MAPPING:

A VALUABLE TOOL FOR PRODUCED WATER SYSTEM TROUBLE SHOOTING

Presented by: Jon Berntsen, MATOR AS Norway

The word MAPPING might sound peculiar, but it is a way to try to put a large number of operations into one word. It is literally a methodology to “draw” a map of an existing installation by gathering information regarding separability, emulsion stability, droplet history etc. at various stages of a separation process. To be able to do this job different tools have to be utilised dependant on field situation and if it is crude oil or produced water.

MAPPING: What can we offer the customer by doing this exercise ?

- **Provide an overview of performance and efficiency**
- **Explain the measured performance**
- **Testing of solutions**
- **Reporting, communication and transfer of knowledge**

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The complex nature and behaviour of the fluids in oil and gas processing has traditionally required a conservative approach to the design and selection of separation equipment. Critical design criteria, which can significantly influence the size and performance of a separator or even the type of technology to be used, are based upon or selected from " industry standards ". The selection of chemicals and the effect of chemicals in such a complex process are not completely developed. In an attempt to retrieve the most correct information about the behaviour of the liquids in a pipeline or in a separator at process conditions, we have, during a 14 years period, developed techniques that make this possible. As an example , for droplet size distribution measurement the use of Laser Light Diffraction Technology in conjunction with correct sampling procedures has given data with a high degree of accuracy.
The utilisation of Laser Light Diffraction Technology, which is a well proven technology often used in scientific work at laboratories world wide, gives very good and accurate results, and a good understanding of the technology's capabilities. The challenge was more related to correct sampling and sample preparation prior to analysis by the Laser instrument.

What are we looking for?

All liquid/liquid separation devices are designed to remove the dispersed phase from the continuous phase, typically water from the oil or oil from produced water. The dispersed phase is represented as droplets, with a distribution ranging from very small to larger droplets. It is very important to give an accurate measurement of the droplets size distribution, which is the critical design factor when designing separators or selecting technology.

In a typical offshore process, where pressure and flow have to be controlled, the use of control valves and pumps perform a great impact on the liquids. Figure 1 illustrates some of the conditions inside and around a process separator.

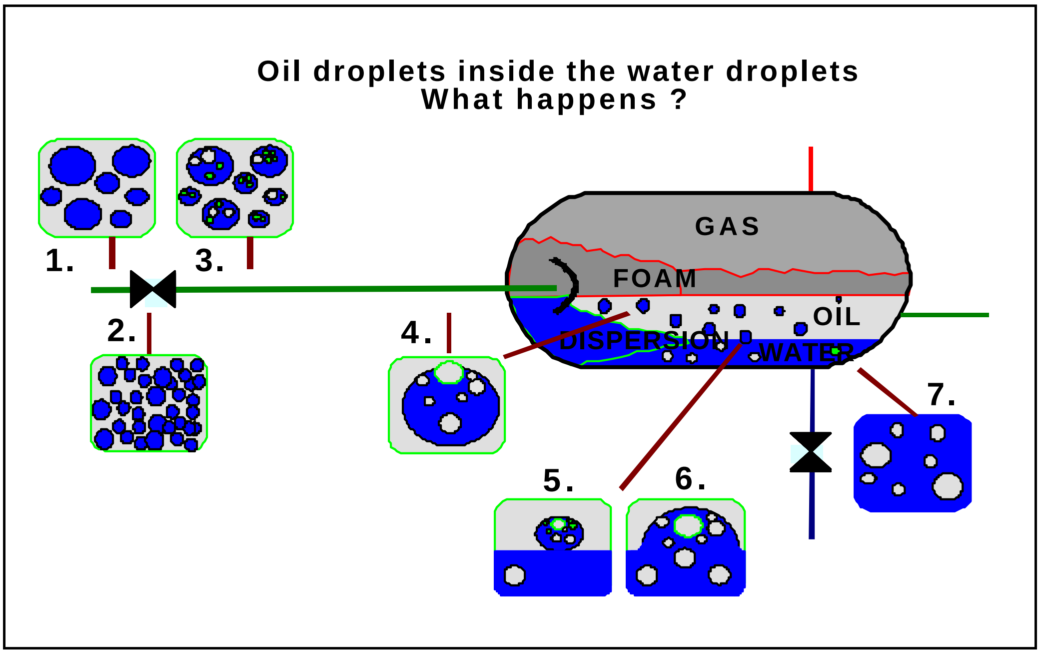


Figure 1

It is well known that the inlet control valve (manifolds) determine the generation of the dispersed droplets in the continuous phase. The creation of the droplet size distribution is very much dependant upon several factors such as: Exposed pressure drop, fluid properties, the various production chemicals impact on the interfacial tension, particle concentration (waxes, asphaltens, solids) and the construction of different equipment (sharp edges, narrow channels).

With so many unknown and normally unpredictable factor in the process, it is not difficult to understand that the calculated or predicted separation performance is often not achieved.

The frequently used method to try to ease or solve the problem to improve separation efficiency, is use of chemicals.

To some extent the chemical injection may increase the performance, but experience from offshore work indicates a rather uncontrolled effect. Experience has indicated even reduced performance after chemical use due to chemical stabilisation of the droplets, reducing or even prohibiting the natural coalescence process.

Water clarifying chemical is frequently used in conjunction with hydrocyclones. Hovever the operators and even the chemical supplier often experience that the effect on improved hydrocyclone efficiency is almost zero !. Instead the effect of chemical treatment take place in the downstream degasser/flash tank. This is another example of incorrect use of expencive chemicals, but with huge potentional for improvement if correct utilized.

Figure 2 illustrates typical fluid properties influencing the produced water quality.

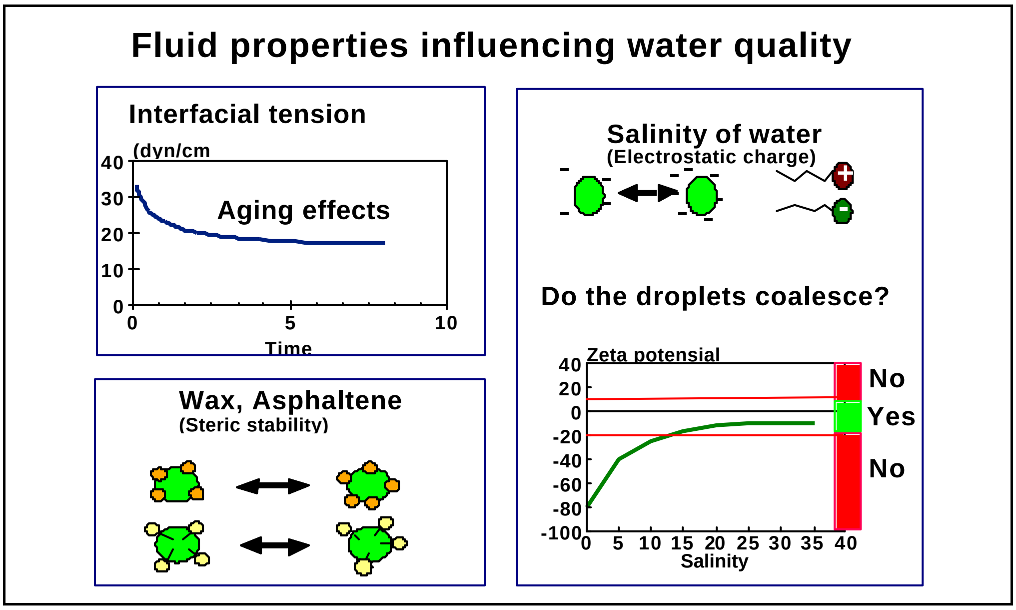
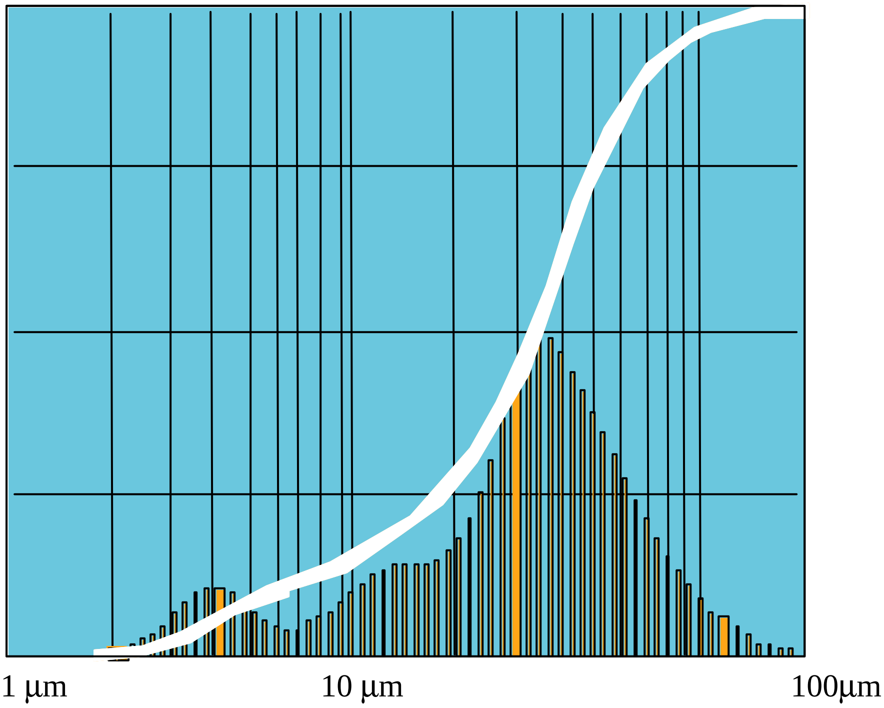


Figure 2

Laser Diffraction Technology is mostly used on water continuous systems where the turbidity makes the operation feasible. BUT, during the last years we have developed and with great success used the same technique on oil continuous systems. By use of correct reference liquid in the sample cuvette and the developed high pressure sampling method, a very interesting " look into " the emulsion system is possible. We used this technique during an extended test on an offshore platform summer 1995, where all process streams were sampled and analysed to determine the droplet size distribution in various emulsions in the process. On this specific platform, emulsion stability continuously caused headache for the operator. By use of this technique we managed to study the influence of variation in chemical injection and the effect of heat on the droplet sizes.
The study showed that the demuslifier did not influence the emulsion stability at all during variation of injection rate from 20 PPM to 100 PPM. The heat test identified an improved in separability when increasing from 90 ^{o}F to 120 ^{o}F. The parameters studied were droplet size distribution and water in oil concentration (BS&W). The droplet size analysis gave a significant signature of change during the heat test, but no change at all during demulsifier test.
Note that this was not part of a chemical optimization plan, but based on the “normally “ used demulsifier.

Figure 3 illustrates a printout from a water droplet size distribution in an emulsion.



In order to achieve this kind of information and to be certain that the correct " picture " is presented, a special sampling and sample preparation technique has to be used. We discovered very early that only a batch sampling could give the correct information compared to online measurement. The reason why is related to the following factors:

* Droplet growth in the pipeline to the instrument.

  In the initial evaluation of sampling and analysing methods to be used, it seemed very practical to use a flow through high pressure cell in the Laser diffraction analyser. We discovered early that the rate of coalescence in small diameter tubing was very high and very much related to the concentration. Various types of tubing material was tested, but the method showed unreliable. Even effect of shearing by flow control valves was experienced, often seen as gas bubbles due to minor pressure drop across the valve.

* Flotation and coalescence in the sample cylinder.

  When sampling from high pressure (> 3 bars) pipelines the effect of valve shearing and gas liberation must be controlled. A conventional high pressure sampling vessel can handle the shearing problem, but not the gas liberation. Since the pressure has to be atmospheric prior to the analysis, gas must be released. This gas release cause excellent condition for flotation and coalescence in the sample vessel, hence, influenced droplet size distribution.

Consequently we had to develop a new sampling technique that could comprise sampling at high pressure without any shearing and avoid the phenomenon related to flotation and coalescence, literally " freeze " the sample. By use of distilled water this requirement is fulfilled ref. figure 2 above by the curve showing the coalescence versus salinity.
The situation is to some degree similar in oil continuous system, but the stabilising liquid has to be defined case by case. Handling and analysing the sample in oil continuous system must be done fast and with a very high degree of consciousness.

As a method to verify the exactness of the results obtained with this technique during testing of produced water, IR (InfraRed) analysis is often used. The software in the Laser Diffraction Analyser can present the concentration of dispersed phase in a volumetric value to be compared with the dispersed concentration from the IR analysis.
It is essential to use different techniques to verify the results. The consequence of basing all action upon one technique or method might be crucial.

Figure 4 illustrates the high pressure sampling principle and a typical printout.

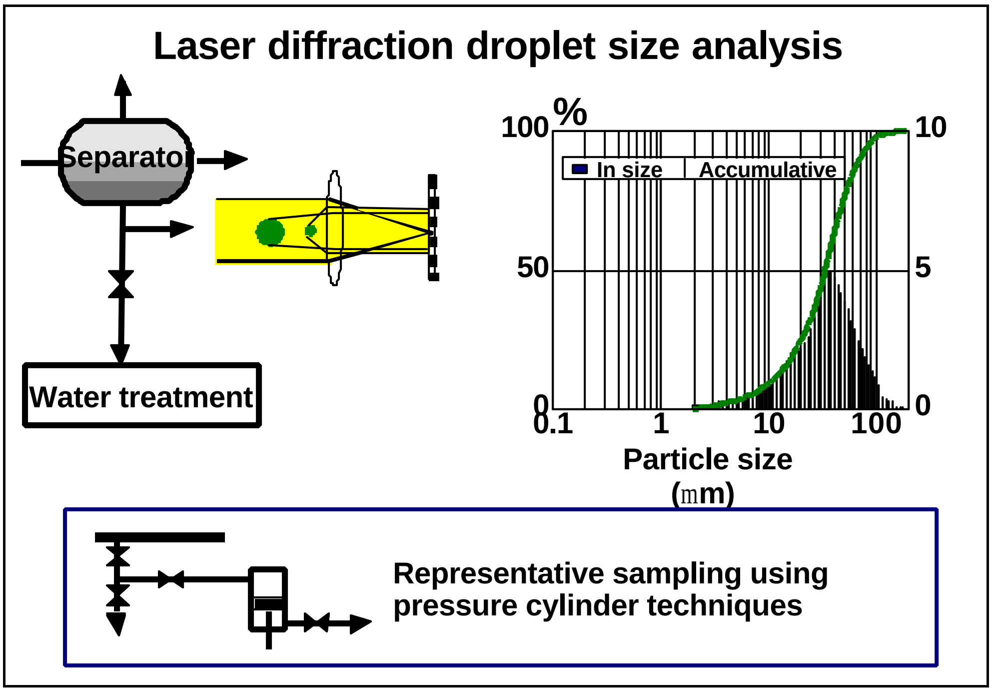
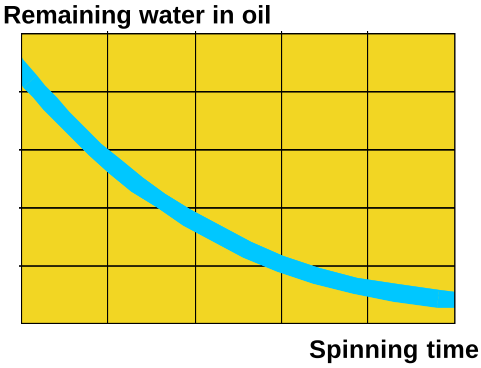


Figure 4

The benefit by employing this technique is that the KEY to understanding of the phenomenon that originates at various places in the process can now be gained.
That comprises the actual effect of chemical influence, pumps, control valves, reject streams, all phenomenon causing a degree of energy dissipation in the process.

The combined technique has with great success been utilised in the North Sea in defining the actual source to problems and in testing of equipment and technology prior to installation in the process. The investment in defining the actual situation is very small compared to the cost of fighting the problem.



Separability graph

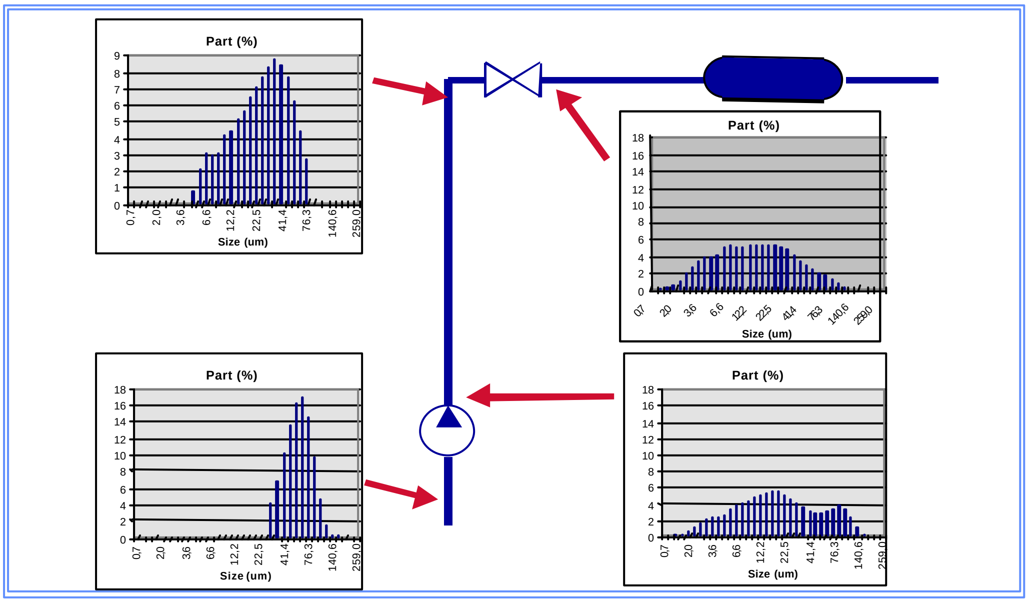
<u>Centrifugal force + heat</u>
Force: up to 1500 g at 3,000 rpm
Heat : up to 100°C (212°F) ± 1°C
Glass tubes: 7 different types
Weight: 32 kg

During the last two years we have increased the use of an “old “ Alfa Laval tool: The HOT SPIN centrifuge. Initially designed to deal with unspecified fluids, known as SLOP OIL, the centrifuge has a unique opportunity in the oil field business. However to be able to understand the whole picture it has to be used together with the Malvern instrument and some specially developed software (PARTFOR).
Emulsion stability is information that is very useful for the operators to have access to. Used in conjunction with chemical treatment it provides quick and accurate information about the possible effect by chemical stimulation.
It is a way to make black magic ”visible and understandable”

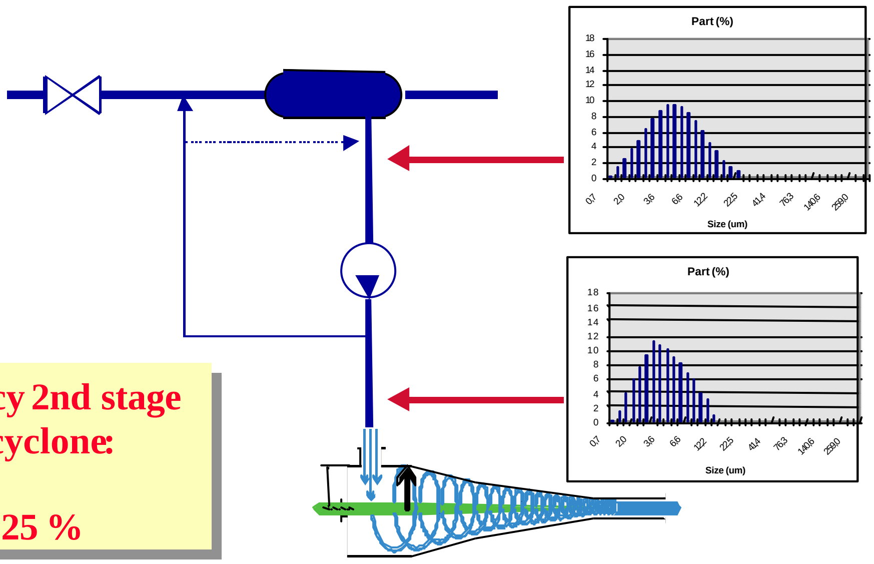
The following illustrations are examples from survey’s offshore where presentations are based on drople size distribution throughout the process, online separtion testing and an example from testing of a new field to be developed.

The versatility of MAPPING is infinite.

Emulsion stability - droplet distribution



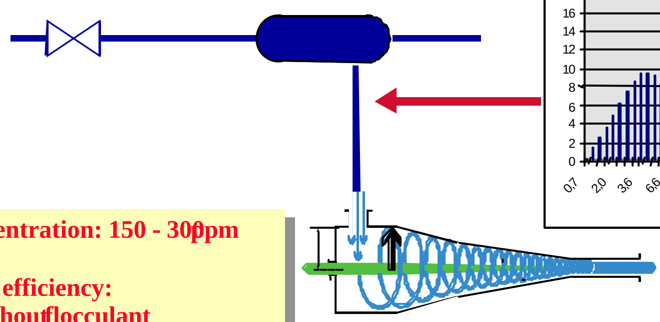
2nd stage hydrocyclone

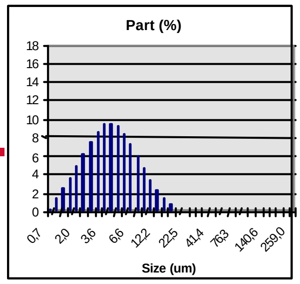


Effiency 2nd stage hydrocyclone:

25 %

Produced waterhydrocyclone





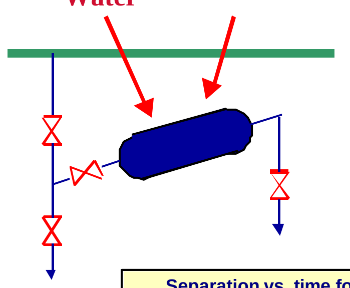
Inlet concentration: 150 - 300ppm

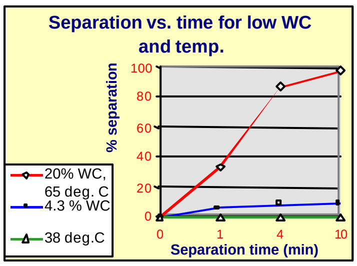
Measured efficiency:
• 40 % withoutflocculant
• 50 % withflocculant

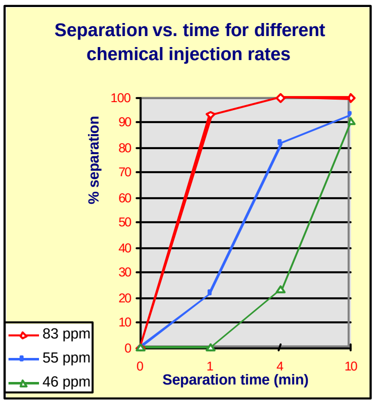
Required efficiency: 80 - 85 %

Operating problems:
• Low pressure
• Obtain sufficient reject flow
• Determine ideal number of liners

MTS - online separation testing

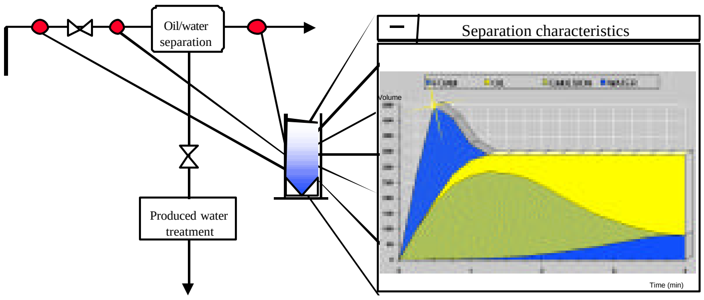






Separation testing

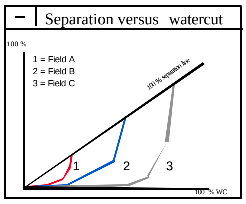
Diagnostic tool for separation characterization



Test rig for realistic evaluation of separation properties

Oil/water separation, emulsion properties, and foam formation is presented as a function of:

- Pressure and temperature
- Pressure drop across a choke valve
- Water cut
- Production chemicals



This test opens a new opportunity to “look into the future” with respect to increasing water cut. A plot for “separability versus watercut” can easily be obtained.

A process can be designed with input from this scientific method, which dramatically improves the probability for an ultimate design. This method has been verified for installations “on stream” in the North Sea.

The test has become one of the best tools for obtaining data for *new generation separator* design. I.e. :

Foam volume and degradation time.
Critical watercut (point for 100% water separation).
Emulsion properties at different watercuts and after commingleing of different formations.