L.A.C.T. UNIT PROVING - THE ROLE OF THE WITNESS

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Introduction

The simplest and most effective way to transfer the ownership of liquid hydrocarbons between a buyer and a seller is through the use of an accurate liquid meter. With the aid of additional components, the liquid meter is capable of unattended measurement. This measurement system is commonly referred to as a Lease Automatic Custody Transfer (LACT) Unit when ownership is transferred at a production lease. When ownership is transferred away from a production lease, such as a transfer between Pipe Line Companies, a measurement system may be referred to as an Automatic Custody Transfer (ACT) Unit.

In order to insure accurate liquid measurement it is necessary to maintain the metering equipment and to perform periodic meter calibrations. Meter calibrations are usually performed on a monthly basis and provided by the purchaser, or in most cases, the receiving Pipe Line Company. The periodic meter calibrations are provided to compare the actual meter throughput to a known volumetric standard such as a Bi-Directional meter prover. Since the total throughput through the meter since the last meter calibration will be adjusted, based on data obtained from field calibration tests, it is recommended and suggested that the seller provide a qualified witness to be present to observe and verify all data and field tests.

Typical LACT Unit

For a witness to understand his role in representing the seller's interest, it is important to understand the operation of a typical LACT Unit. A typical LACT unit would include the following major components:

1. Charge Pump and Motor - The pump is the primary energy source for the entire system.

2. Strainer - The strainer is a device that houses a removable perforated basket that is designed to collect solid materials that may be present in the flowing stream. The strainer basket will trap and collect all materials that are larger than the perforations in the basket. Inline strainers are normally designed to collect a sizable amount of debris, but if the strainer basket is not cleaned on a periodic basis, the strainer basket is capable of rupturing, due to a high differential pressure build-up and then all the collected debris will be emptied into the pump or meter causing very serious damage.

3. Air Eliminator - An air eliminator is a device that is used to remove entrained air or vapor from the fluid stream before it enters the meter. Should air be allowed to enter the meter it would be measured as part of the flowing stream, resulting in meter inaccuracy. The air eliminator is installed upstream of the meter in the highest part of the piping system to allow air to migrate and accumulate until it is eliminated. It is important that all air eliminator discharges be furnished with a soft seated check valve to be used to prevent air inhalation during periods of shutdown.

4. BS&W Probe and Monitor - An electronic device that is capable of determining the amount of Basic Sediment and Water (BS&W) is an integral part of most LACT Units. The system consists of an inline "BS&W Probe" that monitors the entire flowing stream and communicates to an electronic device, called a "BS&W Monitor" that produces an electrical control signal based on the amount of BS&W present in the flowing stream. The ability of this system to accurately signal the LACT Unit on excess BS&W content insures that only the highest quality of "Merchantable Oil" is delivered to pipeline and the pipeline is not having to transfer undesirable BS&W. The electrical control signal feature of the BS&W Monitor is used to control a diverting valve which diverts the fluid stream back to a retreating facility whenever the BS&W content exceeds the Monitor setting. If the BS&W content of the flowing stream drops below the Monitor setting, the diverting valve returns the fluid to the pipeline and normal automatic operation continues.

5. Diverter Valve - The diverter valve is a three-way two-position valve that is installed upstream of the meter and used to direct total fluid flow to either the meter or to the retreating facilities. The diverter valve is equipped with either an electric, hydraulic or pneumatic actuator that is connected to an internal shaft and plug that controls the flow path of the valve. When the LACT Unit is shutdown or an excess amount of BS&W is detected, the actuator positions the valve to a normal divert or "fail closed" position. When the unit is running and the BS&W content is below the BS&W Monitor setting, the actuator positions the valve to a "run" position to allow total fluid flow through the meter.

6. Sampler System - The sampler system consists of a probe that is used to retrieve a representative sample of the flowing stream and a sampler container that is used to store the collected samples over a specified time period. The contents of the sample container are used to determine the true representative value of the entire metered stream during the custody transfer. The representative sample contents will determine composite API Gravity and the total percentage of BS&W.

   The sampler probe is a section of pipe that is installed in a horizontal position in a vertical run of pipe upstream of the meter. The tip of the probe is beveled to a 45 degree angle and is inserted with the bevel located in the center of the pipe with the bevel facing the direction of flow. The outlet of the sampler probe is connected to a three-way electric operated solenoid valve. The solenoid valve is also connected to the sample container and to a "volume regulator". The volume regulator is an adjustable device with a spring return mechanism that is designed to collect a precise amount of fluid each time the solenoid valve is actuated. With no power on the three-way solenoid valve, the sample probe is isolated or blocked and the volume regulator and the sample container are internally connected. When the LACT Unit is in operation and the sampler solenoid is electrically actuated or "energized", the sample probe is connected to the volume regulator and fluid under line pressure is allowed to fill the volume regulator and compress the spring load assembly. As soon as the sampler solenoid is de-energized, the trapped fluid, under pressure, in the volume regulator is injected into the sample container using both the fluid trapped pressure and the spring load assistance of the volume regulator.

   The sampler solenoid is actuated by a transmitter or pulser located on the meter to allow sampling at a fixed rate (one sample per barrel, etc.) only during metering. The sampler does not operate when the meter is not in operation, i.e., periods of shutdown or during an excessive BS&W divert sequence. Other types of sampling probes may use either an electric or a pneumatic actuator to retrieve or extract the sample from the flowing stream.

   The sample container is a storage vessel that is used to collect the contents of all the samples taken during the custody transfer. The container is sized to allow adequate storage during the total custody transfer period, usually 30 days. It is important that the container be vapor tight to prevent the evaporation and loss of entrained vapors that could affect the composite API Gravity - thus affecting the total value of the product.

7. Meter - The meter is used to accurately and precisely measure the total fluid stream and to accumulate the total throughput. The most accurate meter used is the positive displacement meter. The positive displacement meter uses the energy of the flowing stream and divides the stream into small segments through rotation of an inner unit. This precise rotation is connected through a mechanical gear train to a mechanical counter to develop the total throughput of the LACT Unit. In order to provide the many functions required, the following meter accessories may be used;

   a. Automatic Temperature Compensator - used to mechanically correct meter registration to a base of 60 degrees F.

   b. Low Resolution Transmitter - used to electrically actuate the sampling system.

   c. Right Angle Drive - used to mechanically connect the gear train of the meter to a portable high resolution photo- electric transmitter that is used for meter proving and calibration.

   d. Counter - a non-resettable type mechanical counter used to accumulate the total throughput of the LACT Unit.

   e. Meter Monitor Pulser - an electrical transmitter that is mechanically attached to the counter to be used to alarm the LACT Control Panel anytime the meter is not turning and the LACT Unit has been signaled to operate.

   Other meter accessories may be employed on a LACT Unit depending on the application. In some cases electronic Temperature Averagers may be used in lieu of the mechanical temperature compensators.

8. Meter Prover Loop - The meter prover loop is a manifold using three valves connected to two tees. The typical arrangement is to install the valves and tees so that two of the valves are side mounted and one valve is in line. This arrangement allows another meter or "prover system" to be connected to the side mounted valves. By closing the inline valve, all fluid going through the meter would also go through the prover system. The inline valve becomes the "inline prover valve" and since every drop that goes through the meter must go through the prover system, it is necessary that this valve have special internal seats and seals so that any seal leakage can be detected. The most common seats used by the inline prover valve are "block and bleed" seats. The inline prover valve is also furnished with a "tattle-tale" drain valve that can be opened, when the valve is in the closed position, to verify that no leakage occurs across the valve during a proving run.

   The tees that make up the meter prover loop are furnished with thermowells and pressure gauges that are used to compare flowing temperatures and pressures with the prover system during meter calibration.

9. Back Pressure Valve - The back pressure valve is an automatic valve that is used to hold a minimum pressure against the entire LACT Unit. This valve is required to ensure that the meter always operates against a pressure above the vapor pressure of the fluid being metered. Vapor pressure is the minimum pressure and temperature required to maintain the product in the liquid state. When a centrifugal charge pump is used, the back pressure valve holds a constant pressure against the pump that maintains a constant flow rate on the meter. Provided the back pressure setting is always above the vapor pressure of the fluid, it is possible to adjust flow rate through the meter by adjusting the valve.

   In most cases, it is recommended that a back pressure valve also be installed on the discharge side of the diverter valve to prevent the charge pump from operating a very high flow rate due to a lack of back pressure.

10. Check Valve - A check valve is used to prevent backflow of metered fluid from the pipeline back through the LACT Unit. The check valve is installed as the last device in the piping system. The check valve is a two-way type valve with a hinged flapper that allows fluid to pass through the valve in one direction only. Should fluid attempt to reverse direction, the flapper in the check valve contacts a seat to prevent flow.

11. LACT Control Panel - The LACT Control Panel is the electrical brains of the LACT Unit and controls the entire operation of the system. The basic system operates on liquid level switches installed on the "run tank" or "surge tank". When a high level is signaled in the run tank the LACT Control Panel starts the charge pump. Provided there are no problems during operation, the system will run until a low liquid level is signaled and the unit will shut down until the next high level signal is received. In addition to starting and stopping the LACT unit from level switches, the following features are also provided;

    a. Main Power On-Off - a circuit breaker or fused disconnect switch used to remove power from all electrical devices on the LACT Unit.

    b. Hand-Off-Automatic Switch - used to run the LACT charge pump in a manual or automatic mode.

    c. Lightning Arrestor - used to help absorb the electrical surges from lightning.

    d. Divert Controls - used to position the diverter valve based on signals received from the BS&W Monitor.

    e. Monitor Failure control - used to shutdown the system in the event of a failure of the BS&W Monitor.

    f. Meter Malfunction Control - used to shutdown the system in the event the meter does not register when the LACT Unit is in operation.

    g. Set Stop Allowable Control - sometimes used to shutdown the LACT Unit if a preset quantity of product has been delivered through the system.

    h. Alarm Beacon - used to alarm an operator anytime there is a failure on the LACT Unit.

12. Sealing - Any device that affects the quality or quantity of the measurement of the LACT Unit must have a means of security sealing. Such items would include the BS&W Monitor, the Sampler Probe and Sample Container valves and components, Meter and Meter Accessories, Prover Valves, Back Pressure Valves and the LACT Control Panel.

Bi-Directional Meter Prover

The basic principal of operation of the Bi-Directional meter prover is to provide an accurate and repetitive displacement of liquid through a precalibrated volume between two detector switches. Accurate displacement of the liquid is accomplished by forcing an inflated spheroid through a calibrated section of pipe using fluid energy from the stream being metered and recording the metered volume. Since the entire stream of fluid being metered flows through both the meter and the prover, a ratio known as "meter factor" can be determined between the known volume and the volume registered by the meter. This meter factor is used as a multiplier and applied to the volume shown on the meter register to determine true quantity of fluid passing through the meter.

For a witness to understand his role in representing the seller's interest, it is important to understand the operation of a typical Bi-Directional meter prover system. A typical system would include the following major components:

1. Four-Way Diverter Valve - used to divert flow through the prover system without interrupting flow. Since there is not a closed position on the valve, flow can only be diverted.

2. Launch Chambers - used to retrieve the spheroid after each run. Launch chambers are also used to help reduce the velocity of the spheroid after completion of a run.

3. Calibrated Measuring Section - referred to as the volume between detector switches and is expressed as a "round trip".

4. Pre-Run - a section of pipe located upstream of the detector switches to allow ample spheroid travel time (based on fluid flow rate) before contact with the first detector switch. Pre-run is required to ensure that the four-way valve is fully seated before the spheroid contacts the first detector switch.

5. Detector Switches - used to electrically detect the passage of the spheroid and to trigger a gating circuit in the electronic meter prover counter.

6. Spheroid - an inflatable device that is used to displace fluid through the calibrated measuring section.

7. Meter Pulse Generator - an electronic device that is attached to the gear train of the meter to be calibrated that is designed to transmit high resolution electrical pulses to the electronic meter prover counter.

8. Electronic Meter Prover Counter - used to receive high resolution electrical pulses from the meter to be calibrated. The prover counter is started and stopped by the actuation of the prover detector switches based on the passage of the spheroid.

9. Water Draw - a procedure used to calibrate a Bi-Directional meter prover by collecting water displaced by the spheroid into containers of known volume that have been certified by the National Institute of Standards And Technology (NIST).

The advantages of the Bi-Directional meter prover system is that proving is done under actual operating conditions and the meter runs continuously. This procedure eliminates errors resulting from starting and stopping and also reduces proving time. Another advantage is that proving temperatures are stabilized during continuous proving.

Meter Proving Terms

For a witness to understand his role in representing the seller's interest, it is important to understand the procedures used in obtaining "meter factor". A review of terms would include the following:

Prover Volume Corrections Required

The volume of the prover is expressed as a round trip. The prover volume is determined from a calibration test or "Water Draw" using water as a test fluid with the prover volume corrected to a pressure of 0 PSIG and a temperature of 60 degrees F. When the prover is operated, it is necessary to correct prover volume for the following conditions:

1. Liquid Temperature Correction **(Ctl) -** a correction applied to the prover only when the meter being calibrated is equipped with a mechanical automatic temperature compensating device to allow a true volume comparison. This correction is used to correct the volume of the prover to a base of 60 degrees F. This is referred to a "net" proving.

   When proving a meter without a mechanical automatic temperature compensating device it is necessary to apply the liquid temperature correction **(Ctl)** to both the prover volume and the meter volume. This is referred to as a "gross" proving.

2. Prover Expansion Due to Pressure **(Cps) -** a correction applied only to the prover and is used to correct for the change in prover volume due to the effect pressure has on steel from a base of 0 PSIG.

3. Prover Expansion Due to Temperature **(Cts) -** a correction applied only to the prover and is used to correct for the change in prover volume due to the effect temperature has on steel from a base of 60 degrees F.

4. Liquid Compression **(Cpl) -** a correction applied for the effect pressure has on prover volume based on the liquid being proved. This correction is used to correct for compressibility of the liquid from a base pressure of 0 PSIG.

Meter Volume Corrections Required

1. Pulse Factor of Meter - the number of pulses per gallon (or barrel) generated by the meter pulse generator installed on the meter being proved.

2. Liquid Temperature Correction **(Ctl) -** a correction applied to the meter only when the meter being calibrated is not equipped with a mechanical automatic temperature compensating device. This is referred to a "gross" proving.

3. Liquid Compression **(Cpl) -** a correction applied for the effect pressure has on meter volume based on the liquid being metered. This correction is used to correct for compressibility of the liquid from a base pressure of 0 PSIG.

Review

A review of key points to consider in representing the seller's interest as a qualified witness during meter provings and calibrations would include the following:

1. Verification that all pipeline "seals" are in tact since the last meter proving.

2. Verification that the API gravity and temperature of the flowing stream are accurately taken and recorded and that the appropriate API Tables are used to determine API gravity corrected to 60 degrees F.

3. Verification that the flowing temperature has stabilized.

4. Verification that the flow rate through the meter and prover system are within the normal operating range of the meter.

5. Verification that the "tattle tale" drain valve on the inline double block and bleed valve does not leak when closed for meter proving.

6. Verification that the four-way diverter valve does not leak between seats during a proving run.

7. Verification that the electronic meter pulse generator attached to the gear train of the meter to be calibrated provides the necessary pulse outputs.

8. Verification that meter pulses obtained during meter provings are accurately recorded and are within the repeatability and tolerances agreed upon.

9. Verification that the observed temperature at both the meter and the meter prover for each round trip of the meter prover are properly recorded.

10. Verification that the calculations used to determine meter factor are properly recorded.

11. Verification that the contents of the sampler are under pressure and that the sampler contents have been adequately agitated before a sample is withdrawn.

12. Verification that the API gravity, BS&W content and temperature of the sample container contents are accurately taken and properly recorded.

13. Verification that the sample container is emptied and adequately cleaned.

14. Verification that all pipeline seals have been installed.