

ULTRASONIC INTELLIGENT SENSORS

ClampOn DSP-06 Particle Monitor

DIGITAL SIGNAL PROCESSING



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Any owner or operator of a factory would surely like to operate it as efficiently and profitably as possible. An oil or gas well can be regarded as a factory, and the ClampOn DSP-06 Particle Monitor gives operators the best tool for maximizing profits. ClampOn's DSP systems operate on thousands of wells every year, and the company is the world's largest supplier of sand monitoring systems. ClampOn is the natural choice for sand monitoring and management programs!

The DSP-06 has been developed to help oil and gas producers minimize their problems with produced sand from unconsolidated formations; in other words it is a profit generator designed to detect particles in a flowing medium inside a pipe and provide real-time sand data to the operator. The new DSP-06 includes a unique sound-filtering technique that has been field-tested and proven for more than a year and represents a major step forward in optimizing oil and gas production and increasing earnings. Ever since 1995 ClampOn has been delivering ultrasonic sand monitoring systems to the oil and gas industry, making the company the clear leader since its introduction. The high quality and superior performance of our instruments, combined with the ability to give first-class service and support to our customers, has made us the supplier of choice of oil companies, a position we are determined to retain in the future. The new DSP-06 model represents a quantum leap in technology from alternative solutions and will maximize the profitability of production.

What advantages does the DSP-06 offer?

Sand production in oil and gas wells is a serious issue facing oil and gas producers. The challenge is not merely to avoid sand production, but also to increase commercial well productivity, as even small quantities of particles in the well flow can cause significant damage. As an operator you are interested in maximum production and profit from your wells, no matter what technology you use. Operators all over the world have made ClampOn their preferred supplier of sand monitoring systems, due to the patented technology that turns their wells into profit generators. The ClampOn DSP-06 model incorporates a new filtering technique that makes the particle monitor an extremely



useful tool for analyzing the true nature of sand production, helping to control it and finally, increasing the profit from the well! This filtering technique is the result of integrating our experience of thousands of wells, analyzing data and using the results to enhance the technology used in our DSP-06 model.

The enormous capacity of the DSP sensor (the only one on the market) makes it possible to scan through a frequency range of 1 MHz 128 times per second. This illustrates the capacity of our technology and of the filtering technique that is at the heart of acquiring and processing sand data.

The following figures show a sensor installed close to a choke valve on a gas well operating at high pressure and high velocity. The figures illustrate what the signal looked like when using a traditional/alternative system compared to using the new DSP-06 filtering technology. The new filter (ref. Figure 2) was able in this case to reduce unwanted noise by a factor of 500 compared to alternative solutions.

Digital signal processing – the way ahead

The DSP-06 features complete digitalisation, eliminating analogue filters, circuits and amplifiers. The technology incorporates a powerful DSP unit with a large amount of flash RAM, running-feature packed modular software. The sensor operates simultaneously in several ultrasonic frequency ranges, allowing a whole series of new signal processing features to be implemented, including the latest filtering technique. Different types of chokes or flow conditions that generate sound unrelated to sand noise are analyzed and reduced dramatically via the advanced processing and filtering technique in the DSP-06 model. It also improves accuracy and repeatability, important factors in quantifying sand production and a crucial tool in your daily sand management operation.

No other technology comes close to what the ClampOn 2006 model offers customers who need to generate profitable and sand-free production!

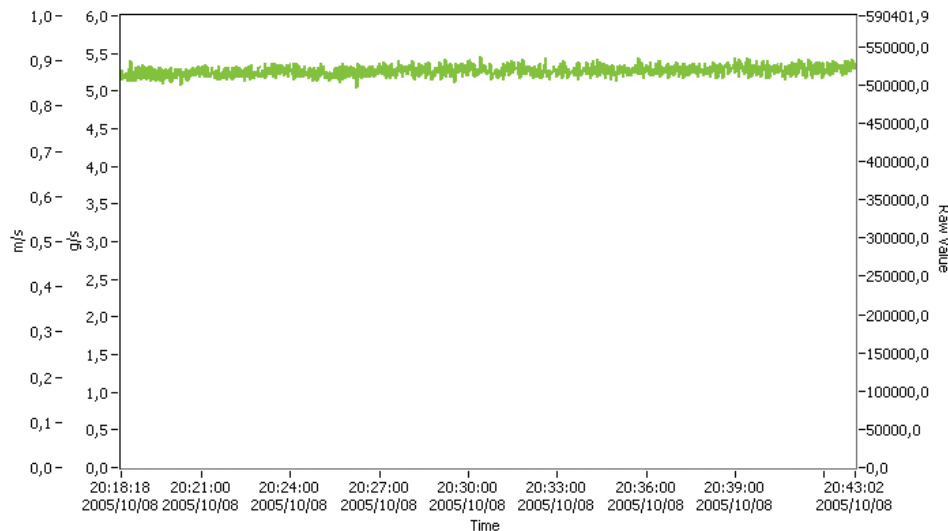


Figure 1. The signal from the sensor experienced on a high flow rate – high pressure gas well using a traditional/alternative sensor without DSP-06 filtering technology.

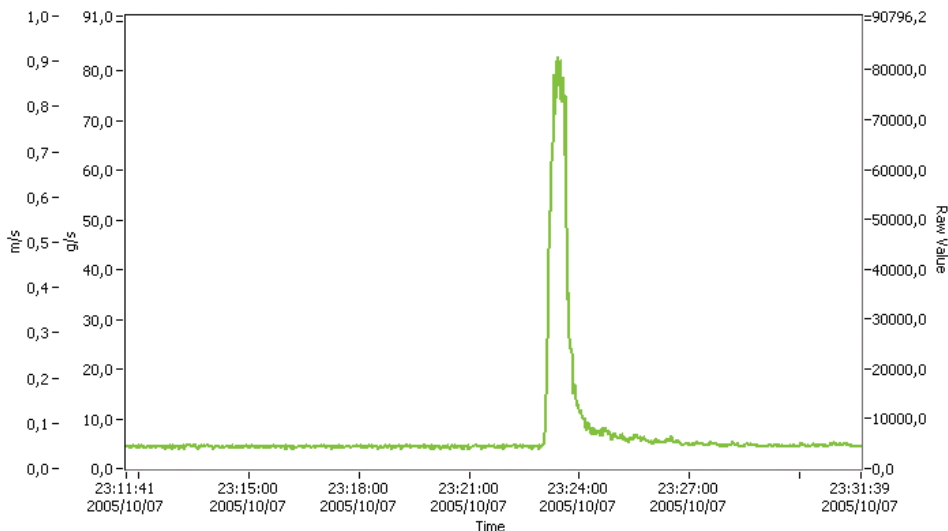


Figure 2. Sensor signal experienced on the same well, now with the new ClampOn DSP-06 filter. This shows how the sensor has completely removed the flow noise, allowing the operator to monitor the true nature of the sand being produced.

Principle of operation

The ClampOn DSP-06 Particle Monitor is based on the ClampOn “Ultrasonic Intelligent Sensor” technology. The sensor is installed two pipe diameters after a bend, where the particles/solids impact the inside of the pipe wall, generating an ultrasonic pulse. The ultrasonic signal is transmitted

through the pipe wall and picked up by the acoustic sensor. In the patented intelligent ClampOn sensor, the signal is processed internally by a DSP engine and filtered before being sent onwards to the computer or the control system (no Calculating Interface Unit required). Here the user can evaluate the data in real time and make the decisions needed for profitable production.

ClampOn Sand Management

When sand is being produced from a reservoir it lowers the production rate and increases maintenance costs; it also represents a serious hazard to its surroundings. Produced sand can never be ignored and any well producing from a sandstone reservoir needs to have some sort of sand monitoring system in place, preferably a real-time sand monitoring system.

In many cases a well is being produced in a conservative manner, at a safe distance below the blue line (ref. Figure 3) in an attempt to ensure that sand is never produced. This is a safe but expensive way of managing sand. A more active sand management plan can significantly improve your production statistics. Above the red line (ref. Figure 3) continuous sand production is likely, something that should be avoided. The potential for safe increased production and improved earnings lies in the area between the blue and red lines.

There are three main factors when performing sand management – the key words are prediction, handling and measurement!

- **Prediction** helps the operator to understand how to produce the well and to manage the sand issues. Sand prediction tools (based on i.e. geological and reservoir data) are also useful when designing the facility in order to ensure that it is prepared for the sand being produced and when planning the sand management strategy.

- **Sand handling**; produced sand will enter the process system and the operator needs to ensure that it is capable of handling the

sand safely. An important aspect of sand management is reviewing erosion rates and removal issues.

- **Measurement** is a cornerstone of a sand management system. When the prediction and handling issues have been carefully considered, including an understanding of erosion risk and sand removal challenges, a reliable method of measurement is required to ensure that the design criteria are met and not exceeded. This is where the ClampOn DSP-06 Particle Monitor comes in. The sensor's superb sensitivity, filtering mechanism and patented solutions for real-time monitoring combine to make it the best tool available to maintain a profitable and safe sand management programme.

ClampOn has been working on the problem of sand production for more than a decade, helping customers all over the world to measure and predict it. Our experience of thousands of wells has given ClampOn unique practical knowledge of how sand production will appear and how it can be measured and dealt with. Over the years ClampOn has had the pleasure of working with many of the best service and research companies involved in sand management. By combining our knowledge obtained from field experience with the ClampOn DSP-06 Particle Monitor, and the high level of

competence of our partners we are able to offer a unique product. Even for an organization with a high level of expertise, the opportunity to obtain assistance from the world leaders in sand management by making one phone call is invaluable.

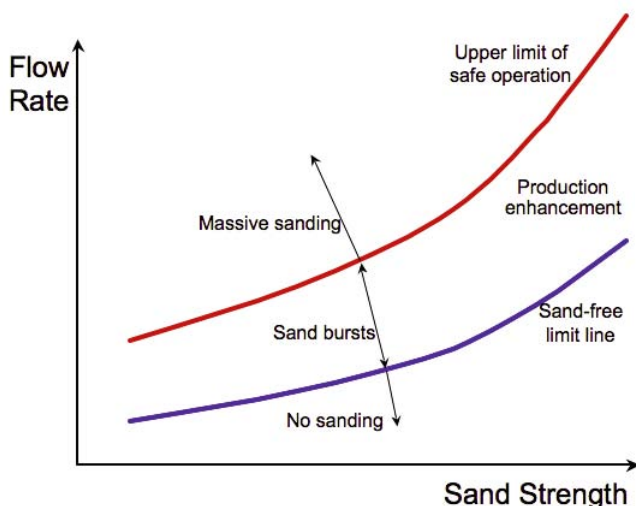
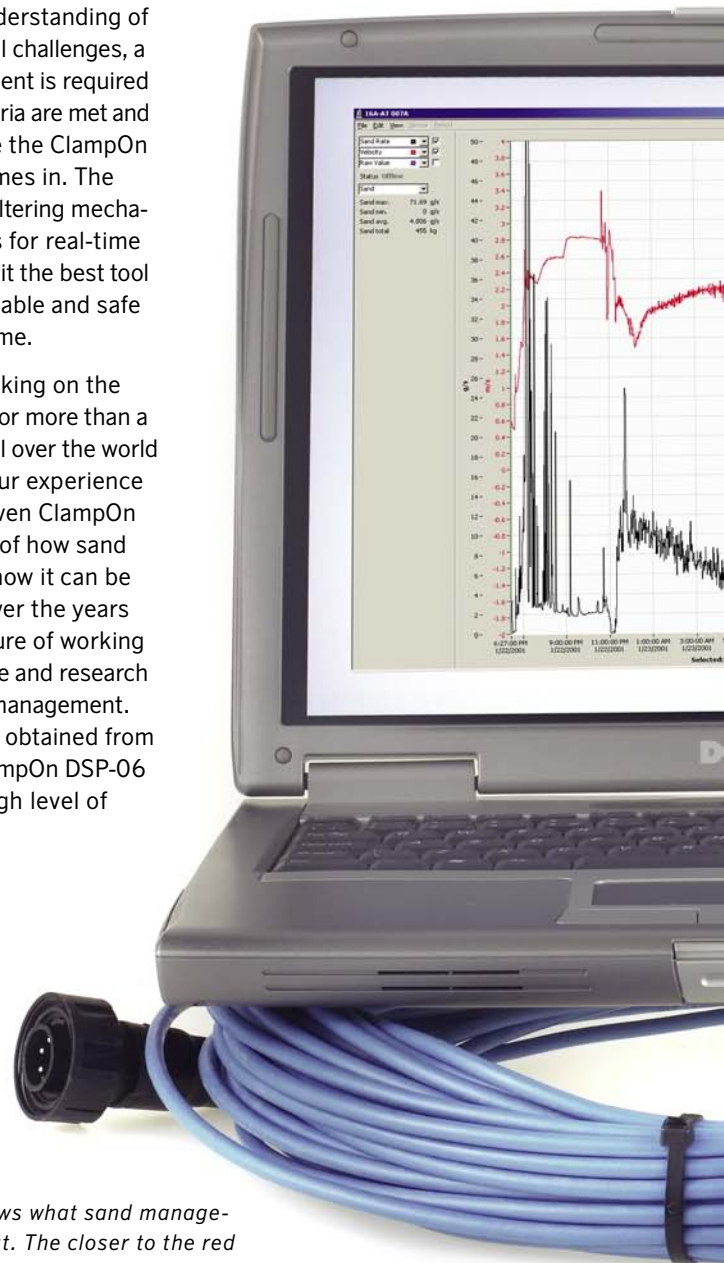


Figure 3 shows what sand management is about. The closer to the red line the operator can produce safely, the more profitable the wells become.

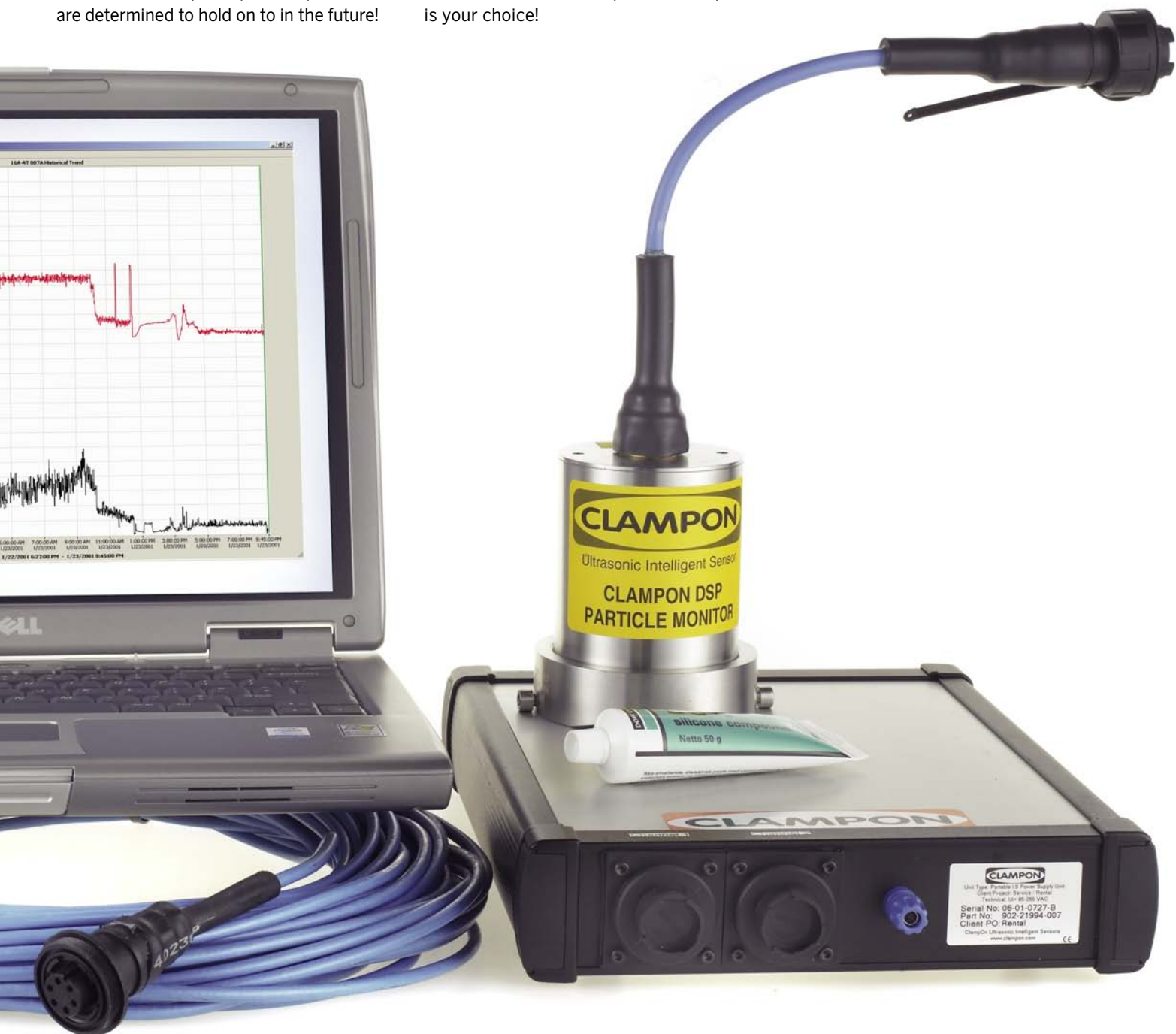


ClampOn - the leader in sand monitoring

To date (May 2006) ClampOn has delivered more than 5000 topside and subsea Particle Monitoring Systems to operators all over the world. Shell Brent, Woodside Australia and others have installed more than one hundred sensors for production optimisation and elimination of erosion damage. Our system is preferred to the alternatives because of its repeatability, accuracy, s/n ratio (ability to discriminate noise), robustness and our company's expertise in this field.

Continuous technology development and personnel training have made ClampOn the winner of all the field and laboratory tests in which we have participated, a position we are determined to hold on to in the future!

The 2006 model offers operators a major step towards improving earnings wherever sand is a problem. If you are interested in increased profits, ClampOn is your choice!



ClampOn – the leading solution to challenges in particle monitoring!

A common problem in sand monitoring is interference from signals generated by sources other than particles, such as noise from liquid/gas mixtures, droplets in high-velocity gas wells, mechanical/structural noise and choke noise and electrical interference.

A good signal-to-noise (s/n) ratio is vital to high-quality measurement and the introduction of the DSP-06 model provides operators with absolutely the best s/n ratio available on the market. Figure 4 illustrates clearly the difference between a traditional/alternative system and a ClampOn system. The red line represents a sensor limited by background noise and with inadequate s/n ratio. In the worst case the sand signal may even drown in the background noise, a hopeless situation from the user's point of view. In high-velocity gas wells, in which liquid droplets collide with the pipe wall at high speed, the red pattern often shows up in flow-sensitive systems. The consequence may well be that the operator reduces production and ruins his own profit goals - even when no sand is being produced.

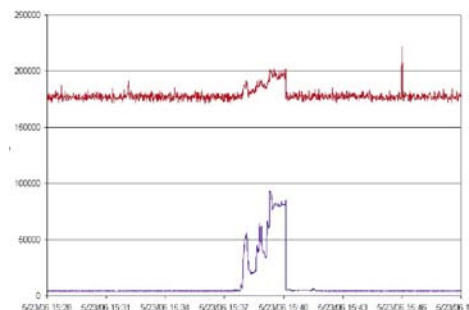
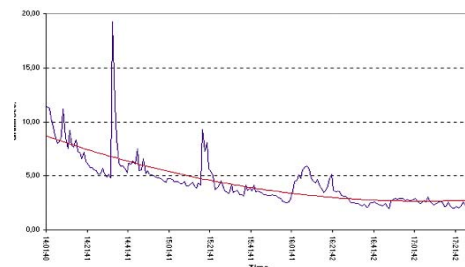


Figure 4. Signal comparison.

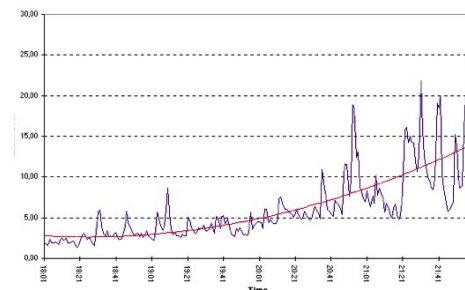
What is required is a clamp-on sensor that clearly distinguishes sand from other sources of noise, as represented by the blue line. ClampOn's DSP-06 technology enables the sensor to discriminate background noise so that the pattern of sound made by the sand particles is illustrated clearly on the operator's computer screen. Since ClampOn entered the market in 1995 our system has won all industrial field trials in competition with other systems. The introduction of the DSP-06 model represents a solution that is even less sensitive to background noise and more quantitatively accurate. The ClampOn system's s/n ratio is also very important for an efficient field installation, due to its low calibration costs.

How to determine the maximum sand-free production level of an oil or gas well

All too often, we meet operators who are worried because they are not fully aware of the nature of sand production - so they reduce production unnecessarily. A cutback in production in the range of 20 to 75% is fairly common in oil and gas wells. The superb quality and reliability of the DSP-06 is the logical way to raise production, thanks to the essential data the sensor gives the operator. Bearing in mind the values that sand production limitations represent it is well worth evaluating the ClampOn sand monitoring systems. It is of vital importance to have a system that responds rapidly and accurately to improve sand detection. Usually, the operator chokes back production immediately when sand is present (or when he believes sand is present). The figure (right) shows a producing well in which sand production is declining. The curve represents what we call a "GOOD" pattern. As the figure shows, sand is being produced due to the increase in production (opening the choke valve). However by using a reliable sand-monitoring system the operator can monitor the development of sand production. The figure shows how sand production is reduced over time due to consolidation of the producing reservoir. This pattern tells the operator that oil and gas production can continue at this level since he will soon have a sand-free well. When the well is finally flowing with no sand production for some time the operator can once again open up the choke and increase production. This will again probably result in sand production, as the figure shows; however, the operator should let the production continue in order to observe the trend in sand production. We are looking for a "GOOD" pattern as shown here. When this curve appears after a time, the operator has a consolidated reservoir.



Good pattern.



Bad pattern.

The above method of increasing production takes some time (usually a couple of days) until the operator sees the opposite "BAD" pattern, which shows that sand production is increasing. When the "BAD" pattern appears on the screen the operator restricts production by returning to the previous setting of the choke valve. This tells him the maximum sand-free level of the well. The well should then be produced over a period of at least 24 hours to ensure that the formation is consolidated and stable. To achieve effective and safe sand free (or tolerable) rate the operator needs the best monitoring equipment that is available. ClampOn offers that solution together with our experience of thousands of wells!

Product specifications

PARTICLE MONITOR

Principle of operation	Passive acoustics, intelligent sensor
Minimum particle size	Depends on flow velocity and conditions. Typical sizes are: Oil/water: 25 microns / 1PPM Air/gas: 15 microns / 1 PPM
Minimum sand rate	0,01 g/s
Minimum flow velocity	0.5 m/s
Uncertainty	±5% (with calibration by means of sand injections)
Repeatability	Better than 1%
Method of installation	Clamped to pipe surface, non-intrusive
Sensor electronics	Intelligent DSP electronics with signal processing
Interface options	All sensors can be supplied with: Digital RS485 (ASCII, binary, ModBus RTU), 4-20mA (active/passive). Options: CANBus, Profibus
Two-way communication	Yes
Software upgrading	Yes
Pipe Surface Temperature	-40 to 225 °C (-40 to 437 °F)
High temperature fixture	500 °C (932 °F)
Flow regimes	Oil, gas, water, multiphase
Diagnostic features	Intelligent health-test of electronic hardware

COMPUTER

Minimum hardware	Pentium III (or equivalent) with 512 MB RAM
Software requirements for ClampOn's software	Windows™ XP/Vista/2000-2008
Input	Serial, Modbus, ethernet, OPC
Signal output	Serial, Modbus, ethernet, 4-20mA, Relay, Client Server



SAFE AREA EQUIPMENT

Mains power supply	12 - 48 VDC or 100-240 VAC 50-60 Hz
Power Consumption	Max 2,1 W per sensor + computer rack module Signal and power barriers and converters supplied for DIN-rail mounting, in portable enclosure or for 19" rack mounting.

TOPSIDE PARTICLE

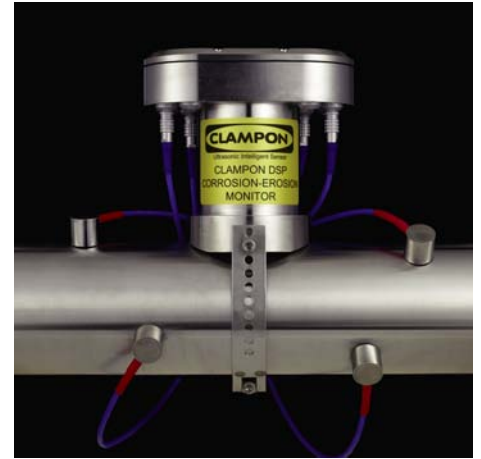
Ingress protection	Ex ia: IP68, Ex de: IP66
Housing material	AISI 316 Stainless Steel
Dimensions / Weight	Ex ia: ø80 x 105 /144mm (ø3.1" x 4.1 /5.7") / 2,6 / 2.8 kg (5.7 / 6.2 lbs) Ex de: ø101 x 211mm (ø4.1" x 8.7") / 7.2 kg (15.9 lbs)
Cable interface	Ex ia: M20 cable access Ex de: 3off M25 cable access
Power / Safety Barriers	Ex ia: ClampOn IS power barrier, IS approved signal barriers. Ex de: Power 12-28VDC. No IS barriers for signal or power
Power Consumption	Ex ia: Typical 1,5 Watt, max. 2,1 Watt per sensor Ex de: Typical 1,2 Watt, max 2,1 Watt per sensor
Cabling	Minimum 4x 0.75 mm2 (pending system configuration)

INTRINSICALLY SAFE (IS) APPROVAL

ATEX	 II 1 G EEx ia IIB T2–T5, Zone 0  II 2 G EEx de IIC T5, Zone 1
CSA C&US	Ex ia IIB T5, Class I Division 1 Group C,D, Zone 0
INMETRO	BR-Ex ia IIB T2-T5, Zone 0 BR-Ex de/dem IIC T5, Zone 1
GOST-R / GGTN	2Ex de IIC T5, Zone 1

ClampOn - the leader in sand, pig and corrosion-erosion monitoring

ClampOn has since the beginning in 1994 grown to be the largest supplier of passive ultrasonic systems for sand/particle monitoring to the international oil and gas sector. All products supplied by ClampOn, particle monitor, pig detector, corrosion-erosion monitor and leak monitor are based on the same, well proven technology platform. Both the topside and the subsea instruments incorporate Digital Signal Processing (DSP), complete digitalization eliminating analogue filters, circuits and amplifiers.



The ClampOn Ultrasonic Intelligent Sensor processes all data in the sensor itself (patented principle), thus enabling the instrument to discriminate between sand-generated and flow-generated noise. This is of importance to the user since changes in flow rates and the gas/oil ratio will not affect the performance of the system.

A good signal to noise (s/n) ratio is vital for quality measurements of this sort, and ClampOn's sensors are the very best in this respect. With the new version, the external noise has been completely eliminated.

The sensors has memory capacity for storing up to 60 days of data, and can even be reprogrammed between being a sand monitor, a pig detector or a corrosion-erosion monitor for monitoring of changes in wall thickness.

Subsea Sensors

The subsea sensors were developed in close collaboration with Shell Deepwater Development Inc. in Houston and FMC

Energy Systems in Norway. The successful outcome of the project was a sand monitoring system that combined an extremely long working life with excellent acoustic properties, offering reliability in the high pressure deepwater environment. ClampOn has since 1998 supplied approximately 500 subsea sensors to the oil and gas industry. The subsea meters have been under a continuous development in order to optimize quality and performance, and to meet the requirements in the market.

ClampOn DSP Pig Detector

The ClampOn DSP Pig detector is a Non-invasive pig detection system designed to be a first stage alarm system for pig detection providing accurate and reliable registration of the time when pigs is passing, and transmits the signal to the operator. The detector can also indicate the amount of debris following the pig during cleaning operations. Available for topside and subsea applications.

ClampOn DSP Corrosion-Erosion Monitor (CEM)

The CEM is monitoring any changes in wall thickness. Two to eight transducers are glued onto the surface of the pipe (or other metal plate structure) and connected to a clamp-on control unit. The control unit will continuously send and receive guided waves between the transducers, resulting in a network of measurement paths that cover the selected area.

The working principle of the instrument is based on transmitting ultrasonic signals that propagate through the pipe material. The transmitted signal is received by a sensor and is analyzed using advanced data processing schemes.



NORWAY: ClampOn AS, Damsgaardsvn. 131, NO-5162 Laksevaag, Bergen, Norway, Phone: +47 5594 8850, Fax: +47 5594 8855, e-mail: mail@clampon.com - **USA:** ClampOn, Inc., 15720 Park Row, Ste. 300 (77084), PO Box 219206 (77218-9206), Houston, TX, USA, Phone: +1 281 492 9805, Fax: +1 281 492 9810, e-mail: info@clamponinc.com - **WEB:** www.clampon.com