OPERATIONAL EXPERIENCE WITH SMALL VOLUME PROVERS

Class #4110.1

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Introduction

Introduced decades ago, Small Volume Provers (SVPs) are now common technology. There are numerous publications providing empirical data and outlining the technical operation of this equipment. The following document will focus on the author's experience, addressing common concerns and questions regarding SVPs.

Definition of a Small Volume Prover

According to **API MPMS Chapter 4, Section 3**, a Small Volume Prover does not allow the accumulation of 10,000 meter pulses during a prover pass. As their name implies, SVPs have a calibrated volume significantly smaller than ball (sphere) provers. Commonly referred to as Ballistic, Compact, or Syncrotrak Provers, SVPs have been commercially manufactured since the early 1980s.

The introduction of low-resolution, helical turbine meters rendered the original API definition obsolete. There are 140-barrel provers that do not collect 10,000 pulses when used with these meters. However, a prover of that size should not be considered an SVP. To avoid confusion, a prover should be defined by the type of displacer and switches it uses. The number of pulses collected should only determine whether pulse interpolation must be used. The newly published **API Chapter 4, Section 2** refers to an SVP as a unidirectional prover with captive displacer.

SVP Characteristics

The defining characteristic of an SVP is external optical switches. These switches have a repeatability of 0.0001 of an inch or better. This allows the prover volume to be very small without sacrificing accuracy. In fact, if an acceptable prover volume was controlled by switch accuracy alone, the SVP volume could be as little as one-tenth of those commonly manufactured today.

Most SVPs have a precision-machined barrel (flow tube), piston, and piston shafts. They are manufactured using metals of varying strength and durability. The availability of superior metals significantly increases the life of many of today's provers. Additionally, the piston and piston shafts are usually sealed with Teflon-based elastomers. These characteristics contribute to fluid compatibility, a wide operational flow range (usually 1000-to-1), and overall ease of operation.

Pulse interpolation is often mistakenly attributed to the SVP. Although necessary for calculating meter pulses when using an SVP, pulse interpolation is a function of the computer system assisting the prover. If the meter to be proved could generate 10,000 pulses in a pass, pulse interpolation would not be necessary. Since this is rarely the case, it is understandable that SVPs and pulse interpolation (via computer) are inextricably linked.

Switches

It is important to properly maintain the optical switches on SVPs. Although they are plastic, SVP switches are expected to retain their integrity under normal usage. Inadequate maintenance may lead to switch breakage, particularly on older models. Replacing a broken switch can be a difficult process. To further complicate matters, changing a switch usually mandates a new water draw.

The development of *replaceable switches* allows for quick and easy changes. As an added bonus, these newer switches can be installed with such accuracy as to eliminate the need for a new water draw. We tested these switches to our satisfaction as well as that of several major oil companies. Using both the water draw and prover bump methods, no change in volume could be demonstrated following the correct replacement of these improved switches.

Seals

Seal life is determined by the degree of particle (trash) contamination in the fluid as well as the number of prover cycles. Counters were installed on two provers to determine the average number of cycles or passes between seal changes. Thanks to Teflon-based seals, it is common to reach and even exceed 50,000 cycles before a seal change is warranted.

Leak Tests

The SVP manufacturers have developed specific leak test procedures that are adequate, when performed on water, in a shop setting. These tests have very tight tolerances and are good practice prior to a water draw. They are even helpful in pinpointing problems with a water draw. However, the same procedures are not as effective on hydrocarbon fluids in field applications. Hydrocarbons have varying degrees of compressibility as compared to water. The compressibility issue, associated piping leaks, and the inability to control temperature often contribute to false results in the field.

We have long maintained that the best leak test in the field is proving a meter at two flow rates, varying by fifty percent. The change in meter factor should be equal to the percent of flow-rate change. The only qualifying condition is that both test flow rates must be within the flow range of the meter. For example, a meter proved at 100 GPM with a meter factor of 0.9950 would be proved again at 50 GPM. The resulting meter factor should be approximately 0.9900 if the error is due to leaking prover seals alone. The amount of time between the switches has doubled; therefore, the leak should be twice as much. Changes in meter factor greater than anticipated would indicate influences other than seal leakage.

Minimum Number of Pulses

Since the introduction of Small Volume Provers, determining the minimum number of pulses required for proving has been a constant point of contention. After studying the available literature and consulting numerous individuals in the industry, the empirical data seemed to dictate a minimum of 300 pulses. However, extensive field tests led Coastal Flow Measurement to establish a company policy of 100 pulses. We found no significant difference when using 100 pulses as the minimum.

With the introduction of helical turbines, the minimum number of pulses has again come into question. Additional study led to a greater understanding of this complex issue. The type of meter, quality of construction, quality of the pulse output, and (most importantly) flow-rate stability during a proving are all factors dictating the minimum number of pulses—not the SVP or pulse interpolation computer. **API Chapter 4.2** addresses this issue and offers guidance for determining the minimum number of pulses required for a proving.

Meter Proving Experiences

Many question the accuracy of proving results obtainable from an SVP with different types of meters. SVPs, by virtue of their small volume, are less forgiving than sphere provers. This is an asset rather than a disadvantage. SVPs detect meter problems earlier than other provers. Because this allows for quicker, more efficient troubleshooting, it should be apparent that SVPs foster preventative rather than reactive maintenance.

The first SVP was designed to prove turbine meters. Because they are rather simple, mechanically, turbine meters may be best suited to a Small Volume Prover. Yet, despite statements to the contrary, we find that SVPs work quite well on PD and Coriolis meters. It is important to note that SVP manufacturers recommend different flow-range capabilities for proving other types of meters. As for repeatability problems using an SVP, these can be resolved with multipass averaging. The result is equivalent to running a bidirectional prover in both directions. **API Chapter 4, Section 3, Appendix B** and **Chapter 12, Section 2, Part 3** address the issue of multipass averaging.

Water Draws

As with any new type of equipment, we were not immediately confident with the results obtained on Small Volume Provers. In an effort to convince ourselves and other industry skeptics, we began to water draw our provers more often than required by API standards. We found it difficult to locate a third party who was qualified to water draw on our SVPs and would do so at a reasonable price. As a result, we obtained a certified test measure (can) along with associated water draw equipment and began performing these calibrations ourselves.

In time, Coastal Flow initiated a program designed to improve water draw procedures and achieve better accuracy and repeatability between runs and from draw to draw. Our research led us to the National Institute of Standards and Testing. NIST uses a gravimetric method to calibrate and certify test measures. Comparison tests show that gravimetrically water drawing a prover produces the same results as a volumetric test measure. However, gravimetric methods produce better repeatability from one draw to the next—especially when different operators perform the water draws.

After considerable experience in the shop and field, we are confident the following recommendations improve SVP water draws using either the volumetric or gravimetric methods:

- Water draw with only one test measure (can). Two cans necessitate dual scale readings and drainings, increasing uncertainty and random errors.

- Minimize the inventory. Inventory is defined as the volume of water in the hose and piping between the prover and the test measure. As the inventory increases, so does the possibility of error. **API Chapter 4, Section 9, Part 2** provides some insight into this issue.

- Minimize associated volume. Associated volume refers to the volume of water in the upstream and downstream piping connecting the prover to the meter. Try to eliminate this area from the prover, altogether.

- Eliminate all air pockets from the prover and/or associated piping.

- Stabilize the water and air temperatures. The more stable these temperatures, the easier it is to water draw.

- Perform five consecutive runs with 0.02% repeatability instead of the three mandated by API.

- Finally, water quality is crucial. Clean, hydrocarbon-free water from an “approved,” potable system (approved city water) will provide more consistent results.

Following the above recommendations has improved repeatability between runs and water draws. Performing 5 runs increases the level of confidence in the water draw and highlights problems with the prover or process that might not become apparent in three runs.

Crude Oil Applications

We are commonly asked if a Small Volume Prover can be used in crude oil applications. Ideally, the SVP can be used on any fluid without making adjustments or changes. However, there is generally a higher concentration of trash or particle contamination in crude oil. This raises a legitimate concern that sand or trash would prematurely wear out the flow tube. While we certainly endorse the use of an SVP, we recommend a chrome-plated, stainless steel tube for extensive use with crude oil. It would last significantly longer than a lined, sphere prover or an unlined, carbon steel prover. In terms of hardness and durability, there is no comparison. At any rate, replacing a flow tube is probably less expensive than relining a sphere prover. Given our considerable experience, we would expect an SVP to outlast any other type of prover in a harsh application. In fact, the level of trash in crude oil would impact the meter long before the prover.

API Measurement Standards

Several references were made to the **API *Manual of Petroleum Measurement Standards*** and those sections will be more accurately referenced at the end of this paper. For those standards not already updated or in print, the latest revisions should be available in the near future.

The evolution of Small Volume Prover technology is evident in the literature. Certainly, some of the earlier **API *MPMS*** sections relating to SVPs are outdated. Since SVPs were commercially introduced, field experience has led to advancements in the technology and the equipment itself.

If you are interested in Small Volume Provers or are currently using the equipment in your business, you are encouraged to familiarize yourself with the **API** standards as they apply to SVPs—particularly the most recent (and upcoming) editions.

Conclusion

Coastal Flow Measurement has never regretted its decision to use and promote Small Volume Provers. We experienced the difficulties associated with introducing new equipment to any business or industry. In retrospect, these were minor setbacks. Using and maintaining Small Volume Provers has greatly increased our measurement knowledge and solidified our confidence in SVP technology. Having said that, we would not hesitate to endorse the Small Volume Prover as the best prover technology on the market.

References:

1. **American Petroleum Institute *Manual of Petroleum Measurement Standards**,* Chapter 4 "Proving Systems," Section 2 "Pipe Provers" (September 2003).
2. **American Petroleum Institute *Manual of Petroleum Measurement Standards**,* Chapter 4 "Proving Systems," Section 3 "Small Volume Prover" (March 2002).
3. **American Petroleum Institute *Manual of Petroleum Measurement Standards**,* Chapter 4 "Proving Systems," Section 9 "Methods of Calibration for Displacement and Volumetric Tank Provers," Part 2 "Determination of the Volume of Displacement and Tank Provers by the Waterdraw Method of Calibration" (March 2005).

4. **American Petroleum Institute** ***Manual of Petroleum Measurement Standards**,* Chapter 4 “Proving Systems,” Section 9 “Methods of Calibration for Displacement and Volumetric Tank Provers,” Part 4 “Determination of the Volume of Displacement and Tank Provers by the Gravimetric Method of Calibration” (to be published in 2007).
5. **American Petroleum Institute** ***Manual of Petroleum Measurement Standards**,* Chapter 12 “Calculation of Petroleum Quantities,” Section 2 “Calculation of Petroleum Quantities Using Dynamic Measurement Methods and Volumetric Correction Factors,” Part 3 “Proving Reports” (October 1998).

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