



Crude Oil Quality Measurement: Loss reduction through technology

by Jon Moreau & Mark Jiskoot

Jiskoot Quality Systems

With crude oil prices stabilising at over \$60 a barrel, loss control is high on the agenda of many companies. The Energy Institute HMC-4A Marine Oil Transportation Database Committee has been collecting and analysing world crude oil shipping data for over 20 years. Their annual report, published last month in *Petroleum Review*, shows a continued reduction in crude oil losses. This is, in part, due to the modernization of the fleet and better operating procedures but it is mainly due to the improvements made in loading and receipt terminal quality measurement systems.

Measurement of oil comprises both quantity and quality. Custody transfer valuation is based on the "useable" oil so both measures are significant to trade and integrity. Internationally recognized standards exist for crude oil quality measurement during custody transfer, primarily for water content and density.

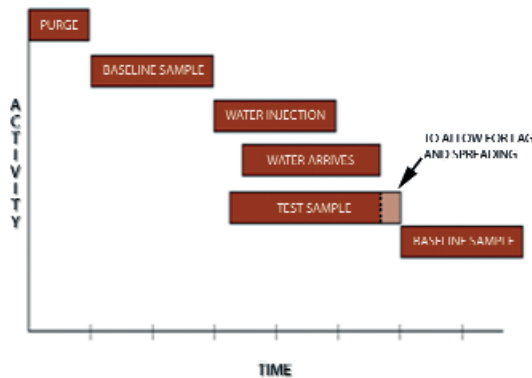
Quality measurement system design and laboratory equipment, handling techniques and analysis methods have improved significantly over the last 20 years. Simultaneously, suppliers and users have worked together to develop/validate and improve measurement performance. One of the most significant steps in achieving this has been the collation and evaluation of water injection "proving" tests. This large (often independently validated) and rapidly growing data set enables a comparative

evaluation of the performance of custody transfer sampling/on-line measurement systems. Proving the accuracy of an installed quality-measurement system is a challenge, even more so than proving a metering system. It requires adjustment of a physical property (in this case water content) and validating that the system accurately measures that change. However, unless an installed system has been proved and certified as compliant with the standards, its use to arbitrate claims or for custody transfer becomes questionable.

Over the last 20 years, the in-situ proving of quality measurement equipment, such as samplers, in accordance with the standards has become common practice. The standards define the process and acceptable performance limits for a sampling system when comparing laboratory results for a baseline sample with those containing a known injected water quantity. Preferably, this process should be independently witnessed to ensure that the procedures are followed rigorously and the results properly documented. In some countries, proving tests are conducted annually and witnessed by the local authorities to certify systems for import duty. In addition to certifying equipment performance, the data from these tests provides a wealth of comparative information about the relative performance of different system types.

Proving Process

The process of proving a sampling system is briefly outlined below. It involves the injection of a metered quantity of water into a measured flowing pipeline. It is a pre-requisite to successful testing that the baseline (background) water content of the oil does not change significantly during the process and this requires due care and validation using pre and post test baseline samples.



Water injection proving process

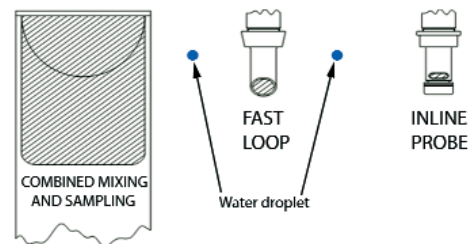
The pre, post and water injection proving samples are analysed in the laboratory. Each test generally comprises two runs and the results are used to calculate the system performance. These are evaluated against the pass/fail criteria in the standards. There is a variance between the methodologies and tolerances in the current standards, which it is hoped will be resolved shortly as the EI and API are developing a single joint standard under the Phoenix Agreement. The water injection proving process validates not only the measurement system but also the installation, laboratory and operating procedures used during the test (i.e. the complete custody transfer sampling process).

Ideal comparative data would comprise a large number of repeated tests of the same system. However, as this is not practical the collated proving results of over 200 different sampling systems from various custody transfer locations worldwide can be used to reveal interesting trends.

Historically, crude oil was a relatively cheap commodity and sampling system designs were primitive with little attention paid to the homogeneity of the water in the oil (i.e. mixing). However, mixing has now been

recognized as the weakest element in the quality measurement chain. This is normally addressed by adding a "mixing element" such as piping (i.e. an expansion loop, etc.) or a static or power mixer to ensure that the pipeline contents are sufficiently mixed. It has been thought for some time that there is a relationship between the size of the sample off-take opening, water droplet sizes and sampler performance but until now there was very little data to support this.

Size	250 x 150mm	Ø33.5mm	22 x 8mm
Area	37,500mm ²	881mm ²	176mm ²

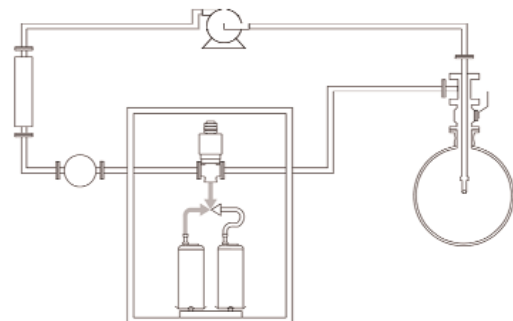


Which is Potentially More Accurate?

Sampler/inlet water droplet size

There are two fundamental designs of sampling/quality measurement system, regardless of the technology used to homogenize the pipeline contents.

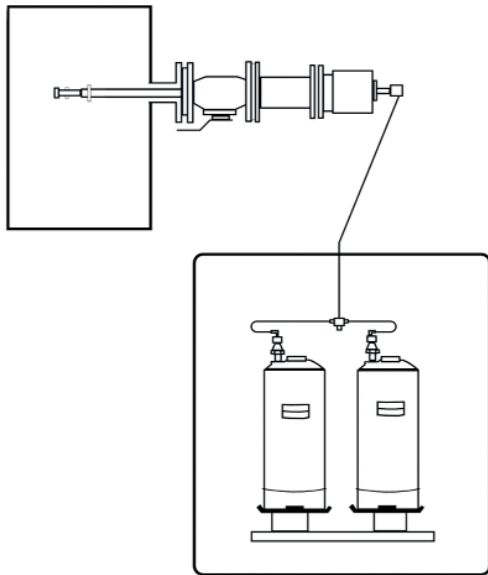
- In-line sampling system - where an insertion probe is installed directly into the pipeline to extract grab samples which are then discharged into a sample receiver, mounted in a housing located near to the sample probe



In-line sampling system

- A bypass (fast) loop sampling system - where a grab sampler is mounted in a pumped bypass loop which takes flow from the centre of the main pipeline. Grab samples are extracted from the loop and discharged

into the receiver, which is mounted in a housing through which the fast loop passes.



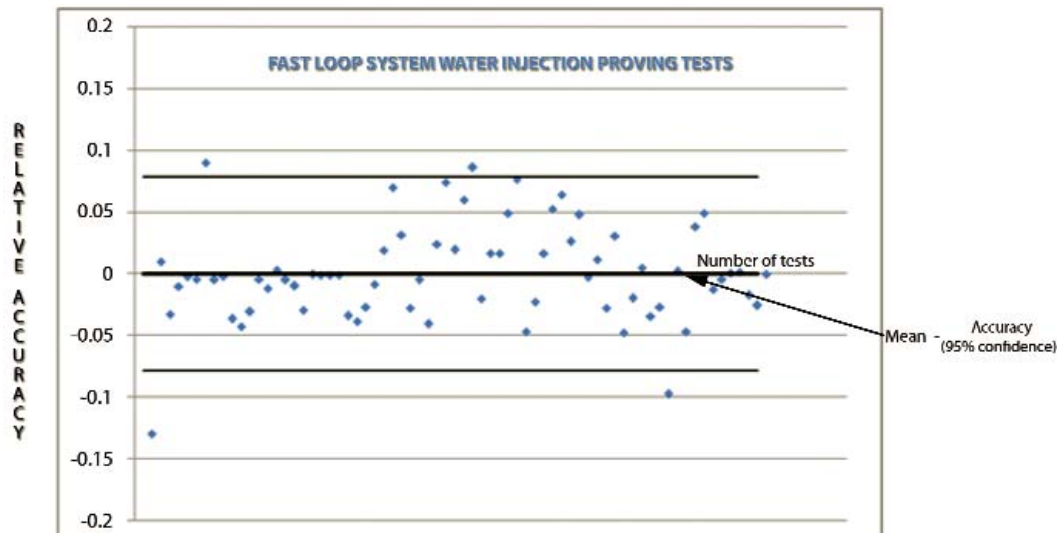
Fast loop sampling system

reading of water). Secondly, the accuracy (95% confidence) for an in-line system is $+0.05\% / - 0.113\%$ with a clear bias towards a negative reading.

One of the major differences between these technologies is that the fast loop system allows the use of a larger sample inlet size. This, in theory, enables a more representative sample to be extracted.

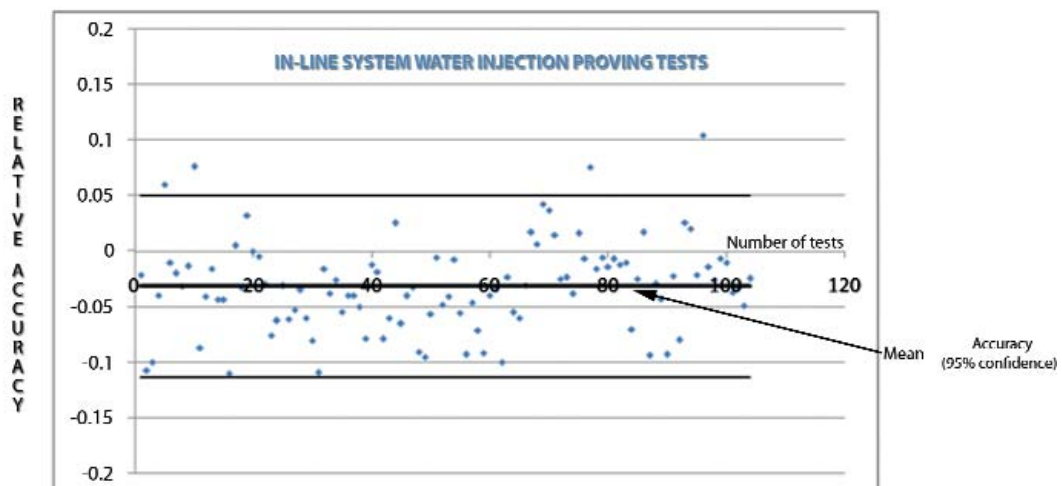
Collating the data from proving tests by type of measurement system gives a better insight into this relationship. For validity, the only data shown here are for sampling systems that have been certified for custody transfer. The accuracy/measurement error of a system that has not been proved and certified could be significantly higher than the figures shown. The water injection proving data enables us to look at the performance of these two types of system independently to evaluate any performance difference between these technologies. The basis of the proving tests is absolute water content and the accuracies shown in this article have been calculated to be relative to the actual water content.

Looking at the performance for in-line systems, two things are evident. Firstly, the average (mean) accuracy for these systems shows a clear systematic bias, with the mean lying at -0.0318% (i.e. an average under-



In-line sampling system accuracy

When looking at fast (bypass) loop systems, the larger inlet size of this type of system delivers not only a reduction in measurement uncertainty but also reduces the systematic negative bias to almost zero with the mean of -0.0003% and an accuracy of +/-0.078% (95% confidence).



Fast loop sampling system system accuracy

Some designs of sampling system perform consistently better than others; however this doesn't mean that any design of sampling system could not pass a water injection proving test. It does outline the importance of proving and certifying whatever equipment is used in accordance with the international standards. Quality measurement technology has moved along significantly in the last 25 years. It is not enough to simply suggest that sampling systems meet standards, it must now be proved.

These results show that well designed fast loop sampling systems generally have lower uncertainties and reduced systematic bias than conventional in-line systems. As a result, this technology is being increasingly deployed and the better measurement it provides will continue to drive some of the future improvements and reduction in losses that the HMC-4A committee strives towards.

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