JISKOOT™ QUALITY SYSTEMS

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Increased Profitability through Effective Measurement

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Abstract

The measurement of a crude oil shipment at an import terminal forms the basic measure of profit performance. Accurate techniques for measurement of flow are well documented and understood. The factor that is often overlooked is the accurate measurement of actual water, density and composition.

Crude oil and water do not mix and therefore it is fundamental that any measurement of water content not only considers carefully how a sample is extracted but also how it is handled and tested. Typical errors in poor sampling techniques result in payment of oil prices both to transport and to process water. While the percentage errors between sampling methodologies may appear insignificant (of the order of 0.05- 0.15%) the volumes of crude traded make the losses significant and can easily justify the installation of an accurate sampling system that both the seller and purchaser can be confident in.

The International standards of ISO 3171 clearly define standards which meet the requirement of accurate sampling of liquid hydrocarbons in pipelines.

Introduction

The petroleum industry in India has travelled a long way from the jungles of Assam's Digboi in 1899 to the waters off Mumbai in 1999. Over the last two decades the national oil companies have done an excellent job of increasing the oil and gas production to meet the growing demands of consumers for oil, gas and petroleum products.

The future

When asked to present this paper, we studied the economic policy to seek clear justifications for the use of sampling technology in this region and the key justifiers are both strongly indicated; namely efficiency and import volume.

The demand for gas and petroleum products is growing at a significantly higher rate than the production from domestic sources. Last fiscal year India had to import oil and gas products worth US$8 billion (including 34.5 million tonnes of crude oil, much of this from the Middle East) and expects that to be US$9 billion this year.

Until recently the economic and market characteristics of the oil and gas industry was under the regulation of the Government. This has started to relax as a result of the liberalisation process embarked upon in 1991. In the last 18 months India has gradually reduced government control of petroleum prices with the aim of reducing its large oil deficit import bill.

It has liberalised many trading activities in the oil and gas sector and the resultant reforms have started to bring about evidence of increasing competitiveness and diversification.

This reduction in government control promotes inward investment and the drive for efficiency, but it is apparent that India is not only striving to meet its own energy demands but sees itself as a conduit between the Middle East and Far East that could be used to process and refine for re-export.

Against a background of increasing competition and growing imports the effectiveness of a fiscal measurement system is a crucial tool to ensure the profitability of future operations.

The importance of measurement

Oil companies establish "loss control groups" to minimise the losses in their overall product life-cycle. Many of these losses can be assigned to leakage, evaporation, process or measurement. When all of the physical losses have been accounted for we are left with the single largest area for error, and in fact the one upon which all the others are based - *measurement error*.

Measurement of imported crude oil is crucial to the profitability of any operation, inaccuracies can have catastrophic effects and the losses can be substantial. Clearly any measurement technology needs to be such that both parties (buyer and seller) involved in any transaction are satisfied. At the end of the day, both the buyer "got what he paid for", for the seller "a fair price for his oil". Ultimately to determine a "fair trade" both buyer and seller need the ability to verify the measurement system from which it was derived.

Measurement has two facets - quantity and quality. The measurement of quantity is well understood and a wealth of international standards exist that define the accuracy, repeatability and acceptable uncertainties for a fiscal measurement system. All too often in the quest for accuracy in quantity measurement the determination of quality is ignored. The two are totally dependent, but naturally quantity is always perceived as more important than quality. Think of a tonne of gold, a tonne of lead, a tonne of air - none of these describe more than a quantity and a perception of value. Many of you can quote the current price of oil, probably in $ per barrel but what if that oil has 5% water in it!

How then can we accurately determine both the quality and quantity of a shipment? What are we looking for and how important is accuracy to both? Quantity is simply a measure of the volume delivered. The accuracy achieved is largely based upon the repeatability and physical accuracy of the measuring system and its sub-components. International standards exist specifying this accuracy, such as the API chapters 5, 6 and 12. It is the belief of the authors that these are well understood and documented in India.

Quality measurement

What do we measure to determine quality? In general the key parameters to be measured are density and water content, water obviously because it has no trade value and in fact can cause upsets to the refining process, and density because a substantial volume of trade is made on the basis of mass, although primary measure is by volume.

International standards

Three standards exist which govern the extraction of samples of crude oil for later analysis. These are API 8.2, IP 6.2 and the ISO 3171. Each of these standards define the key steps to achieve accurate sampling. Of these standards, API is recognised for trade but outside of the American continent compliance with ISO in addition to API is called for. In Europe compliance with ISO or IP is a necessity.

The key difference between the API, IP and ISO standards is with regard to acceptable accuracy. Two of the standards, the ISO and IP define the acceptable accuracy as being 0.05% for every 1% of water present in the shipment. For the API the acceptable level is 0.13%.

In essence, the easiest standard to meet is the API whereas the standard with the widest acceptance and best credibility is the ISO standard.

Accurate sampling is a complete process that consists of several steps each of which are critical to the outcome. The overall accuracy of the system will only be as good as the weakest step.

The standards define four key steps that will ensure the extraction of representative samples:

1. *Homogeneity of pipeline contents (pipeline mixing)*
2. *Extraction of a flow proportional and representative sample*
3. *Sample handling and mixing*
4. *Laboratory analysis*

Pipeline mixing

To sample accurately the sample extracted must represent physically what flows through the pipeline, but the sampler extracts its specimen from a single point on the pipeline cross section. The two principal components - water and oil - do not mix naturally and therefore unless there is a lot of turbulence in the pipeline, the water concentration will vary across the cross section. This means that a sample taken in the wrong place could have either too little or too much water!

In principle the dispersion quality of the oil is a function of the turbulence induced by piping elements or a mixing device. If the extraction mechanism was capable of taking a "slice" of the whole cross section, then no mixing would be required! Following this argument logically, the larger the size of the opening to the extractor, the less sensitive it will be to dispersion quality.

Flow measurement and proportionality

To sample accurately requires that the sample be taken flow proportionally, this creates two problems - the first being the flow measurement and the second being the volumetric performance of the sample extraction device.

Taking as example a ship discharge, the highest concentrations are likely to be water at the start of the discharge, as tanks are changed and at the end of the discharge ("stripping"), this is because the water will have settled to the bottom of the tanks. The start of the discharge and the stripping phases are at very low flow-rates. If these phases are say 5% of the total volume but contain water concentration averages of 20% while the main batch has an average 1% then of the total volume of water the 5% phase represents the same quantity approximately as the other 95% of the batch!

0.05 x 0.20 = 0.01 Water during 'stripping phase'

0.95 x 0.01 = 0.0095 Water during main transfer

= 0.01950 (1.950%) Transaction water content

For this reason the standards require that the flow measurement should be within ± 10% and the grab volume repeatability should be within 5%. Consider a flow-meter which is 10% high at low flow-rate and 10% low at high flow-rate then the measurement would be thus:

0.05x 0.20 x 1.1 = 0.011

0.95 x 0.01 x 0.9 = 0.00855

= 0.01955 (1.955%)

Measurement error can therefore bias the sample accuracy. Beside the flow-meter the sample extraction device should be capable of repeatable volumes irrespective of line pressure, process viscosity etc. The history of pressure sensitivity in sampling devices is legendary.

Sample handling and mixing

In designing a sampling system the type of receivers are a key issue and the method by which they may be handled, mixed, sub-sampled and samples stored is critical. The type of receivers to use depends greatly on the type of operation, facilities that transport a variety of crudes will have different demands for inter-batch contamination than those shipping out a single and consistent crude type. For example, when sampling for heavy metals, the system and receivers must be extremely well cleaned, whereas if the system is for loading, say Arabian light crude, every batch from the same tank, then cross contamination is unlikely to cause a significant bias. Likewise the considerations of RVP and density will vary by operation.

One item on which all designers should be clear is the effect of the quality of the operations staff used for each step of the process. In general the number of critical handling steps undertaken in the field should be minimised because these steps are largely uncontrolled and un-auditable. This is why portable receivers are normally recommended; uncoupling a portable receiver and removing it to a laboratory takes a mixing and sub-sampling procedure and places it in an environment with a much higher degree of control (and comfort).

Another issue raised frequently is loss of light ends, particularly with higher vapour pressure oils. The loss of light ends affects density measurement but this can be easily avoided by ensuring that the receiver relief pressure is set above the RVP of the fluid at the maximum temperature that the receiver is likely to experience.

Where the product is a light hydrocarbon or perhaps where the oil is spiked with gas, such as happens in the North Sea then high pressure receivers must be used.

The constant pressure cylinders used for light hydrocarbon are generally not suited to crude/water duty as sufficient energy cannot be imparted to the fluid to mix it for sub sampling, cylinders with "balls" or manually agitated baffles have been consistently found inadequate for dispersing water into crude pre-analysis.

Laboratory analysis

The laboratory analysis step is of course the key to the whole system and without adequate analysis methods any efforts to provide a representative sample have no value.

There are three analysis methods currently in use:

- *Centrifuge*
- *Distillation*
- *Karl Fischer*

In general centrifuge (ASTM 4007) has been dropped in favour of Coulometric Karl Fisher (ASTM D 4928) which has been found to be substantially better, the fundamental differences being in speed of result and in accuracy.

Proving

The real test for a sampling system is to prove the system in its entirety i.e. as a complete system. This can only be done by water injection and there are many who will provide this service. Third parties should witness this operation and all the inspection companies should be invited to attend. There is no substitute for proving a sampling system, it should be repeatable and repeated if primary characteristics of the system are changed - crude types, operational rates, fundamental system components, etc.

Field data

Many oil suppliers like to state that their production is dry or "trace". True to say that the lighter the crude the drier the potential shipments become, but this is only true if the oil is separated out in the process, the tanks well sealed and/or the water drawn from the tanks prior to loading.

It is a strange reality that the ships unloading oil from these "dry suppliers" always seem to have similar total out-turn volumes but higher water contents! We are frequently advised by one receipt port that we should be calling at the reciprocal load port for this very reason.

Published PM-L-4A committee results (the international loss control committee), for year ending 1995, continue to show improvements in loss reduction. This has been linked directly to improved measurement standards and practices at both load and receipt terminals.

While the industry average now appears to be 0.22% it is apparent that the quoted figures for some Middle Eastern crudes still exceed these. The overall total for these crudes still shows a loss of -0.265%, the worst being Arab medium at -0.34%. What is also interesting about the local figures is that they clearly bear out the relationship between API and measurement accuracy.

Given a uniform style and sampling methodology, these figures are predictable, the extra light crude is probably shipped drier than any of the other crudes because water is easily and quickly separated. The heavy on the other hand is likely to have higher background water levels from the process.

Conclusion

The determination of crude oil quality through effective sampling techniques can and does provide measurable returns on capital investment. Accurate sampling is not just a requirement of international standards. It can, correctly performed, add real value to an operation's bottom line.

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