LACT UNIT STANDARDS: A CASE STUDY

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ABSTRACT

The drop in oil prices has required everyone to reevaluate their operations to reduce operating costs and improve profit. One potential way to maximize a lease's profit is to ensure that a LACT Unit is properly built, maintained, operated, and proved. ARCO Oil and Gas Company (AOGC) recently revised their LACT Unit Design and Operation Standards to address these issues. This paper briefly discusses several sections of those new standards which have a significant impact on measurement quality.

INTRODUCTION

Most oil produced in the United States is sold through Lease Automatic Custody Transfer (LACT) Units. If a lease produced 1000 BOPD, then a 1% error in volume measurement at $20/BBL oil would cost $73,000 per year in lost revenue and depending upon contract conditions a 0.5 API error in gravity could cost $35,600 per year in lost revenue. Armed with this fact, management created a LACT unit committee and charged them with surveying current equipment and operating procedures, updating written company design and operating standards, and disseminating the information and training to the levels which will benefit the company most.

The committee reviewed the operation of AOGC's existing LACT unit locations, the LACT unit manuals of six other producing and pipeline companies, and the appropriate API documents. The compilation of this information resulted in a three part manual containing policy, operation, and design sections.

In the remainder of the paper, I will present a short discussion on LACT unit components, then report some of specific design and operational recommendations AOGC is implementing to improve measurement accuracy, and equipment reliability.

LACT UNIT EQUIPMENT

A typical LACT unit as shown in Figure 1 includes the following components:

Charge Pump and Motor	The primary energy source for the entire system. Its purpose is to move oil through the LACT unit.
Strainer	The strainer is a device that houses a removable perforated basket designed to collect solid materials present in the flowing stream.

Air/Gas Eliminator An air/gas eliminator is a device used to remove entrained air or vapor from the fluid stream before it enters the meter. The air eliminator is installed upstream of the meter in the highest part of the piping system to allow air to migrate and be vented.

BS&W Probe and Monitor The BS&W probe/monitor is an electronic device that is capable of determining the amount of basic sediment and water (BS&W). The system consists of an inline BS&W probe that senses the flowing stream and communicates to an electronic device, called a "BS&W monitor" which produces an electrical control signal based on the amount of BS&W present. The signal from the monitor is used to control a divert valve which diverts the fluid stream back for retreating whenever the BS&W content exceeds the monitor setpoint.

Divert Valve The divert valve is commonly a three-way two-position valve that is installed upstream of the meter. The divert valve is equipped with either an electric, hydraulic, or pneumatic actuator which controls the outlet flow path of the fluid.

Sample System The sample system consists of a probe used to retrieve a representative sample from the flowing stream and a container used to store the collected samples. A mixing pump blends the container contents so that the BS&W content and API gravity during the custody transfer period can be determined.

The sample probe is a section of pipe installed horizontally in a vertical run of pipe upstream of the meter. The probe is located in the center one-third of the pipe with the tip facing the direction of flow.

The outlet of the sample probe is usually connected to a three-way solenoid valve which is connected to the sample container. A precise amount of fluid is collected each time the solenoid valve is actuated. The sample solenoid is actuated by a pulser located on the meter to allow sampling at a fixed rate, i.e. one cc per barrel during metering.

The sample container is storage vessel that is used to collect the samples taken during custody transfer. It is important to remember that the container be pressurized (vapor tight) to prevent the evaporation and loss of entrained vapors.

Meter The meter is used to accurately measure the total fluid stream and to accumulate the total throughput. The most common type is the positive displacement meter but turbine meters are occasionally used in high volume applications. The positive displacement meter divides the stream into small segments through the rotation of an inner element. This precise rotation is connected by a mechanical gear train to a counter which registers the total throughput of the LACT unit. In order to provide the many functions required, the following meter accessories may be used:

Automatic Temperature Compensator - used to mechanically correct meter registration to a base of 60 F. Electronic temperature averagers may be used in lieu of mechanical temperature compensators.

Low Resolution Transmitter - used to electrically actuate the sample system.

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

Counter - a non-resettable counter used to accumulate the total throughput of the LACT unit.

Meter Pulse/Monitor - an electrical transmitter that is mechanically attached to the counter which signals the LACT control panel if the meter is not turning and is in the sales mode.

Meter Prover Loop

The meter prover loop is usually a three-valve manifold used to divert the metered flow through a prover. By closing the "block and bleed" valve all fluid going through the meter will go through the prover. The "block and bleed" valve is also furnished with a "tattle-tale" drain valve that must remain open to verify that no leakage occurs across the valve during a proving run.

Back Pressure Valve

The back pressure valve is used to hold a fixed pressure on the LACT unit. This valve is required to ensure that the meter always operates above the vapor pressure of the fluid being metered. It is very important that the back pressure be set above the highest normal delivery pressure. This will eliminate flow rate fluctuations which can cause measurement inaccuracies in the metered volumes. In most cases, it is recommended that a back pressure valve also be installed on the retreating line to control the recycle (divert) rate.

Check Valve

A check valve is used to prevent backflow from the pipeline and is installed as the last device in the piping system.

LACT Control Panel

The LACT control panel controls the entire operation of the system. The basic system operates on liquid level switches installed in the run or surge tank. In addition to starting and stopping the LACT unit from level switches, the following features are also provided:

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

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

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

Divert Controls - used to position the divert valve based upon signals received from the BS&W monitor.

Meter Failure Control - used to shut down the system in the event the meter does not register when the LACT unit is in normal operation.

Set Stop Allowable Control - use to shut down the LACT unit if a preset quantity of product has been delivered through the system.

Alarm Beacon - used to alert an operator when there is a failure on the LACT unit.

DESIGN CONSIDERATIONS FOR IMPROVED MEASUREMENT QUALITY

This section will address specific recommendations to be considered during the design of a new or rebuilding of an old LACT unit. Although not all inclusive, several ideas are presented for each major component in the system which should improve measurement quality.

Each LACT unit should be furnished with sufficient tankage to promote good gas separation, preferably one day's production. These tanks should be equipped with downcomers when possible. Also, any recirculating lines should be located at least 90 degrees from the LACT suction line. The tank level controls should operate to deliver sufficient head to properly load the charge pump at all times.

The BS&W monitor is a very important part of the LACT unit. The monitor is calibrated at the factory for the specific length of cable received; consequently, the cable length cannot be altered without a complete factory recalibration. The probe should be internally plastic coated to inhibit paraffin buildup and upstream piping to the probe should provide a well mixed fluid. It is also recommended that the BS&W monitor be capable of interfacing with a recording device.

The divert valve actuator should be electric or electro-hydraulic if possible instead of pneumatic, since pneumatic valves are much easier to tamper with. Also, a back pressure valve should be installed on the recirculating line downstream of the divert valve.

The strainer/air eliminator is commonly a combined device which should be located at the highest point in the system upstream of the meter. A differential pressure gauge should be installed across the strainer so that any plugging may be easily detected.

Another extremely important part of the LACT unit is the sample system. The sample probe should be designed and located according to API specifications. The use of static mixers upstream of the probe to ensure proper mixing is highly recommended. The sample extractor should repeatedly take a measurable sample. Piping between the extractor and the sample container should be as short as possible, insulated, and slope continuously downward. The sample container should be between five and thirty gallons with a good rule of thumb being one gallon per every 50 BOPD sold within the limits above. The container should be internally plastic coated with an easily accessible quick opening cover and contain internal spray bars for proper sample mixing during closeouts. A reliable back pressure valve set at a minimum of 10 psi should be installed on the sample container. The whole sample system should be capable of complete draining once the sample analysis has been performed.

In most cases, the meter will be a precision positive displacement meter. At locations moving greater than 100 BOPD or where a history of high meter failure exists, a second "check" meter should be considered. Usually this meter will be identical to the first but will only be used when the first meter fails or there is reason to doubt its accuracy. The check meter should be proved in the same manner as the primary meter. In AOGC's first check meter location, payout occurred only several months after installation when the check meter registered a 250 bbl difference from the primary meter. Upon investigation the primary meter was found to be in error and the pipeline agreed to a full credit which was 200 bbl over the figure we would have received according to their over and short report for that day. The issue of check meters must be agreed upon with the pipeline company but in most cases will be beneficial to all involved.

Temperature compensation has long been the focus of debate. Many companies prefer automatic temperature and gravity compensators (ATG) while others prefer only automatic temperature compensators (ATC). What is certainly true is that most of the occurrences of and dollars in meter repair are related to mechanical temperature compensators. Therefore in many applications an electronic temperature averager (ETA) has definite advantages over mechanical compensators. Typical installed cost of these units is $2500. A possible recommendation might be in installations over 500 BOPD or where high compensator failure warrants the change. In non-ETA locations the ATC is believed to be the most reliable type of mechanical temperature compensator.

The term flow computer can define many different types of equipment on the market today. Current functions can include temperature and pressure measurement as well as compensation calculations, flow accumulation, proving functions, and failure detections. The LACT unit of the future will no doubt include these features as well as others such as continuous recording BS&W measurement, meter factors, and online gravity determination to output an actual net sales readout. In this author's opinion the development of these technologies will improve the accuracy of crude measurement and should be supported whenever possible.

Other miscellaneous design considerations are as follows: separate check and back pressure valves on the LACT discharge, isolation from pipeline cathodic protection, sumps and drains under connections and bleeds to ensure an environmentally sound unit, and proper sealing of components affecting the quality or quantity of crude oil measurement.

OPERATIONAL CONSIDERATIONS

Without a doubt, the most effective method to increase income when dealing with LACT units is to properly train field personnel in the daily operation, maintenance, and witnessing of provings and oil run close-outs.

Guidelines for periodic inspections of the LACT unit should be formulated for the lease operator or pumper. Figure 2 shows an example of some of the items which should be verified on a daily, weekly, and close-out basis. Although not intended to be an all inclusive list, this is a starting point for routine maintenance and trouble shooting.

A calibration schedule should be set up for components such as the BS&W monitor, ATC/ATG, and/or the electronic temperature averager. Even if no problems are indicated it is still recommended to tear down and inspect the meter(s) yearly. Cleanliness is also worth mentioning as buildup of paraffin or BS&W can result in lost efficiency and poor shake-outs. Tanks, lines, sample pots, probes, etc. should all be cleaned regularly.

The witnessing of crude oil run close-outs and meter provings should be a very high priority to a company's field personnel. Therefore, AOGC developed a program that performs a cost/benefit type analysis for each property and then prioritizes them from high to low. With this information, the most can be made of the limited company resources. The formula which can be used for oil as well as gas transactions is as follows:

$$WFR = \frac{WCOST}{(PVPD) \times (PRICE) \times (BENEFIT) \times 0.01}$$

Where:

WFR = Witnessing Frequency Rate, which is the number of days required to payout the cost of witnessing (DAYS).

WCOST = Witnessing Cost ($). If unknown, start with $80.

PVPD = Product Volume Per Day (BOPD or MCFPD).

PRICE = Product Price per unit volume ($/BO or $/MCF)

BENEFIT = Average Benefit estimated if witnessed (%). (Should develop actual figures, but might start with 0.75% for gas and 0.25% for oil.)

Proving of the LACT meter(s) as well as the meter prover itself is essential to ensure proper measurement. AOGC developed the following minimum standards for meter proving: quarterly for deliveries < 50 BOPD, monthly for deliveries between 50 and 5000 BOPD, and twice monthly for deliveries over 5000 BOPD. It is also recommended that LACT meters be proved as soon as possible after meter repairs.

The following guidelines were developed to help make the decision of whether a meter should be repaired. A new or rebuilt meter should have an original meter factor between 0.9900 and 1.0100. The meter factor should not deviate more than 0.0050 from its original or rebuilt factor. Also the meter factor should not devaite from the previous proving by more than 0.0015 for a twice monthly and 0.0025 for a monthly or quarterly proving.

A graph of meter factor versus volume can be a helpful tool in analyzing and predicting meter failures. A meter proving check and action list such as that shown in Figure 3 can also aid the witness in effectively performing his job.

The other phase of witnessing deals with the run close-out and sample determination. The company personnel should be well trained in the recommended API specifications for the determination of BS&W content, API gravity, and temperature. That person should check that the gauger has clean solvent that contains no free water; he should know how to accurately take a BS&W reading from a centrifuge tube; he should ensure the sample was properly heated and that no paraffin with a melting point below 140 degrees F was counted as BS&W; etc. Enough emphasis cannot be placed on the importance of proper training of the field witnessing personnel.

As a final note in the operations section one should be familiar with the purchasers tariff agreement. Typically the agreement will allow the producer to sell oil with a BS&W content of 1% but usually with no more than 0.3% free water. Many times we as producers may fall into the trap of trying to produce near perfect oil at 0.05 to 0.1% BS&W. To do this will cost in the form of extra chemical and heat for separators; therefore, a more economical alternative may be to produce 0.3 to 0.5% BS&W oil. However, some pipelines charge a direct fee for the water transported. This example emphasizes that the producer needs to comprehend all aspects of the tariff in order to optimize lease performance.

SUMMARY

In summary, we have shown the significance and economic impact of proper crude oil measurement through LACT units. A review of the different components of a LACT unit was presented. Both proper equipment design and operation were shown to significantly impact crude oil measurement quality. Considering both operation and design, proper operation including scheduled maintenance and witnessing of provings and close-outs by well trained and confident personnel is the most beneficial and the quickest to show results.

ACKNOWLEDGEMENTS

I would like to thank ARCO Oil and Gas Company for allowing me to write this paper as well as each of the members of the Central District's LACT Unit Committee.

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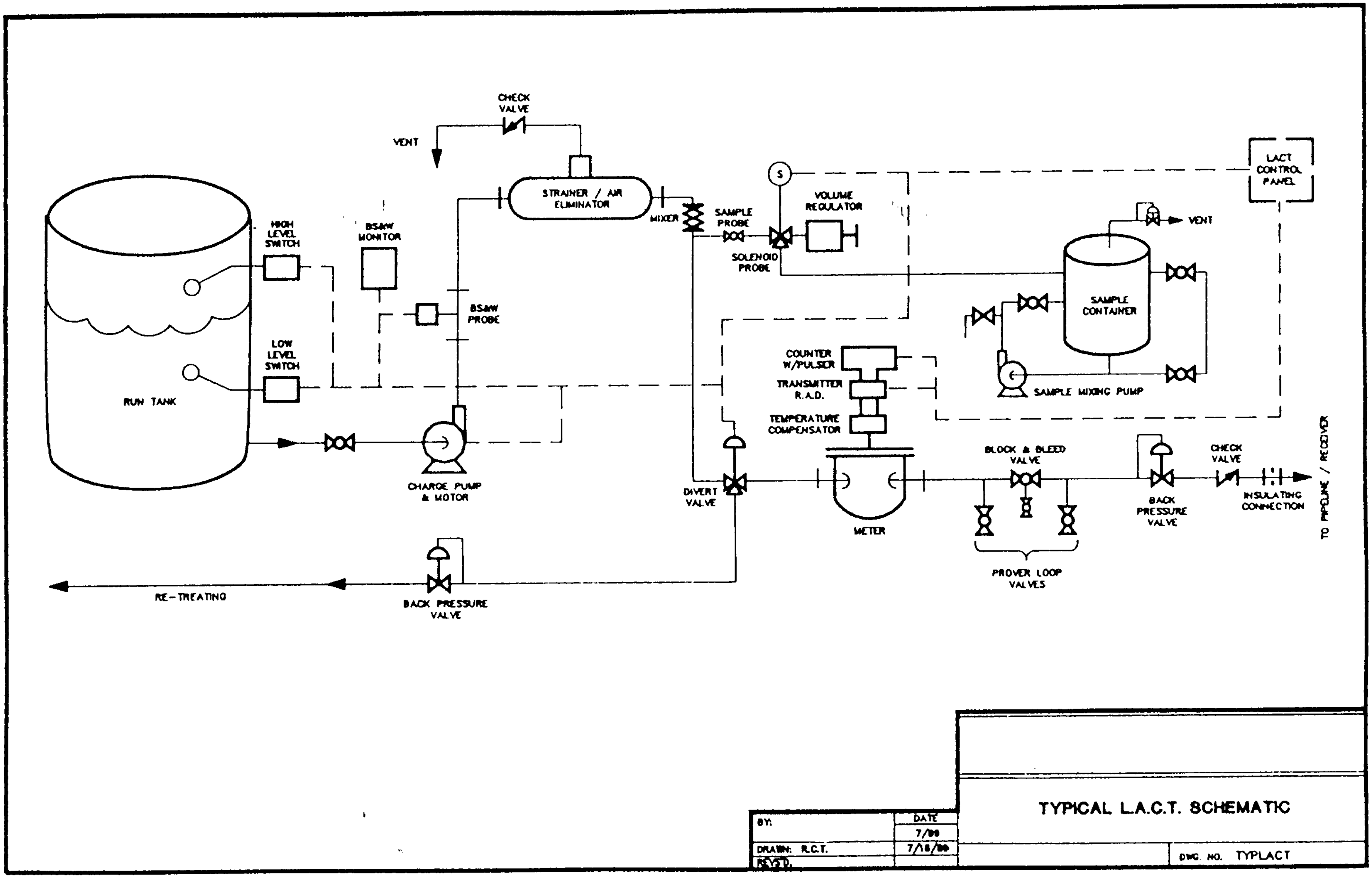

Figure 1 - Typical LACT schematic

Preventive Maintenance

LACT Unit Daily Check List	Check meter reading daily --> A short meter reading could indicate a meter failure.
	Check level in sample container --> No increase in level could indicate a sample system failure (repair or report at once).
	Check sample pot pressure --> No pressure could indicate sample system failure (repair or report at once).
	Check LACT unit for leaks --> A LACT unit should have no leaks.
	Check pressure gauge upstream and downstream of the back pressure valve --> The back pressure valve should hold a minimum of 20 psig back pressure on the LACT unit. A back pressure valve failure may cause a fluctuation in the flow rate.
	Check strainer, air eliminator, and differential pressure gauge --> Be certain that strainer is not plugged and the air eliminator is working.
	Check instantaneous sales rate, record on gauge sheet, and compare with previous day's sales rate on gauge sheet --> Instantaneous rate should be approximately the same from day to day. Excessive fluctuations may indicate a measurement problem, and the cause should be determined.
LACT Unit Weekly Check List	Check LACT unit alarms.
	Check level switch(es) at run tank for proper operation. Check the meter(s) for any registered movement while LACT unit is shut down.
Close-Out Check List	Clean sample pot and sight glass after each close out.
	Check and adjust sample volume size, if necessary.

Figure 2 - Example of preventive maintenance checklist

METER PROVING CHECKLIST

Date: ____________________

Lease Name and Number: ____

Prover Operator: ____ Witness: ____

Mark "Y" or "N" for "Yes" or "No" in the space provided as you observe the meter prover operator perform each function. Refer to Action List for the item numbers. Attach checklist to meter prover report.

1. ___ Were seals on LACT unit and prover loop valves intact?
2. ___ Were serial numbers on all removed seals verified?
3. ___ Were the number of pulses per barrel generated by the pulse generator verified and did pulse generator count 1000 pulses +/- one (1) in test mode?
4. ___ Was pulse interpolation used and if so was prover volume greater than 3 meter element revolutions or 3000 pulses? If no was prover volume greater than 20 meter element revolutions or 10,000 pulses?

If any questions in this group answer "N", see Item 1.

5. ___ Does prover operator have a valid certificate of prover calibration? *If answer "No", see Item 2.*
6. ___ Was the LACT meter totalizer reading taken and recorded?
7. ___ Was atmospheric temperature taken and recorded?
8. ___ Was the prover purged of oil from previous provings before the API gravity test was performed?
9. ___ Did prover-operator vent all vapors from prover after connecting it to LACT Unit?
10. ___ Was the block and bleed valve checked for leakage?
11. ___ Were prover pressure and temperature monitored during the meter proving process?
12. ___ Was an API gravity and a BS&W test performed as per API standards?
13. ___ Was API gravity corrected to 60°F?
14. ___ Was prover volume corrected to 0 psig and 60°?

If any questions in this group answer "No", see Item 3.

15. ___ Were prover thermometers checked against a certified type thermometer to assure that they are accurate to 1/2°F. or better?
16. ___ Were prover pressure gauges calibrated to an accuracy of two (2) percent of full scale reading?

If any questions in this group answer "No", see Item 4.

17. ___ Was prover report filled out accurately and calculations verified?
18. ___ Did you sign and receiver a copy of the prover report?

If any questions in this group answer "No", see Item 5.

19. ___ Were there any leaks before, during, and after the meter proving process? If "Yes", see Item 6.
20. ___ Were all the seals that were removed for the proving process replaced with new seals and the serial numbers recorded?
21. ___ Were all valves returned to their proper position after proving the meter?

If any questions in this group answer "N", see Item 7.

22. ___ Were 5 or more runs made with acceptable repeatability?
23. ___ Was the calculated meter factor within the limits per Action List Item 8(B).

If any questions in this group answer "N", see Item 8.

Figure 3a - Meter proving checklist

ACTION LIST

1. A. Immediately notify your supervisor.
   B. If tampering is obvious, do not allow anything at the site to be disturbed pending investigation.
   C. Record serial number and location of seals that are involved.
   D. Make written record of any other observable evidence.
   E. Gauge all tanks and record the tank readings. Record meter and allowable counter readings.
   F. Proceed with proving only after being cleared by your supervisor.

2. A. Request the prover provide a valid certificate of calibration before the next proving with serial numbers that match the prover S.N.
   B. Make note under "remarks" on proving form.
   C. If this occurs after one warning, see Action Item No. 1(A) and 1(F).

3. Ask the prover to perform the proper test of take the proper action or make corrections, etc. If he refuses:
   A. Do not sign the proving form in the signature block. Make a notation of the problem in the remarks block.
   B. Inform the prover that ARCO will not accept the results of this proving.
   C. Obtain the prover's name, company, supervisor's name, and telephone number.

4. A. Allow the proving to continue, but after proving, witness will check prover thermometer or pressure gauge.
   B. Request the prover utilize properly checked and accurate instruments in the future.
   C. Periodically compare results using your own thermometer and pressure gauges.

5. Do not sign any document unless it is complete and accurate. Request a copy. If there are not enough carbons, insist a duplicate be made. If refused, see Action Item No. 1(A).

6. Stop the proof run and repair the leak. If a leak develops that you cannot repair, abort the proof run and see Action Item No. 1(F).

7. Any area that should be sealed and is not sealed by the prover should be sealed by you or other designated person(s) before you leave the facility. Personally verify that all valves and switches are in the proper position before leaving the facility.

8. A. Calibration of P.D. meters shall be as prescribed by API Manual of Petroleum Measurement Standards. When a LACT P.D. meter is being calibrated to determine a meter factor, proof runs shall be made and recorded until five consecutive proof runs agree within a tolerance of 0.05% (0.0005). If four proof runs are made without the prescribed agreement, the proving operation must be examined for cause of the discrepancy. If the cause if not found, the meter mechanism shall be examined for mechanical defects.

   B. Calibrators shall not be adjusted except where necessary following a major meter overhaul. The meter factor properly determined as above shall not be allowed to deviate more than 0.0025 for monthly provings, 0.0040 for bi-monthly provings, and 0.0050 for quarterly provings without an investigation of the cause. When the degree of meter factor deviation exceeds these values, the meter should be examined for mechanical defects or the entire system should be inspected to determine any abnormality. A written explanation shall be made under "remarks" on any proving report which indicates that a meter does not perform within the prescribed limits.

Figure 3b - Action list