CONSTRUCTION STANDARD

FOR

MEASUREMENT OF LIQUID HYDROCARBONS

CUSTODY TRANSFER

SECOND EDITION

JUNE 2014

FOREWORD

The Iranian Petroleum Standards (IPS) reflect the views of the Iranian Ministry of Petroleum and are intended for use in the oil and gas production facilities, oil refineries, chemical and petrochemical plants, gas handling and processing installations and other such facilities.

IPS is based on internationally acceptable standards and includes selections from the items stipulated in the referenced standards. They are also supplemented by additional requirements and/or modifications based on the experience acquired by the Iranian Petroleum Industry and the local market availability. The options which are not specified in the text of the standards are itemized in data sheet/s, so that, the user can select his appropriate preferences therein

The IPS standards are therefore expected to be sufficiently flexible so that the users can adapt these standards to their requirements. However, they may not cover every requirement of each project. For such cases, an addendum to IPS Standard shall be prepared by the user which elaborates the particular requirements of the user. This addendum together with the relevant IPS shall form the job specification for the specific project or work.

The IPS is reviewed and up-dated approximately every five years. Each standards are subject to amendment or withdrawal, if required, thus the latest edition of IPS shall be applicable

The users of IPS are therefore requested to send their views and comments, including any addendum prepared for particular cases to the following address. These comments and recommendations will be reviewed by the relevant technical committee and in case of approval will be incorporated in the next revision of the standard.

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GENERAL DEFINITIONS:

Throughout this Standard the following definitions shall apply.

COMPANY:

Refers to one of the related and/or affiliated companies of the Iranian Ministry of Petroleum such as National Iranian Oil Company, National Iranian Gas Company, National Petrochemical Company and National Iranian Oil Refinery And Distribution Company.

PURCHASER:

Means the “Company” where this standard is a part of direct purchaser order by the “Company”, and the “Contractor” where this Standard is a part of contract documents.

VENDOR AND SUPPLIER:

Refers to firm or person who will supply and/or fabricate the equipment or material.

CONTRACTOR:

Refers to the persons, firm or company whose tender has been accepted by the company.

EXECUTOR:

Executor is the party which carries out all or part of construction and/or commissioning for the project.

INSPECTOR:

The Inspector referred to in this Standard is a person/persons or a body appointed in writing by the company for the inspection of fabrication and installation work.

SHALL:

Is used where a provision is mandatory.

SHOULD:

Is used where a provision is advisory only.

WILL:

Is normally used in connection with the action by the “Company” rather than by a contractor, supplier or vendor.

MAY:

Is used where a provision is completely discretionary.

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APPENDICES:

1. SCOPE

This Standard represents the minimum technical requirements for the construction and installation of positive displacement meters, turbine meters, coriolis meters, ultrasonic meters and all accessory equipment used in custody transfer of liquid hydrocarbon.

In any case, manufacturer installation instruction should be strictly followed.

Note 1:

This is a revised version of this standard, which is issued as revision (1)-2005. Revision (0)-1997 of the said standard specification is withdrawn.

Note 2:

This is a revised version of this standard, which is issued as revision (2)-2014. Revision (1)-2005 of the said standard specification is withdrawn.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the company and the vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

API (AMERICAN PETROLEUM INSTITUTE)

RP 551	"Process Measurement Instrumentation"
MPMS Chapter 4 Section 2	"Manual of Petroleum Measurement Standards Chapter 4-Proving Systems, Section 2-Displacement Provers"
MPMS Chapter 4 Section 4	"Manual of Petroleum Measurement Standards Chapter 4-Proving Systems, Section 4-Tank Provers"
MPMS Chapter 4 Section 5	"Manual of Petroleum Measurement Standards Chapter 4-Proving Systems, Section 5-Master Meter Provers"
MPMS Chapter 4 Section 6	"Manual of Petroleum Measurement Standards Chapter 4-Proving Systems, Section 6-Pulse Interpolation"
MPMS Chapter 5 Section 1	"Manual of Petroleum Measurement Standards Chapter 5-Metering, Section 1- General Considerations for Measurement by Meters"
MPMS Chapter 5 Section 2	"Manual of Petroleum Measurement Standards Chapter 5-Metering, Section 2-Measurement of Liquid Hydrocarbons by Displacement Meters"
MPMS Chapter 5 Section 3	"Manual of Petroleum Measurement Standards Chapter 5-Metering, Section 3-Measurement of Liquid Hydrocarbons by Turbine Meters"
MPMS Chapter 5 Section 4	"Manual of Petroleum Measurement Standards Chapter 5-Metering, Section 4-Accessory Equipment for Liquid Meters"

MPMS Chapter 5 Section 5	"Manual of Petroleum Measurement Standards Chapter 5-Metering, Section 5-Fidelity and Security of Flow Measurement Pulsed-Data Transmission Systems"
MPMS Chapter 5 Section 6	"Manual of Petroleum Measurement Standards Chapter 5-Metering, Section 6- Measurement of Liquid Hydrocarbons by Coriolis Meters"
MPMS Chapter 5 Section 8	"Manual of Petroleum Measurement Standards Chapter 5-Metering, Section 8- Measurement of Liquid Hydrocarbons by Ultrasonic Flow Meters Using Transit Time Technology"
MPMS Chapter 6	"Metering Assemblies"
MPMS Chapter 21 Section 2	"Manual of Petroleum Measurement Standards-Chapter 21: Flow Measurement Using Electronic Metering Systems- Section 2: Electronic Liquid Volume Measurement Using Positive Displacement and Turbine Meters"
API Spec. 6D	"Specification for Pipeline Valves"
API Std. 598	"Valve Inspection and Testing"
API Std. 600	"Steel Gate Valves-Flanged and Butt-welding Ends, Bolted Bonnets"
API Std. 1104	"Welding of Pipelines and Related Facilities"

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

ASME BPVC Sec. VIII	"ASME Boiler and Pressure Vessel Code, Sec. VIII: Rules for Construction of Pressure Vessels"
ASME B1.20.1	"Pipe Threads, General Purpose (Inch)"
ASME B16.5	"Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Metric/Inch Standard"
ASME B31.3	"Process Piping, ASME Code for Pressure Piping, B31"
ASME B31.4	"Pipeline Transportation Systems for Liquids and Slurries, ASME Code for Pressure Piping, B31"

BSI (BRITISH STANDARDS INSTITUTION)

BS 6169-1	"Methods for volumetric measurement of liquid hydrocarbons- Part 1: Displacement meter systems (other than dispensing pumps)"
BS 6169-2	"Methods for volumetric measurement of liquid hydrocarbons- Part 2: Turbine meter systems"
BS EN ISO 10434	"Bolted Bonnet Steel Gate Valves for the Petroleum, Petrochemical and Allied Industries"
BS EN 1560	"Founding, Designation System for Cast Iron, Material Symbols and Material Numbers"

	BS 3293	"Specification for Carbon Steel Pipe Flanges- (Over 24 inches Nominal Size) for the Petroleum Industry"
ISO	**(INTERNATIONAL ORGANIZATION FOR STANDARDIZATION)**	
	ISO 2714	"Liquid hydrocarbons - Volumetric Measurement by Displacement Meter Systems other than Dispensing Pumps"
	ISO 2715	"Liquid Hydrocarbons-Volumetric Measurement by Turbine Meter Systems"
	ISO 7278-3	"Liquid Hydrocarbons – Dynamic Measurement – Proving Systems for Volumetric Meters- Part 3: Pulse Interpolation Techniques"
ISA	**(INTERNATIONAL SOCIETY OF AUTOMATION)**	
	RP 31.1	"Specification, Installation, and Calibration of Turbine Flowmeters"
IPS	**(IRANIAN PETROLEUM STANDARDS)**	
	IPS-C-IN-140	"Construction and Installation Standard for Level Instruments"
	IPS-C-IN-120	"Construction and Installation Standard for Temperature Instruments"
	IPS-C-IN-130	"Construction and Installation Standard for Flow Instruments"
	IPS-C-IN-110	"Construction Standard for Pressure Instruments"
	IPS-C-IN-160	"Construction and Installation Standard for Control Valves"
	IPS-E-IN-190	"Engineering Standard for Transmission Systems"
IP	**(THE INSTITUTE OF PETROLEUM)**	
	Part 9 - Sec. 1	"Positive Displacement Meters"

3. UNITS

This standard is based on international system of units (SI), as per IPS-E-GN-100 except where otherwise specified.

4. POSITIVE DISPLACEMENT METERS

4.1 Installation Design Consideration

All types of positive displacement-meter installations should take into account the following considerations:

a) The installation shall be able to handle the maximum and minimum flow rates, the maximum operating pressure, and the temperature range of the liquid. The installation shall include devices that keep the operation of the meter within design limits.

b) Strainers, filters, air/vapor eliminators, or other protective devices shall be provided upstream of the meter to remove solids or gas that could cause premature wear or measurement errors. A differential pressure gauge shall be used to determine when the filter or strainer should be cleaned. Differential pressure instrument should be used for more safety.

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 shall comply with all applicable regulations for electrical equipment in hazardous areas.

e) The connections for proving facilities shall be provided.

f) Precautions for operating newly installed meters

When a new meter installation is placed in service, particularly on newly installed lines, foreign matter can be carried to the metering mechanism during the initial passage of liquid.

Protection should be provided from malfunction or damage by foreign matter, such as air or vapor, slag, debris, welding splatter, thread cuttings, pipe compound, etc. Following are suggested means of protecting the meter from foreign matter:

- Temporarily replace the meter with a spool.
- Put a bypass around the meter.
- Remove the metering element.
- Install a protective device upstream of the meter.

g) If a bypass is permitted around a meter or a battery of meters, it shall be provided with a blind and positive shutoff double block-and-bleed valve with a telltale bleed. The bypass line could be used only under permission of all authorized parties.

h) An un-interruptible regulated power supply (UPS) shall be provided for continuous meter operation.

4.2 Installation

Positive displacement meters shall be installed according to manufacturer's instructions and shall not be subjected to undue piping stress and vibration. Flow conditioning is not required for displacement meters. Fig. 1 is a schematic diagram of a typical meter station.

4.2.1 Valves

4.2.1.1 In general all valves should be designed so that they will not admit air when they are subjected to vacuum conditions.

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

4.2.2 Piping installation

4.2.2.1 Positive displacement meters shall be installed in horizontal position.

4.2.2.2 Protective devices such as strainers, filters, sediment traps, settling tanks, water separators or a combination of these items, may be installed singly or in an interchangeable battery limit, depending on the importance of continuous service.

4.2.2.3 Meters shall be protected from pressure pulsation and excessive surges and excessive pressure caused by thermal expansion of the liquid. The installation of surge tanks, expansion chambers, pressure-limiting valves and relief valves is recommended for this kind of protection.

When pressure relief valves are located between the meter and the prover, a means of detection spills from the valves shall be provided.

4.2.2.4 The release of vapor can be minimized or eliminated by maintaining sufficient back pressure downstream of the meter. This can be achieved by installing the appropriate type of throttling valve downstream of the meter.

4.2.2.5 Each meter shall be installed so that neither air nor vapor can pass through it. If necessary, air/vapor elimination equipment shall be installed as close as possible to the upstream side of the meter. The vapor vent lines on air/vapor eliminators shall be of adequate size. A tight-closing check valve in the vent line will prevent air from being drawn into the system when air eliminators are operating bellow atmospheric pressure.

4.2.2.6 Meters and piping shall be installed so that accidental drainage or vaporization of liquid is avoided. The installation shall prevent air from being entered into the system through leaky valves, piping, glands of pump shaft, connecting lines, etc.

4.2.2.7 Lines from the 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 can be drawn off before proving. The distance between the meter and its prover shall be minimized.

4.2.2.8 The installation of a bank of meters connected in parallel is recommended where the flow rate is too great for any one meter. In this case, throttling valves may be installed downstream of the meters to regulate flow through the prover while each meter is being proved.

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

4.2.2.10 Meters shall be installed in the altitude suggested by the manufacturer.

4.2.2.11 A reliable temperature measuring device and a separate thermowell shall be installed immediately downstream of the meter to permit determination of the temperature of the metered liquid.

4.2.2.12 To determine meter pressure, a pressure gage and a pressure transmitter of proper range and accuracy shall be installed near outlet of each meter.

4.2.2.13 As hydrocarbons are readily flammable, precautions against electrostatic arcing shall be designed into the metering system so as to prevent ignition.

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

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 rates.

Temperature control is especially important when the meter is not operating. The meter manufacturer should be consulted about high and low limits for viscosity and temperature.

4.2.3 Common seal points for displacement-meter installations are meter-cover and accessory stack flange bolts, meter counter mounting bolts, calibrator and compensator adjustments, right-angle drive covers, and covers for electrical and control boxes.

5. TURBINE FLOWMETERS

5.1 Installation Design Consideration

The design of turbine-meter installations should take into account all considerations mentioned in 4.1. Additionally, the installation should ensure appropriate flow conditioning both upstream and downstream of the meter or meters.

5.2 Installation

Turbine meters shall be installed according to manufacturer's instructions. Fig. 2 is a schematic diagram of a typical turbine meter system.

5.2.1 Flow conditioning

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

5.2.1.2 Flow conditioning requires the use of sufficient lengths of straight pipe or a combination of straight pipe and straightening elements that are inserted in the meter run upstream of the turbine meter (Fig. 3).

5.2.1.3 When only straight pipe is used, the liquid shear, or internal friction between the liquid and the pipe wall, shall be sufficient to accomplish the required flow conditioning. Experience has shown that in many installation, pipe lengths of 20 times meter-bore diameter upstream of the meter and 5 times meter-bore diameter downstream of the meter provide effective conditioning. Appendix A should be referred to for guidance in applying this technique.

5.2.1.4 A straightening element usually consists of a cluster of tubes, vanes or equivalent devices that are inserted longitudinally in a section of straight pipe. Straightening elements effectively assist flow conditioning by eliminating liquid swirl. Straightening elements may also consist of a series of perforated plates or wire mesh screens, but these forms normally cause a larger pressure drop than do tubes or vanes (Fig. 3).

5.2.1.5 Proper design and construction of the straightening element is important to ensure that swirl is not generated.

The following guidelines are recommended to avoid the generation of swirl:

a) The cross-section should be as uniform and symmetrical as possible.

b) The design and construction should be rugged enough to resist distortion or movement at high flow rates.

c) The general internal construction should be clean and free from welding protrusions and other obstructions.

5.2.1.6 Flow-straightening sections shall be used, and there shall be ample distance between the meter run and any pumps, elbows, valves, or other fittings that may induce swirl or non-uniform velocity profile. Flanges and gaskets shall be internally aligned, and gaskets shall not protrude into the liquid stream. Meter flanges shall be doweled or matched by some method to ensure that the straightening sections and the meter are properly aligned during and after assembly.

5.2.2 Valves

5.2.2.1 The performance of valves in turbine-meter installation can affect the measurement accuracy. The flow or pressure control valves on the main meter run should be capable of rapid, smooth opening and closing to prevent shocks and surges. Other valves, particularly those between the meter 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 shutoff integrity.

5.2.2.2 Valves for intermittent flow control should be fast acting and shock free. This would minimize the adverse effects of starting and stopping liquid movement.

5.2.3 Piping installation

5.2.3.1 Turbine meters are normally installed in a horizontal position. If space limitation dictates a different position manufacturer should be consulted.

5.2.3.2 The installation of bank of meters in parallel may be used, where the flow range is too great for any one meter or for its proving. 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.

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

5.2.3.4 Protective devices shall be installed to remove from the liquid abrasives or other entrained particles that can 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 interchangeable battery limit, depending on the importance of continuous service.

5.2.3.5 Meters shall be adequately protected from pressure pulsations and excessive surges as well as excessive pressure caused by thermal expansion of the liquid. This may require the installation of surge tanks, expansion chambers, pressure limiting valves or other protective devices. A means of detecting spillage from pressure limiting valves or pressure relief valve shall be provided when such valves are located downstream of the meter.

5.2.3.6 When a flow limiting device is required, it should be installed downstream of the meter run. An alarm should be installed for flow rates bellow design minimum. If a flow limiting or pressure-reducing device is installed on the inlet side of the meter, it shall be installed as far as possible upstream of the meter run and shall maintain enough pressure on the outlet side of the meter run to prevent any vaporization of the metered liquid.

5.2.3.7 Each meter shall be installed so that air or vapor is prevented to pass through it. Air or vapor eliminators may be installed upstream of the meter if necessary. The eliminators shall be installed as close to the meter as practically possible, but it must not be so close that it creates swirl or a distorted velocity profile at the entry to the meter. Any vapor shall be vented in a safe manner.

5.2.3.8 A flow straightener is effective in eliminating swirl, and the upstream rotor support of turbine flow meter acts, to some extent as a straightener. Unusual downstream disturbances, such as pump inlet, may require a straight line downstream or in extreme cases a downstream straightener may be necessary.

5.2.3.9 Turbine flowmeters should be installed in the same position as they were calibrated, usually in the horizontal position. When installed in a position other than horizontal, a difference in axial thrust balance may cause a change in calibration factor. For small turbine meters, the angular position of the transducer coil should be similarly considered.

5.2.3.10 The piping shall not have points or pockets where air or vapor might accumulate and be carried through the meter by the added turbulence resulting from increased flow rate. The installation shall prevent air from being entered into the system through leaky valves, piping, glands of pump shafts, separators, connecting lines and etc.

5.2.3.11 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. 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.

5.2.3.12 Mixing of dissimilar liquids should be minimized by special consideration given to the location of each meter and its accessory equipment and its piping manifold.

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

5.2.3.14 A thermometer and a temperature transmitter shall be installed immediately downstream of downstream meter run so that metered stream temperature can be determined. The device shall not be installed upstream within the flow conditioning section or downstream closer than the manufacturer's recommended position.

5.2.3.15 To determine meter pressure, a pressure gage, and transmitter of proper range and accuracy shall be installed near the outlet of each meter.

5.3 Common seal points for turbine-meter installations are the mechanical-counter enclosures, pickup mounting fittings preamplifier housings, electrical conduit covers, and control-box covers. When sealing electrically operated systems that have many accessories, power supplies, and read-outs becomes burdensome, the equipment is often housed in a building or enclosure that can be locked or sealed to meet the system's needs.

6. ULTRASONIC FLOW METERS

6.1 General

Ultrasonic flow meters measure the flow by penetrating the pipe with ultrasonic time difference. The flow meter operates by alternatively transmitting and receiving ultrasonic signal pulses between the two transducers. The ultrasonic signals are first transmitted in the direction of fluid and then against fluid flow. Since sound energy in a moving liquid is carried faster when it travels in the direction of flow than against it, a time difference between the signals time-of-flight will occur. If the fluid is not moving, the time difference is zero and the flowmeter will indicate zero flow. The transit-time (or time-of-flight) of the signals is accurately measured in both flow directions and the difference in time calculated. The time difference of the ultrasonic signals is proportional to the flow velocity in the pipe. The measured flow velocity is multiplied with the cross-sectional area of the pipe; hence the flow rate of the fluid can be calculated.

Ultrasonic flow meters shall be installed according to manufacturer's instructions. Additionally for installation of ultrasonic flow meters the considerations mentioned in 4.1 and the following items shall be considered.

The meter run design shall consider the user's minimum and maximum flow rates, Reynolds number, temperatures and pressures. Additionally, it shall consider the following physical properties; viscosity, relative density, vapor pressure and corrosiveness. Operating within the linear flow range of the UFM based on the specific application is desirable.

Temperature devices, temperature test thermowells, pressure and density sensing devices shall be installed to accurately represent the actual metering conditions. Immediately downstream of the meter run is the preferred location (see Figure 9).

The meter run design shall ensure that each meter is liquid filled under all operating conditions. Placement of the meter(s) at high points in the system shall be avoided. UFMs may be installed in any position or plane. However, care shall be taken to ensure that the acoustic transducers are not located on the top or bottom of the pipe to minimize the effects of air or sediment. The meter's installation orientation should be in accordance with the manufacturers' recommendation.

Steps shall be taken to minimize the amount of water in the fluid being measured. Depending on the flow regime, the acoustic properties of the oil, the water droplet size and distribution, and the amount of water, UFMs may become less accurate because paths may become inoperable.

Meters shall be adequately protected from excessive pressure through the proper use of pressure relief devices. This kind of protection may require the installation of surge tanks, expansion chambers, pressure-limiting valves, pressure relief valves, and/or other protective devices.

UFMs shall not be exposed to vibration levels or vibration frequencies that might excite the natural frequencies of electronic system boards, components or ultrasonic transducers. Vibration levels shall not exceed those specified by the manufacturer.

Even though a UFM design has been tested to withstand electrical noise influences, the UFM or its connected wiring shall not be exposed to any unnecessary electrical noise, including alternating current, solenoid transients or radio transmissions, especially at ultrasonic frequencies.

Where an acoustic couplant is used, it is advisable that the user check the acoustic couplant conditions in order to avoid ultrasonic signal attenuation due to loss or degradation of the acoustic couplant.

6.2 Flow Conditioning

Flow conditioning elements intended to reduce swirl or velocity profile distortion shall be required. The design shall ensure appropriate flow conditioning upstream and downstream of the meter. Typically, straight pipe lengths of 10 pipe diameters with a flow conditioning element upstream of the meter and 5 pipe diameters downstream of the meter provide effective conditioning, unless the meter manufacturer’s experience and recommendations along with flow research support different lengths (see Figure 9).

The inside diameter of the meter run piping shall be the same as the inlet-outlet of meter. Welds shall be internally ground smooth and all gaskets shall be installed to not protrude into the pipe. Methods to ensure proper internal alignment are recommended.

The flanges, and adjacent upstream pipe, shall be straight and cylindrical, and all have the same inside diameter as the internal diameter of the inlet of the meter, preferably within 1 % but at maximum within 3 %, and be carefully aligned to minimize flow disturbances, especially at the upstream flange.

The effects of different piping configurations or flow conditioning elements on the flow conditioning installation requirements has not been fully evaluated; therefore, consult the manufacturer for design considerations.

Meter proving repeatability, as well as the derived meter factor, may be affected by the flow conditioning design including the type and location of the flow-conditioning elements. For example, in cases where the meter cannot be proved immediately after meter run servicing, the original rotational position of the flow conditioning element shall be maintained since experience has shown this can affect meter performance (i.e., meter factor).

If the meter is utilized in bi-directional flow both inlets of the meter shall conform to the upstream requirements and a meter factor shall be determined for each direction. In this case temperature, pressure and/or density instrumentation shall be located downstream of the meter run relative to this direction.

6.3 Valves

6.3.1 Valves require special consideration since their location and performance can affect measurement accuracy.

6.3.2 The preferred location of the flow or pressure control valves should be downstream of the meter run and prover takeoff valves. Valves should be capable of smooth operation to prevent shocks and surges.

6.3.3 Valves, particularly those between the meter and prover (e.g. 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.

6.4 Electronics

The UFMs electronics system, including power supplies, microcomputer, signal processing components and ultrasonic acoustic transducer excitation circuits, may be housed in one or more enclosures mounted locally or remotely to the meter and is referred to as the Signal Processing Unit.
UFMs and their interconnecting cables are all susceptible to Electromagnetic Interference (EMI). Since the electrical signals of the UFMs are at relatively low power levels, care must be taken to avoid interference generated from nearby electrical equipment and wiring. UFMs employ various materials and methods to provide shielding against EMI. Cable jackets, rubber, plastic and other exposed parts shall be resistant to ultraviolet light, oil and grease.

6.5 Insulation

Under normal circumstances, it is not necessary to insulate the meter body or adjoining pipework. However, in some limited circumstances, such as cryogenic or laminar flow applications, insulating the meter and pipework may be necessary to avoid incurring additional uncertainty.
In low Reynolds number applications, where the flow may be in laminar or transitional regimes, insulation may be effective in preventing the formation of thermal gradients, which can result in additional uncertainty in the path geometry factor. In order for insulation to be effective in laminar and transitional flows, insulation should be applied from a point upstream, where the flow is well mixed, up to and including the meter itself and the straight pipe immediately downstream of the meter.

7. CORIOLIS METERS

Coriolis meters shall be installed according to manufacturer's instructions. Additionally for installation of coriolis meters the considerations mentioned in 4.1 and the following items shall be considered:

7.1 Each manufacturer produces coriolis meters with different sensor designs and each will have different tubing configurations. Tubing configuration will influence:

- **a.** The pressure drop across the meter
- **b.** Susceptibility to erosion, flashing, and cavitation
- **c.** Minimum and maximum flow rates
- **d.** Accuracy of the measurement.
- **e.** Susceptibility to coating and clogging

7.2 Flow sensors often restrict the cross-sectional flow area resulting in higher fluid velocity and pressure drop than experienced in the associated piping. The pressure drop for a particular installation will depend on the tube configuration along with the viscosity and density of the fluid and the desired flow rate. Consider the amount of pressure drop required by the flow sensor with respect to total pressure drop allowed in the system. Consult the flow sensor manufacturer for appropriate methods to calculate velocity and pressure drop through the sensor to assess the potential for erosion.

7.3 High fluid velocities, when coupled with abrasive particles in the stream, may cause erosion and sensor failure. Select the flow sensor to provide required accuracy within the allowable system pressure drop constraints while avoiding erosion.

7.4 To help mitigate the hazards associated with a tube failure, additional or optional equipment provided by the meter manufacturer or the user may need to be considered such as:

a. Flow sensor housings, constructed as a pressure containing vessel, designed to contain fluid under pressure to a specified pressure limit.

b. Burst disks, pressure relief valves and drains, or vents on the housing, to relieve pressure inside the housing and allow fluids released due to a tube fracture to be directed away from the flow sensor to an area less hazardous to operating/maintenance personnel.

7.5 The stream velocity and pressure drop experienced in the flow sensor could cause cavitation which will cause inaccurate measurement and may damage the sensor. Provide sufficient pressure to avoid cavitation or flashing in the vicinity of the meter (at or immediately upstream/downstream) at all times while measuring the parameters of interest. The relatively high fluid velocities, which often occur in coriolis meters, cause local dynamic pressure drop inside the meter that may lead to cavitation. A guideline which may be used is to maintain the pressure at the outlet of the meter above the pressure defined by following equation:

$$P_b = 2\Delta p + 1.25p_e$$

Where

P_b = minimum back pressure (psig),

Δp = pressure drop through the flowmeter at the maximum operating flow rate (psi),

p_e = equilibrium vapor pressure of liquid at the operating temperature (psia).

For some high vapor pressure products such as ethylene and high-purity ethane, this guideline may not be sufficient.

7.6 Consider the fluid characteristics and flow sensor design to provide for adequate draining, vapor elimination, and cleaning ability. On light hydrocarbon streams with high vapor pressure characteristics, flow sensors should be installed in a manner which avoids trapping any vapors. Since these liquids vaporize as pressure drops, self-draining features are not likely required. Heavier hydrocarbons may be less likely to vaporize at low pressures and therefore may require means to drain the sensor.

7.7 For streams containing materials capable of collecting in the sensor, consider the susceptibility of the tube designs to clogging, plugging, or fouling. Different tube configurations may be more or less likely to promote the accumulation of sediments or coatings within the tubes. Besides restricting flow, the accumulation of material within the tube is likely to affect the accuracy of the density signal output of the sensor.

7.8 The flow sensor, coriolis transmitter, and their interconnecting cables are all susceptible to Electromagnetic Interference (EMI). Since the electrical signals of the coriolis meter are at relatively low power levels, care must be taken to avoid interference generated from nearby electrical equipment and wiring. Coriolis meters employ various materials and methods to provide shielding against EMI.

7.9 Avoid installations near sources of flow pulsation and vibration.

7.10 Consideration should be given to the support of the sensor, the alignment of the inlet and outlet flanges with the sensor, and the orientation of the sensor (vertical or horizontal, upward or downward).

7.11 Piping should be anchored to avoid transferring any stresses from the piping to the flow sensor. Piping vibration and fluid pulsation may affect the ability of the flow sensor to accurately measure stream parameters as the external vibration or pulsation approaches the resonant frequency of the sensor. Consult the manufacturer for vibration or pulsation frequencies to be avoided. Pulsation dampeners may be required in some situations.

For more detailed information refer to MPMS 5.6.

8. INSTALLATION OF ACCESSORY EQUIPMENT FOR LIQUID METERS

Accessory equipment is any device that enhances the utility of a measurement system, including read-out, registers, monitors and flow conditioning equipment.

All equipment must be installed according to the manufacturer's recommendations and must conform to all applicable regulations. The read-out device or register must be compatible with the meter and transmission system. The equipment shall be installed in such a manner that easy accesses for maintenance purposes should be provided.

The installation shall be protected against excessive environmental temperature and humidity. Electrical safety factors (including hazardous area classifications), electromagnetic and radio frequency interferences, weather proofing, fungus proofing and corrosion shall be considered.

8.1 Installation of Mechanical Accessories

8.1.1 All field mounted instruments shall be located so that they are readable from the point of operation isolating valves etc. They shall be mounted so as to be free from vibration and accessible for maintenance and services.

8.1.2 The metering station shall include a properly sized, totally enclosed drainage system to station boundary and shall further include all vents, drains, thermal relief valves, air eliminators and the like. Instrument bleed points and sampling points shall discharge into the closed system, via valved drain tunnels.

8.1.3 Easy access for operation and maintenance of accessory equipment shall be provided via walkways to meters, meter runs, instruments, valves, controls, prover chambers, four way valves, strainers and the like.

8.1.4 PD meters with ticket printers mounted on meters shall be provided with rain covers and ticket protection.

8.1.5 All field instrumentation shall be identified by tag numbers attached to the equipment.

8.1.6 Field mounted transducers shall either be equipment mounted, (thermal elements with thermowells), or supplied with universal mounting brackets. The universal mounting bracket shall be suitable for mounting the transducer on a 2 inch stand pipe or flush mounting or a flat surface.

8.1.7 Air eliminator and strainer combination shall be mounted on the inlet side of the meter. Vent pipe shall never be less than ¾ inch. On pressurized systems, the restrictions in vent system and strain exerted on eliminator by piping must be minimized.

8.2 Installation of Pulse Generator Components

8.2.1 A measurement system consists of at least three components: a meter (pulse producer/conditioner), a transmission line (pulse carrier) and a read-out device (pulse counter and display/monitor). These three components must be compatible, and each component must meet the specifications recommended by the manufacturers of the meter and accessory equipment.

8.2.2 Great care should be exercised in effectively isolating the meter system from external electrical influences. To minimize unwanted noise, earth grounding shall be separate from other electrical grounding networks. Shielding the transmission cables of meter and prover detectors is essential.

8.2.3 The appropriate technically compatible signal transmission cable shall be used, as recommended by the equipment manufacturer. In this regard the recommendations of IPS-E-IN-190 shall be followed.

8.2.4 The supply voltages to preamplifiers shall be checked to ensure that they are of proper magnitude and do not exceed noise or ripple maximums as specified by the equipment manufacturer.

8.2.5 For each metering station an electrical distribution board with suitable sized circuit breakers shall be provided, for power supplying to MOVs, FCVs, hydraulic power pack for provers, etc.

8.2.6 In an electrical transmission installation, great care should be exercised to maintain the signal amplitude at the highest level possible and to reduce the magnitude of noise. The following steps should be taken to maintain the optimum signal levels:

a) Minimize the length of the transmission line from the meter to the read-out device.

b) Ensure the correct impedance matching.

c) If dictated by the transmission distance or the manufacturer's requirements, introduce a signal preamplifier into the turbine meter's transmission system.

d) Ensure that all pickup coils are securely mounted and properly located.

e) Ensure that all terminals and connectors are clean and tight.

f) Replace components that give a weakened signal as a result of deterioration.

8.2.7 Most electronic read-out devices condition a wave form to count each pulse or to measure the frequency of meter output so that flow rate can be indicated. Since signals may have a relatively low power level, installation of conditioners shall be suitable for low-power-level signals.

8.2.8 The following points should be considered so that the signal-to-noise can be optimized. Only shielded transmission cable 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, 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.

8.2.9 The data transmission lines should not share a conduit/tray with anything other than shielded cables or cables from direct temperature sensors. If the maximum electrical power carried by any one transmission cable is ten or more times greater than the minimum power carried by any flowmeter signal data transmission cable, separate conduits/trays should be provided. In the event that separate conduits/trays are not feasible, additional cable shielding should be incorporated and circuits tested to verify necessary fidelity of signals. Data transmission cables should not be run in parallel with power cables. When this is not possible the cables should be sufficiently spaced to prevent interference or be adequately shielded.

If it is necessary for transmission cables and power cables to cross, this should be at right angles whenever possible.

When transmission cables are run in ducts or inside control cabinets, every attempt should be made to keep the shielded cable bundle intact and separate from other conductors. All spare transmission cable and conductors that are run in a conduit/tray with an active transmission line should have the shield and conductors grounded at the same single point as the active line. The grouping of cables to intrinsically safe devices with other current-carrying cables requires special consideration in hazardous areas, and governing regulations must be followed. In this regard the recommendations of IPS-E-IN-190 shall also be followed.

8.3 Security

Consideration should be given to sealing the meter systems to prevent or identify unauthorized attempts at tampering with or manipulating system components. The accuracy, usefulness, and output of a measurement system can be compromised in many ways, resulting in the loss of credit for hydrocarbon liquids that pass through the meter. Meter systems are often equipped with security seals made of wire, plastic, or paste that when broken or disturbed indicate possible tampering. Electronic systems can also be secured with key locks, access codes, and so forth. Each system should be reviewed to define its exposure risk and to identify appropriate locations and techniques. In this regard the recommendations of manufacturer and API MPMS Ch. 21.2 and API MPMS Ch. 5.5 shall be followed.

9. CONSTRUCTION OF METER PROVERS

9.1 Installation of Pipe Prover

9.1.1 General consideration

9.1.1.1 All components of the prover installation, including connecting piping, valves, and manifolds shall be in accordance with applicable codes. Once the prover is on stream, it becomes a part of the pressure system. If installed above ground, the prover section and related components shall have suitable hangers and supports prescribed by applicable codes and sound engineering principles. When proving systems are designed and installed, precautions should be taken to cope with expansion, contraction, vibration pressure surges, and other conditions that may affect piping and related equipment.

9.1.1.2 Consideration should be given to the installation of suitable valving to isolate the prover unit from line pressure when it is not on stream (for example, during maintenance or removal of the displacer).

9.1.1.3 All units shall be equipped with vent and drain connections. Vent valves should be installed on the topmost portion of the pipe and should be located where all air/gas is vented from dead spaces that are not swept by the displacer. Provision shall be made for the disposal of liquids or vapors that are drained or vented from the prover. This can be accomplished by pumping liquids or vapors back into the system or by diverting them to a collecting point. Common vents and closed loop vents shall not be used.

9.1.1.4 Temperature and pressure measurement devices and gauges shall be installed in suitable locations at inlet and outlet of every mechanical prover in order to accurately determine the temperature and pressure of the liquid between the detectors.

9.1.1.5 Blind flange or valve connections shall be provided on either side of a leak free block valve in the piping system to serve as a connection for proving portable meters or as a means for calibrating the prover by the master-meter method. Connections at the inlet and outlet shall be provided for calibration by the waterdraw method. Figs. 4, 5 and 6.

9.1.1.6 Suitable pressure relief valves with adequate discharge piping and leakage detection facilities, shall be installed for the control of thermal expansion and contraction of the liquid in prover section while it is isolated from the mainstream. Where practical, pressure relief valves shall not be installed in piping between the meters and the prover.

9.1.1.7 Local and remote controls shall be suitably protected with lockout switches, circuits or both.

9.1.1.8 Suitable safety devices and locks shall be installed to prevent inadvertent operation of or unauthorized tempering with equipment.

9.1.1.9 All automatic meter-proving systems may have emergency manual facility for use in the event of failure of the power source or in the event of an accident.

9.1.1.10 All types of mechanical provers shall be installed downstream from adequate straining of filtering equipment.

9.1.1.11 All wiring and controls shall conform to applicable codes. Explosion proof components shall conform to the appropriate class and group applicable to the location and operation. All electrical controls and components shall be placed in a convenient location for operation and maintenance.

Manufacturers' instructions shall be strictly followed for installation and grounding of such items as electronic counters, tachometers and signal cables.

9.1.1.12 All instrumentation on pipe provers shall be conveniently accessible for maintenance and operation purposes.

9.1.2 Prover location

Pipe provers may be either mobile (portable) or stationary.

9.1.2.1 Mobile prover

A mobile prover is normally mounted on a road vehicle or trailer so that it can be taken to various sites for on site proving of meters in their installed positions while they are in normal operation. Mobile provers are occasionally skids so that they may be transported by road, rail or sea. Mobile provers are always provided with a means of safely and conveniently connecting them to the metering system. Mobile provers are designed to operate in the meter's environment. Provisions must be made to electrically ground the prover.

All regulations and codes related to the transportation of hazardous materials shall be applied when portable meter provers are moved on public roads and contain flammable or combustible liquids or are empty but not gas free.

9.1.2.2 Stationary prover

A Stationary prover is connected by a system of pipes and valves to a meter or battery of meters. Its sole function is to prove the meters one at a time at intervals, as required.

9.1.2.3 Central prover

A Central prover is permanently installed at a location where pumping facilities and a supply of liquid are available. It is used to prove the meters that are periodically brought to the prover and temporarily connected. After a meter is proved centrally, caution must be exercised to ensure that the meter is not mishandled in a way that could destroy its reliability before the meter is reinstalled in the line.

9.1.2.4 Master-meter prover

The master-meter is an indirect prover that uses the concept of transfer proving. A flow meter with exceptional linearity and repeatability is selected to serve as master-meter (intermediate standard) between a meter or prover operating in the field and a master-meter prover.

Two separate stages are required in master-meter.

Proving:

First, the master-meter must be proved using a meter prover (master prover) that has been calibrated by water-draw method, and secondly after transfer to field, this proved master-meter is used to calibrate other field provers (stationary provers), or to determine the meter factor of field operating meter.

9.1.3 Prover's equipment

9.1.3.1 Fabrication of prover

The materials of prover shall conform to applicable codes, pressure and temperature ratings, corrosion resistance, and area classifications. Pipe, fittings, and bends should be selected for roundness and smoothness to achieve a consistent sealing of the displacer during a prover pass.

Flanges or other provisions shall be provided for access to the inside surfaces of the calibrated and prerun sections. Care shall be exercised to ensure and maintain proper alignment and concentricity of pipe joints. Flanges shall be match bored and uniquely doweled. Gaskets used in the calibrated section shall be designed to seal on a flange-face metal to metal make-up, with the sealing being obtained from an O-ring-type seal. All internal welds and metal surfaces shall be ground smooth to preclude damage to and leakage around the displacer.

Internally coating the prover section with a coating material that will provide a hard, smooth, long-lasting finish will reduce corrosion and prolong the life of the displacer and the prover. Internal coatings are particularly useful when the prover is used with liquids that have poor lubricating properties.

9.1.3.2 Temperature-measurement devices shall be installed at the inlet and outlet of the prover. Caution must be exercised to ensure that the temperature sensors are located where they will not be shut off from the liquid path.

9.1.4 Compact prover

Pipe provers may be divided into four main types, depending upon whether the displacer is a sphere or a piston, and upon whether the mode of operation is unidirectional or bidirectional. Irrespective of the above classification, certain provers may be described as 'compact'.
As a guide, however, it can be said that compact provers generally possess these attributes:

- A calibrated volume no more than about one tenth of that of a typical unidirectional or bidirectional sphere prover designed to handle the same maximum flow rate.
- A precision-bore cylinder containing a displacer, whose position is detected with some form of high precision non-mechanical device.
- An associated system of interpolating pulses between the primary pulses emitted by a meter.

Compact Prover provides high accuracy, rapid operation and continuous flow for proving a flow meter in an operational line. This is accomplished without interrupting normal flow and without the use of manually operated bypass valves.
The result is a complete packaged proving system significantly reduced in size and weight.
Compact Prover designed with flexible mounting configurations on a truck or trailer for field proving of flow meters, or can be permanently installed in a testing facility.
Pulse interpolation electronics permit exact time determination and pulse counting which provides high accuracy proving with a smaller volume and fewer flow meter pulses than any conventional prover technology.
The use of a small displacement volume is made possible by Compact Prover which is attributed to two major factors; high precision switches, and data acquisition using double chronometry. The switches are used for defining prover volume by detecting the piston position.

Double chronometry allows a much higher degree of meter pulse resolution to conventional pipe provers. (See Fig. 10)

9.2 Installation of Tank Prover

A tank prover is an open or closed volumetric measure that generally has a graduated top neck and may have a graduated bottom neck. The volume is established between a shutoff valve or bottom-neck graduation and an upper-neck graduation (see Fig. 7).

9.2.1 General considerations

All components of the prover installation, including connecting piping, valves, and manifolds, shall be in accordance with applicable pressure codes.

Once a closed prover is on stream, it becomes part of the pressure system. Provision shall be made for expansion and contraction, vibration, reaction to pressure surges, and other process conditions.

Consideration shall be given to the installation of valving to isolate the tank prover from line pressure when the system is not in use or during maintenance. All provers shall be equipped with vent and drain connections.

Provisions shall be made for the disposal of liquids or vapors that are drained or vented from the tank prover. The disposal may be accomplished by pumping liquids or vapors back into the system or by diverting them to a collecting point.

Blind flanges or valve connections shall be provided on either side of a double block-and-bleed valve in the tank piping system. These connections can serve as locations for proving portable meters or as a means for calibrating the tank prover by master-meter or waterdraw method.

The construction of the tank prover shall be strong and rugged enough to prevent distortion of the vessel that would significantly influence measurement when the tank is full of liquid at the proving pressure. Prover tanks shall be constructed for complete drainage of liquid to a lower reference level without trapping pockets of liquid or sediment.

Changes of cross section shall be gradual and sufficiently sloped so that as the prover is filled, gas bubbles will not be trapped but will travel to the top of the prover. As the prover is emptied, the liquid will quickly drain.

Accessories shall be installed in locations that are convenient for quick and practical operation and precise readability.

9.2.2 Installation of equipment

9.2.2.1 Safety devices

Safety relief valves, with discharge piping and leak detection facilities shall be installed to control thermal expansion of the liquid in the prover and its connecting piping while they are isolated from the main stream.

Grounding devices shall be provided to protect against electrical shocks or static discharge in both tank prover and electrical instrumentation.

9.2.2.2 Necks

Tank provers may have top and bottom graduated necks or a top graduated neck only Fig. 7. Both top and bottom necks should have gage glasses or another suitable means for indicating the liquid level.

9.2.2.3 Temperature measurement

The location of temperature sensors in the prover is important. The use of one sensor in prover tanks that holds up to 380 liters is acceptable. The use of two sensors is recommended in prover tanks that have a capacity of at least 380 liters but not more than 1900 liters. Three sensors should be used in prover tanks with more than 1900 liters capacity. If one sensor is used, it should be placed in the center of the vertical-tank height. If two sensors are used, one should be located in the upper third of the vertical-tank height and the other in the lower third. If three sensors are used, one should be located within each third of the vertical-tank height. When more than one sensor is used, sensors should be equally spaced around the tank circumference. Where tank operating pressure allows, temperature sensors should be installed directly through the prover tank shell without using a well. A stem immersion depth of one third of the tank radius is recommended; however, a minimum depth of 30 centimeter is desirable, provided that the sensor does not extend past the center.

The sensor well, when used, should be constructed so that it has the smallest possible diameter and metallic section consistent with the necessary strength.

9.2.2.4 Pressure measurement

A pressure gauge is required on closed tank provers. Gauge connections shall be above the upper most liquid level and sloped to avoid trapping vapors or liquids.

9.2.2.5 Connections

Prover inlet and outlet connections will depend on the particular application involved, if a submerged fill pipe is used, it shall be permanently installed and equipped with a vapor bleed valve. The prover outlet connections shall be sized to permit rapid emptying of the tank between proving runs, and provisions shall be made for indicating the draw down level. All inlet and outlet valves shall be of the double block-and-bleed type.

9.2.2.6 Gauge glasses

Gauge glasses fittings on prover tanks should be installed directly into the walls of the neck or the body of the prover. Additional gauge glasses may be provided to cover the main body of the prover. The suggested maximum length for any single gauge glass is 60 centimeters.

10. COMMISSIONING OF METERING STATIONS

10.1 General

Before commissioning an installation, the commissioning engineer shall ensure:

1) Correct mechanical installation of the equipment.

2) A satisfactory electrical installation with particular attention to weather proofing and classified areas suitability of electrical devices, especially junction boxes.

3) Satisfactory wiring, in compliance with applicable Standards and electrical safety codes.

10.2 Testing

The procedures for commissioning of different type of metering systems should be clearly defined by the manufacturers. All necessary electrical test apparatus, including an oscilloscope and pulse generator, should be provided for those personnel responsible for the inspection and maintenance of the system. The pulse generator used should be capable of simulating the pulse form of the particular type of transducer being substituted such equipment must be of a type which is electrically safe for the environment in which it is to be used.

A typical test method which may be used is to inject a train of test pulses into a transmission system at the transmitter connections. This test signal should have a strength of not more than 50 percent at the normal transmitter signal. The test signal shall be monitored by the installed receiving apparatus, and the signal received shall conform with the test signal within two pulses in one hundred thousand.

The test shall be performed at minimum flow, 25%, 50%, 75% and maximum flow amongst which the meter normally operates, except during startup and shutdown.

10.3 Inspection

10.3.1 Need for inspection

It is essential that regular inspection of all apparatus, systems, and installations (including cable conduit and the like) is carried out with competent personnel according to a schedule that has been agreed upon after consultation between the manufacturers and the users.

10.3.2 Guide lines

All normal precautions relating to safety must be taken into account, especially those pertaining to hazardous atmospheres.

Following any repairs, adjustments, or modifications, those parts of the installation that have been disturbed shall be checked for compliance with the system specification.

10.3.2.1 Ground continuity

The ground path impedance of each circuit shall be low enough to permit the passage of a current at least three times the current rating of the circuit fuse or protective device.

All grounding connections shall be checked to ensure that they are clean and tight, and the ground path impedance associated with each item of apparatus shall be measured at intervals determined by the engineer responsible for the system.

If there is no likelihood of a flammable atmosphere being present, impedance measurements shall be made at a current of not less than 15 amperes. When there is any risk of a flammable atmosphere being present, impedance measurements shall be made with an intrinsically safe continuity tester. Grounding continuity does not guarantee the effectiveness of cable shielding

10.3.2.2 Protective devices

All protective devices such as alarms, trips, and standby equipment shall be examined and tested at commissioning period by the system engineer. This is necessary to ensure that equipment is operating at design settings.

10.3.2.3 Outside interference

If other apparatus has been installed adjacent to the new meter station, then the system shall be tested to ensure that no signal is induced into the system by the adjacent apparatus. The transmission system shall be tested for continuity, insulation and signal impedance.

10.3.2.4 Inspection records

A system shall be established to record the results of inspections and tests for all apparatus, systems and installations and the details of corrective actions taken. The records shall include details of all modifications, additions, or deletions none of which are to be made without prior permission. The signal strength produced during normal operation shall be measured at the receiver and compared with the values obtained when the system has been installed or most recently modified.

10.3.2.5 Spares

Vital spares according to manufacturers' recommendations should be readily available for the correct commissioning of equipment.

All spare parts shall comply with the same standards, specifications and tests of the original equipment and shall be fully interchangeable with the original parts without any modifications at the site. They shall be preserved to prevent deterioration during shipment and storage in humid tropical climate.

10.3.2.6 Commissioning of meters

When a new meter installation is placed in service, particularly on newly installed lines, foreign matter can be carried to the metering mechanism during the initial passage of liquid. Protection shall be provided from malfunction or damage by foreign matter, such as air or vapor, slag, debris, welding splatter, thread cuttings or pipe compound, the following are suggested means of protecting the meter from foreign matter:

a) Temporarily replace the meter with a spool.

b) Remove the metering element.

c) Install a protective device upstream of the meter.

Line shall be operated without the measuring element until examination indicates that entrained foreign matter is being satisfactorily removed by the filter or strainer provided.

APPENDICES

APPENDIX A

FLOW-CONDITIONING TECHNOLOGY WITHOUT STRAIGHTENING ELEMENTS

A.1 Scope

Effective flow conditioning can be obtained by using adequate lengths of straight pipe upstream or downstream of the meter. This Appendix presents an empirical method for computing the length of upstream straight pipe required for various installation configurations and operating conditions.

Experience has shown that a nominal length of 20 diameters of meter-bore piping upstream of the meter and 5 diameterbore piping downstream of the meter provide effective conditioning in many installations, however, the required length of upstream piping should be verified for each installation, using the method presented in this Appendix. This technique does not predict the length of the straight pipe required downstream of the meter. A minimum of 5 diameters of meterbore piping should be provided downstream of the meter unless a different length is supported by the manufacturer's recommendations or tests.

A.2 Calculation of Upstream Flow-Conditioning Length

Based on empirical data; the length of a straight pipe required upstream of the meter can be calculated as follows:

$$L = (0.35\ D)\ (k_s/f)$$

Where:

L = Length of upstream meter-bore piping, in meter (feet).

D = Nominal meter bore, in meter (feet).

k_s = Swirl-velocity ratio, dimensionless.

f = Darcy-weisbach friction factor, dimensionless.

Notes:

1) The values for f is taken from L.F. Moody "Friction Factors for Pipe Flow", transaction of ASME, NOV. 1944, Vol. 1.66.

2) Values of the swirl-velocity ratio, k_s, for several piping configurations are shown in Figs. A.1 through A.5.

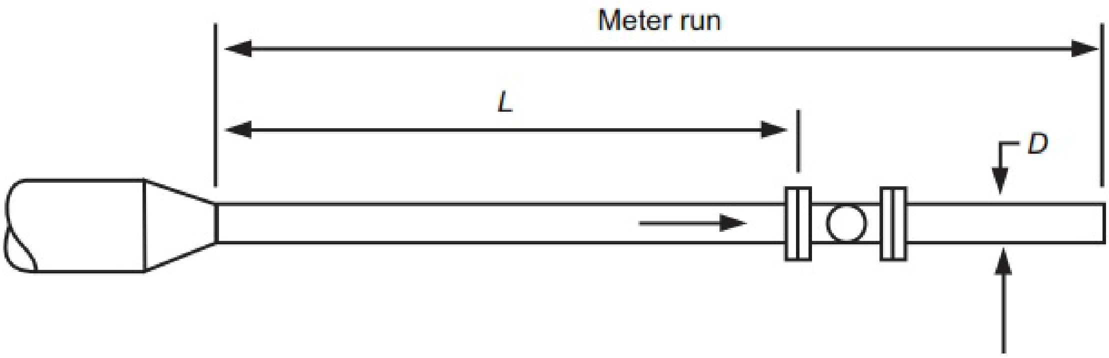
A.3 Example

Table A-1 lists values for L and L/D in Figs. A.1 through A.5 based on L/D = 20 k_s (f = 0.0175).

TABLE A.1 – VALUES FOR L AND L/D FOR FIGURES A.1 THROUGH A.5

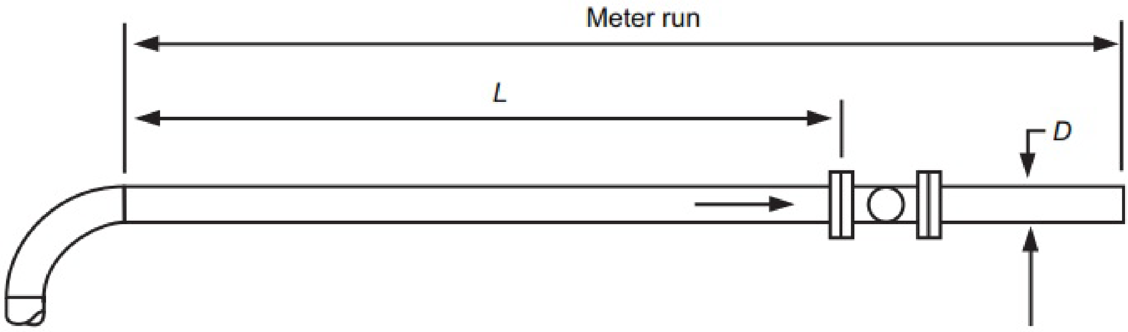
FIGURE NO.	K_s	L(METER)	L/D Ratio
A-1	0.75	2.30	15
A-2	1.00	3.1	20
A-3	1.25	3.8	25
A-4	Unknown		
A-5	2.5	7.6	50

The L/D ratio is inversely proportional to the pipe-friction factor and directly proportional to the swirl-velocity ratio. Since 1/f is minimum for conditions of maximum pipe roughness for any given Reynolds number in the region of turbulent flow, the best straightening for a minimum length of straight pipe occurs with a pipe of maximum roughness.



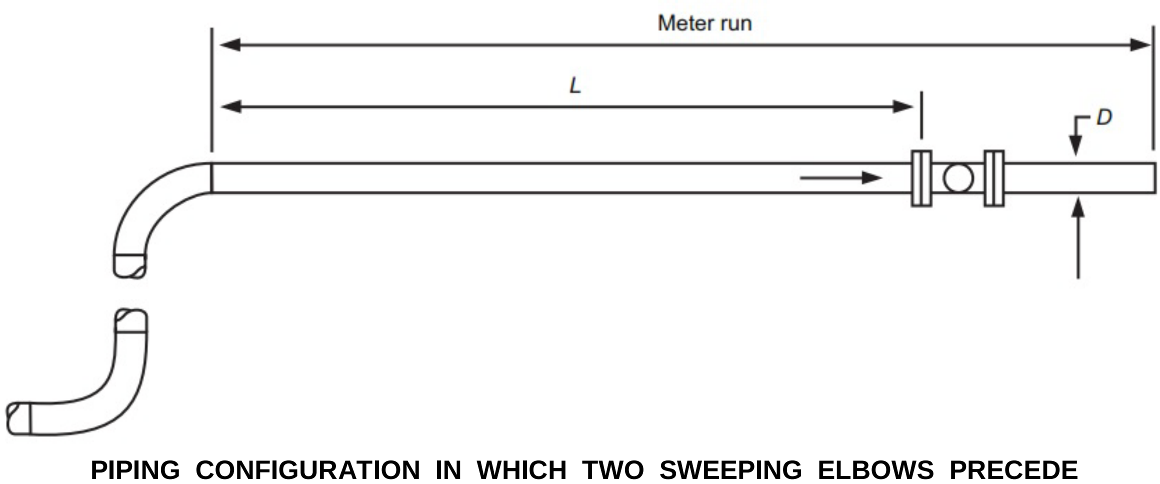
PIPING CONFIGURATION IN WHICH A CONCENTRIC REDUCER PRECEDES THE METER RUN (K_s = 0.75)

Fig. A.1



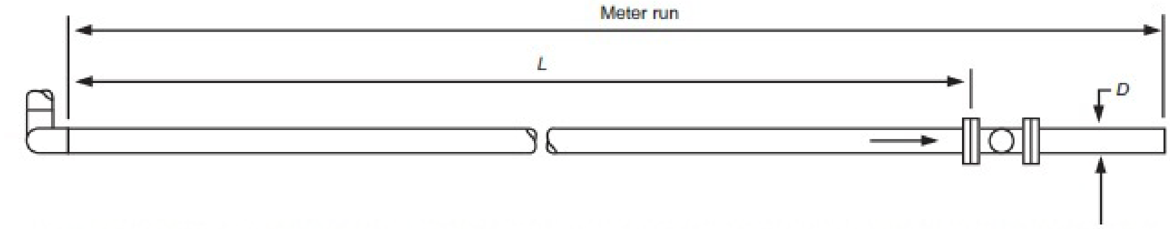
PIPING CONFIGURATION IN WHICH A SWEEPING ELBOW PRECEDES THE METER RUN (K_s= 1.0)

Fig. A.2



PIPING CONFIGURATION IN WHICH TWO SWEEPING ELBOWS PRECEDE THE METER RUN (K_S=1.25)

Fig. A.3

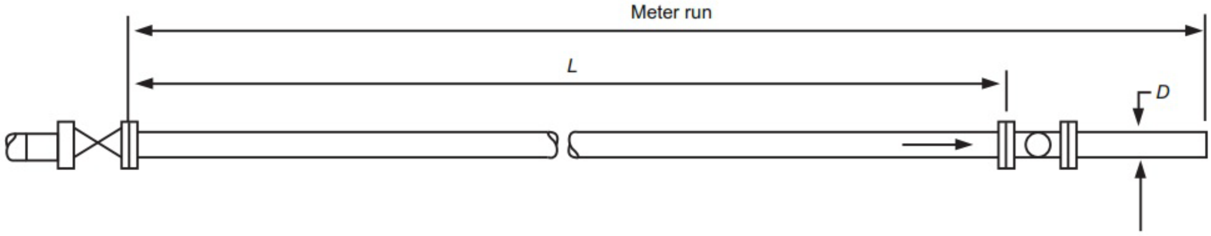


Note: Based on MPMS 5.3 ADDENDUM 1, JULY 2009, Appendix A

PIPING CONFIGURATION IN WHICH TWO SWEEPING ELBOWS AT RIGHT ANGLES PRECEDE THE METER RUN

(K_s = Unknown)

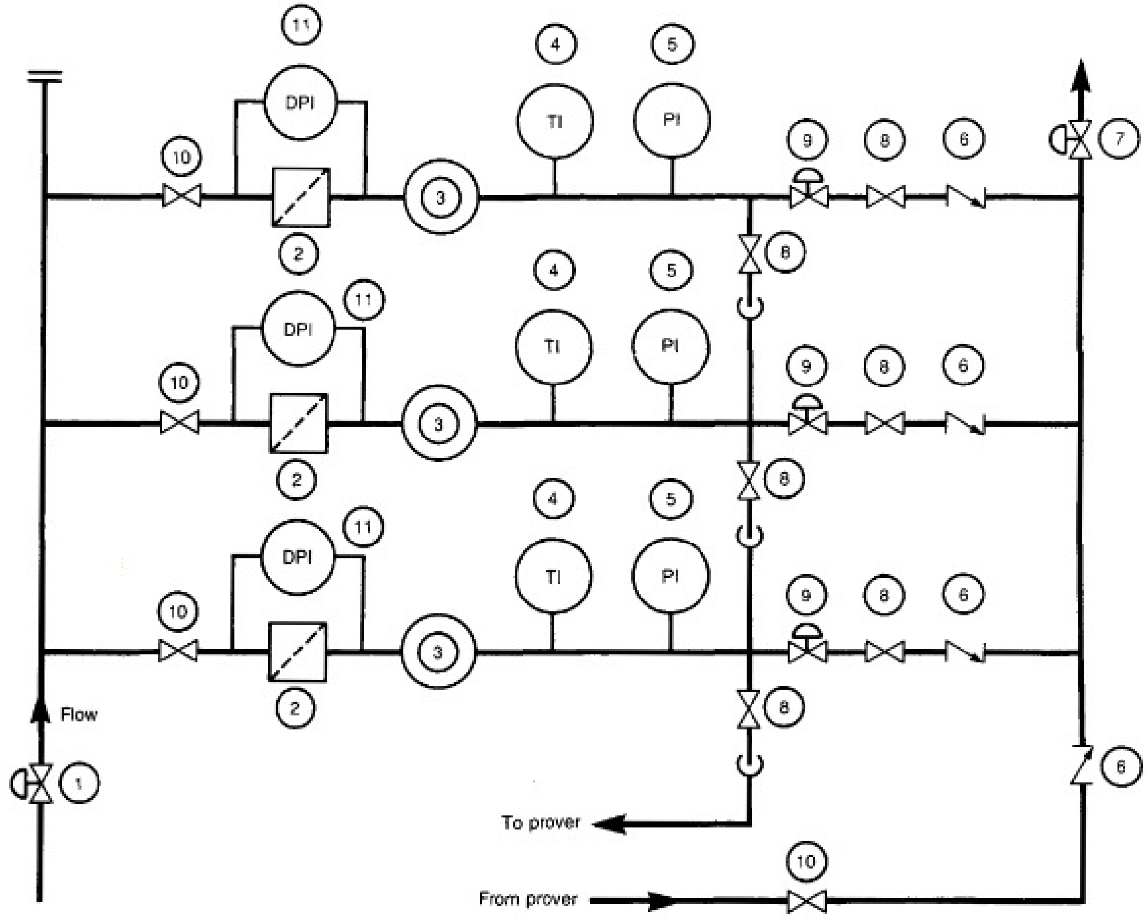
Fig. A.4



PIPING CONFIGURATION IN WHICH A VALVE PRECEDES THE METER RUN

(K_s = 2.50)

Fig. A.5

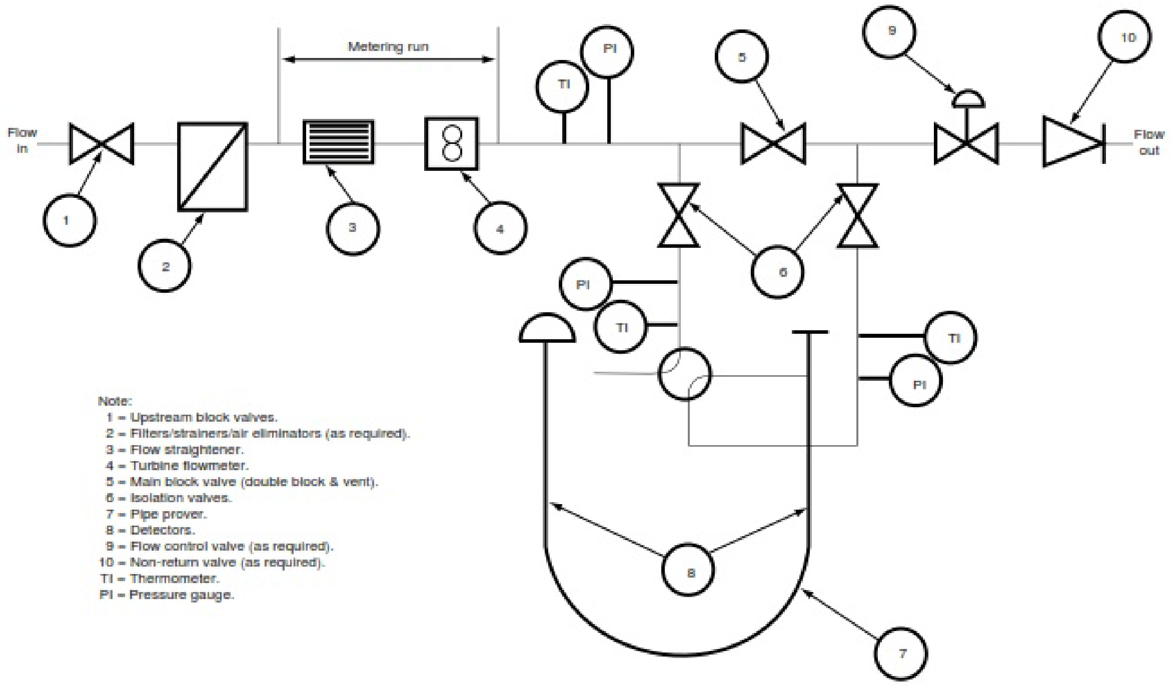


1 pressure reducing valve-manual or automatic if required
2 filter strainer and/or vapor eliminator (if required) for each meter or whole valve
3 displacement meter
4 temperature measurement device
5 pressure measurement device
6 check valve if required
7 control valve if required
8 pressure shutoff double block and bleed valve
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 valve shall have provisions for pressure relief (preferably not to be installed between the meter the and the prover)

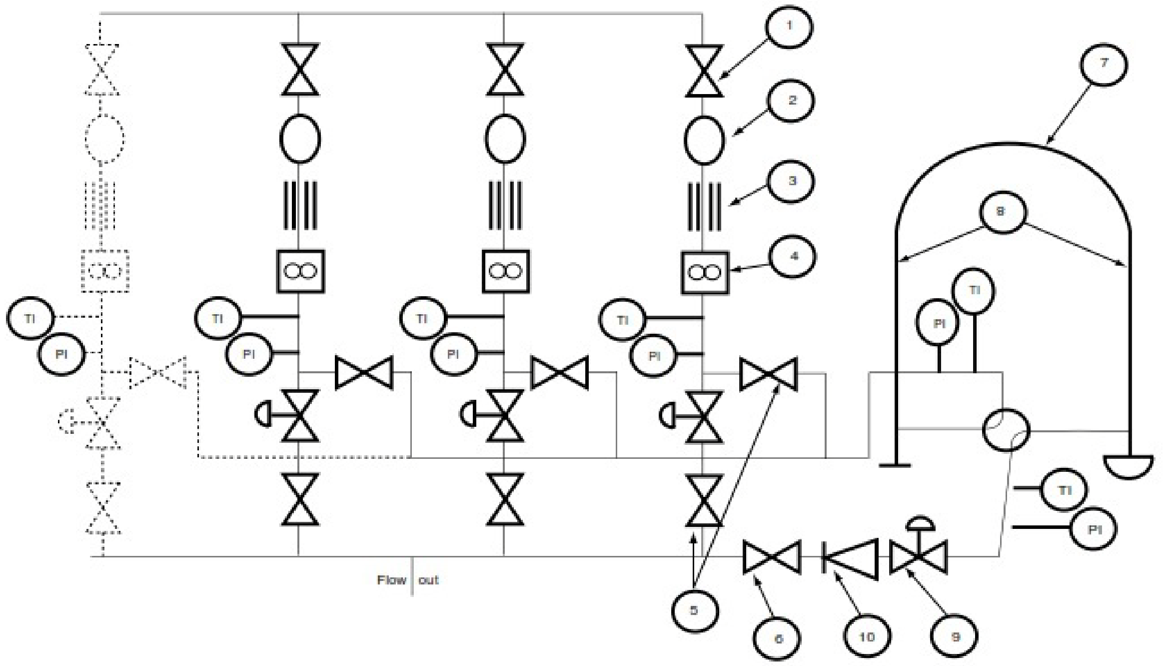
TYPICAL SCHEMATIC ARRANGEMENT OF METER STATION WITH THREE DISPLACEMENT METERS

Fig. 1



SIMPLE TURBINE FLOWMETER INSTALLATION

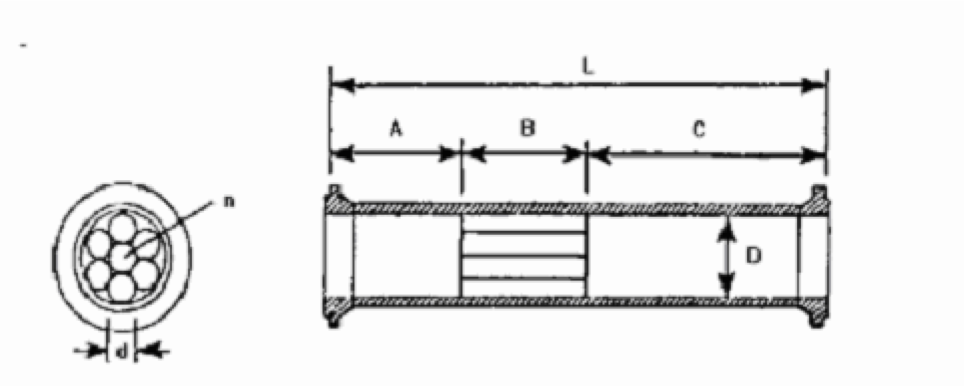
Fig. 2a



Note:
1 = Upstream block valves; 2 = Filters/strainers/air eliminators (as required); 3 = Flow straighteners; 4 = Turbine flowmeters; 5 = Main blockvalves (double block-and-bleed); 6 = Isolation valve; 7 = Pipe prover; 8 = Detectors; 9 = Flow control valves (as required); 10 = Non-return valve (as required); TI = Thermometer; PI = Pressure gauge.

TYPICAL MULTI-STREAM METERING INSTALLATION

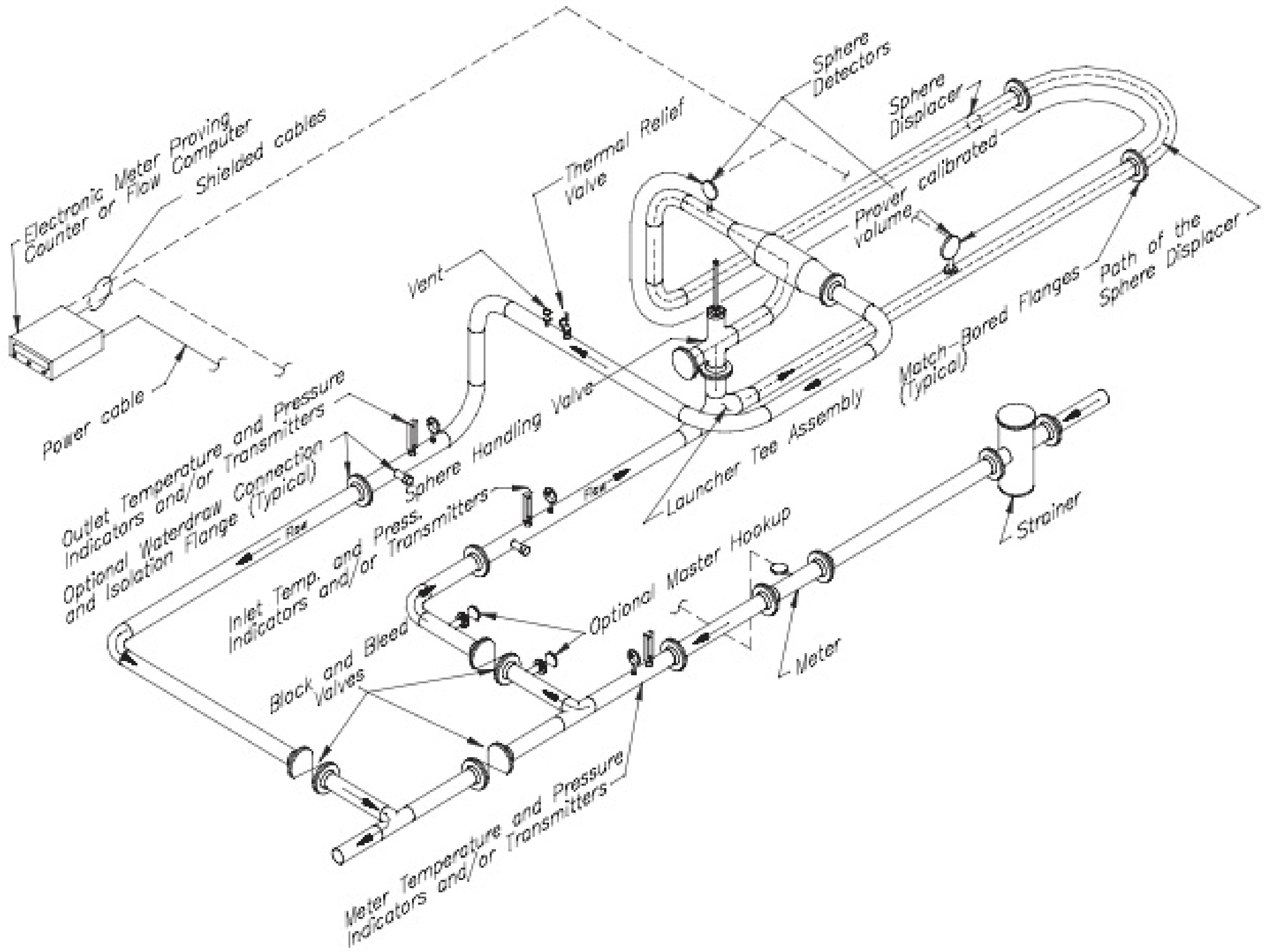
Fig. 2b



Note: this figure shows assembles installed upstream of the meter downstream of the meter, 5D minimum of straight pipe should be used.

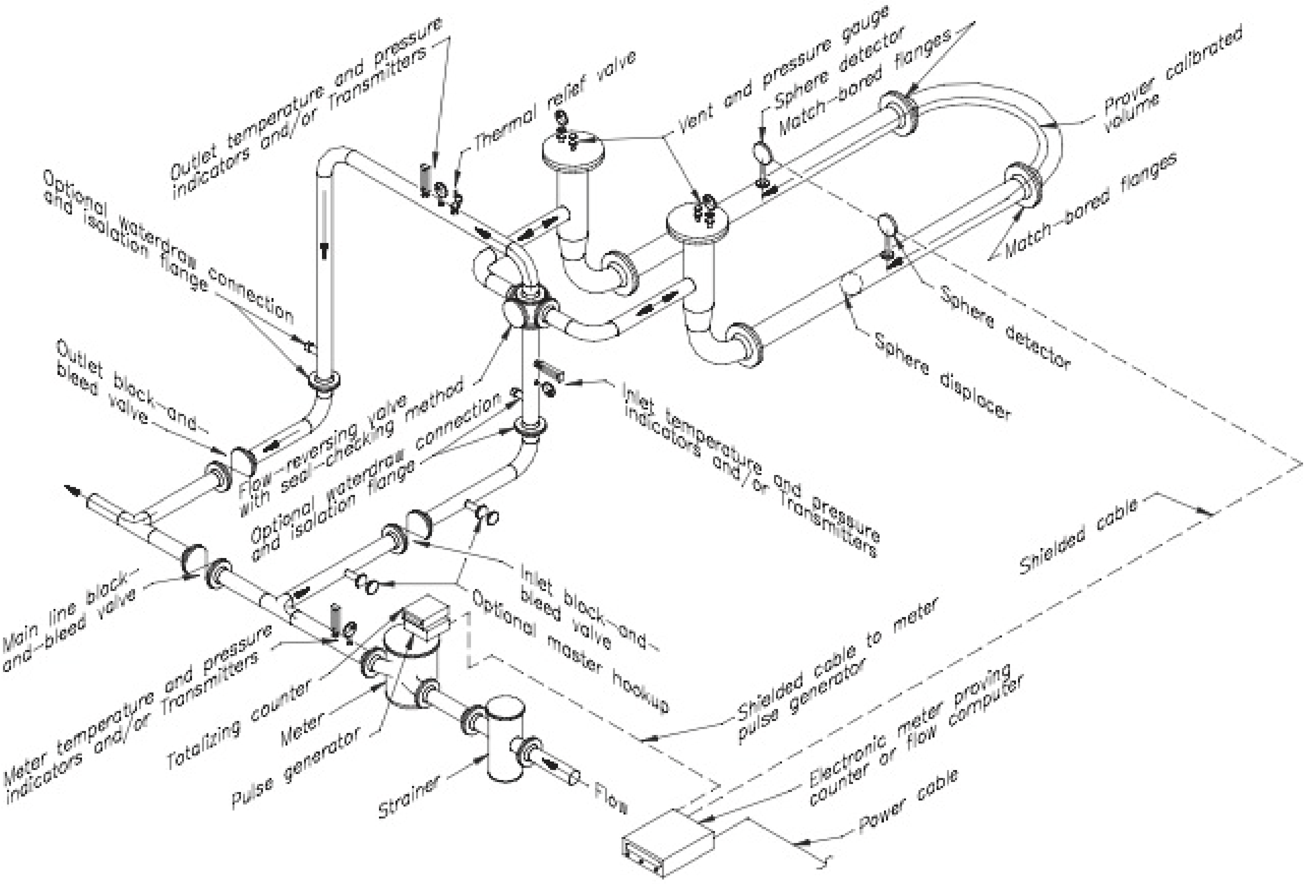
L= overall length of straightener assembly (> 10D)
A= length of upstream plenum (2D-3D)
B=length of tube or vane type straightening element (2D-3D)
C=length of downstream plenum (> 5D)
D= nominal diameter meter
n= number of individual tubes or vanes (>4)
d= nominal diameter of individual tubes (8d>10)

EXAMPLES OF FLOW – CONDITIONING ASSEMBLIES WITH STRAIGHTENING ELEMENTS
Fig. 3



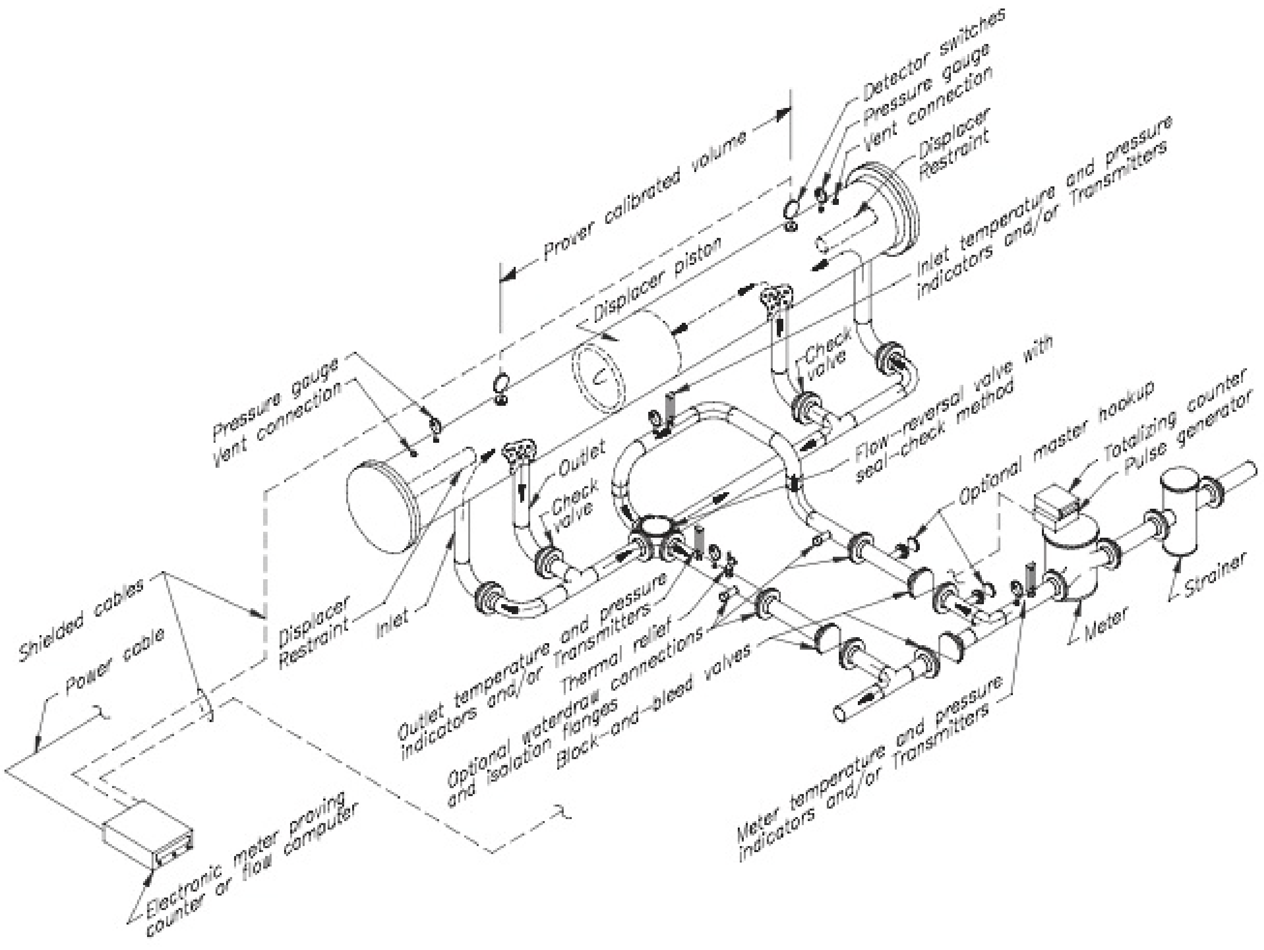
TYPICAL UNIDIRECTIONAL RETURN - TYPE PROVER SYSTEM

Fig. 4



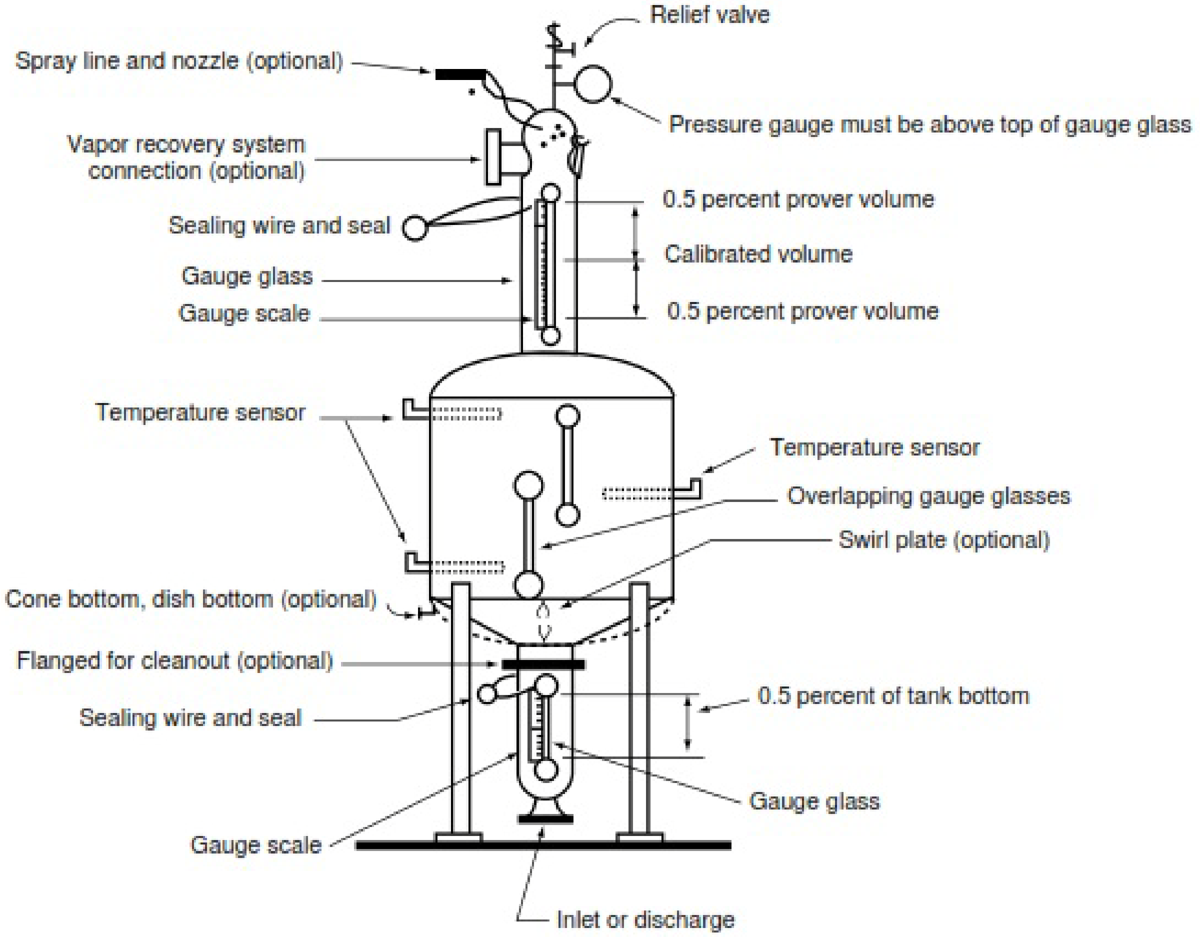
TYPICAL BI-DIRECTIONAL U – TYPE SPHERE PROVER SYSTEM

Fig. 5



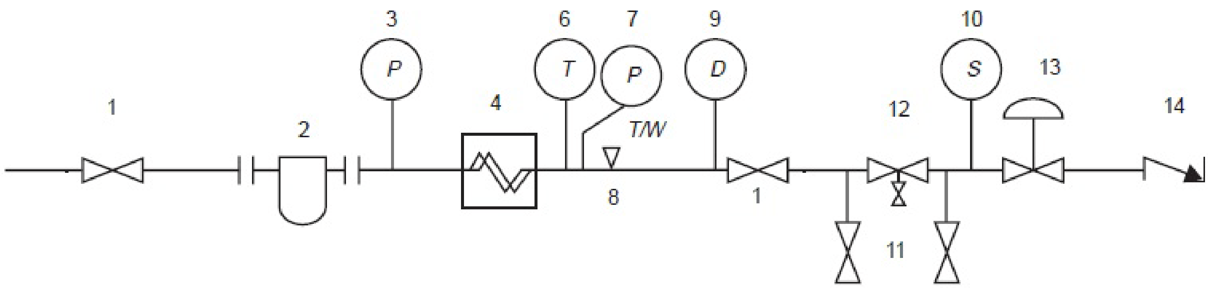
TYPICAL BI-DIRECTIONAL STRAIGHT-TYPE PISTON PROVER SYSTEM

Fig. 6



CLOSED STATIONARY TANK PROVER

Fig. 7

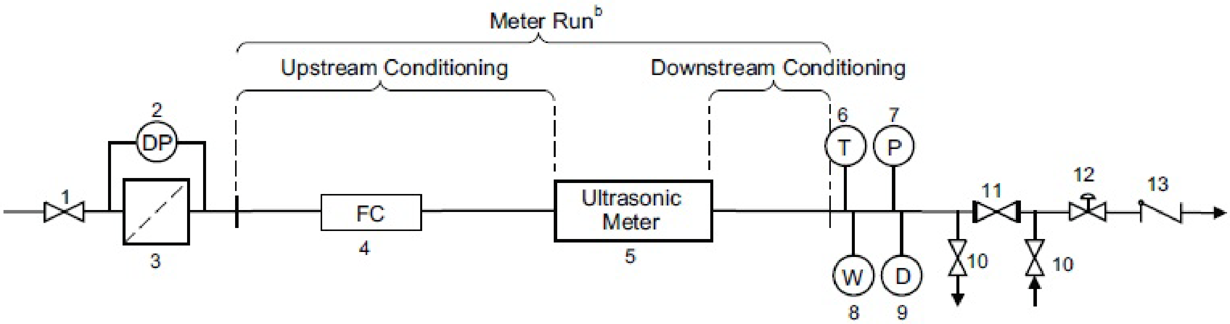


1. Block valve
2. Strainer/air eliminator
3. Pressure indicating device
4. Coriolis meter
6. Temperature indicating device
7. Pressure indicating device
8. Test thermowell
9. Density measurement/verification point
10. Manual sample point or autosampler (optional) with probe
11. Proving connection, block valves
12. Block and bleed isolation valve for proving/zeroing
13. Control valve
14. Check valve

Note: All sections of line that may be blocked in must have provisions for pressure relief.

TYPICAL SCHEMATIC FOR CORIOLIS METER INSTALLATION

Fig. 8



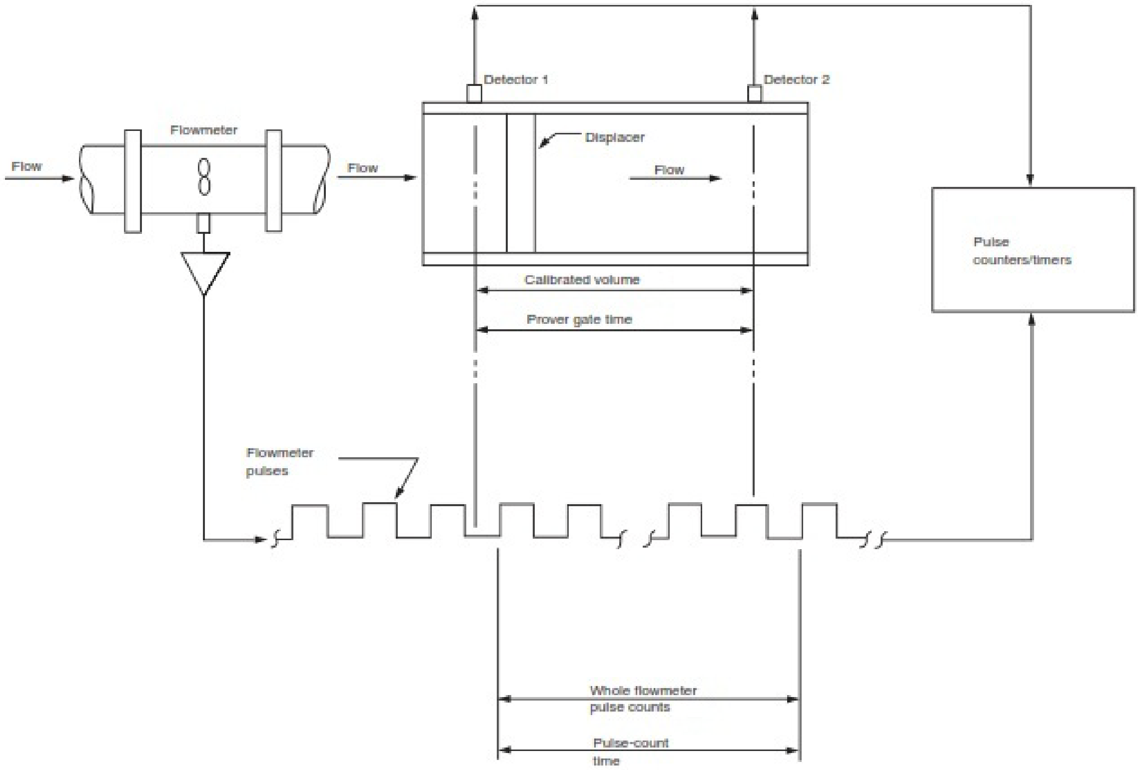
Key
1. block valvea
2. differential devicea
3. strainer and/or air eliminatora
4. flow conditioning elementa
5. ultrasonic flow meter
6. temperature measurement device
7. pressure measurement device
8. temperature test well
9. densitometera
10. prover take-off valve
11. double block and vent valve
12. flow control valvea
13. check valvea

Notes:
a Element may not be required.

b See Section 7.1, Flow Conditioning

TYPICAL ELEMENTS OF A SINGLE UFM INSTALLATION

Fig. 9



DOUBLE-CHRONOMETRY TIMING DIAGRAM

Fig. 10