# EXPERIENCE WITH OPERATION AND CALIBRATION OF LIQUID DENSITOMETERS OFFSHORE

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# EXPERIENCE WITH OPERATION AND CALIBRATION OF LIQUID DENSITOMETERS OFFSHORE

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## INTRODUCTION

Accurate density measurement is of prime importance today because of its use in the determination of mass flow within multi user pipeline systems and their associated allocation agreements. The measurement of gas and liquid flow depends upon the measurement of density. In the case of gas, usually by orifice plate, mass flow is proportioned to square root of the line density. The error in the mass flow measurement resulting from error in density measurement is therefore approximately half the error in the density measurement. With liquid flow measurement however, generally by means of turbine meters, mass flow is calculated as the product of the volume flow at line conditions and the line density. Error in mass flow due to densitometer error will therefore be directly proportional to the densitometer error. Errors in liquid density measurement can therefore be said to have twice the significance of gas density measurement when considering the overall uncertainty in flow measurement.

Before a system can be operated successfully, it must first of all have been installed properly. We would therefore, firstly like to talk about some of the points that should be considered when designing a densitometer installation.

## PROCESS LOCATION AND DENSITOMETER LOOP DESIGN

Carefully choose the location of the densitometer in relation to other items of process plant. It may be possible, as in figure one, to utilize the differential across an existing piece of process equipment. This simple installation is however, only of use where there are no wax problems, as there is no facility for flushing the loop with a solvent. In difficult conditions it is more advisable to utilize a design along the lines of Figure Two, which has facilities for solvent cleaning. This second design does not require a process differential pressure to operate as the integral pump circulates the oil through the loop.

As with any type of sample loop, before a representative sample can be obtained, great care must be taken in positioning the input to the loop. Ideally, this should be about 4 - 5 pipe diameters downstream of a point in the process where mixing is occurring (eg pump discharge, restriction orifice, control valve, turbine meter etc). An elbow may not be acceptable as a mixing device as water separation may occur due to certrifugal effects.

For best results under most conditions, the probe should be mounted horizontally with the pipework falling away from the probe. This arrangement helps to ensure any entrained water that is collected by the probe passes through the loop. With a vertical probe, under certain conditions the water may build up at the probe and fall back out of the loop. This can, however, usually be avoided by flow in excess of isokinetic velocity.

The length of pipework between the sample probe and the densitometers should be kept to an absolute minimum. This requirement is to eliminate, as far as possible, any problems regarding pressure and temperature equalisation. Temperature and/or pressure differences between the volumetric meter and the density meter should not cause a mass metering error in excess of 0.03%. In addition, if pyknometry is to be accomplished successfully, the length of pipework between the densitometer outlet and the pyknometer inlet must be the absolute minimum.

Any valves fitted between the probe and the outlet of the densitometers and/or pyknometers should be of the full bore type. If any other type of valve is used flashing may occur which will result in the loss of density measurement. In line with the above, any flow regulation for the loop should take place at the point of return to the process.

Very often in densitometer fast loop installations other analytical instruments are fitted to the loop (eg water in oil monitors and samplers) these instruments should be fitted after the densitometers. The reason again being that the flow path within these instruments may result in flashing and/or changes in temperature and pressure.

In use, various problems associated with the nature of the process medium may occur. These problems can generally be grouped as follows:

1. DEPOSITION OF FOREIGN MATERIAL ON THE DENSITOMETER INTERNALS

The two substances which are most commonly deposited on the densitometer tubes are wax and scale.

The first of these two substances, wax, is the most commonly experienced and is thankfully relatively easy to remove. The wax is best removed by either flushing with a solvent or by mechanical cleaning. If it is suspected wax deposition is going to be a problem, it is worth considering a system along the lines of Figure Two, which includes integral solvent flushing facilities. The amount of wax deposition may be reduced by careful design of the pipework and flow path in relation to the densitometers.

The second substance, and more serious of the two is scale. However, experience has shown that the level of scale formation in metering systems, including the densitometers, can be reduced and in some cases eliminated by the injection of a scale inhibitor. Once scale has formed on the densitometer internals it results in an erroneously high density reading and is extremely difficult, if at all possible, to remove on site. As scale formation takes place on all process steelwork, including the turbine meter, on which a relatively small amount of scale can shift the turbine meter factor dramatically. This shift, if it occurs can be used as a warning that scale formation is taking place.

If there is suspicion that either of the above problems has occurred, a relatively simple check can be made on the operation of the densitometer. This check is accomplished by isolating the densitometer from the process and after it has been thoroughly flushed and cleaned, allow dry ambient air to enter the tubes. Then, by measuring barometric pressure and ambient temperature, together with relative humidity if necessary, the reading of the densitometer can be compared to published tables.

2. CORROSION

On systems where the level of water in the crude is significant crevice corrosion of the tubes has been shown to be a problem. This corrosion occurs most when the densitometer is out of service as the water and oil separates. There is very little that can be done to prevent this corrosion, due to the limited choice of densitometer materials available. Therefore, the metering engineer should be aware of the possibility of corrosive produced waters.

3. FLASHING OF THE CRUDE WITHIN THE DENSITOMETER

When the phenomenon of flashing occurs, the gas bubbles that are created within the densitometer result in a loss of density measurement. The flashing off of gas from the oil occurs because the pressure of the oil has fallen below the vapour pressure. As previously discussed, this situation can be created by a poor design of system. However, flashing can also occur on live crude systems during a plant trip, as the pressure of the oil in the densitometer falls close to, or below, the pressure of the oil in the separators. In this event, great care should be taken to ensure this gas is fully flushed from the densitometers immediately on start-up otherwise a significant metering error will occur.

ROUTINE CHECKING OF DENSITOMETERS IN THE FIELD

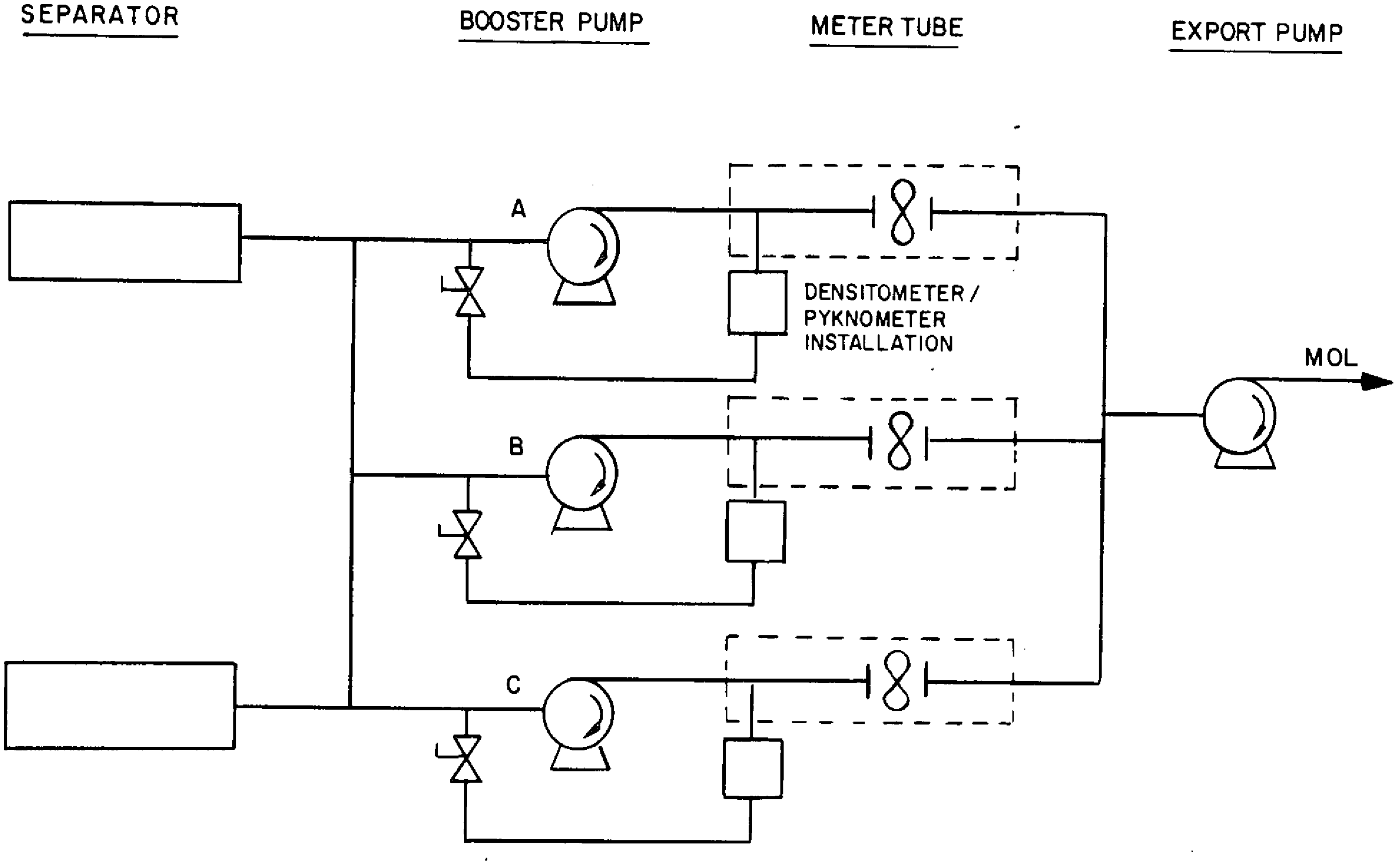
The types of densitometers used almost universally in offshore applications (ie vibrating tube type) are factory calibrated and sealed, allowing no real ability to adjust on site. Each unit comes with its unique calibration certificate upon which the appropriate coefficients are given to allow the conversion from frequency to density to be made. The calibration method employed by the manufacturer is a sophisticated process involving extreme pressure and temperature stability combined with the use of pure calibration liquids. This means that successful verification of density transducers in the offshore environment is extremely difficult to achieve.

Although some very highly commendable work has been reported in the field of offshore pyknometry[1], the fact remains, that it is a difficult practical operation to achieve with any degree of success, and should therefore, not be entered into lightly. In addition to any pyknometry carried out, if the densitometers are to perform correctly, it is important to monitor and, if possible, cross compare their output density readings. This can be achieved by carrying out air density checks, the regularity of which being decided by experience, and also cross comparing the output from parallel meter runs. If it is not possible to compare meter runs in parallel, then during periods of stable flow conditions it may be possible to change tubes and compare density readings. This practice of comparing density readings on a frequent basis is invaluable, particularly where scale is a problem, as both densitometers on the one stream may drift high to the same degree. On installations where pyknometry is not carried out, the practice of returning densitometers to the manufacturers for routine (typically annual) recalibration may be a solution.

Perhaps, as a final note on the verification of densitometers, the specialist metering companies who already carry out annual recalibration of the platform provers may consider offering the additional service of a pyknometry calibration for densitometers.

REFERENCES

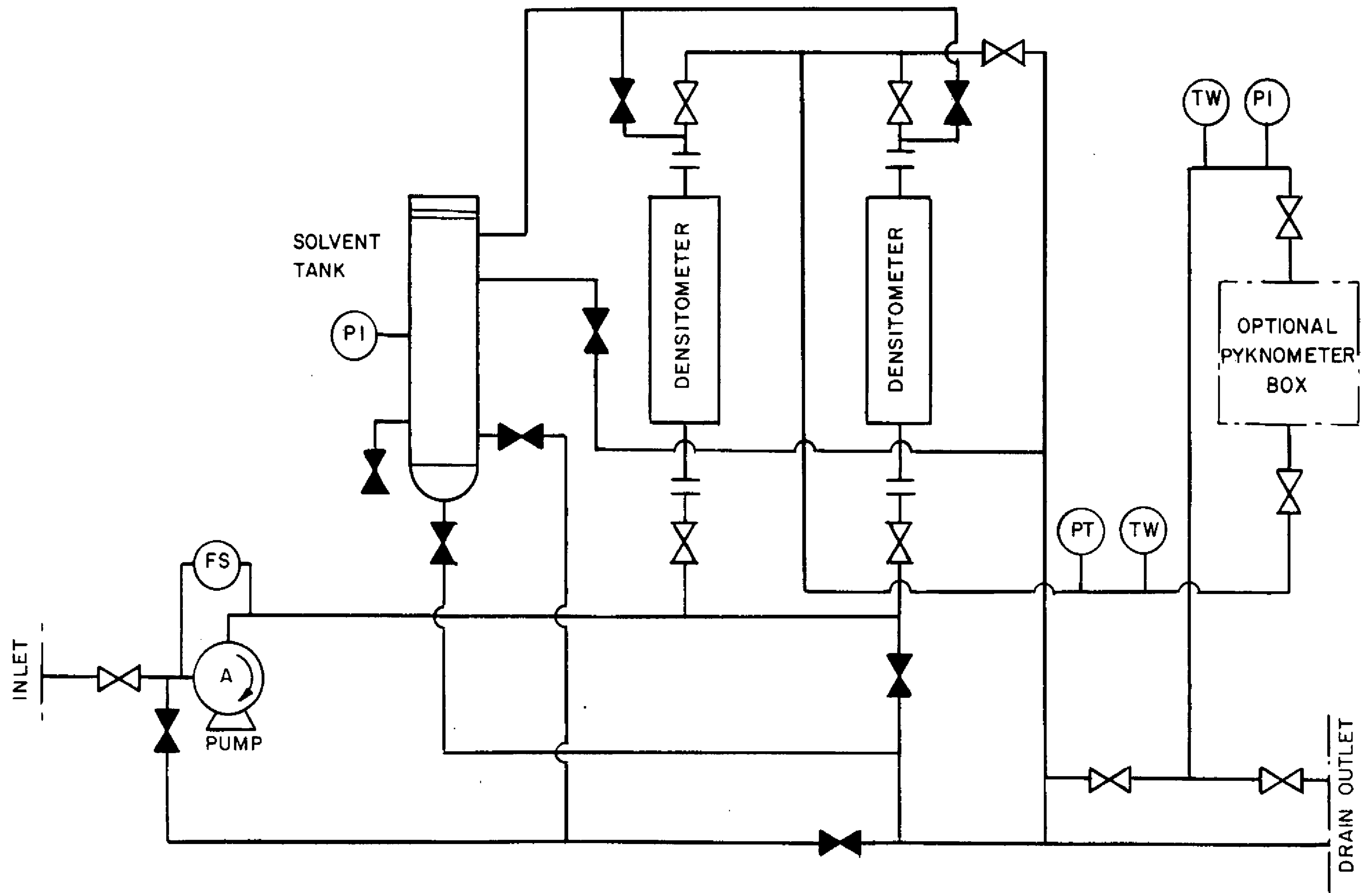
1 INSTITUTE OF MEASUREMENT CONTROL, May 1983, Boulter and Greig. "Validation of inline density meters by high pressure liquid service pyknometers".




SIMPLE DENSITOMETER INSTALLATION

( SUITABLE ONLY FOR LIGHT CRUDES WITH NO SUSPENDED SOLIDS )

FIG. 1




DENSITOMETER INSTALLATION WITH INTEGRAL PUMP AND SOLVENT TANK

FIG. 2