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OPERATIONAL EXPERIENCE WITH SMALL VOLUME PROVERS
Class #4110.1

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Introduction

The following document will focus on experiences working with the Small Volume Prover and addressing common questions and concerns.

Small Volume Provers (SVPs) have become the standard in most custody transfer applications. Today, there are over 500 SVPs located throughout the US and abroad. Over 25 years ago, the first Small Volume Prover was put into service. The Small Volume Prover can be used on multiple fluids and over a wide range of flow rates. One of the most common reasons for choosing a Small Volume Prover is it's compact size and large flow rate capacity. Today's SVP can handle rates from 0.01 gpm to 18,000 BPH. With a SVP sized to handle 18,000 BPH, the total prover volume is approximately 120 gallons.

Definition of a Small Volume Prover

API Chapter 4.2 refers to SVPs as a "unidirectional prover with captive displacer". In the past, a SVP was considered to be any prover that collected less than 10,000 pulses. But as meters have evolved along side of the provers, some meters, no matter how large the prover volume, will not produce 10,000 pulses. Therefore, we will refer to SVPs as unidirectional with captive displacer using high speed repeatable switches and computer-based computations.

Small Volume Prover Characteristics

External optical switches that respond quickly and are repeatable within 0.0001 of an inch along with precision machined barrel, piston, and piston shafts allow the prover volume to be very small without sacrificing accuracy. In addition to the switches and machined parts, the seals used are a Teflon-based elastomer that allows for a wide range of fluid capabilities and an extended life of the seals. SVPs use pulse interpolation to generate five significant digits during the collection of pulses. The development of high speed computers and digital communications has allowed the SVP to evolve.

Maintenance: Mechanical

SVPs are typically low maintenance. Monthly inspections for chains, chain tension, shaft-seal leaks, bushings, and bearings are the extent of the general maintenance. The seal life is based on the cleanliness of the operational fluid. Typically with clean fluid, you should get 40,000 to 50,000 cycles between seal changes.

Maintenance: Electrical

SVPs have optical switches, interface board, and relays that are used to launch piston and capture data. Optical switches should be checked for proper alignment. Inadequate maintenance may lead to switch breakage, particularly on older model SVPs. With the development of precision machining, the optical switches can now be replaced without performing a new water draw, but, many companies still mandate that if a switch is replaced a waterdraw must follow. Some interface boards have LEDs to indicate whether or not the optical switch is working. Even with this tool you may have to manually function test both switches and interface board to determine if there is a problem. Relays are controlled by the interface board which opens and closes the relay to make the motor and/or pump run to return the piston to the home position.

Leak Tests

Manufacturers have developed specific seal leak tests and procedures. These tests are used to determine if there are any leaks around the piston. The leak test is performed in only one position of the flow tube (meaning, a leak test does not test the overall length of the flow tube). These tests should be performed prior to a water draw to determine if a seal change is needed or at any time to test the integrity of the seals if the SVP is suspect. If at all possible, leak tests should be performed with water in a controlled environment. In some cases, that may not be possible and can be performed in the field with refined products. If performed in the field, close attention must be paid to the fluid temperature and in verifying an air free SVP. It is almost impossible to perform a leak test in the hydrocarbon environment because hydrocarbons have a high degree of compressibility. Another great leak test you can perform is to prove a meter at normal flow rate and then again at a flow rate reduced by 50% from normal. The average meter factor error should double at the reduced flow rate because you have increased the flow time (prover to meter comparison time) by double.

Minimum Number of Meter Pulses

SVPs, unlike conventional provers, do not have a requirement for a minimum number of pulses to be collected during a pass. Historically, the industry along with old empirical data agreed that the minimum number of pulses for SVP was 300 pulses. We have conducted our own tests that show no variation in meter factor when as low as 100 pulses are collected. **Please remember the higher the number of pulses collected results in better resolution.**

Meter Proving Experiences

The SVP may be used in many applications despite statements to the contrary. We have used SVPs to prove many different types of meters, from mechanical meters (Turbines, PD) to electronic-based meters (Coriolis, Ultrasonic, and Magnetic). We have had great success proving each of these meters. Some electronic-based meters have trouble with repeatability, but that problem can typically be overcome by averaging passes. For more information on pass averaging, reference the recommendations in API Chapter 4.3, Appendix B.

The one constant we continue to see with Coriolis meters is reproducibility in the meter factor. Typically, the lack of reproducibility is related to floating zeros. For various reasons, some meters lack zero stability. Consideration should be given to items that produce zero instability (pipe stress and varying process conditions) before meter installation.

Waterdraws

There are two types of waterdraw (prover calibration) methods, the oldest being volumetric and the newest which is gravimetric. The volumetric method uses a test measure with a certified volume. This volume is determined and certified at the NIST using the gravimetric method. We use the gravimetric method, which removes one step of the process. This method seems to improve volume repeatability and reproducibility year-to-year.

Waterdraws can be very tedious and you must have good procedures that are closely followed. Some points that I would like to make are as follows:

- Waterdraws using more than one test measure adds uncertainty and can increase random errors.
- Minimize inventory. Inventory is defined as “the volume of water in the hose and piping between the prover and test measure”. As the inventory increases, so does the possibility of error. API Chapter 4, Section 9, Part 2 provides insight on this issue.
- Minimize associated volume. This refers to the inlet and outlet piping to and from valves or blinds. If possible, place blinds at the prover inlet and outlet.
- Eliminate all air pockets. Air compresses and expands with water pressure changes which allow the volume to increase or decrease.
- Stabilize temperatures. Make sure both water and air temperatures have stabilized. If both are stable, waterdraws tend to be more repeatable.
- Perform 5 runs rather than 3 as mandated by API and achieve still 0.02% repeatability. This will improve the uncertainty of the waterdraw.
- 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 will improve repeatability between runs and waterdraws. Performing 5 runs decreases the uncertainty of the water draw and highlights prover or procedure problems that might not become apparent in 3 runs.

Gravimetric Waterdraw

As mentioned, over time we have found the gravimetric method is very repeatable. There are several reasons for this that I would like to discuss. The first, which could be the most important, is *clingage*. When using a test measure, once the test measure has been filled, it must be emptied to the exact same condition that it was calibrated to; meaning any water more or less left in the test measure will change the volume on the next fill. For instance, field water might have more air entrained than the water used to calibrate the test measure. If so, it could have more *clingage* than calibration water which could change the volume remaining in the test measure and thus the next measured volume of the prover. In contrast, when using the gravimetric method, each time you empty the water container you zero the scale. This duplicates the starting point for each volume determination run and minimizes random errors, which improves uncertainty, and accuracy. Next, in a volumetric waterdraw, the gauge glass must be read. One key to reading it properly is one's line of sight, being level with the gauge/scale. If you have three individuals read a gauge glass, you typically will get three different answers. With the gravimetric method, everyone can read the digital scale readout the same.

Crude Oil Applications

Over the past several years, several SVPs were put into crude oil service. One SVP is an S-25 portable unit proving LACT units in the South Texas Region. Most of this crude is Light Crude but the actual gravities range from 25° API to 65° API. We have great success proving both mechanical and Coriolis type meters. However, with that said, as you move into production type fluids, there is concern about the amounts of sand and trash in the fluid. Trash can wear the seals out at a rate faster than normally expected. Given our considerable experience, we would expect a SVP to outlast any other type of prover in a harsh application.

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 considerable advancements in the technology.

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 Liquid 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 in the market.

References:

1. **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).
2. **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).
3. **American Petroleum Institute *Manual of Petroleum Measurement Standards***, Chapter 4 "Proving Systems," Section 3 "Small Volume Prover" (March 2002).