The ViPA Particulate Monitoring System

- **On-line**
- **Rugged & Compact**
- **Continuous Operation**
- **Size Distributions**
- **Concentration Measurements**
- **Automatic Differentiation Between Particle Types**
- **Size Oil Droplets and Solids Separately at the Same Time**
- **Differentiate Between Different Types of Solids**
- **User Definable Alarms for Size and Concentration for Each Type of Particle**
- **4 - 20 mA Ouput & Digital Alarms**
- **Trend Analysis - Identify Upsets Before They Occur**

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What Process Benefits can a ViPA System Provide?

The ViPA uses on-line image analysis techniques to simultaneously provide information on the particle and droplet size distributions and the relative concentrations of both oil and solids in produced water.

The ability to monitor significant parameters throughout the oily water separation and disposal process allows previously unattainable levels of control, offering the opportunity to avoid many current process problems in the future.

What are the potential benefits of the some of the possible installation points for this technology within the oily water process train?

Having true oil droplet size distribution information (a size distribution without solids) after the first stage separator could improve the accuracy and control of the dosing of demulsifier chemicals, minimising their usage, environmental impact and cost. This information would also allow the confident specification of coalescers, where required, and give genuine information on separator efficiency.

Continuously monitoring the oil concentration in overboard water would allow operators to improve the quality of water discharged. Providing information on the trends in discharge levels would allow pre-emptive action to be taken to maintain a process within specification. Information on droplet sizes at this point in combination with oil concentration data provides a diagnostic tool to identify areas in the separation train that may be experiencing problems. Information on solids present in discharge water could be used to develop solids treatment regimes and to identify where and when solids loadings are being generated.

Where produced water is re-injected, determining the size and concentration of both oil droplets and solid particulates is a powerful tool to reduce injectivity losses, as the size and concentration of different materials affect the formation's porosity differently. Where the formation is soft and injection has to be maintained at less than fracture pressure this becomes increasingly more important.

How Does a ViPA Work?

The **ViPA**, **Vi**sual **P**rocess **A**nalyser, is an on-line instrument for the monitoring of particle and droplet sizes and concentrations. The ViPA can operate continuously on-line at high pressure and elevated temperatures.

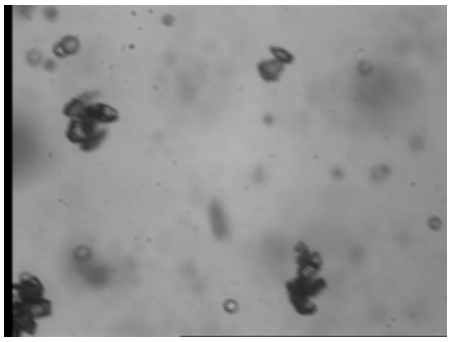
The ViPA package consists of the ViPA software set and a compact and robust measuring head (with a built-in cleaning mechanism) that can be located up to 1100 yards from the control computer (6.25 miles with upgraded unit). The compact measuring head (approximately 17 x 8 x 6 inches) is installed on a bypass line very close (typically a few inches) to a quill type sampler, this ensures the most representative possible sample is used.

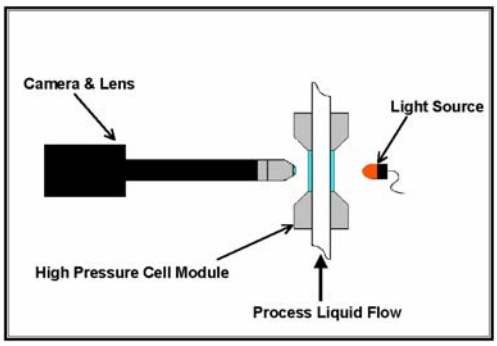
Using image analysis techniques to differentiate between particles and droplets in real time, the ViPA monitors up to seventeen parameters about each particle and droplet continuously including size and concentration.

The ViPA software includes a set of trend algorithms that use statistical tests to determine if a process will exceed pre-determined specifications during a set period. This provides the opportunity to pre-empt process upsets by taking action before an impending problem occurs.

4 – 20 mA outputs further allow control signals to be tied to measured parameters, for example, the d_{50} mean size of oil droplet could be mapped to a control signal for a demulsifier dosing pump.

The ViPA uses a video microscope in a ruggedised assembly consisting of a video camera and lens and a light source to examine the contents of a liquid. Produced water flows through the ViPA's cell module, which has a pair of transparent windows, and the camera looks through the water at the light source. This allows the video microscope a backlit view of the objects in the water flow, whether these are solid particles, liquid droplets or gas bubbles. The



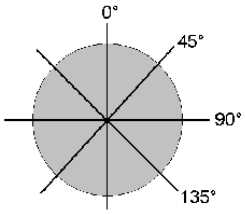


ViPA operates by freezing a single frame of the video image and analysing the objects present. A database of information is built by rapidly acquiring and analysing sequences of these frozen images.

Above is a typical image from the ViPA, the image is of ground garnet mixed with a light lubricating oil. The individual garnet crystals are approximately 35µm in size.

Typically, using three parameters for each object seen; size, shape factor and concentration allows information on the size and concentration for oil droplets and solids to be calculated.

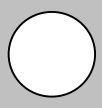
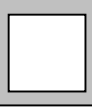
Size.



The ViPA measures four diameters for every object. These Diameters are measured at fixed angular intervals. These diameters are called Feret Diameters and the ViPA reports size as average Feret Diameter.

Shape Factor.

Shape Factor is mathematically described as: **4.ΠArea / Perimeter^2.**
The shape factor for a perfect circle (sphere) is always 1. As the length of perimeter increases compared to the area enclosed, shape factors decrease very rapidly.

Shape	Shape Factor	Shape	Shape Factor
	1.0		0.19
	0.75		0.0000061

Shape factor is one of the tools that the ViPA can use to distinguish between different types of particles.

For example:

The non-continuous phase of a liquid-liquid emulsion, such as oil in water, exists as perfectly spherical droplets.
Most solids are irregular in shape.

Therefore, in a liquid flow system containing both of the above, shape factor can be used to distinguish and discriminate between the two types of particles or particle populations, i.e. the oil droplets and the solids.

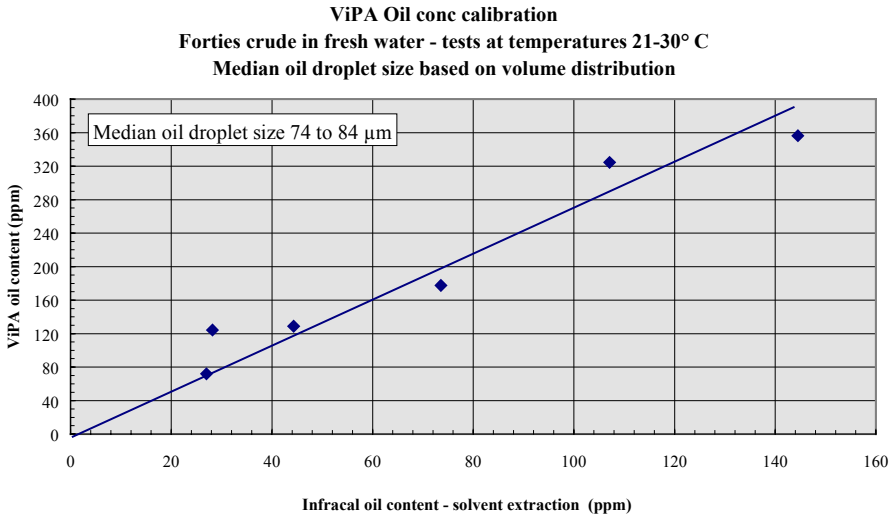
The ViPA can use sets of user defined values for parameters such as shape factor to determine the limit values of a population. Then, in real-time, the ViPA can determine which population an object belongs to and record it's statistical information into a separate database for each population.

Concentration.

The ViPA reports concentration as visible parts per million (ppmv). There is a known volume of liquid for each frame that the ViPA analyses. This volume is calculated as:
(the width of the analysed image) x (the height of the analysed image) x (the depth of focus of the image). In each frame the ViPA calculates the volume of the objects for each particle or droplet population/class. At the end of each analysis the ViPA software sums up the volume of all the objects in a population/class and the volume of all the frames, which then allows ViPA to report a volume/volume concentration for each run.

The measured concentration is reported as visible ppm, because only those objects seen are measured and included in the calculation. In other words, materials passing through the cell between frames and objects that are not in focus are not seen and hence not measured.

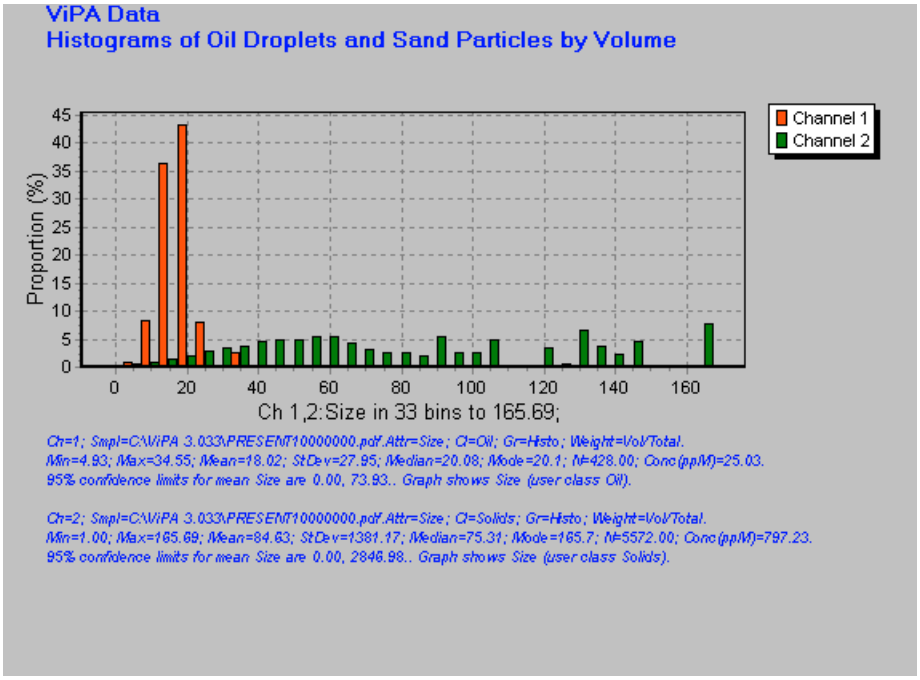
However, while the concentration figures are not absolute, they are repeatable and indicate how the concentration of a material is changing relative to previous or later measurements. Work has been done demonstrating the strong correlation between the concentration reported by the ViPA and those reported by other industry accepted methods such as the Rivertrace system and the Infracal solvent extraction method.[1]



[1] "On-line determination of particle size and concentration (solids and oil) using ViPA Analyser - A way forward to control sub sea separators" presented at the IBC Production Separation Systems Conference. May 2000.

Data Ouptut From ViPA

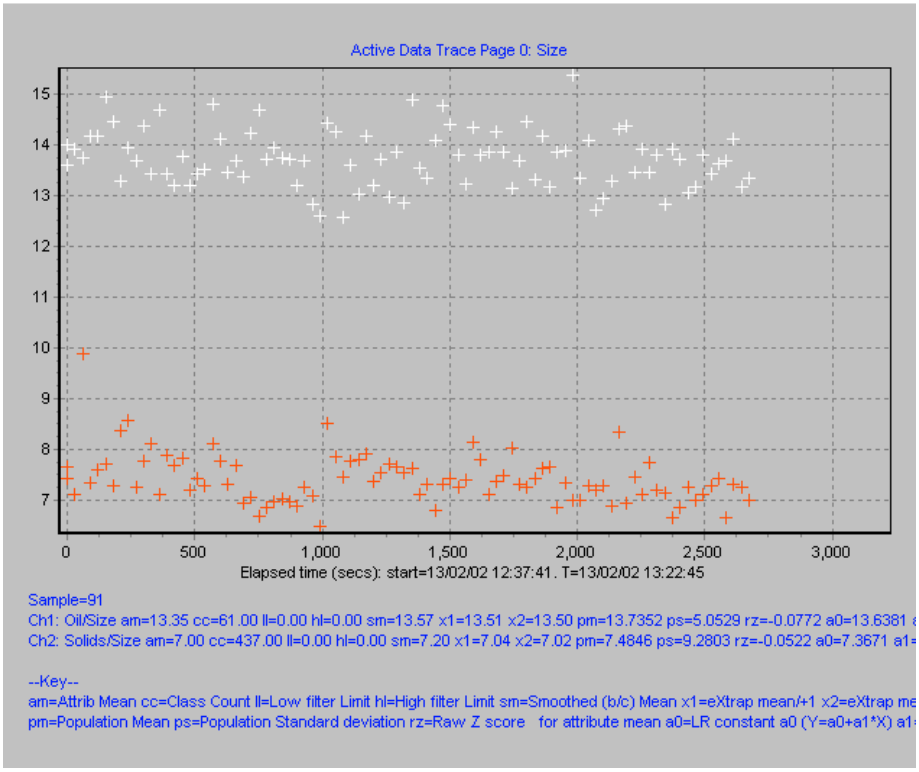
Typical Histogram:



Data Recorded:

For each of the seventeen measured parameters a full set of sample statistics including: Minimum, Maximum, Mean, Standard Deviation, Median, Mode, Number and Concentration.

Typical Continuous Monitoring Graph:



ViPA Specifications:

General:

Measured Parameters	Seventeen parameters, including size, shape, relative concentration.
Unit Dimensions	from: 300 (l) x 160 (w) x 120 (h) (mm)
Net Weight	from: 5 Kg.
Cell Module	High Pressure & Temperature. Max Continuous Pressure 115 Bar (Static test at 350 Bar).
Materials	All parts in contact with the environment or liquid flow from 316 SS or industrial sapphire.
Computer	Pentium III 600 MHz, 256 MB SDRAM. 19" rack mount, industrial and desktop options all available.
Power Supply	230V, 50Hz, 500W smoothed supply required.
Purge Systems	Compact Purge from Orga BV
Certification	EEx-p Control units by Expo-Telektron to ATEX/Cenelec & NPFA496
Gas Supply	4 bar or greater supply of clean instrument air or inert gas
Cable	Cable runs <10metres - broadcast quality shielded multicore copper cable Cable runs >10metres (max 2000 metres) - Tactical grade 4 core fibre optic

Optical System:

Video Camera	762 x 562 Element high speed progressive scan CCD	
Illumination	Staring light source @660 nm	
Magnification	High quality x 10 objective	
Field of View	470µm	
Range	Minimum for particle count:	1.6µm
	Maximum for spherical particle:	300µm

Software:

Single click operation following initial setup. Multiple setup files available. Analysis of single sample, continuous operation, data display and printing all automatable.

Full analysis of up to eight particle populations simultaneously.

Automated algorithms for light correction, rejection of out of focus particles, etc.

User definable particle filters for creating sub-populations, and alarm functions.

Data Output:

Standard data displays in table, histogram or graphical formats.

Export in ASCII format for spreadsheet and data handling software packages.

Cumulative trend data for process monitoring and process upset prediction.

4-20 mA Analogue Ouputs and Digital Alarms. Minimum of 8 analogue and 8 digital channels available.

Options:

On-line wash device/automated on-line wash device.