

ULTRASONIC INTELLIGENT SENSORS

ClampOn SandQ™ Monitor

DIGITAL SIGNAL PROCESSING



ULTRASONIC INTELLIGENT SENSORS

FLOW & SAND



ClampOn SandQ™ Monitor

Every factory owner or operator wants to operate his plant as efficiently and profitably as possible. An oil or gas well can be regarded as a factory, and the ClampOn SandQ™ Monitor gives operators the best tool for maximizing profits. ClampOn's instruments are in operation on thousands of wells every day, and the company is the world's largest supplier of sand monitoring systems.

The ClampOn SandQ™ sensor is the answer for operators who want to keep their wells producing safely at the highest level possible; i.e. anyone who needs a quantitative, real-time and accurate measure of produced sand particles!

The capability of measuring particles without having flow data available has been demanded by the market for years. The ClampOn SandQ™ provides operators focusing on sand management and corrosion-erosion issues with even more important information than previously available.

The unique, patented SandQ™ sensor is designed for installation after a bend, where the turbulent flow profile is fully developed, and it enables users to measure the amount of particles directly by the sensor itself, without the need for flow input from external sources. This produces a dramatic reduction in field calibration costs – the SandQ™ sensor does not need to be calibrated after leaving ClampOn.

The ClampOn SandQ™ shares the same interfaces and communication protocols as the existing DSP Particle Monitor. This means that all clients who already use ClampOn instruments can integrate the new SandQ™ into their existing system – it is simply a quick swap. The SandQ™ is intrinsically safe, and carries EEx ia IIB approval.



The SandQ™ fitted onto a production pipe.



ClampOn is well known in the upstream oil and gas sector, and the company has been the leader in providing sand and pig monitoring systems to the offshore industry for many years.

What advantages does the SandQ™ offer?

Sand production in oil and gas wells is a serious issue for oil and gas producers. The challenge is not merely to avoid sand production, but also to optimize well productivity, as even small quantities of particles in the well flow can cause significant damage.

An operator is interested in maximum production and profit, no matter what technology is used. Operators all over the world have made ClampOn their preferred supplier of sand monitoring systems, due to the company's patented technology for sand monitoring and sand production management. The ClampOn SandQ™ incorporates a new filtering technique combined with flow monitoring capabilities making the instrument an extremely useful tool for analyzing the true nature of sand production, helping to control it, and finally, maximizing the profit from the well.

High-capacity digital signal processing – the way ahead

The SandQ™ features complete digitalization, keeping the amount of analogue filters, circuits and amplifiers to a minimum. The patented technology incorporates a powerful signal processing unit, running feature-packed, modular software. The sensor operates in several ultrasonic frequency ranges simultaneously, permitting the implementation of a host of new signal-processing features. Different types of noise-generating chokes and flow conditions are analyzed and dealt with via the advanced processing and filtering techniques of SandQ™. With the SandQ's advanced Digital Signal Processing unit (DSP) sensitivity, accuracy, repeatability and the ability to suppress unrelated noise (flow noise) are superior to all traditional and alternative systems. These important factors in quantifying sand production make SandQ™ a crucial tool for your daily sand management operations.

Figure 1 shows a sensor installed close to a choke valve on a gas well operating at high pressure and high velocity. The figures

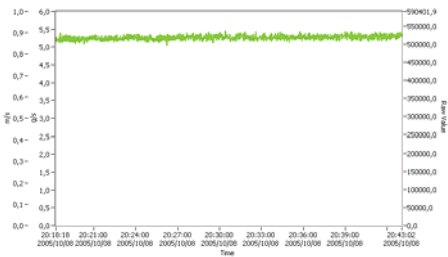


Figure 1. The signal from the sensor on a high flow-rate, high pressure gas well using traditional/alternative sensor without DSP-06 filtering technology.

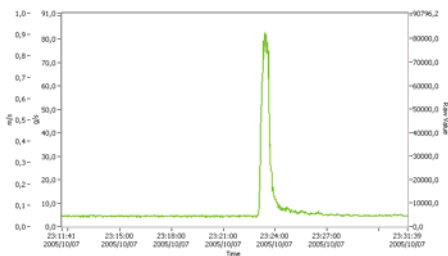


Figure 2. Sensor signal experienced on the same well, now with the new ClampOn DSP-06 filter. This shows how the sensor has completely removed the flow noise, allowing the operator to monitor the true nature of the sand being produced.

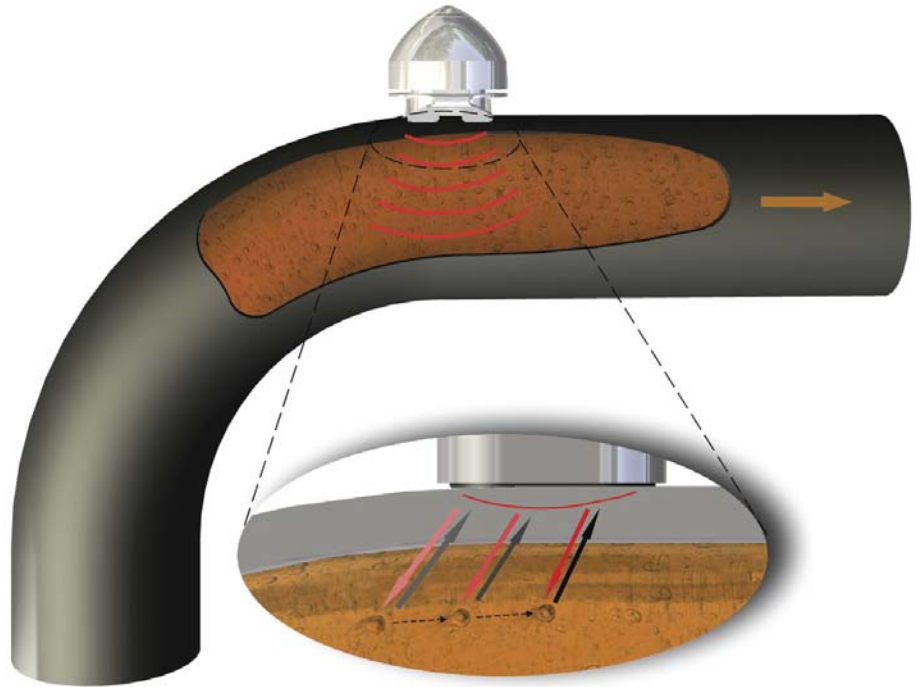


Figure 3. The illustration shows how a particular bubble is being «followed» by ultrasonic scanning to measure flow.

illustrate what the signal looked like with an alternative system compared to the new ClampOn SandQ™ filtering technology. The new filter (Figure 2) was able in this case to reduce unwanted noise by a factor of 500 compared to alternative solutions.

No other sensor comes close to what ClampOn SandQ™ offers in terms of production optimization and profitability!

Principle of operation

In order to measure the amount of sand being produced, we have combined two separate instruments into one. The SandQ has built in mix flow velocity measurement. The sensor is installed a few pipe diameters downstream of a bend, where the flow is turbulent.

The SandQ™ measures sand/particles through passive ultrasonic technology; it detects the ultrasonic signal that is generated by particles impacting on the inside of the pipe wall, just after the bend where the sensor is located.

Product flow is measured using an active Pulse-Doppler technique. The built-in Doppler element tracks the particles/bubbles in the

flow via an extremely high updating pulse rate (8000 pings per second). The pulse rate is so rapid that at typical flow velocities of 0.3 to 20 m/sec, the distance a bubble or particle travels between pulses is much less than the beam-width of the pulse. This allows the bubbles or particles in the fluid to be «pictured» by several pulses, thus tracking the movement of the particles. ClampOn developed this technique in order to handle challenging multiphase measurements, enabling the instrument to trend the flow very accurately. The flowing media may be a single-phase liquid or a multiphase flow, and all signal processing is done internally by a DSP engine before the results are sent to a computer or control system (no Calculating Interface Unit required). The SandQ™ is delivered fully calibrated and there is no need for individual site calibration to operate this unit, which can be simply clamped to the pipe wall.

With the ClampOn SandQ™, field operators can evaluate sand and flow data in real time and make the decisions required for optimized 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 an unconsolidated 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 4) 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 4) 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 keywords are prediction, handling and measurement

- **Prediction** helps the operator to understand how to produce the well and manage sand issues. Sand prediction tools (based on 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.

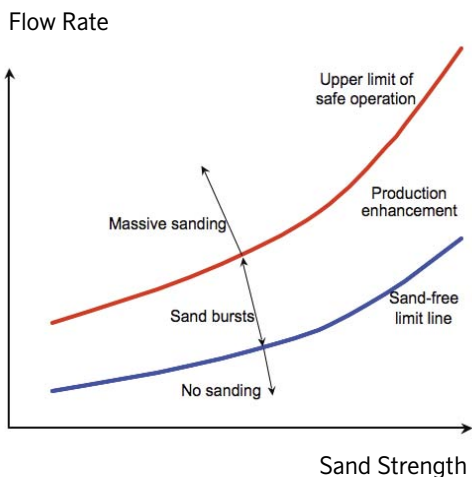


Figure 4 shows what sand management is about. The closer to the red line the operator can produce safely, the more profitable the wells become.

SandQ measurements – 2 ID downstream bend – difference from reference

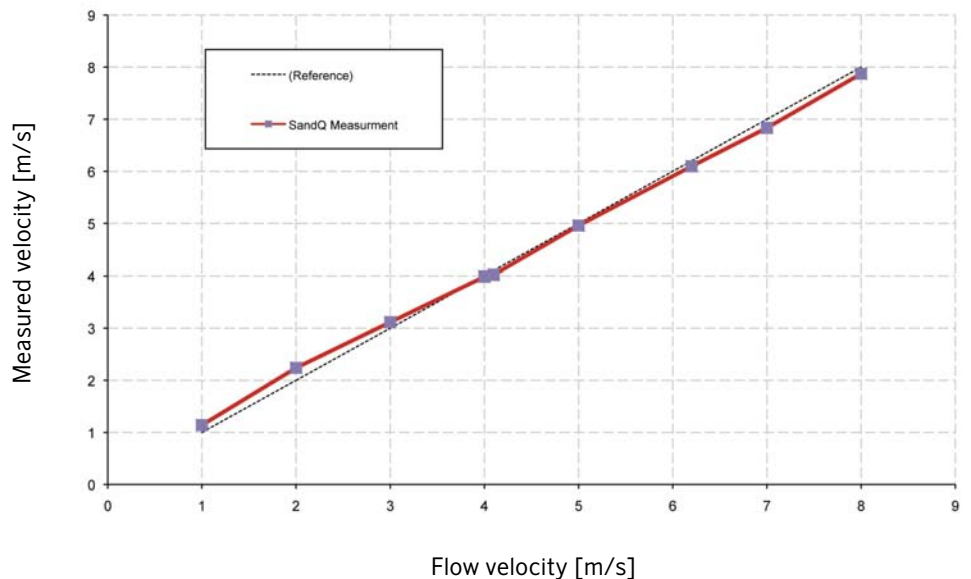


Figure 5. The plot shows how accurate the SandQ measures flow velocity, even when installed very near a bend/elbow.

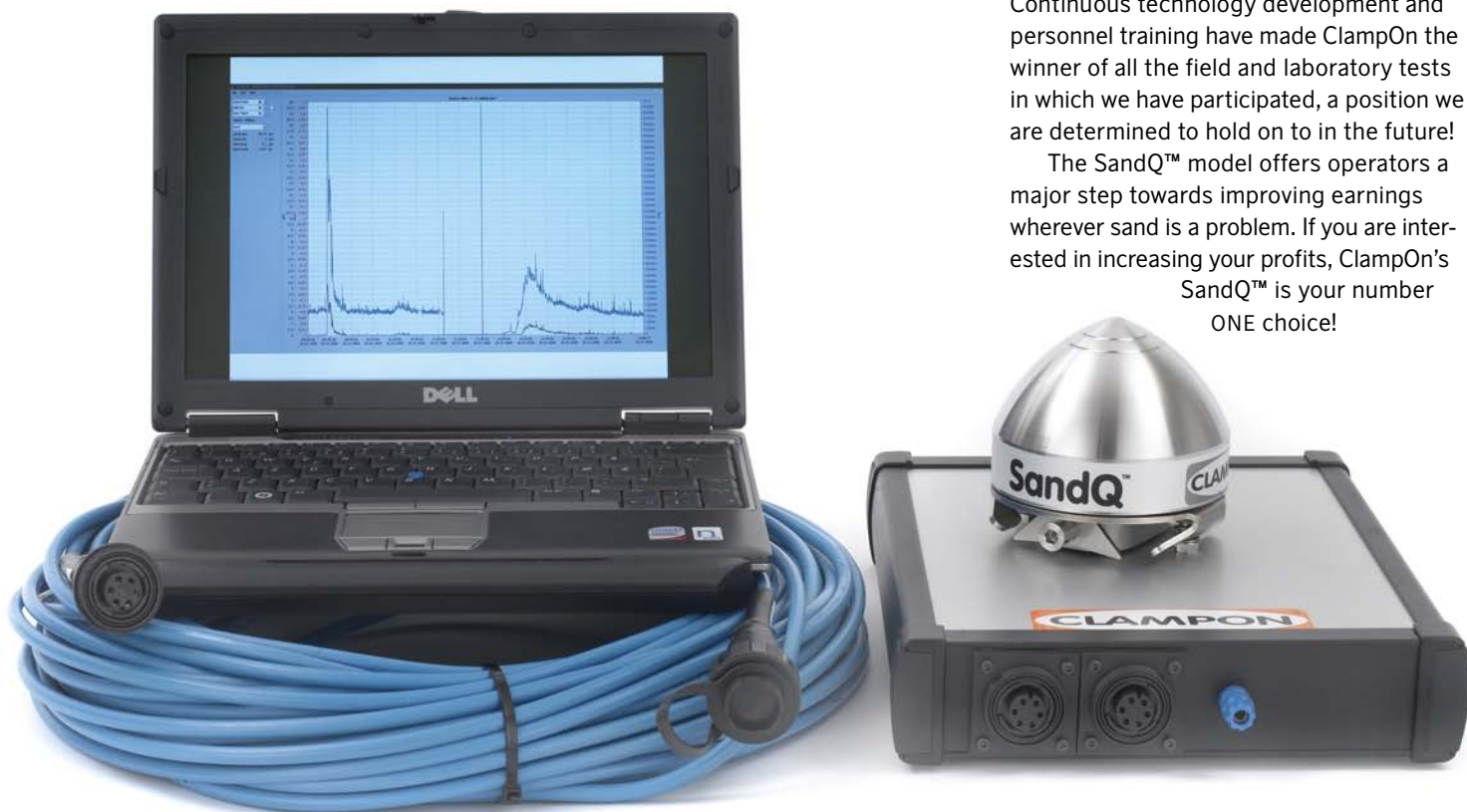
- **Sand handling**; produced sand enters the process system and the operator needs to ensure that it is capable of handling the sand safely. An important aspect of sand management is reviewing erosion rates and removal issues.

- **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 SandQ™ 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 program.

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 appears 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. Combining our knowledge obtained from field experience with the ClampOn Monitor, and the high level of competence of our industry partners enables us to offer a unique product. Even for international companies that possess a high level of expertise, the opportunity to obtain assistance from the world leaders in sand management by making one phone call is invaluable.

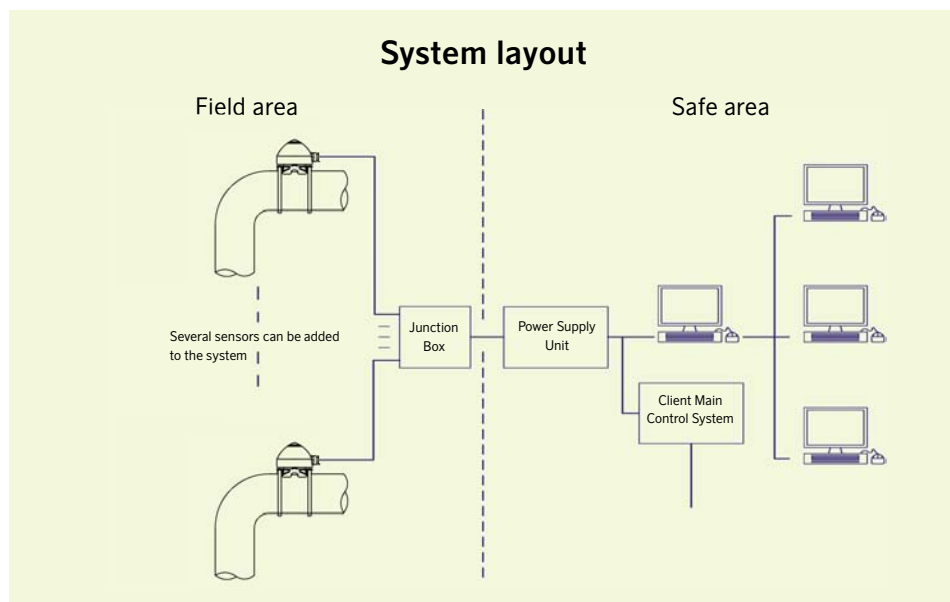
ClampOn - the leader in sand monitoring

To date (August 2008), ClampOn has delivered more than 6500 topside and subsea Particle Monitoring Systems to operators all over the world. Shell Brent, Woodside Australia and others have each installed more than one hundred sensors for production optimization and elimination of erosion damage. Our system is preferred to the alternatives because of its repeatability, accuracy, s/n ratio and 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 SandQ™ model offers operators a major step towards improving earnings wherever sand is a problem. If you are interested in increasing your profits, ClampOn's SandQ™ is your number ONE choice!



Key words

- Sensitivity
- Noise discrimination
- Repeatability
- Real time measurement

Figure 6. Typical sensor layout with sensors and junction box connected through a power supply unit to dedicated computer(s) and/or client control system.

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 SandQ™ model provides operators with absolutely the best s/n ratio available on the market. Figure 7 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.

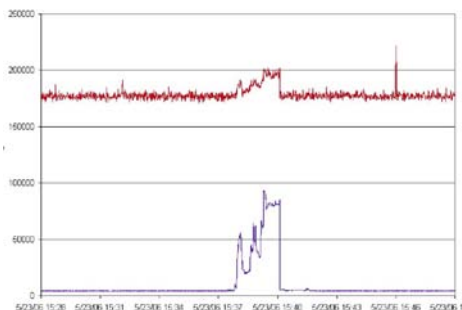


Figure 7. Signal comparison.

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 SandQ™ 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 SandQ™ 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 SandQ™ 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). Figure 8 (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 in figure 8. When this curve appears after a time, the operator has a consolidated reservoir.

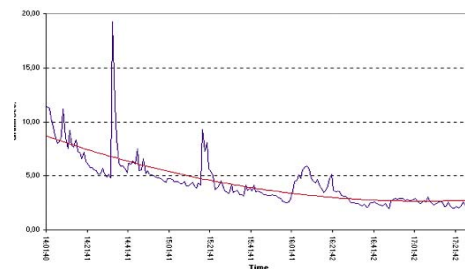


Figure 8. Good pattern.

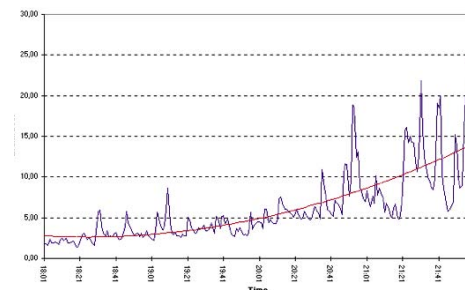


Figure 9. Bad pattern.

The above method of increasing production takes some time (usually a couple of days) until the operator sees the opposite «BAD» (figure 9) 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

SandQ™ MONITOR

Principle of operation	Passive/active acoustics, intelligent sensor
Minimum particle size:	Minimum detectable particle size and sand rate depends on flow medium and flow velocity. 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%
Flow element	Velocity 0.5 – 20 m/s Accuracy ±15% Min. pressure Liquid >0.5 Bar Multiphase/Gas 30 Bar - Contact Manufacturer for more details
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)
Two-way communication	Yes
Software upgrading	Yes
Pipe surface temperature	-40 to 225 °C (-40 to 437 °F)
High-temperature fixture	Contact Manufacturer for more details
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

Ingress protection	IP68
Housing material	AISI 316 Stainless Steel
Dimensions/Weight	109 mm x 101 mm [4.3 in x 4.0 in]
Cable interface	M20 cable access – delivered w/5m (16ft) flying lead
Power/Safety Barriers	ClampOn IS power barrier, IS-approved signal barriers
Power Consumption	Typical 1.5 Watt, max. 2.1 Watt per sensor
Cabling	Minimum 4x 0.75 mm ² (pending system configuration)

INTRINSICALLY SAFE (IS) APPROVAL

ATEX	Ⓔ II 1G EEx ia IIB T2-T5, zone 0
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ClampOn - the leader in sand, pig and corrosion-erosion monitoring

ClampOn has since the beginning in 1995 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.

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 1000 subsea sensors to the oil and gas industry. The subsea monitors have been under a continuous development in order to optimize quality and performance, and to meet the requirements in the market.

ClampOn DSP Corrosion-Erosion Monitor (CEM)

The CEM is monitoring any changes in wall thickness. Two to eight transducers are mounted on the pipe surface (or other metal plate structure) and connected to a ClampOn 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.

ClampOn DSP Pig Detector

The ClampOn DSP Pig Detector is a non-intrusive pig detection system designed to act as a first-stage alarm system for pig detection. It provides accurate and reliable registration of the time when a pig is passing and transmits the signal to the operator. The detector can also indicate the amount of debris preceding the pig during cleaning operations.



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