November 2005

Part 4 –
Small Volume Provers (SVPs)
Operating Procedures for the Use of SVPs When Testing Loading Rack Meters

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This is the fourth in a series of articles on small volume provers (SVPs). Part 1 of the series identified the various types of pipe provers, which include conventional pipe provers and SVPs and associated components, and definitions of the types of pipe provers. Part 2 of the series addressed the history, design, and operation of small volume provers. Part 3 of the series, addressed the mathematical determination of meter performance using SVPs. This article provides operating procedures for the use of SVPs when testing loading rack meters. The reader is encouraged to reference Parts 1, 2, and 3 on the NIST WMD website at www.nist.gov/owm.

A number of weights and measures jurisdictions have reported an increase in the number of service companies using SVPs to test, calibrate, and/or repair liquid measuring devices, such as loading rack meters, for their customers. It has been reported that one of the reasons meter owners are favoring SVPs is because it reduces the testing time by approximately 25 % – 30 %.

Given the increase in the use of SVPs, many jurisdictions have requested additional information on what to look for when weights and measures officials witness the testing of meters with SVPs and certify meters based on these tests. This article includes operating procedures and a list of reference materials to assist weights and measures officials with the witnessing of loading rack meter testing using SVPs.

Operating Procedure
Pre-Test Procedures

a. *Traceability:* As with all field standards, the weighs and measures official must verify that the SVP has been calibrated by a laboratory, whose measurements are traceable to a national measurement laboratory. A copy of the last calibration certificate must be obtained from the operator of the SVP. The certificate should include at minimum the following information:

1. The date of calibration (to ensure it is current),
2. The materials of construction (needed to apply corrections),
3. The base volume(s) (see Section II (g) for more information on this item), and
4. The standards used to calibrate the SVP.

b. *Safety.* The weights and measures official should contact the facility operator for safety information that is particular to the installation or liquids being tested.

c. *Operator Knowledge.* Ensure the operator of the SVP is familiar with the particular installation, weights and measures requirements for SVPs (NIST HB 105-7), and has received the proper training on the use and operation of the SVP. (Training in industry varies. Many manufacturers of SVP provide SVP operators with manuals on the SVP operation, and the SVP operator may receive on-the-job training.)

d. *Verifying Proper Operation of the SVP.* There are a number of components and conditions that must be checked to ensure proper operation of the SVP. The SVP must be checked to ensure:

1. it is of appropriate size for the meter under test (see NIST HB 44 Section 3.30, Paragraph N.3.5. and the SVP manufacturer's operation manual);
2. the appropriate operating conditions and liquids are used. (This is not possible to check without disassembling the SVP and having knowledge of the SVP design so this is left to the SVP operator.);
3. the appropriate seals and elastomers are used. (This is not possible to check without disassembling the SVP and having knowledge of the SVP design so this is left to the SVP operator.);
4. the appropriate temperature and pressure measuring instruments are used and they are suitable and have current calibrations (see manufacturer's specifications);
5. it is operating at its designed pressure (see manufacturer's specifications); and
6. appropriate correction tables for temperature, pressure and density are used (see API temperature, pressure and density tables).

II. SVP Set-up

The operator of the SVP will be responsible for the set-up and connection to the metering system, but there are a number of items in the set-up of the SVP that must be checked to minimize inaccuracies in the measurement.

a. *Documentation.* Ensure the following documentation is available at the site:

1. The liquid producer's most recent product density figures;
2. Records of the last product tested;
3. Proper temperature and pressure correction tables (see API temperature and pressure tables).

b. *Hardware.* Perform a visual inspection of the hardware, including the following:

1. Hoses, piping and valves. If excessive wear is observed, the operator must be notified that corrective action is needed.
2. Prover connection fittings (gaskets). Ensure they are in good condition.

c. *Safety.* Ensure proper safety equipment is present and operational.

1. Prior to connecting the prover, ensure that grounding cables are in place. The prover should be grounded to the installation, the receiving vessel, and a suitable ground.
2. Review documentation of last product tested to avoid "switch loading." A description of switch loading can be found on the NIST Weights and Measures

Division website at www.nist.gov/owm. Click on “NIST/W&M Training”, then click on “Loading Rack Meter”, then click on “Chapter 4 Safety”.

d. *Product Return.* Prior to connecting the SVP to the metering system, ensure there are provisions for product return.

e. *Location and Position.* The SVP should be located as close to the metering installation as possible and allow for safe working conditions (for example, the SVP should be away from traffic, sparks or open flames). The SVP must also be level to allow for proper air/vapor venting.

f. *Additional Equipment.* Ensure the operator supplies, in addition to the prover counters/controllers (PCC), a pulse totalizer or counter as appropriate.

g. *Base Volume (Set-up of the PCC)* . Check that the correct base volume has been entered into the PCC.

Note: Many SVPs have two base volumes. The one on the outlet side of the piston is called either the downstream volume or rod-out volume; the volume on the other side of the piston is called the upstream or rod-in volume. If the SVP is located at the normal delivery outlet, the upstream volume is what should be used during the prove. If the SVP is installed via proving taps, upstream of the meter, it is the downstream volume that should be employed.

h. *Checking Average Number of Passes per Run.* Some documented procedures for SVP have established a maximum number of passes per run based on the approximate size of the meter. As noted in Part 1 of the series of articles on SVPs, a “prover pass” is a single pass of the displacer through the calibrated section. It has been documented that without a maximum number of passes it may be possible to average out repeatability problems with the system. The maximum number of SVP passes for average positive displacement (PD) meter sizes (*based on a SVP with a 60 L (approximately 15 gal) calibrated volume) is noted in the following table:

Number of Runs *	Number of Passes per Run	Approximate PD Meter Size
3	10	4” or larger
3	5	3”
3	2	2”

III. Connecting the SVP to the Loading Rack Meters

As noted above, the SVP operator will be responsible for the set-up and connection of the SVP to the metering system. The connection is generally performed as outlined below:

a. *Prover/Meter Connection.* Typically the inlet of the SVP is connected to the delivery end of the metering installation using appropriate API or dry break fittings, and then the SVP outlet is connected to a return line or vessel.

b. *Venting the SVP. (*Perform during temperature stabilization, see Section III (c.) below.)

1. If the SVP was previously used with a test liquid having a low vapor pressure and a low vapor pressure liquid is being tested, then while the prover is filling, all vapors should be vented to the atmosphere.
2. If the SVP was previously used with a test liquid having a high vapor pressure such as propane, and a high vapor pressure liquid is being tested, then the vapor contained in the prover will be compressed into liquid by introduction of line pressure. Therefore, no venting will be required.
3. If the prover has been used in other service or the metering system has been drained, there may be air or other non-condensable gases in the prover. It is good practice to check the vents to ensure you are working with all liquid during the temperature stabilization process.

c. *Stabilizing the SVP.* Liquid should be continually passed through the meter until the temperature and pressure stabilizes to within ± 0.5 °C and ± 50 kPa.

1. Check for leaks during stabilization.
2. Check to verify that all seals are adequate.

d. *Test Pulser.* As appropriate, a test pulser is attached to the meter. With some flow computers, the pulse signal is picked up from the flow computer itself. Ensure that a raw pulse output is used (see Part 3 of this series of SVP articles for further information on sources of pulses).

e. *SVPs with Hydraulic or Pneumatic Operation.* Review the SVP manufacturer's manual to ensure that the hydraulic or pneumatic spring pressure versus the flow rate and operating pressure settings are set to the manufacturers requirements prior to proving.

f. *Internal Diagnostic Program.* The operation of the PCC is tested by running a diagnostic program.

IV. Calculating the Proving K, if Appropriate

After stabilization of the SVP is complete (see Section III c. above), the proving Kfactor should be calculated, if appropriate.

a. *Pulses from the Same Source.* As explained in Part 3 of this series of SVP articles, when both the flow computer and the prover controller receive pulses from the same source, the meter base K-factor is equal to the proving K-factor. This practice is common and there is no reason to calculate a proving K-factor in such instances; however, it should be determined that this is the number entered into both units or inaccuracies may result.

b. *Pulses from Different Sources.* As explained in Part 3 of this series of SVP articles, the SVP controller may receive pulses from a different pulser than the flow computer. This occurs when a separate pulser is interfaced to the meter for proving or when a mechanical register, which has no pulser, is tested with an SVP. In this instance the proving K-factor must be calculated as follows:

1. Information regarding the programmed meter factor or meter accuracy factor versus the flow rate should be obtained from the flow computer and recorded.
2. Stop all liquid flow, shut down all compensating devices, and set the flow computer and additional pulse counter to zero. Conduct a run at the normal meter operating flow rate of at least 10,000 pulses or for one minute, whichever is the shortest. No. of Runs*
3. The displayed gross meter volume, total pulse count, flow rate, temperature, and pressures should be recorded.
4. If the flow computer is capable of a pulse output, the raw pulse output and the raw volume should be selected.
5. Verify that the volume delivered at the normal operating meter flow rate is greater than 90 % of the total volume delivered.
6. Calculate the proving K-factor (see Part 3 of this series of SVP articles for equations).
7. Repeat Steps 1 – 6 and calculate the proving K-factor two additional times (for a total of 3 times).
8. Look for agreement of the factors to within ± 0.01 % (i.e. a 0.02 % spread)
9. Average the K-factor values from the three runs rounding to five significant figures. This average K-factor value should be used in the calculation of the meter factor.

V. Testing Runs

A minimum of three runs should be conducted at each operating speed to establish meter repeatability. Each run consists of several passes (see Section II, h.). As noted in Part 1 of this series of SVP articles a “prover pass” is a single pass of the displacer through the calibrated section.

a. Reset the pulse totalizer, the PCC, and the meter register to zero prior to the run.

b. Enter the proving K factor that was determined (see IV b. 9.) into the PCC as the Base K factor.

c. The run is initiated by a launch signal that is sent from the PCC.

d. The PCC automatically records the SVP temperature and pressure readings for each pass of each run.

e. The temperature and pressure at the meter must be recorded manually for each pass if it is not automatically recorded by the PCC.

f. Test data is automatically recorded and can be printed out.

g. Evaluate the meter repeatability by comparing three successive pulse counts or proving runs. According to some documented procedures the MF for each run is compared to ensure that they are within 0.05 %.

h. As described in Part 3 of this series of SVP articles, the PCC calculates the temperature and pressure corrections (Ctlm and Cplm), the corrected prover volume, and the corrected meter volume (CPV and CMV), and then calculates the new or "as found" meter factor (Mfn) (see Part 3 of this series of SVP articles for a detailed description of the equations).

i. The meter factor is printed on the worksheet and should be used to calculate the meter registration error.

VI. Calculation of Meter Registration Error

As described in Part 3 of this series of SVP articles, the percent meter error is calculated using the new meter factor.

a. Meters equipped with mechanical registers or flow computers:

$$\text{the Meter Error in \%} = (1 - \text{Mfn}) \times 100$$

b. Meters equipped with other flow computers:

$$\text{the Meter Error in \%} = (\text{Programmed Meter factor} - \text{Mfn}) \times 100.$$

c. Compare the percent meter error to the percent tolerances of NIST Handbook 44. As noted in Section VII below, to calibrate the meter flow computer, the new meter factor is entered into the meter flow computer at the end of the inspection.

VII. Calibrating the Flow Computer

The new meter factor that was determined at the time of testing should be entered into the flow computer.

a. Verify that the correct meter factor is programmed.

b. Depending on the format, either the meter factor or meter accuracy factor must be entered into memory.

c. The original base K-factor must not be changed.

VIII. SVP Resources for Weights and Measures Officials

Currently there are no formalized Evaluation Procedure Outlines (EPOs) for testing meters with SVPs. This series of articles on SVPs are intended to assist weights and measures officials with witnessing the evaluation of meters using SVPs. The following documents have been used to develop these articles on SVPs and may be useful to weights and measures officials. These resources are available upon request or are available on the NIST WMD website and include the following documents:

a. **NIST Handbook 105-7 "Specifications and Tolerances for Dynamic Small Volume Provers"–** Available at www.nist.gov/owm.

b. **NIST Handbook 44 "Specifications, Tolerances, and other Technical Requirements for Weighing and Measuring Devices"—** Available at www.nist.gov/.

c. **Measurement Canada Authorized Service Provider Training Manual–**Available upon request. This manual includes samples of PCC printouts and meter proving report forms.

d. **Draft EPO for Proving Loading Rack Meters With SVPs–**Available upon request. This draft EPO includes work sheets.

We extend our thanks to Dennis Beattie of Measurement Canada, Emerson Process Management, and Marathon Ashland Petroleum for their assistance in the preparation of this article.