On-line Oily Water Monitoring - Field Experience Using the Jorin ViPA.

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Abstract.

During the calendar year 2001, the Jorin ViPA has had extensive field use during trials, process evaluations and in permanent installations.

Extensive work has been done in BP installations onshore in the UK and offshore in the North Sea. Further work has been done in the North Sea with Enterprise Oil, Statoil and other offshore operating companies[1]. Work has also been carried out onshore at a test facility in Tulsa and offshore on several platforms in the Gulf of Mexico[2]

Data from some of this fieldwork is presented to demonstrate the ability of the ViPA system as an oil-in-water concentration monitor and further data illustrates the value of the additional information that the system provides, in terms of: oil droplet size distributions, solids size distributions and solids concentration.

The oil-in-water concentration data reported is accompanied by laboratory analysis of the same samples and, in all cases, shows strong correlation between the online ViPA data and the laboratory analyses.

The measurement of oil droplet sizes allowed an immediate determination of the cause of a process problem, where oil droplet sizes were seen to be increasing through a hydrocyclone separator vessel it was quickly determined that the reject orifices had blocked and that the vessel was acting as a coalescer.

The measurement of solids sizes and concentrations has highlighted the effect that high solids loading have on the oily water separation process, in nearly all cases high solids loadings have coincided with poor separation process performance.

During the onshore work information on solids sizes and concentrations has offered insights to the nature of solids present in the water and potential treatment regimes to cope with these types of material.

Acknowledgements

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Introduction

The ViPA is an on-line system that uses a video microscope assembly to capture 'still photographs' of the contents of a water stream. Each photograph or image is analysed by the ViPA software package and data on the droplets and solid particles in that image are recorded to database. Between 14 and 25 images are analysed each second and in this way a large database of information is rapidly built. Information that the ViPA system can report includes the

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[1] In some cases permission has been granted to present field data on the proviso that the data source is not reported.

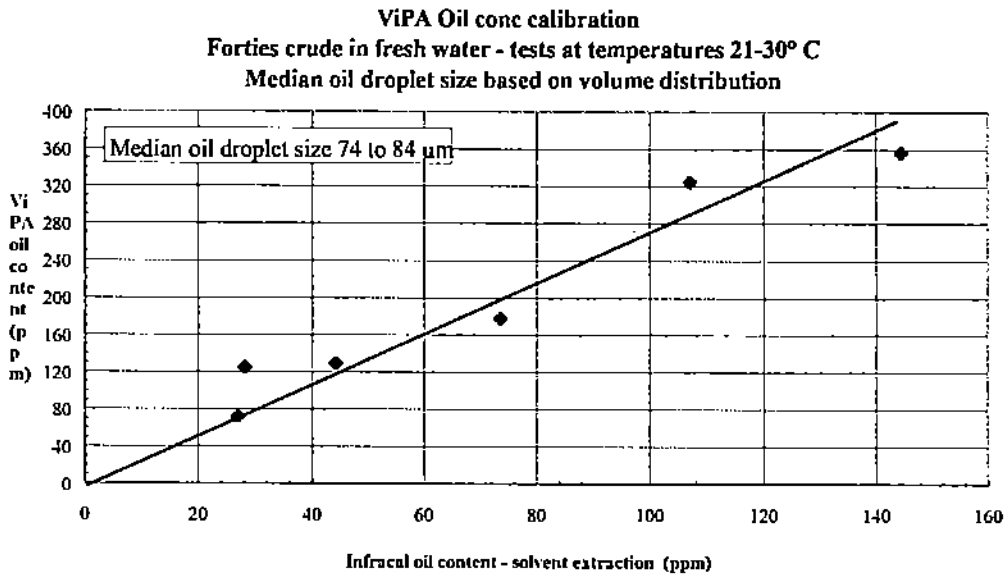
[2] Currently all fieldwork carried out in the USA remains client confidential and is not reported here.

size distributions and concentrations for several different types of material simultaneously, for example, oil and solids or oil, bacterial agglomerates and other solids.

During 2001 the ViPA has been used extensively within BP's facilities and data from the following are presented: Dalmeny Oil Tank Farm, Coryton Refinery, Andrew Platform and Harding Platform. Further data from a test loop, Enterprise's Nelson Platform and from one further North Sea platform completes the data presented.

Oil-in-Water Concentration Data

The following data is from Merpro Limited's test loop.



The comparison shows the straight line correlation between oil concentration in ppm reported by the ViPA and from the same samples using the Infracal solvent extraction unit.

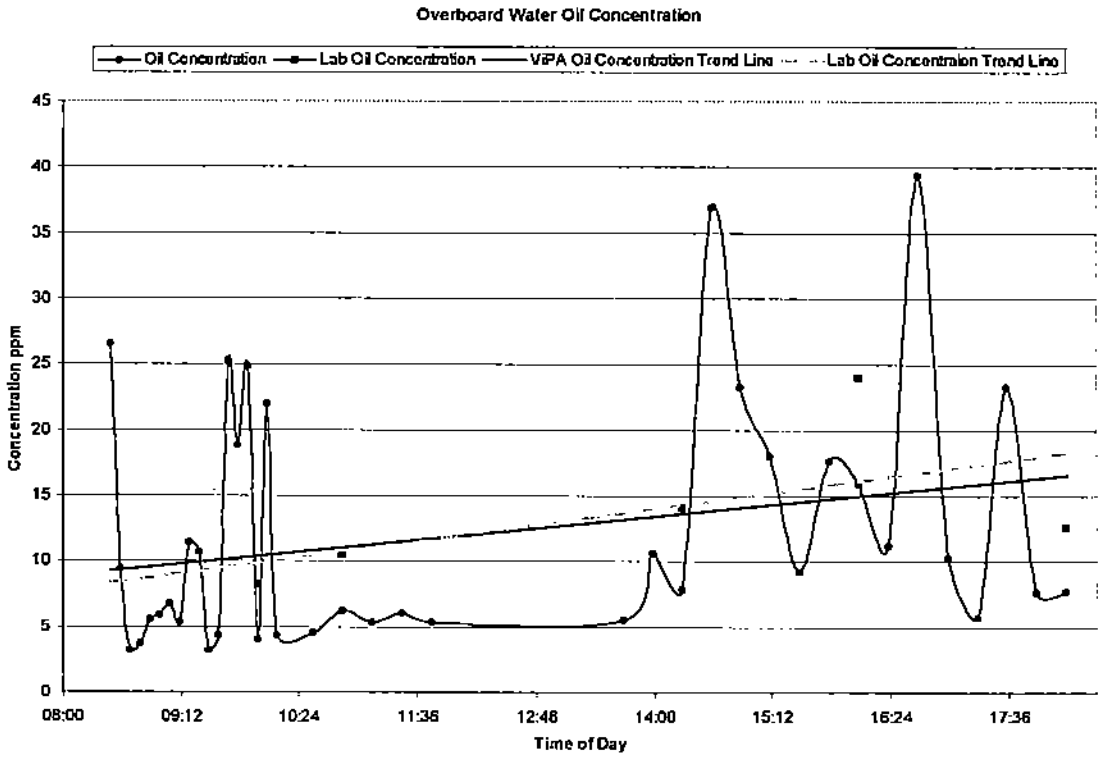
The following data is from Enterprise Oil's Nelson Platform.

The graph below shows a ten hour period of the ViPA's regular oil concentration data reporting in overboard water, together with five samples analysed in the laboratory from the same sample point. In all cases the laboratory method reports approx. 7 - 10 PPM more oil than the ViPA, this will be due in part to the dissolved hydrocarbon content of the water[3] and in part to the difference the analytical methods.

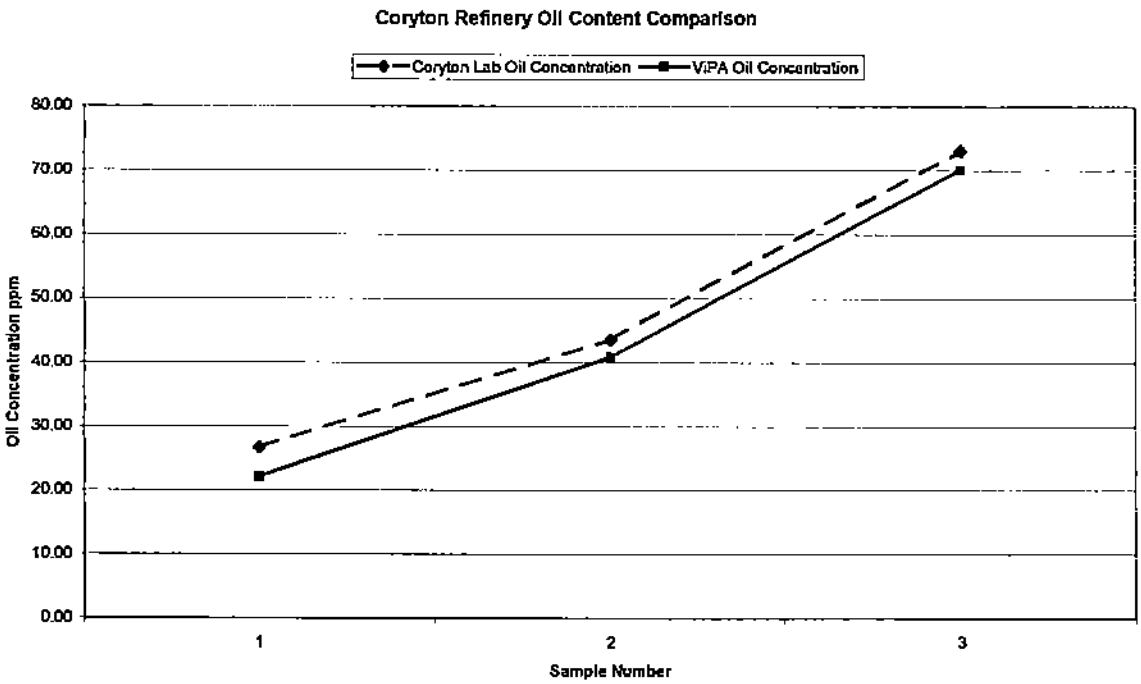
Trend lines have been added to the graph to show the correlation between the ViPA and lab methods. Even stronger correlation would be expected with an increase in the number of laboratory analyses carried out.

This graph also demonstrates the value of on-line monitoring as although the process does not exceed the statutory discharge limit, there are clearly periods of higher oil content in the discharge which were broadly matched to periods of higher solids concentrations, see Solids Monitoring section for further information.

[3] The ViPA is a visual technique and is limited to the analyses of material that can be seen in the images - dissolved material is invisible and, therefore, not reported by the system.

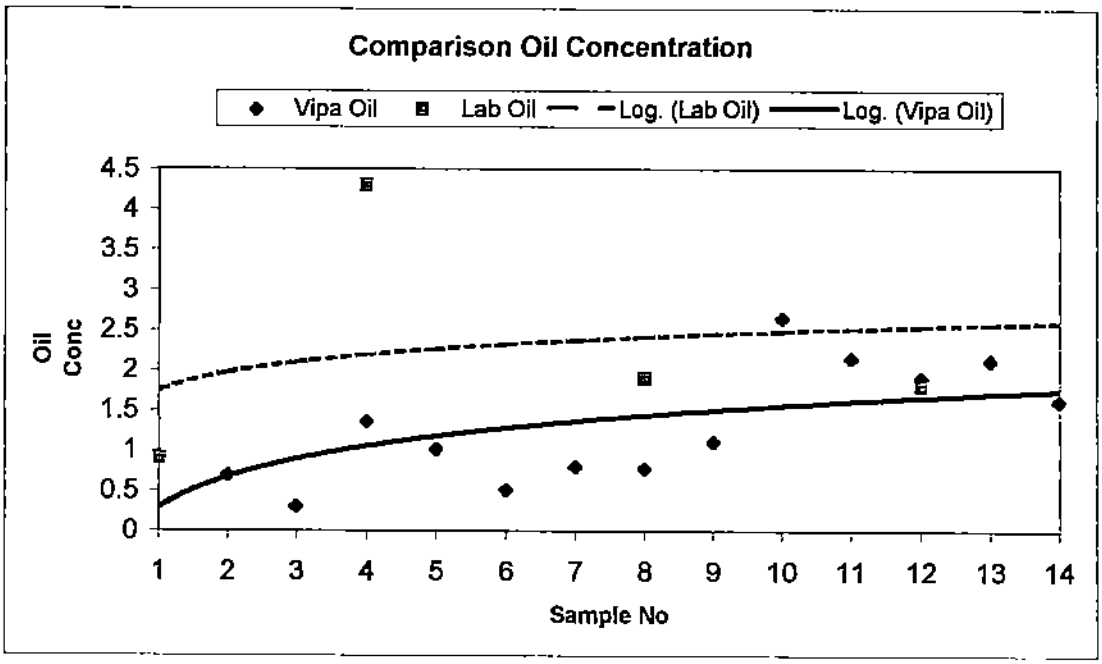


The following data is from BP's Coryton Refinery.



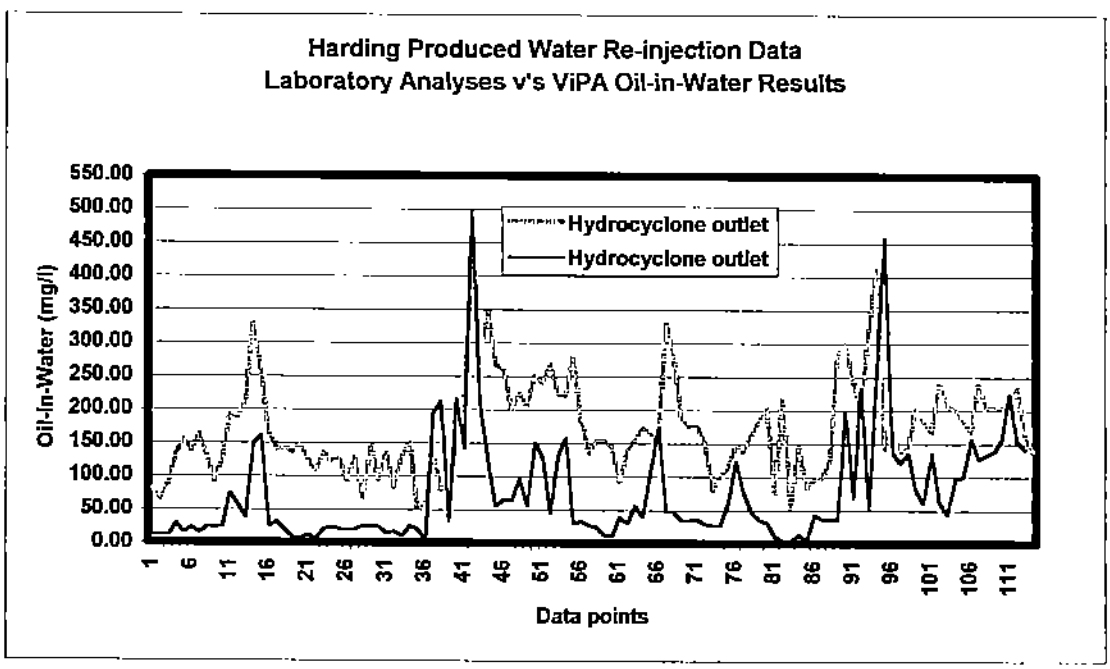
This graphs shows oil in water as determined by the ViPA and by solvent extraction. The dissolved oil content was determined to be between 1.75 and 2.5 PPM and difference between the ViPA figures and the lab figures were approx. 3 to 4.5 PPM. During the trial, the amount of oil in the water was deliberately allowed to increase to make a comparison across a broad range of concentrations.

The following data is from BP's Dalmeny Tank Farm.



The tank bottom water at the Dalmeny tank farm has long residence times and therefore low free oil concentrations. It was not possible to take simultaneous samples for the laboratory analyses so these samples were taken at approximately ten minute after the ViPA analysis. Trend lines have been added to demonstrate the correlation more clearly.

The following data is from BP's Harding Platform.



The data from Harding represents approximately six months of operation, the produced water on Harding is injected and the ViPA is used to monitor both oil concentrations and drop sizes. BP have not indicated which result represents the ViPA results and which the solvent extraction data, however, they have been satisfied by performance of the ViPA.

Oil Droplet Size Monitoring

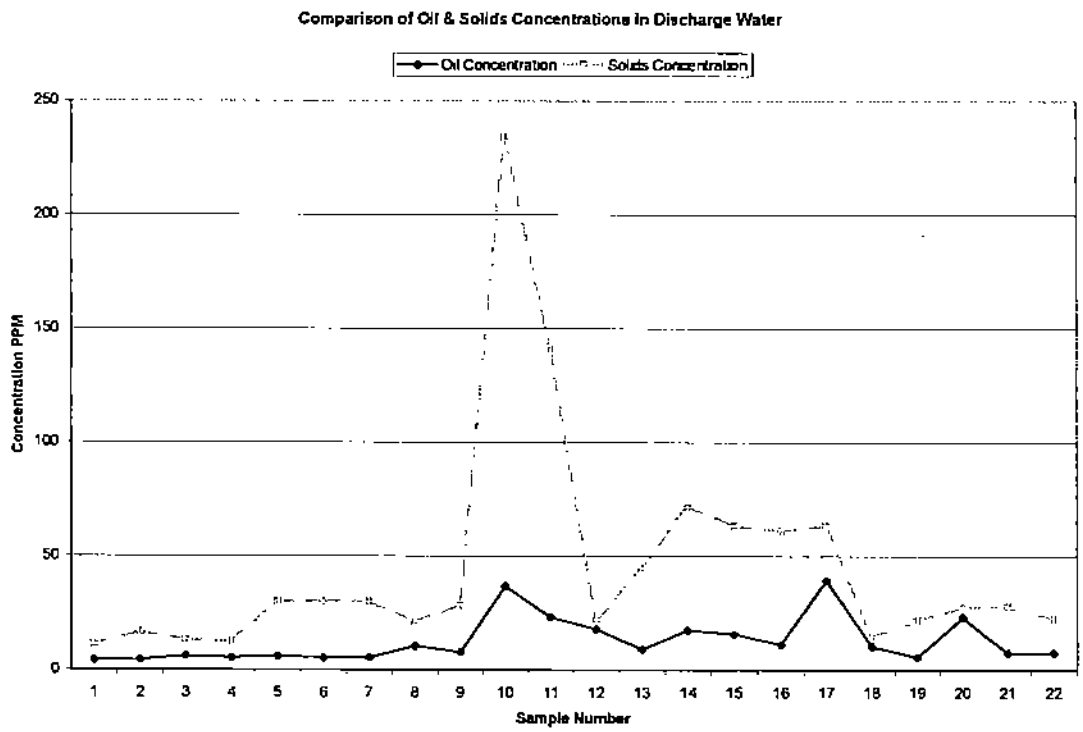
The following data refers to the mean oil droplet sizes and oil concentrations from the inlet and outlet of a hydrocyclone vessel:

Sample No	Inlet		Outlet	
	Size (µm)	Concentration PPM	Size (µm)	Concentration PPM
1	14.35	425	18.55	639
2	14.77	434	20.68	625
3	15.45	506	17.45	651
4	16.03	434	24.31	524

It can be seen from the table that the oil droplet sizes increase as they pass through the cyclone vessel. It was determined from this data that the reject orifices of the cyclones were becoming increasingly blocked and that the vessels were not separating oil and water but were beginning to act as coalescers.

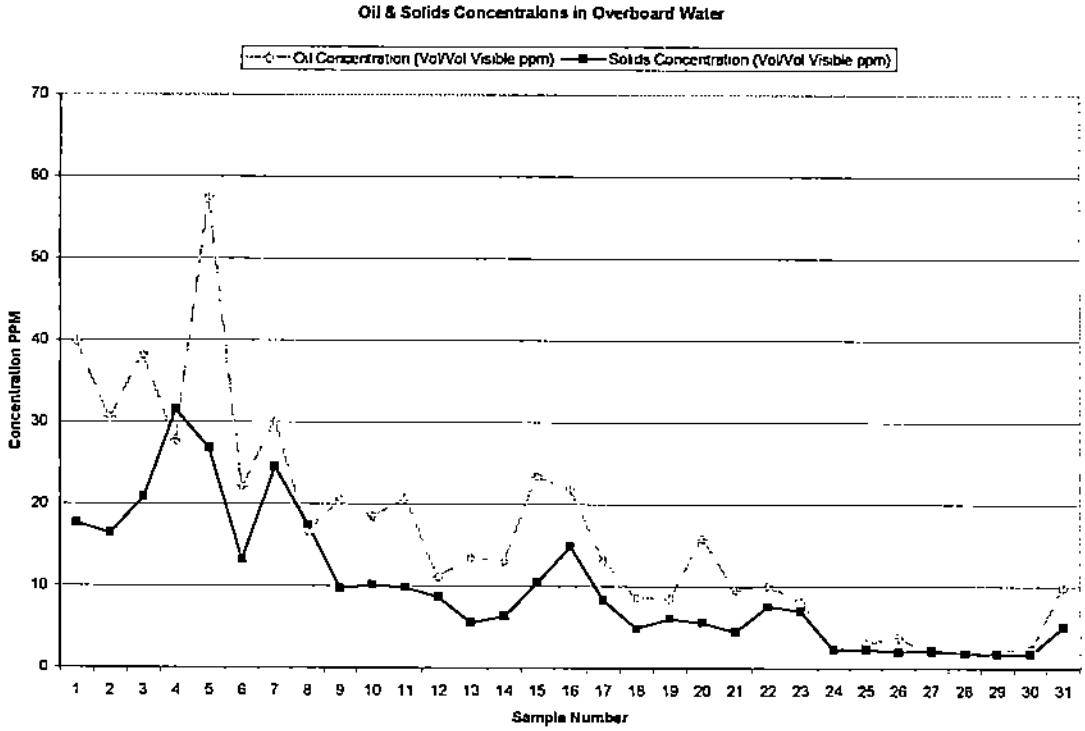
Solids Monitoring

The following data is from Enterprise's Nelson Platform.



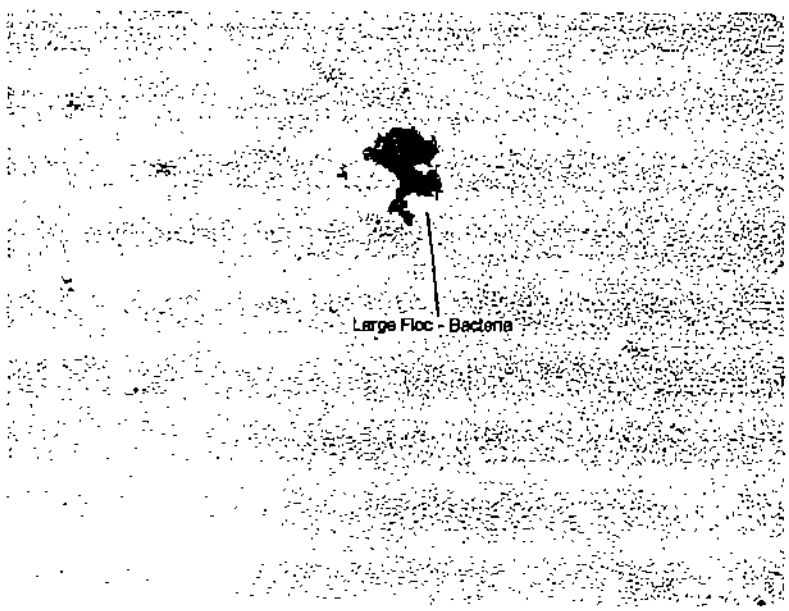
It can be seen from the above graph that there is a correlation between the increases in the concentration of solids in the discharge water and the increases in the concentration of oil. It was further determined that the larger the solids were the greater the effect on the process. Further investigation of the process revealed broken baffles in a vessel were periodically agitating the solids in the vessel bottom and sending them through the water treatment train. The increase in the levels of solids was having a detrimental effect on the separation efficiency and leading to increases in oil discharge levels.

The following data is from BP's Andrew Platform.



The above graph compares the oil concentration and the solids concentration in the overboard water on Andrew during a thirty-six hour operating period. It can again be clearly seen that there is a strong correlation between increased solids loading and increased levels of oil present in the discharge.

The following image is from BP's Dalmeny Tank Farm.



The above image from the tank bottom water at Dalmeny shows a large bacterial flocculent and many small iron sulphide particles. Due to the sulphur reducing nature of the bacteria there are safety and odour control problems associated with the discharge water on the site. The ability to identify and quantify the bacteria should enable a new process to be initiated to minimise the bacteria levels using as little energy and bio-cide as is possible.

Conclusions.

If it is accepted that continuous online monitoring is generally preferable to occasional lab tests, then the case for continuous monitoring of more than just oil concentration is strong. The fact that oil concentrations are higher than acceptable is indicative of a process problem, but is not a diagnostic tool. Continuous monitoring of oil concentration will ensure that problems are identified quickly and that further action is quickly begun, the continuous monitoring of droplet sizes and solids allows rapid problem diagnosis and greater flexibility as a process control tool.

The data presented is evidence of the ViPA's ability to provide useful process information on:

Oil Concentration Data

The ViPA's range is limited at the upper end to working in less than 0.3% oil (3000PPM) although little work has been done in water containing more than 1000 PPM of oil and no laboratory comparisons have been carried out at very high oil contents. In the range 0 - 500 PPM, the ViPA has demonstrated the ability to perform as satisfactory online oil-in-water concentration monitor, generally reading lower than equivalent laboratory methods by a few PPM.

Oil Droplet Size

Oil droplet sizing is single most important factor is ensuring enhanced separators perform at their optimum levels, this information can, when measured at point of discharge, also be indicative of where problems are occurring within the process.

Solids

Solids are an increasing problem in many fields causing wear and damage to process plant. Further to this, temporary increases in solids loadings can dramatically reduce separation efficiency and even cause discharge limit breaches.

Further Information:

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