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**Series 1 –
Small Volume Provers:
Identification, Terminology and Definitions**

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In 1996 changes were made to Section N.3.5. “Wholesale Devices” in the Liquid Measuring Code of the National Institute of Standards and Technology (NIST) Handbook (HB) 44 “Specifications and Tolerances and other Technical Requirements for Weighing and Measuring Devices.” This change provided for recognition of small volume provers (SVPs) for use as standards in the field to test wholesale liquid measuring devices. In conjunction with the process of adopting changes to NIST HB 44 for recognition of these provers for field use, specifications and tolerances for these field standards were also documented and published in NIST HB 105-7 in 1997.

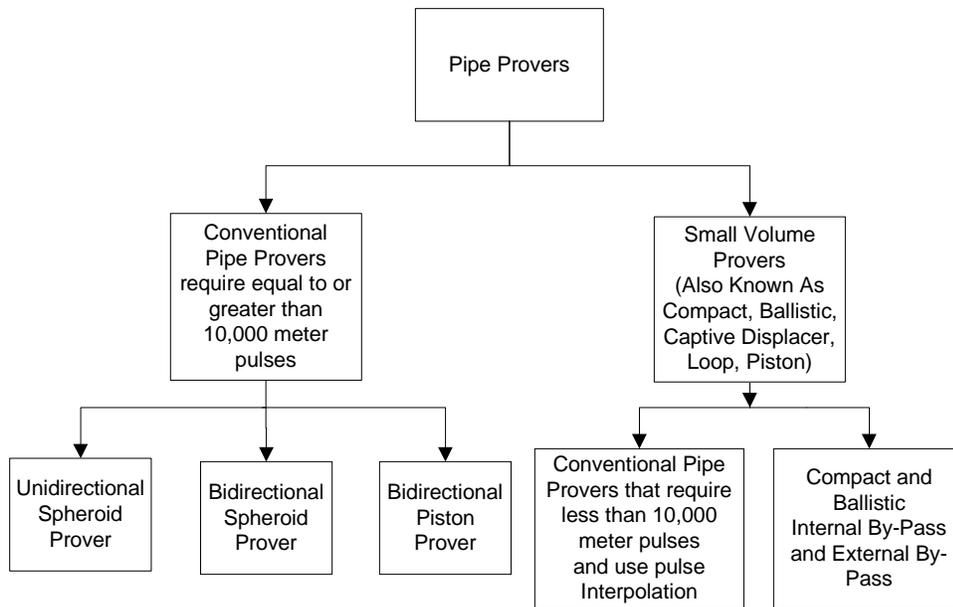
Since officials have begun encountering SVPs in their jurisdictions, NIST WMD has received questions about the design, use, operation, and implementation of SVPs in the inspection and testing of commercial measuring devices. In response to these inquiries, WMD has developed a series of articles designed to assist jurisdictions in addressing these questions.

A number of different types of provers, including SVPs are used to test large meters. Terminology used to describe these provers is often used interchangeably and can be confusing. Consequently, this series begins with the following article in which we define the terms most commonly used to refer to “SVPs”, the terms used to describe other common types of large meter provers, and terms used to describe the operation of these provers.

Subsequent articles in the series will cover the history, design, operation, use, and implementation of these provers in the inspection and testing of commercial measuring devices.

Types of Provers and Associated Components and Operation

The diagram below shows the different types of pipe provers and their subcategories:



The following definitions are associated with SVPs:

Bidirectional prover. A prover which uses a displacer that travels in one direction to actuate detectors in the calibrated section of the pipe and then in the opposite direction through the same calibrated section and the same detectors. The measured volume corresponds to the sum of both passages of the displacer. (OIML R 119)

Conventional pipe prover. See “pipe provers.”

Captive displacer prover. Same as “small volume prover.”

Compact prover. Same as “small volume prover.”

Double chronometry. A pulse interpolation method used in small volume provers to provide for fractional meter pulse counting. (NIST HB 105-7) Generally, double chronometry uses a component that increments time very precisely and operates two counters. Counter one is started when the first detector switch is tripped. The second counter is started after the first counter is started. The first counter is stopped when the second detector switch is tripped. The second counter is stopped after the first counter has stopped. Using the ratio of time counter one to time counter two will allow for accurately counting a fraction of a flow meter pulse.

Detectors. Optical sensors or electronic switches used to start or stop counters and to determine the calibrated section of the prover. (NIST HB 105-7)

Displacer. A piston or sphere (ball) in a pipe prover that is displaced by a flowing liquid between two signaling detectors. The displacer is made of material that is appropriate for the prover’s operating pressure, temperature, and the desired resistance to degradation by the liquid that is being metered.

Sphere displacers may be made of neoprene rubber, which is used for low pressure crude oil and anhydrous ammonia; nitrile, which is used for refined petroleum products such as gasoline, fuel oil, kerosene, and high pressure crude oils; urethane, which is used where abrasive resistance is critical and in low temperature applications; or viton, which is used with liquids that have a high aromatic content. With the exception of solid viton spheroids, the sphere is typically hollow and filled with a 50:50 mixture of glycol and water using a needle valve. The resulting diameter of the sphere is between 2 to 4 % larger than the inside prover dimension and chosen such that the sphere can travel freely but remain sealed to the pipe wall.

The piston displacer is made as light as possible and of non-magnetic material, such as aluminum or a special stainless steel. Wear rings made of non-metallic materials are used to prevent the metal portion of the piston from contacting the inside of the pipe. The piston is equipped with seating rings and cups to achieve the required seal and to provide a running surface. The rings and cups may be constructed of teflon, nitrile, polyurethane, or other appropriate material.

K-factor. A value obtained by dividing the number of meter signal pulses collected during the proving sample by the actual, corrected prover volume. (NIST HB 105-7)

$$\text{K-Factor} = \frac{\text{meter signal pulses}}{\text{corrected prover volume}}$$

Loop prover. **Same as “small volume prover.”**

Master meter prover. A meter that serves as the reference for the proving of another meter. In this proving method, a “standard” or “master” meter is compared to a meter under test. The master meter must be reliable, consistent, and well maintained. (See American Petroleum Institute (API), Manual of Petroleum Measurement Standards (MPMS), Chapter 4, Section 5). Although WMD has typically discouraged the use of master meters for use in legal-for-trade applications (unless certain provisions are in place), industry has used these types of provers for many years.

Meter factor. A value obtained by dividing the actual volume of liquid passed through the meter (corrected prover volume) by the registered meter volume. (NIST HB 105-7)

$$\text{MF} = \frac{\text{corrected prover volume}}{\text{registered meter volume}}$$

Pipe prover. This is the generic name for provers (including “conventional pipe provers” and “small volume provers”) in which a piston or sphere is enclosed within a calibrated length of pipe that is in series with the meter. The piston or sphere is displaced by a flowing liquid between two signaling detectors. The piston or sphere is known as the “displacer” (see definition). The displacer is designed to form a sliding seal against the inside of the pipe and travel at the same speed as the liquid. When the prover is connected in series with a meter, the volume swept out by the displacer as it passes between the detectors equals the volume displaced by the meter during the same interval. “Pulses” (see definition) are generated as the displacer moves between the start and stop detectors. When combined with a pulse totalizer and a flow meter capable of generating a pulse train, the basis for determining the liquid flow meter’s accuracy is established.

API requires that a minimum of 10,000 unaltered pulses be generated during a prover pass for a “conventional pipe prover” to ensure an accurate test. This minimum is based upon the assumption that there is a potential error of 1 pulse each time a detector is passed, which equates to a 2-pulse error per run. The value of 2 pulses per 10,000 equates to a potential 0.02 % error. Note that another type of pipe prover, the “small volume prover” (see definition) can be used with less than 10,000 pulses; however, these provers use pulse interpolation to obtain comparable results.

Piston prover. This is a type of conventional pipe prover or a type of small volume prover in which a piston is used as the displacer.

Prover pass. A single pass of the displacer through the calibrated section. (NIST HB 105-7)

Pulse counter or totalizer. Pipe provers rely on the pulse counter or totalizer to record the number of pulses generated by the meter while the displacer passes through the calibrated section of the prover. As the displacer passes the first detector, the totalizer starts recording the number of meter pulses received until the displacer passes the second switch signaling the count stop.

Pulser (meter pulse generator). A component that transforms the mechanical motion of the meter shaft, that produces indications, into digital signals. The pulser generates a known number of discrete electrical pulses for each revolution of the meter shaft. There are various types of digital pulsers, but most commonly the pulser is a switch that opens and closes with the rotation of the shaft driven by the meter.

Some pulsers use shaft encoders that include a disc containing narrow opaque regions spaced from each other by relatively wide transparent regions. As the meter shaft rotates, light from a light source is directed through the regions toward a light detector. The output from the light detector results in a train of pulses, which relates directly to the rotation of the meter.

Pulses. Signals which are generated by a pulser (see above) for each revolution of the meter shaft. When a pipe prover is connected to a meter and a pulse counter the number of meter pulses are counted as the displacer passes the first detector until the displacer passes the second displacer.

Pulse interpolation. A pulse counting technique used to calculate the total number of meter pulses between two detectors, including fractional pulses. (NIST HB 105-7)

Small volume prover. A type of conventional pipe prover in which a displacer travels through a very short section of the pipe or cylinder. The volume displaced in the calibrated section is usually much smaller than that of a conventional pipe prover. For this reason, high precision detectors and pulse interpolation are necessary to achieve repeatability and accuracy (OIML R 119). Small volume provers require less than 10,000 pulses to be generated while conventional pipe provers require that at least 10,000 pulses be generated for a prover run.

Spheroid prover. This is a type of conventional pipe prover in which a spheroid (ball) is used as the displacer.

Tank prover. See “Volumetric field standards.”

Unidirectional prover. This type of prover uses a displacer that travels in one direction to actuate detectors in the calibrated section of the pipe. The measured volume corresponds to one passage of the displacer. (OIML R 119)

Volume field standards. These are the standards most commonly use by State and local weights and measures officials and others for verification of commercial meters. The standards include both test measures (capacity < 40 L/10gal) and provers (capacity >40L/10gal). NIST Handbook 105-3 Specifications and Tolerances for Graduated Neck Type Volumetric Field Standards, specifies these as standards limited to non-pressurized, graduated neck type metal field standards with or without vapor recovery capabilities where the volume is established between a shutoff valve or bottom-neck zero graduation and an upper-neck nominal graduation. Some refer to these general types as “tank provers” (see also API, MPMS, Chapter 4, Section 4) or “volumetric neck-type provers.”

We extend our thanks to Peter Syrnyk of Emerson Process Management for his assistance in preparing this article.

Look for the next article in this series that will cover the history, use, and operation of small volume provers