapors.
3) H1 is obtained from figure "10" for heavier than air gases or vapors and from figure "9" for lighter than air gases.
4) The area below roof is regarded as a sheltered area provided the ventilation is such that any flammable vapor is quickly dispersed by natural ventilation with no stagnant area, that is natural adequate ventilation.

SECTION 1
* EXAMPLE OF EXTENT OF HAZARD



Release heavier than air

Fig. 13

Notes:

1) The external area is classified as if the largest source in the enclosed area were situated at the top of the aperture.
2) Zone 1 classification exists whenever source of release is under abnormal or normal operating conditions.
All dimensions are in meters.
*** See Fig. 10 and Table 10 of this section.**

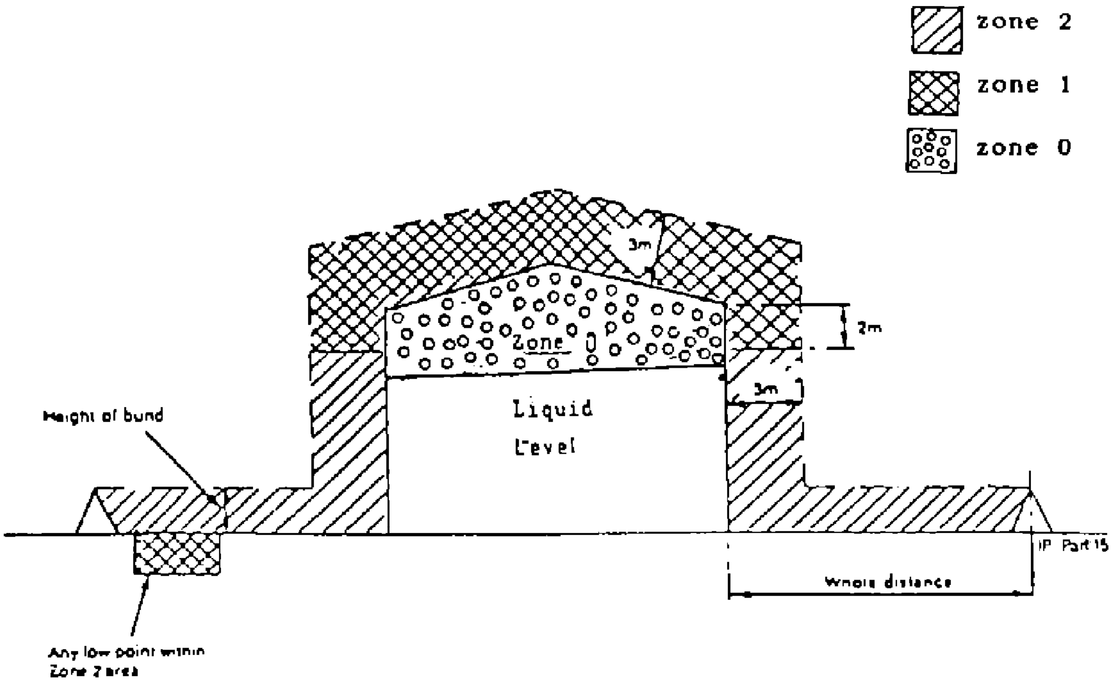
TABLE 11

HAZARD RADIUS	D1	D2	H1	H2
30	30	15	7.5	3
15	15	7.5	7.5	7.5
7.5	7.5	7.5	3	H1+h
3	3	3	3	H1+h
1.5	1.5	1.5	1.5	H1+h
0.3	0.3	0.3	0.3	H1+h

Enclosed Buildings
(containing source of vapor release such as pumps, filling points, storage of full containers, LPG cylinders etc.)

(to be continued)

APPENDIX B (continued)



CONE ROOF TANK CLASSES I, II (2) AND III (2)
Fig. 14

Notes:

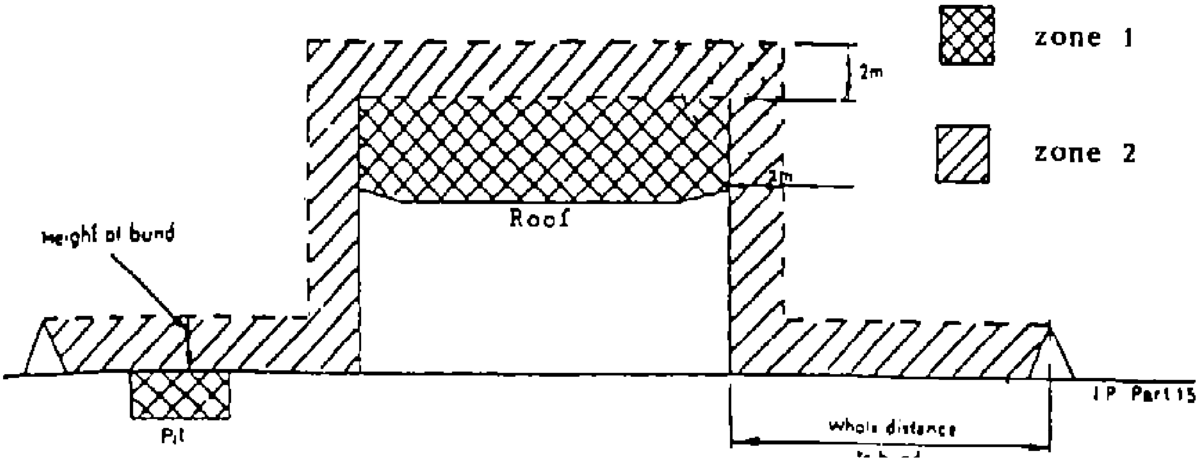
1) Because of the possibility of mist, spray foam formation, the ullage space of Class II(1) and III(1) tanks should be regarded as Zone"0". (See Appendix C)

It is recommended that the area surrounding any vents or opening, on the roof of such tank to be regarded as Zone "1" to a diameter of 1 meter.

2) When unclassified products such as bitumens and heavy residual are stored under confined heated conditions in fixed roof tank, flash points as sampled is not a sufficient and reliable guide to the presence or absence of a flammable atmosphere that may have built up in the tank vapor space, therefore it is prudent to classify the ullage space of all such tanks as zone 0 with small Zone 1 around roof vents and opening.

(to be continued)

APPENDIX B (continued)



FLOATING ROOF TANK WITH PROTECTION BUND
CLASSES I, II (2) AND III (2)

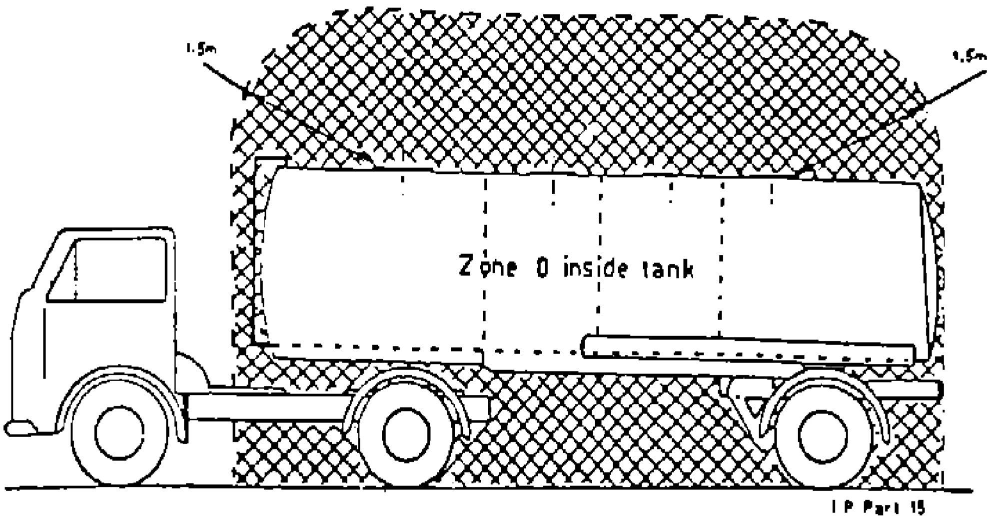
Fig. 15

Note:

This classification is based on the practice that the roof will not be grounded on its leg during the operational cycle since the space so created below the roof would draw in air and creat the possibility of ignition caused by friction.

Roofs should only be landed for inspection cleaning and maintenance under carefully supervised work permit control.

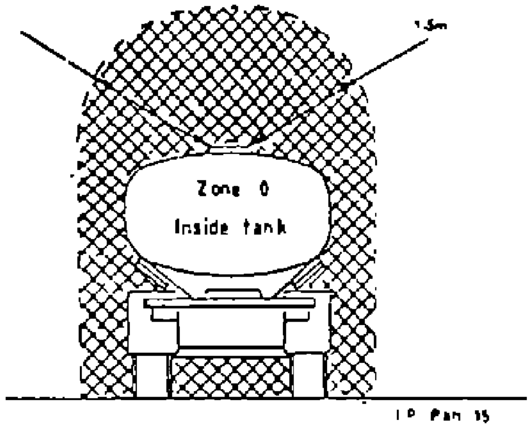
Any vapor space below the roof or between the primary and secondary seals should be treated as Zone 0.

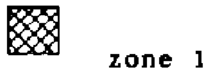


SIDE ELEVATION
Fig. 16a

(to be continued)

APPENDIX B (continued)





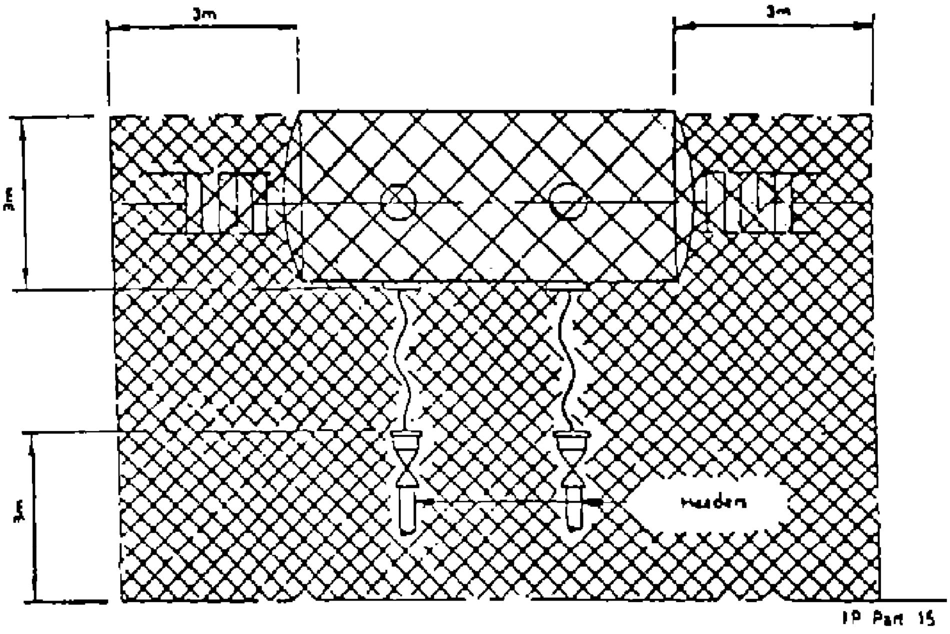
END ELEVATION
Fig. 16b

Filling of Road Tankers Top Loading through Open or Vent Manlids.
Classes I, II (2), III (2)

Notes:

1) This classification applies also for bottom loading with open venting.

2) Internal Zone "0" for compartment applies for all classes of petroleum.



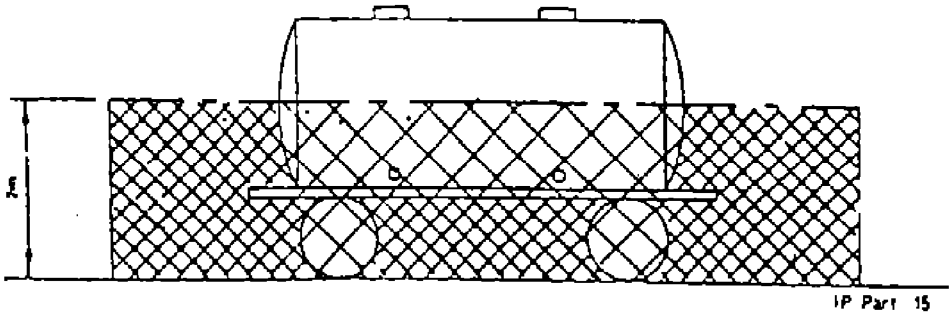
PLAN

Fig. 17a

zone 1

(to be continued)

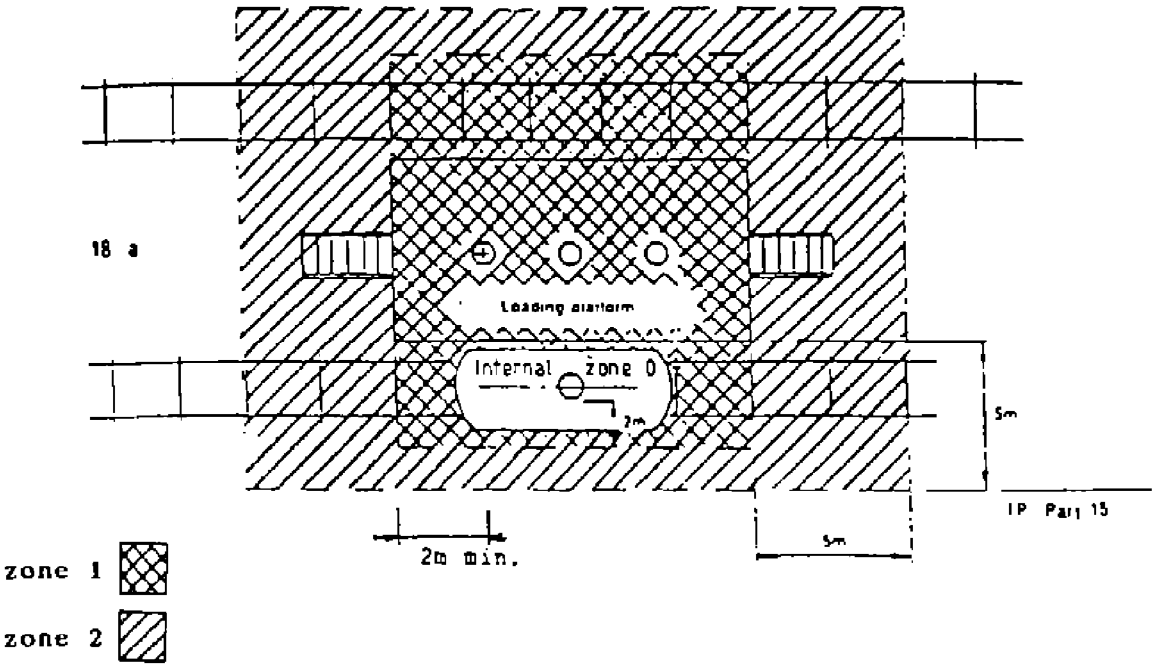
APPENDIX B (continued)



ELEVATION

Fig. 17b

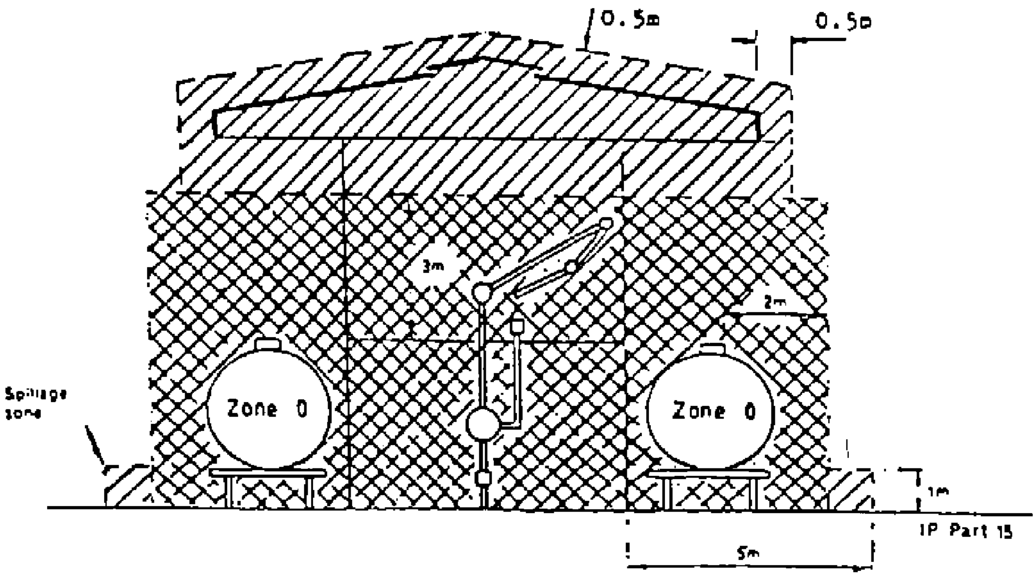
Railcar discharge via hose connection
Classes I, II (2) and III (2)



PLAN-BELOW ROOF SINGLE POINT LOADING
Fig. 18a

(to be continued)

APPENDIX B (continued)

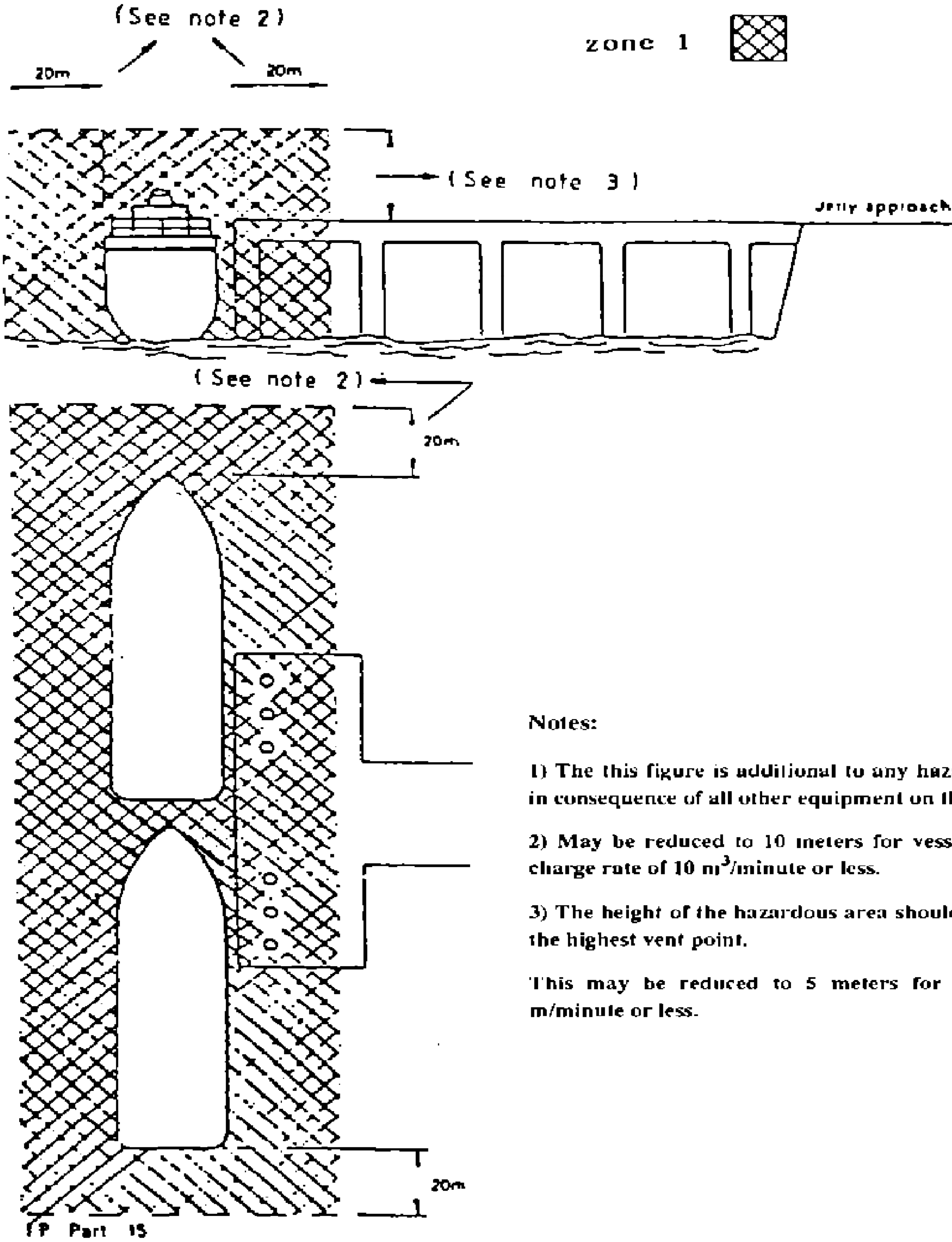


END ELEVATION SINGLE OR MULTI POINT LOADING
Fig. 18b

Rail Tank Wagons Top Loading (loading rate above 2.5 m^3 per minute). Classes I, II (2) and III (2)

(to be continued)

APPENDIX B (continued)



Notes:

1) The this figure is additional to any hazai in consequence of all other equipment on the

2) May be reduced to 10 meters for vessel charge rate of 10 m^3/minute or less.

3) The height of the hazardous area should the highest vent point.

This may be reduced to 5 meters for l m/minute or less.

Fig. 19

Jetties Loading or Combined Loading and Discharge Facilities.
Classes I, II (2) and III (2)

(to be continued)

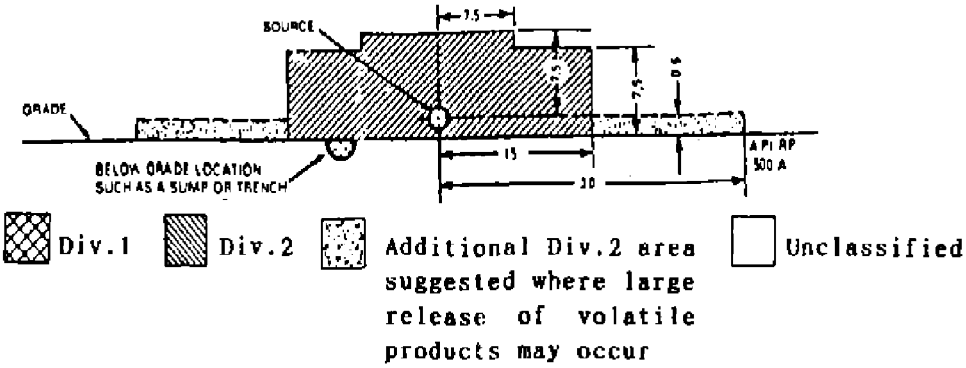
APPENDIX B (continued)

SECTION 2

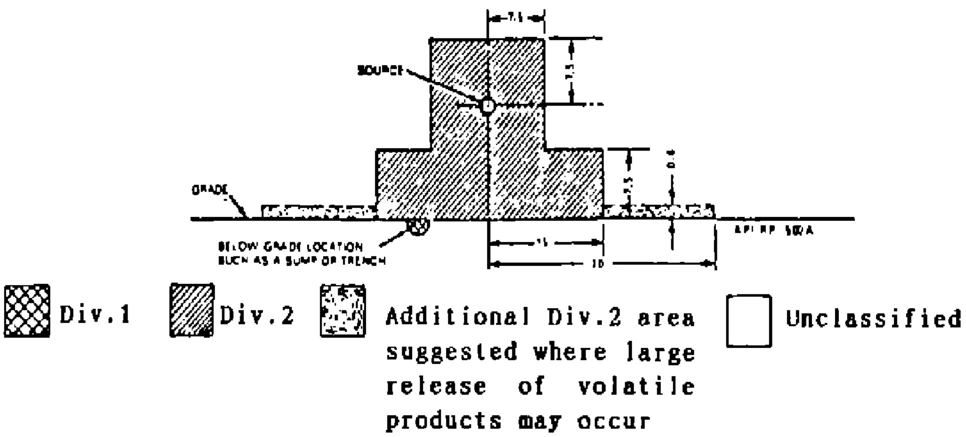
LIST OF FIGURES
EXAMPLES OF EXTENT OF HAZARAD (EXTRACTED FROM API AND NFC)

(to be continued)

APPENDIX B (continued)
SECTION 2
EXAMPLES OF EXTENT OF HAZARD



ADEQUATELY VENTILATED PROCESS AREA WITH HEAVIER THAN AIR GAS SOURCE LOCATED NEAR GRADE
Fig. 20



ADEQUATELY VENTILATED PROCESS AREA WITH HEAVIER THAN AIR GAS SOURCE LOCATED ABOVE GRADE
Fig. 21

Note:

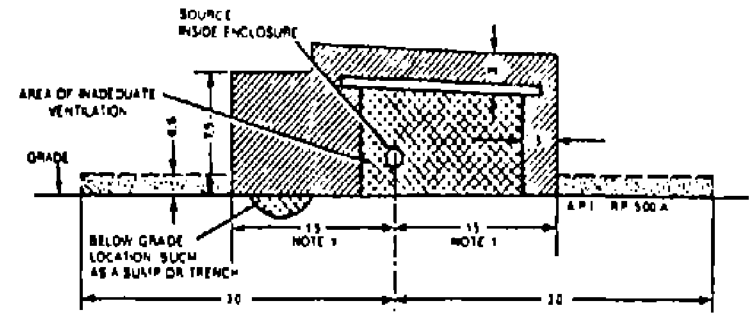
Distances given are for typical refinery installations, they must be used with judgment with consideration given to all factors discussed in the text. In some instances, greater or lesser distances may be justified.

General Note:

In setting limits, it is generally assumed that the flammable gases are heavier than air. Classification on this basis is normally conservative for lighter than air gases such as hydrogen.
However some modification of the limits may be necessary to accommodate certain situations involving lighter than air gases. For classification purposes the term lighter than air should be restricted to those gases having less than 75% of density of air at standard conditions. Gases of greater density should be treated as heavier than air.

(to be continued)

APPENDIX B (continued)



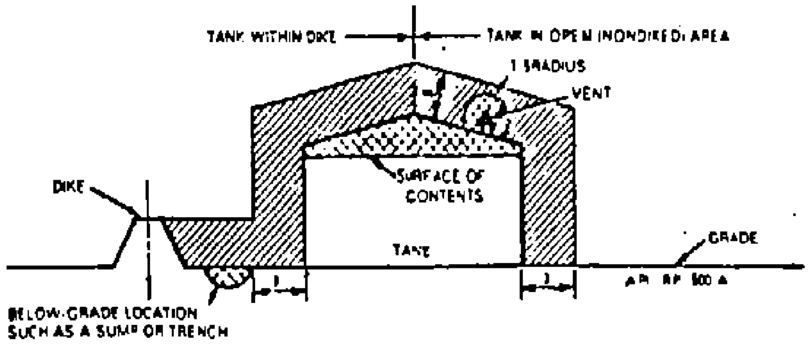
Div.1 Div.2 Additional Div.2 area suggested where large release of volatile products may occur Unclassified

INADEQUATELY VENTILATED PROCESS AREA WITH HEAVIER THAN AIR GAS SOURCE
Fig. 22

Notes:

1) Apply horizontal distances of 15 m from the source of vapor or 3.0 m beyond the perimeter of the building whichever is greater, except that beyond unpierced vaportight walls the area is safe.

2) Distances given are for typical refinery installations, they must be used with judgment, with consideration given to all factors discussed in the text.



Div.1 Div.2 Unclassified

REFINERY TANK WITH HEAVIER THAN AIR GAS SOURCE
Fig. 23

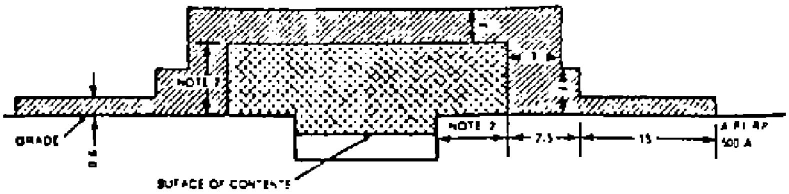
Notes:

1) For floating roof tanks the area above the tank roof and within the shell is classified Div. 1.

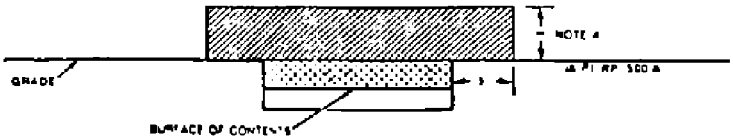
2) Distances given are for typical refinery installations, they must be used with judgment, with consideration given to all factors discussed in the text.

(to be continued)

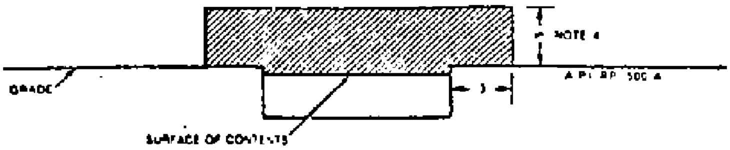
APPENDIX B (continued)



UNIT SEPARATORS, PRESEPARATORS AND SEPARATORS (Note 3)
Fig. 24a



DISSOLVED AIR FLOATION (DAF) UNITS (Note 3)
Fig. 24b



BIOLOGICAL OXIDATION (BIOX) UNITS
Fig. 24c

Div.1   Div.2   Unclassified

Notes:

1) The extent of the classified areas shown shall be modified as required by the proximity of other potential sources of release or of nearby obstructions, such as dikes or hills, that would impede dispersal of vapors. Distances given are for typical refinery installations, they must be used with judgment, with consideration given to all factors discussed in the text.

2) For unit separators and preseparators: 7.5 m, for separators: 3.0m.

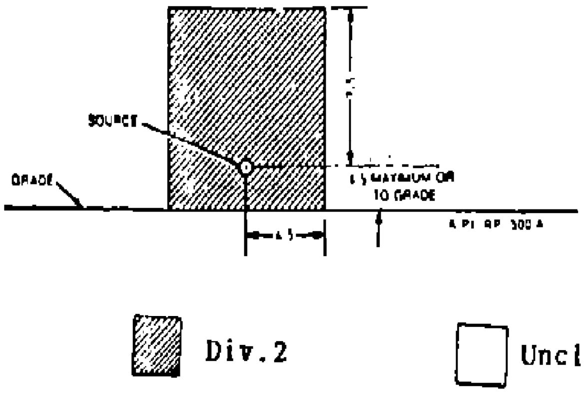
3) Applies to open top tanks or basins.

4) Distance above top of basin or tank. Extend to grade for basins or tanks located above ground.

SEPARATORS, DISSOLVED AIR FLOATION (DAF) UNITS & BIOLOGICAL OXIDATION (BIOX) UNITS
Fig. 24

(to be continued)

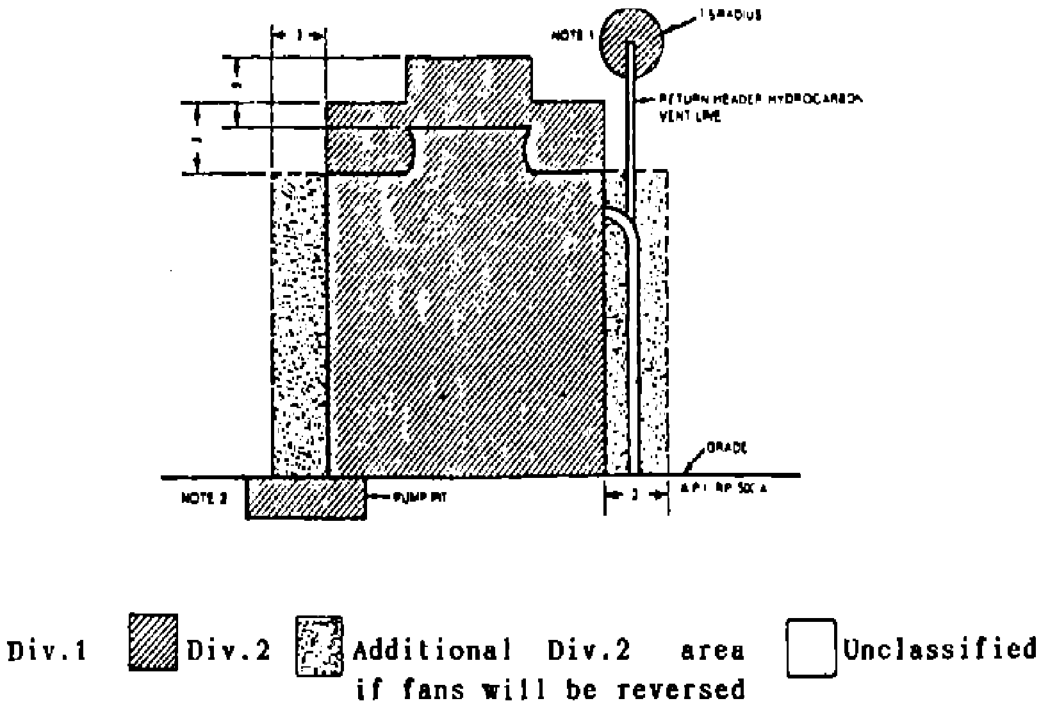
APPENDIX B (continued)



ADEQUATELY VENTILATED PROCESS AREA WITH LIGHTER THAN AIR GAS SOURCE
Fig. 25

Note:

Distances given are for typical refinery installations, they must be used with judgment, with consideration given to all factors discussed in the text.



MECHANICAL DRAFT COOLING TOWER HANDLING PROCESS COOLING WATER
Fig. 26

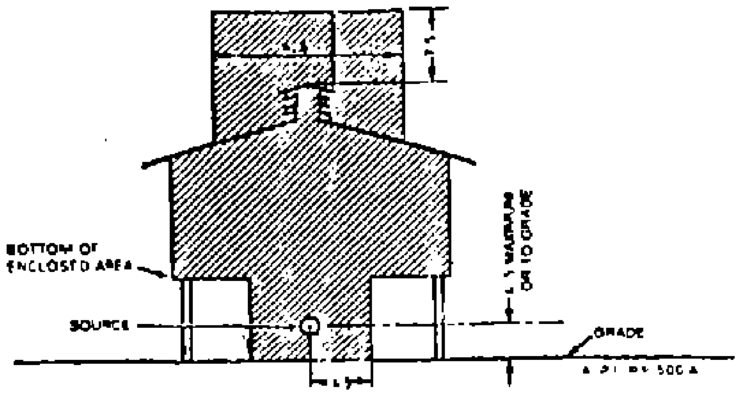
Notes:

1) It is recommended that electrical equipment be located away from the vent area.

2) Reversal of the fans and excessive carry-over from exchanger leaks are the reason for classifying the pump pit Div. 2.

(to be continued)

APPENDIX B (continued)



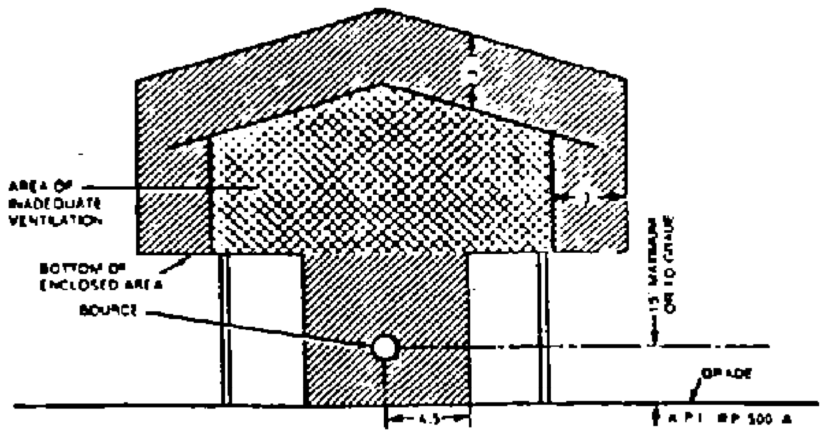
Div.1 Div.2

ADEQUATELY VENTILATED COMPRESSOR SHELTER WITH LIGHTER THAN AIR GAS SOURCE

Fig. 27

Note:

Distances given are for typical refinery installations, they must be used with judgment, with consideration given to all factors discussed in the text.



Div.1 Div.2 Unclassified

INADEQUATELY VENTILATED COMPRESSOR SHELTER WITH LIGHTER THAN AIR GAS SOURCE

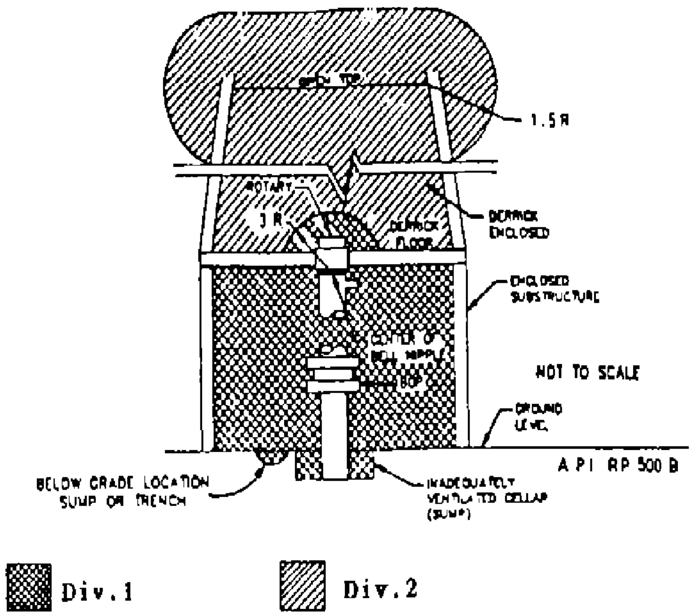
Fig. 28

Note:

Distances given are for typical refinery installations, they must be used with judgment, with consideration given to all factors discussed in the text.

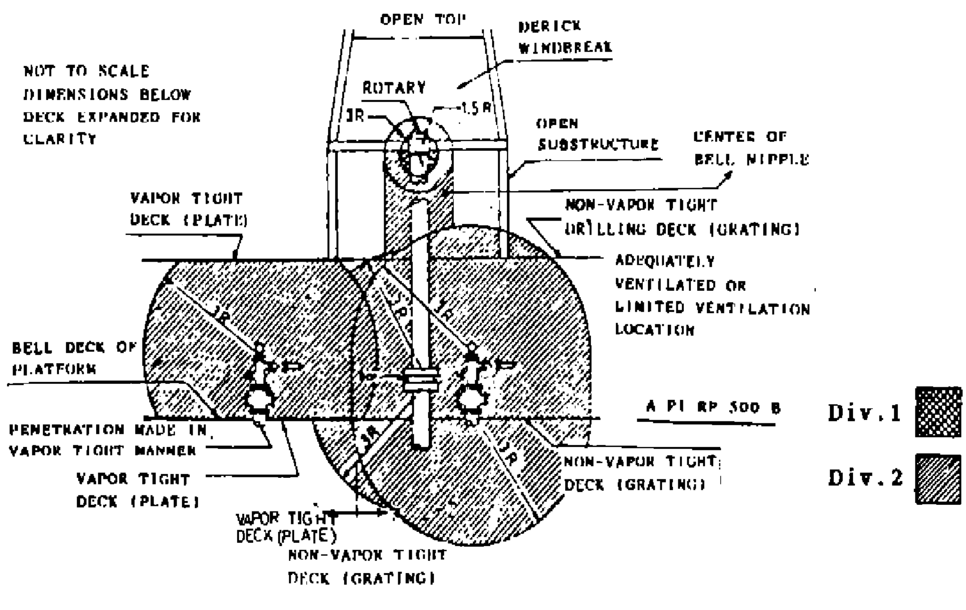
(to be continued)

APPENDIX B (continued)



DRILLING RIG, ADEQUATE OR LIMITED VENTILATION IN ENCLOSED DERRICK (OPEN TOP) AND INADEQUATELY VENTILATED SUBSTRUCTURE

Fig. 29

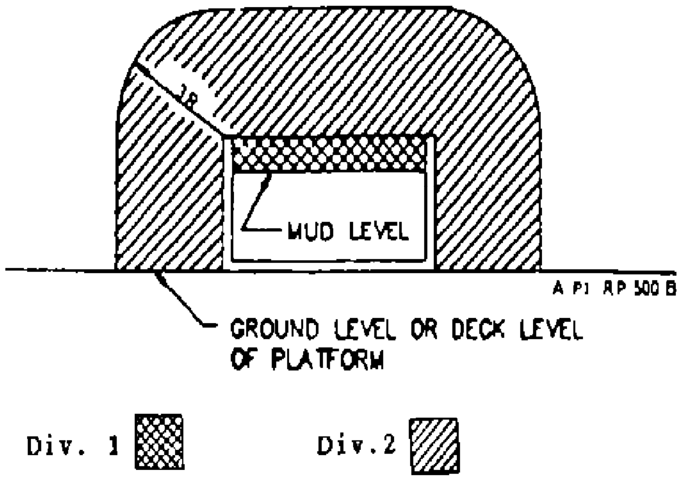


PLATFORM DRILLING RIG, ADEQUATE VENTILATION IN SUBSTRUCTRE AND INSIDE DERRICK, SEVERAL PRODUCING WELLS BENEATH IN AN ADEQUATELY VENTILATED OR LIMITED VENTILATED AREA

Fig. 30

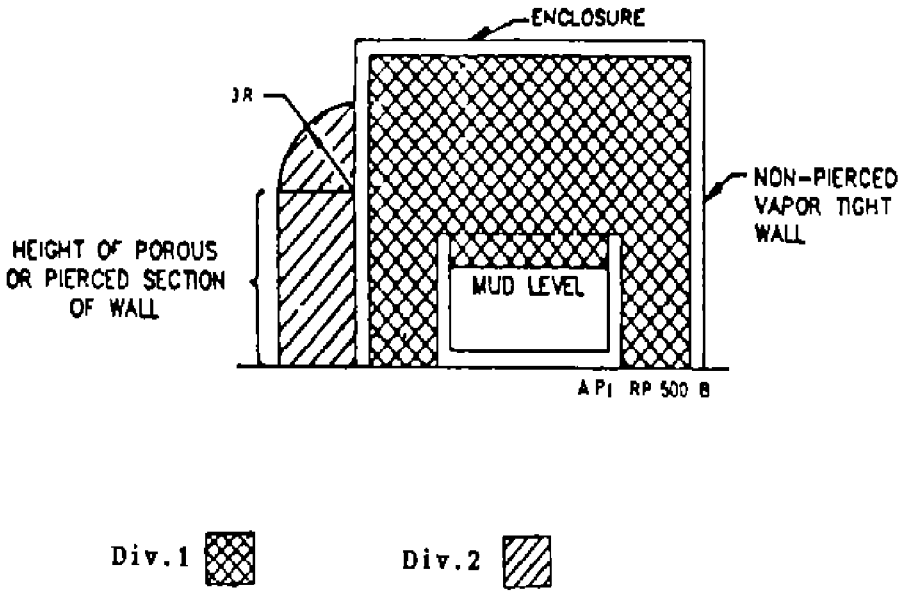
(to be continued)

APPENDIX B (continued)



MUD TANK IN A NON-ENCLOSED ADEQUATELY VENTILATED AREA

Fig. 31

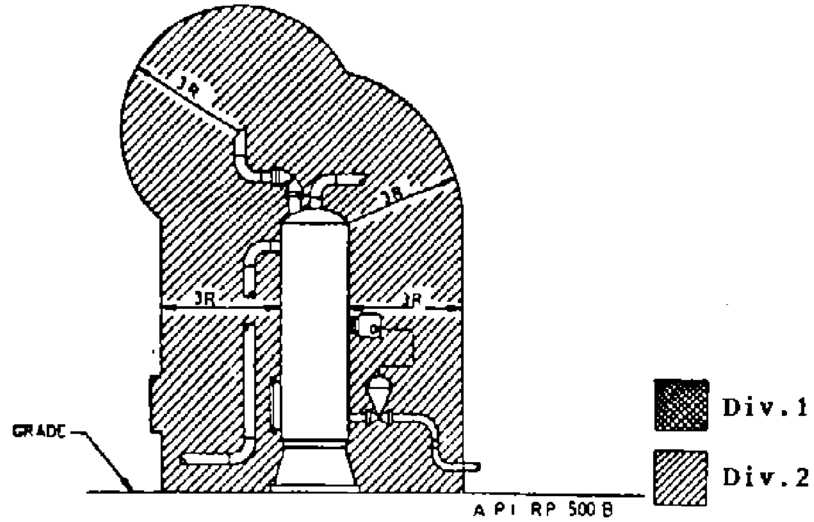


N INADEQUATELY VENTILATED AREA

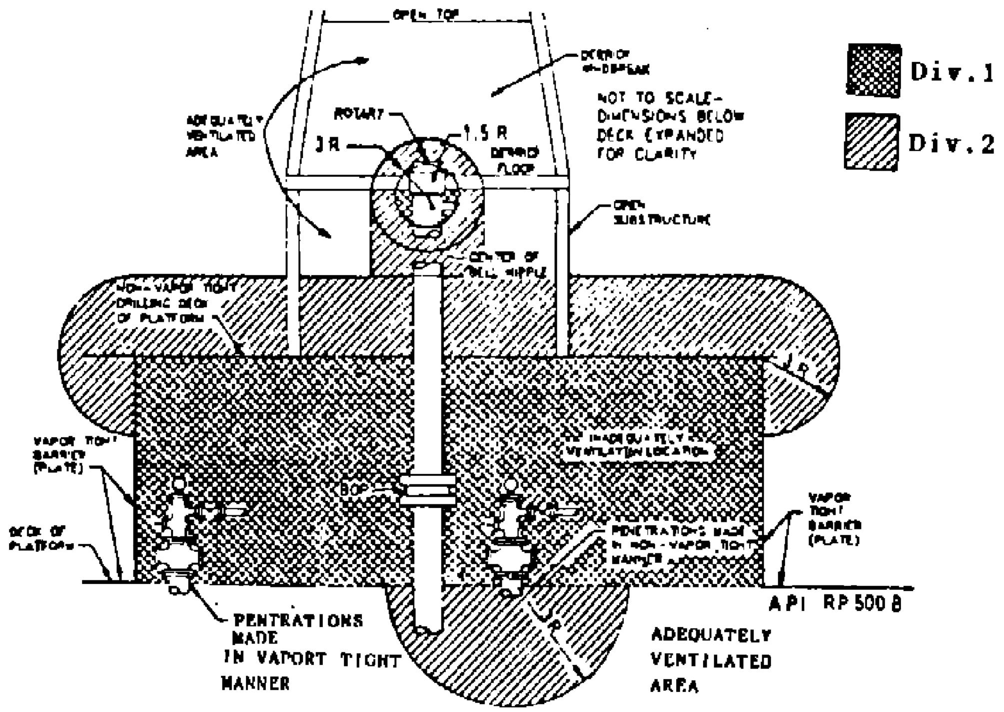
Fig. 32

(to be continued)

APPENDIX B (continued)



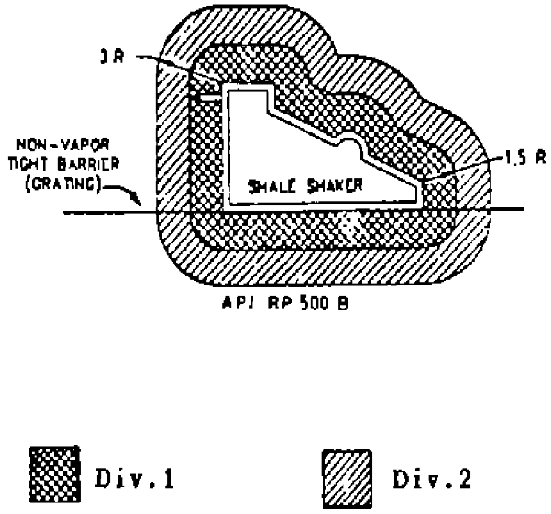
OIL, GAS SEPARATION VESSEL OR PROTECTED FIRE VESSEL
Fig. 33



PLATFORM DRILLING RIG, ADEQUATE VENTILATION IN SUBSTRUCTURE AND INSIDE DERRICK, SEVERAL PRODUCING WELLS BENEATH IN AN INADEQUATELY VENTILATED LOCATION
Fig. 34

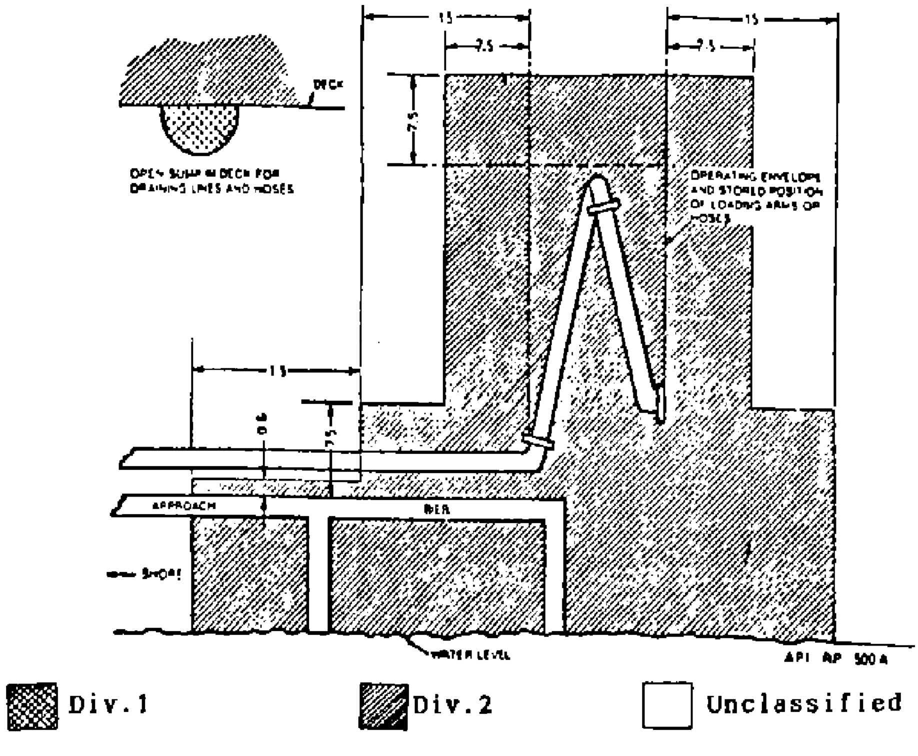
(to be continued)

APPENDIX B (continued)



SHALE SHAKER IN A NON-ENCLOSED ADEQUATELY VENTILATED AREA

Fig. 35



REFINERY MARINE TERMINAL HANDLING FLAMMABLE LIQUIDS

Fig. 36

(to be continued)

APPENDIX B (continued)

Notes:

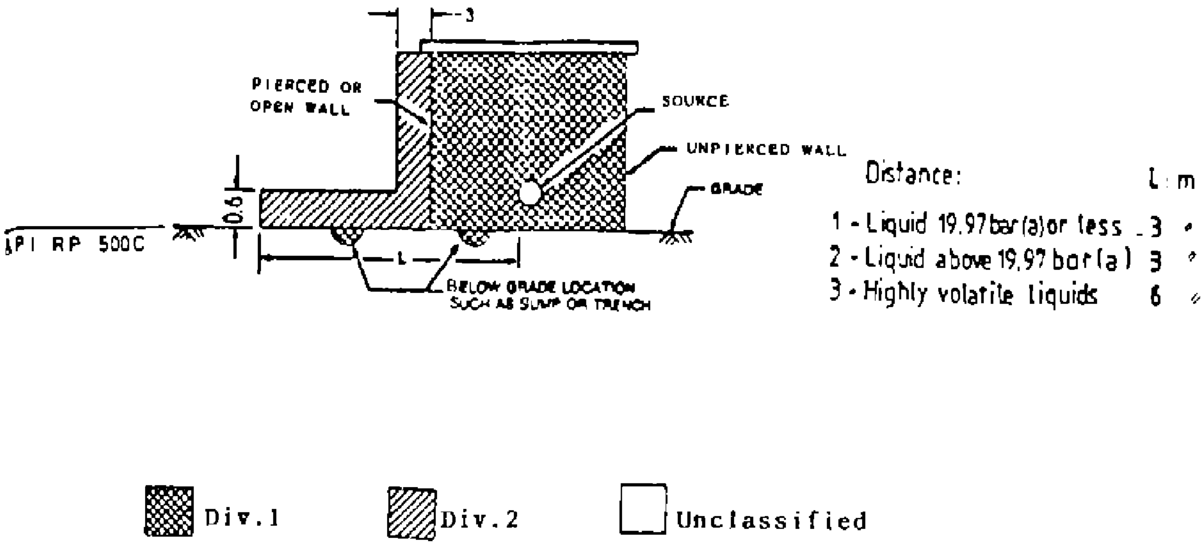
1) The "Source of Vapor" shall be the operating envelope and stored position of the outboard flange connection of the loading arm (or hose).

2) The berth area adjacent to tanker and barge cargo tanks is to be Div. 2 to the following extent:

a) 7.5 m horizontally in all directions on the pier side from that portion of the hull containing cargo tanks.

b) From the water level to 7.5m above the cargo tanks at their highest position.

3) Additional locations may have to be classified as required by the presence of other sources of flammable liquids on the berth.

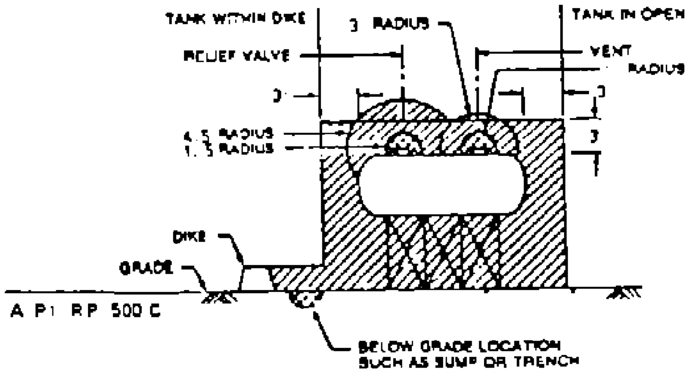


INADEQUATELY VENTILATED BUILDING PIPING WITH VALVES, SCREWED FITTINGS, FLANGES OR SIMILAR ACCESSORIES HANDLING FLAMMABLE SIZED PUMPS.

Fig. 37

(to be continued)

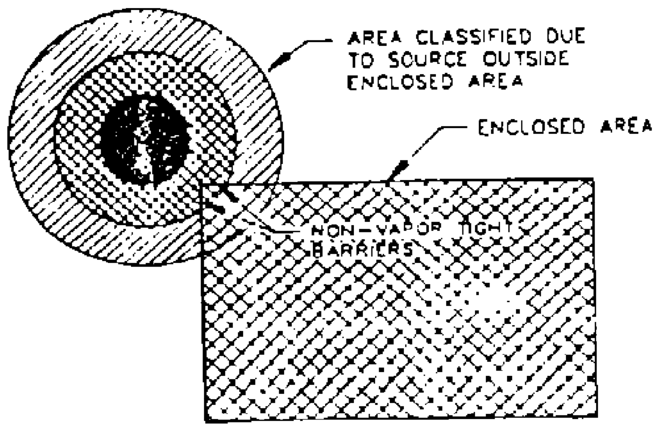
APPENDIX B (continued)



Div.1 Div.2 Unclassified

ELEVATED STORAGE TANK OR VESSEL

Fig. 38



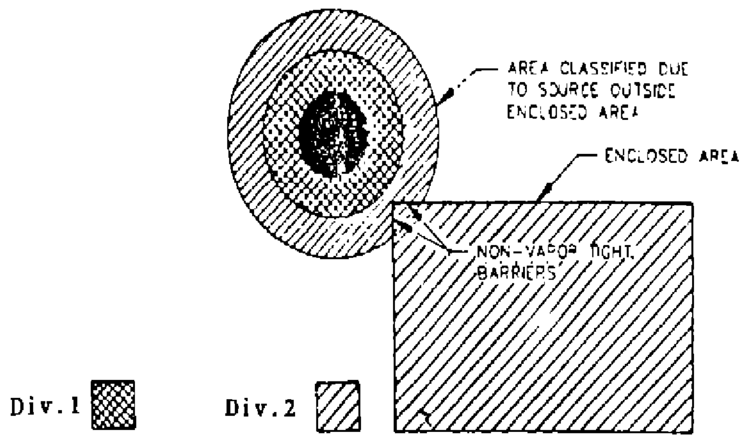
Div.1 Div.2

ENCLOSED AREAS ADJACENT TO CLASSIFIED AREA

Fig. 39

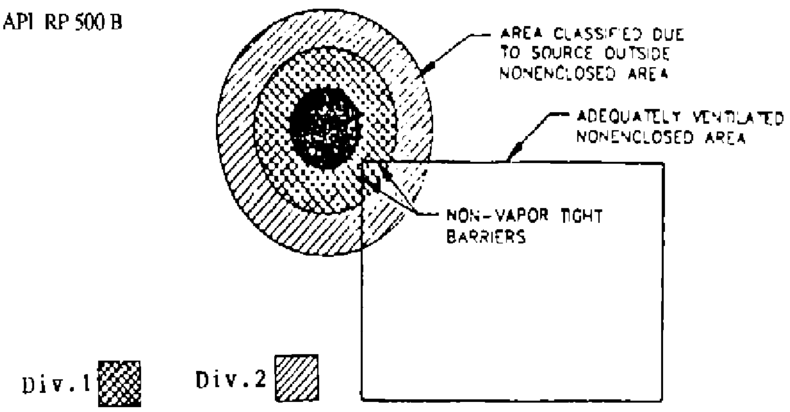
(to be continued)

APPENDIX B (continued)

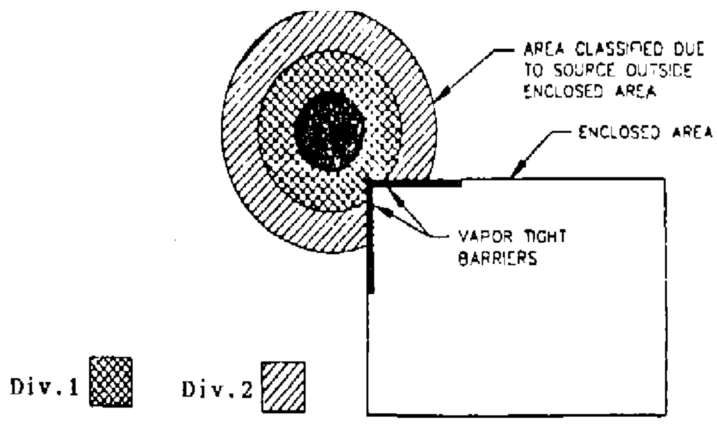


ENCLOSED AREAS ADJACENT TO CLASSIFIED AREAS
Fig. 40

API RP 500 B



ADEQUATELY VENTILATED NON-ENCLOSED AREA ADJACENT TO A CLASSIFIED AREA
Fig. 41



ENCLOSED AREA ADJACENT TO A CLASSIFIED AREA
Fig. 42

API RP 500 B

APPENDIX C
CLASSIFICATION OF PETROLEUM MATERIALS
FROM
PART 15 OF THE IP MODEL CODE OF SAFE PRACTICE
1990

Classification of petroleum by the Institute of Petroleum, based (except for Liquefied Petroleum Gases, LPG) on closed cup flashpoints

Class 0	Liquefied Petroleum Gases (LPG)
Class I	Liquids that have flash points below 21°C
Class II (1)	Liquids that have flash points from 21°C up to and including 55°C, handled below flash points
Class II (2)	Liquids that have flash points from 21°C up to and including 55°C, handled at or above flash points
Class III (1)	Liquids that have flash points above 55°C up to and including 100°C, handled below flash points
Class III (2)	Liquids that have flash points above 55°C up to and including 100°C, handled at or above flash points
Unclassified	Liquids that have flash points above 100°C

(to be continued)

APPENDIX C (continued)

TYPICAL COMMONLY ENCOUNTERED PETROLEUM MATERIALS

CLASS OF PETROLEUM FLASH POINTS	TYPICAL EXAMPLE	TYPICAL FLASH POINTS (°C)	TYPICAL BOILING RANGE (°C)
CLASS 0	LPGs, ETHYLENE, PROPYLENES	—	PROPANE-42 N-BUTANE-1 ISOBUTANE-12
ClASS I			
< 21°C	GASOLINE (PETROL)	-45	ca. 20-205
	STABILIZED CRUDE OIL AVTAG WIDE CUT	—	ca.-1 to 380+
	JET FUEL(JP4; jetB)	-25	ca. 0-220
	BENZENE	-11	80
	TOLUENE	4	110
	NAPHTHA	-2 to 10	30-177
	METHANOL	11	65
ClASS II			
21-55°C	AVTUR/JETA TURBOFUEL	38 min.	150-240
	KEROSENE		
	(a) PREMIUM GRADE	43 min.	160-280
	(b) REGULAR	38 min.	150-280
CLASS III			
> 55-100°C	GAS OIL/DISTILLATE		
	HEATING OIL	55+	250-360
	AUTOMOTIVE DIESEL FUEL	55+	180-360
UNCLASSIFIED			
> 100°C	ATMOSPHERIC RESIDUES		
	(FUEL OILS)	>100	>350

Notes:

1) The IP classes of petroleum conform to the most frequently used flash points divisions in European, EEC and UK regulations and directives, and with the above subdivision of Classes II and III have been standardized upon by the Institute in its various codes of practice to govern the handling of petroleum materials throughout the sections of bulk storage, loading, conveyance, discharge and distribution.

2) For related API flammable and combustible liquids classes see extract from API-RP 500A Fourth edition 1982 (1987) which follows.

(to be continued)

APPENDIX C (continued)

EXTRACT FROM API RECOMMENDED PRACTICE 500A

Flammable and Combustible Liquids Classes

1) Flammable liquids are defined by NFPA 30 as those liquids having a flash point below 37.8 °C and a vapor pressure not exceeding 276 kilopascals absolute (40 pounds per square inch absolute) at 37.8°C. These are further divided into the following general classes:

- **a)** Class IA includes those liquids having flash points below 22.8°C and boiling points below 37.8°C.
- **b)** Class IB includes those liquids having flash points below 22.8°C and boiling points at or above 37.8°C.
- **c)** Class IC includes those liquids having flash points at or above 22.8°C and below 37.8°C.

2) Combustible liquids are defined by NFPA 30 as those liquids having flash points at or above 37.8°C. These are further divided into the following general classes:

- **a)** Class II includes those liquids having flash points at or above 37.8°C and below 60°C.
- **b)** Class III includes those liquids having flash points above 60°C and are subdivided as follows:
- **c)** Class IIIA includes those liquids having flash points at or above 60°C and below 93.3°C.
- **d)** Class IIIB includes those liquids having flash points at or above 93.3°C.

3) The densities of air saturated with gases of these flammable and combustible liquids at ordinary atmospheric temperatures are generally less than 1.5 times that of air. However, when these gases are diluted with sufficient air to make a flammable mixture, the density of the mixture approaches that of air.

4) Class I liquids, where released in appreciable quantities to the atmosphere, may produce large volumes of gas. This is particularly the case with the more volatile liquids in this class, such as natural, motor, and aviation gasolines. The less volatile liquids in this class, such as some of the tinners and solvents, xylenes, and some intermediate refinery stocks, release gases more slowly at normal storage temperatures and are hazardous only near the surface of the liquid.

At elevated temperatures, however, these liquids give off larger volumes of gas that can spread farther. These gases, even when involved rapidly, have a natural tendency to disperse into the atmosphere and, thus, rapidly become diluted to concentrations below the lower limit of the ignitable range. This tendency is greatly accelerated by air movement.

5) Class II liquids include kerosene, most of the solvents, and some heating oils, but do not include diesel fuel and heavier fuel oils. The degree of hazard is low because the rate of gas release is almost nil at normal temperatures for handling and storage. When these liquids are heated, more gas is released and the hazard may be increased near the point of release. Still, the likelihood of ignition by electrical equipment is not as great as for Class I liquids because the gases tend to condense as they are cooled by the surrounding air and so will not travel as far. If heated to extremely high temperatures, the gases may ignite spontaneously when released to the atmosphere.

6) Class III liquids having flash points at or above 60°C, when heated substantially above their flash points, evolve gases that behave in a similar manner to those of Class II liquids.

7) Normally, Class I liquids will produce gases considered to be in the flammable range.

8) Class II liquids should be considered as producing gases in the flammable range near the point of release when handled, processed, or stored under conditions that may cause the temperature of the liquid to exceed its flash point.

9) Class III liquids may release gas in the flammable range at their surfaces if heated above the flash point, but the extent of the classified area, near the point of release, will ordinarily be very small.

APPENDIX D
DATA FOR FLAMMABLE MATERIALS FOR USE WITH ELECTRICAL EQUIPMENT

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Flammable material	Formula	Melting point	Boiling point	Relative vapour density	Flash point	Flammable limits				Ignition temperature	Minimum igniting current	T class of suitable apparatus	Apparatus group
						LFL	UFL	LFL	UFL				
		°C	°C		°C	Vol %	Vol %	mg/L	mg/L	°C	mA		
acetaldehyde	CH_3CHO	-123	20	1.52	-38	4	57	73	1040	140	-	T4	IIA
acetic acid	CH_3COOH	17	118	2.07	40	5.4	16	100	430	485	-	T1	IIA
acetic anhydride	$(CH_3CO)_2O$	-73	140	3.52	54	2.7	10	-	-	(334)	-	(T2)	IIA
acetone	$(CH_3)_2CO$	-95	56	2.0	-19	2.15	13	60	310	535	-	T1	IIA
acetonitrile	CH_3CN	-45	82	1.42	5	-	4.4	16	-	523	-	T1	IIA
acetyl chloride	CH_3COCl	-112	51	2.7	4	5.0	-	-	-	390	-	T2	IIA
acetylene	$CH\equiv CH$	-81	-84*	0.9	-	1.5	100	-	-	305	24	T2	IIC
acrylonitrile	$CH_2{=}CHCN$	-82	77	1.83	-5	3	17	65	380	480	-	T1	IIA
allyl alcohol	$CH_2{=}CHCH_2OH$	-	-	-	21	-	-	-	-	-	-	T	IIA
allyl chloride	$CH_2{=}CHCH_2Cl$	-135	45	2.64	-20	3.2	11.2	105	360	485	-	T1	IIA
allylene	$CH_3C\equiv CH$	-103	-23	1.38	-	1.7	-	28	-	-	-	T	IIB
ammonia	NH_3	-78	-33	0.59	-	15	28	105	200	630	-	T1	IIA
amphetamine	$C_6H_5CH_2CH(NH_2)CH_3$	-	200	4.67	< 100	-	-	-	-	-	-	T	IIA
aniline	$C_6H_5NH_2$	-6	184	3.22	75	1.2	8.3	-	-	617	-	T1	(IIA)
benzaldehyde	C_6H_5CHO	-26	179	3.66	65	1.4	-	60	-	190	-	T4	(IIA)
benzene	C_6H_6	-6	80	2.7	-11	1.2	8	39	270	560	-	T1	IIA
blast furnace gas	mixture	-	-	-	-	28.0	70.0	-	-	-	-	T	IIA
blue water gas	mixture	-	-	-	-	-	-	-	-	-	-	T1	IIC
1-bromobutane	$CH_3(CH_2)_2CH_2Br$	-112	102	4.72	< 21	2.5	-	230	-	265	-	T3	IIA
bromoethane	C_2H_5Br	-119	38	3.75	< -20	6.7	11.3	300	510	510	-	T1	IIA
buta-1,3-diene	$CH_2{=}CHCH{=}CH_2$	-109	-4	1.87	-	2.1	12.5	25	290	430	65	T2	IIA
butane	C_4H_{10}	-138	-1	2.05	-60	1.5	8.5	37	210	365	80	T2	IIA
butanone (ethyl methyl ketone)	$C_2H_5COCH_3$	-86	80	2.48	-1	1.8	11.5	60	350	505	-	T1	IIA
butan-1-ol	$CH_3(CH_2)_2CH_2OH$	-89	118	2.55	29	1.7	9.0	43	350	340	-	T2	IIA
butyl acetate	$CH_3COOCH_2(CH_2)_2CH_3$	-77	127	4.01	22	1.4	8	58	360	370	-	T2	IIA
butyl glycolate (butyl hydroxyacetate)	$HOCH_2COOC_4H_9$	-	356	4.45	61	-	-	-	-	-	-	T	IIB
butyl styrene	$C_6H_6C(CH_2)_3{=}CH_2$	-	-	-	-	-	-	-	-	-	-	T	IIB
butylamine	$C_4H_9NH_2$	-104	63	2.52	-0	-	-	-	-	(312)	-	(T2)	IIA
butyldigol	$CH_3(CH_2)_3OCH_2$-$CH_2OCH_2CH_2OH$	-88	231	5.58	78	-	-	-	-	225	-	T3	IIA
butyraldehyde	$CH_3CH_2CH_2CHO$	-97	76	2.48	< -5	1.4	12.5	42	380	230	-	T3	IIA
but-1-ene	$CH_2{=}CHCH_2CH_3$	-185	-6	1.95	-	1.6	10	35	235	385	-	T2	IIA
but-2-ene	$CH_3CH{=}CHCH_3$	-	4	1.94	-	1.7	9	-	-	(325)	-	(T2)	IIB
carbon disulphide	CS_2	-112	46	2.64	-20	1.0	60	30	1900	102	-	T5	IIC
carbon monoxide	CO	-205	-191	0.97	-	12.5	74.2	145	870	605	90	T1	IIA
chlorobenzene	C_6H_5Cl	45	132	3.88	28	1.3	7.1	60	520	637	-	T1	IIA
1-chlorobutane	$CH_3(CH_2)_2CH_2Cl$	-123	78	3.2	0	1.8	10	65	390	(460)	-	(T1)	IIA

(to be continued)

APPENDIX D (continued)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Flammable material	Formula	Melting point	Boiling point	Relative vapour density	Flash point	Flammable limits				Ignition temperature	Minimum igniting current	T class of suitable apparatus	Apparatus group
						LFL	UFL	LFL	UFL				
		°C	°C		°C	Vol %	Vol %	mg/L	mg/L	°C	mA		
chloroethane (ethyl chloride)	C_2H_5Cl	-138	12	2.22	–	3.6	15.4	95	400	510	–	T1	IIA
2-chloroethanol	CH_2ClCH_2OH	-70	129	2.78	55	5.0	18	160	540	425	–	T2	IIA
chloroethylene (vinyl chloride)	$CH_2{=}CHCl$	-154	-14	2.15	–	3.8	29.3	95	770	470	–	T1	IIA
chloromethane (methyl chloride)	CH_3Cl	-98	-24	1.78	–	10.7	13.4	150	400	625	–	T1	IIA
chloromethyl methyl ether	CH_3OCH_2Cl	-103	60	–	–	–	–	–	–	–	–	T	IIA
1-chloropropane (n-chloropropane)	C_3H_7Cl	-123	37	2.7	-18	2.8	10.7	70	300	(592)	–	(T1)	IIA
2-chloropropane (iso-chloropropane)	$(CH_3)_2CHCl$	–	47	2.7	-32	2.6	11.1	–	–	520	–	T1	IIA
α-chlorotoluene (benzyl chloride)	$C_6H_5CH_2Cl$	-39	179	4.36	60	1.2	–	55	–	585	–	T1	IIA
1-chloro-2, [illegible]	OCH_2CHCH_2Cl	-57	116	3.30	(40)	–	–	–	–	–	–	1	IIA
1-chloro-2,	OCH_2CHCH_2Cl	-57	116	3.30	(40)	–	–	–	–	–	–	1	IIA
3-epoxypropane		-57	116	3.30	(40)	–	–	–					
coal tar naphtha	Mixture								–	272	–	T3	IIA
coke oven gas	Mixture	–	–	–	–	–	–	–	–	500	–	T1	
		–	–	–	–	–	–						
cresol	$CH_3C_6H_4OH$								–	555	–	T1	IIA
crotonaldehyde	$CH_3CH{=}CHCHO$	11	191	3.73	81	1.1	–	45	–	(230)	–	(T3)	IIB
cumene (iso-propylbenzene)	$C_6H_5CH(CH_3)_2$	-75	102	2.41	13	2.1	15.5	–	–	420	–	T2	IIA
		-97	152	4.13	36	0.88	6.5	–					
cyclobutane	$CH_2(CH_2)_2CH_2$								–	–	–	1	IIA
		-91	13	1.93	–	1.8	–	42					
cycloheptane	$CH_2(CH_2)_5CH_2$								–	–	–	1	IIA
		–	119	3.39	< 21	–	–	–					
cyclohexane	$CH_2(CH_2)_4CH_2$								290	259	–	T3	IIA
		7	81	2.9	-18	1.2	7.8	40					
cyclohexanol	$CH_2(CH_2)_4CHOH$								–	300	–	T2	IIA
		24	161	3.45	68	1.2	–	–					
cyclohexanone	$CH_2(CH_2)_4CO$								380	419	–	T2	IIA
		-31	156	3.38	43	1.4	9.4	53					
cyclohexene	$CH_2(CH_2)_3CH{=}CH$								–	(310)	–	(T2)	IIA
		-104	83	2.83	-20	1.2	–	–					
cyclohexylamine	$CH_2(CH_2)_4CHNH_2$								–	290	–	T3	IIA
		[illegible]	[illegible]	[illegible]	[illegible]								

(to be continued)

APPENDIX D (continued)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Flammable material	Formula	Melting point	Boiling point	Relative vapour density	Flash point	Flammable limits				Ignition temperature	Minimum igniting current	T class of suitable apparatus	Apparatus group
						LFL	UFL	LFL	UFL				
		°C	°C		°C	Vol. %	Vol. %	mg/L	mg/L	°C	mA		
cyclopentane	$CH_2(CH_2)_3CH_2$	-93	47	-	-37	-	-	-	-	(380)	-	(T2)	IIA
cyclopropane	$CH_2CH_2CH_2$	-127	-33	1.45	-	2.4	10.4	40	185	495	-	T1	IIA
decahydronaphthalene	$CH_2(CH_2)_3CHCH(CH_2)_3CH_2$	-43	196	4.76	54	0.7	4.9	40	280	260	-	T3	IIA
decane	$C_{10}H_{22}$ (approx.)	-30	173	4.9	96	0.8	5.4	-	-	205	-	T3	IIA
dibutyl ether	$(C_4H_9)_2O$	-95	141	4.48	25	1.5	7.6	48	460	185	-	T4	IIB
dichlorobenzene	$C_6H_4Cl_2$	-18	179	5.07	66	2.2	9.2	130	750	(640)	-	(T1)	IIA
1,1-dichloroethane	CH_3CHCl_2	-98	57	3.42	-10	5.6	16	225	660	440	-	T2	IIA
1,2-dichloroethane (ethylene dichloride)	CH_2ClCH_2Cl	-36	84	3.42	(5)	6.2	15.9	-	-	(413)	-	(T2)	IIA
1,1-dichloroethylene (vinylidene chloride)	$CH_2{=}CCl_2$	-	37	3.4	-18	7.3	16	-	-	(570)	-	(T1)	IIA
1,2-dichloroethylene (1,2-dichloroethene)	$ClCH{=}CHCl$	-122	33	3.55	-10	9.7	12.8	220	650	(440)	-	(T2)	IIA
1,2-dichloropropane	$CH_3CHClCH_2Cl$	<-80	96	3.9	15	3.4	14.5	160	690	555	-	T1	IIA
diethyl ether	$(C_2H_5)_2O$	-116	34	2.55	<-20	1.7	36	50	1100	170	75	T4	IIB
diethyl ketone	$C_2H_5COC_2H_5$	-	-	-	(55)	-	-	-	-	-	-	†	IIA
diethyl oxalate	$(COOC_2H_5)_2$	-41	180	5.04	76	-	-	-	-	-	-	†	IIA
diethyl sulphate	$(C_2H_5)_2SO_4$	-25	208	5.31	104	-	-	-	-	-	-	†	IIA
diethylamine	$(C_2H_5)_2NH$	-50	56	2.53	<-20	1.7	10.1	50	305	(310)	-	(T2)	IIA
2-diethylaminoethanol	$(C_2H_5)_2NC_2H_4OH$	-	161	4.04	(60)	-	-	-	-	-	-	†	IIA
diethyldichlorosilane	$(C_2H_5)_2SiCl_2$	-	-	-	-	-	-	-	-	-	-	†	IIC
dihexyl ether	$(CH_3(CH_2)_5)_2O$	-43	227	6.43	75	-	-	-	-	185	-	T4	IIA
di-isobutylene	$C_2H_5CH(CH_3)CH(CH_3)C_2H_5$	-106	105	3.87	(2)	-	-	-	-	(305)	-	(T2)	IIA
di-isopropyl ether	$((CH_3)_2CH)_2O$	-86	69	3.52	-28	1.4	21	-	-	(416)	-	(T2)	IIA
dimethyl ether	$(CH_3)_2O$	-141	-25	1.59	-	3.7	27.0	38	520	-	-	†	IIB
dimethylamine	$(CH_3)_2NH$	-92	7	1.55	-	2.8	14.4	52	270	(400)	-	(T2)	IIA
dimethylaniline	$C_6H_3(CH_3)_2NH_2$	2	194	4.17	63	1.2	7.0	60	350	370	-	T2	IIA
dimethylformamide (formdimethylamide)	$HCON(CH_3)_2$	-61	152	2.51	58	2.2	15.2	-	-	(440)	-	(T2)	IIA
1,4-dioxane	$OCH_2CH_2OCH_2CH_2$	10	101	3.03	11	1.9	22.5	70	820	379	-	T2	IIB
1,3-dioxolane	$OCH_2CH_2OCH_2$	-26	74	2.55	(2)	-	-	-	-	-	-	†	IIB
dipentyl ether	$(C_5H_{11})_2O$	-69	170	5.45	(57)	-	-	-	-	170	-	T4	IIA
dipropyl ether	$(C_3H_7)_2O$	122	90	3.53	<21	-	-	-	-	170	-	T4	IIB
ditertiary butyl peroxide	$(CH_3)_3COOC(CH_3)_3$	-	-	-	18	-	-	-	-	170	-	T4	IIB
1,2-epoxypropane (propylene oxide) (methyloxirane)	CH_3CHCH_2O	-	-	-	-37	-	-	-	-	-	-	†	IIB

(to be continued)

APPENDIX D (continued)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Flammable material	Formula	Melting point	Boiling point	Relative vapour density	Flash point	Flammable limits				Ignition temperature	Minimum igniting current	T class of suitable apparatus	Apparatus group
						LFL	UFL	LFL	UFL				
		°C	°C		°C	Vol %	Vol. %	mg/L	mg/L	°C	mA		
ethane	CH_3CH_3	−183	−87	1.04	–	3.0	15.5	37	195	515	70	T1	IIA
ethanethiol	C_2H_5SH	−148	35	2.11	−20	2.8	18	70	460	295	–	T3	IIA
ethanol (ethyl alcohol)	C_2H_5OH	−144	78	1.59	12	3.3	19	67	290	425	75	T2	IIA
ethanolamine (2-aminoethanol)	$NH_2CH_2CH_2OH$	10	172	2.1	85	–	–	–	–	–	–	†	IIA
2-ethoxyethanol	$C_2H_5OCH_2CH_2OH$	–	135	3.1	95	1.8	15.7	–	–	235	–	T3	IIB
ethoxyethyl acetate	$CH_3COOCH_2CH_2OC_2H_5$	–	156	4.6	47	–	–	–	–	380	–	T2	IIA
ethyl acetate	$CH_3COOCH_2CH_3$	−83	77	3.04	−4	2.1	11.5	75	420	460	–	T1	IIA
ethyl acetoacetate	$CH_3COCH_2COOC_2H_5$	–	180	–	(84)	–	–	–	–	295	–	T3	IIB
ethyl acetylene	$C_2H_5C{\equiv}CH$	–	–	–	–	–	–	–	–	–	–	†	IIB
ethyl acrylate	$CH_2{=}CHCOOC_2H_5$	> −75	100	3.45	9	1.8	–	74	–	–	–	†	IIB
ethyl benzene	$C_2H_5C_6H_5$	−95	135	3.66	15	1.0	6.7	44	–	431	–	T2	IIA
ethyl cyclobutane	$C_2H_5CHCH_2CH_2CH_2$	–	–	2.0	< −16	1.2	7.7	–	–	210	–	T3	IIA
ethyl cyclohexane	$C_2H_5CH(CH_2)_4CH_2$	–	131	3.87	14	0.9	6.6	–	–	262	–	T3	IIA
ethyl cyclopentane	$C_2H_5CH(CH_2)_3CH_2$	–	103	3.4	1	1.1	6.7	–	–	260	–	T3	IIA
ethyl formate	$HCOOCH_2CH_3$	−80	54	2.55	< −20	2.7	16.5	80	500	440	–	T2	IIA
ethyl methacrylate	$CH_2{=}CCH_3COOC_2H_5$	–	240	3.9	(20)	–	–	–	–	–	–	†	IIA
ethyl methyl ether	$CH_3OC_2H_5$	–	8	2.087	–	2.0	10.1	49	255	190	–	T4	IIB
ethyldigol	$C_2H_5O(CH_2)_2O(CH_2)_2OH$	–	202	4.62	94	–	–	–	–	–	–	†	IIA
ethylene	$CH_2{=}CH_2$	−169	−104	0.97	–	2.7	34	31	390	425	45	T2	IIB
ethylenediamine (1,2-diaminoethane)	$NH_2CH_2CH_2NH_2$	8	116	2.07	34	–	–	–	–	385	–	T2	IIA
ethylene oxide (epoxy ethane) (oxirane)	CH_2CH_2O	−112	11	1.52	–	3.7	100	55	1820	440	40	T2	IIB
formaldehyde	$HCHO$	−117	−19	1.03	–	7	73	87	910	424	–	T2	IIB
formic acid	$HCOOH$	–	101	1.6	68	–	–	–	–	(520)	–	(T1)	IIA
2-furaldehyde (furfuraldehyde)	$OCH{=}CHCH{=}CCHO$	–	161	3.3	60	2.1	19.3	–	–	315	–	T2	IIA
furan	$CH{=}CHCH{-}CHO$	–	–	–	60	–	–	–	–	–	–	†	IIA
heptane	C_7H_{16}	−91	98	3.46	−4	1.1	6.7	46	280	215	75	T3	IIA
heptan-1-ol	$C_7H_{15}OH$	−34	176	4.03	60	–	–	–	–	–	–	†	IIA
heptan-2-one (amyl methyl ketone)	$CH_3CO(CH_2)_4CH_3$	−35	151	3.94	(49)	–	–	–	–	–	–	†	IIA
hept-2-ene (2-heptene)	$CH_3(CH_2)_3CH{=}CHCH_3$	–	–	–	< 0	–	–	–	–	–	–	†	IIA

(to be continued)

APPENDIX D (continued)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Flammable material	Formula	Melting point	Boiling point	Relative vapour density	Flash point	Flammable limits LFL	UFL	LFL	UFL	Ignition temperature	Minimum igniting current	T class of suitable apparatus	Apparatus group
		°C	°C		°C	Vol. %	Vol. %	mg/L	mg/L	°C	mA		
hexane	$CH_3(CH_2)_4CH_3$	-95	69	2.97	-21	1.2	7.4	42	265	233	75	T3	IIA
hexan-2-one (butyl methyl ketone)	$CH_3CO(CH_2)_3CH_3$	-56	28	3.46	23	1.2	8	50	330	(530)	-	(T1)	IIA
hydrogen cyanide	HCN	-	26	0.90	-18	5.6	40	-	-	(538)	-	(T1)	IIB
hydrogen sulphide	H_2S	-86	-60	1.19	-	4.3	45.5	60	650	270	-	T3	IIB
hydrogen (see clause 37)	H_2	-259	-253	0.07	-	4.0	75.6	3.3	64	560	21	T1	IIC
4-hydroxy-4-methylpentan-2-one	$CH_3COCH_2C(CH_3)_2OH$	-47	166	4.0	58	1.8	6.9	-	-	680	-	T1	IIA
isopentane (2-methylbutane)	$(CH_3)_2CHCH_2CH_3$	-	-	-	< -51	-	-	-	-	-	-	T	IIA
isopropyl nitrate	$(CH_3)_2CHONO_2$	-	105	-	20	2	100	-	-	175	-	T4	IIB
iso-octane	$(CH_3)_2CHCH_2C(CH_3)_3$	-	-	-	-12	-	-	-	-	411	-	T2	IIA
kerosine	Mixture	-	150	-	38	0.7	5	-	-	210	-	T3	IIA
(RS)-p-menthe-1,8-diene (dipentene)	$C_{10}H_{16}$	-75	175	4.66	42	0.7	6.1	-	-	237	-	T	IIA
metaldehyde	$(C_2H_4O)_4$	246¶	112*	6.07	36	-	-	-	-	-	-	T	IIA
methane (firedamp)	CH_4	-182	-161	0.55	-	5	15	-	-	595	85	T1	I
methane (industrial)	CH_4	-	-	-	-	-	-	-	-	-	-	T1	IIA
methanol	CH_3OH	-98	65	1.11	11	6.7	36	73	350	455	70	T1	IIA
2-methoxyethanol	$CH_3OCH_2CH_2OH$	-86	124	2.63	39	2.5	14	80	630	285	-	T3	IIB
methyl acetate	CH_3COOCH_3	-99	57	2.56	-10	3.1	16	95	500	475	-	T1	IIA
methyl acetoacetate	$CH_3CO_2CH_2COCH_3$	-	170	4.0	67	-	-	-	-	280	-	T3	IIA
methyl acetylene	$CH_3C{\equiv}CH$	-	-23	1.4	-	1.7	-	-	-	-	-	T	IIB
methyl acrylate	$CH_2{=}CHCOOCH_3$	< -75	80	3.0	-3	2.8	25	100	895	-	-	T	IIB
methyl cyclobutane	$CH_3CHCH_2CH_2CH_2$	-	-	-	-	-	-	-	-	-	-	T	IIA
methyl cyclohexane	$CH_3CH(CH_2)_4CH_2$	-127	101	3.38	-4	1.15	6.7	45	-	260	-	T3	IIA
methyl cyclohexanol	$C_7H_{13}OH$ (isomer not stated)	-38	168	3.95	68	-	-	-	-	295	-	T3	IIA
methyl cyclopentane	$CH_3CH(CH_2)_3CH_2$	-	72	2.9	< -7	-	-	-	-	-	-	T	IIA
methyl formate	$HCOOCH_3$	-100	32	2.07	< -20	5	23	120	570	450	-	T1	IIA
methyl methacrylate	$CH_2{=}CCH_3COOCH_3$	-	-	-	(10)	-	-	-	-	-	-	T	IIA
2-methyl propan-1-ol (isobutyl alcohol)	$(CH_3)_2CHCH_2OH$	-108	107	2.55	-	1.7	10.9	-	-	408	-	(T2)	IIA
methyl styrene	C_9H_{10} (isomer not stated)	-	172	4.1	57	0.7	-	-	-	(495)	-	(T1)	IIA
methylamine	CH_3NH_2	-92	-6	1.07	-	5	20.7	60	270	430	-	T2	IIA
4-methylpentan-2-one (isobutyl methyl ketone)	$(CH_3)_2CHCH_2COCH_3$	-80	116	3.45	16	1.4	7.5	-	-	(459)	-	(T1)	IIA
morpholine	$OCH_2CH_2NHCH_2CH_2$	-3	128	3.0	(40)	-	-	-	-	(310)	-	(T2)	IIA

(to be continued)

APPENDIX D (continued)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Flammable material	Formula	Melting point	Boiling point	Relative vapour density	Flash point	Flammable limits				Ignition temperature	Minimum igniting current	T class of suitable apparatus	Apparatus group
						LFL	UFL	LFL	UFL				
		°C	°C		°C	Vol %	Vol %	mg/L	mg/L	°C	mA		
naphtha	Mixture	–	35	2.5	-6	0.9	6	–	–	290	–	T3	IIA
naphthalene	$C_{10}H_8$	80	218	4.42	77	0.9	5.9	45	320	528	–	T1	IIA
natural gas	Mixture	–	–	–	–	–	–	–	–	–	–	T1	IIA
nitrobenzene	$C_6H_5NO_2$	6	211	4.25	88	1.8	–	90	–	480	–	T1	IIA
nitroethane	$C_2H_5NO_2$	-90	115	2.58	27	–	–	–	–	410	–	T2	IIB
nitromethane	CH_3NO_2	-29	101	2.11	36	–	–	–	–	415	–	T2	IIA
1-nitropropane	$C_3H_7NO_2$	-108	131	3.06	49	–	–	–	–	420	–	T2	IIB
nonane	C_9H_{20}	-54	151	4.43	30	0.8	5.6	37	300	205	–	T3	IIA
nonanol**	$C_9H_{19}OH$	–	178	4.97	75	0.8	6.1	–	–	–	–	†	IIA
n-hexanol†	$C_6H_{13}OH$	-45	157	3.5	63	1.2	–	–	–	–	–	†	IIA
octaldehyde	$C_7H_{15}CHO$	–	163	4.42	52	–	–	–	–	–	–	†	IIA
octane	$CH_3(CH_2)_6CH_3$	-56	126	3.93	13	1.0	3.2	–	–	210	–	T3	IIA
octanol††	$C_8H_{17}OH$	-16	195	4.5	81	–	–	–	–	–	–	†	IIA
paraformaldehyde	poly(CH_2O)	–	25	–	70	–	–	–	–	300	–	T2	IIB
paraldehyde (2,4,6-trimethyl-1,3,5-trioxane)	$(CH_3CHO)_3$	12	124	4.56	17	1.3	–	70	–	235	–	T3	IIA
pentane (mixed isomers)	C_5H_{12}	-130	36	2.48	<-20	1.4	8.0	41	240	285	73	T3	IIA
pentane-2,4-dione (acetylacetone)	$CH_3COCH_2COCH_3$	-23	140	3.5	34	1.7	–	–	–	340	–	T2	IIA
pentanol (mixed isomers)	$C_5H_{11}OH$	-78	138	3.04	34	1.2	10.5	44	380	300	–	T2	IIA
pentylacetate	$CH_3COOC_5H_{11}$	-78	147	4.48	25	1.0	7.1	60	550	375	–	T2	IIA
petroleum	Mixture	–	–	–	<-20	–	–	–	–	–	–	T3	IIA
phenol	C_6H_5OH	41	182	3.24	75	–	–	–	–	605	–	T1	IIA
propane	$CH_3CH_2CH_3$	-188	-42	1.56	–	2.0	9.5	39	180	470	70	T1	IIA
propanethiol (propyl mercaptan)	C_3H_7SH	–	–	–	–	–	–	–	–	–	–	†	IIB
propan-1-ol (propyl alcohol)	$CH_3CH_2CH_2OH$	-126	97	2.07	15	2.15	13.5	50	340	405	–	T2	IIB
propan-2-ol (isopropyl alcohol)	$(CH_3)_2CHOH$	-86	83	2.07	12	2.0	12	–	–	425	–	T2	IIA
propene	$CH_2{=}CHCH_3$	-185	-48	1.5	–	2.0	11.7	35	210	(455)	–	(T1)	IIA
propylacetate	$CH_3COOCH_2CH_2CH_3$	–	–	–	14	–	–	–	–	–	–	†	IIA
propylamine	$CH_3(CH_2)_2NH_2$	-101	32	2.04	<-20	2.0	10.4	49	260	(320)	–	(T2)	IIA
pyridine	Mixture	-42	115	2.73	17	1.8	12.0	56	350	550	–	T1	IIA
p-cymene	$CH_3C_6H_4CH(CH_3)_2$	-70	177	4.62	47	0.7	5.6	–	–	435	–	T2	IIA
styrene	$C_6H_5CH{=}CH_2$	-31	145	3.6	30	1.1	8.0	45	350	490	–	T1	IIA
tetrafluoroethylene	$CF_2{=}CF_2$	–	–	–	–	–	–	–	–	–	–	1	IIB

(to be continued)

APPENDIX D (continued)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Flammable material	Formula	Melting point	Boiling point	Relative vapour density	Flash point	Flammable limits				Ignition temperature	Minimum igniting current	T class of suitable apparatus	Apparatus group
						LFL	UFL	LFL	UFL				
		°C	°C		°C	Vol. %	Vol %	mg/L	mg/L	°C	mA		
tetrahydrofuran	$CH_2(CH_2)_2CH_2O$	-108	64	2.49	-17	2.0	11.8	46	360	224	-	T3	IIB
tetrahydrofurfuryl alcohol	$OCH_2CH_2CH_2CHCH_2OH$	-	178	3.52	70	1.5	9.7	60	410	280	-	T3	IIB
tetrahydrothiophen	$CH_2(CH_2)_2CH_2S$	-	-	-	-	-	-	-	-	-	-	†	IIA
3a,4,7,7a-tetrahydro-4,7-methanoindene	$CHCH{=}CHCH_2CHCHCH{=}CHCHCH_2$	-	-	-	(32)	-	-	-	-	-	-	†	IIA
thiophene	$CH{=}CHCH{=}CHS$	-	84	2.90	-1	-	-	-	-	-	-	†	IIA
toluene	$C_6H_5CH_3$	-95	111	3.18	8	1.2	7	46	270	535	-	T1	IIA
toluidine§§	$CH_3C_6H_4NH_2$	-16	200	3.7	85	-	-	-	-	480	-	T1	IIA
triethylamine	$(C_2H_5)_3N$	-115	89	3.5	0	1.2	8	50	340	-	-	-	IIA
α,α,α-trifluorotoluene	$C_6H_5CF_3$	-	102	5.0	12	-	-	-	-	-	-	†	IIA
trimethylamine	$(CH_3)_3N$	-117	3	2.04	-	2.0	11.6	49	285	(190)	-	(T4)	IIA
trimethylbenzene	$C_6H_3(CH_3)_3$	-45	165	4.15	-	-	-	-	-	470	-	T1	IIA
1,3,5-trioxane	$OCH_2OCH_2OCH_2$	62	115	3.11	(45)	3.6	29	135	1110	410		T2	IIB
turpentine	Mixture	-	149	-	35	0.8	-	-	-	254	-	T3	IIA
vinyl acetate	$CH_3COOCH{=}CH_2$	-	-	-	-7	-	-	-	-	-	-	†	IIA
xylene	$C_6H_4(CH_3)_2$	-25	144	3.66	30	1.0	6.7	44	335	464	-	T1	IIA

* Sublimation temperature.
† T class data not available. Seek expert advice.
‡ Applicable to both *trans* and *cis* forms.
§ Data relate only to *m*-cresol and *p*-cresol; *o*-cresol is less hazardous.
|| Data relate to ortho form. *N,N*-dimethylaniline is slightly more haz
¶ In an enclosed vessel.
** Data relate to the form of-isobutyl carbinol but data for non
†† Data relate to hexan-1-ol. Where data are available for r
‡‡ Data relate to octan-1-ol. Data for other isomers giv
§§ Data relate to both ortho and para forms.

NOTE. The presence of impurities can affect t

(From BS 5345 part 1

APPENDIX E
EXTRACT FROM NATIONAL ELECTRICAL CODE (NFC 70) DESCRIPTION FOR CLASS 1 LOCATIONS (DIVISION 1 & 2)

CLASS I LOCATIONS:

Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitible mixtures. Class I locations shall include those specified in (a) and (b) below.

a) CLASS I, DIVISION 1

A Class 1, Division 1 location is a location:

1) In which ignitible concentrations of flammable gases or vapors can exist under normal operating conditions, or,

2) In which ignitible concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage, or,

3) In which breakdown or faulty operation of equipment or processes might release ignitible concentrations of flammable gases or vapors and might also cause simultaneous failure of electric equipment.

FPN) This classification usually includes locations where volatile flammable liquids or liquefied flammable gases are transferred from one container to another, interiors of spray boots and areas in the vicinity of spraying and painting operations where volatile flammable solvents are used, locations containing open tanks or vats of volatile flammable liquids, drying rooms or compartments for the evaporation of flammable solvents, locations containing fat and oil extraction equipment using volatile flammable solvents, portions of cleaning and dyeing plants where flammable liquids are used, gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape, inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids, the interiors of refrigerators and freezers in which volatile flammable materials are stored in open, lightly stoppered, or easily ruptured containers, and all other locations where ignitible concentrations of flammable vapors or gases are likely to occur in the course of normal operations.

b) CLASS I, DIVISION 2

A Class I, Division 2 location is a location:

1) In which volatile flammable liquids or flammable gases are handled, processed, or used but in which the liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment, or,

2) In which ignitible concentrations of gases or vapors are normally prevented by positive mechanical ventilation, and which might become hazardous through failure or abnormal operation of the ventilating equipment, or,

3) That is adjacent to a Class I, Division 1 location and to which ignitible concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

(to be continued)

APPENDIX E (Continued)

FPN) This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used but which, in the judgment of the authority having jurisdiction, would become hazardous only in case of an accident or of some unusual operating condition. The quantity of flammable material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved and the record of the industry or business which respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location.

FPN) Piping without valves, checks, meters and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Locations used for the storage of flammable liquids or of liquefied or compressed gases in sealed containers would not normally be considered hazardous unless subject to other hazardous conditions also.

Electrical conduits and their associated enclosures separated from process fluids by a single seal or barrier shall be classed as a Division 2 location if the outside of the conduit and enclosures is a non-hazardous location.

CLASS II LOCATIONS:

Class II locations are those that are hazardous because of the presence of combustible dust. Class II locations shall include Those specified in (a) and (b) below:

a) CLASS II, DIVISION 1

A Class II, Division 1 location is a location:

1) In which combustible dust is in the air under normal operating conditions in quantities sufficient to produce explosive or ignitible mixtures, or,

2) Where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitible mixtures to be produced and might also provide a source of ignition through simultaneous failure of electric equipment, operation of protection devices, or from other causes, or,

3) In which combustible dusts of an electrically conductive nature may be present in hazardous quantities.

FPN) Combustible dusts which are electrically non-conductive include dusts produced in the handling and processing of grain and grain products, pulverized sugar and cocoa, dried egg and milk powders, pulverized spices, starch and pastes, potato and wood flour, oil meal from beans and seed, dried hay and other organic materials which may produce combustible dusts when processed or handled. Electrically conductive dusts are dusts with a resistivity less than 10^5 ohm-centimeter.
Dusts containing magnesium or aluminum are particularly hazardous and the use of extreme precaution will be necessary to avoid ignition and explosion.

b) CLASS II, DIVISION 2

A Class II Division 2 location is a location where combustible dust is not normally in the air in quantities sufficient to produce explosive or ignitible mixtures, and dust accumulations are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus, but combustible dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment and where combustible dust accumulations on, in, or in the vicinity of the electrical equipment may be sufficient to interfere with the safe dissipation of heat from electrical equipment or may be ignitible by abnormal operation or failure of electrical equipment.

(to be continued)

APPENDIX E (continued)

FPN) The quantity of combustible dust that may be present and the adequacy of dust removal systems are factors that merit consideration in determining the classification and may result in an unclassified area.

FPN) Where products such as seed are handled in a manner which produces low quantities of dust, the amount of dust deposited may not warrant classification.

CLASS III LOCATIONS:

Class III locations are those that are hazardous because of the presence of easily ignitible fibers or flyings, but in which such fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitible mixtures. Class III locations shall include those specified in (a) and (b) below:

a) CLASS III, DIVISION 1

A Class III, Division 1 location is a location in which easily ignitible fibers or materials producing combustible flyings are handled, manufactured or used.

FPN) Such locations usually include some parts of rayon, cotton and other textile mills, combustible fiber manufacturing and processing plants, cotton gins and cotton seed mills, flax processing plants, clothing manufacturing plants, wood working plants and establishments and industries involving similar hazardous processes or conditions.

FPN) Easily ignitible fibers and flyings include rayon, cotton (including cotton liters and cotton waste), sisal or henequen, istle jute, hemp, tow, cocoa fiber oakum, baled waste kapok, spanish moss excelsior and other materials of similar nature.

b) CLASS III, DIVISION 2

A Class III, Division 2 location is a location in which easily ignitible fibers are stored or handled.

Exception: In process of manufacture.

APPENDIX F

COMPARISON OF CLASSIFICATION OF HAZARDOUS AREAS IN "IEC", "IP" AND "BS" VERSUS THAT IN NEC (NFC) WHICH IS ALSO APPLICABLE IN "API" RECOMMENDED PRACTICE

DEFINITIONS / REFERENCE	AREA IN WHICH AN EXPLOSIVE GAS ATMOSPHERE IS PRESENT CONTINUOUSLY OR IS PRESENT FOR LONG PERIOD	AREA IN WHICH AN EXPLOSIVE GAS ATMOSPHERE IS LIKELY TO OCCUR IN NORMAL OPERATION	AREA IN WHICH AN EXPLOSIVE ATMOSPHERE IS NOT LIKELY TO OCCUR IN NORMAL OPERATION AND IF IT DOES OCCUR IT WILL EXIST FOR A SHORT PERIOD ONLY
IEC 79.10 PART 10 (1986)	Zone 0	Zone 1	Zone 2
IP PART 15 (1990)	Zone 0	Zone 1	Zone 2
BS 5345 PART 2 (1983)	Zone 0	Zone 1	Zone 2
NEC 70 ARTICLE 500 (1987) ALSO NFC 70 ARTICLE 500 (1989)	←	DIVISION 1	DIVISION 2

Notes:

1) Definitions for Zone 0,1 and 2 in hazardous area classification are technically identical (in pertinent part and edition) of IEC, IP and BS.

2) There is no Division 0 (similar to Zone 0) in NEC (covering API) classification of hazardous location, but scrutiny of definition for Class 1 Division in Article 500 NEC 70 (1987) shows that the upper end of Division 1 i.e. the most hazardous locations will come under Zone 0 locations in IEC, IP and BS hazardous classification.

For latest definition of Class 1 Division 1 hazardous location see Appendix "E".

3) There is no hazardous locations with Class II and or Class III classification in Oil, Gas and Petrochemical Industries for the time being and there is no need to be covered in this standard.

Caution:

Only the certified and approved intrinsically safe, light current devices, circuits and systems or special devices which are particularly designed, tested and certified for application in:

a) Zone 0: (shall be installed in Zone 0 to IEC, IP and BS concept). Where an explosive gas is continuously present or present for long time.

b) Division 1: (shall be installed in Division 1 to NEC 70 Article 500 and API-RP 500 A,B,C).Where explosive or ignitible concentrations of flammable gases or vapors exist continuously, for long time or intermittently: i.e., the upper end of hazard in Class 1 Division 1 hazardous location.

4) See also Table 3 in Part 2 for selection of apparatus according to zone, gas and vapor risk.

PART 2

METHOD OF SAFEGUARDING

OF

ELECTRIC INSTALLATION

1. SCOPE

This Recommendation deals with the special precautions necessary to ensure the safe use of electricity in oil, gas, and petrochemical industries where flammable materials are manufactured, processed, handled, or stored. It does not deal with the dangers in Explosive factories nor does it deal with risk arising from static electricity or lightning.

It is concerned mainly with sources of ignition arising from the use of current electricity that is to say electric arcs, sparks, and heating effects.

2. METHODS OF SAFEGUARDING

2.1 Segregation

2.1.1 Definition

Segregation is method of safeguarding where fire resistant impermeable barriers are used to create a lower risk zone or a non hazardous area in which electrical apparatus appropriate to the lowered classification should be used.

2.1.2 Examples of segregation

A switchroom containing industrial type switchgear has fire resistant and impermeable walls adjoining the hazardous area and is so arranged that the distances from the sources of hazard to the doors and other openings in the switchroom comply with the requirements of the classification of the hazardous area.

2.2 Flameproof Enclosures (IEC Concept Code Symbol Exd)

2.2.1 Definition

A flameproof enclosure is defined in IEC 79.1 part 1 As:

An enclosure for electrical apparatus that will withstand an internal explosion of the flammable gas or vapor which may enter it without suffering damage and without communicating the internal flame to the external flammable gas or vapor for which it is designed, through any joints or structural openings in the enclosure.

A flameproof enclosure is designed to withstand the pressure of an internal explosion; it is not necessary therefore to provide openings for pressure relief. Where there is a joint, however, or where a spindle or shaft passes through the enclosure, the products of the explosion can escape. Any path which these may take needs to be of sufficient length and constriction to cool the products of the explosion so as to prevent ignition of a flammable atmosphere external to the enclosure. The dimensions of these flame paths are critical and are specified in IEC 79.1 Part 1.

Flameproof enclosures cannot yet be certified independently of their contents but this situation may change for small enclosures as a result of current work.

Alteration to the disposition of the internal components is not permitted because conditions may be created inadvertently which will lead to pressure piling (a condition resulting from the ignition of precompressed gases in compartments or subdivisions other than those in which ignition was initiated, and which may lead to higher maximum pressure than would otherwise be expected). No modification, addition or deletion to the enclosure or its internal components shall be made without the written permission of the certifying authority (such permission shall be obtained through the manufacturer of the apparatus) unless it can be verified that such change does not invalidate the certification.

It should be noted that a flameproof enclosure is not tested for its ability to withstand the effects of an internal electrical fault.

2.2.2 Enclosure grouping and temperature classification

Flameproof enclosures are grouped according to specified maximum permissible dimensions for gaps between joint surfaces and the surfaces of other openings in the enclosure. IEC 79.1 Part 1 quote the maximum permissible dimensions of gaps for the various enclosure groups but, in practice, joints shall be fitted as close as possible and on no account shall the maximum permissible dimensions be exceeded. Table 7 BS 5345.1 Part 1 lists the enclosure group suitable for use with a particular gas or vapor.

All enclosures are marked with the appropriate Standard group reference. For industrial gases the enclosure groups are IIA, IIB and IIC in IEC 79.1 Part. 1

Enclosures certified for a particular group may be used with gases and vapors appropriate to an enclosure group having larger permissible maximum gap dimensions. For example a group IIB enclosure may be used in place of group IIA enclosure but not vice versa.

Enclosures to IEC 79.1 Part 1 are marked with a temperature class (T1-T6 in accordance with IEC 79.0 Part 0) and shall not be installed where flammable materials are used which have ignition temperatures below the maximum for that class.

2.2.3 Cable entries

It is necessary, at the time of ordering, to specify the number and size of cable entries to a flameproof enclosure. These have to be machinecut by the manufacturer and this operation shall not be carried out on site.

2.2.4 Conditions of use

Flameproof enclosures are primarily intended for use in Zone 1 gas and vapor risks. When used in Zone 2 gas and vapor risks no relaxation of the application, installation or maintenance requirements shall be permitted. Flameproof enclosures must not be used in Zone 0.

Where a flameproof enclosure is exposed to the weather or installed in wet conditions an enclosure which is specifically designed as flameproof/weatherproof shall be used where available. Weatherproofing is usually achieved in this type of enclosure by gasketed joints which are additional to and separate from the flame paths. The weatherproofing of other flameproof enclosures may be achieved by the use of suitable grease in the flame path (see Clause 2.2.6) provided that these are not adversely affected by chemicals with which they may come into contact.

Where a flameproof enclosure is exposed to corrosive conditions its safety features may be impaired by corrosion of the enclosure. It shall therefore, be suitably protected by, for example, painting external surfaces and the greasing of flanges (see Clause 2.2.6). Consideration shall also be given to increasing the frequency of maintenance.

Type Exd protection is applicable to virtually all types of electrical apparatus.

In this type, equipment is housed in an enclosure into which gas can gain access; the gas can be ignited within the enclosure without the explosion damaging the enclosure or being transmitted to any flammable atmosphere external to the enclosure.

The enclosure must be sturdy enough to withstand the explosion and to have closely machined flanges of specified minimum lengths on all covers, spigots, shafts and bearings etc., which provides access paths through all its walls or covers.

Assessment of suitability of a specific enclosure involves comparison with closely specified constructional features along with actual explosion and ignition transmission tests under prescribed conditions.

2.2.5 The effect of tape and obstacles on flame paths

The tape wrapping of flanged joint and other opening or the presence of obstacles near the edges of flanges joints and other openings may impair the protection afforded by a flameproof enclosure to compensate for these effects the rules set out below which are applicable in both zone 1 and zone 2 shall be observed:

2.2.5.1 Tape (usually a grease impregnated linen tape)

I) Group IIC enclosures

Tape shall not be applied to any flanged Joint or spindle or shaft gap.

II) Group IIB and IIA enclosures

a) Tape shall not be applied to spindle or shaft gaps.
b) Irrespective of the flange width. The tape shall be restricted to one layer enclosing all parts of the flange with a short overlap and new tape shall be applied when existing tape is disturbed.

2.2.5.2 Obstacles (such as external covers, guards, supports, pipes, structural steel work etc.).

Where the obstacle is more than 40 mm away from the edge of flanged joint or other opening no special precautions are necessary.

I) Group IIC enclosures

There shall be no obstacle within 40 mm of flanged joint or spindle or shaft gap.

II) Group IIB and IIA enclosures

a) There shall be no obstacle within 6 mm of flanged joint or within 40 mm of a spindle or shaft gap.
b) Where an obstacle is between 6 mm and 40 mm of a flanged joint the gap shall not exceed 0.1 mm irrespective of the flange width.

2.2.5.3 Integral obstacles

Many flameproof enclosures have obstacles external to and integral with the enclosure but since they have been tested and certified in this condition no special rules or precautions are necessary.

2.2.6 The effect of grease, other sealants and paint on flanged joints

Experience has shown that the presence in a flanged joint of grease or non setting jointing compound has caused no deterioration in the flameproof qualities of the joints, the same results has been obtained where the exterior of the flanges has been painted, even if the paint has filled and bridged the gap. Therefor no special precautions are necessary when these materials are applied, except that aluminum paint should not be used because of the potential danger from a combination of aluminum and rust. (see also clause 2.11.4)

2.2.7 Aluminum flameproof enclosures and cables with aluminum conductors

The risks can arise when aluminum is used as a flameproof enclosure material and when aluminum conductors are used inside flameproof enclosures. Until further information is available the following precautions, shall be applied.

Because aluminum flameproof enclosures can eject hot aluminum particles under fault conditions, and because of the danger of arcs burning through the enclosure, the use of such enclosures is restricted to circuits protected by a 15 ampere or smaller fuse.

Cables with aluminum conductors shall not be used in flameproof enclosures unless the possibility of ejecting hot aluminum particles from the enclosures has been minimized by either:

a) Using cable terminating enclosures whose joints are threaded or spigoted, or

b) Using fully insulated conductors, and using terminals which are designed or reduce the likelihood of faults and are shrouded by insulation. The compound filling of boxes is one method of meeting this requirement.

2.3 Intrinsically Safe System (IEC Concept Code Symbol Exi)

2.3.1 Principle

I) In an intrinsically safe system the energy release in those part of the system intended for use in the hazardous area is limited under both normal and specified fault conditions, to well below the minimum energy which can cause ignition.

II) In BASEEFA certification standard SFA 3012 an intrinsically safe system is defined as a system comprising apparatus and interconnecting wiring in which any spark or thermal effect in any part of the system intended for use in the hazardous area is incapable under prescribed conditions, of causing ignition of a given gas or vapor.

Note:

In this part the term intrinsically safe system is also used to describe the self contained intrinsically safe apparatus in which all the circuits are intrinsically safe circuits.

III) Because the minimum ignition energy is very small usually below one millijoule, this method of safeguarding can be applied only to light current application such as:

Instrument, communication and data transmission.

IV) No modification, addition or deletion shall be made to an intrinsically safe system, until a certificate of intrinsic safety has been obtained for the proposed change or until it has been established that the change is permitted by the original certificate issuing authority.

V) All intrinsically safe systems posses power sources, and precautions needs to be taken to ensure that these can not release, unsafe amount of energy in the hazardous area. Intrinsically safe system also require to be protected against invasion from all other circuits and systems, whether these are intrinsically safe or not, thus there are requirements for clearance and creepage distances. Insulation values, earthing, screens etc., to prevent invasion of an intrinsically safe system either directly or by induction.

VI) The two most common forms of intrinsically safe systems are:

1) Those which have parts in the hazardous area and a power supply in the non hazardous area, such a power supply often being an integral part of the associated safe area apparatus see diagram 1.

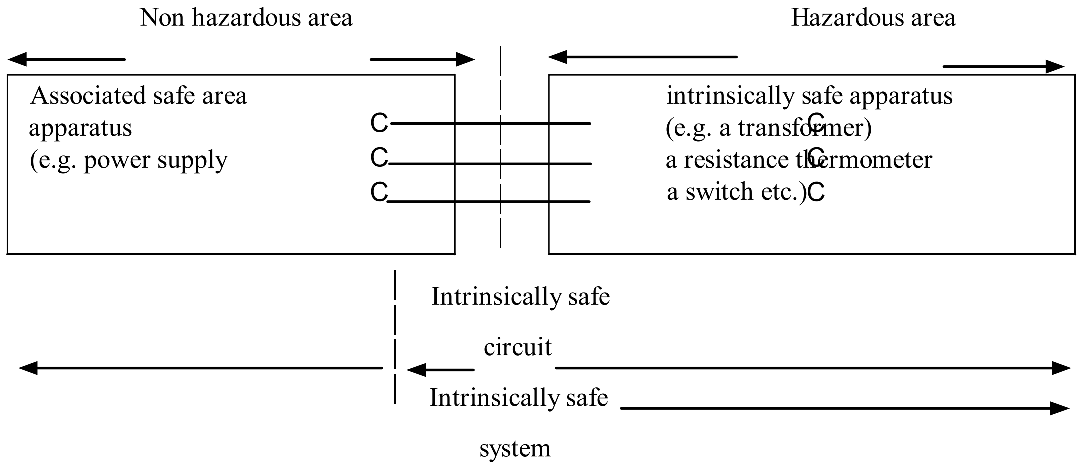


diagram 1

Notes:

1) The associated safe area apparatus and the intrinsically safe apparatus may have individual certificates but the interconnection of such items of apparatus does not necessarily constitute an intrinsically safe system, because an item of apparatus has input and output parameters (e.g., inductance, capacitance, voltage, and current which may not match those of the apparatus in the system). A certificate of intrinsic safety shall therefore be obtained for the complete intrinsically safe system.

In these cases in order to prevent dangerous amount of energy being fed to the hazardous area. The power supply is of special design, and energy limiting components are where necessary installed in the circuit to the hazardous area.

In the case of main power supply, it is usually necessary for the transformer to comply with "BASEEFA" certification standard SFA 3012 requirements (or its equivalent) for inviolate transformers, so that there is virtually no possibility of the main voltage breaking through to the power voltage circuit, current limiting is then usually achieved by the insertion of inviolate resistors in the circuit.

Alternatively when barrier units are used these effectively limit both voltages and current to the hazardous area, provided that the associated safe area apparatus complies with the requirements of the certificate of intrinsic safety. Circuit connected to the hazardous area terminals of a barrier unit need to be certified for use with the barrier unit.

Additional information may be obtained from BASEEFA certification standard SFA 3004.

2) Those which have all parts in the hazardous area and are battery or self powered (see diagrams 2 and 3).

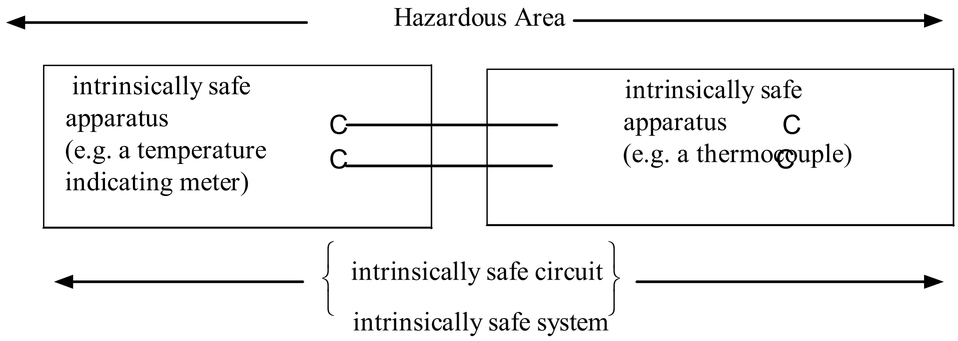


diagram 2

2) The items of intrinsically safe apparatus may have individual certificates of intrinsic safety, but the interconnection of such items of apparatus does not necessarily constitute an intrinsically safe system because an item of apparatus has input and output parameters (e.g., inductance; resistance, voltage, and current) which may not match those of the other apparatus in the system. A certificate of intrinsic safety shall therefore be obtained for the complete intrinsically safe system.

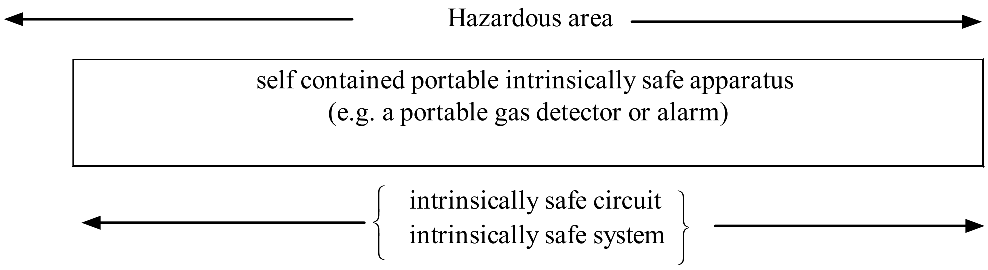


diagram 3

3) This type of apparatus is considered to be intrinsically safe system for the purpose of this part.

Apart from the consideration given to power sources detailed in Notes 2 and 3 above, account has to be taken in all cases of any sources of energy generation or storage which may exist either in the non-hazardous area or the hazardous area. Example of such sources are:

Capacitance and inductance.
Thermoelectric.
Electrochemical devices.
Motors and tachogenerators.

Values of capacitance or inductance which normally would be considered (e.g., 20 picofarads or 100 microhenries) are significant in some circuits and care shall always be exercised to ensure that excessive values are not introduced by the use of long cables of an inappropriate type.

2.3.2 Certification

Intrinsically safe apparatus,circuits and systems shall be certified.

A certificate of intrinsic safety certifies that a specified system or apparatus is intrinsically safe in accordance with the requirements of BASEEFA certification standards SFA 3012. (or its equivalent).

The certificate is valid only when the system or apparatus is installed in accordance with the requirements laid down in the certificate.

Because of misuse and misunderstanding of the term intrinsically safe a check should always be made to ensure that a certificate of intrinsic safety exists and that it applies to the system concerned. A certificate of intrinsic safety for apparatus is not necessarily proof that the system which contains it is safe except in the case of self contained intrinsically safe apparatus which is considered to be an intrinsically safe system for the purpose of this volume (see also the notes to the diagrams in Clause 2.3.1). It is therefore necessary to examine carefully the scope of particular certificate of intrinsic safety and to ensure that all parts of the system both within and outside the hazardous area are fully covered by the certificate or by the series of complementary and cross referenced certificates.

2.3.3 Categories

There are two categories of intrinsic safety "ia and ib". The difference relates to the fault consideration of the apparatus or circuit and defines the safety factor under these conditions. Essentially the definition are as follows:

Ex "ia": Electrical apparatus of this category shall be incapable of causing ignition in normal operation with a single fault and with any combination of two faults applied with the following safety factors:

"1.5" **:** In normal operation and one fault.
"1" **:** With two faults.

Ex "ib": Electrical apparatus of category Exib shall be incapable of causing ignition in normal operation and with a single fault applied with the following safety factors:

"1.5" **:** In normal operation and with one fault.
:1" **:** With one fault if the apparatus contain no unprotected switch contacts in parts likely to be exposed to a potentially explosive atmosphere and the fault is self revealing.

Therefore category Exia apparatus considers up to two faults and even with two faults there will still be a unity safety factor, where as category Exib apparatus considers only one fault.

For either category the safety factor in normal operation or with one fault is 1.5.

Category "ia" is suitable for zone 0, 1 and 2, while category "ib" shall not be used in zone 0, and is only suitable for zones 1 and 2.

Notes:

1) Safety factor is the amount of load above the normal operating rating that a device can handle without failure.

2) Opening shorting or grounding of field installed wiring is considered to be a part of normal operation.

2.3.4 Groups and classes

Intrinsically safe systems are grouped or classified according to the gas used for testing and/or assessment prior to certification. Lists of gases and vapors associated with particular groups/classes are given in table 7 BS 5345.1 part 1 and BASEEFA certification standard SFA 3012.

When choosing system for use in a particular flammable atmosphere the system chosen shall be certified for use in the group/class associated with that atmosphere or in a group/class of lower ignition energy. Thus system certified for group IIB (BASEEFA) Certification Standard (SFA 3012) may be used in flammable atmospheres associated with groups IIA or IIB but shall not be used in flammable atmospheres associated with group IIC.

2.3.5 Temperature classification

Intrinsically safe systems now have also a designated temperature class (T1-T6 in accordance with IEC 79.0 part 0) and shall not be installed where flammable materials are used which have ignition temperatures below the maximum for that class.

Note:

The presence of dust layers may impair normal heat dissipation and result in elevated temperatures of both apparatus and dust.

2.4 Apparatus With Type of Protection "s"

(Special protection to BASEEFA certification standard SFA 3009):

2.4.1 Definition

A concept for those type of electrical apparatus that by nature do not comply with the constructional or other requirements specified for apparatus with established types of protection, but nevertheless can be shown, where necessary by test to be suitable for use in hazardous areas in prescribed zones.

Note:

This concept will largely be superseded by type of protection 'm' encapsulation for which a CENELEC publication No. EN 50028 is prepared.

Examples of apparatus with type of protection "s" are:

Factory sealed fluorescent hand lamps.
Potted solenoid for valve operation complete with cable.

2.4.2 Conditions of use

Apparatus with type of protection "s" are suitable for use in zones 1 and 2.

Apparatus with type of protection "s" is normally suitable for use in all gases and vapors associated with groups IIA IIB, IIC of IEC 79.1 part 1 except where certificate states otherwise.

Apparatus with type of protection "s" shall not be installed where flammables are used which have ignition temperature below the maximum given in IEC 79.0 part 0 for temperature class (T1-T6)

Apparatus with type of protection "s" shall not be used in any flammable atmosphere for which has not been certified.

No modification addition or deletion to such apparatus shall be made without the written permission of the approving or certifying authority (such permission shall be obtained through the manufacturer of the apparatus).

Note:

When the subject apparatus is a torch, correct dry cells shall be used. If high power cell is applied it may invalidate the approval or certification. When selecting apparatus special care shall be taken to ensure that the apparatus and its component parts are constructed so as to guard against electrical and mechanical failure in the intended condition of use.

Particular attention shall be given to the need for weather proofing and protection against corrosion, for apparatus with type of protection "s".

2.5 Electrical Apparatus With Increased Safety Type of Protection Exe.

2.5.1 Type of protection Exe is defined in IEC 79.7 part 7 as follows:

I) The type of protection Exe is the method of protection by which additional measures are applied so as to give increased security against the possibility of excessive temperatures and of the occurrence of arcs and sparks in apparatus which does not produce arcs or sparks in normal service.

II) Type "e" protection is used for equipment which in normal use produces neither sparks arcs nor dangerous temperature. It is necessary only to increase the safety means of additional mechanical electrical and, thermal protection method so that danger from ignition is not expected even during fault conditions.

2.5.2 Condition of use

Whilst type of protection "e" has features in common with type of protection "n" it is, in many respects, more stringent (e.g., in the case of motors lower temperature rises are specified and special overload protection is required to avoid excessive temperatures under all conditions including stalling).

Apparatus with type of protection "e" may be used in Zone 2 gas and vapor risks with any type of enclosure which is suitable for the environment provided it is permitted in the above Standards. Apparatus with type of protection 'e' may also be used in Zone 1 gas and vapor risks provided that:

I) The enclosures of live bare parts and insulated parts are to degrees of protection IP54 and IP44 (see clause 2.11) respectively as a minimum, except that where there is a likelihood of harmful gases and vapors entering the enclosure in quantities likely to cause deterioration of the insulation, the enclosure of insulated parts shall also be to IP54 as a minimum.

II) In the case of motors the methods of control of the rotor and stator winding temperatures are strictly in accordance with the above Standards. The devices used for temperature control, whether of the current dependent or temperature detector type shall be high quality and shall be regularly tested.

Apparatus with type of protection 'e' is marked with a temperature class T1-T6 in accordance with IEC 79.0 part "o" and shall not be installed where flammable materials are used which have ignition temperatures below the maximum for that class.

Although apparatus with type of protection 'e' is suitable for use in all gases and vapors, provided account is taken of surface temperature considerations, it is sometimes used in combination with parts which have some other form of protection (e.g., switches which are flameproof), in which case attention shall be paid to any gas or vapor grouping of the parts with the other form of protection.

No modification, addition or deletion shall be made to apparatus with type of protection 'e' without the written permission of the certifying authority (such permission shall be obtained through the manufacturer of the apparatus) unless it can be verified that such change does not invalidate the certification.

When selecting apparatus special care shall be taken to ensure that the apparatus and its component parts are constructed so as to guard against electrical and mechanical failure in the intended conditions of use.

Particular attention shall be given to the need for weatherproofing and protection against corrosion.

Note:

The main advantage of this type of protection is its economy particularly when it is applied to three phase and single phase induction motors and to the non sparking parts such as stator, and rotor of synchronous motors.

2.6 Electrical Apparatus with Type of Protection "n" IEC Concept Code Symbol Exn.

2.6.1 Definition

A type of protection applied to electrical apparatus such that in normal operation it is not capable of igniting a surrounding explosive gas atmosphere and a fault capable of causing ignition is not likely to occur.

The general requirements of such apparatus are that it shall not in normal operation.

I) Produce an arc or spark unless:

a) the operational arc or spark occurs in an enclosed break device; or,
b) the operational arc or spark has insufficient energy to cause ignition of a flammable atmosphere; or,
c) the operational arc or spark occurs in a hermetically sealed device.

II) Develop a surface temperature or hot spot capable of causing ignition of an external flammable atmosphere.

Note:

This requirement applies to the temperature of internal and external surfaces to which a surrounding atmosphere has access, except internal surfaces within enclosed break devices, hermetically sealed devices or restricted breathing enclosures.

Type "n" protection is intended for use in Zone 2 hazardous areas, its cost and its requirements is less severe than type of protection "e" apparatus 1.

2.6.2 Condition of use

I) Apparatus with type of protection "n" is only suitable for Zone 2 (and safe areas) and shall not be used in Zone 1 classified hazardous areas.

II) Suitability of apparatus for use in all gases and vapors including hydrogen and acetylene when mixed with air shall be tested and certified with due consideration to surface temperature.

III) Temperature classification of this type of apparatus shall comply with requirements of clause 4.3 of IEC publication 79.15 Part 15 for maximum surface temperature. T1-T6

IV) Ingress protection (IP) of apparatus shall be IP 54 and IP 44 part for location of installation in compliance with the requirements of IEC publications 34.5, 144, 529 whichever relevant.

V) No modification addition or deletion shall be made to apparatus with type of protection "n" without the written permission of the certifying authority (such permission shall be obtained through the manufacturer of the apparatus) unless it can be verified that such changes does not invalidate the certification.

VI) When selecting apparatus special care shall be taken to ensure that the apparatus and its component parts are constructed so as to guard against electrical and mechanical failure in the intended conditions of use.

VII) Particular attention shall be given to the need for weather proofing and protection against corrosion.

VIII) Apparatus with type of protection "n" are categorized as follows:

a) ExnA non sparking

b) ExnC sparking apparatus in which the contacts are suitably protected other than by restricted protection enclosure.

c) ExnR restricted breathing enclosure is a method of construction of enclosure in which the possibility of entry of surrounding explosive gas atmosphere is reduced to a low level.

Note:

For more details about electrical apparatus with type of protection "n". reference shall be made to IEC publication 79.15 Part 15.

2.7 Oil Immersed Apparatus Type of Protection "o" IEC Concept Code Symbol Exo.

2.7.1 This type of protection is one in which immersed in non volatile oil such that an explosive atmosphere which may occur above the oil level or outside of the enclosure can not be ignited. (e.g., switchgear, motor starters and transformers).

2.7.2 This type of apparatus is acceptable for zone 2 of hazardous classified areas.

2.7.3 Type Exo apparatus relies solely on keeping sparking contacts below a minimum depth of oil which is decided from type test.

2.7.4 For details of general requirements and tests of type Exo apparatus reference shall be made to IEC publication 79.6 part 6.

2.7.5 Oil temperature

I) Under rated load and normal service conditions the temperature rise and the temperature of the oil at the surface as well as the temperature of any part of the enclosure that is in contact with the explosive gas atmospheres, shall meet the following requirements:

a) If the maximum ambient temperature is not specified it shall be taken to be 40°C.

b) The temperature of oil shall not exceed the maximum value permitted in IEC recommendation relating to the equipment concerned.

c) The temperature of the oil at its surface and of any part of the equipment that is in contact with the ambient explosive gas atmosphere shall not exceed the limit specified in the relevant IEC publication for electrical apparatus for explosive gas atmosphere.

Note:

For apparatus which may have to carry short time current (short circuit current lasting a specified time) special attention to be paid to the behaviour of the equipment in relation to its surface temperature. In any case the permissible temperature as stated above must not be exceeded.

d) The maximum temperature of the oil at any point in the equipment shall in no case exceed 115°C.

This limit is fixed so as to avoid excessive deterioration of the oil.

e) The requirements leading to the lowest limit will be decisive.

2.8 Encapsulated Electrical Apparatus Type of Protection (EExm)

CENELEC concept EExm.

2.8.1 No specification is yet prepared for this type of protection by IEC, however EN 50028 gives the required information for the type EExm, and can be described as an apparatus which is embedded in mass of fire resistant solid insulating materials, the material should withstand against fracture under internal fault condition.

2.8.2 In this type of protection parts that could ignite an explosive atmosphere by either sparking or heating are enclosed in a compound in such a way that this explosive atmosphere can not be ignited.

2.8.3 This type of protection is permitted for use in all zones except Zone O of classified hazardous areas.

2.9 Special Cases

2.9.1 Battery operated lift truck

Since this type of mobile and similar electrical vehicle may be moved in hazardous areas they shall be considered as source of ignition or heat, and a type of protection appropriate to zone shall be considered for them.

Vehicles to BASEEFA certification standard SFA 3006 are certified for use in zone 1 gas or vapor risk.

2.9.2 Battery rooms

In addition to hazards of explosive gases or vapors which may enter into the battery rooms in oil gas and petrochemical plants and installations, the charging of electrical cells or batteries will contribute to the creation of hydrogen from which many explosions have been reported.

Therefore the following actions are required.

I) Adequate ventilation

Ventilation of battery room shall be so designed that the concentration of hydrogen does not exceeded 1% of free air volume of battery room. or

II) Use of electrical apparatus for Zone 1 with appropriate apparatus subgroup and temperature class for hydrogen ie IIC, T1.

Note:

For further information regarding precaution in battery rooms see:

a) BS 6132 code of practice for safe operation of alkaline secondary cells and batteries.
b) BS 6133 code of practice for safe operation of lead acid stationary cells and batteries.

III) It is necessary to exercise the same precautions where lift trucks and electrical vehicles are charged in non open buildings.

2.9.3 Portable and transportable apparatus

Portable and transportable electrical apparatus, including certified types shall be used in hazardous areas only when other alternatives (e.g. fixed electrical apparatus or pneumatically operated apparatus) are impracticable.

Standard industrial portable and transportable electrical apparatus may be used only when a certificate is issued guaranteeing the absence of flammable atmosphere for the period of use in the area concerned.

The danger shall be recognized of certified apparatus being taken into, or used in a flammable atmosphere for which it has not been certified or approved.

For the precautions necessary for portable and transportable apparatus with light metal enclosures reference shall be made to Clause (2.9.4).

Because of the likelihood of damage which may destroy its safety features portable and transportable apparatus shall be subject to frequent periodic inspection and its issue and return shall be carefully controlled.

2.9.4 Risks with light metals and their alloys*

I) It has been clearly established that incendive frictional sparking from light metals and their alloys can occur when suitable conditions of contact arise particularly when the other material in contact is an oxygen carrier such as rust. Suitable safeguards shall therefore be taken to prevent occurrence of such frictional contact when a flammable atmosphere is present, as the simultaneous occurrence of the two sets of circumstances could lead to ignition.

II) For rigidly mounted electrical apparatus with light metal enclosures, and also for aluminum armored or sheathed cable, sited in Zone 2 the frictional sparking risk may be disregarded. This also applies in Zone 1 unless the impact risk is high. In Zone 0 the use of such apparatus and cables shall be avoided.

III) Portable and transportable apparatus with unprotected light metal enclosures shall not be taken into hazardous areas unless suitably protected against frictional sparking by for example, coating the apparatus with a suitable abrasion resistant material.

When such coatings are used they shall be subject to regular and careful inspection. These precautions shall be adopted even for apparatus for use in Zone 2 since it may be difficult in practice to prevent the transfer of unprotected portable apparatus to an area of greater risk.

IV) Provided the protecting cowls are designed so that they are not readily deformed light metal fans (e.g., on motors) may be used in Zone 1 and Zone 2 since other failures (eg bearing failure) are more likely to create a source of ignition (If plastic fans or cowls are used as alternatives they shall be of antistatic material).

V) The precautions relating to the use of aluminum conductors in flameproof enclosures are given in Clause 2.2.7

Note:

The term 'light metal' refers to such materials as aluminium, magnesium and titanium which are characterized by their ability when finely divided to react exothermically with atmospheric oxygen and as a result, to ignite a flammable atmosphere. The term light alloy refers to an alloy containing at least 50% of the light metal by atomic proportions.

2.9.5 Personal electrical apparatus

Items of personal apparatus which are battery operated example radios, walkie talkies, key ring torches, etc., are sometimes carried by personnel and might be taken inadvertently into a hazardous area. These items can constitute a potential source of ignition and following measures shall be taken:

I) Personal communication apparatus, like, radios, walkie talkies, bleepers torches shall not be taken into a hazardous areas unless they have been certified or approved for the purpose.

II) Uncertified items like radios, cameras with electronic light meters with flash attachments, ohm meters, meggers, calculators and similar apparatus shall not be taken into a hazardous area, unless, the work permit or certificate guaranteeing the absence of a flammable atmosphere has been issued.

2.9.6 Avoidance of physical damage to electrical apparatus and cables

The design and layout of electrical apparatus and its system should take account of possible damage which could occur as a result of unplanned events such as careless movements of a vehicle, flying debris following a well blow out, operation of cranes or dropping of tools or loads.

Therefore all cables should be provided with adequate support and protection including trough or tubs, and to be protected against corrosive fluids or organic chemical that could weaken plastic sheathing.

Due consideration should also be given to the vulnerability of cables to fire.

2.9.7 Avoidance of hazards from electrical sources of ignition

Sparks and hot surfaces obviously present the main hazard but the following as example posses a number of less self evident incendive properties the danger of which shall not be overlooked:

I) Incandescent particles emitted through the gaps in flameproof equipment if not properly designed.
II) Circulating currents in the frames of induction motors.
III) Static charges on plastic enclosures and covers.
IV) Inductive and capacitive pick up particularly on unused cable cores.
V) Earth currents.
VI) Chemical ignition from discarded sodium vapor lamps.
VII) High voltage and radio frequency discharge etc. Many of these dangers can be greatly reduced by suitable design, good installation practice and by skilled operation and maintenance.

The apparatus design is subject to the requirements of the standard for the apparatus concerned and also the standard for the ignition protection concept to which reference is made in this standard. (see 2.9.8).

2.9.8 Avoidance of hazards from non electrical sources of ignition

Although the primary objective of area classification is the selection and location of electrical apparatus; non electrical sources of ignition should be considered in process of area classification.

The following are examples of non electrical sources of ignition which may cause explosion in hazardous areas:

I) Mobile sources.
II) Gas detection equipment.
III) Hot surfaces (vessels pipes etc.).
IV) High pressure hydraulic oil system.
V) Fired heaters.
VI) Combustion engines including diesel engines and gas turbines.
VII) Air intakes etc.
VIII) Road and rail traffic.
IX) Electrostatic hazard.
X) Frictional contact with a light metal or alloy.
XI) Pyrophoric scale and deposit hazard.

Notes:

1) Fire fighting and other emergency service vehicles of standard type and design can present a source of ignition.

2) Where they may have to enter plant, storage and distribution areas etc., under normal, emergency or exercise other than fire, their entry should be strictly controlled.

3) Where for contingency measures such vehicles are part of facilities, they should be located in a central non hazardous area remote from possible sources of major hydrocarbon release but with good immediate access.

2.10 Enclosure Protection (IP)

2.10.1 In addition to protection against explosion, measures are required to be applied for a degree of protection for enclosure to safeguard:

I) Persons against contact with internal live or rotating parts inside the enclosure, and to the apparatus against ingress of solid objects dusts etc.

II) The apparatus against the ingress of water spray, jets, heavy seas and even total immersion.

2.10.2 IP classification has been systemized internationally and described in IEC publications 144, 529 and 34.5 (and also, in EN 60034.5 for rotating machines only).

Ingress protection is denoted by "IP" followed by two characteristic numerical.

I) The first characteristic numeral indicates the degree of protection provided by the enclosure with respect to persons also to the equipment inside the enclosure.

II) The second characteristic numerical indicates the degree of protection provided by the enclosure with respect to harmful ingress of water.

Table 1a, 1b gives degrees of protection of enclosures (as defined in IEC publication 144).

Notes:

1) A third characterizing numerical may also be added to indicate protection against mechanical damage (under considera-tion by IEC).

2) Lettering may also be added to indicate whether the machinery shall be tested stationary or in operation for which letters 'S' and 'M' are applied respectively.

The absence of this lettering denotes that the protection is assessed with machine both running and stationary.

Note:

Tests to prove protection of enclosure of equipment against mechanical damage is under consideration by IEC.

TABLE "1a" - DEGREES OF PROTECTION INDICATED BY THE FIRST CHARACTERISTIC NUMERAL

FIRST CHARAC-TERISTIC NUMERAL	DEGREE OF PROTECTION	
	SHORT DESCRIPTION	DEFINITION
0	NO SPECIAL PROTECTION	NO SPECIAL PROTECTION
1	PROTECTED AGAINST SOLID OBJECTS GREATER THAN 50 mm	A LARGE SURFACE OF THE BODY. SUCH AS A HAND (BUT NO PROTECTION AGAINST DELIBERATE ACCESS) SOLID OBJECTS EXCEEDING 50 mm IN DIAMETER.
2	PROTECTED AGAINST SOLID OBJECTS GREATER THAN 12 mm.	FINGERS OR SIMILAR OBJECTS NOT EXCEEDING 80 mm IN LENGTH. SOLID OBJECTS EXCEEDING 12 mm IN DIAMETER.
3	PROTECTED AGAINST SOLID OBJECTS GREATER THAN 2.5 mm.	TOOLS, WIRES, ETC., OF DIAMETER OR THICKNESS GREATER THAN 2 mm. SOLID OBJECTS EXCEEDING 2.5 mm
4	PROTECTED AGAINST SOLID OBJECTS GREATER THAN 1.0 mm.	WIRES OR STRIPS OF THICKNESS GREATER THAN 1.0 mm: SOLID OBJECTS EXCEEDING 1.0 mm IN DIAMETER.
5	DUST - PROTECTED	INGRESS OF DUST IS NOT TOTALLY PREVENTED BUT DUST DOES NOT ENTER IN SUFFICIENT QUANTITY TO INTERFERE WITH SATISFACTORY OPERATION OF THE EQUIPMENT.
6	DUST - TIGHT	NO INGRESS OF DUST.

TABLE "1b" - DEGREES OF PROTECTION INDICATED BY THE SECOND CHARACTERISTIC NUMERAL

FIRST CHARAC-TERISTIC NUMERAL	DEGREE OF PROTECTION	
	SHORT DESCRIPTION	DEFINITION
0	NON-PROTECTION	NO SPECIAL PROTECTION
1	PROTECTED AGAINST DRIPPING WATER	DRIPPING WATER (VERTICALLY FALLING DROPS) SHALL HAVE NO HARMFUL EFFECT
2	PROTECTED AGAINST DRIPPING WATER WHEN TILTED UP TO 15°	VERTICALLY DRIPPING WATER SHALL HAVE NO HARMFUL EFFECT WHEN THE ENCLOSURE IS TILTED AT ANY ANGLE UP TO 15° FROM ITS NORMAL POSITION
3	PROTECTED AGAINST SPRAYING WATER	WATER FALLING AS A SPRAY AT ANGLE UP TO 60° FROM THE VERTICAL SHALL HAVE NO HARMFUL EFFECT
4	PROTECTED AGAINST SPLASHING WATER	WATER SPLASHED AGAINST THE ENCLOSURE FROM ANY DIRECTION SHALL HAVE NO HARMFUL EFFECT
5	PROTECTED AGAINST WATER JETS	WATER PROTJECTED BY A NOZZLE AGAINST THE ENCLOSURE FROM ANY DIRECTION SHALL HAVE NO HARMFUL EFFECT
6	PROTECTED AGAINST HEAVY SEAS	WATER FROM HEAVY SEAS OR WATER PROJECTED IN POWERFUL JETS SHALL NOT ENTER THE ENCLOSURE IN HARMFUL QUANTITIES
7	PROTECTED AGAINST THE EFFECTS OF IMMERSION	INGRESS OF WATER IN A HARMFUL QUANTITY SHALL NOT BE POSSIBLE WHEN THE ENCLOSURE IS IMMERSED IN WATER UNDER DEFINED CONDITTIONS OF PRESSURE AND TIME
8	PROTECTED AGAINST SUBMERSION	THE EQUIPMENT IS SUITABLE FOR CONTINUOUS SUBMERSION IN WATER UNDER CONDITIONS WHICH SHALL BE SPECIFIED BY THE MANUFACTURER

Note:

Normally, this will mean that the equipment is hermetically sealed. However with certain types of equipment it can mean that water can enter but only in such a manner that it produces no harmful effects.

2.11 Cathodic Protection

To avoid corrosion and hence to prevent the creation of holes and source of release in vessels, pipes etc., appropriate cathodic protection design shall be carried out where necessary. (See standard No. IPS-E-TP-820 for Cathodic Protection Engineering).

3. TEMPERATURE CLASS AND GAS IGNITION TEMPERATURE

3.1 Since flammable gas or vapor can be ignited by contact with a hot surface, for all type of protection apparatus, it is necessary to specify an appropriate temperature (T) class such that the maximum accessible surface temperature internally or externally will not exceed the ignitions temperature of the gases and vapors to which it may become exposed, this is achieved by consideration of the following factors:

3.1.1 The maximum surface temperature rating of the apparatus

This is defined under test by an appropriate certifying body as:

The highest temperature which is attained (but within the tolerances) by any part of surface of an electrical apparatus which would be able to produce an ignition of the surrounding atmosphere.

Note:

The most adverse conditions include recognized overloads and any fault conditions specified in the standard for the type of protection concerned.

3.1.2 Where ambient temperatures are above 40°C. This shall be mentioned in apparatus specification and the normal derating shall apply to maintain the maximum internal and external surface temperatures for which the apparatus shall be designed and supplementary certification is required.

3.1.3 Where apparatus are coupled or assembled to form a system the effective system "T" class will be that of the lowest item in the system, i.e., that of the maximum surface temperature in the system.

3.2 Ignition Temperature

Ignition temperature of a gas known also as auto, self ignition or spontaneous ignition temperature is the lowest temperature at which when mixed with air at normal pressure and as a sequence of chemical reactions initiated on account of solely of temperature, the substance will ignite and burn in the absence of any initiating source of spark or flame.

3.3 Selection of "T" Class

3.3.1 There are six recognized international temperature class namely "T1" to "T6" which has been reflected in IEC 79.0 Part 0 (previously IEC 79.8 part 8).

3.3.2 Method of test of ignition temperature of a vapor or chemically pure gas in air at atmospheric pressure is given in IEC publication 79.4 Part 4 and 4A.

3.3.3 In some standards like UL certain subdivision has been made to temperature classes T2, T3 and T4.

For details of temperature class see Table No.2 of this standard.

3.3.4 The maximum surface temperature of any exposed electrical equipment should not exceed 80% of the ignition temperature of the specific gas or vapor in degrees centigrade.

TABLE 2 - RELATION BETWEEN "T" (TEMPERATURE) CLASS AND INTERNATIONAL STANDARDS

MAX. SURFACE TEMPERATURE IN DEGREE CENTIGRADE	IEC.79.0 PART "0"	BS 5501 PART "1"	CENELEC EN, 50014	UL 698
450	T1	T1	T1	T1
300	T2	T2	T2	T2
280	…	…	…	T2A
260	…	…	…	T2B
230	…	…	…	T2C
215	…	…	…	T2D
200	T3	T3	T3	T3
180	…	…	…	T3A
165	…	…	…	T3B
160	…	…	…	T3C
135	T4	T4	T4	T4
120	…	…	…	T4A
100	T5	T5	T5	T5
85	T6	T6	T6	T6

Note:

All temperatures are based on an ambient of 40°C.

Figures are for group II electrical apparatus.

4. PROCEDURE FOR SELECTING ELECTRICAL APPARATUS INCLUDING APPARATUS GROUPING

4.1 Electrical Apparatus for Hazardous Areas Is Divided Into:

Group I Electrical apparatus for mines susceptible to firedamp (methane).
(Group I Apparatus is not considered in this standard).

Group II Electrical apparatus for places with a potentially flammable atmosphere, other than mines susceptible to firedamp.

4.2 Selection of Group II Apparatus

The electrical apparatus of group II is suitable for gases, vapors and liquids in surface application in the petroleum, oil and gas industry both onland and offshore; according to the nature of the hazardous area for which it is intended and is subdivided to subgroups IIA, IIB, IIC, depending on its suitability for use with specific gas. Since ignition of a flammable atmosphere can occur by either arcs sparks or hot contact the following fundamental consideration shall be carefully scrutinized in selection of electrical apparatus for use in hazardous areas:

4.2.1 The type of protection of the apparatus in relation to the area classification of the hazardous area:

Table 3 of this standard gives example of apparatus according to zone gas and vapor risks.

4.2.2 For the temperature classification of the apparatus in relation to the ignition temperature of the gases and vapors involved, see:

- Table 2 of this standard
- Table 7 of BS 5345.1 Part 1

4.2.3 The apparatus gas subgroup (where applicable) in relation to the relevant properties of the gases and vapors involved; for detail see:

- Table 7 of BS 5345.1 Part 1
- Table 4a of this standard for grouping of electrical apparatus. (See also Table 4b).

4.2.4 The apparatus construction and enclosure in relation to the environmental conditions; refer to table 1 of this standard.

Note:

It should be noted that apparatus with type of protection flameproof Exd are not necessarily weather proof.

TABLE 3 - EXAMPLE OF SELECTION OF APPARATUS ACCORDING TO ZONE, GAS AND VAPOR RISKS

ZONE	TYPE OF PROTECTION
0	Ex "ia" (INTRINSICALLY SAFE) Ex "S" (SPECIALLY CERTIFIED FOR ZONE "0"), FOR SPECIAL APPLICATION
1	ANY TYPE OF PROTECTION SUITABLE FOR ZONE "0" AND Ex "d" (FLAMEPROOF ENCLOSURE) Ex "ib" (INTRINSICALLY SAFE) Ex "s" (SPECIALLY CERTIFIED) FOR SPECIAL APPLICATION
2	ANY TYPE OF PROTECTION SUITABLE FOR ZONE "0" OR "1" AND Ex "e" (INCREASED SAFETY) Ex "n" (TYPE OF PROTECTION "N"), UPON PURCHASER APPROVAL Ex "O" (OIL IMMERSED APPARATUS), UPON PURCHASER APPROVAL

TABLE 4a - GROUPING AND CLASSIFICATION OF ELECTRICAL APPARATUS IN DIFFERENT COUNTRIES

UK & CENELEC BS5501: Part 1 EN 50014	IEC 79	UK BS4683	GERMANY VDE 0171		USA NATIONAL ELECTRICAL CODE		TYPICAL GASES AND VAPORS
					GROUP		
IIA	IIA	IIA	1		D	CLASS 1	ETHANE, PROPANE, BUTANE, PENTANE, HEXANE, HEPTANE OCTANE, NONANE, DECANE, ACETIC ACID, ACETONE, METHANOL, TOLUENE, ETHYLACETATE
IIB	IIB	IIB	2		C		ETHYLENE, COKE OVEN GAS DIMETHYL ETHER, DIETHY-LETHER ETHYLENE OXIDE
IIC	IIC	IIC	3n	3a	B		HYDROGEN
				3b			CARBON DISULPHIDE
				3c	A		ACETYLENE
							ETHYL NITRATE

Note:

Groupings in different countries may slightly differ. The above table is for rough comparisons only and reference should be made to the relevant standard to ascertain the grouping for a particular gas. (See also Table 4b).

TABLE 4b - U.S.A HAZARDOUS LOCATIONS CLASSIFICATION AND GROUPING CONCEPT

* HAZARDOUS LOCATION CLASSIFICATIONS

CLASS I HIGHLY FLAMMABLE GASES OR VAPORS	CLASS II COMBUSTIBLE DUSTS	CLASS III COMBUSTIBLE FIBERS OR FLYINGS

Notes:

*** For pertinent definitions see Article "500" of NEC. 70 (1987) in Appendix "E" in part 1 of this part.**

2) Class II and class III are not within the scope of this standard.

GROUPS:

A - Atmospheres containing acetylene

B - Atmospheres containing hydrogen or gases or vapors of equivalent hazard

C - Atmospheres containing ethylether vapors,ethylene, or cyclopropane

D - Atmospheres containing gasoline, hexane, naphtha, benzine, butane, propane, alcohol, acetone, benzol, or natural gas

E - Atmospheres containing metal dust, including aluminum, magnesium, & other metals of equally hazardous charac teristics

F - Atmospheres containing carbon black, coke or coal dust.

G - Atmospheres containing flour starch, or grain dusts.

5. CERTIFICATION AND MARKING

5.1 Certification

A certificate is a document formally attesting a fact. Therefore certification is the exercise of producing a "Certificate".

5.1.1 In the contest of electrical equipment for use in potentially explosive atmospheres it can be said that the act of obtaining a certificate from an unbiased expert (third party) is an ideal way of ensuring that the risk of utilizing such equipment in such atmospheres produces the minimum of risk.

5.1.2 To secure the interest of users to this end, the following requirements shall be met:

I) User of apparatus needs confidence that a particular apparatus is suitable for use in the place intended for installation.

II) The types of protection, grouping, temperature classification etc. Which are awarded to the apparatus complies with the specific standard.

Note:

Purged or pressurized equipment shall be assessed on the basis of the actual site of use.

III) The certifying body and expert organization should be internationally well known, and documentation produced by them shall be recognized by Regulatory Bodies.

IV) Certificate conditions if any, shall be submitted by manufacturer to user.

5.1.3 The name of some of the recognized Certifying Authorities are given below:

- BRITISH APPROVAL SERVICES FOR ELECTRICAL EQUIPMENT IN FLAMMABLE ATMOSPHERES. (BASEEFA).

- ASSOCIATION OF SHORT CIRCUIT TESTING AUTHORITIES (ASTA).

- UNDERWRITERS LABORATORIES (UL).

- EUROPEAN AUTHORITY FOR HARMONIZED STANDARD CERTIFICATION UNDER ECC "NOW EOTC" Which stands for European Organization for Testing and Certification.

- PHISICALSCH TECHNISCHE BUNDESANSTAITS (PTB).

5.2 Marking

Part of the certification procedure is to ensure that the product is suitably indelibly marked with at least the following information:

5.2.1 Manufacturer’s name or trade mark.

5.2.2 Manufacturer type designation for apparatus.

5.2.3 The indication of the testing station, and the certification reference.

5.2.4 Zonal classification.

5.2.5 Identification of the type of protection (s).

5.2.6 The apparatus group or sub-group (as applicable).

5.2.7 The class of maximum surface temperature.

5.2.8 The standard number to which compliance has been certified, the pertinent part number and the date.

5.2.9 Maximum rating (kW., Volt, Frequency......... etc.).

Any other relevant information.

Note:

Manufacturer should be asked to provide complete instructions for the installation and maintenance.

6. PRECAUTIONS IN USE OF ELECTRICAL APPARATUS WITH EQUIVALENT STANDARDS

If for any reason, apparatus certified by an internationally recognized authority "to standards other than this standard" have to be used. The project engineer responsible for the pertinent project shall carefully scrutinize the case and observe the following procedure.

6.1 Study the equivalent standard to ensure a full understanding of the principles of construction, gas/vapor grouping, and temperature classification.

6.2 Study the appropriate relevant codes of practice to ensure a full understanding of the principles of installation and cabling requirements. Where there are any special installation and maintenance requirements these shall be communicated timely to the personnel responsible for their implementation.

6.3 Study the pertinent certificate to ensure that it applies to the apparatus concerned.

6.4 Ensure from a study of clauses 6.1, 6.2, 6.3 above and Table 3 that the apparatus is suitable for use in zone concerned.

6.5 Apply any restriction or additional safeguard given in this part for the equivalent apparatus (e.g. apparatus with type of protection ’e’ if used in Zone 1 is subject to certain restrictions. (See clause 2.5.2).

6.6 Wherever possible examine a sample of the proposed apparatus to ensure that the constructional features are fully appreciated.

Notes:

1) If there is any doubt about the use of equivalent standards, advice may be sought from the following Authorities, as applicable:

BASEEFA
EOTC
UL
PTB

2) Table 4a gives grouping of electrical apparatus in different countries.

3) Table 4b gives U.S.A hazardous locations classification and grouping concept.

4) Some equivalent standards for potentially explosive atmosphere are given in Table '5' in which :

≡ Stands for identical
= Stands for technically identical
 # Stands for related

TABLE 5 - STANDARDS FOR ELECTRICAL APPARATUS FOR POTENTIALY EXPLOSIVE ATMOSPHERES

DESCRIPTION OF STANDARD		BS No.	IEC AND EN No.
FLAMEPROOF ENCLOSURE	"d"	BS 5501 PT.5 (1977)	# IEC 79-1 PT. 1 (1971) AMD 1 (1979) IEC 79. 1A (1975) ≡ EN 50018
INCREASED SAFEY	"e"	BS 5501 PT. 6 (1977)	# IEC 79.7 PT. 7 (1969)
INTRINSIC SAFETY	"i" (ia ib)	BS 5501 PT.7 (1977)	IEC 79-11 PT. 11 (1984)
ENCAPSULATION	"M"	BS 5501 PT.8 (1988)	≡ EN 50028
TYPE OF PROTECTION	"N" (n)	BS 6941 (1988)	# IEC 79.15 PT.15
GENERAL REQUIREMENTS		BS 5501 PT. 1 (1977)	# IEC 7900 PT. 0 (1983) ≡ EN 50014
OIL IMMERSION	"O"	BS 5501 PT. 2 (1977)	# IEC 79-6 PT. 6 (1968)

Note:

The symbols under description of standard, refer to BS They shall be preceded by Ex for IEC., and EEx for EN Standards.

7. PRECAUTIONS IN INSTALLATION

7.1 Types of protection to which reference is made in this part relates not only to apparatus, but also to the whole system; and installation shall be carried out according to the detailed guidance given in standard No. IPS-C-EL-195.

Which shall cover but shall not be limited to the following items:

- Wiring
- Cabling and cable glands
- Cables with aluminum, sheathing and armoring
- Trunking, ducts, pipes and trenches
- Plugging off of unused cable entries
- Means of effecting safe circuit isolation
- Earthing and bonding
- Etc.

8. INITIAL AND PERIODIC INSPECTIONS

8.1 Initial and periodic inspection is beyond the scope of this part and will be dealt within standard No. IPS-E-EL-215.

Complete safeguarding is not achieved unless proper operation, periodic inspection and maintenance is accomplished, after installation.

8.2 Safe operation and maintenance can only be carried out if there is effective documentation, and when the operation and maintenance personnel are fully trained and familiar with the hazard of gas and vapors, instruction manuals, and are made aware and informed of any changes which may affect the scope of hazard in potentially explosive gas/vapor atmospheres, and the precautions to be observed.

9. CHANGE IN EXISTING AREA CLASSIFICATION

9.1 When the areas that were formerly safe become hazardous because of development or other reasons the extension of zones can affect the mechanical ventilation of some enclosed area.

9.2 With the new zones and their extents some air intake could be in zone 2 which changes the ventilation condition and may affect the safety requirements criteria.

9.3 The ventilation systems in such cases shall be re-evaluated and modified to needs.

9.4 To maintain the required safeguard, new system might be installed, the associated fans may demand more power from the normal or emergency power system which might have also impact on power from the normal or emergency power system which might have also impact on power demand.

9.5 Electrical equipment especially motors could become unsuitable for their newly classified areas.

9.6 Emergency equipment and installations such as the fire water pump, control room and emergency power supply system may need relocation to safe areas.

9.7 When a zone changes or ventilation is reduced existing intrinsically safe circuits and systems shall be evaluated for new condition (zones) and to be redesigned and or modified to avoid any danger from them.

9.8 The enhancement as a consequence of change could be in the form of system relocation, increased mechanical ventilation, and incorporation of additional safety and control devices, including pertinent wiring and cabling.

APPENDICES

APPENDIX A
GLOSSARY

Abnormal

In the context of abnormal operation, the untoward, irregular though not necessarily wholly unexpected, deviation from 'normal'operation.

Adequate Ventilation

This is ventilation, natural, artificial or a combination of both. Sufficient to avoid persistence of flammable atmospheres within sheltered or enclosed areas but insufficient to avoid their initial formation and spread throughout the areas.

This will normally be achieved by a uniform ventilation rate of a minimum of twelve air changes per hour.

Associated Safe Area Apparatus

Apparatus designed to form part of an intrinsically-safe system in which not all the circuits are intrinsically-safe circuits, but which affects the safety of the intrinsically-safe system of which it forms a part. Such apparatus may not be installed in a hazardous area unless provided with appropriate protection (e.g. a flameproof enclosure).

Barrier Unit

A device which restricts the voltage and current entering the hazardous area.

BASEEFA

British Approvals Service for Electrical Equipment in Flammable Atmospheres.

Certificate of Intrinsic Safety

A document certifying that a specified system or apparatus is intrinsically safe in accordance with the requirements of BASEEFA Certification Standard SFA 3012.

Dilution Ventilation

Artificial ventilation sufficient to maintain generally as non hazardous an enclosed area containing a source of release or an aperture into a hazardous area.

Enclosed Area

An enclosed area is any building, room or enclosed space within which in the absence or failure of artificial ventilation, the ventilation does not meet the requirement for adequate ventilation.

(to be continued)

APPENDIX A (continued)

Enclosed Break Device

A device incorporating an electrical contact that is made and broken, the enclosure of which will withstand an internal explosion of the flammable gas or vapor which may enter it without suffering damage and without communicating the internal flame to the external flammable gas or vapor, the net volume of the enclosure being not greater than 20 cm^3.

EEC

European Economic Community

EOTC

European Organization for Testing and Certification

Flameproof

The term applied to an enclosure for electrical apparatus that will withstand an internal explosion of the flammable gas or vapor which may enter it without suffering damage and without communicating the internal flame to the external flammable gas or vapor for which it is designed through any joints or structural openings in the enclosure.

Flammable Atmosphere (Explosive Atmosphere)

A mixture of flammable gas, vapor, mist, or dust with air within the flammable range.

Flammable Dust

A dust capable of ignition when mixed with air in certain proportions as a dust cloud, or capable of ignition as a dust layer.

Flammable Gas or Vapor

A gas or vapor capable of ignition when mixed with air in certain proportions.

Flammable Liquid

A liquid capable of forming a flammable mist or vapor.

Flammable Material

Flammable gas, vapor, liquid, mist or dust.

Flammable Mist

Droplets of flammable liquid capable of ignition when in suspension in air.

(to be continued)

APPENDIX A (continued)

Flammable Range (Explosive Range)

The range bounded by the upper and lower flammable limits.

Flammable Vapor

See flammable gas or vapor.

Flash point

The minimum liquid temperature at which sufficient vapor is given off to form a mixture with air which is capable of ignition under prescribed test conditions (Note: The two types of test apparatus commonly used are ’closed cup’ and ’open cup’ the flash point for most liquids being slightly lower when determined by the former method).

Gas or Vapor Density

The density of a gas or vapor compared with the density of dry air at the same temperature and pressure. It is calculated as the ratio of the molecular weight of the gas or vapor compared with the average molecular weight of air.

Hazard

Likelihood of the occurrence of a flammable atmosphere.

Hazardous area

An area which is classified zone 0, 1 or 2.

Hermetically sealed Device

A device in which an electrical contact is made and broken, which is so constructed that the external atmosphere cannot gain access to the contacts and in which the sealing does not depend on the use of o rings or elastomeric materials.

IEC

International Electrotechnical Commission.

Ignition Temperature (Auto Ignition Temperature)

The lowest temperature at which a flammable material ignites spontaneously under prescribed test conditions. (Note: ignition temperatures can vary widely depending on test conditions and should therefore, in general, be used for guidance only).

Inadequate Ventilation

Ventilation natural or artificial which is insufficient to avoid persistence of flammable atmosphere within sheltered or enclosed areas.

(to be continued)

APPENDIX A (continued)

Initial Boiling Point (IBP)

The lowest temperature at which a liquid or liquid mixture commences to boil under prescribed test conditions.

Intrinsically Safe Apparatus

Apparatus which may be installed in a hazardous area in which all the circuits are intrinsically-safe or which is designed to form part of an intrinsically safe system.

Intrinsically-Safe Circuit

A circuit in which any spark or thermal effect produced either normally or in specified fault conditions is incapable of causing ignition of a given gas or vapor.

Intrinsically Safe System

A system comprising apparatus and interconnecting wiring in which any spark or thermal effect in any part of the system intended for use in the hazardous area is incapable, under prescribed conditions, of causing ignition of a given gas or vapor.

Note:

The term intrinsically safe system is used in this part also to describe self-contained intrinsically safe apparatus in which all the circuits are intrinsically safe circuits.

Invasion

The term used to denote breakthrough of dangerous energy levels into an intrinsically safe system eg by insulation failure or induction.

Inviolate

The term used to denote a component, sub assembly or apparatus which in service or in storage is not likely to become defective in such a manner as to lower the safety of an intrinsically safe system.

IP

Institute of petroleum. (Also ingress protection).

Liquefied Flammable Gas

A flammable material which is stored or handled as a liquid and which at 17.5°C and atmospheric pressure is a flammable gas.

(to be continued)

APPENDIX A (continued)

Lower Flammable Limit (Lower Explosive Limit)

The smallest concentration of flammable gas, vapor, mist or dust which, when mixed with air, is capable of ignition and subsequent flame-propagation under prescribed test conditions.

Minimum Ignition Energy

The minimum amount of electrical energy which, under prescribed test conditions, is capable of causing ignition of a flammable atmosphere or a dust layer.

Non Hazardous Area

An area not classified Zone 0, 1 or 2.

Non Sparking

The term applied to apparatus which under normal operating conditions and except when subject to electrical or mechanical failure will not produce arcs or sparks capable of igniting a surrounding flammable atmosphere.

Open Area

An area in an open air situation where vapors are readily dispersed by wind. Typically air velocities should rarely be less than 0.5 meters per second and should frequently be above 2 meters per second.

Pressurizing

A method of safeguarding whereby air or inert gas, in a room or enclosure, is maintained at a pressure sufficient to prevent the ingress of the surrounding atmosphere which might be flammable.

Where appropriate, the pressure may be provided by a mechanical ventilation system.

Pressurizing/purging

A method of safeguarding employing both pressurizing and purging.

PTB

Physicalsch Technische Bundesanstalt.

Purging

A method of safeguarding whereby a flow of air or inert gas is maintained through a room or enclosure in sufficient quantity to reduce or prevent any hazard which, in the absence of the purge, could arise. (To reduce in this context means to reduce the risk that a flammable atmosphere will occur thus permitting the use of electrical apparatus with a lower standard of safeguarding. Where the object is to prevent a hazard, "sufficient" shall take account of the highest likely rate of release of flammable material within or into the room or enclosure).

Where appropriate the purging may be provided by mechanical ventilation of the forced or induced type.

(to be continued)

APPENDIX A (continued)

Restricted Breathing Enclosure

An enclosure which is not hermetically sealed but which is designed to prevent or restrict the entry of gases and which is capable of passing the type test specified in (IEC 79.15 part 15). It is applied at present primarily to lighting fittings to prevent a flammable atmosphere coming into contact with hot lamp surfaces. It is also used as an additional safety feature on fittings with lampholders which are not enclosed break devices.

Segregation

A method of safeguarding where fire resistant impermeable barriers are used to create a lower risk zone or a non hazardous area in which electrical apparatus appropriate to the lower classification should be used.

Sheltered Area

An area within an open area where ventilation may be less than in a true open area, but is adequate ventilation.

Totally Enclosed

The term applied to apparatus within an enclosure which is so constructed that the risk of entry of a flammable atmosphere which may surround it for a short period is small.

Type of Protection "e"

A method of protection by which additional measures are applied to electrical equipment so as to give increased security against the possibility of excessive temperatures and of the occurrence of arcs and sparks during the service life of the apparatus. It applies only to electrical equipment no parts of which produce arcs or sparks or exceed the limiting temperatures in normal service (but see also Clause 2.8).

Type of Protection "n"

A type of protection applied to electrical apparatus such that in normal operation, it is not capable of igniting a surrounding explosive atmosphere and a fault capable of causing ignition is not likely to occur (but see also Clause 2.6).

Type of Protection "s"

A type of protection applied to electrical apparatus which does not meet the requirements of the types of protection specified in BS 4683 but which can be shown by test or otherwise to be suitable for use in flammable atmosphere of gas or vapor (but see also Clause 2.4).

UL

Underwriters laboratories

(to be continued)

APPENDIX A (continued)

Upper Flammable Limit (Upper Explosive Limit)

The largest concentration of flammable gas, vapor, mist or dust which, when mixed with air is capable of ignition and subsequent flame propagation under prescribed test conditions.

Vapor Density

See gas or vapor density.

Well Ventilated

An area of building substantially open where there is little or no restriction to the natural passage of air through it. (A compressor shelter with a large roof ventilator and with the sides open sufficient to allow free passage of air through all parts of the building is considered to be well ventilated).

APPENDIX B

DESCRIPTIONS OF USEFUL PUBLICATIONS PERTINENT TO SUBJECT

1. American Petroleum Institute (API)

RP 521 Guide for pressure relieving and Depressuring systems: 1982.

2. American Society of Mechanical Engineers

ASME / ANSI B.31.3: 1987 Chemical plant and petroleum refinery piping.

3. British Standards Institution

BS 4683 Specification for electrical apparatus for explosive atmospheres (to be replaced eventually by BS 5501).

Part 1: 1971 Classification of maximum surface temperatures.

Part 2: 1971 The construction and testing of flameproof enclosures of electrical apparatus.

BS 4999 Part 105: 1988 Classification of degrees of protection provided by enclosures for rotating machinery (≡EN 60034 Part 5).

BS 5345 Code of practice for selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres (other than mining applications or explosive processing and manufacture).

Part 1: 1989 General recommendations.

Part 2: 1983 Classification of hazardous areas (≡IEC 79-10).

Parts 3 to 9 cover installation and maintenance requirements for electrical apparatus with various types of protection.

BS 5490 1977 (1985) Specification for classification of degrees of protection provided by enclosures (≡IEC 529).

BS 5500 1988 Specification for unfired fusion welded pressure vessels.

BS 5501 Electrical apparatus for potentialy explosive atmospheres.

Part 1: 1977 General requirements (identical with EN 50014).

Part 2 to 9 cover the construction and testing of electrical apparatus with various types of protection (identical with EN 50014 to EN 50020, EN 50028 and EN50039 respectively).

BS 5958 Code of practice for control of undesirable static electricity.

Part 1: 1980 (1987) General considerations.

Part 2: 1983 Recommendations for particular industrial situations.

(to be continued)

APPENDIX B (continued)

BS 6020 Instruments for the detection of combustible gases.

Part 1: 1981 Specification for general requirements and test methods.

Part 2 to 5 cover specifications for safety and performance requirements of various types of instrument.

BS 6132 1983 Code of practice for safe operation of alkaline secondary cells and batteries.

BS 6133 1985 Code of practice for safe operation of lead-acid stationary cells and batteries.

BS 6467 Electrical apparatus with protection by enclosure for use in the presence of combustible dusts.

BS 6656 1986 Guide to prevention of inadvertent ignition of flammable atmospheres by radio frequency radiation.

BS 6959 1988 Code of practice for selection, installation use and maintenance of apparatus for the detection and measurement of combustible gases (other than for mining applications or explosives processing and manufacture).

BS 7117 Metering pumps and dispensers to be installed at filling stations and used to dispense liquid fuel.

Part 1: 1989 Specification for construction.

4. BASEEFA Certification Standards

	SFA 3002 1971	Petrol metering pumps
	SFA 3004 1976	Shunt diode safety barrier
	SFA 3006 1981	Battery operated vehicles
	SFA 3007 1981	Instrument for measuring gas concentration
*	SFA 3008 1970	Increased safety
	SFA 3009 1972	Special protection
*	SFA 3010 1979	Part 1 Electrostatic paint and powder spray guns
*	SFA 3012 1972	Intrinsic safety
	SFA 3013 1972	Oil immersed apparatus

*** Also see relevant BS**

5. Engineering Equipment and Materials Users Association Publication 107

Recommendations for the protection of diesel engines operating in hazardous areas (originally published by the oil Companies Materials Association as MEC-1).

6. Institute of Petroleum (IP)

Part 1	Electrical (5th edition), 1965
Part 2	Marketing (3rd edition), 1978
Part 3	Refining (3rd edition), 1981
Part 4	Drilling and Production Safety Code for Onshore Operations, 1982

(to be continued)

APPENDIX B (continued)

Part 5	(Withdrawn)*
Part 6	Pipeline (4th edition), 1982
Part 7	Airports, 1989
Part 8	Drilling and Production Safety Code for Offshore Operations, 1990
Part 9	Liquefied Petroleum Gas Volume 1(2nd edition), 1987
Part 10	(Withdrawn)
Part 11	Bitumen (3rd edition), 1990
Part 12	Pressure Vessel Inspection, 1976
Part 13	Pressure Piping Systems Inspection, 1978
Part 14	Inspection and Testing of Protective Instrumentation Systems, 1980
Part 15	Area Classification Code for Petroleum Installation, 1990
Part 16	Tank Cleaning Safety Code, 1989

International Safety Guide for Oil Tankers and Terminals (ISGOTT) (Joint publication by international Chamber of Shipping, Oil Companies International Marine Forum, and the International Association of ports and Harbours). (replaces part 5 of IP).

7. Institution of Electrical Engineers

Recommendations for the Electrical and Electronic Installations of Mobile and fixed Offshore Installations.

8. International Chamber of Shipping/Oil Companies International Marine Forum/International Association of Ports and Harbors.

International Safety Guide for oil Tankers and Terminals.

9. International Electrotechnical Commission

IEC 34	Rotating Electrical Machines
IEC 34.5	Classification of Degrees of Protection Provided by Enclosures for Rotating Machines (≡ BS 4999: Part 20)
IEC 79	Electrical Apparatus for Explosive Gas Atmospheres
IEC 79-0	General Requirements
IEC 79-1	Construction and Test of Flameproof Enclosures of Electrical Apparatus
IEC 79-1A	First Supplement Appendix D: Method of Test for Ascertainment of Maximum Experimental Safe Gap
IEC 79-3	Spark Test Apparatus for Intrinsically Safe Circuits
IEC 79-4	Method of Test for Ignition Temperature
IEC 79-4A	First Supplement
IEC 79-6	Oil Immersed Apparatus
IEC 79-7	Construction and Test of Electrical Apparatus, Type of Protection "e"
IEC 79-9	Marking
IEC 79-10	Classification of Hazardous areas
IEC 79-11	Classification and Test of Intrinsically Safe and Associated Apparatus

(to be continued)

APPENDIX B (continued)

IEC 79-12	Classification of Mixtures of Gases or Vapors with air according to their maximum experimental safe gaps and minimum igniting currents
IEC 79-13	Construction and use of rooms or buildings protected by pressurization
IEC 70-14	Electrical Installations in Explosive Gas Atmosphere (other than mines)
IEC 79-15	Electrical Apparatus with Type of Protection "n"
IEC 92-502	Special Features Tankers
IEC 144	Degrees of Protection of Enclosures for Low Voltage Switch gear & Control gear (≡ BS5420)
IEC 529	Classification of Degrees of Protection Provided by enclosures (≡ BS5490)

10. International Maritime Organization

Code for the construction and equipment of mobile offshore drilling units.

11. Liquefied Petroleum Gas Industry Technical Association

COP 1	Installation and maintenance of bulk LPG storage at consumers' Premises Parts I, II and III
COP 7	Storage of full and empty LPG cylinders and cartridges
COP 12	Recommendations for the safe filling of LPG cylinders of depots
COP 20	Automotive LPG refuelling facilities

12. National Fire Protection Association (USA)

Fire protection guide on hazardous materials.

13. UK Health and Safety Executive

Guidance Note GS21 — Assessment of the radio-frequency ignition hazard to process plant where flammable atmospheres occur.
HS (G) 34 The storage of LPG at fixed installation.
HS (G) 41 petrol filling stations:
Construction and operation.

Technology Division Specialist Inspector Report No. 9-The fire and explosion hazards of hydraulic accumulators.

14. UK Statutes

1976 SI 1019	Offshore Installations (operational safety health and welfare) Regulations 1976.
1981 SI 1059	Dangerous Substances (Conveyance by road in road tankers and tank containers) Regulations 1981.
1989 SI 635	Electricity at work regulations 1989.

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Gate.W.E. Module ventilation rates quantified. Oil and Gas Journal. 23rd December 1985, pp.39-42.

Marshall. M.R. The effect of ventilation on the accumulation and dispersal of flammable gases I. chem.E. 4th International Symposium. Harrogate. 1983.