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МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Liquid hydrocarbons — Dynamic measurement — Proving systems for volumetric meters —

Part 2: Pipe provers

Hydrocarbures liquides — Mesurage dynamique — Systèmes d'étalonnage des compteurs volumétriques

Partie 2: Tubes étalons

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 7278-2 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants.*

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Part 2: Pipe provers

0 Introduction

Pipe provers are used as volume standards for the calibration of liquid meters. The purpose of this part of ISO 7278 is to outline the essential elements of a pipe prover, to provide specifications for its performance, and to give guidance on its design, installation and calibration. Pipe provers discussed in this part of ISO 7278 are of the running-start/running-stop type, in which flow is uninterrupted during proving, thus permitting the meter to be proved under its normal operating conditions. This type of prover includes a calibrated section of pipe in which a displacer travels, actuating detection devices which produce electrical signals as the displacer passes each end of the calibrated portion. The displacer finally stops at the end of the run as it enters a region where the flow bypasses it.

Both stationary and mobile provers may be constructed on this principle. The calibrated section of the prover may be straight or folded (U-shaped), and the design may be such that the displacer moves around a closed loop in only one direction (unidirectional) or, alternatively, in both directions (bidirectional).

ISO 7278 consists of the following parts, under the general title *Liquid hydrocarbons — Dynamic measurement — Proving systems for volumetric meters:*

- *Part 1: General principles*
- *Part 2: Pipe provers*
- *Part 3: Pulse interpolation techniques*

Annex A forms an integral part of this part of ISO 7278. Annex B is for information only.

1 Scope and field of application

1.1 This part of ISO 7278 provides guidance for the design, installation and calibration of pipe provers. Calculation techniques for use when calibrating and operating provers are detailed in ISO 4267-2.

1.2 Most of the material in this part of ISO 7278 is general in that it applies to pipe provers for use with different liquids and types of meters and for proving them in different services. This part of ISO 7278 does not apply to the newer "small volume" or "compact" provers.

1.3 The standard reference conditions for petroleum measurement are a temperature of 15 °C and a pressure of 101 325 Pa as specified in ISO 5024.

NOTE — In some countries other reference temperatures are used, e.g. 20 °C and 60 °F.

2 References

ISO 2715, *Liquid hydrocarbons — Volumetric measurement by turbine meter systems.*

ISO 4267-2, *Petroleum and liquid petroleum products — Calculation of oil quantities — Part 2: Dynamic measurement.* [1)]

ISO 5024, *Petroleum liquids and gases — Measurement — Standard reference conditions.*

ISO 7278-3, *Liquid hydrocarbons — Dynamic measurement — Proving systems for volumetric meters — Part 3: Pulse interpolation techniques.*

ISO 8222, *Petroleum measurement systems — Calibration — Temperature corrections for use with volumetric reference measuring systems.*

3 Definitions

For the purposes of this part of ISO 7278, the following definitions apply:

3.1 base volume: The volume of a prover calibrated section, i.e. the length between the detectors, at specified reference conditions of temperature and pressure.

1) At present at the stage of draft.

3.2 K-factor: The ratio of the number of electrical pulses emitted by a meter during a proving run to the volume of liquid passed through the meter.

3.3 meter factor: The ratio of the actual volume of a liquid passed through a meter to the volume indicated by the meter.

3.4 prover calibration: The procedure for determining the base volume of a prover.

3.5 proving; proof: The determination of the meter factor or K-factor.

3.6 range: The difference between the highest and the lowest values within a batch of results.

4 Description of systems

4.1 General

4.1.1 There are several types of pipe prover, all of which are relatively simple and commercially available. All types operate on a common principle, namely the precisely measured displacement of a volume of liquid in a calibrated section of pipe between two signalling detectors, by means of a displacer (a slightly oversized sphere or piston) being driven along the pipe by the liquid stream being metered. While the displacer is travelling between the two detectors, the output of the meter is recorded automatically. Pipe provers may be operated automatically or manually.

4.1.2 A meter being proved on a continuous-flow basis shall, at the time of proof, be connected to a counter which can be started or stopped instantly by the signalling detectors. The counter is usually of the electronic-pulse-counting type. The counter is started and stopped by the displacing device actuating the detector at each extremity of the calibrated section.

4.1.3 There are two main types of pipe prover: unidirectional and bidirectional. The unidirectional prover allows the displacer to travel in only one direction through the proving section, and has a transfer arrangement for returning the displacer to its starting position. The bidirectional type allows the displacer to move first in one direction, then in the other. It therefore incorporates a means of reversing the flow through the pipe prover. (See figures 1, 2 and 3.)

4.1.4 Both unidirectional and bidirectional provers shall be constructed so that the full flow through the meter being proved passes through the prover.

4.2 Unidirectional provers

4.2.1 Unidirectional provers may be subdivided into two categories depending on the manner in which the displacer is handled, namely the manual-return in-line type sometimes referred to as a "measured distance" type, and the automatic-return or circulating type, often called the "endless loop" type.

a) The manual-return unidirectional prover is an elementary form of in-line prover which uses a section of pipeline as the prover section. The entire metered stream may flow continuously through the prover even when the prover is not being used for proving. Detectors are placed at selected points which define the calibrated volume of the prover section. A displacer launching device is upstream of the prover section, and receiving facilities are installed at some point downstream of the prover section. Usually, conventional launching and receiving scraper traps are used for this purpose. To make a proving run, a displacer (a sphere or specially designed piston) is launched, allowed to traverse the calibrated section, received downstream and then manually transported back to the launching site.

b) The automatic-return unidirectional (endless loop) prover has evolved from the prover described in 4.2.1 a) and is shown in figure 1. In this endless loop, the piping is arranged so that the downstream end of the looped section crosses over and above the upstream end of the loop. The interchange is the means whereby the displacer is transferred from the downstream end to the upstream end of the loop without removing it from the prover. The displacer detectors are located at a suitable distance from the interchange inside the looped portion. Such endless prover loops may be manually operated or they may be automated so that the entire sequence for proving a meter can be actuated by a single action. The metered stream may be permitted to run through the prover when the prover is not being used for proving, and the prover need not be isolated from the carrier line unless desired. This permits the movement of several different types of liquid in succession through the prover, and affords a self-flushing action which minimizes intermixing between them, as well as providing temperature stabilization.

4.2.2 A meter proof run in a unidirectional prover consists of a single one-way run, therefore the base volume of a unidirectional prover is the volume of liquid, corrected to standard temperature and pressure conditions, displaced between the detectors during a single trip of the displacer.

4.3 Bidirectional provers

The bidirectional prover has a length of pipe in which the displacer travels back and forth, actuating a detector at each end of the calibrated section and stopping at the end of each run when it enters a region where the flow can bypass it or when the action of a valve diverts the flow. Suitable supplementary pipework and a reversing valve, or valve assembly, either manually or automatically operated, make possible the reversal of the flow through the prover. The main body of the prover is often a straight piece of pipe (see figure 2), but it may be contoured or folded (see figure 3) so as to fit in a limited space or to make it more readily mobile. Normally, a sphere is used as the displacer in the folded or contoured type and a piston is used in the straight-pipe type. A meter proof run usually consists of a "round trip" of the displacer, and the displaced volume in this type of prover is expressed as the sum of the displaced volumes in two consecutive one-way trips in opposite directions.

5 Essential performance requirements

The design of a pipe prover shall ensure that the following performance requirements are met.

5.1 Short-term repeatability

When a unidirectional prover is calibrated using the master meter method, the results of five successive calibration runs shall lie within a range of 0,02 %. When a bidirectional prover is calibrated with a master meter, the results of five successive runs each comprising a round trip of the displacer, shall be within a range of 0,02 %.

The short-term calibration repeatability when using the volumetric or gravimetric water draw methods shall be such that the results of three successive calibration runs are within a range of 0,02 %.

When a prover is used to prove a high-performance flow meter such as one suitable for custody transfer or fiscal measurement, the results of five successive provings shall lie within a range of 0,05 %.

5.2 Valve seating

The sphere interchange in a unidirectional prover or the flow reversing valve or valves in a bidirectional prover shall be fully seated and sealed (so that the displacer is travelling at full velocity) before the displacer meets the first detector. These and any other valves whose leakage can affect the accuracy of proving shall be provided with some means of demonstrating that they are sealed during the proving run.

5.3 Freedom from shock

When the prover is operating at its maximum design flow rate, the displacer shall come to rest safely and without shock at the end of its travel.

5.4 Freedom from cavitation

When the prover is operating at its maximum design flow rate and with the liquids for which it was designed, there shall be no risk of cavitation in the prover, valves or elsewhere, over the specified pressure and temperature range.

6 Equipment

6.1 Materials and fabrication

6.1.1 The materials selected for a prover shall conform with the applicable codes specifying the pressure rating and the area where the prover is to be used. Pipes, pipe fittings and bends shall be selected for internal roundness and smoothness.

6.1.2 In the fabrication of provers, care shall be exercised to ensure proper alignment and concentricity of pipe joints. All welds within the path of the displacer shall be ground internally, and the design shall provide for this requirement. All welding shall be in accordance with applicable codes.

6.1.3 Internal coating of the prover section with a material which will provide a hard, smooth, long-lasting finish will reduce corrosion and wear and will prolong the life of the displacer and prover. Experience has shown that internal coatings are particularly useful when the prover is used with liquids having poor lubricating properties, such as gasoline or LPG.

6.2 Temperature stabilization

Temperature stabilization of the proving system is normally accomplished by the continuous circulation of liquid through the prover section, with or without insulation. When large portions of the prover are buried and the liquids are at or near ground temperature, additional insulation is usually not required. When provers are installed above ground, the application of thermal insulation will contribute to better temperature stabilization. Where a high temperature gradient can appear along the prover pipe, as with heated products, thermal insulation is recommended.

6.3 Temperature measurements

Temperatures shall be measured with an overall uncertainty not exceeding ± 0,5 °C. This requires temperature sensors with a certified accuracy of ± 0,2 °C or better. The temperature sensors shall be installed in thermowells near the inlet and outlet of the prover and in positions which receive active fluid flow during both normal and calibration operations. The thermowells shall be inserted to a minimum of 100 mm in large pipes and as closely as possible to one-half the diameter in small pipes. Thermowells shall be filled with a suitable heat transfer medium. If mercury-in-glass thermometers are used, they shall be of such a design that they can be read while remaining immersed in the heat transfer medium to the recommended depth for the thermometer in use. It is important to match the thermowell with a temperature sensor of suitable immersion requirements.

6.4 Pressure measurement

Pressure measurement devices shall be capable of measuring pressure with an uncertainty of less than ± 50 kPa (± 0,5 bar) at pressures of up to 2 500 kPa (25 bar) and ± 2 % of operating pressure at higher pressures.

6.5 Displacing devices

6.5.1 One type of displacing device commonly used in pipe provers is the elastomer sphere filled with a liquid under pressure, and expanded so that its minimum diameter is slightly larger than the inside diameter of the prover pipe. The diameter shall be such that a seal is provided without excessive friction; this can usually be achieved by inflating the sphere to a diameter which is at least 2 % greater than the inside diameter of the prover pipe. In general, the larger the sphere, the greater this percentage should be. Too little expansion of the sphere can lead to leakage past the sphere and consequent measurement error. Too great an expansion of the sphere may not improve sealing ability and will generally cause the sphere to wear more rapidly and to move erratically. Care shall be exercised to ensure that no gas remains inside the sphere. The elastomer shall be as impervious as possible to the operating liquids and retain its mechanical properties (especially its elasticity) under operating conditions. The liquid employed to fill the sphere shall have a freezing point below any anticipated temperatures. Water or water-glycol mixtures are commonly employed.

6.5.2 A second type of displacing device is the cylindrical piston with suitable seals. This is often used with straight pipe provers that have been internally honed to ensure adequate sealing.

6.5.3 Other displacers are acceptable if they give a performance equal to the two types mentioned in 6.5.1 and 6.5.2.

6.6 Valves

6.6.1 All valves used in pipe prover systems which can contribute to a bypass of liquid around the prover, the displacer or the meter, or which can cause leakage between prover and meter, shall be bubble-tight on low differential pressure tests. A means of checking valve seal leakage during the proving run shall be provided for such valves. If a sphere or spheres are used to provide this sealing mechanism in lieu of a valve, they shall be provided with some means of testing for leakage.

6.6.2 The entire operation of the flow reversing valve or valves in a bidirectional prover, or of the interchange valve in a return type unidirectional prover, shall be completed before the displacer actuates the first detector. This is to ensure that during the trip of the displacer through the calibrated section no liquid is allowed to bypass the prover. The necessary distance between the initial position of the displacer and the first detector, commonly called the pre-run, is dependent on valve operation time and the velocity of the displacer. Any method can be used to shorten this pre-run, whether by faster operation of the valve or by delaying the launching of the displacer. However, caution shall 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 shall be linked by some means to ensure that shock cannot be caused by incorrect sequence of operation.

6.7 Calibration connections

Connections shall be provided on the prover to allow for water draw or master meter calibration at a later date (see figures 1, 2 and 3).

6.8 Detectors

Detection devices and switches shall indicate the position of the displacer accurately, and in a bidirectional prover they shall operate equally well in both directions. Various types of detector are in use, the most common of which is the mechanically actuated electrical switch. Other types, including the electronic proximity, the induction pickup or the ultrasonic type, may be used, provided the required repeatability criteria are met. The precision with which the detector in a prover can detect the position of the displacer (which is one of the governing factors in determining the length of the prover section) shall be ascertained as accurately as possible (see annex A). The diameter of any opening in the wall of the calibrated section of the pipe, including the holes accommodating the detectors, shall be appreciably less than the width of the sealing zone of the displacer.

6.9 Meter pulse generator

An externally fitted pulse generator shall generate electrical pulses of satisfactory characteristics for the type of proving counter employed. The device shall generate a sufficient number of pulses per unit volume to provide the required resolution. The pulse emitter shall be designed to eliminate the generation of spurious pulses due to mechanical vibrations or other influences.

6.10 Electronic pulse counter

An electronic pulse counter is usually used in meter proving because of the ease and accuracy with which it can count high-frequency pulses and because of its ability to transmit its count to remote locations. The pulse-counting devices are equipped with a start-stop electronic switching circuit actuated by the prover's detectors. Proving systems can also be equipped with a pulse interpolation system as defined in ISO 7278-3.

6.11 Equipment for automatic-return unidirectional provers

6.11.1 Equipment necessary for the proper operation of the automatic-return or endless-loop unidirectional prover is centred around the sphere interchange unit. It is within this unit that the sphere is diverted from the flowing stream at the downstream end of the prover, passes through the interchange and is then reinserted at the upstream end of the prover, all automatically.

6.11.2 Sphere interchange may be accomplished with several different combinations of valves or other devices. Each combination comprises a system of devices designed to arrest the sphere and pass it through the interchange, yet prevent any flow of liquid through the interchange which would bypass the prover section during the proving period. Typical combinations of devices are

a) a single special ball valve modified for sphere handling;

b) a dual power-operated check valve assembly;

c) a combination of a ball or gate valve with a power-operated check valve;

d) a dual through-conduit gate or ball valve;

e) a valveless two- or three-sphere assembly;

f) an interchange using a plunger-type valve to block the flow.

6.11.3 The controls and actuators used in connection with unidirectional provers will depend primarily on the degree of automation with which it is desired to operate the proving system.

6.11.4 Separator tees, as shown in figure 1, are sized at least one pipe size larger than the nominal size of the sphere or loop. The design of the separator tee shall ensure dependable separation of the sphere from the stream for all flow rates within the flow range of the prover.

6.11.5 Launching tees are generally one pipe size larger than the displacer sphere and shall have smooth transition fittings leading into the prover. The launching tee shall have a slight inclination downwards toward the prover section, or some other means of ensuring movement of the sphere into the prover during periods of low flow, such as might occur during calibration by the water draw method.

6.12 Equipment for bidirectional provers

6.12.1 In piston-type bidirectional provers of the design shown in figure 2, the outlets and inlets on the prover ends shall be provided with holes or slots. These shall be deburred and shall have a total area greater than 1,5 times the cross-sectional area of the pipe beyond the outlet. In sphere-type bidirectional provers with oversized end chambers (see figure 3), the chambers shall be designed so that the displacer cannot obstruct the inlet or outlet openings and thus prevent liquid from flowing. The receiving chambers shall be sized to ensure that the displacer is arrested without shock under maximum flow conditions.

6.12.2 A single multiport valve is commonly used for reversing the direction of liquid flow, and hence that of the displacer. Other means of flow reversal may also be used. All valves shall allow continuous flow through the meter during proving. The valve size and actuator shall be selected to minimize pressure drop and hydraulic shock.

7 Design of pipe provers

7.1 Initial considerations

Before considering the design of a pipe prover, it is necessary to establish the type of prover required for the installation and the manner in which it will be connected with the meter piping. From a study of the application, intended usage and space limitations, establish the following:

a) whether the prover will be stationary or mobile;

b) if stationary, whether it will be dedicated (on-line) or used as part of a central system;

c) if a stationary, dedicated prover, whether it will be kept in service continuously or will be isolated from the metered stream when not being used to prove a meter;

d) if stationary, what portions, if any, will be below ground level;

e) the permissible range of temperature and pressure;

f) the permissible maximum and minimum flow rates;

g) the physical properties of the fluids that will be handled;

h) the degree of automation that will be incorporated in the proving operation;

i) the size and type of meter that will be proved;

j) the facilities that will be required for safely installing and removing the displacer;

k) the facilities that will be required for safely venting and draining the prover.

7.2 Diameter

In determining the diameters of the pipes to be used in the connecting lines, or manifolding, and the prover, the head loss through the pipe prover system shall be compatible with the head loss considered tolerable in the metering installation. Generally, the diameter of the pipe prover and manifolds shall not be less than the outlet diameter of any single meter to be proved.

7.3 Volume

In determining the volume of a prover between detectors, the following factors shall be considered by the designer:

a) the overall repeatability required of the proving system;

b) the repeatability of the detectors (see annex A, clause A.5);

c) the ability of the electronic counter to indicate only to the nearest pulse, unless pulse interpolation is employed;

d) the discrimination of the meter signal generator, that is, the volume passing through the meter per pulse registered;

e) the maximum permissible flow rate of the system.

7.4 Displacer velocity

7.4.1 It is not the intention of this part of ISO 7278 to limit the velocity of displacers and, provided acceptable performance is guaranteed, there shall be no arbitrary limit imposed upon velocity.

7.4.2 The maximum and minimum velocities of the displacer can be determined from the diameter of the prover pipe and the maximum and minimum flow rates of the meters to be proved. Clearly, some practical limit to maximum velocity of a displacer must exist, partly to avoid mechanical damage to the prover, partly to limit surges and partly to prevent damage to the displacer and the detectors. Nevertheless, the developing state of the art is such that it is inadvisable to set a firm limit on displacer velocity as a criterion of design. The minimum velocity shall be set at a level that ensures smooth travel of the displacer and that prevents intermittent travel of the displacer in fluids with poor lubricating properties.

7.4.3 A velocity of 3 m/s is a typical design specification for unidirectional provers, whereas the displacer velocity in bidirectional provers is usually lower. However, the use of special launching techniques allows bidirectional provers to be used at higher displacer velocities.

7.5 Repeatability and accuracy

7.5.1 The ultimate requirement for a prover is that it shall prove meters accurately. However, this accuracy cannot be established directly as this is dependent on both the repeatability of the meter and the systematic uncertainty in the determination of the base volume of the prover. The repeatability of any prover/meter combination, however, can always be determined experimentally by carrying out a series of repeated measurements under carefully controlled conditions and analysing the results statistically. It is therefore usual to adopt repeatability as the only available criterion of a prover's acceptability. But it should always be remembered that, whereas poor repeatability is an immediate indication that a prover is not performing satisfactorily, good repeatability does not necessarily indicate good accuracy since there is always the possibility of unknown systematic errors having occurred, and operators must always be on their guard against such errors.

7.5.2 The repeatability of a proving system will depend upon its components and, in particular, upon the repeatability of the detector's ability to locate the position of the displacer.

7.5.3 The selection of displacer detectors will have a direct bearing on the ultimate length of the proving section. A more precise detector will allow a shorter length. The required repeatability of the detector's ability to locate the displacer may be measured experimentally by the method described in annex A, clause A.5.

7.5.4 When replacing worn or damaged parts in a detector, great care shall be taken to make sure that neither the detector's actuating depth nor any of its electrical switch components is altered to the extent of changing the calibrated volume of the prover by more than the limit allowed (0,02 %). This is especially important in unidirectional provers because, unlike bidirectional provers, errors due to changes in detector actuation depth in unidirectional provers are not reduced by the compensating effect of round-trip sphere travel. To avoid such errors, one or more of the following shall be done whenever this type of maintenance is carried out:

a) the detector assembly shall be replaced with a precalibrated duplicate unit;

b) if the prover is fitted with twin detectors at each end, the repaired detector shall be reset by the procedure described in clause A.4 of annex A;

c) if neither of the above is done, the prover shall be recalibrated.

NOTE — Provided that either a) or b) above has been followed, and subject to the agreement of the parties involved, recalibration of the prover is not required.

7.5.5 An important source of random error when a meter is proved by a meter prover is counter resolution. A digital counter has a resolution of unity, and hence the pulse count has a random uncertainty of ± 1. For example, if it were desired to limit the uncertainty from this source alone to ± 0,01 %, without the method of pulse interpolation described in ISO 7278-3, it would be necessary to collect at least 10 000 pulses during a proving run or during a single one-way travel of the displacer in a bidirectional prover.

The degree of uncertainty is represented mathematically as follows:

$$U = \frac{1}{n} \qquad \ldots (1)$$

where

U is the degree of uncertainty of the recorded pulse count arising from this source alone, commonly called the resolution;

n is the number of pulses collected during a proving run.

Having established the degree of uncertainty, the minimum volume between the prover detectors is determined as follows:

$$V = \frac{1}{UK} \qquad \ldots (2)$$

where

V is the minimum volume between the detectors;

K is the minimum K-factor (number of pulses per unit volume) of any meter to be proved by the prover.

7.5.6 It follows that prover volumes can be reduced by increasing the pulse generation rate of the meters to be proved. Caution shall be exercised, however, in the use of gear-driven pulse generators on displacement meters to obtain very high pulse generation rates, because with these devices mechanical problems, including backlash, drive-shaft torsion and cyclic variations, can cause irregular pulse generation. Electronic means of pulse interpolation can also be used to reduce the resolution; such techniques shall be used with discretion, however, and provisions governing their use are contained in ISO 7278-3. Pulse interpolation is most effective for meters emitting pulses at regular intervals.

7.5.7 Optimum dimensions of provers

When selecting the minimum acceptable dimensions of a prover for a particular duty, the following considerations shall be taken into account:

a) Decreasing the diameter of the prover pipe necessitates an increase in the length between detectors for a given volume, and thus reduces the effect of errors due to detector resolution. However, it also increases displacer velocity which may become a limiting factor.

b) Increasing the diameter of the prover pipe has the opposite effect, i.e. the velocity of the displacer is reduced. However, the resulting decrease in length increases the effect of errors due to detector resolution, and this may become a limiting factor.

7.6 Example of the calculation of the design parameters of a pipe prover

An example of a calculation of the design and sizing of a pipe prover is provided for reference in annex B. The calculation is illustrative only and is not an integral part of this part of ISO 7278.

8 Installation

8.1 In relation to their method of installation, pipe provers may be classified as either mobile (portable) provers, dedicated provers or central provers.

8.1.1 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. Occasionally, mobile provers are mounted in containers or on self-contained skids so that they may be transported by road, rail or sea. Mobile provers are always provided with some means of connecting them conveniently to the metering system where they are to be used; this usually takes the form of flexible hoses, but any other system complying with the applicable safety standards may be used.

8.1.2 Dedicated prover

A dedicated prover is connected through a system of pipework and valves to a battery of meters in parallel. Its sole function is to prove those meters one at a time, at intervals as required. Although dedicated provers normally serve several meters, the term may also be used where a prover is permanently connected to one meter.

8.1.3 Central prover

A central prover is permanently installed at a location where a supply of liquid and pumping facilities are available, but is not permanently connected to a battery of meters. Instead, it is used for the proving of meters that are periodically brought to the prover, usually complete with their upstream and downstream pipework and flow-conditioning system, and temporarily connected to the prover for this purpose. The central proving system shall be capable of proving a meter under all conditions that will be encountered during the operation of the meter, and especially over its full working range of flow rate and viscosity. After centrally proving a meter, care shall be taken to ensure that the meter is not mishandled in a way that could cause its calibration to have changed by the time it is reinstalled at the operating site.

8.2 General installation guidelines

All components of the prover installation, including connecting piping, valves and manifolds, shall be in accordance with applicable piping and safety codes. Once the prover is onstream, it becomes a part of the system under pressure.

8.2.1. The prover and its accessories shall have suitable hangers and supports in accordance with applicable codes and sound engineering principles. In the design and construction of proving systems, provision shall be made for expansion, contraction, vibration, pressure surges and any other adverse conditions that may affect the installation. Consideration shall be given to the inclusion of suitable valving to isolate the prover unit from line pressure when not operating, thus facilitating maintenance and displacer removal. The system shall be provided with an adequate number of vent and drain connections. Vent valves shall be installed on the topmost portions of the pipe to ensure that all air can be vented from dead spaces not swept by the displacer. Provision shall be made for the safe disposal of liquids or vapours drained or vented from the prover section. This may be accomplished by pumping liquids or vapours back into the system or by diverting them to some collecting point. Thermometers and pressure gauges shall be installed in suitable locations near both the meter and the prover in order to determine the temperature and pressure of each.

8.2.2 Provision shall be made for recalibrating the prover. Examples of suitable connections are shown in figures 1, 2 and 3.

8.2.3 All wiring and controls shall conform to applicable codes. Components shall conform to the class and group appropriate 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 all electrical components, such as electronic counters, controls, power units and signal cables. [1)]

8.2.4 Automatic or manual pressure relief valves, complete with discharge piping and leakage detection facilities, are usually installed to allow for the thermal expansion of the liquid in the prover while it is isolated from the main system. Where there are both local and remote controls, either lockout switches or lockout circuits, or both, shall be provided between the two sets of controls to prevent accidental remote operation of a unit while it is being controlled locally. Suitable safety devices and locks shall also be installed to prevent inadvertent operation of, or unauthorized tampering with, equipment. Automated or power-actuated provers or proving systems shall have emergency manual actuators for use in the event of a power failure.

8.2.5 All types of pipe prover shall be installed downstream from straining or filtering equipment.

9 Calibration

9.1 Principles

9.1.1 Before being placed in service, a pipe prover shall be calibrated to determine its base volume, that is the volume of the prover under standard reference conditions (see ISO 5024). Periodic recalibration of a prover is also required; the interval between calibrations will depend on the frequency of use of the prover and the nature of the liquid or liquids being metered. The prover shall be thoroughly flushed and cleaned before calibration or recalibration.

1) Instrumentation and ancillary equipment for liquid-hydrocarbon metering systems will be covered in a future International Standard.