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Experiences with Compact Provers on Live Crude Oil

1.3.

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Introduction

The Dutch offshore oil industry was faced with a rather unique problem concerning the proving of their offshore metering systems in 1983.

Three offshore platforms which had been pumping crude oil into a common export pipeline required that their existing metering be upgraded to fiscal standards. The fiscal metering point was to be moved from the onshore terminal back to each separate entry into the pipeline offshore. In addition another operator would be using the same pipeline.

The platforms were built without the need to take account of the space requirements of a self contained fiscal metering and sampling system. Space for additional equipment was therefore at a premium. Indeed none was available in the immediate vicinity of the existing operational meters. The total head from the surge tank with additional top pressure used to circulate the oil through any additional metering equipment was limited. Extra weight also needed to be kept to a minimum. The choice of pipe prover, however, was limited by the constraints of space and weight on all three platforms.

During 1982/83 IJkwezen, the Dutch Weight and Measures Dept. were completing calibration trials on a compact prover. Government certification by IJkwezen was issued in Mid 1983.

The combination of these events set the scene for the beginning of the first known permanent compact prover installations offshore to perform all proving operations on crude oil p.d. meters.

Compact Prover Installation

Due to its small dimensions and relatively low weight, the 12 inch prover skid was installed offshore without any need for structural alterations to the platform in order to gain access to its final horizontal resting position.

The prover hydraulic system was drained temporarily to avoid spillage during the actual installation period.

A 90° elbow was fitted immediately downstream of the prover outlet flange to enable the flow tube assembly to be removed easily. Future inspection of the internal prover flow tube required that the rather heavy outlet flange be removed. A sliding overhead hoist was needed.

All the electrical control and safety barriers were removed from the prover skid and relocated in the control room, to enable the operators to prove meters from the control room, and control all water draw sequence testing.

Additional Control Meter for Monitoring Purposes

As there was no user experience for a compact prover operating offshore in continuous crude oil service there was a need to demonstrate that the prover base volume had not changed due to any malfunction.

By incorporating an additional meter in the proving line between the operational meters and the prover it was possible to monitor the base volume of the prover by comparing the respective K factors when proving both the operational and control meters simultaneously.

However, after gaining reasonable confidence in the compact prover results it was decided to discontinue these checks.

Regular water draw checks and seal leak checks are made to confirm if there is any shift in volume, or leakage across the seals.

Commissioning

All piping from the metering manifold to the prover was new and hence thorough flushing of the pipeline was essential to prevent any foreign matter entering the meter tube.

All optical sensors were inspected and found to be in excellent condition having survived a sea journey and several crane liftings.

Water draw calibration tests were carried out to verify the certified volumes established at IJkwezen's laboratories, and to ascertain that the vibrations caused by the shipping pumps situated directly under the prover did not effect the accuracy and repeatability of the prover.

A radio link between the control room and compact meter prover skid was found to be essential during water draw tests. This was certainly a disadvantage due to the high level of noise in the immediate area of the skid.

A local water draw control unit with optical switch status lights is envisaged in the future.

Water Draw

The cleaning and flushing of the provers have been completed extremely quickly and efficiently. "Down-time" of the provers have been kept to an absolute minimum. The stored water quantities required for a water draw are relatively small.

A calibrated measuring tank traceable back to the authorised standard is available on each platform. The water draw method is entirely self contained on the platform. There is no likelihood of delays to meter proving operations due to bad weather whilst waiting for a master meter/master prover skid unit delivery to the platform.

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Seal Leak Test

In order to make the seal leak check more efficient and easier a permanent installation consisting of micrometer feeler gauge and rods of different lengths were made available.

This avoided the protecting tube having to be removed and also lessened the chance of any accidental damage to the optical switches.

Calibration Trials

In order to achieve some operating experience before the fiscal metering point moved offshore, a series of calibration and meter proving trials were started.

As there were no internationally accepted rules for a minimum number of "runs" and passes, it was decided initially to prove all meters with 5 runs (equivalent to pipe prover requirements) and 6 passes (a minimum requirement by IJkwezen based on a minimum number of pulses per swept volume).

The number of runs and passes were varied with no effect on repeatability or "K" factors. 3 Runs and 6 passes have now been accepted by all interested parties as an acceptable standard.

The unanswered questions at the time during prover trials were:

- how reliable were the piston seals?
- was the poppet valve a good design?
- what should be the frequency of the seal leak test?
- would foreign matter enter the piston tube and damage the nickel plating
- how long would it take to repair a compact prover?
- what were the downtime periods?
- what were the practical problems to water draw offshore, especially when heavy crude oil was being metered?

Operational

Within several months from the start of commissioning trials one of the compact provers displayed difficulty in obtaining repeatability. A water draw and leak test confirmed that there was a problem.

This resulted in the prover being stripped to establish the cause. Extremely small score marks were observed in the barrel. It was discovered that the cause was due to a welding particle which had not been thoroughly flushed from the new upstream piping had entered the prover tube. One very small piece had lodged itself between the seal and barrel surface. Additional temporary filters were installed and the problem has not re-occured.

A spare tube was available and replacement time of the prover tube was completed in approximately 24 hours, which included isolating the prover from the process, unbolting the complete prover assembly, hoisting a new tube into place, re-assembly and preparations made for a water draw and leak test.

Interesting facts and figures

It will probably be of great interest to see some operating statistics of the three compact provers related to operational experiences over the last year.

Commissioning/start-up trials February - July 1984.

On-line - September 1984.

Approx. number of passes per prover - 26,000.
This is based on 5 runs 6 passes per meter proved.
This has now been reduced to 3 runs 6 passes with no effect to meter K-factors.

Total downtime - 4 days.

Failures - 1 poppet valve "O" ring.
Shift in volume after prover tube replacement + 0.004 cc.

Optical switches.
One switch located at "Launch Position" became unpredictable in operation and was replaced.

RECOMMENDATIONS

Installation Prover Tube

Compact provers can be sensitive to certain abrasives in the crude oil especially when they are wedged between the piston seal and tube. As already mentioned one of the prover tubes suffered this fate, the remaining two did not.

The question arose
"Was the horizontal mounting position a bad choice?"

It would seem that a vertical positioning of the prover may reduce the possibility of abrasive substances remaining in the tube and hence lessen the chance of severe wear. It is extremely important during pre-commissioning that all piping and prover tube do not have any abrasive particles inside before the system goes online.

Summary

The compact prover is certainly fulfilling its initial role as an acceptable alternative to crude oil flow meter proving.

The distinct advantages such as size and weight were in this particular case essential in making this metering upgrade project economically feasible.

The use of a compact prover as a permanent offshore calibration standard has now been established. The metering and proving facilities have been subjected to close scrutiny from the other parties in the oil transportation agreement and the Dutch Government Authorities.

Re-certification of the prover volumes by the authorities will now be on a 6 month basis until a learning curve has been established to determine how the flow tubes are wearing.

Compact Meter Provers have certainly a part to play in the development of international accepted standards for meter proving.

There is still room for improvement in many design areas of the compact meter provers, however, the experiences gained with actual proving operations on live crude oil, have now opened the door to allow a new generation of compact provers to be developed.

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References

[1] Paper presented at the North Sea Flow Measurement Workshop, a workshop arranged by NFOGM & TUV-NEL

Note that this reference was not part of the original paper, but has been added subsequently to make the paper searchable in Google Scholar.