



Hiland Crude, LLC
a Kinder Morgan company

**Engineering Design LACT & Pipeline
Measurement Rev 1.5**

Rev. 9/16/16



Engineering Design LACT & P/L Measurement

Purpose

This manual is prepared as a guide for the design and installation of lease automatic custody transfer (LACT) and pipeline measurement systems. Hiland Crude must approve all designs prior to the fabrication and installation of all facilities. The customer is responsible to submittal of all drawings and plans in regards to interconnecting facilities with Hiland Crude. All statements within the manual are in compliance with API standards and if a subject is not covered in this manual the API standard will apply at a minimum. Company is define in this document as Hiland Crude LLC.

Requirements for LACT and Pipeline Metering Systems

A LACT system is an arrangement of equipment designed for the unattended custody transfer of liquid hydrocarbons from producing leases to the transporting carrier. The system must determine indicated volume (IV), Gross Standard Volume (GSV), Net Standard Volume (NSV), and quality. It should also provide for safe and tamperproof operation, and meet requirements of accuracy and dependability agreed to by mutually concerned parties including any regulatory agencies affected.

Pipeline measurement systems are defined as a metering station on a pipeline system where custody transfer measurement takes place through one or more meters. A pipeline measurement system is designed to obtain the optimum measurement accuracy for custody transfers.

The accuracy of both systems depend on the primary measurement devices (meters), secondary measurement devices (transmitters), provers, valves, and other equipment selected for the measurement system.

All measurement system designs will take into account the following:

1. The installation will be capable of satisfying the required performance characteristics for the application between the minimum and maximum flow rates, at the maximum operating pressure, and over the temperature range and liquid types to be measured. If necessary, the design should include protective devices that keep the operation of the meter within the design limits specified by the manufacturer.
2. The installation will ensure a maximum operating life. Strainers, filters, air/vapor eliminators, or other protective devices will be provided upstream of the meter to remove solids, and gases that could cause meter damage, premature meter wear, and measurement error.
3. The design and installation will also have the ability to maintain adequate pressure on the liquid in the system at all temperatures to ensure that the fluid being measured will remain in a liquid state at all times.
4. Any Company metering installation will provide for the proving of each meter, whether it be by fixed or portable prover, and should be capable of duplicating operating conditions at the time of proving.



Engineering Design LACT & P/L Measurement

5. The installation will ensure, where necessary, appropriate flow conditioning both upstream and downstream of the meter or meters are included.
6. The installation will comply with all applicable regulations and codes.
7. The installation will also ensure that temperature and pressure measurements will be made using approved temperature and pressure transmitters (See Appendix A). These temperature and pressure transmitters will be wired using a 4-20 mA loop to a Company approved Electronic Flow Measurement Device in order to maintain a flow weighted corrected volume.

Primary Measurement Devices

The Company allows meters for LACT unit and pipeline custody transfer measurement to be one of three different types:

1. Displacement
2. Coriolis
3. Turbine

The three meters above in addition to Ultrasonic Meters may be used in situations of allocation or segment balance measurement is required.

Guidelines for Meter Selection

Displacement, Coriolis, and turbine meters are the Company's decided metering types. In many situations one type of meter is preferred. In most cases any one of these meters is satisfactory. Factors such as pressure, temperature, viscosity, flow range, and contamination will be considered.

Because Coriolis meters are less affected by contaminants, they are often chosen over the other two types of primary measurement devices.



Engineering Design LACT & P/L Measurement

Figure 1 depicts guidelines for selecting a displacement and turbine meter utilizing viscosity and flow rate.

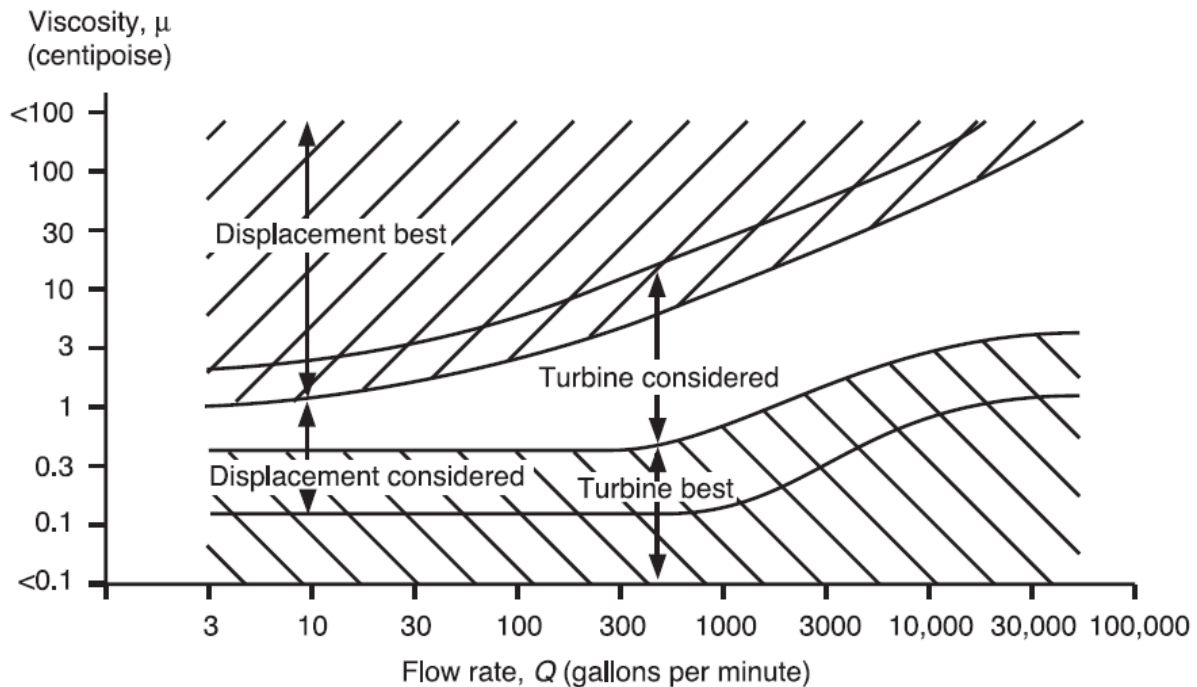


Figure 1—Selection Guide for Displacement and Turbine Meters

Displacement meters have the following relative strengths:

1. Capable of measuring viscous liquids.
2. Ability to register a near zero flow rate.
3. Simple design and operation.
4. Flow conditioning not required.
5. Less back pressure required.

Displacement meters have the following relative weaknesses:

1. Susceptibility to damage by flow surges, gas slugging, corrosion, and erosion.
2. Severe reduction in flow if meter is jammed.
3. Increased maintenance requirements.
4. Sensitive to viscosity changes in low viscous fluids.

Turbine meters have the following relative strengths:

1. Wide flow range for viscous fluids.
2. Small size and weight.
3. Long-bearing life
4. Wide temperature and pressure range



Engineering Design LACT & P/L Measurement

Turbine meters have the following relative weaknesses:

1. Flow conditioning required.
2. Need for back pressure control to prevent flashing, cavitation, and error.
3. Difficulty in measuring high viscosity fluids.
4. Susceptible to fouling or deposits.
5. Sensitive to viscosity changes at higher viscosities.
6. Susceptible to damage by gas slugging or flow surges.

Coriolis meters have the following relative strengths:

1. Low maintenance – minimally affected by abrasive and corrosive substances
2. Not susceptible to damage by gas slugging.
3. Capable of registering a near zero flow rate.
4. Minimally affected by viscosity changes.
5. Direct mass and density measurements.
6. Flow conditioning is not required.

Coriolis meters have the following relative weaknesses:

1. Sensitive to installation conditions, including shock and vibration.
2. Accumulation of internal deposits can affect accuracy.
3. Meter requires periodic re-zeroing under pressure with zero flow.
4. Requires back pressure control.
5. High pressure drop.

Static Mixers

A Static Mixer with design considerations for viscosity, flow rate and pressure drop will be installed upstream of the BS&W monitor.

Settling Requirements

Crude oil settling requirement as specified in the tariff will be considered to have been met for installations utilizing LACT units if the following tank configuration is used and vapor emission repression is not used.

All production is introduced to a single production tank and equalized into one or more additional storage tanks using high tank equalizer lines. Product is transferred from these tanks to a single sales tank by way of a fill line connecting the sales tank to one storage tank, this line to be 12" to 18" above the bottom of the tank. The LACT will start and stop on levels in the sales tank, with a stop 3 feet higher than the top of the sales tank fill line and a start no lower than 8' above the stop level. Kinder Morgan will consider other configurations at the producer's request.



Engineering Design LACT & P/L Measurement

Operational Requirements

The following requirements are subject to change in the case local operations determines there isn't a need for them.

The LACT unit shall start in divert mode on intermediate level and then a divert shall close to ship merchantable oil. Stop charge and delivery pump on low delivery tank level and hold until tank returns to intermediate level. A manual override must be provided to start pumps between levels. A product divert will be enabled when power failures occur. Provide meter failure or low flow detection circuit using meter pulse transmitter from top of meter head to shut-in system if rate drops below a pre-set minimum. The detection circuit must lockout delivery if the meter pulse contacts stop in either the open or closed position. Provision shall be made to remove power from timer (if used) so that timer can be manually reset without damage. The following will be provided to Hiland: Tank levels, E-Transmitter pulses, LACT fail alarm, LACT status, LACT divert and other information as may be requested by Hiland.

Signal Interfaces

Minimum hardwired signal requirements include:

LACT Enable / Disable (from Hiland)

LACT Status (to Hiland)

Other signals deemed necessary by Hiland for operations.

Meter Installation

Meters will be installed according to the manufacturer's instructions and will not be subjected to piping strain and vibration beyond their recommended limits. Flow conditioning is required for all turbine meters, but is not required for displacement meters and Coriolis meters. In cold climates it is necessary to install a heated shelter over the meter to protect the meter, secondary measurement devices, and any of the electronics associated with them.

BS&W Monitoring

A BS&W monitor will be required at every meter inlet unless waived by Company management. This monitor will be attached to a flow computer or PLC which will automatically cause the flow to divert before it is delivered into the pipeline system. The monitor will be installed upstream of the meter. All BS&W monitors will be installed upstream of the static mixer and in compliance with the manufacturer's recommendations.



Engineering Design LACT & P/L Measurement

Charge Pumps

Centrifugal pumps (gear pumps are not allowed) and TEFC motors will be installed upstream of the meter run unless it is determined that the upstream pressure is sufficient enough to flow into the pipeline system and maintain a sufficient enough backpressure for the meter to operate correctly. They will be completely mounted in a common base with a coupling, and coupling guard.

Valves

If a bypass around a meter or battery of meters is permitted, it will be provided with a blind or positive shutoff double block and bleed valve with a telltale bleed. Valves in a meter installation that divert, control, or block flow during a meter proving will be capable of smooth opening and closing. The critical valves will have a leak-proof shutoff with a second method of checking for leakage. A three way divert valve, capable of being sealed, with a hydraulic actuator, positioned downstream of the BS&W monitor and will also be normally closed to the meter when zero actuation energy is applied.

All valves installed on the measurement station will be designed so that they will not admit air when they are subjected to vacuum conditions. Valves for intermittent flow control will be fast acting and shock free to minimize the adverse effects of starting and stopping liquid movement. A check valve to restrict reverse flow will be installed at all custody transfer facilities downstream of the meter and prover connections. Any flow limiting or backpressure control valve will be installed downstream of the meter and prover loop or connections and be of a fail-safe design. The device will be selected or adjusted to prevent vaporization.

Piping Installation

Meters are normally installed in a horizontal position. The Company will allow for Coriolis meters to be installed in a vertical position in order to prevent the settling of contaminants within the meter. Each meter will have different upstream and downstream minimum pipe length requirements for flow conditioning which will be covered in the requirements specific to the individual meter later in this standard.

Where the flow range or pressure drop is too great for any one meter, where shutting down the metering system is impractical, or where frequent service is needed, a bank of meters will be installed in parallel. A means of balancing flow through the meters will be provided.

Meters will be adequately protected from pressure pulsations, excessive flow surges and pressure caused by thermal expansion of the liquid. Relief valves will not be installed between the meter and prover loop piping.

Each meter will be installed as to prevent air or vapor from passing through it. This is achieved by air/vapor elimination equipment being installed as close as possible to the



Engineering Design LACT & P/L Measurement

upstream side of the meter run. The vent lines will be of adequate size, and the safety of the venting system should be given special design consideration. A check valve will be installed in the vent line in order to prevent air from being drawn back into the system.

The piping will not have any unvented high points or pockets where air or vapor may be trapped and carried into the meter by the added turbulence from increased flow rate. Lines from the meter to the prover will also be installed to prevent the possibility of air or vapor from being trapped. Manual bleed valves will be installed at high points to allow air to bleed off, when necessary, before proving. The distance between the meter and the prover will be minimized. The diameter of the connecting lines will be large enough to prevent a significant decrease in flow rate during proving. In multi-meter stations throttling/flow control valves will be installed to regulate flow through the prover while each meter is being proved.

Piping will be designed to prevent the loss or gain of liquid between the meter and the prover.

For meters that are designed to flow in a single direction only, provisions will be made to prevent flow in the opposite direction by check valve installation.

Secondary Measurement Devices

Temperature measurement will only be accomplished by a temperature transmitter wired to a flow computer. The transmitter will be mounted immediately downstream of all meter types. A test thermowell will be provided immediately downstream of each temperature transmitter to verify that the stream temperature is within Company standards for temperature deviation in comparison to a certified thermometer. All thermowells will be situated as to measure the flowing stream in the center third of the pipe.

A pressure transmitter of suitable range approved by the Company (See Appendix A) will be installed immediately downstream of every test thermowell and wired to an Electronic Flow Measurement Device utilizing a 4-20 mA signal in order accurately correct the pressure back to standard conditions. A manifold with the ability to isolate the flowing stream from the pressure transmitter, and vent the transmitter to atmosphere will be mounted to the transmitter and meter run.

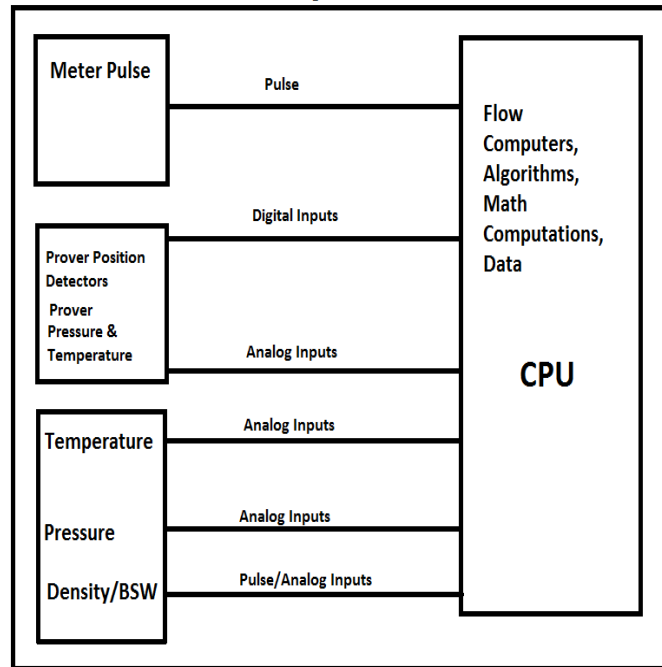
Electronic Flow Measurement

All measurement facilities designed and installed by the Company will include a Company approved flow computer (See Appendix A). Figure 2 shows a typical Electronic Flow Measurement system.



Engineering Design LACT & P/L Measurement

Figure 2 EFM



Power Requirements

All flow computers must be powered with a continuous and reliable power source that is adequate for proper operation. **A power back up system will be installed in order to maintain a continuous one hour of operation in the event of a main power failure.** All cabling will be approved for the class of service and installed in accordance with the NEC or similar applicable electrical agency requirements. Signal cabling will be properly protected from environmental elements and shielded from outside electrical interference. Signal interference should be minimized by providing proper electrical isolation between AC power and signal wires at all times. Electrical isolation may be achieved by using specially designed wire or by routing power cables and signal cables in different conduits.

Proving Facilities

Facilities or connections must be provided for proving the meter under conditions as close to normal as possible. Metering systems will be provided with either manual or automatic means to permit proving the meter under conditions of flow rate, pressure, temperature, and fluid characteristics that exist during the normal operation of the meter. It is required that the meter and prover be paired based on flow rate, temperature, pressure, and fluid characteristics during the design of the station if a fixed prover is being installed at the metering station. Only Company approved provers will be purchased and installed where a fixed prover is deemed necessary by Company management (See Appendix A).



Engineering Design LACT & P/L Measurement

Connections for proving will be installed so air or vapor is not trapped in the piping between the meter and the prover. Adequate bleed-off connections should be provided. The flow sensor/meter will always be installed upstream of the proving connection.

A block-and-bleed valve will be installed between the prover inlet and prover outlet connections on the downstream side of the meter run that will allow fluid to flow through the meter and prover successfully, and simultaneously.

Turbine Meter Requirements

Turbine meters perform better with increased size, therefore, turbine meters smaller than 6" will not be allowed in any transfer of product.

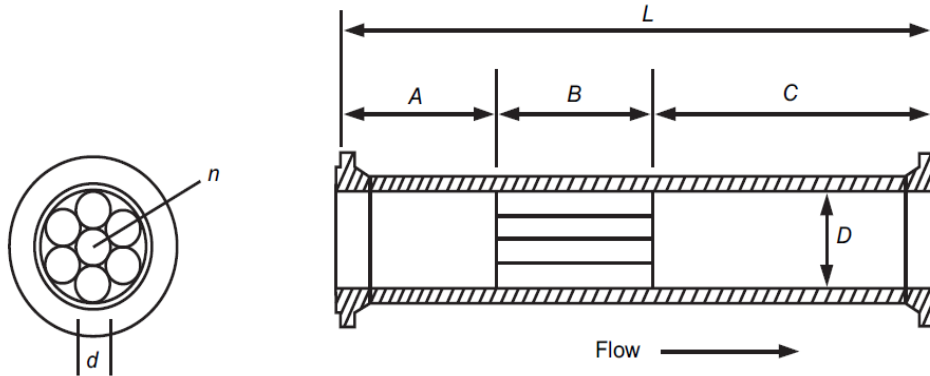
Strainers are a requirement when measuring with a turbine meter and will be installed upstream of the meter and straightening elements as to not have a negative effect on the velocity flow profile of the meter. Strainers used in crude oil service will be equipped with a coarse basket (usually four mesh is sufficient). A differential pressure transmitter will also be installed in order to monitor the health of the strainer to prevent strainer from failing allowing the operator to perform required maintenance upon alarm.

Flow conditioning will be used for all turbine meter installations to overcome the adverse effects of swirl and non-uniform velocity profiles on turbine meter performance. Flow conditioning requires the use of straight pipe and flow conditioning elements that are inserted upstream of the meter, and downstream if the meter is bidirectional. The Company will never use extended straight pipe to take the place of a flow conditioning device. A straightening element or swirl breaker type of flow conditioner consists of a cluster of tube, vanes, or other equivalent devices that are inserted longitudinally in a section of straight pipe. Straightening elements may also consist of perforated plates or vortex generating devices, but these devices may cause an undesired pressure drop. Figure 3 demonstrates the required dimensions of a flow conditioning assembly with a tube type straightening element.



Engineering Design LACT & P/L Measurement

Figure 3



Note: This figure shows assemblies installed upstream of the meter. Downstream of the meter, $5D$ minimum of straight pipe should be used.

- L = overall length of straightener assembly ($\geq 10D$).
- A = length of upstream plenum ($2D-3D$).
- B = length of tube of vane-type straightening element ($2D-3D$).
- C = length of downstream plenum ($\geq 5D$).
- D = nominal diameter of meter.
- n = number of individual tubes or vanes (≥ 4).
- d = nominal diameter of individual tubes ($B/d \geq 10$).

Minimum back pressure is required in order to prevent cavitation. A back pressure valve will be installed downstream of the meter and prover loop. In the absence of a manufacturer's recommendation, the numerical value of the minimum back pressure at outlet will be calculated with the following expression.

$$Pb = 2\Delta p + 1.25pe$$

Pb = Minimum back pressure PSIG.

Δp = Pressure drop through the meter at the maximum operating flow rate for the liquid being measured PSIG.

pe = Equilibrium vapor pressure of the liquid at the operating temperature, PSIA.

Flanges and gaskets will be properly aligned to prevent protrusion into the flowing stream. Meters and the adjoining straightening section will be concentrically aligned.



Engineering Design LACT & P/L Measurement

Displacement Meter Selection

If a new system is to be installed the size of the displacement meter required will be determined as follows:

1. Determine the minimum and maximum station flow rates desired.
2. If pipeline measurement system or LACT unit flow cannot be interrupted install a spare meter run so that measurement may continue at the normal rate if the primary meter run were to fail or require unexpected maintenance.
3. Size each displacement meter for normal operation at 75% of its maximum capacity.

Displacement Meter Requirements

Strainers are a requirement when measuring with a displacement meter and will be installed upstream of the meter. Strainers used in crude oil service will be equipped with a coarse basket (usually four mesh is sufficient). A differential pressure transmitter will also be installed in order to monitor the health of the strainer to prevent strainer from failing allowing the operator to perform required maintenance upon alarm.

A back pressure valve will be installed downstream of the meter and prover loop if the line resistance is not sufficient enough to maintain pressure on the system consistently high enough to prevent vaporization in all operating conditions.

Coriolis Transmitter Considerations & Requirements

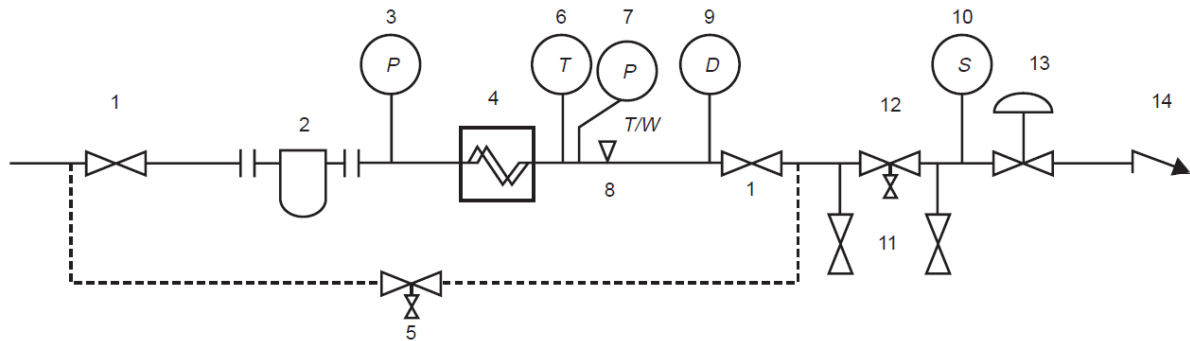
Evaluate the humidity extremes for appropriate protections. Consider fungus proofing and corrosion proofing. Assure that in the case the meter is a bidirectional meter that pressure and temperature measurement is available on both sides of the meter. Assure there aren't any sources of vibration or pulsation that can affect the meter performance. A schematic diagram of a typical meter installation is illustrated in Figure 4. The Coriolis meter should be oriented in a position that will assure the measuring tubes are completely filled with fluid under all flow and static conditions or provisions made to not measure flow during periods of zero flow and possible gas accumulation. All Coriolis installations used for the custody transfer of fluids will be required to install strainers or other protective devices upstream of the meter to remove foreign objects from the flowing stream which may cause measurement error.

Valves up and downstream of the Coriolis meter are preferred in order to stop flow and allow for zeroing the meter. As a minimum a block-and-bleed valve will be installed downstream of both the meter and the inlet prover connection.



Engineering Design LACT & P/L Measurement

Figure 4



- | | |
|--|--|
| 1. Block valve | 8. Test thermowell (optional) |
| 2. Strainer/air eliminator (optional) | 9. Density measurement/verification point |
| 3. Pressure indicating device (optional) | 10. Manual sample point or autosampler (optional) with probe |
| 4. Coriolis meter | 11. Proving connection, block valves |
| 5. Meter bypass (optional) with block and bleed valve or blind | 12. Block and bleed isolation valve for proving/zeroing |
| 6. Temperature indicating device | 13. Control valve (as required) |
| 7. Pressure indicating device | 14. Check valve (as required) |

Note: All sections of line that may be blocked in must have provisions for pressure relief.

Proper mounting of the Coriolis is required. Refer to the manufacturer's preferred recommendations. Consideration should be given to the support of the sensor and alignment of the inlet and outlet flanges with the sensor. Mount the Coriolis transmitter such that it is easily accessed to attach communications, and EFM device connections. Piping should be anchored to avoid transferring stresses from the piping to the flow sensor. Consult the manufacturer for the vibration and pulsation frequencies to avoid. A spool piece of the same diameter and length of the meter should be used in the meter's place during the construction phase of the meter run.

Multiple meters in close proximity whether they are in series or parallel have the ability to interfere with each other's vibration frequencies and can cause an error in measurement. Electromagnetic and radio frequency interference – strong electromagnetic fields can affect the electromagnetic signals from the sensor. The meter sensor and electronics should not be installed near radio frequency or electromagnetic interference sources such as variable frequency motors, transformers, radio transmitters, large switchgear, or high voltage cables. Install power line conditioning if the power to the electronics is not clean. An uninterruptible power supply (UPS) will be provided for continuous meter operation.



Engineering Design LACT & P/L Measurement

The Coriolis meter will be sent to a Company approved calibration facility to be certified by a third party before installation. Company measurement personnel will be consulted before the calibration facility is selected.

Minimum back pressure is required in order to prevent cavitation. A back pressure valve will be installed downstream of the meter and prover loop. In the absence of a manufacturer's recommendation, the numerical value of the minimum back pressure at outlet will be calculated with the following expression.

$$Pb = 2\Delta p + 1.25pe$$

Pb = Minimum back pressure PSIG.

Δp = Pressure drop through the meter at the maximum operating flow rate for the liquid being measured PSIG.

pe = Equilibrium vapor pressure of the liquid at the operating temperature, PSIA.

Ultrasonic Flow Meter Requirements

The design of an Ultrasonic Meter (UM) run will consider the maximum and minimum flow rates, Re Number, temperatures, pressures, viscosity, relative density, vapor pressure, and corrosiveness.

Strainers may not be required for UM installations due to the lack of mechanical moving parts that could be adversely affected by debris.

The meter's installation orientation should be in accordance with the manufacturer's recommendations. The UM may be installed in any position or plane, but the acoustic transducers will not be situated on the top or bottom of the pipe as to prevent from the effects of air, vapor, or water on measurement.

The operating pressure will always be maintained well above vapor pressure of the fluid product. Consult the manufacturer for maximum pressure drop to determine the total back pressure required in the following expression

$$Pb = 2\Delta p + 1.25pe$$

Pb = Minimum back pressure PSIG.

Δp = Pressure drop through the meter at the maximum operating flow rate for the liquid being measured PSIG.

pe = Equilibrium vapor pressure of the liquid at the operating temperature, PSIA.

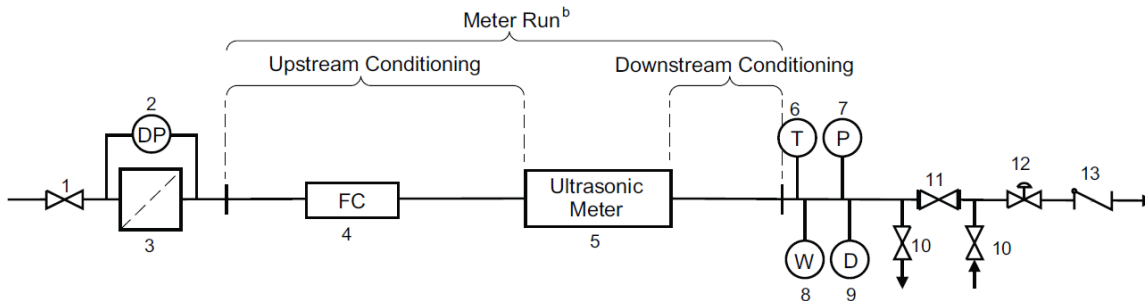
Flow conditioning of all UM's installed is required in order to reduce swirl or velocity profile distortion. The design will ensure appropriate flow conditioning up and downstream of the meter. Typically, straight pipe length of 10 pipe diameters with a



Engineering Design LACT & P/L Measurement

flow conditioning element upstream of the meter and 5 pipe diameters downstream of the meter provide effective flow conditioning and should be used in the case that the manufacturer does not have a recommendation. See Figure 5 below for a typical single UM run installation.

Figure 5



Key

- | | |
|--|-------------------------------------|
| 1. block valve ^a | 8. temperature test well |
| 2. differential device ^a | 9. densitometer ^a |
| 3. strainer and/or air eliminator ^a | 10. prover take-off valve |
| 4. flow conditioning element ^a | 11. double block and vent valve |
| 5. ultrasonic flow meter | 12. flow control valve ^a |
| 6. temperature measurement device | 13. check valve ^a |
| 7. pressure measurement device | |

The inside diameter of the meter run piping will be the same as the inlet and outlet of the meter. Welds will be internally ground smooth and all gaskets installed will not protrude into the pipe.

The preferred location of flow or pressure-control valves will be located downstream of the meter run and prover takeoff valves.

An uninterruptible power supply (UPS) will be provided for continuous meter operation.

The UM will be sent to a Company approved calibration facility to be certified by a third party before installation. Company measurement personnel will be consulted before the calibration facility is selected.

Sampling Requirements

A typical automatic sampling system consists of stream conditioning upstream of the sampling location, a device to physically extract a grab from the flowing stream, a flow measurement device for flow proportioning, a means to control the total volume of sample extracted, a sample receiver to collect and store grabs, and depending on the system, a sample receiver/mixing system. The Company's preferred method of automatic sampling is the flow proportionate method in order to extract a representative sample, although time proportional sampling may be used in the case that the flow rate variation is +/-10% of the average rate over the entire parcel. Figure 6 illustrates the



Engineering Design LACT & P/L Measurement

two typical automatic sampling systems. Automatic sampling-in-line and automatic sampling with a fast loop are the two typical types of sampling systems.

Figure 6

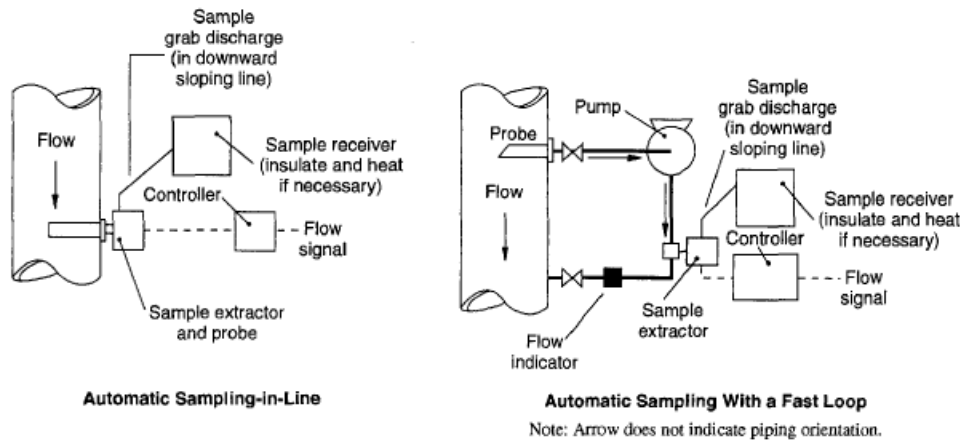


Figure 1—Typical Automatic Sampling Systems

A fast loop provides a continuous flowing stream representative of the main line. The sampler probe or fast loop must be located at a point in the pipe where the flowing stream is properly conditioned. This conditioning will be accomplished by mixing elements added to supplement mixing provided by the basic piping. A static mixer will be installed vertically. The mixer is a pipe with a number of internal baffles and blades fixed to the walls. The required size of the mixer depends on flow rate, pipe diameter, and the fluid properties. A power mixer consists of rotating elements that are inserted in the pipeline and driven by some power systems. This type of mixer is used where the space is limited and a static mixer cannot be fitted.

Samples are best taken directly from the flowing pipeline, however, because of the size of some pipelines or the need to locate sampling and analysis equipment away from the pipeline, sometimes a fast loop sample is taken. A fast loop is piping or tubing flowing with a well-mixed product taken from the main pipeline. The product flows to the analyzing and sampling equipment and then usually back into the pipeline. The product is driven through the fast loop by the pressure difference between the removal point and the return point.

The flow in the fast loop must be isokinetic to ensure that a representative sample of the main pipeline product is passed to the analyzing and sampling devices. Isokinetic flow is obtained if the flow velocity through the slipstream is equal to or slightly greater than the flow velocity in the main pipeline.

In some cases the differential pressure is not enough to obtain an isokinetic flow. In such cases, the differential pressure will be increased by returning the fast loop line back to a storage tank rather than back into the pipeline or by a pump downstream of the sampling equipment.



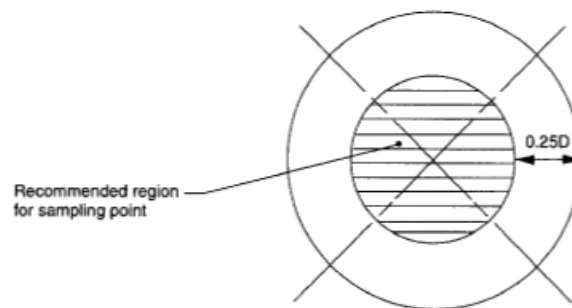
Engineering Design LACT & P/L Measurement

To control and adjust the flow velocity, the loop should be equipped with a flow indicator and a regulation valve. The maximum recommended transit time between the pipeline and the sample or analysis point is 60 seconds.

The removal point for the fast loop should use a probe as described below. The fast loop removal point can be upstream or downstream of the meter. It may not, however, bypass the meter.

The recommended sampling area is shown in Figure 7. The probe opening must face upstream and the external body of the probe will be marked with the direction of flow to verify that the probe is properly installed. The probe must be located in a zone where sufficient mixing results in adequate stream conditioning. This zone is generally from 0.5 – 4 pipe diameters from static mixers, and 3-10 diameters from power mixers. When static or power mixers are used the manufacturer of the device will be consulted for the probe's optimum location. The holdup volume in the probe and extractor should be minimized by sloping the line from the outlet of the extractor to the sampling receiver continuously downward and contain no dead space. The preferred installation of a combined probe –extractor is in the horizontal plane.

Figure 7



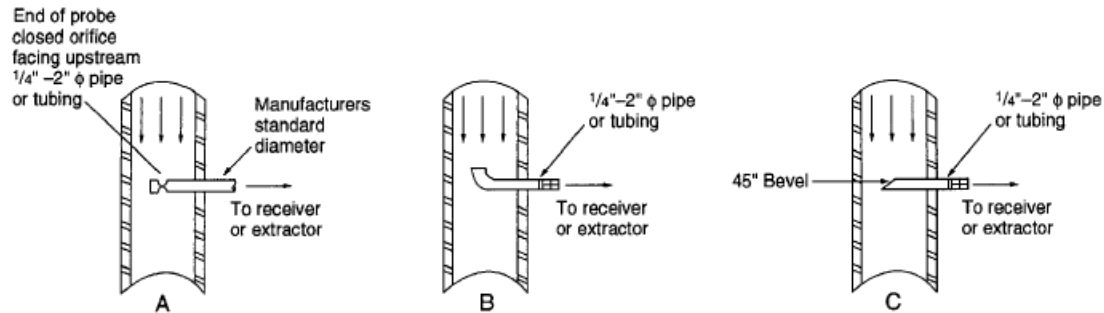
The mechanical design of the probe is required to be compatible with the operating conditions of the pipeline and the fluid being sampled.

- a. A closed-end probe equipped with an open orifice.
- b. A short radius elbow or pipe bend facing upstream. The end of the probe should be chamfered on the inside diameter to give a sharp entrance.
- c. A tube cut at a 45-degree angle with the angle facing upstream.



Engineering Design LACT & P/L Measurement

Figure 8 Probe Designs



An automatic sample extractor is a device that extracts a sample from the flowing medium. The extractor need not be an integral part of the probe. The sample extractor will extract a consistent volume that is repeatable within +/- 5% over the range of operating conditions and sample rates.

A sample controller in the form of the Company approved flow computer will be utilized to select sampling frequencies.

All custody transfer meters will be used to pace the automatic sampler.

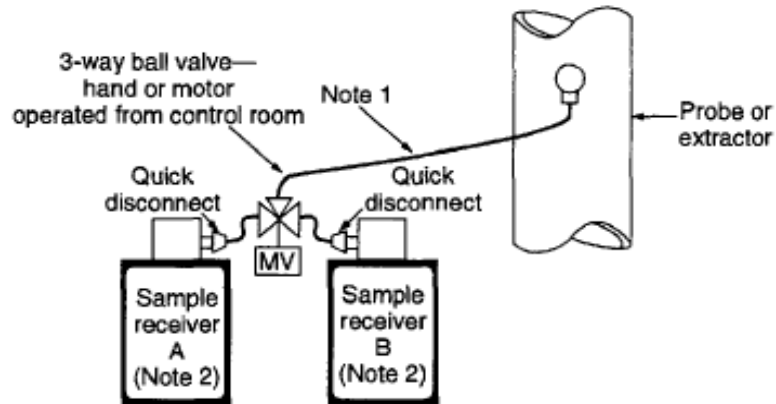
A sample receiver container is required to hold and maintain the composition of the sample in liquid form.

Receiver design must allow for preparation of a homogenous mixture of the sample. The bottom of the receiver must be continuously sloped downward toward the drain, there will be no internal pockets or dead spots. Internal surfaces of the receiver will be designed to minimize corrosion, encrustation, or clingage. A means will be provided to monitor the filling of the receiver. A relief valve must be provided and set at a pressure that does not exceed the design pressure of the receiver. A pressure gauge will be provided. A means to break vacuum will be provided. Receivers will be sheltered from the effects of ambient conditions. Facilities for security sealing will be provided. The system must be capable of draining the receiver, mixing pump, and associated piping. The circulating system may not contain any dead legs. The sample must flow into a connection at the top of the receivers.



Engineering Design LACT & P/L Measurement

Figure 9 Stationary Receiver Installation



Hiland Crude reserves the right to modify the entirety of this document at any time.



Hiland Crude, LLC
a Kinder Morgan company

Engineering Design LACT & P/L Measurement

Engineering Design LACT & Pipeline
Measurement Rev 1.5
Appendix A
(Approved Equipment)



Engineering Design LACT & P/L Measurement

Company Approved Measurement Equipment

Pressure Transmitter

1. Rosemount 3051S

Temperature Transmitter

1. Rosemount 3144P

Meter Types and Brands

1. Coriolis Meters
 - a. FMC
 - b. Micromotion
2. Displacement Meters
 - a. FMC
3. Turbine Meters
 - a. Faure Herman Helical Turbines
4. Ultrasonic Meters
 - a. Daniel
 - b. FMC

Flow Computers

1. Fisher ROC 809L
2. Fisher ROC 827L