DESIGN, OPERATION AND MAINTENANCE OF LACT UNITS

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INTRODUCTION

This paper presents an overview of the design, operation and maintenance of Lease Automatic Custody Transfer (LACT) units. These units are used for the automatic unattended measurement of quantity and quality of crude oil and sometimes other wellhead liquids when transferred from a producer to a pipeline for the account of a purchaser or consignee. This transfer usually takes place at a production lease site, hence, the use of “Lease” in the name. This can be on land or offshore delivering into pipelines, barges, or tanker loading and offloading operations. Similar units used to measure the transfer of other liquids or liquids between pipelines are often called ACT units since they usually are not associated with a crude oil production lease.

LACT units can range from small single meter, low pressure systems with portable proving connections to high-pressure systems with multiple meters and an on-site dedicated meter prover.

Multiple smaller meters in parallel, instead of a single large meter, permit a larger range of permissible flow rates and reduces the prover size. Additionally, if one meter run fails, the LACT Unit can still operate at a somewhat lower capacity.

LACT unit configurations vary considerably, but most units contain the basic equipment described here. More detail can be found in the American Petroleum Institute Manual of Petroleum Measurement Standards (API MPMS) Chapters 5, 6, 7, 8, 9, and 10.

To ensure correct measurement of a petroleum liquid, the Lease Automatic Custody Transfer (LACT) equipment just be properly designed, operated and maintained.

DESIGN

Design considerations typically include product characteristics such as flow rate, viscosity, specific gravity, temperature, operating pressure and water content. Other design considerations include equipment selection for pumps, S&W monitoring, sampling, meters, control valves, meter proving facilities, etc. LACT units are usually designed to ANSI B 31.4 piping code.

Flow rate dictates sizes for pumps, meters and certain ancillary equipment. Low to moderate flow rates may be satisfied with a single meter run. High flow rates may require two or more meter runs in parallel.

LACT units are usually installed on the suction side of shipping pumps to permit use of low-pressure equipment. High-pressure equipment can be very costly. Positive displacement shipping pumps must be fitted with pulsation dampeners to avoid shocking the meter with flow pulsations.

The basic elements of a LACT unit are:

Metering

The heart of the LACT is the meter which measures custody transfer volumes, usually in barrels. Most crude oil LACT units use positive displacement meters, but other types of meters are gaining popularity.

The meter is usually installed downstream of a three-way valve and a property sized thermal relief valve. The meter measures the product stream and allows totalization either through a local totalizer or electronic pulses to a flow computer.

The meter provides signals to a flow computer or PLC (Programmable Logic Controller) to allow:

- . Totalization of Oil Quantity
- Sample Pacing
- . Meter Proving
- . Meter Failure Alarm

Types of Meters

Historically, Positive Displacement (PD) and turbine meters have been the most often used meters in LACT units. Other meters are gaining acceptance, though, as experience and API standards become available. Liquids with higher viscosity usually require PD meters, while liquids with low viscosity can be measured with turbine meters. The manufacturer's recommendations on the type of meter to be used should be followed.

Positive Displacement (PD) Meters

PD meters range in size from 2-inches to 16-inches and in flange ratings from 150# ANSI to 600# ANSI. Flow rates range from 60 to 13,000 barrels per hour. Larger sizes are available but are very costly. For high flow rates, it generally is better to use multiple meters in parallel.

Turbine Meters

Turbine meters range from 1-inch to 24-inches and ANSI ratings from 150# to 2500#. The flow rates range from nine barrels per hour to 57,100 barrels per hour.

Heliflow Meters

Heliflow meters, although new on the market, are gaining acceptance for applications in the mid-viscosity ranges. Flow computers using double chronometry have allowed the Heliflow meters, which have a lower pulse frequency, to be used as custody transfer meters.

Coriolis meters

Coriolis meters feature no moving parts, high turndown ratios, and the ability to measure density as well as throughput. Coriolis meters measure directly in mass, but can measure volume by using the simultaneous internal density measurement.

Meter accessories usually include the following:

1. A readout (register head) which is usually a large numeral counter that (optionally) may be reset to zero at the start of a run, and a small numeral non-resettable counter which is used for custody transfer measurement. The counter may also be fitted with a ticket printer that automatically stamps the ticket with the non-reset reading as the ticket is inserted (opening reading) and the closing reading when the ticket is pulled.

2. A high frequency pulse generator to provide pulses to a high-speed counter during meter proving. Alternatively, the meter stack may include a right angle drive to which a portable photoelectric transmitter may be attached to generate high frequency pulses.

3. A low resolution (low frequency) pulse generator used to operate samplers, meter failure alarms, local or remote meter totalizer, or remote combinator. A combinator is a device that provides the total volume from several meters.

4. Automatic temperature compensation. The common device on positive displacement meters is the ATC or ATG which is a mechanical device that converts measured barrels to equivalent barrels at 60 °F. The ATC has a fixed conversion ratio. The ATG includes a gravity selector that permits the use of different conversion ratios based on different API gravities. Many newer LACT units use electronic compensating totalizers to make the conversion to 60 °F barrels. The electronic units suffer fewer failures than the mechanical units. Another device is the electronic temperature averager. This unit does not make the temperature conversion, but provides an average temperature over the run period. This average temperature is then used by a computerized accounting system to correct measured volumes to equivalent 60 °F volumes. Many flow computers include the ability to directly convert volumes to 60 °F volumes.

Other meter instrumentation, located downstream of the meter may include:

- Temperature transmitter(s) with platinum RTD (Resistance Temperature Device) installed in a S.S. (Stainless Steel) thermowell.
- Pressure transmitter(s) with a pressure gauge mounted with a three-way gauge valve.
  (Temperature and pressure transmitters send live readings to remote locations and/or to a flow computer for temperature compensation.)
- Thermowells installed close to temperature transmitters to facilitate calibration of the temperature transmitter or with a certified glass thermometer

Charge Pump and Motor

A charge pump is used to move liquid from the lease shipping tank through the LACT unit to a shipping pump. The charge pump must be sized to provide the desired flow rate(s) at design pressures for normal operation. Centrifugal pumps are generally selected because they provide smooth flow without pulsations. Gear pumps are sometimes used because they deliver a constant flow rate regardless of pressure, but must be equipped with adequate pressure relief to protect the LACT against over pressure if the unit is inadvertently blocked in. The LACT Unit should have a full flow relief valve upstream of the meter, and small sun-pressure relief valves between block valves.

Special consideration is required when sizing the charge pump, to ensure that adequate NPSH (Net Positive Suction Head) is available to prevent cavitation, and that the discharge pressure is enough to overcome pressure drop through the LACT Unit to allow the required flow and pressure to the pipeline shipping pump inlet.

Strainer/Air Eliminator/Deaerator

Strainer

A strainer should be included on the suction of the charge pump to protect the pump, meter and other equipment in the LACT Unit from grit and debris. The strainer contains a removable basket with a liner made from screen wire or perforated sheet metal. The strainer basket is usually made of carbon steel or stainless steel with 1/8' diameter holes on 3/16" centers. If required, wire mesh for lining the bucket is available in mesh sizes ranging from 20 to 325.

A differential pressure indicator should be installed across the strainer to show pressure drop caused by debris accumulation. If the basket becomes plugged with debris, the liquid pressure may "blow" (i.e., rupture) the basket. The strainer basket should be checked and cleaned periodically.

Air/gas Eliminator

A combination air/gas eliminator is often included downstream of the charge pump to remove entrained air or vapor from the liquid stream. If not removed, air or vapor would be included in the metered volume and would be sold as oil. Also, slugs of air or gas may over spin and damage PD meters.

The air eliminator is a small chamber on top of the strainer and is located at the highest part of the system to allow air to be discharged and not metered. It should be piped with a soft-seated check valve to prevent air from being introduced into the system during shutdown. This type of strainer does not protect the charge pump.

Deaerator

The combination strainer/air eliminator is not a replacement for a Deaerator. The combination strainer/air eliminator may be suitable for removing slugs of air or gas from very light, low viscosity crudes. Heavy viscous crudes often require a separate air/gas eliminator (deaerator) with adequate residence time (typically ten seconds) to permit air and vapors to disengage from the heavy oil. Foamy crudes also require separate air/gas eliminators with longer residence times to provide time for the foam to break. The gas deaerator can be a horizontal or vertical vessel depending on the type of application and space limitations.

S&W Monitor and Divert Valve

LACT units are also equipped with S&W monitors that test the oil for the presence of water. The S&W probes usually are internally coated capacitance type devises installed in a vertical run for continuous monitoring. S&W monitors have a scale graduated in percent units with an adjustable range of 0 to 3% and require an accuracy of 0.1%.

LACT units generally include a vertical piping loop in which are mounted the S&W monitor and the sampler. Preferred orientation for the S&W monitor is vertical flow rising, and for the sampler vertical flow falling.

The S&W monitor, also called "cut monitor" is used to continuously measure the S&W content in the crude oil. If the S&W content exceeds a preset value (usually 1% or less) it signals an alarm and either shuts down the LACT unit or causes a divert valve to stop flow to the meter and diverts the off-spec oil back to a holding tank.

The S&W probe is installed upstream of a three-way divert valve and communicates with the "monitor" unit that is normally installed in the control panel. The "monitor" is wired to the solenoid valves controlling the three-way valves on the bad oil divert line. These will send oil back to treating facilities if a high S&W signal is received for a given time. This arrangement allows oil to continuously flow through the S&W probe so that when a good oil signal (i.e., oil within the allowable S&W range) is received for a set time, the three-way valve will return to the normal flow position and permit good oil to flow through the meter.

The divert valve may also be activated to divert flow on meter failure and/or sampler failure.

The maximum allowable S&W content varies according to individual contracts, pipeline tariffs and general practice in different parts of the country. For example, The Texas Railroad Commission allows up to 2% S&W, but many contracts and pipeline tariffs limit S&W to 1% or less. Some heavy oil regions, notably parts of California, allow up to 3% S&W in pipeline crude oil.

Sampling System

The sampling system consists of a sampler that is used to retrieve a representative sample of the flowing stream and a sample container that is used to store the collected samples over a specified time period, e.g., monthly, biweekly or weekly. The contents of the sample container are used to determine the true representative value of the metered stream during the custody transfer. The representative sample contents will determine composite API Gravity and the total percentage of S&W. It is very important to ensure accurate and representative samples, because API Gravity determines the value of the crude oil, and all S&W must be deducted from the shipment, as it has no value.

Samplers are electrically or pneumatically operated devices that periodically take small representative quantities liquid out of the line.

Sampler location and flow velocity at the sampling point are critical. Modern LACT units usually include a static mixer immediately upstream of the sampler probe. This assures that the liquid stream passing the sample probe is uniform and that each sample "bite" is truly representative of the bulk liquid stream. A minimum linear velocity of 3 feet per second is required for proper static mixer operation. The designer is referred to API MPMS Chapter 8 for more details.

A very common and inexpensive sampler consists of a small pipe or piece of tubing inserted horizontally through the LACT pipe wall, with a beveled end located in the center of the pipe. On the outside of the pipe, the tube is connected to a small solenoid-operated valve which periodically opens for a short time to permit the line pressure to force a small amount of fluid through the tubing and valve into a sample container.

Many modern LACT units are equipped with isokinetic samplers. Isokinetic means that the velocity of the liquid traveling through the probe is essentially the same as in the pipe. Theoretically, this ensures a more representative sample.

Isokinetic samplers also have an additional advantage in that they capture and lock in the sample in a tiny chamber at the end of the probe. Most also forcefully expel the sample to the container and do not rely on line pressure.

The sampler should be paced by the meter to provide a "flow weighted" composite sample. Many older LACT units have samplers that are paced by a timer instead of by the meter. This may be suitable for units that operate at a constant flow rate.

Sample bite size should be set to accumulate the maximum amount of sample allowed by the sample container during a run ticket period. Each bite should be at least one milliliter, and may be up to several milliliters in size. A bite of 1.5 ml is common.

The sample is stored in a sample container. One type of container is the sample pot. This container can be any size and is mounted on the LACT skid. As the sample is collected, it is deposited into the sample container. The vapor-tight sample storage vessel is usually sized to allow one-month storage, but may be sized to hold samples for a day, a week, two weeks or other specified time period. The vessel is provided with a circulation pump or internal mixer. At the end of the specified time, the contents of the sample pot are thoroughly mixed and a portion is drawn off to be checked for composite API Gravity and S&W with equipment in the back of a pickup truck or pumped from the pot into another container (e.g., a tin can or glass bottle) and transported to a laboratory for analysis.

A sample container that is popular for smaller systems is the portable sample container which is a five-gallon steel pressure bottle very similar to a propane bottle. This device is fitted with quick connect fittings so that a full container can be easily removed and replaced with an empty container. The full container may be taken to a remote laboratory for mixing and analysis.

Another type of sample container is the balanced-pressure sample cylinder. Line pressure is maintained on one side of a piston in the sample cylinder by connecting that end of the cylinder to the LACT piping. The other end of the cylinder is connected to the sampler. This way, the sample in the cylinder is always at the same pressure as the liquid in the LACT piping. This type of sample system is most suitable for liquids with light ends that would be lost in a sample pot. The sample cylinder is connected with quick disconnects, so that it can be easily removed and transported to a laboratory.

The sample line from the sampler to the sample container must slope downward to the container, and must not have any high or low points that could trap water.

The sampler must be disabled when the unit is in “bad oil divert mode”.

Total sample collected should be at least 10,000 bites. This means that sample containers usually have a capacity of 5-10 gallons. Containers come in a variety of configurations. Desirable features include:

- Quick opening closure to facilitate inspection and cleaning after each custody transfer.
- Internal coating to prevent corrosion and elliptical bottom to help with rundown and drainage.
- Sight glass or other type indicator to permit visual determination of the amount of collected sample.
- Circulating pump to permit agitation and circulation of the contents. Circulation rate should be 5 gpm or more.
- Spray bar to wash the inside top and sides of the container to help ensure a homogenous mixture through agitation and circulation.
- Pressure gauge to monitor the internal pressure of the container.
- Relief valve set to protect the container from over-pressure.
- A small inline mixer and side tap in the circulating line to permit withdrawing a well-mixed representative sample for testing.
- A means to completely drain and flush the container after withdrawing the test sample.

Meter Proving Provisions

Meters must be proved periodically to ensure accuracy.

A proving manifold includes a full flow inline valve with a bypass valve on each side of it. Opening the bypass valves and closing the inline valve diverts flow from the meter through a prover connected to the bypass valves. The inline valve must be of the “double block and bleed” type (q.v.) so that it can be checked to assure there is no leakage through the valve. An accurate proving can be obtained only if all the oil that goes through the meter also goes through the prover.

The valve configuration is such that flow during normal operation is blocked from the prover connections and flows straight through the inline block and bleed valve to the shipping pump. When it is desired to prove the meter, the two side out valves are opened and the middle block and bleed valve is closed, thus diverting flow through a prover and back to the LACT piping and the shipping pump.

A prover is a device for calibrating (proving) a meter to develop a meter factor that will be applied to the custody transfer measurements from that meter. Most provers in use today are “pipe provers” of the unidirectional, bi-directional or small volume type. Large installations, particularly those using several meters, may have a permanent prover installed as part of the LACT skid. Smaller LACT units, particularly those located in remote leases, use portable provers which are mounted on trailers or trucks to be taken periodically to the LACT sites for meter proving. In either type of installation appropriate valving and prover connections are required to ensure meter proving in accordance with API Manual of Measurement Standards Chapter 4.

Offshore LACT units are often equipped with permanent dedicated provers. The bi-directional pipe prover is often the prover of choice because of the versatility of configuring a bi-directional prover in tight offshore spaces. The prover pipe may be set on a separate skid or wrapped round the periphery of the LACT skid

Meter prover design and operation is beyond the scope of this paper. Refer to API MPMS Chapter 4.

Prover Instrumentation

When a stationary dedicated prover is included with a LACT unit, the following instrumentation is required on the outlet of the prover:

- Temperature transmitter with platinum RTD installed in a S.S. thermowell.
- Pressure transmitter with a pressure gauge mounted with a three-way gauge valve.
- Test S.S. thermowell used to calibrate the temperature transmitter.
- Thermal relief valve properly sized.

Block and Bleed Valves

Block and bleed valves are used when it is necessary to know positively that no liquid is passing through a closed valve. The valve shuts off both the inlet and outlet of the valve. The valve body cavity between the inlet and outlet can then be drained to verify that no liquid is passing from the inlet to the outlet.

The meter prover inline block valve must be double block and bleed. Any bypass lines around the meter must also be double block and bleed. In multiple meter assemblies, double block and bleed isolation valves must be installed at each meter to ensure that the prover measures flow from only one meter at a time.

Back Pressure Valve

Downstream of the prover manifold will usually be either a backpressure controller or a flow controller to maintain pressure above the vapor pressure of the fluid being metered and to ensure steady flow conditions through the meter.

When it is essential to maintain a constant pressure on the meter for maximum accuracy, the pressure sensing port of the back pressure valve may be piped to a tap on the line between the meter and the prover connections. This way the pressure at the meter will not be changed when the prover is turned into the flowing stream.

Check Valves

A check valve is usually located at the outlet of the skid to prevent backflow through the meter train from other connections on the pipeline when the meter train is not running.

LACT Control Panel

A local explosion proof control panel should include:

- Start and Stop, Off Switches
- High and Low Level alarms
- Hand-Off-Automatic Switch
- Pump status, e.g., on off, low suction
- Meter failure alarm
- Low or no flow alarm
- Sampler failure alarm
- S&W status, i.e., good or bad oil
- S&W Divert Controls
- Monitor failure alarm
- Meter operating pressure
- Meter operating temperature
- Flow rate of (each) meter
- Meter select Switch
- Strainer high differential pressure
- Internal Battery Back-up for Power Loss

Any of these indicators may be used for automatic proving or telemetered to a central location for remote proving.

Control panels for LACT units, which include stationery provers, may also include:

- Proving counter
- 4-Way valve position
- Seal indication of 4-way valve
- Seal indication of prover manifold valves
- Prover operating pressure
- Prover operating temperature

At remote locations, the control panel may be located off the skid, but nearby, or on the skid and may provide for manual proving, in which case the panel should include electrical connections for a prover counter, detector switch plug in, power for the counter, and a portable pulse generator for PD meters.
If located in a MCC room (Motor Control Center), the panel may be equipped with a PLC (Programmable Logic Controller), flow computer, and printer to allow for automatic proving and batch reports by pushing a button, provided the prover's four-way valve is equipped with a remote actuator, and pressure and temperature transmitters are installed on the LACT unit for readout in the MCC.

Densitometer

Densitometers (usually of the vibrating tube type) are devices that directly measure the density of a liquid as it flows through the system. Densitometers are not commonly used on crude oil LACT units, but often are required on light hydrocarbon LACT units. A densitometer measures the actual density of the liquid at the temperature and pressure in the unit. This density must be converted to equivalent 60-degree API gravity.

The density on a LACT Unit is normally taken on a slipstream across a pressure drop. The densitometer liquid direction of flow is always downward to keep the vibrating tube free of debris. The densitometer can be mounted vertically or at a 45° angle.

The densitometer is checked with a device called a Pycnometer, which is a sphere of precisely known volume and is connected periodically to be filled with liquid and weighed. The weight of the liquid in the sphere is used with the pycnometer volume to calculate a density, which is then compared with the reading of the densitometer.

General Considerations

Many factors go into the design of LACT units, including flow rates, space limitations, temperature, viscosity, corrosion, and customer specifications.

The temperature of the measured liquid will determine the special components required on the LACT Unit. If the temperature is high, special seals will be needed on many of the components such as the meter, sampler, water monitor, valves, pumps, etc. If the temperature of the measured liquid is very low, special alloy materials may be needed for components and piping. NACE (National Association of Corrosion Engineers) trim may be required for corrosive conditions.

Other important general design practices include:

Space

Units can be built in any number of configurations and footprints, but configuration must not limit serviceability of the various pieces of equipment. Space can be a main consideration if the unit is for an offshore platform. Adequate space must be provided for repair or removal of the various components. Consult manufacturers' literature to determine the recommended distances required to remove or repair the various components.

Viscosity

High Viscosity can cause several problems.

- PD meters may require high viscosity clearances and high temperature trim on units above 150° F
- If heat traced and insulated, the instrumentation may require special trim.
- Prover sphere material must be suitable for operating temperatures.

Pressure

The maximum possible pressure of the liquid in the LACT Unit will determine the wall thickness of the pipe, the ANSI rating of the flanges and the pressure rating of the various other components. Although many LACT Units are built with 150# ANIS flanges and components, it is not uncommon to see pressures requiring 300# and 600# ANSI ratings. The cost of the entire uni goes up when 300# or 600# ANSI flanged components are used.

Valves and Flanges

Welded valves should not be used. Although cheaper initially, they inhibit maintenance.

Raised face weld neck forged steel flanges are used on must LACT Units and provers. These flanges allow for easy maintenance of LACT components, and provide tight, leak free connections.

Valve Operators

Electric of pneumatic operators are sometimes used on valves, either for remote operation or because the valves are too difficult to operate by hand. If an electric or pneumatic operator is used, valve-position switches should be installed to send signals back to the control cabinet to indicate the position of the valve.

Vents and Drains

Adequate drains and vents must be provided so that the operator can drain the unit to operate or repair a failed component. This requires drain valves installed between each set of block or isolation valves, and vents at high points of LACT Unit piping and on strainers to release air and gas that could become trapped in the high points.

Thermal Relief Valves

Thermal relief valves are used when it is possible for pressure to build up due to heat from direct sunlight (sun pressure) or high ambient temperatures and, thereby, damage equipment between two shutoff points. Thermal relief valves are small and are sized to relieve pressure due to thermal expansion only. Thermal relief valves are not designed to relieve the total flow of the LACT.

Fabricated Skid

Fabricated structural steel skids are used to mount the LACT components. Structural steel skids should be provided with lifting lugs to allow the assembly to be moved easily. Either steel or composition grating can be installed to cover the skid for walkways. Checkered steel plate can also be used to cover the skid. Drip pans can be provided to rout any leaks to drains.

Drain System

A LACT Unit should have a drain system that allows liquid from each component that has a drain fitting to be taken to a common drain and drip collection point. This is usually done with an open drain system. If a closed drain system is required for safety or environmental reasons, sight glasses or other devices must be installed at appropriate points to ensure that no liquid is lost during normal operation downstream of the meter.

Protective Coating (Paint)

All exposed steel surfaces are normally sandblasted to "white metal" followed by a painting system suitable for the service the equipment will experience.

Transmitters and Gauges

Temperature transmitters and gauges are placed in thermowells that extend into the center third of the pipe. Pressure transmitters and gauges should have a valving arrangement that will allow the pressure devices to be checked and calibrated while mounted on the piping.

Electrical

All electrical equipment must be installed in accordance with applicable codes. This often means fully explosion proof.

The classification of areas for electrical installations for LACT Units and other production equipment is given in API RP 500B which gives the National Electric Code (NEC) electrical classification for oil field equipment.

The three NEC areas of classification are:

Unclassified – Areas where no danger of explosive gases occur.

Class 1 Division 2 – Areas where explosive gases could occur during maintenance but are not usually in the area during normal operation.

Class 1 Division 1 – Areas where explosive gases are present or can be present at any time.

The equipment requirements for each of these classifications are discussed in the NEC and API 500B.

Environmental and Personnel Protection

Offshore and other hostile environments may require protection against atmospheric corrosion and provision for washing down the unit.

Thermal insulation is required to protect personnel from surface temperatures that may exceed 140 °F.

The location of the LACT Unit will determine the need for heat tracing, insulation, protective coating, and if the LACT Unit will need to be placed in a building for protection from the elements. It is common for LACT Units to be placed inside buildings where ambient temperatures are either extremely hot or extremely cold.

Sealing

Any device that affects the quality or quantity of measurement must have a means of security sealing. This would include the S&W Monitor, Sample Probe, Sample Container Valves and Components, Meter and Meter Accessories, Prover Valves, Back Pressure Valves and LACT Control Panel. Some frequently operated items, such as valves, may be more conveniently secured with chains and padlocks.

OPERATION

Initial Startup

Initial startup requires special considerations. Before introducing flow into the unit, conduct all the equipment checks listed under "Maintenance."

Before initial operation of a new LACT unit, verify the operating voltage to the electric motor, verify the rotation of the pump, and verify the alignment of the coupling between the motor and the pump.

Remove the internals from the meter(s). Construction debris and grit in the piping can severely damage meters, and large slugs of air can over speed meters and result in damage. It is good practice to replace the strainer basket with a heavier courser mesh construction basket, as welding slag, rust and other debris are almost always present in new construction.

Bypass the prover so that initial flow does not carry damaging material into the prover.

1. On initial startup, before any liquid is directed to the LACT Unit, all pumps should be off and all valves should be closed.

2. Turn on the power to the LACT. All equipment not needing power at this point should be left off.

3. If the LACT is equipped with a pump, flood the pump slowly with liquid. Vent any air trapped in the pump with the valve provided at its high point.

4. Open all vent valves on the LACT and slowly open the inlet valve and other valves that direct liquid to the meter and other equipment (except the

prover). Discharge valves should remain closed at this point.

5. Allow the LACT to fill with liquid while checking for leaks and releasing air to drain or atmosphere. Filling the equipment slowly protects the equipment from surges, and prevents large amounts of liquid from being spilled if there are any leaks. Close each vent and drain valve when liquid only is present at the valve.

6. Start pumping liquid into the system at a low rate (use pump bypass or throttling valve) and gradually increase to design flow rate monitoring all pressures and moving parts. Watch the pressure drop across the strainer to avoid plugging. Flow liquid through the unit for 20-30 minutes to thoroughly flush the system.

7. After flushing is complete, reinstall the meter internals and the regular strainer basket. Slowly fill the system with liquid, venting all air thorough the high point vents. Line up the valves for normal operation and turn the control panel to "Automatic."

8. Start the jump and slowly open the discharge valves and set the backpressure. As a rule of thumb, the backpressure should be at least 20 psi greater than the vapor pressure of the liquid being measured. Check the meter to be sure it is registering.

9. Observe the sample system to be sure it is taking sample bites at the proper intervals. Verify sample bite size either by allowing the sampler to expel liquid through a bleed valve into calibrated glassware or by measuring the total sample collected in the sample container and comparing with the total number of bites taken during the test.

10. Increase the volume to the desired flow rate, set the pressure control and/or flow control valves, and open the inlet and outlet block valves to full open.

11. Check all remaining components for proper operation.

12. Do a manual calculation on the volume and flow totals to ensure the mechanical and flow computers are working properly.

13. Reduce flow rate, open vents on the prover, and slowly direct flow to the prover by opening the prover valves and slowly closing the block and bleed valve in the proving manifold. When all air has been vented from the prover, close the vent valves. Increase flow rate to normal and flush the prover for about 20 minutes. Then run the ball a few times to make sure the ball will run properly and smoothly. Verify that the detector switches are working and that pulses are being accumulated in the proving counter.

14. Make a "count check" to verify that the meter is putting out the correct number of counts per barrel. Disconnect (or bypass) the detector switches from the proving counter, and temporarily install a manual switch that can be used to start and stop the counter. Watch the meter register head (or totalizer). When the meter reading is a convenient number, e.g., xx00.0, start the counter with the manual switch. After enough liquid has run through the meter to accumulate at least 10,000 counts on the proving counter, use the manual switch to stop the counter as the meter register turns a convenient number, e.g., 10 or 20 barrels more than the starting register reading. Note the readings on the meter register as precisely as possible at the time of starting and stopping the proving counter. Divide the total number of counts on the proving counter by the number of barrels passed between the start and stop. The result is the number of pulses per barrel. Do this three times and average the results. If the meter is automatically temperature compensated, then a temperature correction needs to be made to the counts per barrel. (With a little practice, one can become quite accurate with this exercise.)

15. Prove the meter. The frequency of proving will be determined by the use of the LACT Unit. For batch operations the usual practice is to prove at the beginning of the batch, in the middle of the batch, and again toward the end of the run. For continuous operation each meter should be proved at a minimum of once per day for the first 30 days to develop meter characteristics. After the first month the interval can be changed to weekly or monthly if the meter repeats continuously. These are guidelines only. Refer to API MPMS Chapter 4 for additional suggestions. It is also good practice to reprove meters whenever flow rate, temperature, pressure or density changes more than 10% in either direction for more than 10 minutes.

16. All calculations should be checked at regular intervals to ensure no errors have been introduced into the flow computer or PLC

17. All equipment, S&W monitors, temperature transmitters, pressure transmitters, etc. should be checked monthly. Follow the manufacturer's instructions for calibration.

18. Calibration of prover (water draw) – The prover should have a water draw (a check of the volume between the detector switches) before it is put into service on site. Even though the prover probably was calibrated by the water draw method at the factory, the prover piping could have been damaged, loosened or misaligned during transportation, or the detector switches could have been reset. After the first water draw on-site, the prover should be checked for volume according to the guidelines in the API MPMS. If any part of the prover is disassembled between the detector switches or there is a change in the position of the sphere detection switches, a water draw should be performed.

Normal Operation Checks

Normal operation should include the following periodic checks:

- Periodic maintenance and lubrication
- Verification of meter operation
- Verification of ATG, ATC, Totalizer, or Flow Computer operation
- Verification of sampler operation
- Verification of S&W monitor operation
- Calibrate S&W monitor and temperature averager following manufacturer's instructions.
- Meter Proving
- Verification of alarms, shutdown features, and divert valve action
- Check strainer for plugging or damage
- Check meter transmitters
- Check backpressure valve or flow controller.
- Check the divert valve by simulating bad oil to be sure it will divert on bad oil.
- Check meter failure switch. This can be done by blocking the flow causing a signal to be sent to the unit telling it to shut down.
- Check high and low levels on the shipping tank(s) to ensure they are set for proper starting and stopping of the LACT unit.

If using a Coriolis meter, Zero the meter in accordance with manufactures recommendation when first installed and anytime that piping changes are made or meter orientation is changed. It is not necessary to Zero a Coriolis meter every time it is proved.

MAINTENANCE

Regular maintenance can greatly increase the life and accuracy of the measurement equipment. Follow manufacturer recommendations along with the following guidelines:

- Periodic (typically, monthly) inspection and lubrication of meter packing gland(s), gear train, stack accessories and the ATC or ATG
- Inspect gear train for adequate lubrication, binding and wear. Lubricate gears per manufacturer's recommendations. Replace worn gears
- Check meter for abnormal noises. If noise is excessive, open and repair as necessary, then prove meter
- Check for leaks at all packing glands, seals and flanges
- Check registration of the counter for intermittent or pulsating movement. This could indicate damage in the gear train.
- Periodically inspect and lubricate accessories or stack components, e.g., transmitters, counter, right angle drives, etc.
- Inspect and lubricate ATC calibrator with light household oil. Heavy weight oils tend to stay in the opening of the oiler and not move through the tube to the calibrator.
- Check operation of ATG, especially if ambient temperature remains at fairly constant temperature for long periods of time. The roller and disk assembly have a tendency to wear a groove on the disk, and the unit may not respond properly when the temperature does change.
- Check ATC and ATG bulb and bellows according to manufacturer instructions.
- Check and calibrate, if necessary, all temperature and pressure transmitters.

Automatic temperature correction devices can be tested by the following procedure:

1. Stabilize the system, then make 5 normal proving runs, average the counts, and record the average temperature of the 5 runs.
2. Remove the product temperature-sensing device (bellows, bulb, sensor, etc.) from the thermowell, but do not remove from the unit. Seal the thermowell with a blank plate or plug. Immerse the sensing element in a thermos bottle with water 10 to 20 degrees different than the average temperature observed in the first 5 proving runs. Place a precision thermometer (accurate to 0.10 °F) in the thermos to measure the temperature of the water.
3. Stabilize the system by allowing product to flow through the LACT long enough for the

temperature correction device to adjust to the new temperature. Make 5 proving runs and average the counts. Record the temperature of the water in the thermos.

4. Divide the larger number of proving counts by the lower number of counts obtained in steps (1) and (3). Subtract 1.0000 from the result. Example: 10,050/10,000 – 1.0000 = 0.005.
5. Determine the difference in temperature between the two provings. Example, 80 °F - 60 °F = 20.
6. Divide the result of step (4) by the result of step (5). This represents the thermal coefficient that the temperature correction device used. Example: 0.005/20 = 0.00025.
7. Compare this with the actual thermal coefficient for the API gravity of the oil in the LACT unit.

Inspect strainers periodically. First, check the flow rate, the operating pressure, and for any leaks. Any changes in flow rate or operating pressure may indicate that the strainer is filling with debris. Leakage may be observed at the flange or cover gaskets, the drain valve and the differential pressure indicator. Abnormal differential pressure indicates plugging of the basket. Inspection of a strainer upon opening should include inspection of the strainer basket for holes, tears or a blow out. If the basket is damaged, it should be replaced. The screen should be cleaned of all foreign matter.

Valve maintenance should include inspection for leakage at the bonnet, and the block and bleed indicator if present. If the valve has an external grease fitting, lubricate with the manufacturer's recommended product. Check the operation of all valves and valve operators. Check for excessive resistance to turning manually or any change in the sound during operation of a motor operator.

Upon opening a valve, check the seals and seats for any excessive wear or damage. Replace O-rings after opening. Inspect the shaft and trunnion for wear. Trunnion-mounted valves are especially susceptible to accumulation of trash in the lower trunnion mount and, thus, subject to wear.

Check pump(s) for pressure output, excessive vibration, and loose or broken bolts.

Inspect pump(s) for leaks. Check the stuffing box or mechanical seal for leaks. If a stuffing box is leaking excessively, tighten the packing until the leakage is reduced to a weep. Stuffing boxes are designed for some weeping as a form of lubrication. Experience will tell how much leakage is adequate and how much is excessive. If tightening the packing gland that is leaking excessively does not reduce leakage, the stuffing will need to be replaced. A mechanical seal that leaks excessively should be replaced.

Pumping capacity may be checked by the pressure output with the flow rate.

Calibrate the S&W monitor per manufacturer's specifications. Check operation of the S&W monitor by simulating a bad oil signal and verify the cycling of the three-way divert valve and all applicable alarms.

Check samplers to verify that they are stroking and that sample is delivered to the sample container. This may be done by watching the level rise in the sight glass on the container, or by breaking the connection between the sampler and sample line to visually detect oil being expelled by the sampler. It is not adequate to simply check the electrical signal from the meter to the sampler controller. The sampler may be plugged or leaking. This would not be revealed by an electrical check.

Check all transmitters. The output of a high frequency transmitter, e.g., 1,000 pulses per barrel, may be verified by connecting the proving counter in a test mode. It should output 1,000 ±1 pulse. If not, verify operation and especially the integrity and cleanliness of the optical disk. Temperature and pressure transmitters should be checked and calibrated in accordance with manufacturer's recommendations.

Ensure all instruments on the LACT and prover are calibrated properly. All instruments and equipment used to do the calibration on the LACT and prover should have been recently calibrated to a standard and should be in like-new condition.

Check to make sure all the mechanical equipment operates properly, the 4-way valve on the prover seats properly, the block and bleed valves do block and bleed, etc.

Check the system for leaks, especially leaks to drain. Although a properly designed LACT and prover system requires all drains after the meter to be able to be visually inspected, some systems may have hidden sources of leaks. Check prover drain valves to be sure they are not leaking.

When proving, the proper flowing conditions must be maintained throughout the proving operation. No drastic changes in flow rate, temperature or pressure should occur.

A proving must be made at the same flow rate as the meter flow rate under normal operating conditions.

Always double-check any component suspected of malfunction. For example, if while proving a meter, the prover ball is suspected of not being properly inflated, check another meter, if possible, to see if the condition exists there also. Many times in a hunt to find the problem other equipment is changed so that even if one problem is found, the original problem can still exist. The best tool for good maintenance is an accurate and complete log of all shipping and proving documents. This log plotted on a graph will quickly show developing problems and help pinpoint them.

Troubleshooting a LACT

Make sure all instruments on the LACT and prover are calibrated properly. All instruments and equipment used to do the calibration should have been recently calibrated to a standard and should be in like-new condition.

If proving repeatability cannot be achieved, the problem could be trapped air or gas. This is the most common prover problem, and is solved by opening all high point vents until all air or gas is eliminated. While opening the vents, move the prover ball in each direction to ensure all the air is eliminated. Air or gas in a prover may cause the ball to jerk as it moves through the prover. The jerking action is caused by the air compressing and then expanding forcing the ball to move forward at an accelerated rate.

If temperature changes more than one degree during proving and electronic compensation is not used, the volume will change enough to invalidate the prove. Temperature affects the metal wall of the prover and the liquid in the prover and in the meter.

If pressure changes during the prove and electronic compensation is not used, the volume may change enough to invalidate the prove. Pressure affects the metal wall of the prover and the liquid in the prover and in the meter. Although pressure change is not as critical as temperature change, it may affect the proving.

CONCLUSION

This paper covers the basics of LACT units and should serve as a guideline for those learning about LACT units. It may also serve as a checklist for those who are actively engaged in design, operation and maintenance of LACT units. More information is in the API Manual of Petroleum Measurement Standards.

LACT Units are precision pieces of equipment and must be treated as such. Improvements and new developments in electronic equipment and in measurement technology tend to make LACT units more reliable and more accurate while requiring less maintenance. However, the measurement technician needs to be more highly trained than ever before to understand and work with the equipment and instrumentation used in modern LACT Units.

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