THE CAUSES AND EFFECTS OF ERROR IN CRUDE OIL MEASUREMENT

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ABSTRACT

This paper discusses the common causes and effects of measurement error in LACT unit custody transfers. The discussion covers the major components of a LACT unit, and their effects on measurement accuracy. It also pinpoints how the neglect of each of these components causes the loss of millions of dollars to the oil industry through inaccurate measurement. Also discussed is how the failure to strictly observe API procedures, during the testing of the crude oil sample, can result in measurement error. Although these errors may be small percentage wise; when multiplied by monthly or yearly sales, the results can amount to a substantial dollar amount.

INTRODUCTION

After several years of observation and study into the measurement practices of crude oil production companies, an obvious conclusion is that there needs to be a general awakening on the part of producers to promote better measurement controls at their points of custody transfer. At some point in the early history of oil and gas production, the measurement of these products had to be considered. Since a cubic foot of natural gas could not be seen, it was obvious that some engineering and research had to be done in order to accurately measure this product. The research has progressed through time, until today there are some 13 different correction factors to be applied to a standard cubic foot of gas before you can have an accurate measurement. As a result of all of this research, a gas contract between a buyer and a seller today, is a very thick document. This contract is very specific, down to the smallest detail, as to how this product is to be measured..

When the subject of crude oil measurement was approached, it wasn't given much thought because anyone could see that a tank of oil was a tank of oil. Consequently, over the years, only the purchaser performed any research into crude oil measurement. The result of this research has established only three standards for crude oil measurement: API gravity, CPL (correction for the effect of pressure on liquids), and CTL (correction for the effect of temperature on liquids). With this being the history of crude oil measurement in the industry, there has evolved a nonchalant attitude on the part of producers. The result of this attitude is that the crude oil industry is the only industry in the world in which the producer allows the buyer to tell him how much product he has sold and what it is worth. This sale is also made without there being so much as a contract between the buyer and the seller. Over the years, the top priorities of producers have been drilling costs and procedures, and production costs and enhancement methods. They have assumed someone was taking care of the measurement of their product at the point of custody transfer. They were right; the buyer. Consequently, there are thousands of dollars lost every day in the oil industry by the producers.

CAUSES AND EFFECTS OF MEASUREMENT ERROR

Since most crude oil transactions are measured through a LACT unit (Lease Automatic Custody Transfer Unit), we will devote the remainder of this paper to the components that make up a LACT unit, and their effect on measurement accuracy.

The first place for measurement error in a LACT unit is the sample probe. Good sampling practices require that the sample probe extend into the middle third of the flowing stream. The probe should have the end beveled at a 45 degree angle. The probe should be installed with the bevel facing the flowing stream. The sample point should always be in a vertical riser downstream of the charge pump. In a flowing stream of crude oil, the water or heavier sediments tend to collect to the wall of the pipe. A sample taken from the outside of the stream (or the wall of the pipe), would not be representative of the total contents of that stream. Any separation of these contents tend to remix after they pass through an elbow. Thus the rule for placement of a probe is, three pipe diameters past the third elbow downstream of the charge pump.

The next place for measurement error in a LACT unit is the sample volume. The sample volume is controlled by a sample volume regulator. The size of the sample is not important. It is important that an equal sample be taken from every bbl of oil that passes through the LACT meter. At the end of the crude oil run period, the sample container should contain a true and representative sample of that total crude sale. We will discuss the implications of this later when we discuss the sample container.

The next component, that has an important role in the measurement process, is the meter itself. LACT unit meters are always positive displacement meters. Positive displacement meters have an internal measurement chamber. The known volume of that chamber is transferred by a series of gears to a meter register. Since we have meter and gear wear, and the temperature of the crude oil varies, a meter factor has to be established periodically. This meter factor is applied to the meter reading to insure the accuracy of the meter. The meter factor is established by the proving process, which we will discuss in more detail later in this paper.

The next component, that has measurement significance, is the proving loop. The proving loop is a series of three valves which are used to divert the flowing stream of oil, that has passed through the meter, to also pass through the meter proving device. During a meter proving, it is essential that every drop of oil that passes through the meter, must also pass through the proving device.

The last device on a LACT unit that has a significant impact on accuracy, is the back-pressure valve. The purpose of the back-pressure valve is to maintain a constant pressure and flow rate through the meter. If back-pressure is not maintained in the meter, then there is the possibility of a lightend hydrocarbon break out in the meter. The meter has no way of knowing whether the fluid is gas or oil. The other duty of a back-pressure valve is to maintain a constant flow rate. When a meter is proved, a factor is established at that flow rate. That factor is only good at that particular flow rate.

Probably one of the most important, and the most ignored components in the LACT unit measurement process is the sample container. Let's go back and review what we are doing with the LACT unit. We are automatically transferring the custody of a large volume of crude oil from the producer to the buyer. During this process, we are withdrawing a minute portion (1 to 2 cc), from each barrel that passes through the meter, and transferring it to a sample storage container. This sample is then stored, for up to thirty days, until the pipeline company comes to perform the tests and read the meter. This determines the value, and the volume of this thirty day transaction. The first important function of a sample container is to maintain the integrity of that sample. In other words, it shouldn't be contaminated by anything nor should any of the contents be lost. The most common problem with sample containers is the loss of light end hydrocarbons. These are an integral part of the crude oil sample. A good sample container will be vapor tight, and will hold pressure up to 15 psi.

Another important function of a sample container is to have a mixing system that will produce a completely homogeneous mixture in about ten minutes of mixing time.

To emphasize why these two functions are important, let's look at the testing procedures. After the mixing process is completed, the gauger (the buyer's representative), will pull a 50cc sample out of the container in order to run a centrifuge test. The centrifuge test determines the amount of S&W (sediment and water), that the crude oil contains. The S&W content is a direct deduction from the net barrels recorded on the meter register. Let's look at a typical example. Assuming you had a month's crude oil run of 50,000 bbls, and you had 10 gallons of sample in the sample container, the 50cc sample, would equal 13 one hundredths of one percent of that 10 gallon sample. 50cc would also be six ten millionths of one per cent of the 50,000 bbl run. To emphasize the importance of these numbers, remember you are impacting a $900,000.00 transaction with these tests.

Another costly error in the measurement transaction, is the centrifuge test itself. The 50cc sample, mentioned above, is combined with 50cc of diluent. In reference to A.P.I. standards, this combined sample is then to be heated to 140 degree F. The purpose of this heating procedure is to insure that the paraffin in the crude oil will remain in suspension during the centrifuging. This heating is very seldom done unless someone is there to insist that the A.P.I. procedures are followed. If the 140 degree F. rule is not followed, the resulting centrifuging will give a false reading. The centrifuge tube will show several tenths of one percent, of paraffin on top of the water line. Paraffin is a saleable product and should not be deducted from the total crude oil run. A .3 of one percent deduction from a 50,000 bbl run would be a $2550.00 loss of revenue. The yearly loss would amount to over $30,000.00. As you can see, these tenths of a percent errors can amount to significant dollar losses.

The other test performed on the crude oil sample is the A.P.I. gravity determination. The A.P.I. gravity from a sample container has nothing to do with the volume of crude oil that has passed through the meter. It's purpose is to determine the quality of the crude oil. In effect, the gravity determines the price the producer will be paid for his product. A.P.I. gravity is a means of determining the density or weight of a known volume of crude oil. The higher the gravity,(or the less dense it is), means that the crude oil contains a higher percentage of valuable light end hydrocarbons. Thus, crude oil values are determined by pricing schedules which are based on the A.P.I. gravity. As was previously mentioned, it is essential to have a completely vapor tight sample container. If the sample container is not vapor tight, the crude oil sample will lose the valuable light end hydrocarbons to the atmosphere, before the sample is ever tested for A.P.I. gravity. This condition will always result in a dollar loss to the producer.

The common procedure for determining A.P.I. gravity is to fill a tall cylinder with crude oil from the sample container. This cylinder is then set aside, and a thermo-hydrometer is inserted into the fluid. The thermo-hydrometer is allowed to float in the fluid until the crude oil and the thermo-hydrometer are stabilized,(3 to 5 minutes). Here we have another condition for error in the accuracy of crude oil measurement. Remember, we pulled this sample from a stream of oil that has already passed into the custody of the pipeline. We stored this sample in a vapor tight container to maintain it's integrity. Now we take this sample from a pressure environment, and put in an atmosphere environment. This pressure reduction immediately allows the light end hydrocarbons to escape to the atmosphere. We are now going to read the gravity of a sample which has been changed, not a sample of the crude oil that passed through the meter into the pipeline. The most accurate method would be to take that gravity reading in an enclosed hydrometer case, which would not allow the escape of these valuable light end hydrocarbons.

Another possibility for error is the reading of the gravity and the temperature on the thermo-hydrometer itself. These readings should be taken with care. All A.P.I. gravity is corrected to a standard of 60 degrees F. A misreading of the observed temperature can cause an expensive error in the corrected gravity.

In over 150 tests to determine the difference between open and enclosed gravity readings, the results show an average increase of .4 degree A.P.I. gravity. This increase amounts to .06 per barrel,(based on West Texas sour crude). This .06, times your company's annual production can amount to a very large dollar amount; as an example: .06 x 1,000,000 bbls would be $60,000.00.

The last area for measurement error in L.A.C.T. units is the meter proving process. The meter proving is performed periodically,(usually once each month). A meter prover is a device with a known volume. The prover is attached to the proving loop with the block valve closed. This hook up allows everything that passes through the meter to also pass through the prover. In simple terms, a meter proving is accomplished by passing oil that has passed through the meter, through the proving device which has a known volume. The volume registered on the prover is divided by the volume registered on the meter, the resulting calculation is a meter factor. This factor, when applied, will bring the meter reading to unity. One of the most common errors during a meter proving , is the leaking of the block valve in the proving loop. This valve leakage will allow some of the oil that has passed through the meter, to bypass the proving device. This condition will always produce a lower meter factor. This erroneous meter factor will always cost the seller, never the buyer. To eliminate this possibility, the proving loop has to have a good double seal block and bleed valve. On this valve, the bleeder is to remain open during a meter proving to ensure that the block valve does not leak,(even a drip).

Another area for close observation is the observed temperature and pressure. These readings will be applied to the A.P.I. correction tables for C.T.L. and C.P.L. From these tables, additional factors are applied to the prover volume. The resulting calculation will bring the prover volume to standard conditions, (60 degrees F. and 0 P.S.I.). Any misreading of these observations, or correction tables will cause an erroneous meter factor. Another problem area is inaccurate calculation in the proving report. These calculations should always be double checked.

One other important element in the meter proving process is the flow rate. We have mentioned before that a meter factor is only accurate at the flow rate used during the proving procedure. The normal flow rate should be observed before the proving device is tied into the proving loop. The flow rate then should be checked to see if the prover has altered this normal rate. If the prover has changed this rate, then the back pressure valve should be adjusted to bring the flow rate to normal. After the proving, the back pressure valve will have to be readjusted.

This paper has not covered everything that is involved in Lease Automatic Custody Transfer, but we feel we have covered the most common errors that occur daily in the crude oil production industry. These errors occur, not because of willfull neglect, but because the production industry has developed into a multi-billion dollar industry that has assumed someone in their company was watching this measurement process. In a large production company, you will find only a few individuals who have the authority to make a single $10,000.00 purchase. That same company allows an individual, who is usually on the bottom of their pay scale, to make a $1,000,000.00 oil sale, and this individual will not have had any measurement training. This disparity in priorities needs to be addressed by every production company.

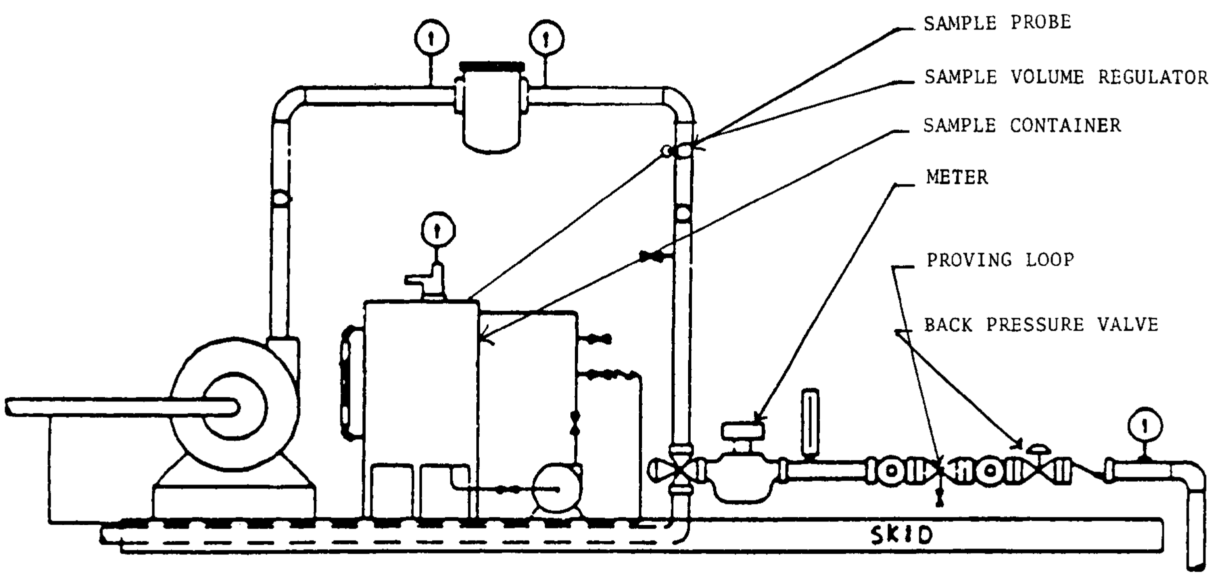
I will close this paper with two thoughts.

THE RULES OF MEASUREMENT ACCURACY DO NOT JUST HAPPEN, THEY HAVE TO BE ENFORCED.

MEASUREMENT, WITHOUT ACCURACY, IS JUST A GUESS.

ACKNOWLEDGEMENTS

I am grateful to Amoco Production Company for allowing me through the years, to take a concentrated look into crude oil measurement.



Lease Automatic Custody Transfer Unit