Meeting the sand control challenge... - by ClampOn AS

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Meeting the sand control challenge

Sand production from unconsolidated formations in oil and gas wells has been a world-wide challenge for the petroleum industry for many decades. The challenge is not merely to avoid or stop sand production, but to be able to maintain commercial well productivity after efforts to control sand are implemented. At the same time, the control method selected must be justified by a reasonable payback time of the investment cost. ClampOn AS of Norway gives a detailed description of monitoring alternatives.

Produced sand is a major problem in many production situations since small amount of sand entrained in the produced fluid can result in significant erosion and erosion-corrosion problems. Even in 'sand free' or clean service situations where sand production rate is only a few pounds per day, erosion damage could be very severe at high production velocities. Sand erosion can also cause localised erosion damages to protective corrosion scales on pipe walls and result in accelerated erosion-corrosion damage. In a high velocity gas well sand erosion is a serious problem since it can erode holes in the pipe work in a very short time period.

Produced sand can result in serious damage to the reservoir, where in some cases the reservoir collapses as a result of the sand production. Again, this scenario is a costly experience for the operator who has to overhaul and complete the producing reservoir zone.

The most commonly used practice for controlling sand erosion in a gas and oil producing well is simply to limit the production (or the flow velocity of the fluid). Quite often we see that producers worry over the consequences of sand production that he limits the oil and gas production seriously. Guidelines for this are stated in American Petroleum Institute (API RP14E).

When sand is produced it usually comes in batches, in other words in large or small quantities. However, the time period for the batches can vary both for the individual well itself as from well to well. When sand has been constantly produced over a period of time one should be aware of the conditions within the reservoir itself.

The above factors are the basic reasons for measuring sand production. By using an efficient monitoring device with a high degree of repeatability and sensitivity the producers are capable of not only avoiding erosion-corrosion or reservoir damages, but also increase the oil & gas production. The increase in production can be as dramatic as shown in a couple of examples in this paper. However to be able to do this you need repeatability, sensitivity and also real time measurement!

Measuring sand production

There are several techniques available in order to measure or detect sand production, and mainly we can divide them into two groups - intrusive devices and clamp-on (non-intrusive) devices.

The intrusive devices can be divided into the following categories:

a) Intrusive sensors where the gas intrudes when a hole has been eroded in the sensor and activates an alarm
b) Tuning fork principle working on acoustical principle
c) Erodable resistance probes

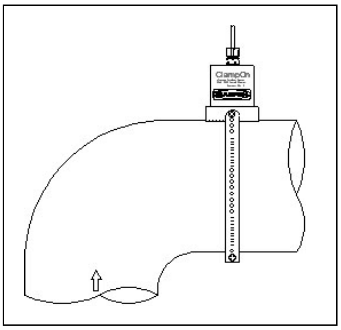
It seems that alternative c) of the above-mentioned systems is the most commonly used today among the intrusive types. This type uses the 'Whetstone Bridge' as a principle for measurement techniques, and is a well-proven and working principle. However all the intrusive systems have some disadvantages due to their intrusiveness: Sand and particles in the flow causes erosion on the probe and it has to be replaced. They are not able to give the user a quick respond to the sand that is produced - it is not real time measurement.

Two topside sand monitoring sensors mounted after a 90° bend.

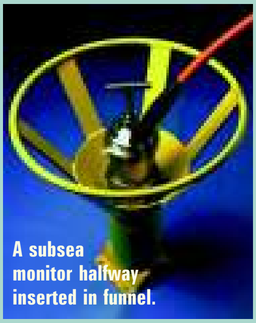
When installing these units into the pipe one has to be aware that the point of location is critical. If the probe is installed in a flow pattern or regime that is not representative for the actual conditions wrong readings will be the results. During installation, welding and drilling of holes has to take place - and when the unit has been installed it cannot be relocated. When replacing the existing probe one has to remove pressure from the flow line or use a high pressure tool to replace the existing probe.

Clamp-on acoustic monitors

Clamp-on acoustic-type monitors are installed after a bend. When the flow is passing the bend, particles (such as chalk or sand) will be forced out and hit the inside of the pipe wall and generate an ultrasonic pulse. The ultrasonic signal is transmitted though the pipe wall and picked up by the acoustic sensor itself. The ***ClampOn 2000 Particle*** system is a small and compact sensor with a weight of only 2 kg. The installation of the system itself takes only a short time. Also, compared to other non-invasive systems no welding or drilling of holes takes place. Several sensors can be connected to one computer or directly to the SCADA system. The ultrasonic head needs a small area (5 mm in diameter) where the painting has been removed, and between the ultrasonic head and the pipe wall silicon grease is used to improve the contact.

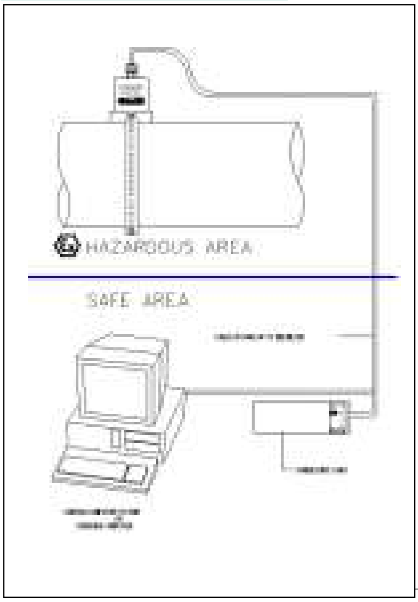


The ClampOn 2000 Particle Moni-tor is an Ultrasonic Intelligent Sensor, meaning that the signal processing takes place in the field-mounted sensor itself. Experience with other ultrasonic measurement systems directed us to the conclusion that having the brain separated from the body causes unreliable measure-ment. This method of processing the data in the field unit itself has been patented.



A subsea monitor halfway inserted in funnel.

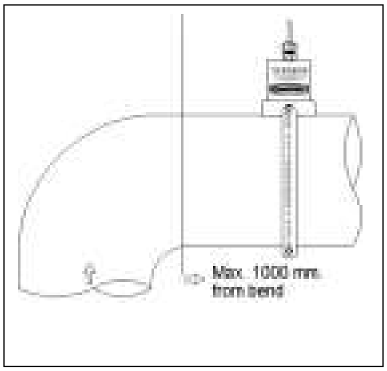
The signal from the field sensor can either be send directly to the main computer (SCADA) or to a ClampOn computer. The distance between the sensor and the computer sitting in a safe area can be as much as 2,000 m by using twisted pair cable. With the usage of fibre cable, signals can be transmitted up to 5,000 m. The ClampOn computer basically takes the ASCII signal from the field unit and presents the results of the measurements for the user in a Windows' program.



Read mode, showing second signals

The software as it appears on the screen.

Windows™ has been selected to give the user an easy and well known environment to work in. The report window gives the user quantitative information on sand produced in g/s, minutes, or hours, if desired. Further, the user has different possibilities of showing trends, maximum and minimum values of produced sand over a period of time. Signal data can be stored for up to a year. The results can be exported to Microsoft Excel and can easily be printed out by the user when needed.



System maintenance

The most critical part for all ultrasonic systems is the field equipment. Through development of the system in co-operation with users, certification institutions and sub-suppliers, the sensor has become compact and extremely sensitive. To give you an example, the sensor is able to take pipe wall surface temperatures as high as 180°C. All parts are 316SS (or customers' specifications) to protect ultrasonic and electronic parts. No special maintenance is required. If failure occurs, it is a simple matter to disconnect the sensor and ship it back for replacement.

However, as with the intrusive systems with their disadvantages, we also have to mention that acoustic non-intrusive sand monitoring systems have their weak sides. These weak sides were the main challenge for ClampOn to solve in order to come up with a more compact, sensitive and reliable system to increase the users benefit.

The three main problems for acoustic systems are sound generated by sources other than sand particles from the well. These include:

- electrical interference
- mechanical structural noise
- noise from liquid/gas mixture

As already mentioned, experience with other ultrasonic measurement systems directed us to the conclusion that having the brain separated from the body could cause unreliable measurement related to the three factors. When the sensor comprises both brain and body, it is beneficial for the signal to noise ratio.

Mechanical and structural noise has been avoided by choosing a high frequency band where these problems do not existing. A simple test for a user will be to use a hammer on the outside of the pipe wall - if the system is triggered by the hammer and shows particles, the quality and value of the monitor needs to be discussed. The ClampOn system is totally immune to mechanical noise, due to our choice of frequency band, type of ultrasonic head used and the fact that the processing takes place in the sensor itself.

A more serious problem is that other existing systems on the market today are pulsed by noise made by liquid/oil mixture or gas mixtures. A good sand monitoring system should, when sand is not present in the flow line, show a very calm and steady line on the computer screen. We have, however, experienced too often that such a system shows sand free oil and gas production when there actually is sand. The consequences for the operator are that he reduces production capacity unnecessary. Our solution to this is to have the brain of the system in the field together with a sensor, working in the correct frequency range. The ClampOn 2000 Particle Monitor has the best signal to noise ratio compared to competitors using similar measurement principle in order to overcome the problem mentioned above.

Calibration

We often get questions from users regarding accuracy and repeatability of sand monitoring systems. In the following we have described what the user can expect from a ClampOn 2000 Particle Monitor:

Repeatability - When we are dealing with sand monitoring words such as calibration, accuracy and repeatability it can sometimes be confusing. For some oil producers accuracy is not of great importance, their main concern is repeatability. They want a sand monitor that gives them the best possible trend and then repeatability is the key word.

The ClampOn 2000 sand monitoring system has repeatability better than 1%. (This can be confirmed by using a sand injector on site to verify the performance.)

Accuracy - Other oilfields require a high degree of accuracy. The reason is that they are very concerned about how much sand they are producing. How will the sand affect the piping (erosion)? How will the sand affect the reservoir itself, and when do they have to clean out the separator? Also, the sand itself is a problem offshore since they have to remove it.

Different methods of calibration

Alternative 1 (In-house calibration)
When installing the ClampOn 2000 Monitor and using only the in-house calibration you can expect a deviation in the range of 25 to 50%. Repeatability: ± 1%

Alternative 2 (In-house calibration plus adjustment for flow)
When you install the meter you adjust the reading for the actual flow conditions you have in that particular well. This will give you accuracy in the range of ± 15 to 25%. Repeatability of ± 1%

Alternative 3 (Field calibration by using a sand injector)
You install the meter and in addition you install the sand injector upstream of the meter. Then we inject sand into the flow line to adjust/verify the ClampOn 2000 Particle Monitor. Accuracy in the range of ± 5 to ± 15%.

In other words a repeatability of ± 1% can be expected and is not dependent of the method of calibration.

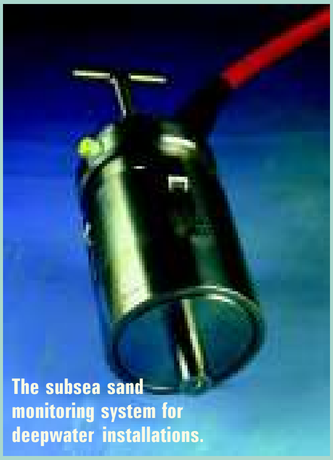
When the operator installs a monitor on a well, one should usually let it run for some time in order to find what we call the zero level. This is to adjust the system for background noise. Usually this takes around 30 to 60 minutes. The operation is easy - however some time is needed.

If you already produce sand it will be detected and shown immediately on the computer screen. The repeatability is still ± 1%, and you will still have a good trend - however the accuracy will suffer. Our experience is that sand is never produced continuously, therefore we measure the trend until a sand free period comes up in order to establish the zero level.

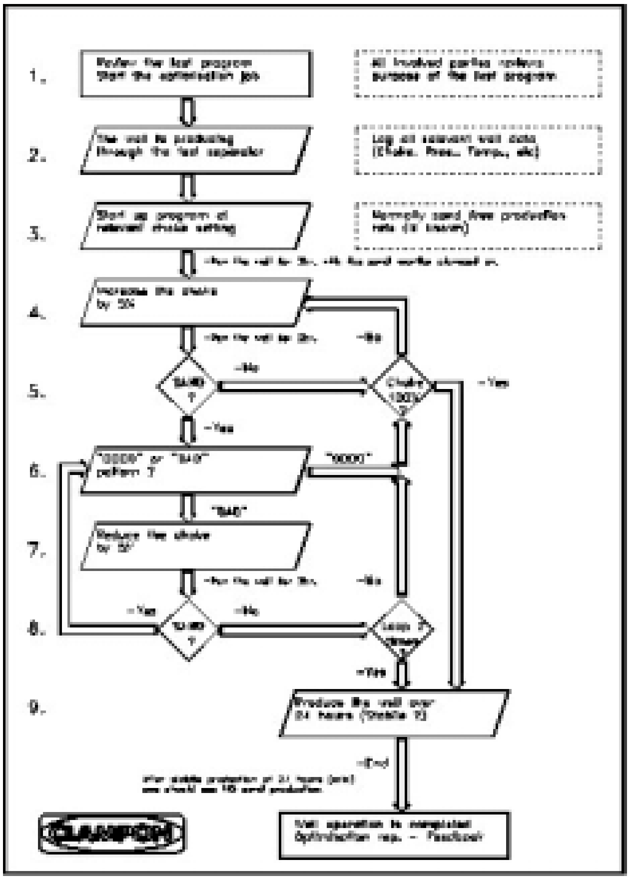
All the above mentioned factors are of crucial interest for using the ClampOn 2000 Particle Monitor for maximum sand free oil/gas production.

Finding the maximum sand-free production level

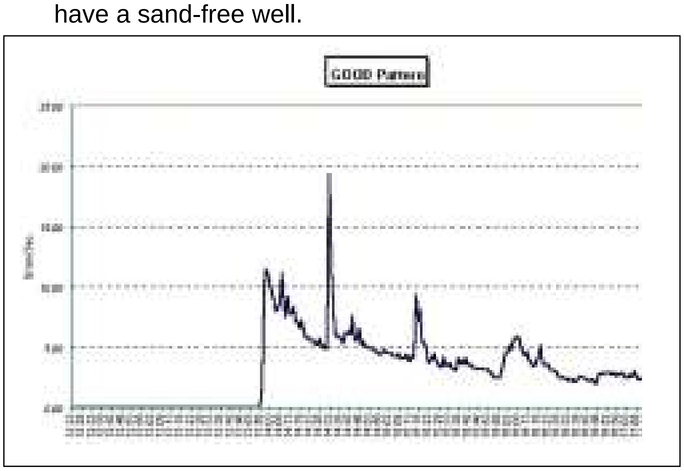
Too often we have seen a worried operator that, since he is not fully aware of the nature of his sand production, reduces production unnecessarily. A cutback in production in the range of 20 to 75% is fairly common in oil and gas wells. Bearing in mind the values such production limitations represent, it is well worth evaluating sand monitoring systems as a way of increasing production without high investment costs. It is of vital importance to have a system that responds rapidly and accurately to improve the sand detection.


The subsea sand monitoring system for deepwater installations.

Usually the operator chokes back production immediately when sand is present (or when he believes sand is present). In the following paragraphs we try to explain how to maximise production while maintaining a well-consolidated reservoir.

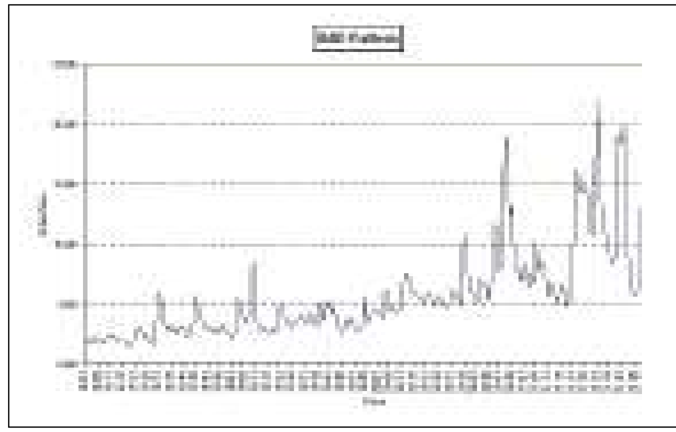


The figure below shows a producing well in which sand production is declining. The curve represents what we call a 'GOOD' pattern. As the figure shows, sand is being produced due to the increase in production (opening the choke valve). However, by using a reliable sand-monitoring system the operator can monitor the development of the sand production. The figure shows how sand production is being reduced over time due to consolidation of the producing reservoir. When you have this pattern it tells the operator that the production of oil and gas can continue at this level since he will quite 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 shown in the figure; however one should let the production continue in order to see the trend in sand production. We are looking for a 'good' pattern as shown above. When this curve appears after a time, the operator has a consolidated reservoir.

The above method of increasing production requires quite some time (usually it takes a couple of days) until the operator sees the opposite ('bad') pattern, meaning 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. *Then the operator knows the maximum sand-free level of the well, and he reduces oil and gas production to the previous sand-free level.* Then the well is produced over a period of at least 24 hours to ensure that the formation is consolidated and stable.

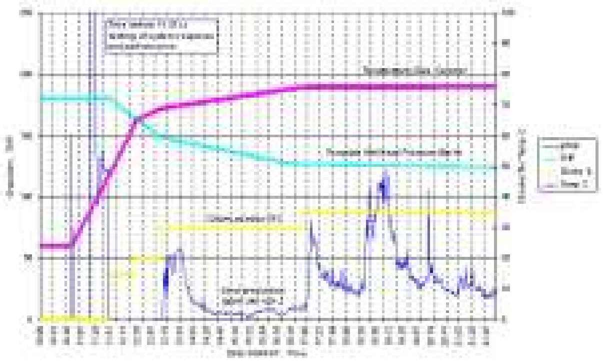
Well optimisation – a real-life example of a well

In the following, we take a closer look at a well optimisation work-over for Conoco on the UK sector. The curves are marked and we are going to examine those that indicate choke position versus sand production. The graphs show how much sand is being produced in grams per second, choke opening in per cent and finally pressure (BarA) and temperature in degrees Celsius.

Curve 1 - The early peaks on the sand curve at 11:00 to 12:00 were caused by testing the system by scratching very fine sandpaper on the pipe wall.

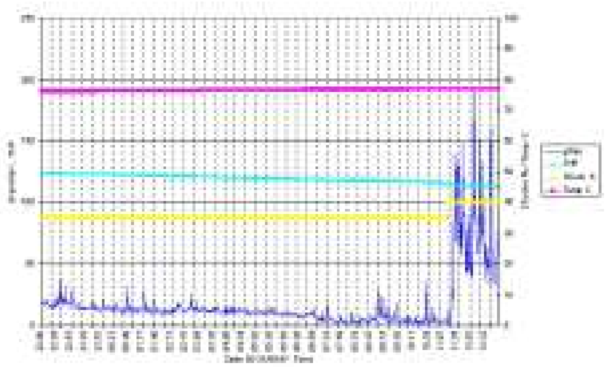
12:00 - The choke opens up to 15% and runs for one hour, after which it is opened to 20% and 30%. At this choke position the sand comes immediately, showing that sand is being loosened from the pipe wall when the choke opening is increased.

17:00 - Once again the choke is opened up to 35% and the well starts to bring up more sand from the well bore. This is sand from the well itself, and after approximately half an hour we can see that the sand production is declining. Production continues at this level and we have the first bottoming up of produced sand at 18:26. Production continues at this level throughout the night in order to prove and ensure that no sand is being produced from the reservoir.



curve 1

Curve 2 - 22:00 to 11:00, when we look at the curve we can see that the well is clean and is producing virtually no sand at 11:00. By 11:35 the choke is opened to 40% and once again we can see that the well is producing sand. The opening of the choke gives the well a 'kick', and this can be seen quite clearly in the sand production curve.

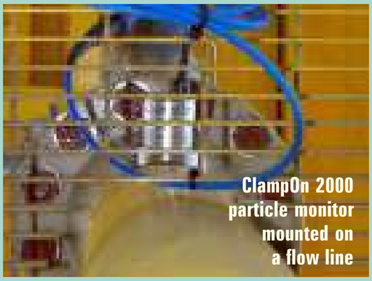


curve 2

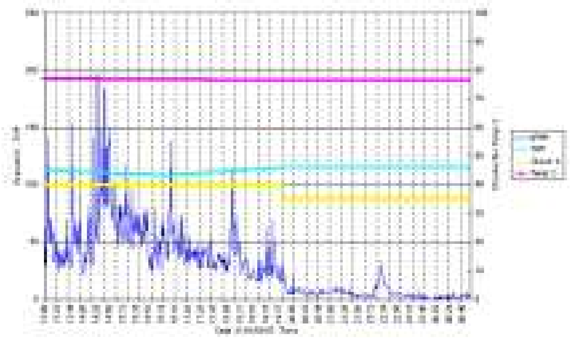
Curve 3 - The peaks at 11:35 due to a choke opening at 40% show that more sand is coming from the well bore to the surface.

14:00 – 14:30 - Sand production is increasing and is probably coming from the reservoir itself – this sandstorm lasts from around 14:30 to 15:20. After 15:00 we can see a clear reduction in the quantity of sand coming to the surface.

Important: At about 16:40 we can see that the pressure is increasing! This means that the reservoir is consolidating! We can see a reduction in sand produced and at some point the well will be free of sand. However in this case the platform was not able to handle the sand being produced, so the choke was set back from 40% to 35%. Sand production is kept to a minimum and is still declining.

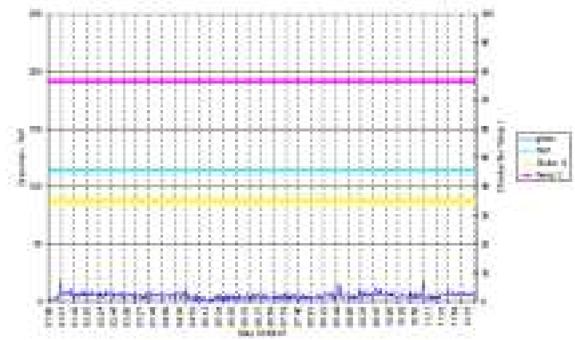


ClampOn 2000 particle monitor mounted on a flow line



curve 3

Note. At a later stage the choke opening on this particular well was increased to 60%.



curve 4

Some examples:

BP Cleeton	Increased production from 115 MMscf/d to 180 MMscf/d
BHP Ravenspurn	Increased production by 300%
Conoco Caister	Production rose by 35%
Statoil (Statfjord Field)	Increased value of production worth 540 000 USD/day

Conclusion

We have discussed different methods for sand monitoring in gas and oil wells in this paper. We have given examples on non-intrusive as well as intrusive devices, and the actual installation and maintenance for the various sand monitoring systems available on the market today.

As a conclusion we may say that the advantages of using non-intrusive, real-time measurement devices are:

Safety
- no hot taps required
- line pressure not an issue

Affordability
- no loss of production during installation
- less man hour needed for installation
- optimisation of production

Portability
- one man installation and set up
- easily moved from one flow line to another

Reliability
- no moving parts
- no erosion of the sensor

This article was prepared for PetroMin by ClampOn AS in Bergen, Norway, to whom we express our thanks.

Web: www.clampon.com