ISOKINETIC CRUDE OIL SAMPLING

BY
DAVID J. FISH
EXECUTIVE VICE PRESIDENT
WELKER ENGINEERING COMPANY
SUGAR LAND, TEXAS

PUBLISHED IN "PIPE LINE INDUSTRY" ♦ APRIL, 1992

PRESENTED AT PERMIAN BASIN MEASUREMENT SOCIETY
ODESSA, TEXAS ♦ MAY, 1997

ISOKINETIC CRUDE OIL SAMPLING

David J. Fish
Executive Vice President
Welker Engineering Company

The sampling technique employed in extracting a representative sample for crude oil BS&W analysis has received more scrutiny in the last ten years from concerned oil companies, than any other sampling technique. The revenue implications are considerable, if the sample is not accurate. Whether it is pipeline custody transfer, tanker loading/unloading, or refinery input, a representative composite of the oil for laboratory analysis is critical.

The design of the equipment should be centered on the concept of extracting a sample from the pipeline, which is truly representative of the product. This is done by taking a sample in isokinetic conditions; actually and physically taking a sample from the flowing conditions.

Different sampling locations may present negative obstacles which must be designed around, or at least reduced as much as possible to preserve the integrity of the sample accuracy, but these obstacles must be considered and dealt with. The sampling of crude oil is decidedly more important now than it has been in past years.

The object of crude oil sampling is to determine the quality of the oil at the custody transfer point. The amount of basic sediment and water in the oil, a chemical analysis of the oil and shrinkage, and the API gravity should be determined.

The purpose of a crude oil sampling system is to withdraw from a pipeline a small representative portion of the product that contains the water, oil, and contaminants in the same proportion as is flowing in the stream.

SAMPLE SYSTEMS

When sampling crude oil, two major items must be present:

1. The pipeline must be conditioned so that the point of sample is representative of the composition of the pipeline.

2. A sampling device must be able to sample the product under pipeline conditions (pressure, temperature, viscosity and contaminants) and also take a complete sample while not destroying the benefits of the conditioning system.

A Sampling System should be designed and developed on these two principles. A conditioning or mixing system should be designed for crude oil service. It must provide a mixture of the pipeline which is adequately dispersed and distributed across the pipeline diameter. A sampler then grabs a sample of this mixture with a collection device designed to allow the mixture to flow through the collection point under isokinetic conditions.

Sampling is not just `another' function of measurement; it is the heart and soul of the profit figure. Crude oil sampling goes on past the pipeline, into the laboratory, analysis and accounting. It must start correctly if it is to end well! Companies have to seriously weigh the question of perceived convenience versus accuracy in analysis and the monetary savings.

The object of mixing in the line is to ensure the droplets of water are small enough to be sampled and the contaminants are uniformly distributed across the line. If a good mixture is not present, a good sample is not possible.

Piping configurations, pumps and other turbulence producing devices do not provide mixing for good representative sampling. While they do provide some mixing characteristics, they do not provide distribution and dispersion of the pipeline contents adequate for proper sampling.

The sampler should be a positive displacement pump that voids the sample "grab" area with each stroke. This is to ensure there are no contaminants left to alter the next sample.

The positive displacement pump also should be used so the sample will be pumped into the container, regardless of the pipeline conditions, ambient temperature, wax content, pour point, sand and sediment content, or other physical properties of the sample that inhibit the free flow into the container.

A properly designed insertion sampler ensures an accurate sample is being withdrawn from the flowing stream. The retractable type sampler allows for pigging, inspection, and maintenance without shutdown and isolation of the main line piping.

The world's best sampler is useless unless it sees an optimally mixed pipeline. The world's best mixer is wasted if the sampler cannot properly retrieve the mixture.

A third critical point, not to be addressed in this paper, is the sample container. Careful consideration should be taken with the type (pressurized or non-pressurized), style (mixer or non-mixer), and design (features). A poorly designed container will adversely affect your sample analysis.

SAMPLING POINT AND DESIGN

A sampler may be located in the pipeline and subjected to isokinetic velocity conditions, and yet, by design, distort the contents of the stream into the sample collection chamber. While this renders the "sampler" isokinetic, it does not help the sample at all, if the collection point does not take FULL advantage of the isokinetic conditions. The sample taken should be removed from the pipeline at a location where the flowing stream at the sample point is representative of the contents of the stream, and is at flowing conditions (velocity). The sampling device should not alter the profile or velocity of the flowing stream at the sample point, i.e., at the moment of sample. The sample should be physically "taken" in isokinetic conditions, not simply diverted or routed out from isokinetic conditions.

In crude oil sampling "isokinetic" as normally defined, is not the only critical point. A "mixed isokinetic stream" and a sampler that takes full advantage of that condition, is important!

The following are a few typical and widely differing definitions given by major oil companies worldwide, for the term "isokinetic sampling":

1. If, at the point at which the sample separates from the main flow, the velocities of both the sample and the main flow are equal, then the sampling is said to be isokinetic.

2. If, at the point at which the sample separates from the main flow, the velocities of both the sample and the main flow are equal, then the sampling is said to be 100 per cent isokinetic. Lower or higher sampling rates are expressed as percentages of the isokinetic sampling rate.

3. The withdrawal of samples from the main line shall be based upon the isokinetic principle whereby drawing of the sample occurs when the linear velocity of the liquid through the opening of the sampling probe is the same as that in the pipe at the probe opening. These systems shall follow the requirements of API Chapter 8.2.

   Samples shall be collected by a flow-proportional sampler with provision for time proportioning as a back-up.

4. A sample taken from a pipeline in which the linear velocity of the liquid through the opening of the sample probe is equal to the linear velocity of the liquid in the pipeline and is in the same direction as the bulk of the liquid in the pipeline approaching the probe.

5. A sample which contains the same proportions of the various flowing constituents as the total volume of the liquid being transferred.

6. Any technique for collecting a sample from an appropriately mixed flowing stream in which the sample collection chamber is so designed that the stream entering it has a velocity equal to that of the stream passing around and outside of the sample collection chamber.

7. Any technique for collecting a sample from a flowing stream in which the collector is so designed that the stream entering it has a velocity equal to that of the stream passing around and outside the collector. *Inline sampling* has long been the desired method for sampling of crude oil. The removal of the equipment for service required either a retriever for

> the equipment or a maintenance shutdown. *Slipstream sampling* has become an alternative because it allows the sampler to be isolated and removed for repair without effecting the main pipeline. Years ago, with oil at much lower cost, inline equipment was often left inoperable until a shutdown. At today's prices, this is not acceptable. The need to service the equipment is critical, and shutdowns are expensive and frequently impractical. Therefore, the equipment must be retrievable either manually, mechanically or by an automatic insertion device, or it must be in a system which can be isolated.

There is, however, a major issue of sampling crude oil which is being overlooked in the interest of maintenance; that being the integrity of the sample. A truly isokinetic sampler should be placed downstream of a mixer and retrieve a sample from the pipeline at that point. This is the point where the mixture is at its' best, and that is where an isokinetic sample should be taken for the best result. To divert the sample to a bypass and physically sample the product at a removed point raises serious questions about the mixture at that remote point.

Several tests were run in the mid 80's comparing *inline sampling* and *slipstream sampling.* The results showed that little or no difference was seen between the two systems.

There is one very major point which was overlooked in this issue. The *inline sampler* and the *slipstream probe* were both located in a large diameter pipeline which was void of any line conditioning. The fact that both samplers had similar results is totally predictable, as neither unit was introduced to the free water flowing at the bottom of the pipeline. It went undetected.

Whether the user favors an *inline sampling* device or a *slipstream sampling* device, the main pipeline must be conditioned for distribution and dispersion of the water across the diameter of the pipeline. Without this having been done, the integrity of the sample is positively in question.

The important issue related to the *slipstream sampling* system is that, if you avoid the use of the main line mixer, the whole sampling issue is open to serious question and debate. A *slipstream sampling* system requires the same main line conditioning as an inline probe sampling system. From that point on, a slipstream system becomes a very difficult and expensive system to install and maintain. The slipstream system must be truly representative of the main pipeline. This requires several additional considerations in design.

A probe must be properly designed to divert the flow out of the pipeline into the slipstream. The inlet of the probe is to be formed so as to cut a coupon from the stream and not encourage or discourage water entry other than that which is representative of the amount in the pipeline.

The flow in the slipstream must be controlled and duplicate the velocity in the pipeline. If the slipstream pump is too slow, a bow wave effect will be present at the probe entry, free water will negotiate around the entrance and a low water cut will enter the system. If the pump is too fast, it will create a suction of the probe entry, encourage free water into the entrance and a high water cut will enter the system. A slipstream system thus requires an variable speed motor and pump, along with a controller. This also requires additional power and maintenance over the life of the system. Conditions of a 30:1 plus turn down ratio in flows will simply add wear and tear to the pump and motor in this service.

The slipstream system requires additional piping, valves, meter signal for flow rate and a redundant mixer immediately in front of the sampler, to re-mix the slipstream.

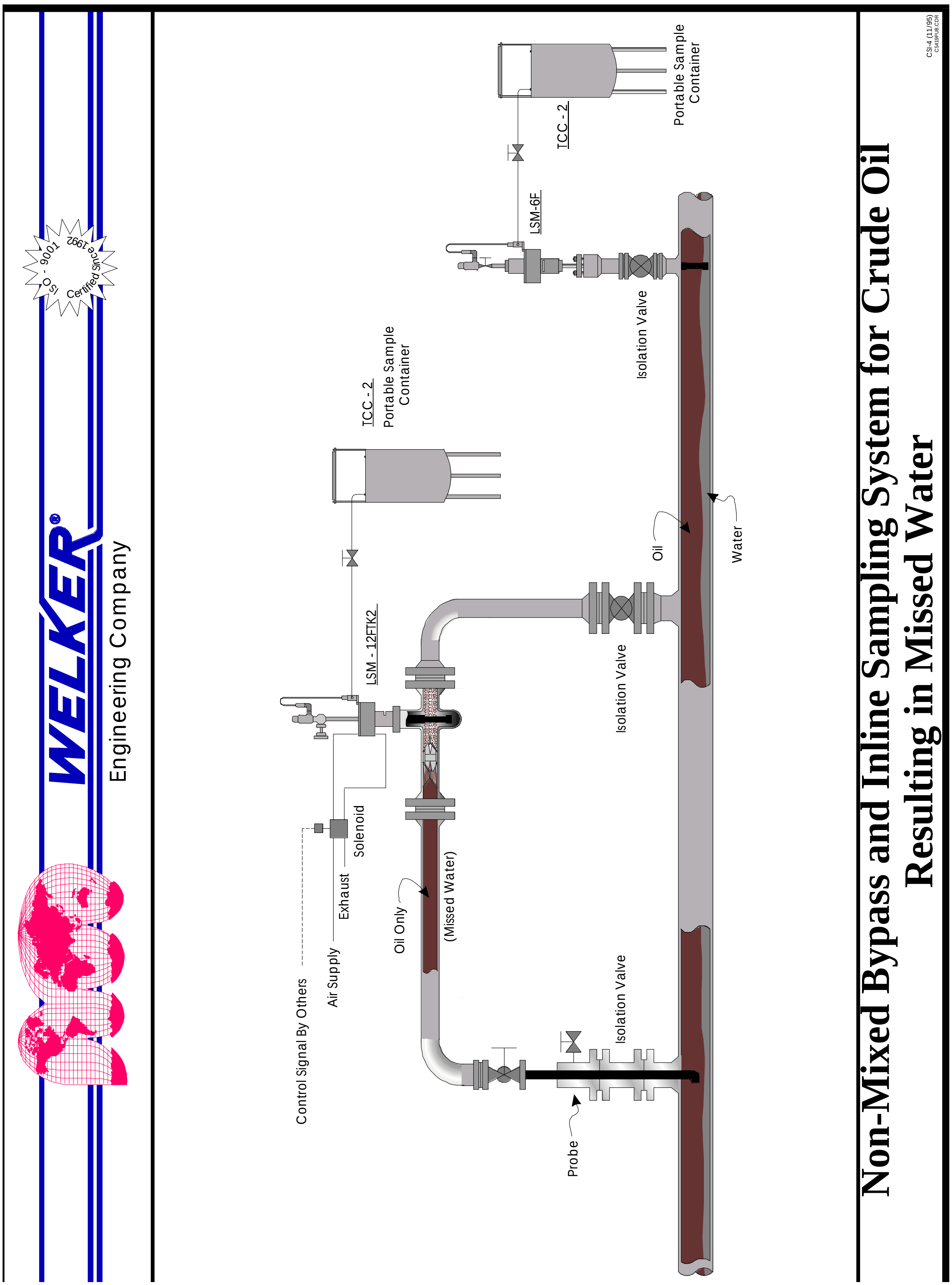
Unless the slipstream is at optimum performance, it falls short of the product which is present at the outlet of the main pipeline mixing system. A handful of unnecessary variables have been added to the sampling system to cause a doubt of the integrity of the sample, as well as increase the difficulty of proving the system. A properly designed slipstream can be a truly isokinetic system, but it will also be more expensive and maintenance prone. An inline sampler which is removable under pressure, is an easier installation, and also provides a truly isokinetic sample point for the actual physically taken sample. The sample which is available here will never be any better and, in reality, can only become worse. This approach has been tested and shown superior in the test results for years.

CONCLUSION

Without adequate mixing for distribution and dispersion of the total product, no sampler can provide an accurate sample. Likewise, a sampling device which is not designed and positioned for *isokinetic sampling* of crude oil cannot provide a representative sample of the conditioned pipeline.

Sampling is truly an art. Failure to use proper techniques can cost companies huge sums of money daily. Sampling is too critical to be left to guess work, old outdated methods, or unproven techniques.

DJF/edo


WELKER
Engineering Company
ISO - 9001 Certified Since 1992
Control Signal By Others
Air Supply
Exhaust
Solenoid
Oil Only
(Missed Water)
LSM - 12FTK2
ICC - 2
Portable Sample Container
Probe
Isolation Valve
Isolation Valve
Oil
Water
Isolation Valve
LSM-6F
ICC - 2
Portable Sample Container
Non-Mixed Bypass and Inline Sampling System for Crude Oil
Resulting in Missed Water