JISKOOT™ QUALITY SYSTEMS

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The "Art" of Crude Oil Sampling

By Mark Jiskoot

Crude oil is sampled to establish the composition quality, density and water content. The quality is normally known when the oil is purchased, as is the approximate density, and for a cargo there is an "expected" water content. However receipt terminals can often be surprised by a water content that is far higher than the "bill of lading" as stated by the loading port. Depending on how the purchase contracts are written, discovery of more water may give rise to a claim first on the shipper and then on the supplier.

To evaluate the water content of crude oil requires that the sample be fully representative of the cargo and this requires that several steps be taken.

There are of course national and international standards (ISO 3171, API 8.2, IP 6.2) that are applied to this measurement, but often they are overlooked or misunderstood leading to a much higher degree of uncertainty than is desirable or achievable.

How much is this worth?

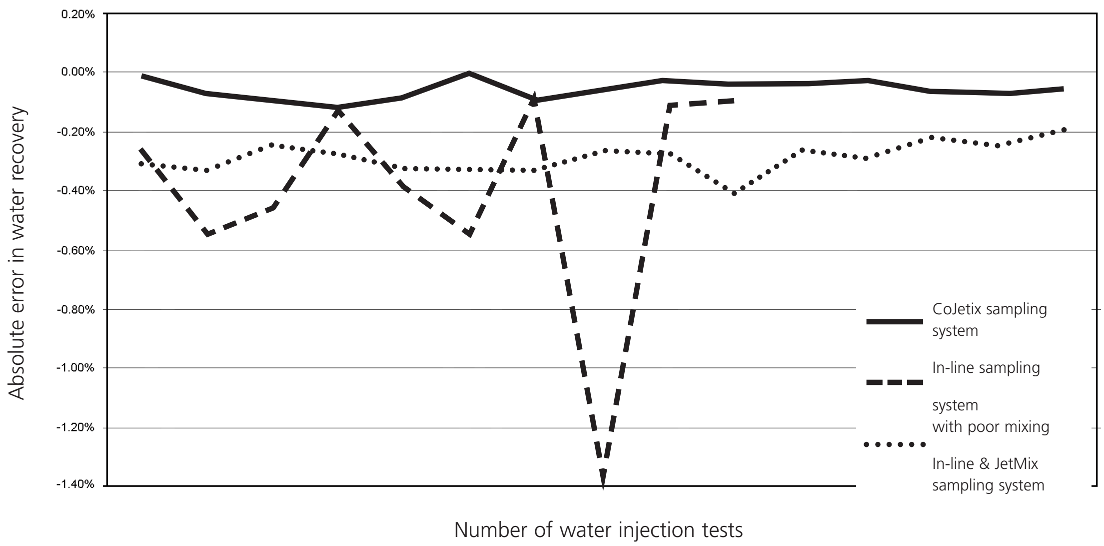
In the overall "loss" equation under-measurement in sampling can account easily for about 0.3 - 0.5 % of the value of the total cargo volume. In money terms this could be as much as $100,000 to $150,000 on one ship!

Whether or not this is of interest to a particular terminal/refinery will depend on corporate accounting methods, but clearly if the oil company is shipping and paying for water at an oil price, this is directly from the profits! In some places of course customs duty or production royalty is also paid. Without fail engineers still overlook crucial process or installation detail when designing sampling systems.

Crude oil as received from a ship is not homogenous and the percentage water fraction changes over the unloading cycle. To be able to dispute the cargo value (and if necessary to argue in a court), the sampling system installation must meet some strict rules:

- Located correctly (as close as possible to the point at which the ownership changes - the "custody transfer" point).
- Extracted from a well mixed pipe.
- Representative (i.e. flow proportional and identical to what flowed in the pipeline).
- Collected in a receiver that does not change the properties of the sample and one that has a capability to be remixed to allow extraction of a sub sample.
- Adequate laboratory analysis technique and procedure.
- Must be able to provide a "proving test" result (a real physical test) that shows that the system meets the uncertainty demands of the standards.

Variances in water recovery from water injection testing of proven automatic sampling systems



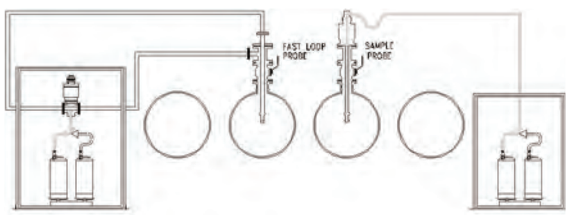
Sounds easy?

Remember that sampling is like any process in that the accuracy is determined by the weakest link in the chain. The actual sample in the laboratory upon which a $50 million cargo will be based will be less than 1ml!

Considerable work has been done over the last 20 years in understanding and reducing the uncertainty of the sampling process. A simple fact to remember is that of 200 water injection proving tests, in only two instances have sampling systems shown more water than they should have (one of these was a system where the piping configuration threw free water into the path of the sampler!).

Uncertainties are therefore generally NEGATIVE.

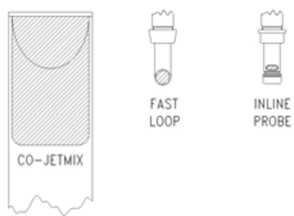
Just how much you under-measure the water content by will depend on your system design. The Europeans have pioneered deployment of "fast loop" systems whereas tradition in the USA has been and continues to largely be based on In-line systems.



Fast loop sampling system *In-line sampling system*

An enhancement to the fast loop system is one that combines a JetMixer, this is known as a CoJetix. The fundamental difference between In-line and fast loop systems, and the feature (if correctly implemented) which appears to guarantee success, is the design/size of the opening to the loop. An inlet size larger than 33mm diameter has been proven to give the best results.

Size	250 x 150mm	Ø33.5mm	22 x 8mm
Area	37,500mm²	881mm²	176mm²

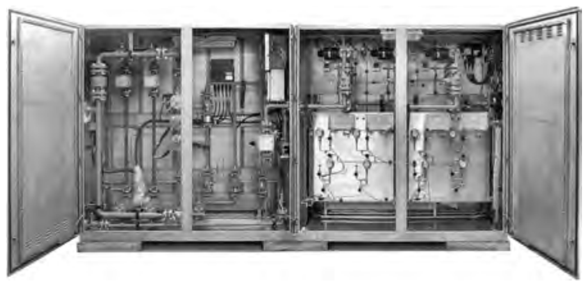


These benefits are shown repeatedly in the results taken from "proving" sampling systems by water injection.

The average uncertainty of an In-line system is-0.118% and that of a fast loop system is -0.035%

Fast loop systems also benefit from the fact that they can easily be integrated with densitometers, viscometers and on-line water measurement devices.

Much work has been achieved in the design of sampling devices, sample collection receivers, controllers and performance monitoring although older specifications still ignore what has been learned.



Integrated sampling and analysis system

The primary issue that is still overlooked is that of pipeline mixing or conditioning. Sometimes it is quite possible to locate the sampling system in a region where adequate turbulence exists to ensure that any water in the oil is evenly distributed across the pipeline, in other installations the range of flow rates that exist from minimum to maximum make it simply impossible to find a place where mixing exists without using some device to add energy.

Take for example a tanker discharge where the flow rates may vary from 250 m3/hr to 15,000 m3/hr. Under these circumstances additional turbulence energy MUST be added. Some oil production sites have seen a dramatic change in flow rates over time, normally a reduction, or a change in the process properties, for example a reduction in viscosity. However, they may have overlooked that these changes will have influenced the uncertainty of the sampling system.

There are simple ways to estimate the dispersion energy levels by use of the ISO, API or IP standard, some vendors may do this for you or you may do it yourself on websites (for example www.jiskoot.com).

This can be seen in the graph where the C1/C2 ratio is a measure of the water concentration in the top of a horizontal pipe divided by that at the bottom. Where there is significantly more water in the bottom of the pipe then the ratio tends towards zero. An acceptable number for sampling is 0.9 or greater.

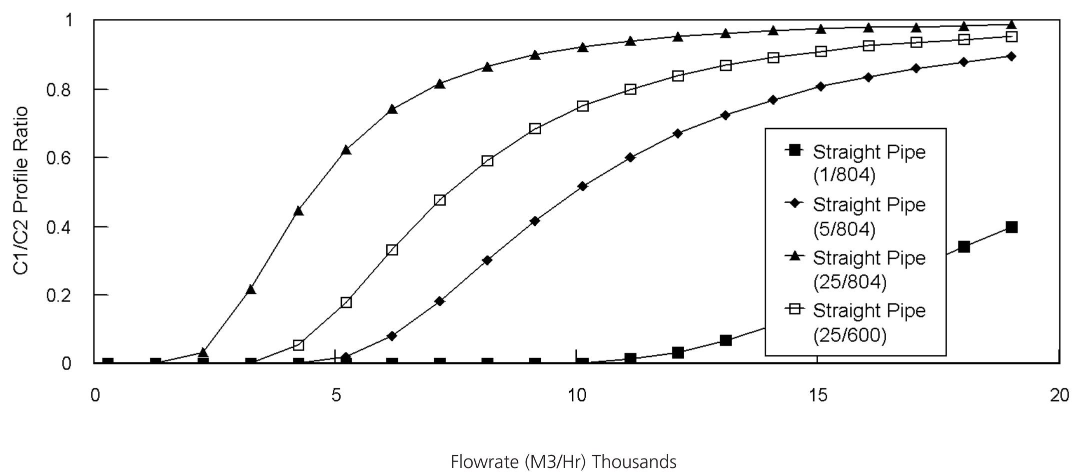
Location

Beside the issue of mixing, particularly at low velocities, water tends to get trapped "upstream" of vertical risers. Imagine a length of 42" horizontal pipe with a run underground and a riser as the figure. This installation was originally sampled by an In-line probe downstream of a static mixer on the upstream side of this loop. It had failed several attempts to prove it. It was apparent that given the range of flow rates the static mixer would be incapable of providing adequate dispersion over the full flow range.

A new CoJetix system was purchased but due to site constraints was installed downstream of the underground loop which of course forms a potential trap for water. As part of this installation an on-line water monitor and a densitometer were implemented along with a sophisticated data monitoring and collection system. This gives us a very accurate representation of the changing density and water contents.

The basic mechanics of the underground loop caused problems of its own. Imagine if there was no oil flow in the pipe and water was pumped in, we would all expect that the water would settle evenly across the

Crude Oil/Condensate
Profile ratio vs Flowrate C1/C2 from ISO 3171



bottom of the pipe. At low flow rates the water slowly accumulated in the pipeline, but not all of the water is deposited.
As the total volume of water increases this results in a rise in the oil velocity over the water layer, which will result in two effects:

- The rate at which water is deposited will be reduced.
- The degree of turbulence at the interface leads to the creation of wavelets (slugging /noise) that result in a less stable water content.

Unfortunately the regime was never given sufficient time to develop fully where it seems likely that increasing instability and higher water concentration slugs would have formed.

This can be seen clearly in the graph showing the input of water injection against recorded output from the water cut monitor.

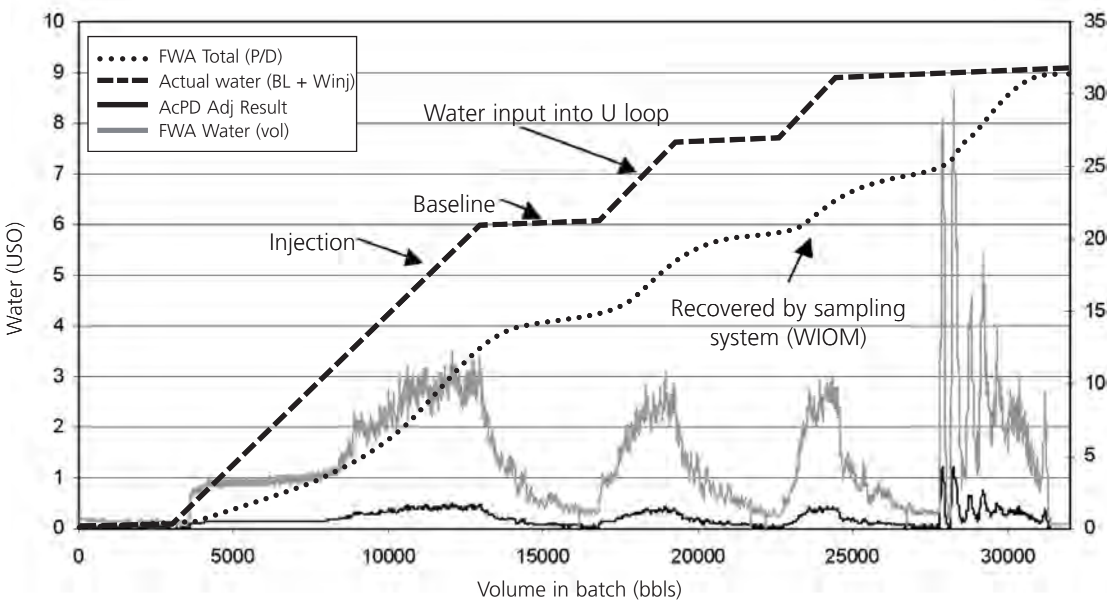
In the final phase of the test the flow rates in the pipeline were progressively increased until all of the water that had been injected had been recovered. This was a clear indication of the retention problems. The whole process would have been missed had a water-cut device not been available and the sampling system would clearly have failed a water injection testing procedure. Because the phenomenon was "visible" this enabled the testing agency to modify the testing procedure to ensure that the loop was cleared before and after the injection test. What it also highlighted in this case is the requirement that the logistics of ship unloading needed to be controlled and understood to allow the sampling results to be meaningful.

Longer term testing against the current fiscal system using an in-line probe downstream of a static mixer is already showing significantly higher water recovery for the new CoJetix system.

These are but a quick view of the main issues at no great depth, but should serve as a warning. Sampling is more complex than it first appears. There are many influences and constraints in designing an accurate sampling system. You can learn more by visiting the "teach me" section of the Jiskoot website on www.jiskoot.com

The author would like to thank all those that gathered data on the water trap testing but in particular Gary Potten, Director, Project Operations, Jiskoot Quality Systems USA.

Water injection testing



MEASUREMENT SYSTEMS
DIVISION HEADQUARTERS
HOUSTON, TEXAS
+1 800 654 3760

JISKOOT QUALITY SYSTEMS
HEADQUARTERS
TUNBRIDGE WELLS, KENT, UK
+44 1892 518000
ms-jiskootinformation@c-a-m.com

JISKOOT QUALITY SYSTEMS
US TECH CENTER
HOUSTON, TEXAS
+1 281 582 9500
ms-jiskootsales@c-a-m.com

USA • CANADA • UK • CHINA • UAE • ALGERIA • MALAYSIA • INDIA • KENYA
www.c-a-m.com/jiskoot