ENGINEERING STANDARD

FOR

MEASUREMENT OF LIQUID HYDROCARBONS

(CUSTODY TRANSFER)

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APPENDICES:

0. INTRODUCTION

This Engineering Standard is concerned with the measurement of liquid hydrocarbons custody transfers by means of meters. Two principal types of meters which are mostly used, displacement meters and turbine meters are covered.

1. SCOPE

This Engineering Standard Specification covers the minimum requirement for proper engineering specification, installation, selection, operation and maintenance of meter station designed for dynamic measurement of liquid hydrocarbons with acceptable accuracy, safety, reliability, maintainability and quality control. The application criteria for turbine and displacement meters together with considerations regarding the liquid to be measured are also covered in this Standard.

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The edition of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard . The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor.

API (AMERICAN PETROLEUM INSTITUTE)

RP-550	"Manual on Installation of Refinery Instrument and Control System"
RP-500 A	"Classification of Areas for Electrical Installation in Petroleum Refineries"
API 2545	"Method of Gauging Petroleum and Petroleum Products"
Chapter 5	Manual of Petroleum Measurement Standards Liquid Metering
Section 1	General Consideration for Measurement by Meters
Section 2	Measurement of Liquid Hydrocarbons by Displacement Meters
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Chapter 1	Manual of Petroleum Measurement Standards "Vocabulary"
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Chapter 7	Manual of Petroleum Measurement Standards "Temperature Determination"
Chapter 8	Manual of Petroleum Measurement Standards "Sampling"
Chapter 12	Manual of petroleum Measurement Standards "Calculation of Petroleum Quantities"
Chapter 13	Manual of Petroleum Measurement Standards "Application of Statistical Methods"

BSI (BRITISH STANDARDS INSTITUTE)

BS 6169	"Methods for Volumetric Measurement of Liquid Hydrocarbons"
Part 1	"Displacement Meter Systems (Other than Dispensing Pumps)"
Part 2	"Turbine Meter Systems"
BS 6439	"Fidelity and Security of Dynamic Measurement of Petroleum Liquids and Gases in Cabled Transmission as Electric and/or Electronic Data"

ISO (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION)

ISO 2715	"Liquid Hydrocarbons-Volumetric Measurement by Turbine Meter Systems"
ISO 2714	"Liquid Hydrocarbons-Volumetric Measurement by Displacement Meter Systems Other than Dispensing Pumps"

	ISO 6551	"Petroleum Liquid and Gases-Fidelity and Security of Dynamic Measurement Cabled Transmission of Electric and/or Electronic Pulsed Data"

IP (THE INSTITUTE OF PETROLEUM)

Part 9 Sec. 1	"Positive Displacement Meters"
IP 205/71	"Automatic Tank Gauging"
IP 2 02/73	"Tank Calibration, Section 3"

ISA (INSTRUMENT SOCIETY OF AMERICA)

RP 31.1	"Specification, Installation, and Calibration of Turbine Flow Meters"
S 5.1	"Instrumentation Symbols and Identification"
RP 12.1	"Electrical Instruments in Hazardous Atmospheres"
S 12.10	"Area Classification in Hazardous Dust Location"
S 12.11	"Electrical Instruments in Hazardous Dust Locations"
S 18.1	"Annuciator Sequences and Specifications"

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

D 1750-62	"ASTM Table for Positive Displacement Meter Prover Tanks"

IPS (IRANIAN PETROLEUM STANDARDS)

E-IN-110	"Pressure Instrument"
E-IN-120	"Temperature Instrument"
E-IN-130	"Flow Instrument"
E-IN-140	"Level Instrument"

3. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

4. GENERAL CONSIDERATION FOR MEASUREMENT BY METERS

4.1 Field of Application

The field of application of this engineering Standard is the volume measurement of liquid crude oils and refined products, which are normally in the liquid phase at atmospheric pressure and ambient temperature.

This Standard is also concerned with the metering of hydrocarbons which can be made and kept liquid by maintaining the proper pressure and temperature.

The metering of two-phase fluids will not be covered in this Standard.

4.2 Guidelines for Selecting the Type of Meter

Custody transfer metering of petroleum liquids shall be done with high performance versions of either positive displacement (P.D) Meters or turbine Meters.

Although factors such as pressure, flow rate and fluid contamination may influence the type of meter selected, viscosity and flow rate should be considered first.

The viscosity of the meters liquid affects whether a positive displacement meter or turbine meter will provide the best overall accuracy for a particular custody transfer application. Fig. 1 provide a guide line for P.D and turbine Meter selection as a function of viscosity and flow rate.

4.2.1 Selecting displacement meters

The following strengths and weaknesses shall be considered when selecting the displacement eters.

Displacement meters have the following strengths:

a) Accuracy.
b) Capability to measure viscous liquids.
c) Capability to function without external power.
d) Operation near-zero flow rate.
e) Simplicity of design and operation.

Displacement meters have the following weaknesses:

a) Flow surges may damage the meter.
b) High cost of large meters.
c) Susceptibility to corrosion and erosion.
d) Higher maintenance requirement.

4.2.2 Selecting turbine meters

The following strengths and weaknesses shall be considered when selecting the turbine meter.

Turbine meters have the following strengths:

a) Accuracy.
b) Wide flow range.
c) Small size and weight.
d) Wide temperature and pressure range.

Turbine meters have the following weaknesses:

a) Flow conditioning is required.
b) Back pressure control is needed to prevent cavitation.
c) Inability to meter high-viscosity liquids.
d) Sensitivity to viscosity changes at high viscosities.

5. MEASUREMENT OF LIQUID HYDROCARBONS BY POSITIVE DISPLACEMENT METERS

5.1 Introduction

In principle, a displacement meter is a flow measuring device that separates a liquid into discrete volumes and counts the separated volumes. The registered volume of the displaced meter must be compared with a known volume that has been determined by proving.

5.2 Principle of Operation

P.D meters repeatedly entrap a known quantity of fluid as it passes through the meter. When the numbers of times the fluid is entrapped is known, the quantity of fluid that has passed through the flow meter is also known.

In practice, this type of meter senses the entrapped fluid by generating pulses, each of which represents a fraction of the known quantity entrapped.

5.3 Types of Positive Displacement Meters

5.3.1 Helical gear positive displacement meters

Two radially-pitched helical gears are used to continually entrap liquid as it passes through the meter causing the rotors to rotate in the longitudinal plane. Flow through the meter is proportional to the rotational speed of the gears.

5.3.1.1 Helical gear meter shall be applicable to non-abrasive lubricious liquids. Slippage can pose a problem in low viscosity applications, especially if there is any wear of machined parts, so most applications are on high viscosity liquids.

5.3.1.2 This type of P.D meter is somewhat tolerant of dirt, as there are few passages that are easily plugged, but is susceptible to overspeed and bearing damage.

5.3.1.3 Volumetric flows can be measured with an accuracy ranges from approximately 0.2 to 0.4 percent rate, depending on the application and the meter design. Non viscous flows shall be measured less accurately than viscous flows due to errors caused by increased slippage through the meter at low viscosities.

5.3.2 Oscillating piston positive displacement meters

A cylindrical measurement chamber with a partition plate separating the inlet from the outlet port is used.

The motion of the piston is transmitted to a magnet assembly that is used to drive a meter magnet external to the flow stream. It can also be used to drive a register or a transmitter.

As the meter entraps a fixed quantity of liquid each time the meter is rotated, the rate of flow is proportional to the rotational velocity of piston.

5.3.2.1 Oscillating piston meters shall be used on viscous liquid service where turndown is not of great Importance. This meter is somewhat tolerant of dirt, there are few easily plugged passages, but large or abrasive solids can be compressed between the piston and the meter body, thereby distorting the piston.

5.3.2.2 This type of meter can measure volumetric flows with an accuracy of up to approximately ±0.5 percent rate, depending on the application. Non viscous flows shall be measured less accurately due to errors caused by increased slippage through the meter at low viscosities.

5.3.2.3 The maximum flow through oscillating piston meters shall be a function of usage. These meters generally have different flow ratings for continuous and intermittent service where the intermittent service. Turndown ratio in a intermittent liquid application may be typically 5:1 to 6:1. In continuous application, the maximum turndown can be as low as 3:1 to 4:1.

5.3.2.4 This design shall be applicable to clean non-abrasive liquids. Slippage can pose a problem in low viscosity applications, especially if there is any wear of machined parts; therefore, most applications shall be on higher viscosity liquids.

5.3.3 Oval gear positive displacement meters

The differential pressure across the meter causes forces to be exerted on a pair of oval gears, often called rotors, causing them to rotate.

As the upstream pressure is greater than the downstream pressure, the force exerted on the upstream end of the lower face of upper rotor is greater than on the downstream end. This tends to make upper rotate in clockwise direction and lower rotor in a counter clock wise direction.

5.3.3.1 This meter can measure volumetric flows with an accuracy that ranges from approximately ±0.25 to 1 percent rate, depending on the application and meter design. Non viscous flows shall be measured less accurately due to errors caused by increase slippage through the meter at low viscosities.

5.3.3.2 The maximum flow through this P.D meter shall be dependent upon lubricity and viscosity of the liquid.

Turndown in an intermittent lubricious liquid application can be as high as 20:1. The same meter in an intermittent non-lubricious liquid application may have a maximum turndown of 4:1. In continous operation, the turndown is further reduced to approximately 3:1.

5.3.3.3 Oval gear meters shall be applicable to non-abrasive lubricious liquids with viscosities from approximately 0.2 CP to 500.000 CP. Slippage can pose a problem in low viscosity applications, especially if there is any wear of machined parts. Therefore, most applications shall be on higher viscosity liquids.

5.3.4 Rotary positive displacement meters

Rotary positive displacement meters converts the entrapment of liquid into a rotational velocity proportional to the flow through the meter.

As the meter entraps a fixed quantity of liquid each time the meter is rotated, the flow is proportional to the rotational velocity of one of the rotating parts.

5.3.4.1 Rotary flow meters shall be used on liquid service where accuracy is of importance but turndown is not. These meters shall be applicable to clean non-abrasive liquids.

5.3.4.2 This design can measure volumetric flows with an accuracy that ranges from approximately ±0.1 to 0.2 percent rate, depending on the application. Nonviscous flows shall be measured less accurately than viscous flow due to errors caused by increased slippage through the meter at low viscosity service.

5.4 Design Consideration

All types of Displacement meter stations shall meet the following requirements:

a) They shall be suitable for the maximum and minimum flow rates, the maximum permissible operating pressure, the temperature range and the type of liquid to be measured.

Protective devices shall be included to limit or control the operation within the design conditions of the meter station.

b) The regulations for electrical equipment in hazardous areas shall be considered when there is a possibility of a hazardous atmosphere being present at the meter station.

c) They shall be designed in a manner which will result in the maximum dependable operating life. This may require that strainers, filters air/vapor eliminators or other protective devices be installed upstream of the meter to remove abrasive or other particles from the liquid which could stop or cause premature wear of the meters.

A differential pressure gauge shall be used to determine when the filter or strainer should be cleaned.

d) The installation should ensure adequate pressure on the liquid in the metering system at all temperatures so that the fluid being measured shall be in the liquid state at all times.

e) Connection for proving facilities of each meter shall be provided and the installation should be capable of duplicating normal operating conditions at the time of proving.

5.5 Selection of Displacement Meter and Ancillary Equipment

5.5.1 Consideration shall be given to, and Manufacturer consulted, regarding the following when selecting a meter and its ancillary equipment

a) The properties of metered liquids, including viscosity, vapor pressure, density ranges, toxicity, corrosiveness and lubricating ability. These properties may influence meter characteristics and choice of materials of construction.

b) The maximum and minimum rates of flow and whether the flow is continuous, intermittent, fluctuating, bidirectional or reversible.

c) The meter's rangeability, accuracy and the degree of precision required.

d) The range of operating pressure, acceptable pressure losses accros the meter when run at the maximum expected flowrate and whether pressure on the liquid is adequate to prevent vaporization.

e) The operating temperature range and the applicability of automatic temperature compensation and necessity heat tracing.

f) Effects of corrosive contaminants on the meter and the quantity, size, particle distribution and type of foreign matter, including abrasive particles, water and vapor which may be carried in the stream. These may influence the size of straining, filtering and vapor or water separation equipment from the point of flow rate capacity and pressure drop.

g) The class and type of piping connections and materials and dimensions of the equipment to be used.

h) The space required for meter station and the proving facility.

i) The method by which a meter in a bank of meters can be put on or taken off line as the total rate changes and the method by which the meter can be proved at its normal operating rate.

j) The type, method and frequency of proving.

k) Maintenance methods and cost, spare parts required.

l) The adjusting method for meter registration. A means where by a meter read-out may be adjusted so that correction for meter factor is not necessary, and the ease or reliability of the adjustment and its suitability for sealing.

m) Type of indicating or recording devices required and the standard units of volume in which read-out is required.

n) The need for accessory equipment, such as pulsers, additive injection apparatus, combinators, devices for predetermining quantity, and automatic temperature compensators. When meterdriven mechanical accessory devices are used, caution must be taken to limit the total torque applied to the metering element. Consideration should also be given to using electrical transmitter on the meter, and to having various functions operated electrically therefrom.

o) Automatic pressure lubrication for nonlubricating or dirty liquids.

p) The flow or pressure control valves on the meter run should be capable of rapid, smooth opening and closing to prevent shocks and surges. Other valves particulary those between the meter or meters and prover such as the stream diversion valves, drain and vent valves require leakproof shut-off, which may be provided by a double block-and-bleed valve with telltale bleed or by another similarly effective method of verifying shut-off integrity.

5.5.2 Automatic temperature compensators, if installed, shall be chosen to respond to the temperature range of the measured liquid within the required measurement tolerances under all ambient conditions.

5.5.3 Meter capacity shall be based on flow rate range required and allowable pressure drop requirements. Size of inlet /outlet connections do not indicate flow capacity.

5.6 Installation Design Considerations

Meters shall be installed according to the Manufacturer's instructions and shall not be subjected to undue piping strain and vibration. Flow conditioning is not required for displacement meters. (Fig. 2)

5.6.1 Valves

5.6.1.1 Generally all valves especially spring loaded or self closing valves, should be designed so that they will not open to admit air.

5.6.1.2 Valves in a meter installation which may affect measurement accuracy during metering or proving shall be capable of rapid yet smooth opening and closing. They shall provide a leak-proof shut-off with a method of checking for valve leakage, e.g. block and bleed valve.

5.6.1.3 For intermittent flow control, valves should be of the fastacting, shock-free type to minimize the adverse effects of starting and stopping liquid movements.

5.6.1.4 A flow-limiting device, such as a flow rate control valve should preferably be installed downstream of the meter. The control valve should be selected or adjusted so that sufficient pressure will be maintained to prevent vaporization.

5.6.2 Piping

5.6.2.1 Each meter shall be installed in such a manner as to prevent passage of air or vapor through it. If needed, air/vapor elimination equipment shall be installed as close as possible to the upstream side of the meter. The vent lines on air/vapor eliminators shall be of adequate size. The safety of the venting system should be given special design consideration.

Air eliminators can not vent when they are operating bellow atmospheric pressure, and under adverse conditions, they may even draw air into the system. A tight closing check valve in the vent line will prevent air farm being drawn into the system under these conditions.

5.6.2.2 A bank of meters connected in parallel is recommended where they are required in continous service,or where the flow rate is too great for any one meter. Each meter in a bank should be protected against an excessive flow rate, and means should be provided for balancing the flow between individual meters.

5.6.2.3 For meters designed for flow in one direction only, provision shall be made to prevent flow in the reverse direction.

5.6.2.4 Meter installation requires that protective devices be installed to remove from the liquid abrasives or other entrained particles that could stop the metering mechanism or cause premature wear. Strainers, filters, sediment traps, setting tanks, water separators, a combination of the these items, or any other suitable devices can be used. They should be properly sized and installed so that they do not adversely affect the operation of the meter. Monitoring devices shall be installed to determine when the protective device needs to be cleaned.

5.6.2.5 Meters and meter piping shall be protected from pressure pulsation and excessive surges as well as excessive pressure caused by thermal expansion of the liquid. This may require the installation of surge tanks, an expansion chamber, relief valves, pressure limiting valves or other protective devices. Pressure relief valves placed downstream of the meters should not be linked to those placed upstream. A means of detecting spillage from relief valves shall be provided.

5.6.2.6 A back pressure valve may be required to maintain the pressure on the meter and the prover above the fluid vapor pressure. In general, displacement meters do not accelerate fluid velocity and are not subject to the resulting pressure reduction that can cause cavitation in other types of meters.

Whenever possible, flow-limiting devices should be installed downstream of the meter and proving system. An alarm may be provided to signal that flow rates have fallen bellow the design minimum.

If a pressure reducing device is used on the inlet side of the meter, it shall be installed as far upstream of the meter as possible. The device shall be installed so that sufficient pressure will be maintained on the outlet side of the meter installation to prevent any vaporization of the metered liquid.

5.6.2.7 Any condition which may cause the release of vapor from the liquid shall be avoided by proper design and by operation of the meter within the flow range specified by the Manufacturer. The release of vapor can be minimized or eliminated by maintaining sufficient back pressure down stream of the meter. This can be achieved by installing the appropriate type of back pressure, throttling the reducing valve downstream of the meter. The required back pressure may be recommended by Manufacturer.

5.6.2.8 Meters and piping shall be installed so that accidental drainage or vaporization of liquid is avoided. The piping shall have no unvented high points or pockets where air or vapor may accumulate and be carried through the meter by the added turbulence that results from increased flow rate. The installation shall prevent air from being introduced into the system through leaky valves, piping, glands of pumps shafts, separators, connecting lines and so forth.

5.6.2.9 A reliable temperature measuring device shall be installed immediately downstream or upstream of the meter to provide determination of the metered fluid temperature for correction of thermal effects on the stream or meter.

Where several meters are operated in parallel on a common stream, one temperature measuring device in the total stream, located sufficiently close to the inlet or outlets, is acceptable. Test thermowells should be provided near each meter to verify that the stream temperatures are identical.

5.6.2.10 Where determination of meter pressure is required a pressure gauge, recorder or transmitter of suitable range and accuracy shall be installed near the inlet or outlet of each meter.

5.6.2.11 A heat traced manifold that maintains a heavy hydrocarbon in liquid state shall be designed to meet the following:

a) An excessively high temperature can not occur.

b) The temperature can not fall bellow the level at which the viscosity of the liquid becomes too great for the displacement meter at the required flow vates. Temperature control is especially important when the meter is not operating.

5.6.2.12 Piping shall be designed to prevent the loss or gain of liquid between the meter and the prover during proving.

5.6.2.13 Means shall be provided for relieving excessive pressures on the meter piping likely to be caused by thermal expansion of the liquid when the meters are not running.

5.6.2.14 Lines from meter to the prover shall be installed in a manner to minimize the possibility of air or vapor being trapped. Manual bleed valves should be installed at high points so that air or vapor can be drawn off before proving. The distance between the meter and its prover shall be minimized. The diameter of the connecting lines shall be large enough to prevent a significant decrease in flow rate during proving. In bank of meter stations, throttling valves may be installed downstream of the meters to regulate flow through the prover while each meter is being proved.

5.6.2.15 Mixing of dissimilar liquids in metering shall be minimized, so that special consideration should be given to the location of each meter, its accessory equipment and its piping manifold.

5.6.2.16 When placing a meter station in service, the measuring elements shall be removed from the meter or a pipe spool shall be provided and the line shall be operated without the measuring element until examination indicates that entrained foreign matter is being satisfactorily removed by the filter or straining equipment provided. Alternatively, initial line flushing should be carried out as nearly as possible at the maximum designed flow rate, before the meter is installed.

5.7 Meter Performance

Meter performance is defined by how well a metering system produces, or can be made to produce, accurate measurements. Meter factors must be determined when commissioning a meter.

5.7.1 Meter factor

Two types of meter proving may be used depending upon the meter's intended application and anticipated operating conditions.

5.7.1.1 In the first type the meter calibrator mechanism shall be adjusted until the change in meter reading during a proving equals, or very nearly equals, the volume measured in the prover.

Adjusted meters shall be used on retail delivery trucks and on truck and rail-car loading racks, where it is desirable to have direct-reading meters without having to apply mathematical corrections to the reading.

An adjusted or direct-reading meter is correct only for the liquid and the flow conditions at which it was proved.

5.7.1.2 In the second type of proving a meter factor is calculated.

The meter factor is a number obtained by dividing the actual volume of liquid passed through the meter during proving by the volume registered by the meter.

5.7.1.3 When direct reading is not required, the use of a meter factor is preferred for several reasons. It is difficult or impossible to adjust a meter calibrator mechanism to give exact registration within 0.02% which is the usual resolution with which a meter factor is determined. In addition, adjustment generally requires one or more reprovings to confirm the accuracy of the adjustment. In applications where the meter is to be used with several different liquids or under several different sets of operating conditions, a different meter factor can be determined for each liquid and for each operating conditions. An adjusted or direct registration is valied for only the one liquid and the one flow rate for which it was adjusted.

5.7.1.4 The following variables may affect the meter factor:

a) Specific gravity
b) Flow rate
c) Liquid viscosity
d) Liquid temperature
e) Flowing liquid pressure
f) Cleanliness and lubricating qualities of the liquid
g) Change in measuring-element clearances due to wear or damage which affects the slippage
h) Torque load required to drive the register, printer and all accessory equipment
i) Hydraulic head loss (pressure loss across the meter)
j) Malfunctions in the proving system

5.7.2 Causes of variations in meter factors

The variables that have the greatest effect on the meter factor are flow rate, viscosity, temperature, and foreign material (for example, paraffin in the liquid).

If a meter is proved and operated on liquids with inherently identical properties, under the same conditions as in service, the highest level of accuracy may be expected. If there are changes in one or more of the liquid properties or in the operating conditions between the proving and the operating cycle, then a change in meter factor may result, and a near meter factor must be determined.

5.7.2.1 Variation in flow rate

Meter factor varies with flow rate. At the lower end of the range of flow rates, the meter-factor curve may become less reliable and less consistent than it is at the middle and higher rates. However, a meter shall be used within its linearity range.

If a change in total flow rate occurs in a bank of two, three, or more displacement meters installed in parallel, the usual procedure is to avoid overranging or underranging an individual meter by varying the number of meters in use, thereby distributing the total flow among a suitable number of parallel displacement meters.

5.7.2.2 Variation in viscosity

The meter factor of a displacement meter is affected by changes in viscosity that result in variable slippage.

Viscosity may change as a result of changes in the liquids to be measured or as a result of changes in temperature that occure without any change in the liquid. It is preferable to reprove the meter if the grade of liquid changes or if a significant viscosity change occurs.

5.7.2.3 Variation in temperature

In addition to affecting the viscosity of the liquid, changes in liquid temperature, have other important effects on meter performance, as reflected in the meter factor.

The mechanical clearances of the displacement meter may be affected by temperature. Higher temperature may partially vaporize the liquid, cause two-phase flow, and severely impair measurement performance.

5.7.2.3.1 As the temperature of the liquid in the meter and in the prover are not usually the same, both volumes shall be corrected to a volume at a base or reference temperature so that a correct meter factor can be obtained. For such corrections, the related petroleum measurement tables should be used.

5.7.2.3.2 Either an automatic temperature compensator or a manually calculated temperature correction based on the observed temperature of the delivery may be used to correct registered volume to a volume at a base or reference temperature.

5.7.2.4 Variation in pressure

5.7.2.4.1 If the pressure of the liquid when it is metered varie from the pressure that existed during proving,the relative volume of the liquid will change as a result of its compressibility. the potential for error increases in the proportion to the magnitude of the difference between the proving and the operating conditions.

For greatest accuracy, the meter shall be proved at the operating conditions.

5.7.2.4.2 The physical dimension of the meter will also change as a result of the expansion or contraction of its housing under pressure. The use of double case meters prevents this problem.

5.7.3 Meter specification

The following specifications are recommended for positive displacement meters used in custody transfer:

Linearity: ±0.15% or better, over the linearity flow range.
Repeatability: 0.02% or better.

Appendix A will show the specification data sheets used for ordering positive displacement meter.

6. MEASUREMENT OF LIQUID HYDROCARBONS BY TURBINE METERS

6.1 Introduction

Turbine flow meters have been widely accepted as a proven technology that is applicable for measuring flow with high accuracy. Turbine flow meters can be superior to other technologies in the turbulent flow regime.

6.2 Principles of Operation

A turbine meter, being an inferential type of volumetric flow meter, is actually sensing flow velocity by measuring the rotational velocity of a bladed rotor. The flowing liquid causes the rotor to move with a tangential velocity that is proportional to volumetric flow rate by assuming a constant flow area. (Fig. 3) The movement of the rotor can be detected mechanically, optically or electrically and is registered on a read-out.

6.3 Design Consideration

Turbine metering installation shall comply with the following requirements:

a) The installation should be capable of handling maximum and minimum flow rates, the maximum operating pressure, and the temperature range and type of liquid to be measured. Protective devices shall be provided to limit or to control the operation conditions within the design ranges of the metering installation.

b) The installation should ensure a maximum, dependable operating life. Strainers, filters, air/vapor eliminators, or other protective devices may be provided upstream of the meter to remove solids that could cause premature wear or gases that could cause measurement errors.

c) The installation should ensure adequate pressure on the liquid in the metering system at all temperatures so that the fluid being measured will be in the liquid state at all times.

d) The installation should ensure appropriate flow conditioning both upstream and downstream of the meter or bank of meters.

e) The installation should comply with all applicable regulations for electrical equipment in hazardous areas if there is a possibility of hazardous atmosphere being present at the installation site.

f) There shall be provisions for proving each meter for the entire range of normal operating conditions.

g) All construction materials in contact with the hydrocarbon liquid shall neither affect nor be affected by the liquid.

6.4 Selection of Turbine Meters and Accessory Equipment

Consideration shall be given to, and the Manufacturer consulted regarding, the following when selecting a meter and its ancillary equipment:

a) The properties of the metered liquids, including viscosity, density, vapor pressure, corrosiveness, and lubricating ability.

b) The operating flow rates and whether flow is unidirectional or bidirectional, continuous, intermittent or fluctuating.

c) The range of operating pressures, acceptable pressure losses through the meter when run at the maximum expected flow rate, and whether pressure on the liquid is adequate to prevent vaporization.

d) The operating temperature range and the applicability of automatic temperature compensation.

e) The nature and quantity of abrasive and corrosive cotaminants that may be carried in the liquid stream, including the size and distribution of solid matter.

f) The types of read-out and printout devices to be used, signal preamplification and the standard units of volume or mass that are required. (Fig- 4)

g) The compatibility of meter read-out equipment and flow rate indication, and the method of meter registration adjustment, if applicable.

h) Power supply requirement for continuous or intermittent meter read-out.

i) Electrical code requirement

j) The fidelity and security of pulse-data transmission systems.

k) The meter characteristics including, maximum allowable pressure loss and frequency and voltage of output. (Fig. 5)

l) The space required for the meter installation and the proving facility. (Fig. 6)

m) The type, method, and frequency of proving.

n) Class and type of end connections installed on meter.

o) Maintenance methods, costs and spare parts.

6.5 Installation Design Considerations

6.5.1 Flow conditioning

6.5.1.1 The performance of turbine meters is affected by liquid swirl and non-uniform velocity profiles that are induced by upstream and downstream piping configurations, valves, pumps, joint misalignment, protruding gaskets, welding projections, or other obstructions. Flow conditioning shall be used to prevent swirl and nonuniformity of velocity.

6.5.1.2 Flow conditioning requires the use of sufficient lengths of straight pipe or a combination of straight pipe and straightening devices that are inserted in the meter run upstream of the turbine meter. (Fig. 7)

6.5.1.3 When only straight pipe is employed, the liquid shear, or internal friction between the liquid and pipe wall, shall be sufficient to accomplish the required flow conditioning. Experience has shown that in many installations, pipe lengths of 20 meter-bore diameters upstream of the meter and 5 meter-bore diameters downstream of the meter provide effective conditioning.

6.5.2 Valves

6.5.2.1 The flow or pressure control valves on a meter run should be capable of rapid, smooth opening and closing to prevent shocks and surges. Other valves particularly those between the meter or meters and the prover (for example, the stream diversion valves, drains and vents) require leak proof shutoff, which may be provided by a double block-and-bleed valve with telltale bleed or by another similarly effective method of verifying seal integrity.

6.5.2.2 All valves, especially spring-loaded or self-closing valves, shall be of such design that they will not open to admit air when subjected to hydraulic shock or to vacuum conditions.

6.5.2.3 For intermittent flow control, valves should be of the fast-acting, shock-free type to minimize the adverse effects of starting and stopping liquid movement.

6.5.3 Piping

6.5.3.1 A working basis for the design of a turbine-meter assembly and its related equipment is shown in schematic diagram of (Fig. 6).Certain items may or may not be required for particular installation; others may be added if necessary.

6.5.3.2 Where the flow range is too great for any one meter or its prover, a bank of meters may be installed in parallel. Each meter in the bank shall operate within its minimum and maximum flow rates. A means shall be provided to balance flow through each meter.

6.5.3.3 Meters shall be installed so that they will not be subjected to undue stress, strain or vibration provision shall be made to minimize meter distortion caused by piping expansion and contraction.

6.5.3.4 Measurement systems shall be installed so that they will have a maximum, dependable operating life. In certain services, this requires that protective devices be installed to remove from the liquid abrasives or other untrained particles that could stop the metering mechanism or cause premature wear.

If strainers, filters, sediment traps, settling tanks, water separators or a combination of these items are required, they shall be sized and installed to prevent flash vaporization of the liquid before it passes through the meter. Protective devices may be installed singly or in an inter changeable battery form. In services where the liquid is clean or the installed meter does not require or warrant protection, emission of protective devices may be acceptable. Monitoring devices should be installed to determine when the protective device needs to be cleaned.

6.5.3.5 Measurement systems shall be installed and operated so that they provide satisfactory performance within the viscosity, pressure, temperature, and flow ranges that will be encountered.

6.5.3.6 Meters shall be adequately protected from pressure pulsations and excessive surges and from excessive pressure caused by thermal expansion of the liquid. This kind of pressure may require the installation of surge tanks, expansion chambers, pressure limiting values, pressure relief valves, and/or other protective devices. When pressure relief valves or pressure-limiting valves are located between the meter and the prover, a means of detecting spills from the valves shall be provided.

6.5.3.7 Conditions that contribute to vaporization of the liquid stream shall be avoided through suitable system design and through operation of the meter within the flow range specified by the Manufacturer. Vaporization can be minimized or eliminated by maintaining sufficient back pressure in and immediately downstream of the meter.

This is generally accomplished by placing a back-pressure valve downstream of the meter to maintain pressure on the meter and the prover above the vapor pressure of the liquid. In some operations, the normal system pressure may be high enough to prevent vaporization without the use of back-pressure valve.

For low-vapor-pressure liquids, the numerical value of the minimum back pressure should be calculated as follows:

$$\mathbf{Pb \sim = 2\ \Delta P + 1.25\ P_v}$$

Where:

Pb = minimum back pressure, in Bar
ΔP = pressure drop across the meter at the maximum rate of flow, in Bar
P_v = absolute vapor pressure at the maximum operating temperature in Bar A

With high-vapor-pressure liquids, it may be possible to reduce the coefficient of 1.25 to some other practical and operable margin. In either case, the recommendations of the meter manufacturer should be considered. (Fig. 8)

6.5.3.8 When a flow-limiting device or a restricting orifice is required, it should be installed downstream of the meter run. An alarm may be desirable to signal that flow rates have fallen bellow the design minimum. If a flow limiting or other pressure-reducing device is installed, it shall maintain enough pressure on the outlet side of the meter run to prevent any vaporization of the metered liquid. Also minimum differential pressure must be maintained accross the meter.

6.5.3.9 Every meter shall be installed in such a way as to prevent passage of air or vapor through it. If necessary, air/vapor elimination equipment shall be installed upstream of the meter. The equipment shall be installed as close to the meter as is consistent with good practice, but it must not be so close that it creates swirl or a distorted velocity profile at the entry to the meter. Any vapors shall be vented in a safe manner.

6.5.3.10 Lines from the meter to the prover shall be such that the possibility of trapping air or vapor is minimized. Manual bleed valves should be installed at high points so that air can be drawn-off before proving. The distance between a meter and its prover shall be kept short and the diameter of the connecting lines shall be large enough to prevent a significant decrease in flow rate during proving.

Flow-rate control valves may be required downstream of each meter, particularly in multimeter installations, to keep the proving flow rate equal to the normal operating rate for each meter.

6.5.3.11 Piping shall be designed to prevent the loss or gain of liquid between the meter and the prover during proving.

6.5.3.12 Special consideration shall be given to the location of each meter, its ancillary equipment and piping manifold in order to minimize mixing of dissimilar liquids.

6.5.3.13 Most turbine meters will register flow in both direction, but seldom with identical meter factors. If flow must be restricted to a single direction because of meter design, flow in the opposite direction shall be prevented.

6.5.3.14 A thermometer, or a thermometer well that permits the use of a temperature-measuring device, shall be installed in or near the inlet or outlet of a meter run so that metered stream temperatures can be determined. The device shall not be installed upstream within the flow-conditioning sections or downstream closer than the Manufacturer's recommended position. If temperature compensators are used, a suitable means of checking the operation of the compensators is required.

6.5.3.15 To determine meter pressure, a gauge, recorder, or transmitter of suitable range and accuracy shall be installed near the inlet or outlet of each meter.

6.5.3.16 Meter runs shall be constructed from single straight pipe pieces. Welded pieces on the meter runs are not acceptable.

6.5.3.17 Meter run shall be constructed in a way to have no velocity component other than the direction of flow.

6.6 Meter Performance

Meter performance is defined by how well a metering system produces, or can be made to produce, accurate measurements.

6.6.1 Meter factor

Meter factors shall be determined by proving the meter under conditions of rate, viscosity, temperature, density, and pressure similar to those that exist during intended operation. Meter performance curves can be developed from a set of proving results. The curve in (Fig. 5) is called a linearity curve.

6.6.1.1 The meter factor is obtained by dividing the actual volume of liquid passed through the meter during proving by the volume registered by the meter.

6.6.1.2 Variable conditions which may affect meter factor values are:

a) Flow rate.
b) Viscosity of the liquid.
c) Temperature of the liquid.
d) Density of the liquid (specific gravity).
e) Line pressure and pressure drop across the meter.
f) Cleanliness and lubricating properties of the liquid.
g) Changes in mechanical clearances or blade geometry due to wear or damage.
h) Changes in piping, valves, or valve positions that affect fluid profile.
i) Conditions of the prover.
j) Changes in inlet fluid velocity profile.

6.6.2 Causes of variations in meter factor

Many factors can change the performance of a turbine meter.

Some factors, such as entrance of foreign matter into the meter, can be remedied only be eliminating the cause. Other factors, such as th build up of deposits in the meter, depend on the characteristics of the liquid being measured, these factors must be overcome by properly designing and operating the meter system.

The independent variables which have the greatest effect on the meter factor are flow rate, viscosity, temperature pressure, lubricity properties and foreign matter (such as paraffin in liquid).

6.6.3 Meter specifications

The following specifications are recommended for turbine meters used in custody transfer:

Linearity : ±0.15 % or better, over the linear flow range.
Repeatability: 0.02% or better, at any point throughout the specified flow range.

Appendix A-2 will show the specification data sheet used for ordering turbine meter.

7. ACCESSORY EQUIPMENT FOR LIQUID METERS

This chapter is intended to be a guide for the selection and application of accessory equipment that is used with liquid-hydrocarbon meters to obtain accurate measurements and possible maximum service life.

7.1 Definitions

7.1.1 Accessory equipment is any device that enhances the utility of a measurement system, including eadouts, registers, monitors, and liquid-or flow-conditioning equipment.

7.1.2 A read-out is a device that displays numbers or symbols and incorporates electric or electronic features.

7.1.3 A register is a mechanical device that displays numbers.

7.2 Selecting Accessory Equipment for Meters

Accessory devices should be selected so that trouble will not arise from the following:

a) Environment

Temperature and humidity extremes should be evaluated, and the installation should be protected accordingly. Electrical safety factors (including the hazardous area classification), electromagnetic and radio frequency interferences weatherproofing, fungus proofing, and corrosion should be considered.

b) Maintenance

Easy access should be provided for maintenance, and spare parts that have been recommended by the manufacturer should be obtained.

c) Compatibility

The read out device or register shall be compatible with the meter and its transmission system.

d) Installation

All equipment must be installed and operated according to the manufacturer's recommendations and must conform to all applicable regulations and codes.

7.2.1 Shaft driven (mechanical) accessories

A variety of shaft-driven accessories should be applied to displacement meters and sometimes to turbine meters. A mechanical linkage, usually a gear train, transmits force and motion from the rotation measurement element to the exterior of the meter, where the accessories are attached.

Care should be exercised in selecting the number and type of accessories so that excessive torque, which can overload the meter, is avoided. Some of the accessory devices are discussed here.

7.2.1.1 Adjuster (calibrator)

A mechanical meter adjuster, or calibrator, changes the drive-system gear ratio between the volume-sensing portion of the meter and the primary register. The calibrator should adjust the register so that it shows the direct reading of the volume passed through the meter. Adjusters may be gear changing, friction driven, or clutch driven, depending on the design, the adjustment range may cover from 1 to 10 percent of throughput.

7.2.1.2 Registers

A shaft-driven primary register should be attached directly to the meter. The primary register should display the selected units of measurement, and displays fractions of these units, if required. A primary register may be a totalizer only or totalizer with a separate nonresetable register. A primary register should be secured and sealed to the meter to prevent tampering.

7.2.1.3 Printer

A shaft-driven primary printer may accompany a primary register. The primary printer should record on a measurement ticket the amount of liquid that is delivered. The ticket shall be printed in units of measurement, and in fractions of the these units, if required.

7.2.1.4 Temperature compensator

A temperature compensator is a variable-ratio mechanism located in the meter's drive train. It should have a temperature sensor that works with the variable-ratio mechanism to correct the flowing volume to standard reference temperature. The temperature compensator must be set for the appropriate thermal coefficient of expansion of the liquid hydrocarbon that is measured.

7.2.1.5 Pulse generator

A pulse generator provides pulses in a quantity that is directly proportional to meter throughput. pulsing devices can have various types of output signal, including switch closures, square-wave signals, and sine-wave signals.

7.2.1.6 Preset device

A preset device can be preset for any quantity of meter throughput. At the preselected quantity, the device shall stop the flow of liquid or shall perform desired functions automatically. It may or may not be an indicating device.

7.2.1.7 Combinator

A combinator should be used to combine the output of two or more meters into a single output that can then be used to drive desired accessories.

7.2.2 Pulse-Driven (electronic) accessories

A variety of pulse-driven accessories can be used with both displacement and turbine meters. The pulses generated by high-resolution pulsars for displacement meters and the inherent pulse generated by most turbine meters represent discrete units of volume and can be used to provide input signals to the other read out devices.

7.2.2.1 Electronic adjuster (calibrator or scaler)

An electronic adjuster, also called a factoring center, manipulates the pulse signal to achieve a unity meter factor for direct reading of volume. The device should be capable of being calibrated to 1 part in 10,000.

7.2.2.2 Read-out

An electrically driven primary read-out indicates volumes in the desired standard units of measurement. It also indicates fractions of these units, if required. The accuracy of the read-out depends on system resolution, which is proportional to the number of pulses per unit volume.

During power failure, standby power shall be used to verify and retain meter registration even if a mechanical means is available.

7.2.2.3 Printer

The following common types of electrical printers shall be used. The first type is designed so that each adjacent digit advances the next digit into position as it would in a mechanical totalizer. This type of printer is simple, inexpensive and widely used, but it has limited speed and longevity.

The second type of printer includes individual digit modules that remain in a rest position until they are called on to print the throughput volume that is stored in a memory. This type of printer has high resolutions, high speed, and exceptional longevity.

7.2.2.4 Flow computer

A flow computer shall accept the meter output pulse signal and convert it to volume or mass flow quantities as required. Their capabilities shall include real-time compensation for meter factor, pressure, temperature, density, scaling of signals, transmission, and display of data.

7.2.2.5 Preset totalizer

A preset totalizer is a totalizing counter that actuates a contact closure when the measured volume equals a value that was preselected on a manually adjustable counter.

7.2.2.6 Proving counter

A proving counter is a high-resolution digital-pulse totalizer that provides a display of the high-frequency pulsed output from the meter. Pulse totalizers shall be started and stopped with an on/off gating circuit that is operated from the prover's mounted detectors. The totalizer may be an electromechanical counter or an electronic counter.

7.2.2.7 Flow rate indicator

A flow rate indicator should be able to converts an input signal to a visual display of flow rate in the desired units. The device shall be used for general operational information and to monitor system flow rate during meter proving.

7.2.2.8 Frequency converter

A frequency converter should convert an input frequency, or a pulse train, to a proportional analog signal for retransmission to other devices that require analog input signals.

7.2.2.9 Stepper drive

A stepper drive converts a frequency input to an acceptable form for driving a stepper motor. The device shall be used to drive various mechanical devices that require a rotary input (for example, counters, ticket printers, and compensators).

7.2.2.10 Temperature compensator

A temperature compensator should be able to combine an input signal from a volume meter and an input from a temperature sensor to provide a corrected output to standard reference temperature.

7.2.2.11 Combinator

A combinator shall accept two or more simultaneous input frequencies and display their sum total.

7.2.3 Interface connections to pulse driven accessories

Interface connections are the connections between the meter's volume-sensing device and its driven equipment.

7.2.3.1 Shielded cable

Acceptable pulse transmission length of shielded twisted-pair of conductor between volumetric meter and related electronic equipment if a signal of ample strength (>100 millivolts peak to peak) is transmitted shall be 330 meters.

Shielding shall be grounded at the receiving end only to prevent ground loop effects. The cables should be routed so that proximity to sources of electrical interference is avoided.

7.2.3.2 Preamplifiers

A preamplifier should be used to shape the pulse of a meter output so that the performance of downstream accessories will be enhanced. For long transmission line a preamplifiers should be used. The reamplifiers should always be located at the meter so that the original low-level signal will be amplified and ncreased to a satisfactory level.

7.2.4 Installing considerations for pulse-driven accessories

7.2.4.1 A turbine meter system has a minimum of three components: the meter (pulse producer), the transmission line (pulse carrier) and the read-out device (pulse counter and display). It is essential that these three components be compatible and that each meets the recommended specifications of the turbine meter Manufacturer.

7.2.4.2 Great care shall be exercised in effectively isolating the system from external electrical influences. To minimize unwanted noise, earthing (grounding) shall be independent from other grounding network and shielding of meter and prover detector transmission cables is essential.

7.2.4.3 Most turbine meters have the capability of producing an electrical output which may be used to operate a wide variety of read-out devices. More than one pick-up may be required according to design criteria.

7.2.4.4 Every turbine meter system shall meet two general requirements to operate properly. The read-out device shall be sufficiently sensitive to respond to every pulse produced by turbine meter throughout its operating range. The signal-to noise ratio shall be sufficiently high to prevent spurious electrical signals from influencing the read-out device.

7.2.4.5 The electrical output signal of a turbine meter may be considered to be a train of electrical pulses.

The following types of devices that produce electrical signals shall be used with turbine meters:

a) Inductance system

In this system, the rotating element of the turbine meter employs permanent magnets that may be embedded in the hub or the blade tips or attached to the rotor shaft or to a ring driven by the rotor.

Regardless of the design, magnetic flux from a moving magnet induces a voltage in a pickup coil that is located near the magnetic field.

b) Variable reluctance system

In this system, a fixed, permanent magnet is centered inside the pick up coil housing so that a variation in magnetic flux results from the passage of a highly permeable, magnetic rotor material near the pick up coil.

c) Photoelectric system

In this system, a beam of light is interrupted by the blades of the rotor or by elements of a member that is driven by the rotor so that a pulsed signal output is developed.

d) Magnetic reed-switch system

In this system, the contacts of a reed switch are opened and closed by magnets embedded in the rotor or in a rotating part of the turbine meter. the switch action interrupts a constant input so that a pulsed signal output is produced.

7.2.4.6 Pulse characteristics which influence proper system operation and shall be considered in design stage are:

a) Amplitude

Any read-out device connected to a pulse producer shall have the sensitivity needed to operate with the pulse amplitudes generated over the rated flow range;

b) Frequency

The read-out device shall be capable of coping with the maximum output frequency of the pulse producer at its highest expected flow rate;

c) Width

The duration, after shaping, of every pulse generated by the pulse producers, shall be long enough to be detected by the read-out device;

d) Shape

A sine-wave output shall not be used to operate a read-out device requiring a square-wave input without preamplification and shaping.

7.2.4.7 Great care shall be exercised in the electrical transmission installation so that the signal amplitude from the turbine meter can be maintained at the highest level while reducing the magnitude of noise, whenever possible. Optimum signal level should be maintained by :

a) Limiting the length of transmission from the meter to the read-out devices;

b) Ensuring the correct impedance;

c) Using the technically compatible signal transmission cable as recommended by the equipment manufacturer;

d) Introducing a signal preamplifiers into the transmission system at the turbine meter, if transmission distance dictate so;

e) Ensuring that supply voltages to preamplifiers and constant amplitude pulse generating systems are of proper magnitude and do not exceed the minimum noise level or ripple requirements as specified by the equipment manufacturer;

f) Ensuring that all pick-up coils are securely mounted and properly located;

g) Periodically inspecting and cleaning all terminals, connectors, connector pins and wiring junctions;

h) Replacing components which, through deterioration, give a weakened signal.

7.2.5 Conditioners

Conditioners shall be used with displacement and turbine meters to ensure the most accurate and reliable performance.

Conditioning includes, but not limited, to flow control, pressure control, and removal of unwanted foreign material, such as dirt, water, or gas.

7.2.5.1 Strainers

A strainer shall be installed upstream of the meter as a protective device. It includes a basket or barrier (usually made of metal cloth or screen) that stops and collects foreign material, such as rust, scale, welding beads, slag, sand and gravel before entering the meter. The mesh size varies according to the needs of the meter system;

Meter manufacturers should provide criteria for selecting mesh size. A suitable device for indication of differential pressure accross strainer shall be provided such as differential pressure gauge or differential pressure transmitter.

7.2.5.2 Air/vapor eliminators

Air or vapor in a flowing stream will be measured as liquid and will result in an error in the indicated volume. Large volume of air, such as those that may exist in an empty piping system, can result in overspeeding and damage to a meter. Under these conditions, air elimination equipment shall be used.

Selecting the size and type of air eliminator for an installation requires that careful consideration be given to piping and other equipment and to the operating details of the system. These details should include the quantity of air, the type of liquid being handled (with particular reference to its viscosity and foaming characteristics), the size and length of piping, the type and location of the pumps, and the rate of flow. The piping downstream of the eliminators must remain filled with liquid to prevent air or vapor from being measured along with the liquid.

7.2.5.3 Control of flow

Meter stations should include a manual or power-operated valve for starting, controlling and stopping the flow of liquid. In general, power-operated valves should open and close slowly to prevent flow pressure surges.

To avoid overspeeding a meter, it may be necessary to include a control valve that will limit the maximum rate of flow to the rated maximum of the meter.

In multirun metering stations, a control valve should be used downstream of each meter to balance flow when one or more meters are taken off line or when proving would take place.

If it is necessary to prevent the flow of liquid from reversing direction, a valve that allows flow in only one direction should be used.

A minimum back pressure must be maintained to prevent liquid from vaporizing or flashing. This may require the use of a back-pressure controller and a control valve that can maintain the require back pressure under any line pressure.

If a meter is equipped with a counter that can be preset for delivering a particular volume, the on/off valve should be controlled by the counter so that the flow can be stopped at the proper time. The preset counter may be linked to the valve by mechanical, electrical or other means.

7.2.6 Monitors

Some conditions and properties of liquid hydrocarbons have a greater effect on measurement accuracy than do others; monitors may therefore be desirable to asses the temperatures pressure, density, and viscosity of the flowing liquid.

The accuracy and resolution of thermometers, temperature recorders, pressure gages, pressure recorders, and hydrometers used in a measurement system should be appropriate for the meter needs and scale of operation.

Since metering requires the highest accuracy possible, the equipment should allow for precise reading and should be checked or calibrated frequently.

8. FIDELITY AND SECURITY OF FLOW MEASUREMENT PULSED-DATA TRANSMISSION SYSTEMS

8.1 Introduction

The purpose of this section is to assist users of electrical or electronic pulsed data transmission systems used in the metering of fluids to meet certain criteria for the design, installation, use and maintenance of such equipment. The object is to establish and maintain the credibility of indicated data against influences acting to impair the fidelity of the system.

8.2 Field of Application

The recommendations set forth are concerned only with the fidelity and security of pulsed-data, cabled transmission systems between a flow meter or flow meter transducer and a remote totalizer.

The different levels of security which should be applied to transmission systems are designated E to A from the lowest to the highest order of security, respectively.

8.3 Definitions

8.3.1 Fidelity

The exactitude with which the primary indication reproduces the inherent precision of the measurement.

8.3.2 Noise

Unwanted signals which may impair fidelity, and which occur for periods exceeding 0.2 second.

8.3.3 Transients

Disturbances having a duration of 0.2 See. or less.

8.3.4 Methods of comparison

As used in level A through D, is the determination of the fidelity of primary indication by use of redundant, alternate, or secondary source to verify the desired level of security.

8.3.5 Unrevealed error

Any lack of fidelity outside the prescribed limits of error, including errors caused by functional failure and by external influence.

8.4 Levels of Security

Five levels of security may be identified and considered, of which level E shall be used as a minimum acceptable level. Other levels shall be selected according to project requirements.

8.4.1 Level E

Error reduction is achieved solely by correctly installed apparatus of good quality. This is a straight forward scaler totalizer system. The use of a preamplifier transmitter to drive the transmission line is beneficial to the majority of applications, as is the provision of signal conditioning.(Fig. 9)

8.4.2 Level D

A level D system consists of manual error monitoring at specified intervals by methods of comparison. This level of security is intended to give protection against functional errors and failures and is a method of verification by manuals action. The read-out can be visually checked against an independent totalizing system. The secondary read-out may be permanent or temporary, local or remote. Manual comparison made during a periodic check will monitor the integrity of the transmission and totalizer elements. (Fig. 10)

8.4.3 Level C

This level of security consists of automatic error monitoring and error indication at specified intervals by methods of comparison. A level C is intended to give protection against functional errors and failures and this may be achieved by design methods, (Fig. 11). If the pulses delivered becomes numerical out of step, warning will be given by the comparator (differential counter). It is intended that this type of error monitoring be carried out periodically; the monitoring equipment may thus be shared with other metering systems. Level C security is inferred from the results obtained during the monitoring period.

8.4.4 Level B

Level B consists of continous monitoring, error indication, and alarm signaling by methods of comparison. This level of security is intended to give warning of transients and other spurious influences, in addition to functional errors and failures, (Fig. 12). Simultaneous interfering pulses must be detected and indicated. Alarm is given if pulses are lost or gained on either channel.

8.4.5 Level A

Level A consists of continous verification and correction by methods of comparison. this level is intended to give protection against transients and other spurious influences, in addition to functional errors and failures, (Fig. 13).

An incidental advantage of level A is its ability to detect some mechanical faults in the transducer.

Simultaneous pulses caused by symmetrical interference are automatically rejected and do not influence the system. Alarm will be given in all circumstance when impaired pulses are received by the comparator. It may be desirable to provide redundancy in one or all of the elements of the system.

8.5 System Design Considerations

8.5.1 General design criteria

The design approach should take into account the noise interferences. Low-level high-impedance signals become attenuated by line losses, and the overall signal-to-noise ratio can further be impaired by the greater probability of noise in longer lines.

As a precaution, suppliers of signal processing equipment should be advised of radio frequency used in close proximity so radio frequency interference immunity can be investigated.

8.5.2 Totalizers

8.5.2.1 Primary totalizer

It is basic to security requirements that the value of the totalizer count can not be impaired during delivery. The use of a nonresetable counter is mandatory for revenue accounting systems and is recommended for all other primary systems.

8.5.2.2 Secondary indication

Where it is acceptable, ancillary devices need not have as high a degree of security as the primary indication.

However, such devices should be given basic approval as part of an overall approval and should be compatible with it.

8.5.3 Typical sources of error

Typical sources of error which should be taken into consideration are as follows:

1) Electromagnetic interference
2) Transients
3) Power supply variations and/or interruption
4) Inadequate signal level as a result of line loss
5) Common-mode noise induced in cabling
6) Series-mode noise induced in cabling
7) Noise introduced from ground loops problems
8) Excessive gain and frequency response of the system elements.
9) Spurious signals induced from other meters sharing the same multicore cable.
10) Short circuit or open circuit of conductor pair or short circuit of either conductor to ground or shield.
11) Bad connections, temperature variations and extremes, vibration shock, and adverse environmental conditions.

8.5.4 Signal pre-amplifiers

A signal pre-amlifier should be introduced into the transmission system at the transducer, if transmission distance or manufacturers' requirements so dictate.

8.5.5 Standby power supply

Where a power interruption could result in a significant error in measurement, provision for an uninterruptable power supply should be considered.

8.5.6 Test requirements

Careful consideration should be given to the form of tests to be applied to the electronic system for fidelity and security purposes.

8.5.7 General precautions

The gain and frequency response of the system elements should be restricted to that required by the application.

Sensitivity controls on pre-amplifiers, scalers, and others shall not be capable of unauthorized adjustment. The totalized pulse counts existing at the time of any power failure shall be retained. Cable pairs and the instrument input circuit shall be protected from excessive transient voltages or currents as well as electrical storms.

8.6 Installation Design Considerations

8.6.1 Signal amplitude

The following points should be observed so that the signal amplitude from the transducer to the receiver can be maintained at a high level.

8.6.1.1 The installation recommendation specified by the manufacturers should be carefully followed, whilst complying fully with statutory requirements and/or codes of safety.

8.6.1.2 The length of transmission lines from the meter to the read-out equipment shall be held to a minimum.

8.6.1.3 Proper impedance matching shall be ensured.

8.6.1.4 The supply voltages to pre-amplifiers and should be checked to ensure they are of proper magnitude and do not exceed noise or ripple maximums as specified by equipment manufacturer.

8.6.2 Signal-to-noise ratio

The following points should be observed so that the signal-to-noise ratio can be optimized.

8.6.2.1 Only shielded transmission cables of the proper material, size, and number of conductors shall be used. Individual twisted shielded pairs afford the maximum protection against noise. Helical lay cables are acceptable for many installations. Parallel lay cables should be avoided. The shield of transmission cable should be grounded at one point only. To prevent formation of ground loops. A continuous run of transmission cables should be used whenever possible. Where joints are unavoidable, continuity of the shield shall be assured. Joints should be encapsulated to maintain the electrical specification and security of the cable. When multi-read-out devices are used and wired in parallel. shielded cables should be used for connecting wiring.

8.6.2.2 The data transmission lines should not share a conduit with anything other than shielded cables or cables from direct current sources, for example temperature sources. If the maximum electrical power carried by any one transmission cable is ten or more times greater than the minimum power carried by any flow meter signal data transmission cable, separate conduits should be provided. Data transmission cables should not be run in parallel with power cables. When this is not possible, the cables should not be closer than 0.5 m. If it is necessary for transmission cables and power cables to cross, this should be at right angles whenever possible.

8.6.2.3 When transmission cables are run in ducts or inside control cabinet, every attempt should be made to keep the shielded cable bundle intact and separate from other conductors.

All spare transmission cables and conductors that are run in a conduit with an active transmission line should have the shield and conductors grounded at the same single point as the active line

8.6.2.4 The grouping of cables to intrinsically safe devices with other current-carrying cables requires special consideration in hazardous areas, and governing regulations shall be followed.

8.6.2.5 Several methods of attenuating noise may be used, for example, band-pass filters and isolating transformers.

9. PROVING SYSTEM

In a custody transfer liquid metering station, some methods shall be provided to calibrate the meter. This shall be done by comparing the meter reading with a known volume of liquid which is accurately measured. The purpose of proving a meter is to determine its meter factor which by definition is "a number obtained by dividing the actual volume of liquid that passes through a meter by the volume indicated or registered by the meter.

9.1 Definition of Terms

9.1.1 Calibration: is the procedure used to determine the volume of a prover.

9.1.2 A prover pass: is one movement of the displacer between the detectors in a prover.

9.1.3 A prover round trip: is the result of the forward and reverse passes in a bidirectional prover.

9.1.4 A meter prover: is a vessel of known volume utilized as a volumetric reference standard for the calibration of meters in liquid petroleum service.

9.2 Proving and Meter Factor

The purpose of proving a meter is to determine its meter factor. Therefore, obtaining a meter factor is the first step in calculating the Net Standard volume of a receipt or delivery of petroleum products.

9.2.1 General consideration

A meter that requires flow conditioning should be proved with its normal flow-conditioning sections at the expected operating rates of flow under the pressure and temperature at which it will operate with the liquid to be measured. A meter that is used to measure several different liquids should be proved with each liquid.

Meter proving must be performed with a high degree of accuracy, thus thorough inspections of provers and their accessories should be made frequently to ensure the reproducibility of proving result.

9.3 Conventional Pipe Prover

Conventional pipe provers should be used as volume standards for proving liquid meters that generate at least 10.000 unaltered pulses during a provering run. The reference volume (the volume between detectors) switches required for a pipe prover depends on factors such as the resolution of the proving register, the repeatability of the detector, switches and the repeatability of the proving system as a whole.

9.3.1 Pipe prover systems

All types of pipe prover system operate on the common principle of the repeatable displacement of a known volume of liquid from a calibrated section of pipe between two signaling detectors. Displacement is achieved by means of slightly oversized sphere or piston that is driven along the pipe by the liquid stream being metered. The corresponding metered volume is simultaneously determined. A meter that is being proved on a continious-flow basis shall be connected at the time of proof to a counter that can be instantly started or stopped by the signaling detectors. The counter shall be an electronic pulse counter. The counter is started and stopped when the displacing device actuates the two detectors at the ends of the calibrated section. The two types of continuos-flow pipe provers which shall be normally used unidirectional and bidirectional. Other types of provers are in use based on special requirement.

9.3.1.1 Unidirectional provers

The unidirectional prover allows the displacer to travel in only one direction through the proving section and has an arrangement for returning the displacer to its starting position. (Fig. 14)

The interchange is the means by which the displacer is transferred from the downstream to the upstream end of the loop without being removed from the prover. The displacer detectors are located inside the looped portion at suitable distance from the interchange. Continuous or endless prover loops may be automated or manually operated.

The base volume of a unidirectional prover shall be the calibrated volume between detectors corrected to standard temperature and pressure conditions.

9.3.1.2 Bidirectional provers

Bidirectional provers have a length of pipe through which the displacer travels in two directions, actuating a detector at each end of the calibrated section and stopping at the end of each prover pass when valve action diverts the flow. Suitable supplementary pipework and a reversing valve or valve assembly that is either manually or automatically operated make possible the reversal of the flow through the prover. The main body of the prover shall be a straight piece of pipe, but it may be countered or folded to fit in a limited space or to make it more readily mobile. An elastomer spheroid shall be used as the displacer in the folded or countered type; a piston or sphere may be used in the straight-pipe type. (Figs. 15, 16).

9.3.2 Performance requirements of pipe prover

9.3.2.1 Calibration repeatability for prover volume

When the prover volume is calibrated, the results, after correction, of two or more consecutive runs shall lie within 0.02 percent (0.01 percent of the average) to determine the prover volume.

9.3.2.2 Valve seating

The sphere interchange in a unidirectional prover or the flowdiverter valve or valves in a bidirectional prover shall be fully seated and sealed before the displacer actuates the first detector. These and any other valves whose leakage can affect the accuracy of proving shall be provided with some means of demonstrating during the proving run that they are leak free.

9.3.3 Equipment

9.3.3.1 Temperature measurement

Temperature stabilization is normally accomplished by continuously circulating liquid through the prover section with or without insulation. When provers are installed above ground, thermal insulation shall be applied for temperature stabilization.

Temperature measurement sensors shall be of suitable range and accuracy and shall be installed at the inlet and outlet of the prover.

9.3.3.2 Pressure measurement

Pressure-measurement devices of suitable range and accuracy shall be used at suitable locations to measure pressure at the meter and the prover.

9.3.3.3 Displacing devices

One type of displacing device commonly used in pipe provers is the elastomer sphere hydrostatically filled with liquid under pressure. The displacer is expanded to provide a seal without excessive friction to a diameter greater (normally 2.4 percent) than that of the inside diameter of the prover pipe. In general the larger the sphere, the greater the percentage of inflation required.

Insufficient expansion of the sphere can lead to leakage past the sphere and consequently to measurement error.

Care must be exercised to ensure that no air remains inside the sphere. The displacer shall be as impervious as possible to the operating liquids. The liquid used to fill the sphere shall have a freezing point below any expected temperatures. Water or water-ethyleneglycol mixtures shall be used. Another commonly used displacer is the cylindrical piston with suitable seals.

9.3.3.4 Valves

All valves used in pipe prover systems that can provide or contribute to a bypass of liquid around the prover or to leakage between the prover and meter shall be of the double block-and bleed type and with a provision made for seal verification.

Full positioning of the flow-reversing valve or valves in a bidirectional prover or the interchange valve in a unidirectional prover must be accomplished before the displacer is allowed to actuate the first detector. The distance before first detector, commonly called prerun, depends on valve operation time and the velocity of the displacer. Methods used to shorten this prerun, such as faster operation of the valve or delay of the displacer launching, require that caution be exercised in the design so that hydraulic shock or additional undesired pressure drop is not introduced. If more than one flow-directing valve is used, all valves should be arranged by linkage or another means to prevent shock caused by an incorrect sequence of operation.

9.3.3.5 Detectors

Detection devices must detect the position of the displacer within specified tolerance. The most common type of detector is the mechanically actuated electrical switch. Other types include the electronic proximity switch and the induction pick up may be used if they provide satisfactory repeatability. The repeatability with which the detector in a prover can signal the position of the displacer must be ascertained as accurately as possible.

9.3.3.6 Peripheral equipment

A meter pulse generator shall be provided for transmission of flow data and must provide electrical pulses with satisfactory characteristics for the type of proving counter used. The device should generate a sufficient number of pulses per unit volume to provide the required discrimination.

9.3.3.7 Proving counter

An electronic pulse counter shall be used in meter proving because of the ease and accuracy with which it can count high-frequency pulses. The pulse-counting devices shall be equipped with an electronic start/stop switching circuit that is actuated by the pipe prover’s detectors.

9.3.3.8 Sphere interchange

The sphere interchange valve which is used on unidirectional pipe prover is a device for transferring the sphere from the downstream end of the proving section to the upstream end. Sphere interchange may be accomplished with several different combinations of valves or other devices to minimize bypass flow through the interchange during the sphere-transfer process. A verifiable leaktight valve seal is essential before the sphere reaches the first detector switch of the proving section.

9.3.3.9 Flow reversal valve

A single multiport valve should be used for reversing the direction of the displacer. All valves shall be leak free and allow continous flow through the meter.

A methods of checking for seal leakage during a proving pass shall be provided for all valves. The valve size and actuator shall be selected to minimize hydraulic shock.

9.3.4 Design of pipe provers

9.3.4.1 General consideration

From a study of the application, intended use and space limitations, the following should be established:

a) Whether the prover is to be stationary or mobile.

1) If the prover is stationary, whether it will be dedicated (on line) or used as part of central system

2) If the prover is stationary and dedicated, whether it will be kept in service continuously or isolated from the metered stream when it is not being used to prove a meter.

3) What portions of a stationary prover are desired below ground.

b) The ranges of temperature and pressure that will be encountered.
c) The maximum and minimum flow rates expected.
d) The maximum allowable pressure drop across the prover.
e) The physical properties of the fluids to be handled.
f) The degree of automation to be incorporated in proving operation.
g) Available utilities.

9.3.4.2 Volume

The volume of the prover between detectors shall be determined by considering the following:

a) The overall repeatability of the proving system.
b) The repeatability of the detector.
c) The accumulation of 10,000 pulses.
d) The resolution of the meter pulse generator (the number of pulses per unit volume).
e) The maximum and minimum flow rates of the system.

9.3.4.3 Displacer velocity

The maximum velocity of a displacer shall be established to prevent damage to the displacer and the detectors. Most designers agree that 3 meters per second is a typical design specification for unidirectional provers, where as velocities up to 1.5 meters per second are typical in bidirectional provers. Higher velocities may be possible if the design incorporates a means of reducing surges and displacer velocity before the prover completes its pass. Minimum displacer velocity must also be considered, especially for proving meters in a liquid that has little or no lubricating ability, such as gasoline that contains high proportions of aromatics or liquefied petroleum gas. Provided that acceptable performance can be assured, no arbitrary limit is imposed on velocity.

9.3.4.4 Repeatability and accuracy

9.3.4.4.1 General consideration

The ultimate requirement for a prover is that it proves meters accurately; however accuracy can not be established directly because it depends on the repeatability of the meter, the accuracy of the instrumentation, and the uncertainty of the prover base volume. The repeatability of any prover/meter combination can be determined by carrying out a series of repeated measurements under carefully controlled conditions and analyzing the results statistically. Repeatability is usually adopted as the primary criterion for a prover's acceptability.

The minimum linear distance between detector switches depends on the detector's ability to repeatedly locate the displacer. The total error of the displacer location during a proving pass shall be limited to 0.02 percent of the volume between the detectors.

9.3.4.4.2 Replacing the detectors

When the worn or damaged parts of a detector are replaced, care shall be taken to ensure that neither the detector's actuating depth nor its electrical switch components are altered to the extent that the prover volume is changed. This is especially true for unidirectional provers because changes in detector actuation are not compensated for round trip sphere travel as they are in bidirectional provers.

9.3.4.4.3 Counter resolution

The resolution of a digital counter is unity. The indicated pulse count therefore has a 1 pulse uncertainty for a pass between detectors. For example, to limit the pulse uncertainty to ±1 pulse during, a prover pass, at least 10,000 pulses would have to be collected during a single pass. This uncertainty is represented mathematically as follows:

$$U = \frac{\pm 1 \text{ pulse}}{N}$$

Where:

U = degree of uncertainty of the recorded pulse count during a prover pass.
N = minimum number of pulses to be collected during a prover pass.

9.3.4.4.4 Pulse generation

Prover volumes can be reduced by increasing the pulse-generation rate of the meters to be proved.

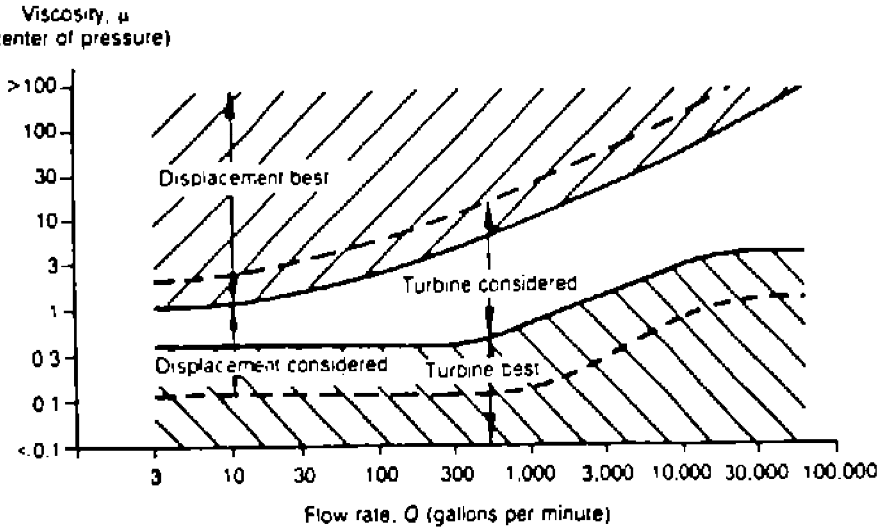
Care must be taken when gear-driven pulse generators are used on displacement meters to obtain very high pulse-generation rates, since mechanical problems such as back lash, drive-shaft torsion, and cyclic variations can cause irregular pulse generation.

9.3.5 Calibration of pipe provers

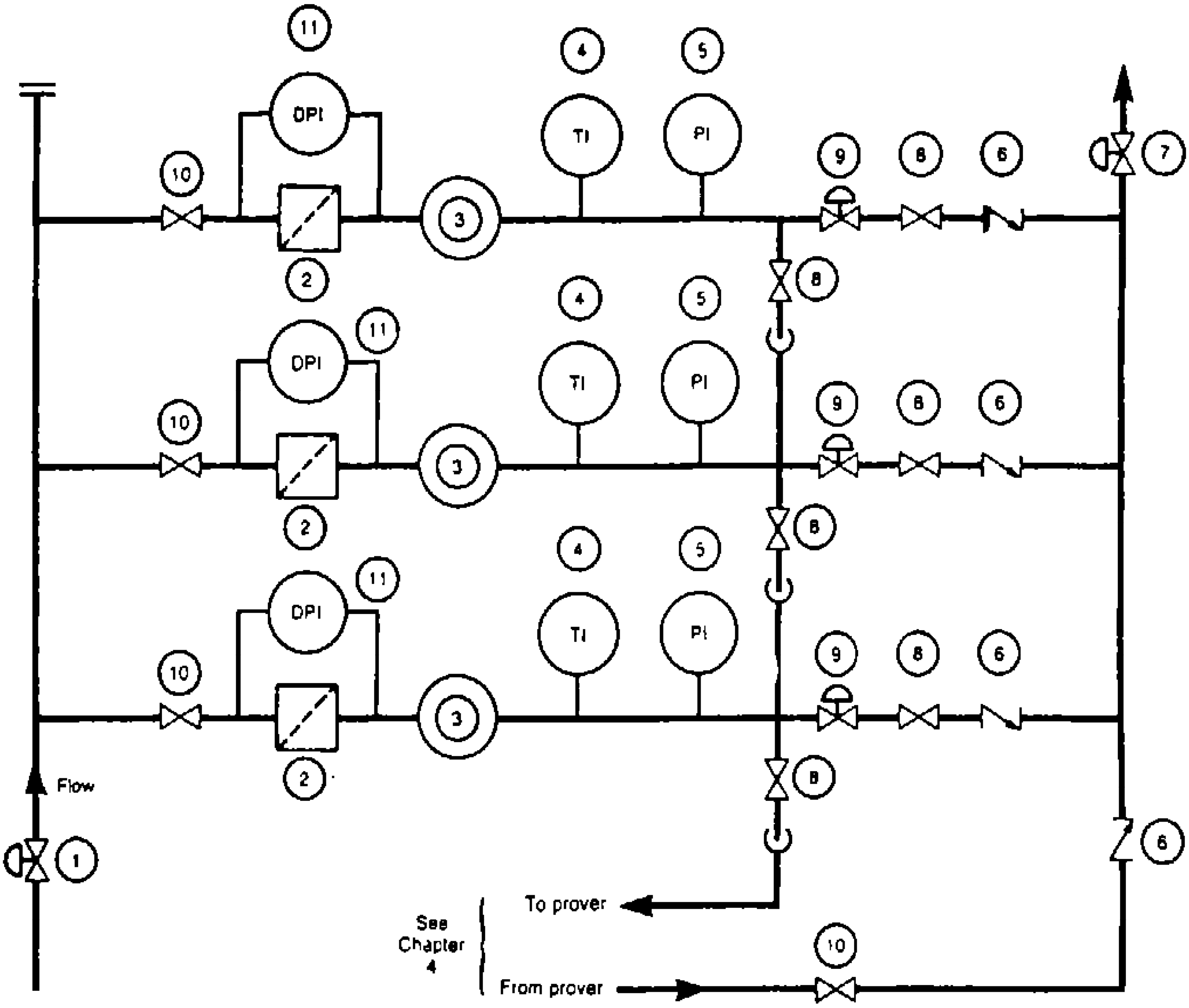
Calibrating a pipe prover involves determining the base volume displaced between the detectors. A pipe prover must be calibrated before it is placed in service to determine its base volume at standard conditions.

Periodic recalibration of the prover is also required.

The base volume shall be documented on a calibration certificate. The base volume of a unidirectional prover is the calibrated volume corrected to standard conditions and displaced between detectors for a single pass. The base volume of a bidirectional prover is the sum of the volumes displaced between detectors for a round trip of the displacer corrected to standard conditions. Pipe provers shall be calibrated according to procedures described in API Manual Chapter 4.



SELECTION GUIDE FOR DISPLACEMENT AND TURBINE METERS
Fig. 1

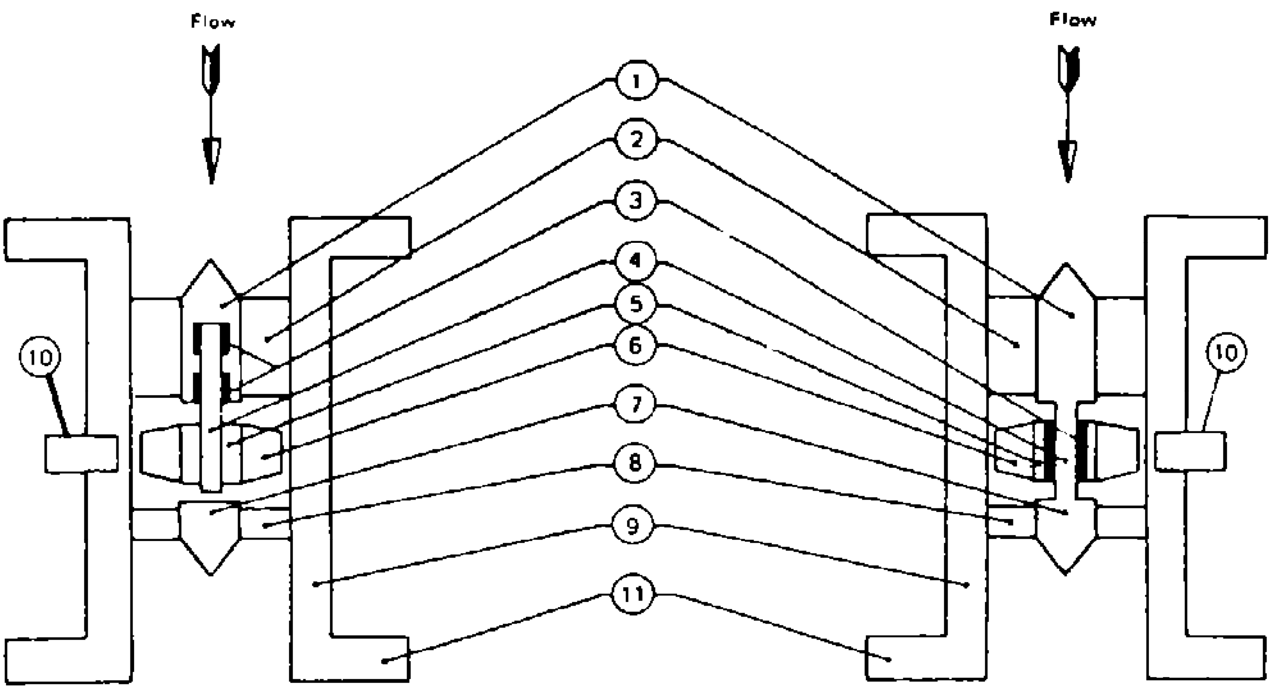


1. Pressure-reducing valve .... manual or automatic, if required.
2. Filter, strainer, and/or vapor eliminator (if required) for each meter or whole station.
3. Displacement meter.
4. Temperature measurement device.
5. Pressure measurement device
6. Check valve, if required.
7. Control valve, if required.
8. Positive-shut-off double block-and bleed valves.
9. Flow control valve, if required.
10. Block valve, if required.
11. Differential pressure device, if required.

Note: All sections of the line that may be blocked between valves shall have provisions for pressure relief (preferably not to be installed between the meter and the prover).

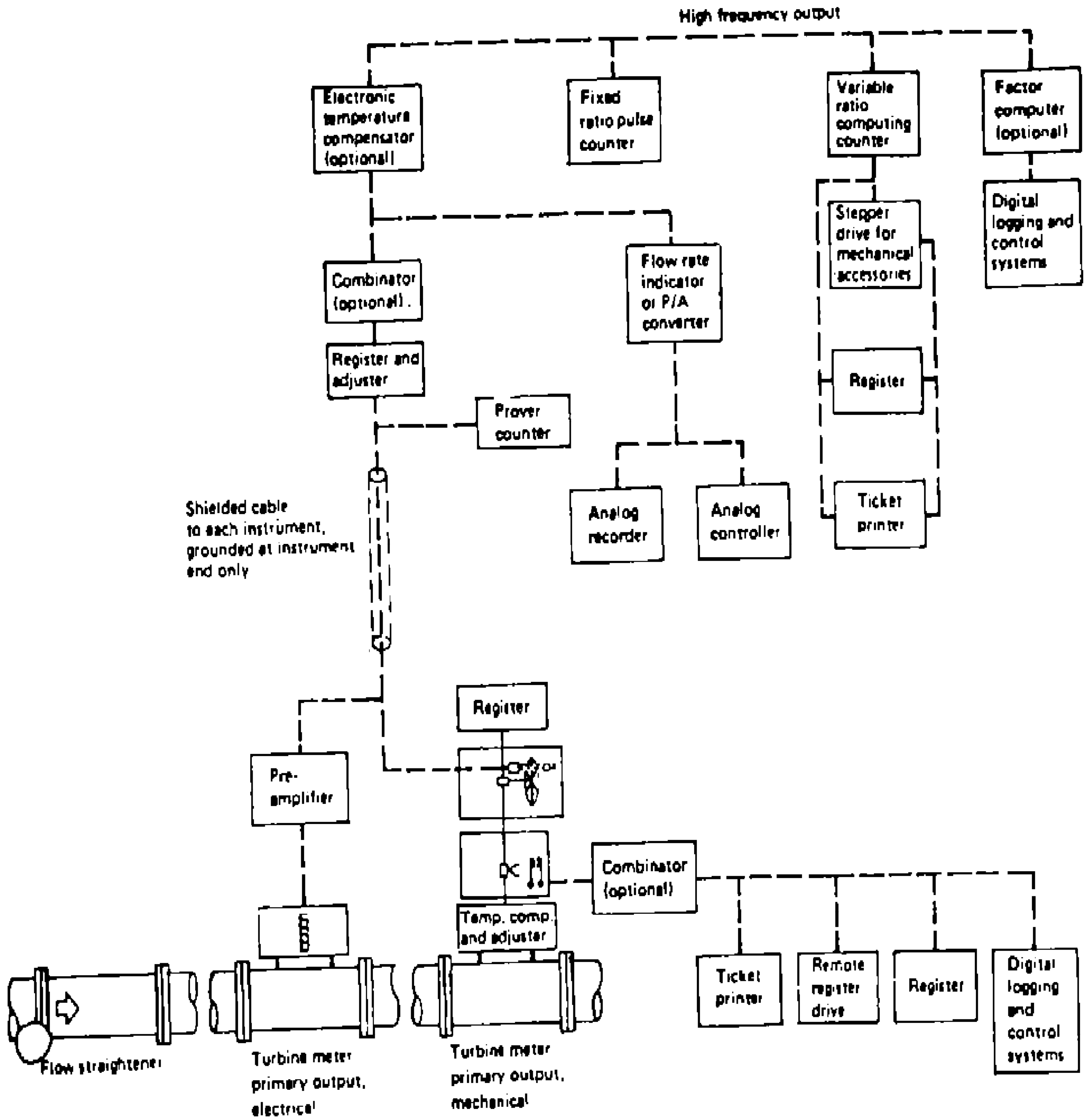
TYPICAL SCHEMATIC ARRANGEMENT OF METER STATION WITH THREE DISPLACEMENT METERS

Fig. 2

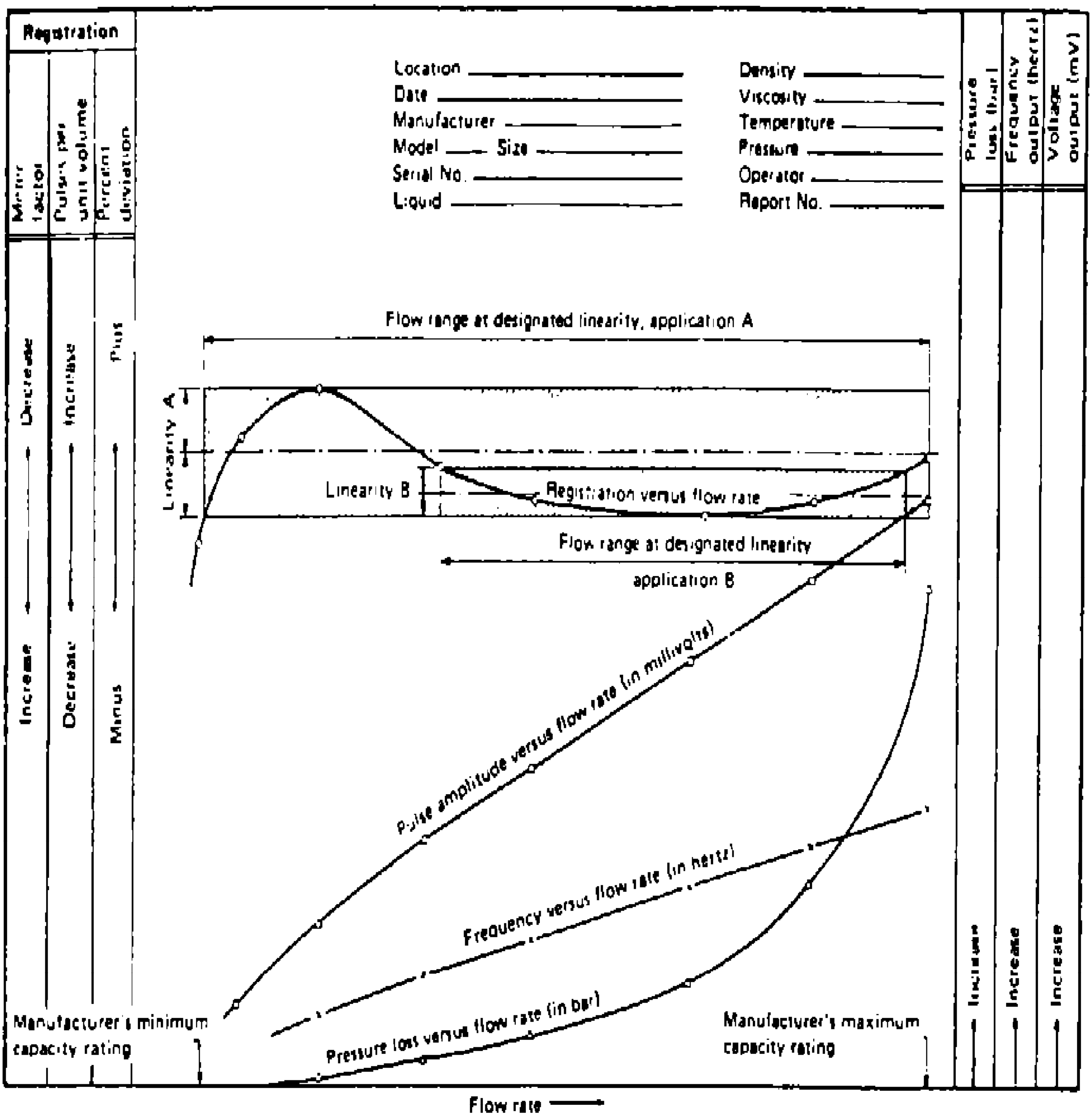


1 Upstream stator
2 Upstream stator supports
3 Bearings
4 Shaft
5 Rotor hub
6 Rotor blade
7 Downstream stator
8 Downstream stator supports
9 Meter housing
10 Pick-up
11 End connections

NAMES OF TYPICAL TURBINE METER PARTS
Fig. 3



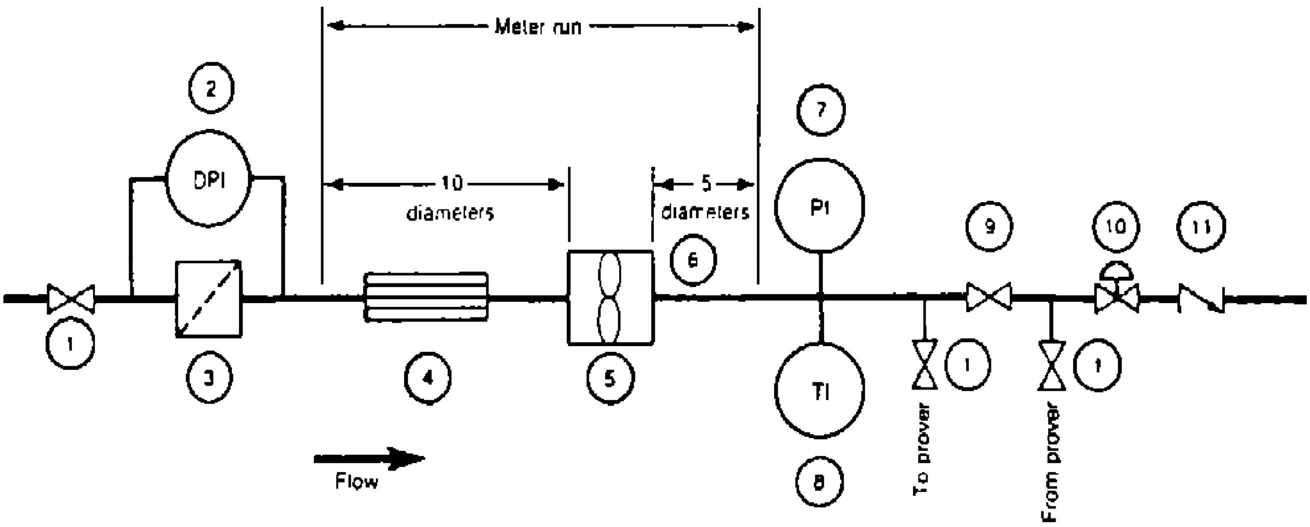
AVAILABLE TURBINE METER INSTRUMENTATION
Fig. 4



NOTE – The meter characteristic curves shown are to be considered as illustrative only and shall not be construed as representing the likely performance of any given model or size of turbine meter.

TURBINE-METER PERFORMANCE CHARACTERISTICS

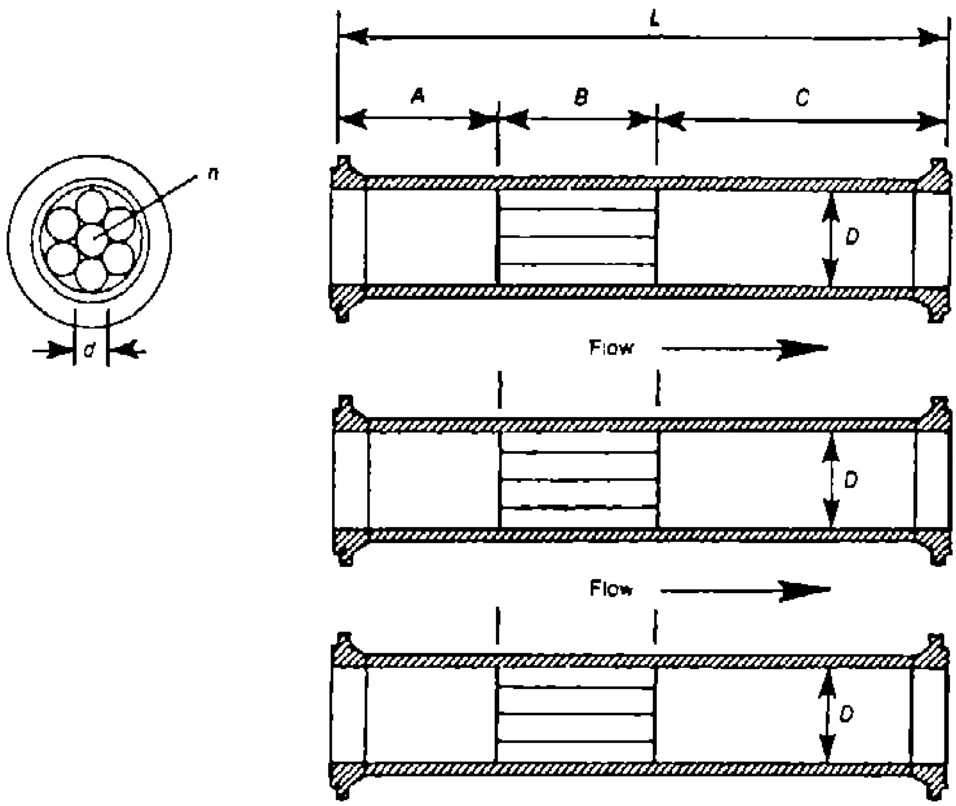
Fig. 5



1. Block valve, if required.
2. Differential pressure device, if required
3. Filter, strainer, and or vapor eliminator (if required) for each meter or whole station.
4. Straightener assembly per Figure 4.
5. Turbine meter.
6. Straight pipe.
7. Pressure measurement device.
8. Temperature measurement device
9. Positive shut-off double block-and bleed valve.
10. Control valve, if required.
11. Check valve, if required.

Note: All sections of line that may be blocked between valves shall have provisions for pressure relief (preferably not installed between the meter and the prover).

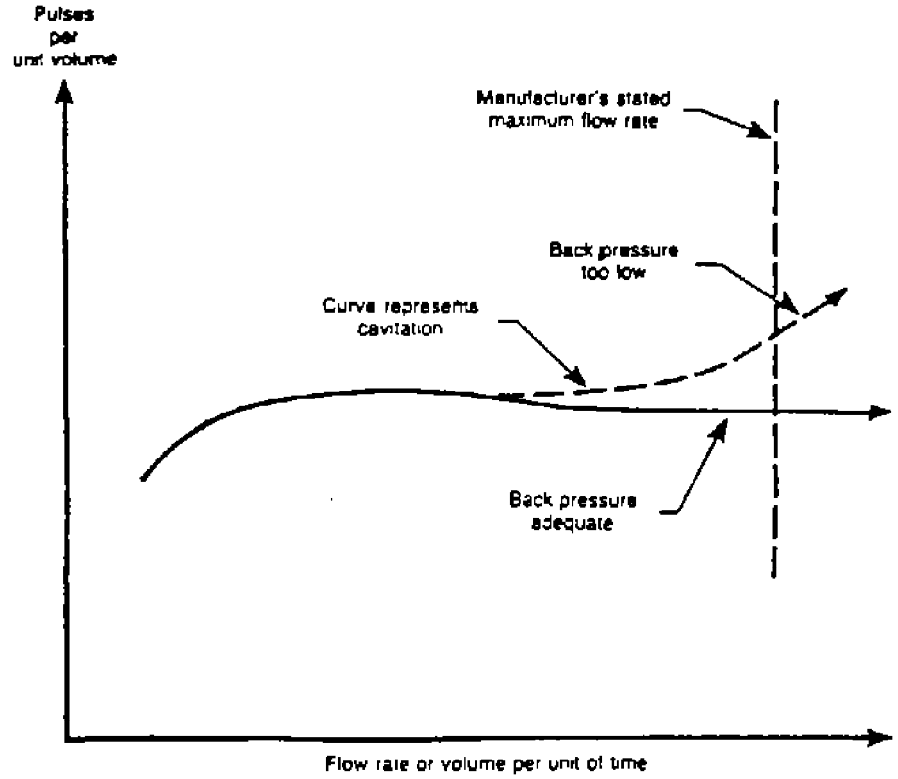
SCHEMATIC DIAGRAM OF A METERING RUN UTILIZING TURBINE METER
Fig. 6



Note: This figure shows assemblies installed upstream of the meter. Downstream of the meter, 5D minimum of straight pipe should be used.

L = overall length of straightener assembly (≥ 10D).
A = length of upstream plenum (2D-3D).
B = length of tube or vane-type straightening element (2D-3D).
C = length of downstream plenum (≥ 5D).
D = nominal diameter of meter.
n = number of individual tubes or vanes (≥ 4).
d = nominal diameter of individual tubes (B/d ≥ 10).

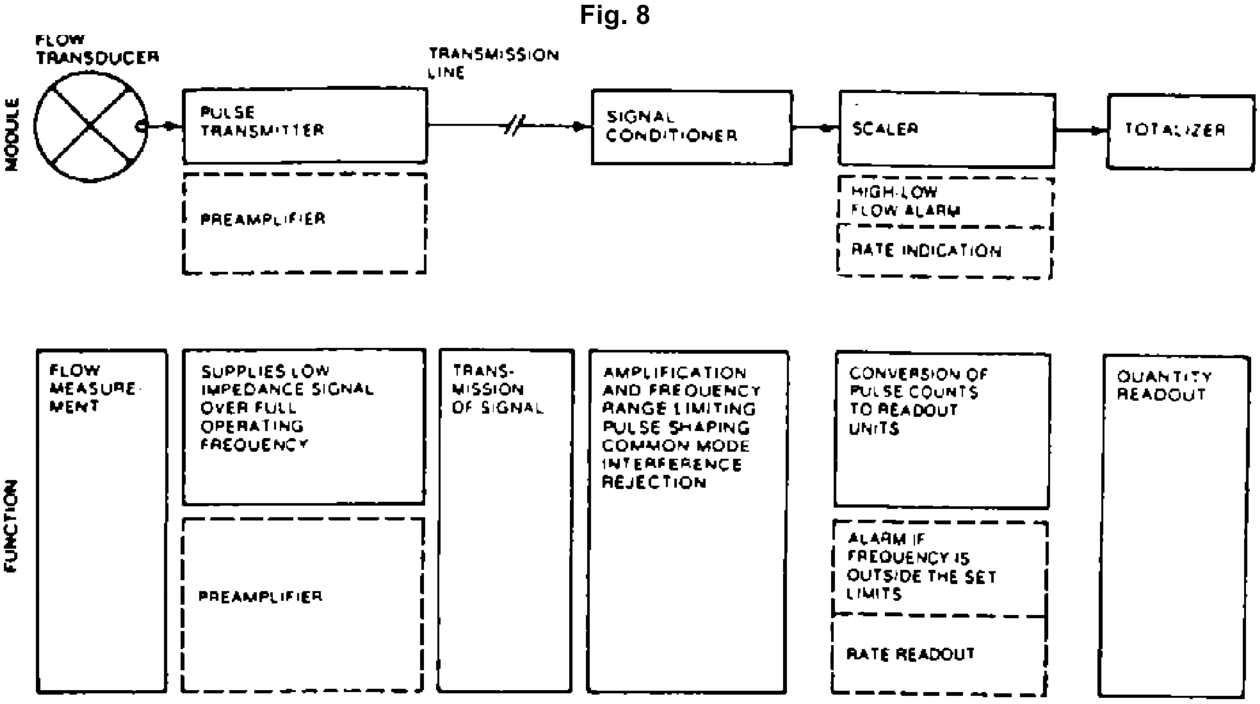
EXAMPLES OF FLOW-CONDITIONING ASSEMBLIES WITH STRAIGHTENING ELEMENTS
Fig. 7



Note: All curves are for example only.

EFFECTS OF CAVITATION ON ROTOR SPEED

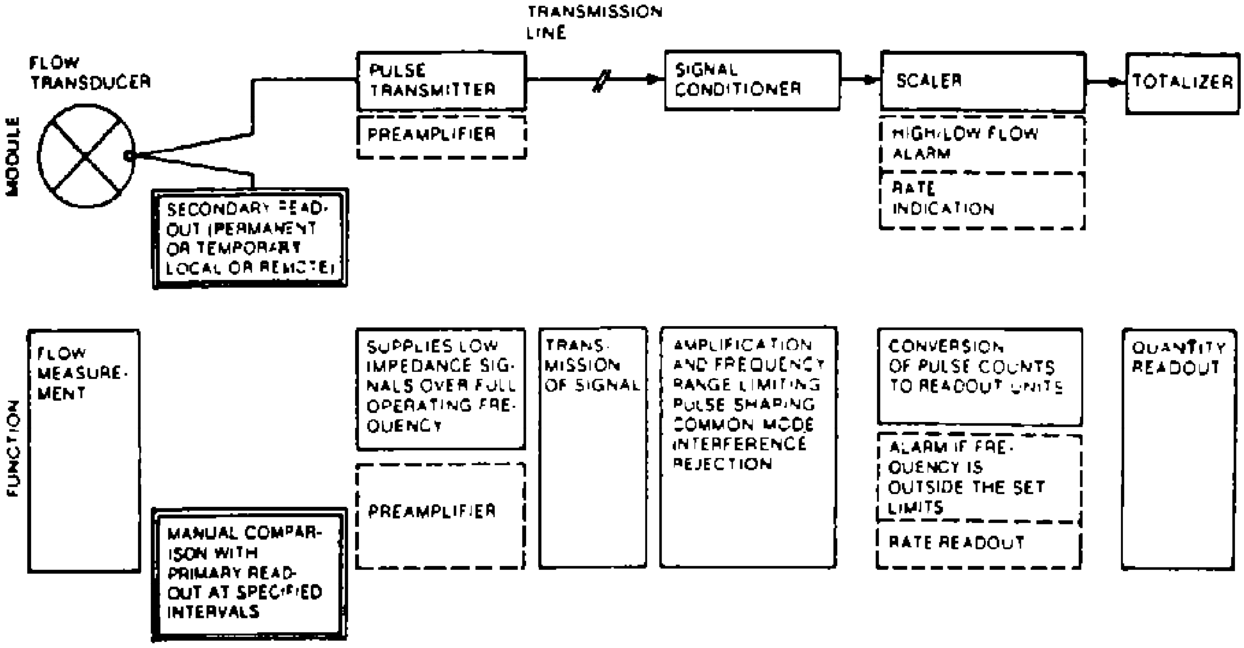
Fig. 8



NOTE: The modules and functions shown in full are essential. Those shown dotted are optional

TYPICAL FUNCTIONAL ARRANGEMENT FOR A LEVEL E PULSE SECURITY SYSTEM

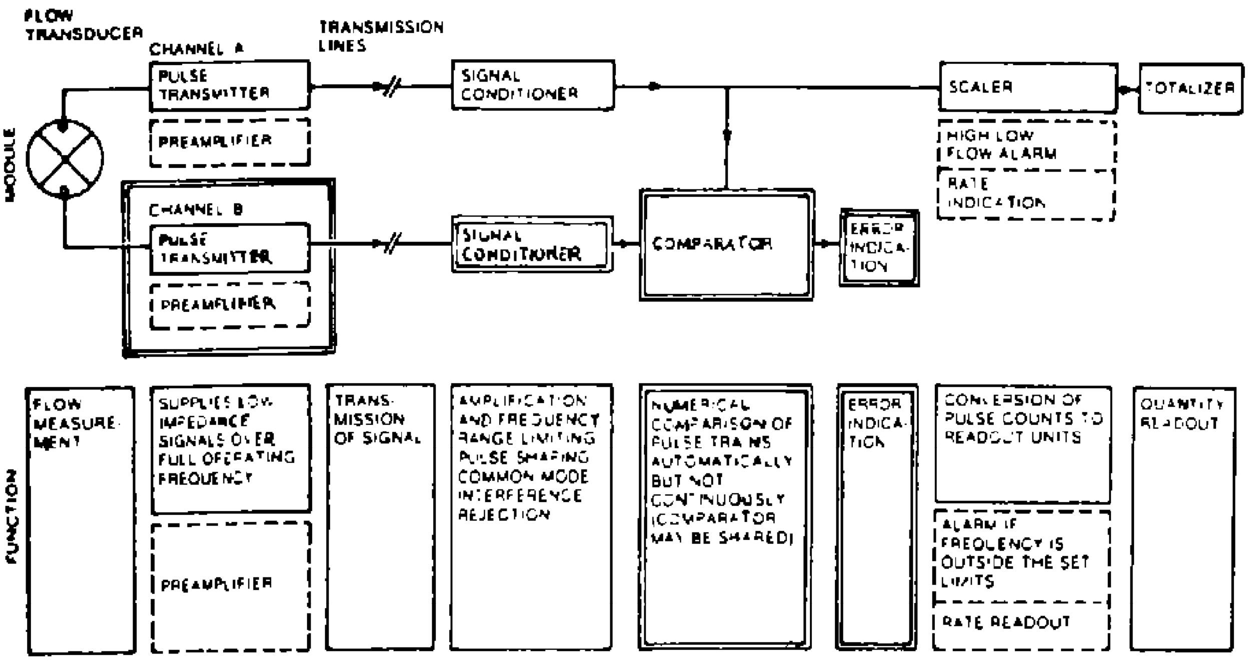
Fig. 9



NOTE The modules and functions shown in full are essential Those shown dotted are optional The modules and functions boxed in double lines indicate the difference from Level E

TYPICAL FUNCTIONAL ARRANGEMENT FOR A LEVEL D PULSE SECURITY SYSTEM

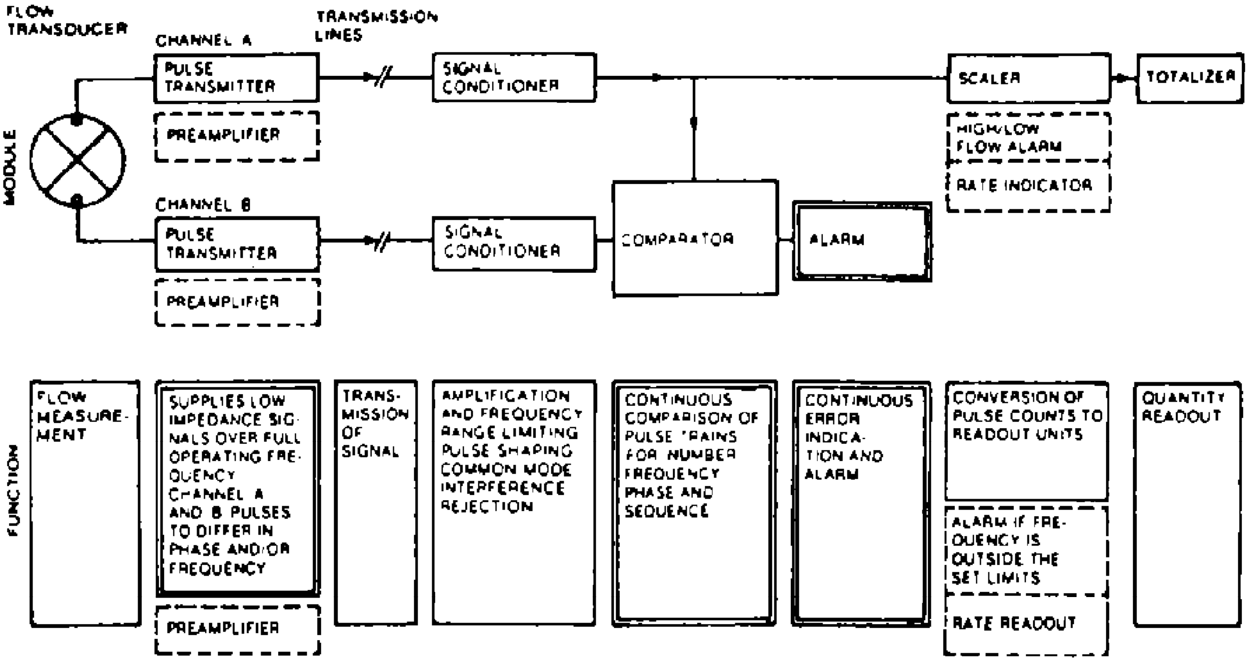
Fig. 10



NOTE The modules and functions shown in full are essential Those shown dotted are optional The modules and functions boxed in double lines indicate the difference from Level D

TYPICAL FUNCTIONAL ARRANGEMENT FOR A LEVEL C PULSE SECURITY SYSTEM

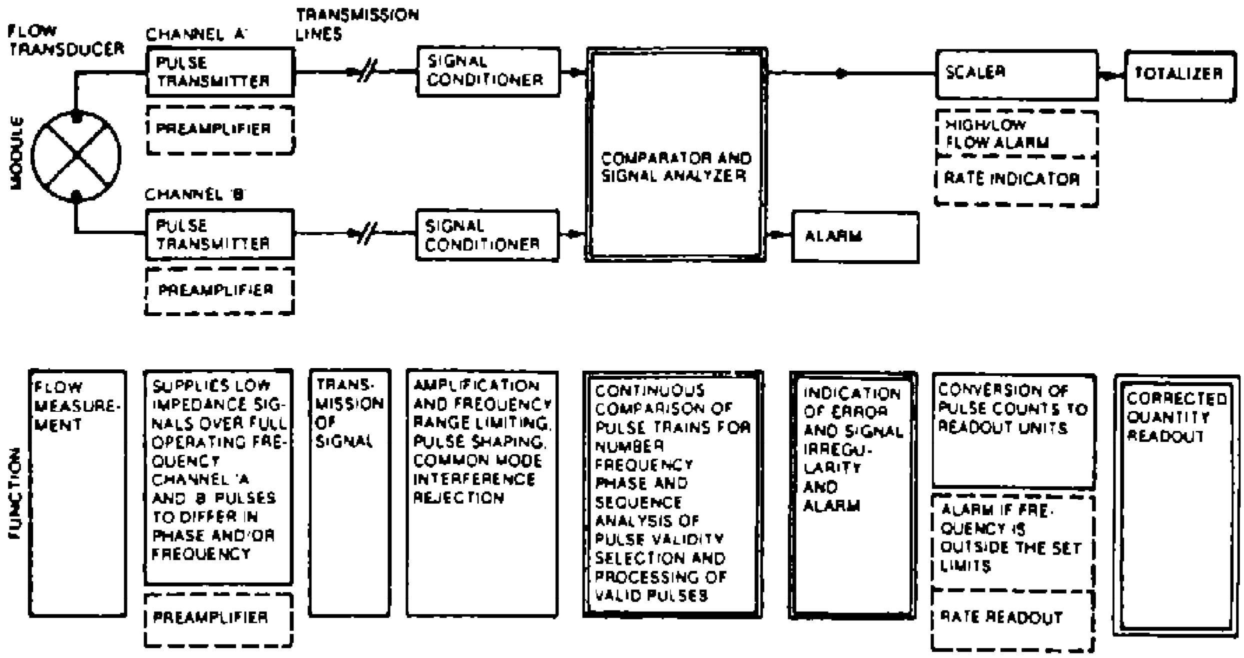
Fig. 11



NOTE The modules and functions shown in full are essential. Those shown dotted are optional. The modules and functions boxed in double lines indicate the difference from Level C.

TYPICAL FUNCTIONAL ARRANGEMENT FOR A LEVEL B PULSE SECURITY SYSTEM

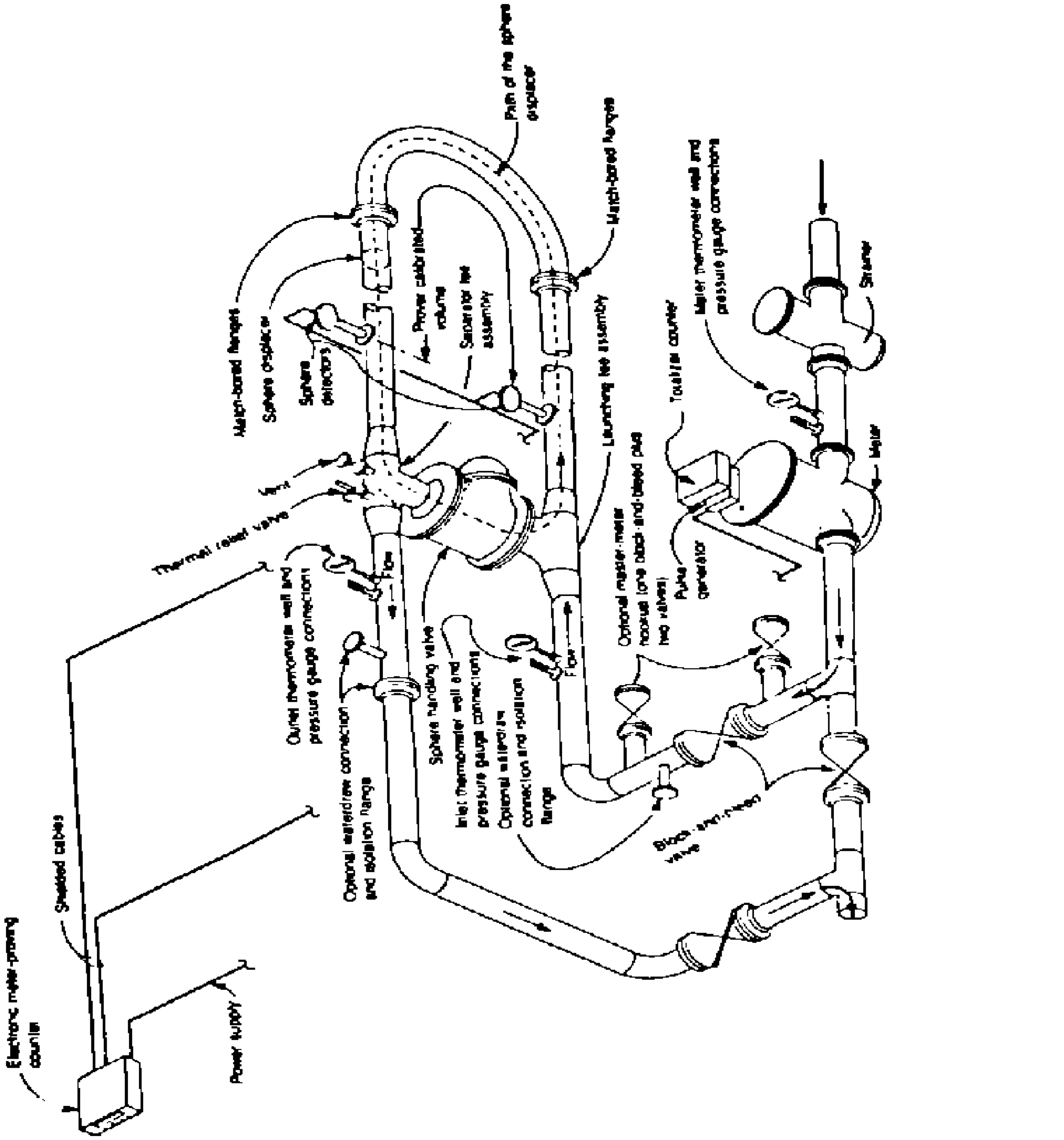
Fig. 12



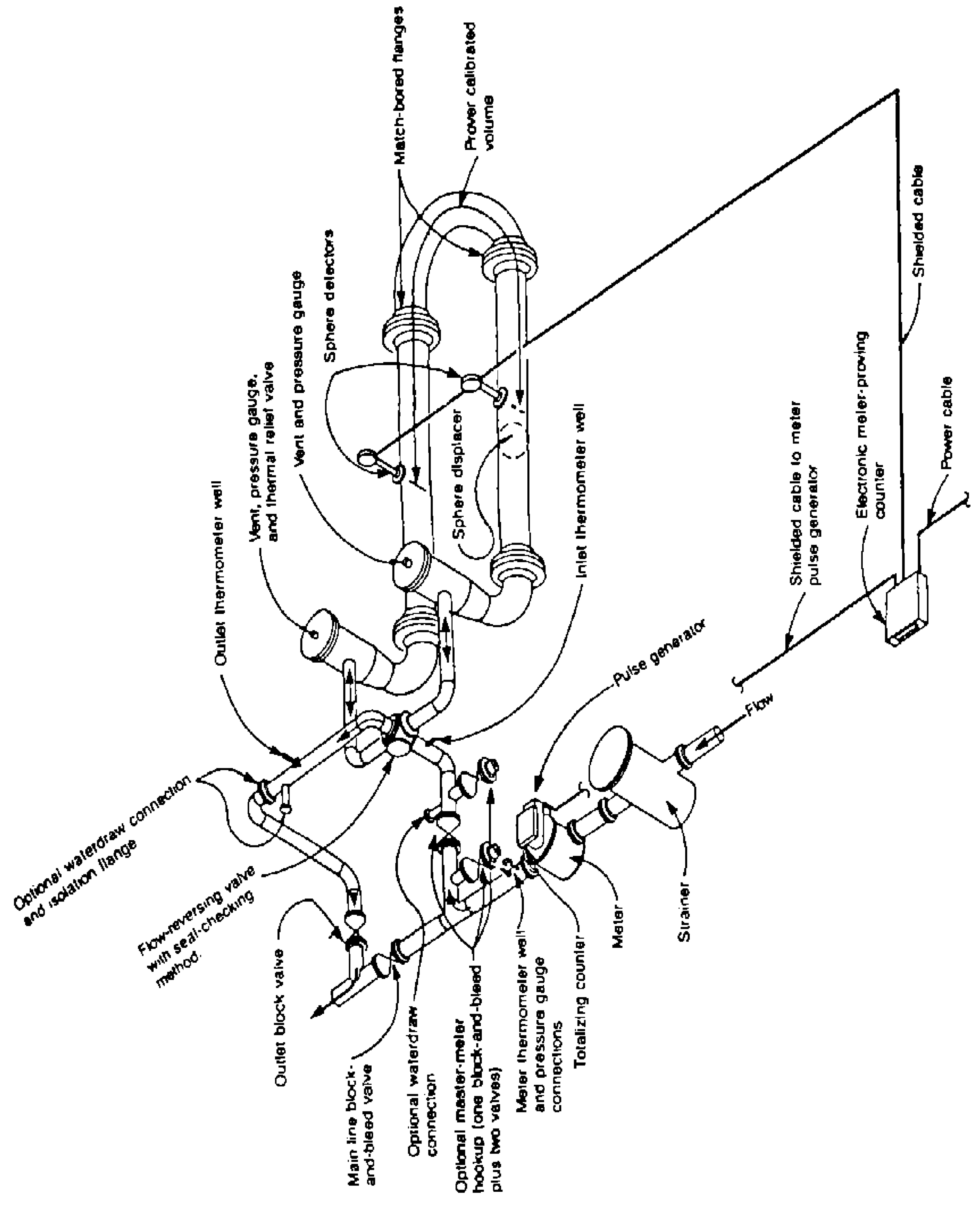
NOTE The modules and functions shown in full are essential. Those shown dotted are optional. The modules and functions boxed in double lines indicate the difference from Level B.

TYPICAL FUNCTIONAL ARRANGEMENT FOR A LEVEL A PULSE SECURITY SYSTEM

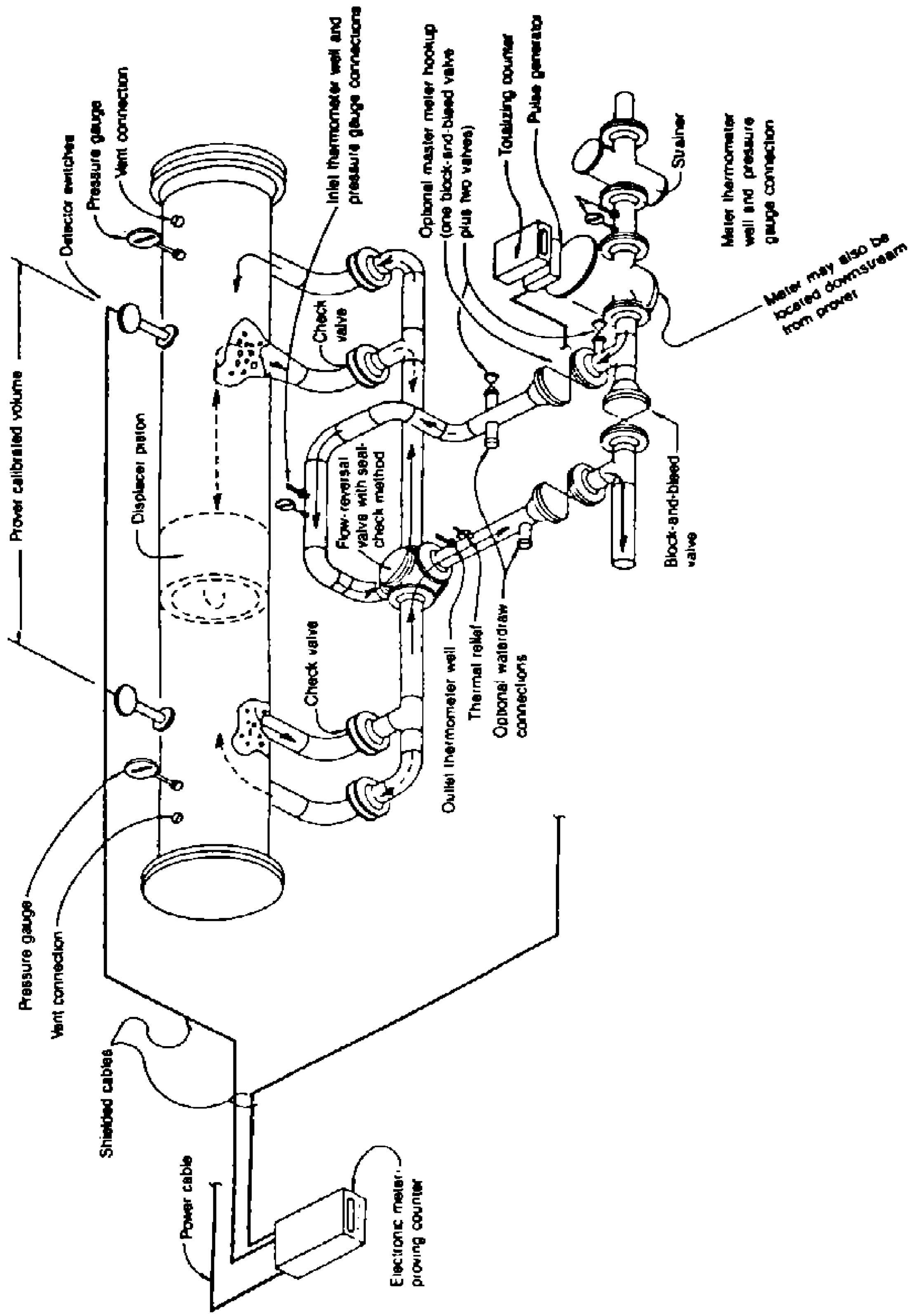
Fig. 13



TYPICAL UNIDIRECTIONAL RETURN-TYPE PROVER SYSTEM
Fig. 14



TYPICAL BIDIRECTIONAL U-TYPE SPHERE PROVER SYSTEM
Fig. 15



TYPICAL BIDIRECTIONAL STRAIGHT-TYPE PISTON PROVER SYSTEM

Fig. 16

APPENDICES

APPENDIX A-1
SPECIFICATION FORMS FOR POSITIVE DISPLACEMENT METERS

©ISA S20

Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves

	POSITIVE DISPLACEMENT METERS				SHEET ____ OF ____		
	NO	BY	DATE	REVISION	SPEC NO		REV
					CONTRACT		DATE
					REQ. P.O.		
					BY	CHK'D	APPR

	1	Tag Number				
	2	Service				
	3	Line No./Vessel No.				
METER	4	Type of Element				
	5	Size				
	6	End Connections				
	7	Temp. & Press. Rating				
	8	Flow Rate Range				
	9	Totalized Units				
	10	Enclosure Class				
	11	Power Supply				
	12	Materials: Outer Housing				
	13	Main Body Cover				
	14	Rotating Element				
	15	Shaft				
	16	Blades				
	17	Bearings: Type & Material				
	18	Packing				
	19	Type of Coupling				
	20					
COUNTER	21	Register Type				
	22	Totalizer				
	23	Reset				
	24	Capacity				
	25	Set Stop				
	26					
FLUID DATA	27	Fluid				
	28	Flow Rate: Min. / Max.				
	29	Normal Flow				
	30	Oper. Press / Oper. Temp.				
	31	Oper. Specific Gravity				
	32	Oper. Viscosity				
	33	Coef. of Expansion				
OPTIONS	34	Flow Units				
	35	Shut Off Valve				
	36	Switch: Single or 2-Stage				
	37	Temp. Compensator				
	38	Transmitter Type				
	39	Transmitter Output				
	40	Air Eliminator				
	41	Strainer: Size & Mesh				
	42					
	43					
	44					
	45	Manufacturer				
	46	Model Number				

Notes:

ISA FORM S20.26

(to be continued)

APPENDIX A-1 (continued)

POSITIVE DISPLACEMENT METERS

Instructions for ISA Form S20.25.

1. Tag No. of instrument.

2. Process service.

3. Pipe line or vessel identification.

4. Write in type of rotating element, such as, disc, piston, vane, helical, rotors, etc.

5. Show connection pipe size.

6. Specify end connections type and ANSI rating such as 300 lb R.F.

7. Specify the manufacturer's recommended body pressure and temperature rating, such as 250 psi at 190°F.

8. Write in manufacturer's recommended normal operating range.

9. Specify smallest totalized unit, such as "Tens of Gallons", "Pounds", Barrels".

10. Specify enclosure electrical classification, if applicable, such as "Class 1, Group D., Div. 2", "General Purpose", etc.

11. Specify power supply, if applicable.

12. Specify materials of construction. If no preference, write in, MFR. STD. (Manufacturer's Standard).

13-18. Specify materials of construction, if no preference, write in, Manufacturer's Standard (MFG-STD).

19. Specify type of coupling.

20. Specify coupling such as "Magnetic", or MFR. STD.

21. Specify register type such as horizontal, vertical, inclined, inline reading, dial reading, print, etc.

22. Specify number of figures such as 6 digit, 5 digit, or 0-99, 999, etc.

23. If totalizer reset required, write in type. If reset is not required, write in "none".

24. Write in number of figures or maximum quantity (in flow units) that can be held in counter.

25. Specify by writing in "yes" if a set-stop is required to operate shut-off valve, switch, etc.

27-34. Specify fluid data as completely as possible, note at operating conditions. Be sure to note if liquid is at saturation conditions.

35. Specify by writing in "yes" if a shut-off valve is required. Valve to be manufacturer's standard construction unless otherwise noted.

36. Specify by writing in "yes" if a switch is required. Two switches are required for 2-stage shut-off control.

37. Write in "yes" if manufacturer's standard temperature compensator is required. Write in "no" if not required.

38. Specify, if transmitter is required, by writing in type such as pulse, rate of flow, etc.

39. Give transmitter output in pulse per gallon, 4-20 mA, etc.

(to be continued)

APPENDIX A-1 (continued)

40. Write in "yes" if air eliminator is required, otherwise write in "no".

41. Specify, if strainer is required, by writing in type such as "Y" "Basket", etc. Strainer to have same pressure and temperature rating, end connections and material as meter body unless otherwise noted.

45-46. Identify manufacturer’s name and model number after selection is made.

APPENDIX A-2
SPECIFICATION FORMS FOR TURBINE METERS

©ISA S20

Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves

	POSITIVE DISPLACEMENT METERS				SHEET ____ OF ____	
	NO	BY	DATE	REVISION	SPEC NO	REV
					CONTRACT	DATE
					REQ P.O.	
					BY / CHK'D	APPR

	No.	Item				
	1	Tag Number				
	2	Service				
	3	Line No./Vessel No.				
METER	4	Type of Element				
	5	Size				
	6	End Connections				
	7	Temp & Press Rating				
	8	Flow Rate Range				
	9	Totalized Units				
	10	Enclosure Class				
	11	Power Supply				
	12	Materials: Outer Housing				
	13	Main Body Cover				
	14	Rotating Element				
	15	Shaft				
	16	Blades				
	17	Bearings: Type & Material				
	18	Packing				
	19	Type of Coupling				
	20					
COUNTER	21	Register Type				
	22	Totalizer				
	23	Reset				
	24	Capacity				
	25	Set Stop				
	26					
FLUID DATA	27	Fluid				
	28	Flow Rate: Min. / Max				
	29	Normal Flow				
	30	Oper Press / Oper Temp				
	31	Oper Specific Gravity				
	32	Oper Viscosity				
	33	Coef of Expansion				
OPTIONS	34	Flow Units				
	35	Shut-Off Valve				
	36	Switch: Single or 2 Stage				
	37	Temp Compensator				
	38	Transmitter Type				
	39	Transmitter Output				
	40	Air Eliminator				
	41	Strainer: Size & Mesh				
	42					
	43					
	44					
	45	Manufacturer				
	46	Model Number				

Notes:

ISA FORM S20.28

(to be continued)

APPENDIX A-2 (continued)

TURBINE FLOWMETERS

Instructions for ISA Form S20.24.

Refer to ISA Standard S31, "Specification, Installation, and Calibration of Turbine Flowmeters"

1. Show meter tag number. Quantity is assumed to be one unless otherwise noted.

2. Refers to process service or applications.

3. Give line number or process area.

5. Specify size and style of connections, such as "1 in. NPT", "2 in. 150 lb ANSI", etc.

6. Pressure and temperature design rating required.

7. Nominal flow rating is obtained from manufacturer's data. This usually defines linear range of selected meter.

8. Turbine meter accuracy figures are in terms of percent of instantaneous flow rate.

9. Degree of linearity over nominal flow range.

10. K factor relates cycles per second to volume units. Enter this figure after selection is made.

11. Excitation modulating type only expressed as volts___ at___ hertz.

12-16. Specify materials of construction or write in "MFR STD".

17. Specify sleeve or ball bearings, or none if floating rotor design.

18. Bearing materials -- will be MFG STD if not stated otherwise.

19. Maximum speed or frequency which the meter can produce without physical damage.

21. Pickoff may be standard hi-temp., radio-frequency type (RF) or explosion proof. Minimum output voltage ____ volts peak to peak.

22. Specify electrical classification of enclosure such as General Purpose, Weather Proof, Class 1, Group D, etc.

23. Specify fluid data as indicated, using line 28 for additional item if required.

34. Give Tag No. of secondary instrument if different from meter Tag. No.

35. Pre-amplifier if used.

36. Specify function of instrument, such as rate indicator, totalizer, or batch control.

37. Flush, surface or rack.

38. Power Supply i.e., 117 V ac.

39. Applies to rate indicator.

40. Give output range such as "40-20 mA", 21-103 kPa (3-15 psig), etc.

41. May be used for number of digits, and to state whether counter is reset or non-reset type.

42. Specify range of compensation, if required, in pressure and/or temperature units or viscosity units.

(to be continued)

APPENDIX A-2 (continued)

43. Pre-set counter.

44. Specify NEMA classification of enclosure.

45. Specify strainer size and mesh size. Request Vendor's recommendation if not known.

50. Fill in after selection is made.

51. Fill in after selection is made.

52. Fill in after selection is made.