Field Testing Gas Meters by Transfer Proving

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Introduction:

This document will provide the reader with a basic overview of transfer proving techniques and procedures with respect to rotary and diaphragm gas meters. It defines what a transfer prover is, the need for transfer proving meters for accurate measurement uncertainty verification, the theory of transfer proving, and recommended operational procedures. This paper also explores some best practices for companies that do meter proving in field installations. Although other methods of meter testing will be briefly discussed here, the main focus of this paper and presentation is testing gas meters in the field using a Transfer Prover

With the increased use of Natural Gas as a fuel, higher natural gas prices, and the new federal regulations, buyers and sellers of natural gas are seriously looking at ways to improve their natural gas measurement and reduce the occurrence of Lost and Unaccounted for gas in their measurement systems. Although the installed field meter has been completely checked and calibrated at the factory, and a performance curve developed, there are many things that can affect a meter after it is installed in the field. All meters need to be tested for accuracy. Most state Public Utility Commissions (PUC's) have requirements for testing intervals for gas meters installed in custody transfer applications.

Many utility companies remove their larger meters from service and take them into the shop for test and repair, while others find it is more economical to test their large size meters in the field. How the meter testing is handled – whether it be in the field or in a meter shop – is generally dependent on state PUC rulings or established company best practices. Greater emphasis on accurate measurement by gas companies has enhanced the need for better methods of field-testing meters. The most common method as listed by the American Gas Association in the Gas Measurement Manual, Meter Proving Part No. Twelve, include the following:

1. Low pressure flow proving
2. Critical flow proving
3. Sonic Flow Nozzle proving
4. Differential testing – Rotary Meters
5. Spin Testing- Turbine meters
6. Transfer Proving

Low Pressure Flow proving

This test method includes comparing the time for a measured volume of gas to pass through the meter and prover with the calculated true time for that volume of gas to pass through the orifice in the prover. Equipment needed in this test method is essentially a small, accurately manufactured orifice meter comprising of an upstream flow tube with straightening vanes and one half flange, and a set of orifices. When testing with air instead of gas, a blower and power source are required. Also needed are an accurately calibrated manometer, an accurate stopwatch, a thermometer, an aneroid barometer, and some methods for obtaining the specific gravity of the gas.

Critical Flow Proving

The critical flow prover method of testing is based on a principle of critical flow or critical velocity at operating pressures between 15 psig and 500 psig. With air or gas flowing through a well-rounded orifice or nozzle, the velocity will increase as the pressure differential across the orifice increases until it reaches critical or sonic velocity. The maximum speed at which gas or air will travel is reached when the absolute pressure on the upstream side of the orifice equals or exceeds approximately twice the absolute pressure on the downstream side. The prover consists of a set of flow tubes, connected with a flange union orifice holder between them. The orifices are individually calibrated for a standard time in seconds which is, the time required to pass on cubic foot of air at the upstream pressure when the upstream pressure is at least twice the downstream pressure and the temperature is 60 °F. Equipment is required to determine the gas specific gravity, the temperature of the gas at the prover and at the meter, the pressure of the gas on the upstream side of the orifice and at the meter, and supercompressibilitty.

Sonic flow Nozzle Proving

Sonic flow nozzles are commonly used instead of critical flow orifices in proving meters at elevated pressures. Each nozzle is stamped with its standard air time, or seconds for one cubic foot of air to flow through the nozzle at 60 F and 24.696 psia. Two methods are used: One, for up to 500 psig from 20 to 100 °F. The second method is for pressures up to 1000 psia at temperatures between 0-200°F.

Differential Testing

The test method is used to determine a pressure difference in a rotary meter's internal resistance, a condition which can affect meter accuracy. This method is an approved method of testing by most state PUC's and has been steadily gaining acceptance by LDC's. A differential rate test consists of taking a differential pressure reading across the inlet and outlet differential taps of an installed rotary meter and then comparing the recent test to the "born on" differential of the meter when it was initially installed.. Test equipment can include differential test devices such as a manometer or electronic differential tester, pressure gauge, stop watch, and some method to check gas specific gravity. Additionally, in recent years, EVC's (Electronic Volume Correctors) that mount integrally to the rotary meter have been introduced that constantly monitor differential pressure and provide the LDC with valid differential test results.

Spin Testing Turbine Meters

A spin test is used to check for indication of internal friction or external drag and determine if a significant change has occurred from its original accuracy, corresponding to a reduction in meter registration.

Transfer Prover testing

The use of a Transfer Prover in field testing diaphragm, rotary and turbine meters is very popular among gas utilities. This method uses a calibrated master meter that is accuracy tested on equipment traceable to N.I.S.T., NMi or some other approved certifying agency, to check the accuracy of another meter – generally referred to as the "field meter" or "meter under test".

Which Test Method Will Work Best for Your Company?

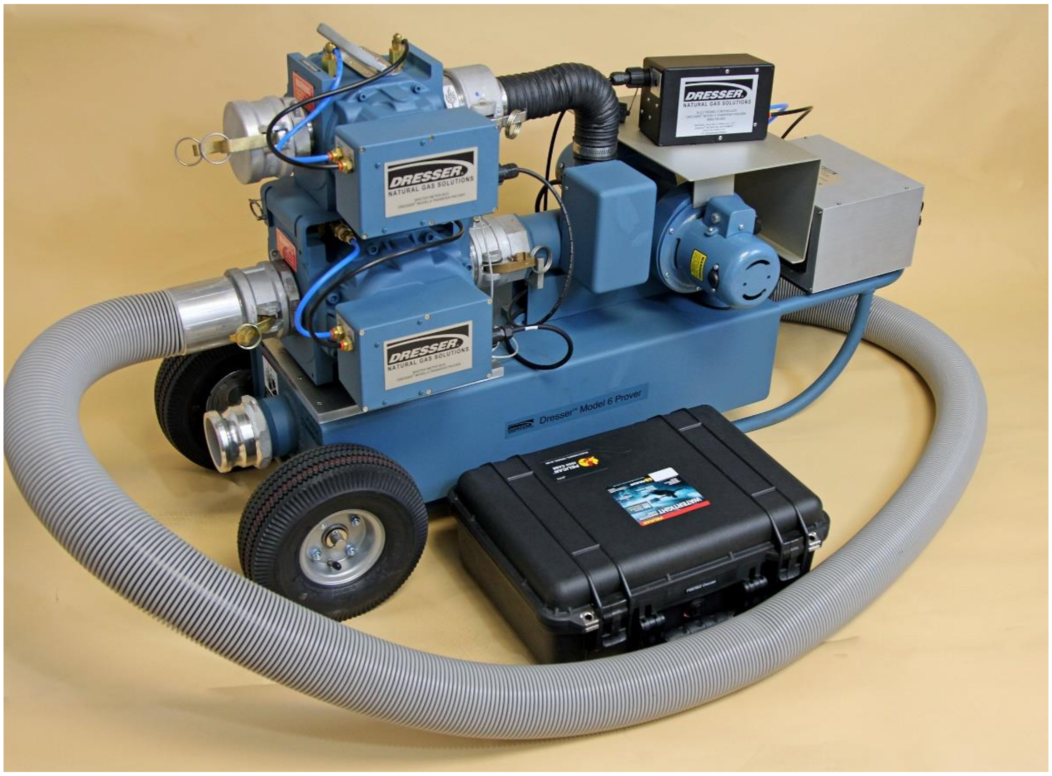
- The low pressure flow prover and the critical flow prover require somewhat complex calculations to determine meter proof. The omission of data or the propensity for incorrect calculations, can cause the compounding of errors before the final accuracy can be calculated.
- The rotary meter differential pressure test and the turbine meter spin test are used to check for increases in friction, a condition which can affect meter accuracy. These tests are considered to be inferential tests as they infer that if the health of the meter is challenged, the accuracy of that meter may have eroded over time.

Test results obtained from a transfer prover are considered accurate and repeatable These different methods and devices have their advantages and disadvantages, and can be divided into two categories, *primary and secondary*.

- A primary measurement device, such as a bell prover, piston prover or sonic nozzle prover, have had their measurement accuracy checked and verified against measurements for which there are national or international standards. As stated previously, these would be N.I.S.T (National Institute of Standards and Technology), NMi (Netherlands Measurement Institute) and various others.
- A secondary device is one that has been checked against a primary device and is then used to prove another meter. Transfer proving was initially developed to provide an easier and more accurate field meter proving method. Because of the capacity capabilities of transfer provers, they are widely utilized in meter shops where bell prover capacity is limited, allowing for shop testing of larger capacity meters. The most commonly used field transfer prover has a maximum capacity of 10000 cfh, allowing for a quick accuracy test of many meters to their full rated capacity, and for other large capacity meters at an acceptable flow rate.

Theory of Operation

The transfer prover is an integrated, computer-controlled system designed for shop or field proving of rotary and diaphragm-type positive displacement gas meters. It may be used to test turbine-type gas meters when an approved acoustic filter is positioned between the outlet of the field meter with the filter mounted directly to the inlet of the master meter on the prover.



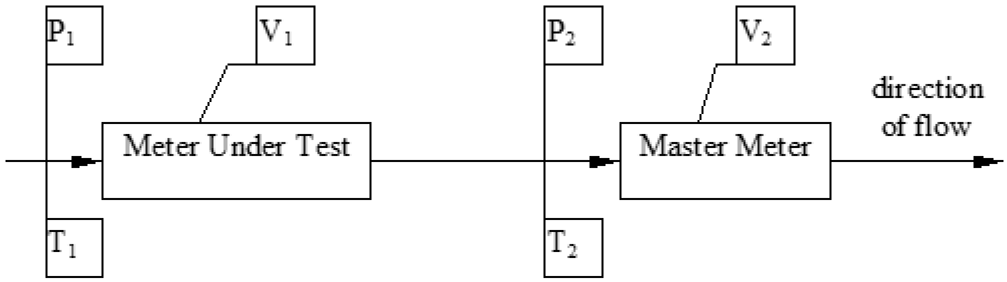
The Dresser Model 6 Transfer Prover

The prover is designed for transfer proving utilizing air only as the test medium, and electric blowers mounted on a manifold or a skid, provide the test air flow (vacuum).

More commonly available transfer provers use the thermodynamic law of the conservation of mass. Charles and Boyles Laws, in conjunction with the Ideal Gas Law, are applied in the prover software. The following equation expresses the theoretical relationship.

THEORY OF OPERATION

A typical test set-up of the transfer prover and its operating principle is depicted, below:



$$\frac{P1V1}{T1} = \frac{P2V2}{T2}$$

Where, P= Pressure

V=Volume

T= Temperature

Temperature and pressure differences between the field and master meter are measured and compared and the difference in performance is expressed in terms of field meter accuracy.

Transfer Prover Operation and Set Up

The operating principle of a transfer prover test is the comparison of volume registration by the meter under test (field meter) to the volume registered by a measurement standard. The accuracy of the meter under test can be characterized based on the difference in its performance parameters as compared to the master meter. Temperature and pressure differences between the field and master meter are measured to enable correction of the test data to a common base of comparison. The difference in performance is expressed in terms of accuracy (Proof and percent error are also displayed).

The transfer prover uses blowers to pull a vacuum, drawing ambient air into the field meter and passing directly through a connecting hose into a Master Meter. The vacuum method of testing is basic to all commercially available transfer provers. The rotary meter transfer proving system is not affected by specific gravity or relative humidity of the flowing gas since under normal conditions, no condensation or change of moisture contact should occur as the gas passes from the field meter to the master meter.

Transfer provers have evolved since the first Dresser Model 3 Transfer Prover was introduced in the 1970's. Provers of more recent design incorporate computer interfaces with Windows based software and backend system connectivity, minimizing the chances for human error. Modern transfer provers typically store factory provided preconfigured tests for various meter types and sizes as well as providing the user the opportunity to configure and save their own commonly used test configurations. A built-in self-check feature assures reliable system performance, while a field meter purge requirement prior to starting a test assures a high level of safety. The Dresser transfer prover is typical of commercially available transfer provers on the market today and will be utilized in this paper for descriptive purposes. Transfer provers from other manufacturers may differ slightly in shape, size, or performance, but the basic operating principle is the same.

The transfer prover is designed to reduce or eliminate system harmonics induced by pulsation at varying flow rate which can greatly affect test results.

The prover consists of one or more rotary positive displacement master meters mounted on a wheeled cart for portability. The 10M Master Meter is calibrated over a flow range of 100 cfh to 10000 cfh. An optional 2M master meter provides testing capability from 35 cfh to 2000 cfh. These flow ranges cover the capacities for testing most diaphragm and rotary meters. The Blowers are mounted downstream of the meters and discharge to atmosphere through a muffler or silencer, minimizing noise when testing in public areas or in meter shops. Comprehensive testing has demonstrated compliance with OSHA regulations concerning acceptable noise levels. The connection from the field meter to the prover is made with a flexible hose with quick disconnect fittings at each end. A cable is used to connect the temperature, pressure and pulser connections between the filed meter and the controller.

The standard transfer prover operates on a 120 VAC +/-10%, 48-62 HZ. Power consumption with blowers on high is approximately 1000 watts. Minimum power requirements with a portable power supply are 2400 KVA when suing an inverter, or 3 KVA when using a generator.

The transfer prover has been designed for operation by one person with a minimum of effort. Transportation of the unit may be accomplished by a station wagon, service van, or trailer. The prover is a precision instrument and should be operated and maintained in accordance with factory recommendations. Care should be given when transporting, ensuring it is properly secured and covered for protection from moisture and dirt. The ambient temperature operating range is 32 to 140 °F.

The accuracy and repeatability of the transfer prover system is related to the permanent accuracy characteristic of the rotary positive displacement master meter. The accuracy of the Master meter is determined from a factory calibration test on a bell or piston prover. Accuracy preset values for each master meter are linearized and incorporated into the prover software to make the reference standard highly accurate throughout its designed operating flow range. A chart showing the calibration and differential curves is provided with each prover.The following recommendations should be followed during field testing:

- Use a suitable and stable power source in accordance with factory recommendations.
- The prover should be in the same temperature environment as the field meter to decrease temperature differential.
- The flexible prover hose should not be in direct sunlight or placed on a hot surface while running a meter test. This increase in temperature differential between the master meter and field meter under test can affect accuracy test results.

Maintenance

To maintain a high standard of accuracy for the Prover, it is strongly recommended that the complete proving system be returned to the factory for Remanufacture and recertification using one or more as the following criteria:

1. As dictated by State regulatory agency or Company procedure.
2. Every three to five years, depending upon Prover system condition and frequency of use.
3. Check the Master Meter differential against the original factory differential curve supplied with the new or recertified Master Meter. If the differential remains within the limit of 1.0" w.c. at 50% of flow (10,000 acfh) of the value shown on the original curve, the meter accuracy is considered unchanged.
4. Return the Master Meter to the factory for Remanufacture & Recertification if any of the following conditions are applicable: The differential does not meet the criteria in item #3 (above) at any time or after completing the recommended maintenance procedures, or reference Meter tests results consistently exceed ± 0.5% as compared to the original curve.
5. The transfer prover is a precision instrument and should be operated and maintained in accordance with factory recommendations, in order to ensure accurate and repeatable results. Dirt and grease should never be pulled through the master meters from the field meter under test. Care should be practiced when transporting the prover, making sure that it is properly secured and protected from moisture and dirt.