Design, Operation & Maintenance of LACT Units
Class # 2090

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Introduction

Reliable hydrocarbon transportation from supply to demand is among the most critical factors in sustaining our way of life. When entering or exiting a transportation network, hydrocarbons are measured for environmental protection and accounting systems. A Lease Automatic Custody Transfer (LACT) Unit is a metering point at a lease or production facility through which hydrocarbons are being measured, while unattended, for sale from one party, such as a production company, to another party, such as a pipeline company. The purpose of the LACT Unit is to determine the volume of hydrocarbons injected into a transportation network. The term LACT Unit is predominantly used to refer to a unit at a production facility that automatically measures crude oil being injected into a pipeline system or storage terminal prior to downstream delivery to a refinery for processing; however, much of the content covered in this paper applies universally to hydrocarbon flow metering.

LACT Unit Methodology

A LACT Unit measures several process variables from which a net standard volume can be derived. The API Manual of Petroleum Measurement Standards (MPMS) Chapter 12 explains meter ticket net standard volume calculation requirements in detail. This basic algorithm can serve as a starting point to identify required LACT Unit equipment. Net standard volume, or standard volume of merchantable hydrocarbons at reference conditions, is a calculated value of the difference between a gross standard volume (GSV), or total fluid volume at reference conditions, and a sediment and water (S&W) volume, or volume of non-merchantable hydrocarbons. The following formula is used to determine the total merchantable standard volume or net standard volume (NSV).

$NSV = GSV \times CSW$ where

GSV is the total fluid measured at standard conditions, including both merchantable hydrocarbons and non-merchantable components such as sediment and water. Volume at standard conditions indicates volume that is adjusted for temperature and pressure effects.
CSW is a correction factor for sediment & water required to adjust or reduce the gross standard volume for non-merchantable content; equivalent to the merchantable fraction of fluid.
NSV is a gross standard volume that has been adjusted for impurity content.
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GSV can be calculated using the following formula:

$GSV = IV \times CCF$ and $CCF = MF \times CTL \times CPL$ where

IV is an uncompensated indicated volume registered by a LACT flow meter,
MF is a meter factor that compensates an indicated volume for meter inaccuracy,
CTL is a density-dependent factor to compensate for the temperature of the measured liquid, and
CPL is a density-dependent factor to compensate for the pressure of the measured liquid.

CSW can be calculated using the following formula:

$CSW = 1 - \frac{S\&W\ (\%)}{100}$ where

CSW is a value between 0 and 1, inclusive, representing the merchantable fraction of the gross standard volume.

Given the above calculation input variables, the following equipment is typically installed on a LACT Unit to measure the process variables required to calculate a net standard volume.

Table 1. LACT Unit Measurement & Associated Equipment

Process Measurement	Typical Process Equipment	To Generate	Comment
Volume Registration (process)	Flow Meter	IV	
Volume Displacement, Volume Registration (for comparison with process meter registration)	Displacement Prover or Master Meter Prover	MF	Also requires prover temperature and pressure measurements of both liquid in prover and prover material (steel)
Temperature (of metered liquid, liquid in prover, and prover steel)	Temperature Device (e.g. temperature transmitter)	CTL (and CTS)	
Pressure (of metered liquid, liquid in prover, and prover steel)	Pressure Device (e.g. pressure transmitter)	CPL (and CPS)	
S&W %	Sampling System and Sample Container System	CSW	Samples are typically retained for calculation purposes in crude oil service.
Density	Sampling System and Sample Container System (typical for crude oil measurement) or Density Meter (typical for refined product measurement)	CTL, CTS, CPL, CPS	Required for temperature correction factors, pressure correction factors, and commodity classification purposes

A LACT Unit is equipped with one or more flow meters to produce an indicated volume (IV). A meter prover is used to determine a flow meter's accuracy and produce a meter factor (MF). Temperature and pressure devices are installed at the flow meter and at the meter prover to produce temperature and pressure compensation factors (CTL and CPL, respectively). CTL and CPL factors are density dependent and LACT Units also require the equipment necessary to determine liquid density or gravity. Given a liquid density, the American Petroleum Institute's Manual of Petroleum Measurement Standards includes algorithms to produce CTL and CPL factors based on liquid temperature and pressure, respectively.

For the purposes of determining S&W (%), a LACT Unit in crude oil service typically includes an automatic line-sampling device and a sampling container system to capture and retain a volume-weighted liquid sample. Retained samples are tested for sediment & water content and density or gravity, which is a market value variable in addition to temperature and pressure correction variables. In refined products service, a sampling system is often not utilized while a density meter provides a density measurement and the S&W % is assumed to be negligible.

In addition to understanding the components necessary to obtain quantity and quality factors of meter inaccuracy, temperature affect, pressure affect, and impurity content, it is important to note that custody transfer quality design must ensure reliability and accuracy. In addition to pure custody transfer purposes, a LACT Unit's gross standard volume is typically also used as a transportation system's computationally monitoring program input for leak detection purposes.

LACT Unit Design

Prior to designing a LACT Unit, operating ranges must be clearly defined and understood. LACT Units can be constructed, inspected, and tested without flaw according to the unit design and still significantly underperform in service if this critical step of defining design criteria is insufficiently addressed. Some key questions that must be definitively answered are listed below.

Design Definition Considerations

- What flow meter system accuracy is required?
- What is the instantaneous flow rate range? Flow meters are sized by instantaneous flow rate profile and not by measured volume, so facility throughput (e.g. daily volume or monthly volume) does not provide enough information for flow meter selection.
- Is the flow rate profile stable enough for a single flow-rate proving to be applicable? With significantly varying flow rate, a meter accuracy factor (meter factor or K-factor) curve can be established from which the appropriate factor for the running flow rate is applied.
- Will flow rate be continuous or intermittent?
- What is the fluid density range? Meter types vary and some perform better than others in a given density range.
- What is the fluid viscosity range? Similar to density-dependent performance, meter types vary and some perform better than others in a given viscosity range.
- What is the temperature range? Temperature correction is one of the more significant factors in hydrocarbon measurement. API MPMS temperature correction algorithms are derived from empirical data tested across a given temperature range, beyond which temperature correction uncertainty increases. API MPMS Ch 11 provides more information.
- What is the system pressure rating?
- Are there redundancy / load rating requirements? For example, is a 3 X 50% system (2 half-capacity meters with one spare meter) or 2 X 100% system (1 full-capacity meter with one spare) preferred or required?
- What is the estimated throughput? Higher throughput could be interpreted as higher measurement risk and drive more stringent requirements. In crude oil systems, throughput must also be estimated to properly size sampling and sample container systems.
- In crude oil service, how many sample containers are required? Redundant sample containers could be configured one per meter run or meter samples could be commingled into a primary and secondary sample container configuration. A station sampler upstream or downstream of all meter runs could also be installed.
- Will calculations be performed in the facility flow computer or will an alternate software package house the algorithms?
- Are any operational requirements applicable (e.g. S&W monitoring)?
- What control functions are required?
- Will certain measurement parameters be transmitted and monitored off-site?

Once the operating parameters are defined and understood, the LACT Unit components can be designed and/or assessed with respect to the defined operating envelope. Some design criteria are included below by typical LACT Unit components.

Hydrocarbon Storage

Hydrocarbons are pumped from facility storage, through the LACT Unit for measurement purposes, to the suction side of pipeline pumps, then into a transportation pipeline. Facilities are typically equipped with both wet oil storage, which is storage for fluid above the merchantable S&W content limit and, and dry oil storage, which is storage for fluid at or below the merchantable S&W content limit. In a dry oil tank, the operating pressure should be verified to ensure that pressurized liquids entering the transportation network do not induce any further vaporization within the transportation network. The dry oil tank outlet piping should be connected reasonably above the tank bottom where unsuspended sediment and water accumulates. The inlet and outlet dry oil tank piping connections should also be configured such that the fluid entering the tank does immediately exit the tank without reasonable dilution. In this manner, the dry oil tank can serve as a dampener for oil having a high S&W content entering the dry oil tank. Working tank volume should also be sufficient enough to avoid inefficiency related to significantly frequent pump cycles. Working tank volume should also be sufficient enough to provide the required pump cycle time for verification and calibration tasks performed while flowing, including flow meter proving and temperature device verification. Because a meter factor is accurate within a specific flow rate range, the dry oil tank capacity should also ensure the required flow rate stability, especially with facilities at which a meter factor established at a single flow rate and applied across an entire ticketing period.

Charge Pumps

The purpose of the charge pump is simply to provide sufficient pressure to the LACT Unit. Charge pumps are typically centrifugal pumps to prevent pulsating flow of a displacement pump, which can induce measurement error.

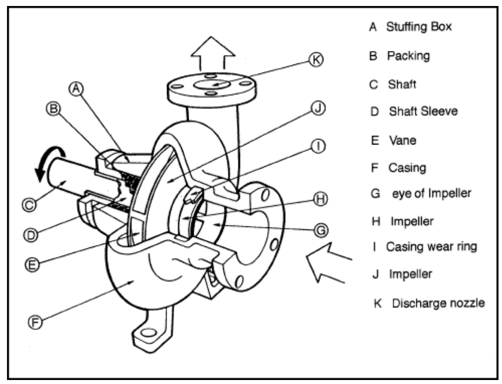

Figure 1. Centrifugal Pump

Water Monitors

Water monitors measure the water content of a flowing stream and can be used for control or diagnostic functions. If a water monitor senses the flowing stream has a water content above a non-merchantable limit, the stream can be routed back to the facility wet oil storage for further separation or treatment, the unit can be shut down, or an alarm can notify personnel for appropriate reaction. Most LACT water monitors are capacitance type devices in which the fluid stream passes between two electrodes or plates. Because the dielectric constant of the stream changes predictably with water content, a fluid stream's water content can be electrically measured and transmitted for control or diagnostics.

Divert Valves

A divert valve is a two-position 3-way valve installed downstream of a water monitor and upstream of flow meter. The valve is installed in a single input, dual output configuration. Upon detection of a non-merchantable water content, the valve can be actuated to divert the output flow from the flow meter connected to one output port to the wet oil tank connected to the other output port. In addition to diverting flow from the flow meter due to non-merchantable hydrocarbon detection, valve control is typically configured to also move to divert position at system startup and upon pneumatic or electrical signal failure.

Figure 2. Three-way Valve Body

Flow Meters

The flow meter is the LACT Unit's primary device and must accurately determine hydrocarbon quantity. A flow meter must also produce the same relative measurement performance under constant operating conditions within a short period of time, which is defined as repeatability. Quality measurement requires both accuracy and repeatability as illustrated in Figure 3.

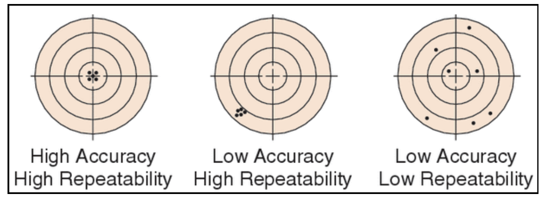

Figure 3. Accuracy and Repeatability

Additionally, flow meter performance must be stable over time or reproducible because a meter accuracy factor, such as a meter factor, established at a single testing time is deemed applicable and applied to a volume measured over a much greater ticketing period. A meter factor control chart can serve as a useful tool in analyzing meter performance over time.

A LACT flow meter typically transmits meter pulses proportional to volume to a flow computer or other accessory equipment for volume registration. Local volume registration at the flow meter is also typically included.

There are many different flow meter types and the main types used in LACT Unit service include displacement, turbine, helical turbine, Coriolis, and ultrasonic. Viscosity range, flow rate range, and accuracy requirements must be carefully considered when selecting a flow meter type. These requirements should be clearly defined for the manufacturer as different accuracy requirements or operating conditions can sometimes prompt different materials, components, manufacturing tolerances, or factory testing.

Flow Conditioning

Many meter types, such as turbine meters, require a uniform and swirl-free flow profile to accurately measure the flowing stream. Mechanical flow conditioning components have proven more effective than lengthy straight piping sections immediately upstream of meters in providing a sufficient flow profile. Flow conditioners isolate the meter from the upstream piping elements that distort flow profile. Tube bundles reduce flow swirl by separating the overall flowing stream into smaller flow streams. Flow profile plates reduce distorted flow profiles by partially blocking and redistributing the flowing stream. Flow conditioners considered as high performance will address at least flow swirl and distortion. Turbine meters, for example, perform better when the velocity across the flowing stream is relatively constant so that the turbine meter rotor remains balanced relative to the shaft.

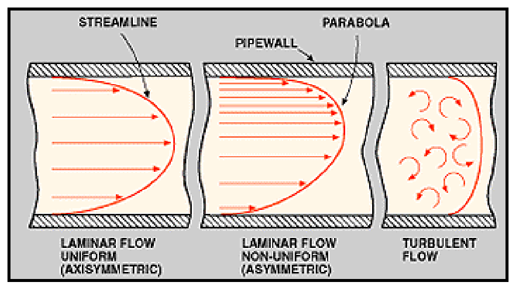

Figure 4. Flow Profiles

Meter Strainers

Meter strainers remove material that can potentially damage a flow meter or other metering components from the flowing stream. Pipeline type basket strainers are typically installed upstream of each LACT meter and allow top entry access for inspection and cleaning. The strainer is often fitted with differential pressure indication to indicate when cleaning is due.

Strainer piping connections should be sized with respect to flow velocity, which should typically be limited to 15 feet per second. While a strainer for displacement metering can typically have the same piping size connections, a strainer for turbine metering service would typically have connections one or two pipe sizes larger than the meter size.

Strainer baskets should also be sized relative to meter type and size. Table 2 lists some common basket size suggestions for displacement and turbine meter runs.

Figure 5. Pipeline Strainer

Table 2. Common Strainer Basket Sizes

METER TYPE	METER SIZE	BASKET	LINER
Displacement	2 to 8 inch	1/8 inch holes, 3/16 inch center to center	N/A
Displacement	10 to 16 inch	1/4 inch holes, 3/8 inch center to center	N/A
Turbine	2 inch	1/2 inch flattened expanded metal	30 mesh
Turbine	3 inch	1/2 inch flattened expanded metal	20 mesh
Turbine	4 to 8 inch	3/4 inch flattened expanded metal	10 mesh
Turbine	10 to 12 inch	1/8 inch holes, 3/16 inch center to center	N/A
Turbine	16 to 20 inch	1/4 inch holes, 3/8 inch center to center	N/A

Air Eliminators

Air eliminators allow expel air or gas from a flowing stream before entering the LACT metering or sampling systems and the transportation system. Air eliminators are typically float-actuated devices mounted at the top of an increased volume container that decreases fluid velocity allowing time for the air or gas to escape. Many air eliminators also include baffles to induce separation of entrained air or gas.

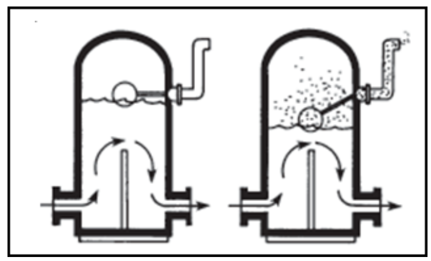

Figure 6. Air Eliminator Principle

LACT Units often utilize the increased volume of the strainer to serve as the air eliminator body and a small float-actuated air release head is mounted on the strainer lid. If this combination strainer/air eliminator is not located at the highest point between the pump and the meter for servicing purposes, and additional air release head is typically located at the highest point to ensure piping is completely liquid-filled after draining and refilling for maintenance purposes.

Temperature Devices

Because fluids contract with temperature decrease and expand with temperature increase, it is critical to accurately measure and transmit temperature to adjust volumes to a standard temperature, such as 60 deg F that is the agreed upon standard temperature at which hydrocarbons are bought and sold through LACT Units in the United States. Temperature devices are utilized on LACT Units to compensate for temperature effects on meter volumes (CTL_m), prover volumes (CTL_p), and prover piping (CTS_p).

Figure 7. Temperature Transmitter

Thermocouples and resistive thermal devices (RTD’s) are two of the most common temperature sensor types. RTD is the sensor of choice for today’s LACT Units due to accuracy, linearity, and stability advantages. RTD’s protrude into, while isolated from, the flowing stream with the use of a thermowell. The thermowell should protrude into the center third of the flowing stream (at least 0.33 ID from the pipe wall). Because any protrusion into a flowing stream acts as a fulcrum that can stress the process connection, the connection size, type, thermowell length, and process conditions should all be considered to prevent mechanical failure.

LACT Units typically utilize SMART temperature transmitters, which include a microprocessor to perform an ohm to digital conversion associated with the transmitter input from an RTD and to perform a digital to analog conversion for devices that are transmitting temperature via an analog signal such as a 4 to 20 mA current signal. SMART transmitter models are also available that can be connected to and assigned an address on a network for digital temperature transmission to an averaging device.

LACT Units must accommodate verification and calibration of instrumentation. For temperature device verification and calibration purposes, an adjacent thermowell and RTD is included to accommodate a traceable temperature instrument such as a glass or electronic thermometer.

Conventional LACT Units likely include a stand-alone temperature averaging device while newer LACT Units utilize a flow computer to average temperature samples. With either approach, a volume-weighted average must be calculated for applying a volume representative temperature correction factor over a ticket period so the same device must have a volume registration input.

Pressure Devices

Because fluids contract with pressure increase and expand with pressure decrease, pressure must be accurately measured and transmitted to adjust volumes to a standard pressure, such as 0 psig that is the agreed upon standard pressure at which hydrocarbons are bought and sold through LACT Units in the United States. Pressure devices are utilized on LACT Units to compensate for pressure effects on meter volumes (CPL_m), prover volumes (CPL_p), and prover piping (CPS_p).

Figure 8. Pressure Transmitter

As with temperature, LACT Units typically utilize SMART pressure transmitters with the input conversion being a pressure to digital conversion. The transmitter is equipped with a diaphragm with which deflection is measured to determine process pressure.

LACT Units must accommodate verification and calibration of instrumentation. For pressure device verification and calibration purposes, process isolation and test connection valves are included so that a gauge and/or pump can be connected to the input side of the transmitter.

Because pressure variance affects liquid volume calculation much less significantly than temperature variance, conventional LACT Units often did not include a pressure-averaging device. Conventional LACT Units also experienced a more stable pressure, so a single reading was often applied over a ticket period with little adverse affect. Newer LACT Units utilize a flow computer to average pressure samples and provide a volume-weighted average to be calculated for applying a volume representative pressure correction factor over a ticket period.

Density Devices

In liquid measurement, density is typically expressed in API gravity units, which is related linearly to specific gravity. In addition to density being used to categorize a liquid for accounting and commercial purposes, liquid density is also used in the derivation of temperature and pressure correction factors.

In refined products service, a density meter or densitometer is often used to determine density. In crude oil service, and therefore at most LACT units, volume-weighted liquid samples are accumulated in a sample container and the composite density is determined for application across the ticket period.

Crude oil samples are typically tested using a hydrometer and thermometer or a combination thermohydrometer after a retained sample is mixed until homogenous and drawn into a cylinder for testing.

Check Valves

LACT Units should include check valves as necessary to prevent liquids from flowing backward through the unit and flow meters both during expected operating conditions and upon failure of other LACT Unit devices such as piping drain valves, etc.

Back Pressure Valves

Back pressure valves maintain a positive liquid head pressure to keep the LACT unit liquid-packed. A minimum LACT Unit back pressure setting is typically 20 psig or 20 psig above the liquid Reid vapor pressure (RVP), whichever is greater.

Back pressure should be installed at the exit of the LACT Unit so that back pressure is maintained on the metering, meter proving, and sampling systems. LACT Unit back pressure valves should be spring-operated fail-closed valves.

Because LACT Units typically discharge to the suction side of pipeline pump, a pipeline pump suction low pressure shutdown function could ensure back pressure is maintained above the required minimum and a back pressure valve would not be necessary.

For systems with divert valves, the back pressure on the divert system should be near the normal operating mode back pressure to prevent fluid shock when switching between sales and divert operating modes.

Meter Provers

The purpose of a meter prover is to provide a known volume for comparison with a flow meter's indicated volume to establish a meter accuracy factor (meter factor and/or actual K-factor). The general concept is to place a flow meter and meter prover in series and ensure all liquid flowing through the meter and only the liquid flowing through the meter is flowing though the prover. A meter prover is a link in the traceability chain from volume standards at the National Institute of Standards and Technology (NIST) and the process flow meter.

Meter prover types include sphere displacement, piston displacement, captive displacement (small volume), master meter, and tank provers.

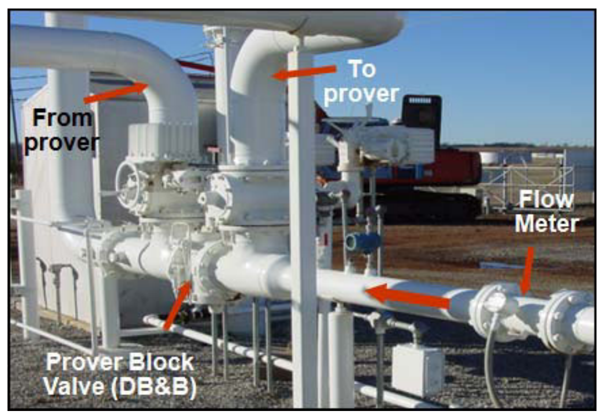

Figure 9. Prover Manifold Valves

LACT Units can also be equipped with a stationary facility prover or can be tested with the use of a portable prover which is typically economically determined by proving frequency and site location. Offshore facilities have stationary provers while stationary and portable provers are both widely used at onshore facilities.

Double-block-and-bleed (DB&B) valves or valve configurations are utilized to ensure that all meter flow and only flow from the meter being tested is routed through the prover. DB&B valves essentially seal on both valve surfaces (double block) and provide a cavity in the valve body at which no flow can be assured. A "T" piping configuration with 3 valves could also be utilized for DB&B purposes; however, the cavity that is drained will be much larger than with a single DB&B valve.

In concept, displacement meter proving registers meter pulses into a prover accumulator while the displacer is between the gates or switches, between which the volume is known. A meter factor is derived by comparing the gross standard volume registered by the meter to the gross standard volume of the prover.

A master meter prover utilizes a highly accurate meter (i.e. master meter) to serve as a known volume and provide a comparison to the volume metered by the process meter. A meter factor is derived by comparing the gross standard volume registered over the same liquid displacement.

For LACT Units, a prover pass or one displacement between the prover switches must prove a resolution of 1 part in 10,000. Therefore, conventional prover size is inversely proportional to the number of pulses per unit volume (K-factor) generated by the meter.

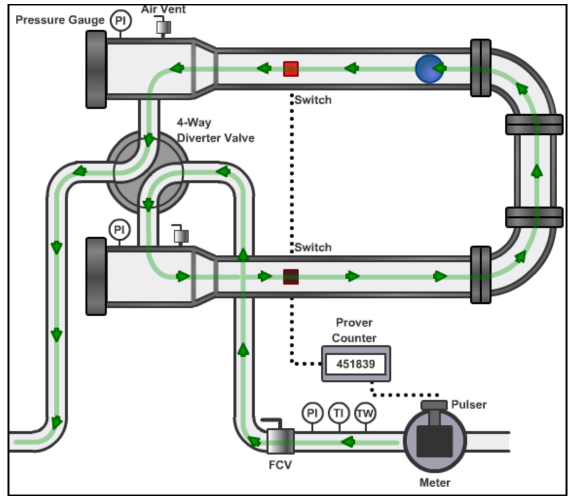

Figure 10. Bi-directional Sphere Prover Concept

Because turbine meters have an inherently smaller K-factor due to mechanical components, pulse interpolation, a method to mathematically dissect pulses and provide greater resolution, is applied in turbine meter applications. With Coriolis and ultrasonic meter types, the K-factor is a programmed output, so there is a clear need for a prover sizing relationship related to raw metered volume and not necessarily to a processed meter output. For turbine meter applications, provers are often sized according to a 900 unaltered pulse requirement, for which unaltered is interpreted as not yet modified by an algorithm such as pulse interpolation.

Provers are calibrated by volumetric or gravimetric water draw. When utilizing a volumetric prover calibration method, it is also prudent to design the prover size in alignment with the available test measure (seraphin can) sizes. For example, a 50 gallon prover is more appropriate than a 1 barrel (42 gallon) prover because 42 gallons would require the usage of a small invertible 1 gallon test measure.


Figure 11. Test Measure

<u>Sampling Systems</u>

The purpose of the sampling system in crude oil service is to extract a representative composite sample for quality determination, including density and S&W content testing. In order for extracted samples from a single point within the pipe to be representative of the entire flow stream, the stream must be homogenous in the area of extraction. The most common method of creating a homogenous fluid stream is to install a mixing component such as a static mixer. A static mixer design is applicable across a specific flow rate range and a specific liquid viscosity range. The static mixer manufacturer should be able to assure a mixer design is appropriate for a given set of operating conditions.

The sample should be extracted from this homogenous zone at equal volume-spaced intervals to provide a composite volume-representative sample. This rate can be calculated based on sample probe grab volume, sample container size, total expected throughput volume during sampling period, and desired container fill percentage or volume.

The pipeline sampling system can be water-injection tested to assure the extracted sample is representative of the entire flow stream. This test is performed by knowing the water content of the flowing stream and injecting a known volume of water into the flowing stream just prior to the sampling system and comparing the theoretically calculated and the empirically determined water content or volume. Therefore, the LACT Unit should include a water injection port upstream of the sampling system and downstream of any pipe disturbances or water traps such as a strainer.

Sample Container Systems

The samples extracted by the sampling system should be retained in a sample container for density and S&W content determination. As the retained sample is only a small portion of the measured crude oil stream, the sample extracted from the sample container for testing is only a small portion of the sample retained within the container, so being able to ensure a homogenous mix prior to extraction is again the most critical factor in sampling accuracy. Each sample container system design should be water injection tested to ensure measured results are in alignment with theoretically calculated results.

Figure 12. Sample Container System

The challenge of homogenous sample mixing both from the flowing stream and again from the sample container holding the extracted sample can be quantified for context. Given some parameters very common for LACT Units of 1 sample every 10 barrels of the flowing stream, a sample extraction volume of 3 cubic centimeters per sample, a target retained sample size of 16 gallons (80% of a 20-gallon container), and a 50 cubic centimeters sample testing size, the actual tested volume equates to ~1.56 parts per billion of the volume from which the sample was drawn and expected to be homogenous.

The sample container system should have an o-ring seal to prevent water or humidity entry and be able to contain pressure up to at least 12 psig. Sample containers should be easily opened for inspection and cleaning purposes. The sample container should be equipped with a relief valve and vacuum breaker to ensure a positive seal is intact. The sample container should also have some type of level indication for operational verification and a level scale from which periodic readings can be recorded.

The mixing pump should be sized and operated to provide rigorous enough sample mixing while not agitating so much that an emulsion is formed. Some designs size the pump rate at half the container capacity per minute, but any sample container system design should be performance tested with the internal spray-bar and pump installed.

Control & Calculation Functions

LACT Unit control functions should include monitoring of the S&W content of the flowing stream and appropriate alarm or shutdown functions upon sustained detection of any non-merchantable S&W content. Flow meter failure should also be detected and responded to with appropriate shutdown or alarm functions. Some consideration should be given to the most effective way to detect whether a meter should be flowing as an input into the meter fail logic. Sample container high level detection often generates an alarm and can also be configured to switch sample containers and automatically close out current meter tickets. LACT Control panels should also have the meter proving functions incorporated, which requires a remote-operated prover interchange or valve (e.g. 4-way valve). The LACT Unit panels should be wired to a printer for routine and alarm reporting.

From a calculation perspective, LACT Unit panels should utilize a flow computer for measurement-related calculations. Flow meters, temperature devices, pressure devices, density devices (if applicable), samplers, prover detector switches, prover valve controls, sampler control/alarm devices should be wired to a flow computer so that all critical calculations are housed in a single traceable, verifiable, reliable, and secure piece of equipment. The flow computer should at a minimum produce proving, batch, configuration, audit trail, daily, and snapshot reports.

In addition to component-related considerations, some additional general or metering system-related considerations that should be defined are also listed below.

Equipment Redundancy

For LACT Units, redundancy should be considered for charge pumps, strainers, air eliminators, water monitors, sample systems, sample container systems, divert systems, flow meters, and flow computers.

Over Pressure Protection

As with any process piping system, the LACT Unit should be assessed for any required overpressure protection. If installed, overpressure protection devices should not be installed between the meter and prover or between the meter and sampling system.

If flow through an overpressure protective device (e.g. device failure) would cause measurement error, accompanying flow detection should be considered.

Control & Diagnostics

The LACT Unit panel should transmit control, alarm, and diagnostic data wherever appropriate to ensure safe, environmentally conscious, and effective unit operation. Onsite and off-site operational alarms and shutdowns should be clearly defined.

Security

The LACT Unit should provide security against intentional and unintentional access to equipment that can cause measurement error. Appropriate LACT Unit components should accommodate wire-sealing, especially in an environment where any regulatory security requirements apply.

LACT Unit Operation & Maintenance

A LACT Unit operating company should have clearly defined operating procedures that specify operating requirements and expectations. Operating procedures should cover meter proving requirements, including frequency, applicable conditions, associated instrumentation or device verification, valve integrity verifications, required documents and forms, and record-keeping requirements. For example, a procedure should exist that specifies appropriate action if a meter is tested and found to have drifted by more than an allowable limit. Operating procedures should at least address the following tasks:

- Meter Proving. (Frequency, Number of runs to average, Within what tolerance, Maximum number of runs, Required Records)
- Flow Conditioner Inspection (if applicable)
- Temperature, pressure, and density device verification and calibration
- S&W monitor verification and calibration
- Sampling System Verification
- Divert Valve Functionality
- Strainer Inspection and Cleaning
- Air Eliminator Functionality
- Prover (Coating & Displacer Inspection)
- Back Pressure Valve or Shutdown Functionality
- LACT Panel Software Back-ups

LACT Unit personnel should also have received the appropriate training and should be required to demonstrate operating or measurement task proficiency at some periodic frequency.

All test equipment and instruments, including thermometers, hydrometers, gauges, and S&W testing apparatus, used to determine, or verify a device that determines, the quantity or quality of the liquid hydrocarbons flowing through the LACT Unit should be traceable to an accredited standards institute such as NIST.

Verification frequencies for all appropriate valves, primary devices, secondary devices, and tertiary devices should be defined, specified, and included in the facility operating procedures.

Some task scheduling mechanism should exist so that responsible personnel are informed and understand expectations for any given site visit.

All LACT Unit record-keeping requirements should be documented, including storage location, retention period, and disposition requirements.

Conclusion

LACT Unit construction, commissioning, and startup can be an effective sequence of events if operating parameters and any special requirements are identified in the design project phase. When LACT Unit projects, as with any projects, are executed poorly, it is most often due to a lack of communication in clearly defining and understanding design requirements near the onset of the project. LACT Unit design must be verified against standard and special operating specifications prior to issuance for construction for effective, enjoyable project execution.

After startup, successful continued operation is not a given constant. Operating conditions can change over time and some amount of continued effort may be necessary to ensure a design is still applicable for delivering the expected results. For example, if throughput declines over time at a production facility, the appropriate meter size may need to be reviewed or a resulting shorter cycle time may no longer be appropriate for completing required measurement tasks.

As the industry universally wrestles more each year with measurement personnel turnover, measurement training and competency demonstration are issues that can directly affect LACT Unit operation and performance. The most effective method to address operating and personnel affects on LACT Unit performance is to clearly define and periodically review facility operating procedures, instruments, tools, frequencies, and records.

LACT Units are custom-designed specifically for their specific installation, so to operate, service, or support LACT Unit operation can be a challenge. When one strives to understand the underlying principles, working with LACT Units serves as a continuing learning experience and can be quite rewarding.