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*Full Length Research Paper*

# Minimizing the risk of erosion damage of some wells in Niger Delta Field with clampon DSP monitor

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**The mobilization of sand in oil and gas production facilities is one of the challenges plaguing the production department of petroleum industries. Its effects on oil facilities are detrimental to theproductivity of the well. This paper is a case study, which describes how Clampon DSP monitor was applied in sand management in an XY field in the Niger Delta oil province, with a key concern to minimize the risk of erosion damage to facilities from sand production, while maximizing production. In 2006, to optimize production without compromising safety and environment, management of the field initiated a project to minimize the risk of erosion damage to facilities by installation of a real time sand detection and erosion monitoring device on the wellheads of Wellwellheads: X15 and X17 and the inlet manifold of wells: WX3, WX4, WX5, WX6 and WX7. Employing varying choke sizes for maximum sand free rate (MSFR) or to a Maximum Acceptable SandRate (MASR). During the sand monitoring periods at their baseline (normal) chokes with subsequent bean-ups, depending on the well's potential, the corresponding sand production rates were estimated amidst other factors. The result generated by the Clampon DSP monitor showed that majority of the wells were sand producers.**

**Keywords:** Sand production/Mobilization, Clampon DSP Sand Detector, erosion damage,detection and erosion monitoring, surface and subsurface facilities, maximizing production.

## INTRODUCTION

One of the challenges faced today in the Oil and Gas Industry, especially the production aspect of its operations, is the issue of sand production and it is becoming more critical as field operators are following aggressive production schedules.Ifthese high rates of production are maintained without considering the basic sediment and water (BS&W), it may lead to major flow assurance problems. Sand production usually occurs as the formation is being dislodgedleading to formation failure that may arise from instability in the wellbore and perforation cavity as a result of continuous influx of formation solids into the wellbore through the perforation tunnel. Since sand production is unpredictable, it requires a smart portfolio of actions in order to minimize the risk of erosion damage and increaseproductivity.

Sand production is considered unacceptable, adds no economic value when produced into topside facilities, createsdisposal issues and several integrity challenges which has made the field operators implement an innovative approach which has restricted ratesto reduce sand production and decrease the risk of erosion leading to a loss of containment. The issue of sand production is a problem in the Niger Delta oil province whose formation is unconsolidated, the unconsolidated nature of the formation has led to instability in the wellbore during drilling and completions causing some wells to cave in. The problem of instability has made so many companies in this region to invest on supporting research into the causes and solutions of wellbore instability.

During production, most of these wells were completed with sand control techniques such as sand screen, internal gravel packing and chemicals (SCON) this is usually costly and slows production. Despite the cost of installation on whatever sand exclusion method adopted, it cannot guarantee a complete insolation of sand into the

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facilities. Consequently, it is imperative to monitor the sand content of the produced fluids so that if a well starts producing sand, it can be shut-in before it blocks or damages subsurface and surface equipment. Therefore, to optimize production without compromising safety and environment, management of XY field initiated a project in 2006 to minimize the risk of erosion damage to facilities by installation of real time sand detection and erosion monitoring device on the wellhead and inlet manifold with varying choke sizes for maximum sand free rate (MSFR) or to a Maximum Acceptable Sand Rate (MASR).

So much research workhas been done on sand predicting models to establish the erosion of its grains in an oil sand body (Morita et al, 1987, Bratli and Risnes, 1981, Papamichos et al, 2001; Chin and Ramos, 2002) which did not adequately predict when the initial sand production will occur in the life of the field and its effect on the subsurface and surface production facilities. The focus of this study is to detect the early influx of sand particles through installed sand detection and monitoring devices to avert the havoc on piping and other production equipment that occur as it progresses downstream, though it is not a new concept in sand production management. Thus, to reduce the risk of sand particles eroding production equipment, there is need for real time sand monitoring tools on flow lines which are able to provide quantitative information on a continuous basis, a clear picture and an immediate response when sand is detected. These tools for sand control usually bring the most effective results when they are implemented early in the life of a well, before sand production leads to potential permanent problems.

Gunningham et al., (2008) used quantitative risk assessment for sand management process on the Lunskoye high gas rate platform offshore Sakhalin island to provide a systematic analysis of failure modes with mitigating measures and recommended formulating action plans based on cost and benefit review, analyzed the impact of sand-face completions, wellhead desander and responses when excessive sand is detected. They stated that when effective stresses exceed the strength of the sandstone, sand production will occur which will result in failure of rocks and disaggregation. Thus, if disaggregated sand is transported to the facilities in the gas and liquid stream, it will result in erosion of the flowlines and settle in areas of low flow velocities leading to plugging. If the sand continues for a long period and are not removed from the wellbore, the completion interval will gradually sand up and a corresponding decline in production, this requires a workover and cleanout to return production to normalcy.

Matthis (2003) and Acock et al. (2004), stated that sand management approach focuses on reducing the impact of solids mobilzed on operations through appropriate completion and facility designs, implementation, management of the operations after being implemented andadequately monitored. This implies that sand management forms a strategy for production operation when a formation produces sand and/or fines and are transported to the facilities which require the well production to be optimized and platform down-time to be minimized. Gunningham et al. (2008), used Lunskoye sandface completion and facilities to assess residual risks to the operation due to sand production. They designed a sand management plan to address designs and operational procedures focusedon reducing the quantity and impact of sand observed in the facilities, as well as monitoring and inspection schemes which track the impact of any sand on the integrity of the facilities. Remedial and contingency options as well as operational procedures, which help manage any unexpected and unmanageable sand production being identified and assessed using quantitative risk assessment.

There are cases of unexpected massive sand production. Farrow (2001) presented four main remedial options to manage risks associated with unexpected sand production. These are: (1) Do nothing case where you allow sand to produce with no major operating changes and if equipment are damaged by sand, repair and replace. Also, continuous monitoring to detect damage due to sand either with flowline acoustic sand detectors, Ultrasonic testing/Non-destructive testing (UT/NDT), etc. (2) Bean back or shut-in individual sand producing wells to prevent or minimize sand production. Thus, establish the sand free rate or acceptable sand rate (3) Install a desander or in-line separator to remove sand once it gets to the topsides and (4) downhole solutions by shutting off sand producing zones, installation of downhole control or recompletion/sidetracking of well to avoid sand production from the intervals using an alternative completion.

Morita et al. (1987), stated in their work on an analytical approach for realistic sand production prediction that for us to properly characterize sand, it has to be broken into several distinct periods in the life of the well and reservoir. Thus, at the early transient stage, the quantity of sand produced has minimal risk of damage from small cavities around which permeability is reduced. During this period, the amount of failed sand removed from cavities is limited as the remaining material acts as a support to the intact sand skeleton in the vicinity of the cavity surface. Lei-Ming Yeow et al.(2004), stated that sand production is unlikely during the early stage of production for the multi-field gas development. Also, reservoir pressure depletion can significantly increase sand production risk, particularly in the over-pressured reservoir formations. After significant reservoir pressure depletion (say 50%), sand production is expected to occur in some of the over-pressured formations.

Andrews et al (2005), stated that sand production is monitored byacoustic methods andbywellsamples collected from a sand trap during well testing. Each well flow line is equipped with a dual acoustic sensor system. The two sensors are mounted on separate pipe bends and are separated by 10 meters or more. The employment of two independent detectors per well enhances the reliability of the measurements, adds redundancy to the system in case of errors and also offers the possibility of self-correlation. Assuming that back ground noise is random and does not correlate between the two sensors, a cross correlation of the two signals can improve the signal to noise ratio and will also provide a direct determination of sand flow velocity between these two points.

## Sand Detection

Sometimes, even if a sand control technique such as gravel packing, chemical means of sand control and resin-coated gravel is installed at the early stage of the field, sand can still be detected as the field ages. Hence, sand-detection technology can assist in determining the maximum sand –free production rate. It also provides a method to monitor long term success after application of a sand-control treatment. Devices to detect the presence of sand in produced fluids can substantially improve the safety and productivity of wells in sand-producing areas. A research conducted by Hendel et al (1977), said that the design of gravel packs for the protection of sand entering into the formation is for maximum productivity and for the selection of the gravel pack.

## Statement of Problem

Sand begins to produce in Oil and Gas wells as a result of ageing of the field (Reservoir depletion), premature failure of the wellbore, improper well completion and the production from unconsolidated formation. This is probably the biggest challenge to operators in the oil industry. As sand is continuously produced,it fills up the wellbore thereby choking back the productivity. Also, sand fills up the process system thus halting the production operations to the remove sand or even system tripping; it erodes well equipment and facilities, causing breakdown and sometimes even blow outs. Sand production is a major risk to safe and economic operations of oil and gas facilities. Casing may collapse and the wells can also have low productivity as a result of high sand production. Hence, the Clampon DSP Sand Detector is installed at the bend of pipes, offers an opportunity to identify the sand producing intervals and failures in sand control devices (gravel packs, screens etc).

## OBJECTIVES AND BENEFITS OF STUDY

The objectives of this researchcannot be over emphasized. It is no doubt that Nigeria (Niger Delta) is among the leading oil producers. Therefore, in other to produce our oil and gas fields in a safe and economic way, a real time monitoring device should be installed and an adequate control measure taken in the case of sand influx. Hence, this work is important to:

- Increasing the productivity index of Oil and Gas wells by preventing sand influx.
- To avert or reduce the occurrence of wellbore failure, thereby reducing operational costs from catastrophic breakdown of well and/or reservoir.
- Improved reliability/safety of down hole and surface equipment to prevent erosion.
- To ascertain the merits and demerits of the use of sand control devices.
- Prolonged life of the reservoir for greater production-output by managing operational parameters.
- Identifying sand producing flowing strings or wells that have the potential of sand production in the near future.
- Improving time estimation for sand removal/ de-sanding program
- Improving sand management strategies

## METHODOLOGY

The methodology behind sand production assessment and control management involves some key stages. The method used in this study todetect and control sand production is given in the flow chart below:

## The Equipment Used

- 3 Clampon DSP particle monitors
- Two 2-Channel PSU-boxes with power supply cable, quick connector and signal converter.
- 6X50m Twisted-pair cables (300m)
- 1 Acer Travel Mate 2303WLMi Celeron Laptop computer and accessories

## Description of Clampon DSP Particle Monitor

The Clampon DSP Particle Monitor is designed to give an early detection of any solids/particles in oil or gas production systems to minimize the risk of erosion damage. The particle monitor is a non-invasive instrument that provides a quantitative measurement of solid/particle production in oil, gas and multiphase flows. The particle monitor is based on passive acoustics. When

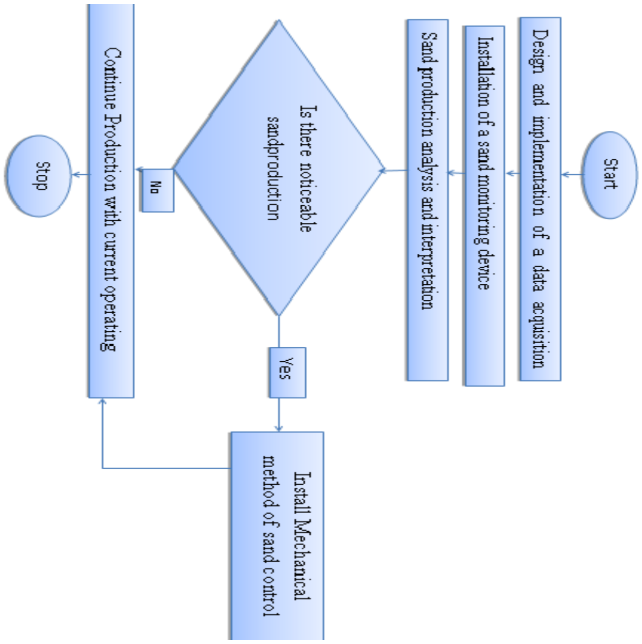


**Figure 1.**Flow chart of sand detection and control.


**Figure 2.** Clampon DSP particle monitor

mounted after a 90 degree bend, the monitor picks up the energy from particles that collide with the inside of the pipe wall due to the lack of force to change their direction.

Filtering of sound with frequencies that are unwanted in the further processing takes place in the built-in electronics. The electronics calculates the amount of energy on the spot and sends this out from the field in a digital format – eliminating signal-transfer related sources of noise and distortion.

### Location of the Monitor on the Selected Bend

The location of the installation spot should be where the sound from the sand is most severe, i.e. right where the sand hits the pipe wall. Given a specific 90-degree bend this will be dependent on the flow velocity and flow medium. The rule of thumb is one to three pipe diameters downstream of the entry to the bend (see figure 3 below). If the bend is slack, i.e, radius is large, the monitor should be mounted in the bend itself. The figure exemplifies good locations on two different 90-degree bends.

## RESULT AND DISCUSSION

Production of sand above the design and acceptable limits, for a prolong period of time will result in erosion of subsurface and surface facilities. If the conditions are left

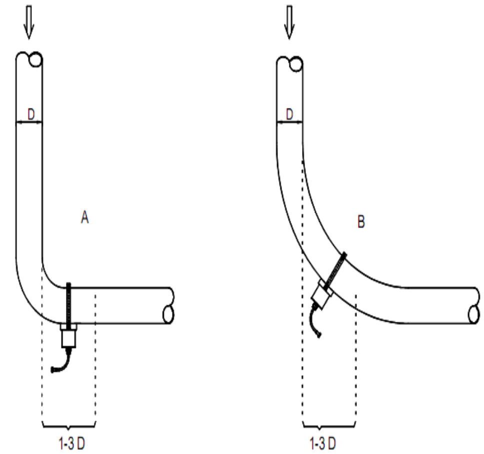


**Figure 3.** location of the monitors

**Table 1.** Summary of Result

| Well | Choke | Avg. Sand Produced (PPTB) | Max Sand Produced (PPTB) | Water cut (%) |
|---|---|---|---|---|
| **X15** | 32 | 0.0346 | 1.2833 | 0 |
| **X17** | 32 | 0.005 | 0.8 | 0 |
| **WX3** | 60 | 1.2 | 125 | 11.8 |
| **WX4** | 64 | 0.1083 | 35.46 | 25.4 |
| **WX5** | 64 | 2.89 | 319.9 | 12.5 |
| **WX6** | 80 | 0.2565 | 75.28 | 70 |
| **WX7** | 20 | 0.0245 | 29.575 | 44 |

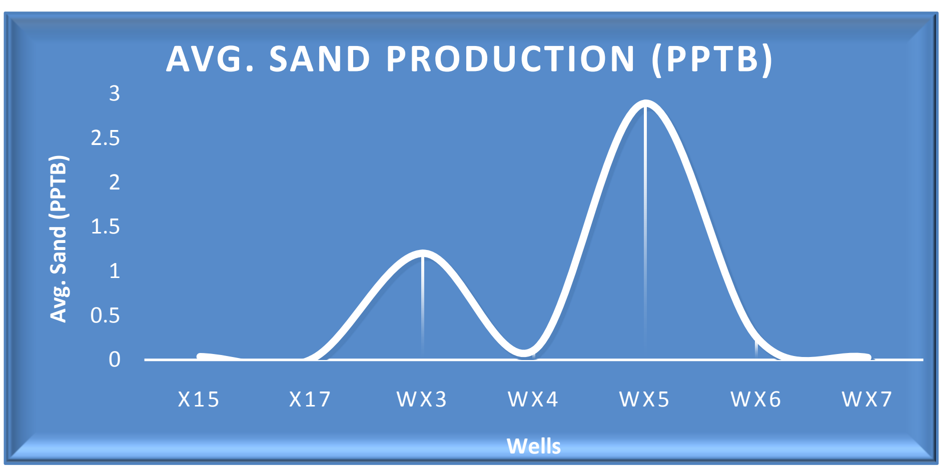


**Figure 4.**Average sand production.

to continue without intervention, there willbe loss in production and damage to these facilities of the which is still applicable to fields in other parts of the world with unconsolidated formations or general potential to sand Mobilization.

Prior to the installation of sand detection tool in this field, a nearby field was seriously affected as a result of excessive sand production which lead to workover operation to change corroded sand screen, tubing and surface choke. This gave rise to the conceptofminimi-

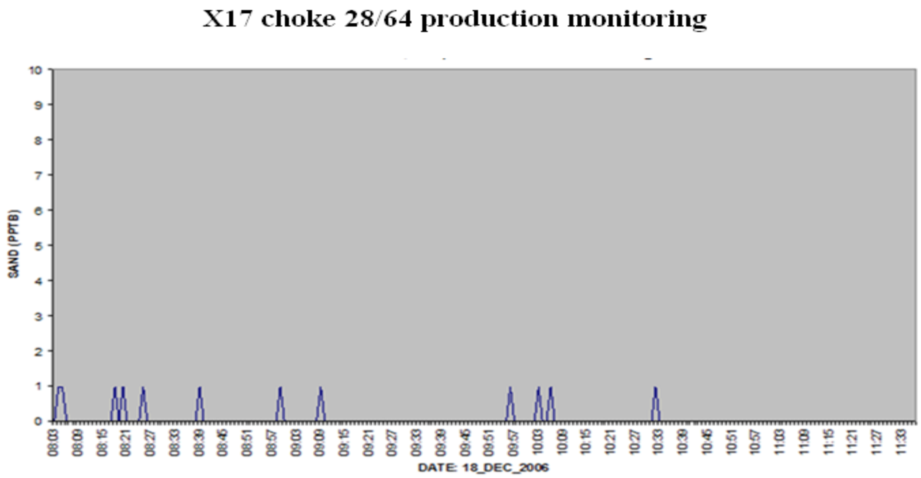


**Figure 5.** X17 production monitoring

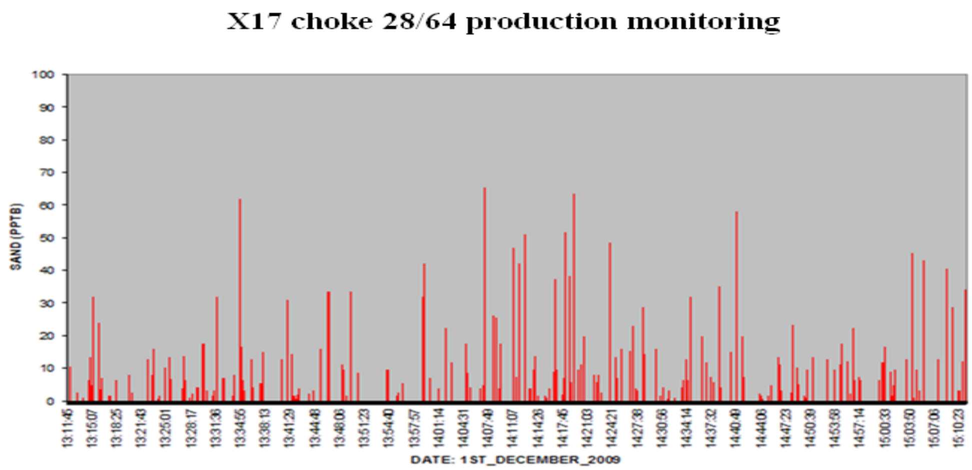


**Figure 6.** X17 production monitoring

zing the possible risk of erosion damage of these wells used as case study in this paper.As part of the sand management strategy of theXY field in the Niger Delta to reduce the risk of erosion on surface and subsurface equipment, the wells were assessed using Clampon DSC monitor, which was aimed to identify sand production early enough reduce any potential risks.

During the sand monitoring periods, the wells were monitored at their baseline (normal) chokes. Subsequent bean-ups were done depending on the well's potential and corresponding sand production rates were estimated amidst other factors. The export delivery line was also monitored. Well X15 and X17 were monitored at the manifold while well WX3, WX4, WX5, WX6 and WX7 were monitored at the inlet manifolds to establish a relationship between wellhead and manifold monitoring as shown on the tables of the appendix. The output result generated from the Clampon DSP monitor showed that majority of the wells were low sand producers with an average sand production below 1 PPTB in 2006. A point to note here, is that; the quantity of sand produced depends on the fluid: viscosity, velocity, water cut, and formation: permeability, grain size and bonding material.Also, the pace and manner with which bean-up of wells were done. Table 1 shows the summary of result from the wells.

The result of sand production rate obtained when the wells were bean-up at the manifold for Well X17, gave an average of 0.005PPTB production with 32/64 choke size and a maximum rate of 2.953PPTB with 24/64 choke size. This well has a low sand production tendency,with almost zero water cut.Therefore the trend should be maintained for some time, bearing in mindthat the well canproduce water in thefuture (figure 5).Figure 6, shows a noticeable sand production of an average of 35 PPTB when monitored three years later ascompared to the sand production that was less than 3PPTB on maximum rate in 2009 which might be as a result of high production rate and/or ageing of the field.

From appendix B, figure7and 8Well X15, wenotice production less than 1PPTB on the first day and an inconsistent production on the second day with value up to 4 PPTB which is an indication that the well has the potential of producing sand in the future. WX3 is a high sand producer and should be monitored carefully, however the well slugs made the interpretation of results more difficult. WX4 is a low sand producer but has a high water cut. This should be monitored very also for the water production as that could lead to sand influx into the well.WX5 has an average sand production of 133g and water cut of 12.5% but difficult to interpret result because of the slug it exhibits. This implies that the well has the tendency to produce sand in the near future.

Though WX6 showed less than 1 PPTB sand production, it exhibited an estimated daily sand production of 186.38g,water cut is 70%, this well is a likely sand production candidate and should be watched very carefully. Well WX7 showed a very low sand production with a high water cut of 44, and should be monitored also for potential sand production. Sudden increments in water cut could lead to a significant increase in sand production.

## CONCLUSION

Analyzing the results of the wellhead and inlet manifold, the sand production measured at manifold is similar to but slightly higher than that measured at wellhead. These results however are not conclusive. It is expected that sand should drop off gradually while on transit from the wellhead to the inlet manifolds. Deviation from this expectation could be as a result of the movement of already accumulated sand in the flowlines. The piping configuration could also have a part to play in this process. Information on the movement of sand from wellhead to inlet manifold is necessary to draw and establish a definite correlation between the two forms of monitoring. Therefore, the following were observed:

- X17 showed traces of sand production.
- X15, WX4, and WX7 are low sand producers.
- WX6 is an average sand producer. All wells termed as low and average sand producers could be managed quite easily by conventional sand control measures. During production, the water cut levels should be closely monitored.
- WX3 (especially X17 and WX5) are all high sand producers and should be observed closely. Water cut levels should be observed during production, and Sand control methods could be used to contain these wells but there is fear of flow line and bean erosion if surface control measures are employed alone and the wells areleft to flow under the same prevailing flow conditions. Slugging in the wellsmade interpreting their results a little bit complicated.
- Therefore, Scheduled and regular monitoring should be carried out on all wells especially on the ones with average and high sand production.
- For purposes of establishing the relationship between wellhead and manifold sand production monitoring, monitoring should be scheduled more frequently, Sand injection would then be employed in order to observe movement of injected sand from wellhead to manifold.

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**Appendix A**

**Table 2.**production data for (X15 and X17)

| RESULT TABLE - PRODUCTION DATE | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Well | **Choke** | **Date** | **Start Time** | **Stop Time** | **Gross (rb/day)** | **BS&W (%)** | **GOR (scf/stb)** | **Upstream Pressure (psi)** | **Downstream Pressure (psi)** | **Pipe ID (in)** | **Net Oil (rb/day)** | **Gas Rate (Mscf/ day)** |
| X15 | 24 | 16.12.06 | 9.49 | 14.15 | 1113 | 0 | 824 | 1058 | 395 | 2.75 | 1113 | 917.11 |
| | 30 | 17.12.06 | 8.13 | 15.13 | 2141 | 0 | 923 | 1044 | 406 | 2.75 | 2141 | 1976.1 |
| | 32 | 18.12.06 | 14.00 | 17.31 | 2468 | 0 | 991 | 1029 | 426 | 2.75 | 2468 | 2445.7 |
| | 32 | 19.12.06 | 7.56 | 17.06 | 2468 | 0 | 991 | 1029 | 426 | 2.75 | 2468 | 2445.7 |
| | 32 | 20.12.06 | 7.54 | 17.32 | 2468 | 0 | 991 | 1029 | 426 | 2.75 | 2468 | 2445.7 |
| | 32 | 21.12.06 | | | | | | | | | | |
| X17 | 24 | 16.12.06 | 9.49 | 17.00 | 12.88 | 0 | 18.32 | 1073 | 1015 | 2.75 | 1288 | 1071.6 |
| | 28 | 18.12.06 | 8.03 | 11.36 | 19.27 | 0 | 12.27 | 1030 | 377 | 2.75 | 1927 | 2364.4 |
| | 32 | 21.12.06 | 11.02 | 16.31 | 23.80 | 0 | 12.32 | 1014 | 353 | 2.75 | 2380 | 2932.1 |

**Table 3.**result of sand production for (X15 and X17).

| | | | | | Sand Result | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Well | Choke | Date | Start Time | Stop Time | Avg Sand (g/s) | Avg. Sand (PPTB) | Max Sand (g/s) | Max Sand (PPTB) | Total Sand over period logged in grams | Estimated daily sand produced in grams |
| X15 | 24 | 16.12.06 | 9.49 | 14.15 | 0.0001 | 0.0231 | 0.01 | 0.1708 | 3 | 11.6 |
| | 30 | 17.12.06 | 8.13 | 15.13 | 0.0004 | 0.0367 | 0.03 | 0.2663 | 10.2 | 35.7 |
| | 32 | 18.12.06 | 14.00 | 17.31 | 0.0008 | 0.0581 | 0.01 | 0.7700 | 9.6 | 65.2 |
| | 32 | 19.12.06 | 7.56 | 17.06 | 0.0004 | 0.0321 | 0.02 | 1.5400 | 13.8 | 36.1 |
| | 32 | 20.12.06 | 7.54 | 17.32 | 0.0002 | 0.0137 | 0.02 | 1.5400 | 4.8 | 15.3 |
| | 32 | 21.12.06 | | | | | | | | |
| X17 | 24 | 16.12.06 | 9.49 | 17.00 | 0.0003 | 0.0378 | 0.02 | 2.952 | 6 | 22.2 |
| | 28 | 18.12.06 | 8.03 | 11.36 | 0.0006 | 0.0553 | 0.01 | 0.986 | 7.2 | 48.4 |
| | 32 | 21.12.06 | 11.02 | 16.31 | 0.0000 | 0.0050 | 0.01 | 0.800 | 1.2 | 5.2 |

**Table 4.** production data for (WX3, WX4, WX5, WX6 & WX7) from the wellhead.

| RESULT TABLE - PRODUCTION DATE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Well | Choke | Date | Gross (rb/day | BS&W (%) | GOR (scf/stb) | Upstream Pressure (psi) | Downstream Pressure (psi) | Pipe ID (in) | Net Oil (rb/day) | Gross Gas (Mscf/day) | Water (BWPD) |
| WX3 | 44 | 24.03.2007 | 1180 | 11.75 | 434 | | 345 | 2.75 | 1041.4 | 1694 | 138.7 |
| WX3 | 69 | 30.03.2007 | 1621 | 11.75 | 434 | 435 | 377 | 2.75 | 1430.5 | 1863 | 190.5 |
| WX4 | 64 | 07.03.2007 | 804 | 25.4 | | | 450 | 2.75 | 600 | 2362 | 204 |
| WX5 | 64 | 17.03.2007 | 101 | 12.5 | 11888 | 130 | 119 | 2.75 | 88 | 1625 | 13 |
| WX6 | 80 | | 1414 | 70 | | 195 | 165 | 2.75 | 424 | 795 | 990 |
| WX7 | 20 | | 44 | 44 | | 176 | 160 | 2.75 | 25 | 1147 | 19 |

**Table 5.** result of sand production for  from the welhead.

| | | | | | Sand Result | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Well** | **Choke** | **Date** | **Start Time** | **Stop Time** | **Avg. Sand (g/s)** | **Avg. Sand (PPTB)** | **Max Sand (g/s)** | **Max Sand (PPTB)** | **Total Sand over period logged in grams** | **Estimated daily sand produced in grams** |
| **WX3** | 44 | 28.03.2007 | 8.25 | 17 | 0.003 | 0.502 | 0.52 | 83.76 | 91.68 | 269.2 |
| | 44 | 29.03.2007 | 7.12 | 11.49 | 0.006 | 0.97 | 0.62 | 99.87 | 95.15 | 519.7 |
| | 60 | 20.03.2007 | 7.59 | 13.2 | 0.008 | 1.2 | 1.1 | 125 | 109.7 | 782.7 |
| **WX4** | 64 | 28.03.2007 | 8.25 | 17 | 0.0007 | 0.175 | 0.1 | 23.64 | 21.74 | 64.11 |
| | 64 | 29.03.2007 | 7.53 | 16 | 0.0003 | 0.073 | 0.07 | 16.55 | 8.54 | 26.66 |
| | 64 | 20.03.2007 | 8 | 13.2 | 0.0003 | 0.077 | 0.28 | 66.2 | 5.97 | 28.2 |
| **WX5** | 64 | 31.03.2007 | 11.05 | 16.3 | 0.002 | 2.89 | 0.17 | 319.9 | 28.28 | 133 |
| **WX6** | 80 | 01.04.2007 | 11.18 | 17.02 | 0.002 | 0.223 | 0.49 | 65.87 | 32.69 | 143.1 |
| | 80 | 02.04.2007 | 8.11 | 16.03 | 0.002 | 0.29 | 0.63 | 84.69 | 55.79 | 186.4 |
| **WX7** | 20 | 01.04.2007 | 11.18 | 17.02 | 0.0002 | 0.021 | 0.13 | 17.48 | 3.01 | 13.18 |
| | 20 | 02.04.2007 | 8.11 | 12.35 | 0.0002 | 0.028 | 0.31 | 41.67 | 3.03 | 17.84 |

**Appendix B**

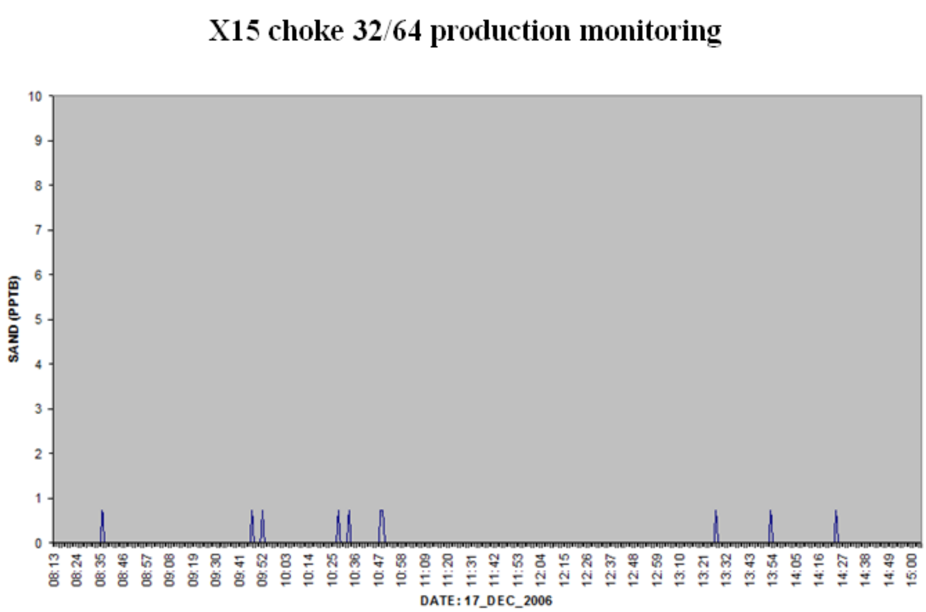


**Figure 7:** X15 production monitoring.

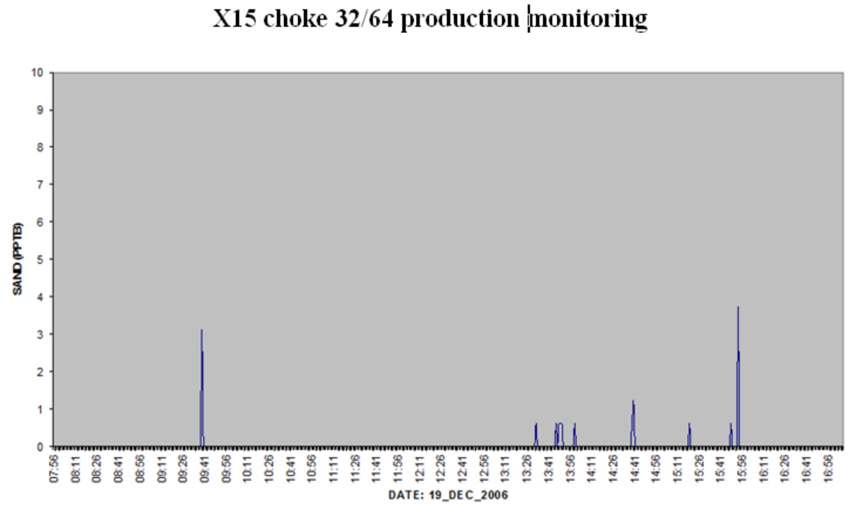


**Figure 8:** X15 production monitoring.

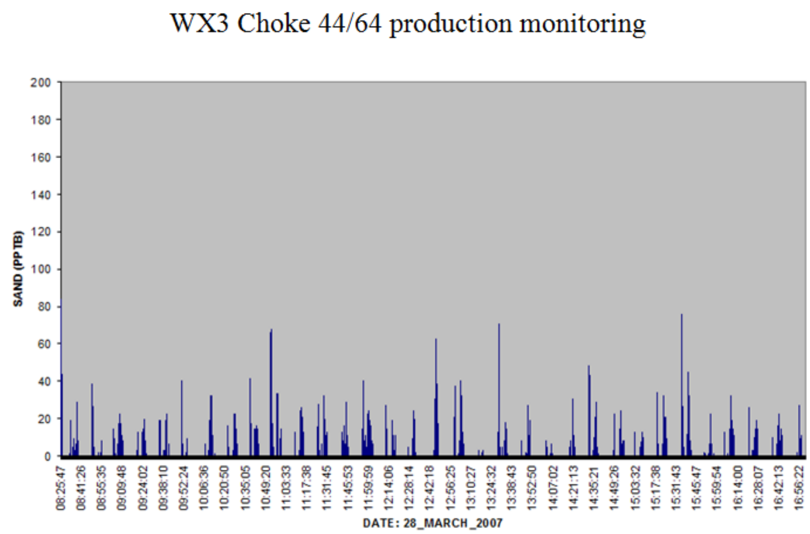


**Figure 9.**WX3 production performance.

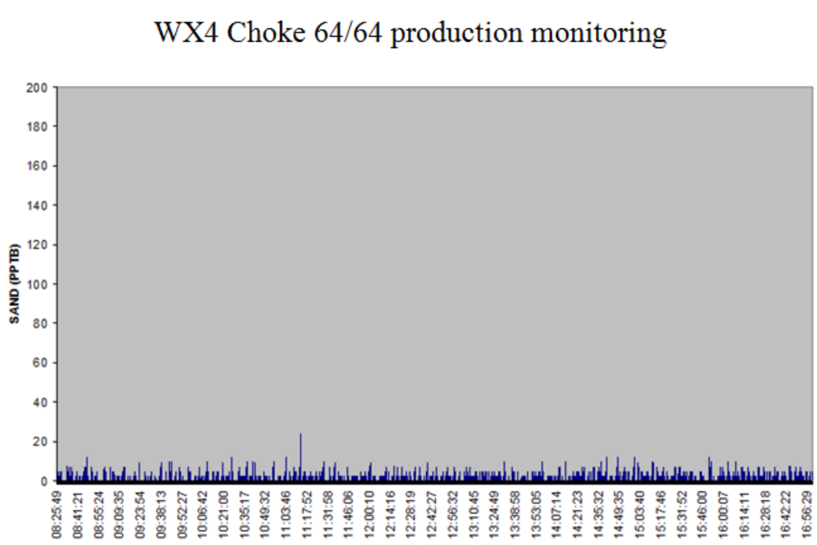


**Figure 10.** WX4 production monitoring

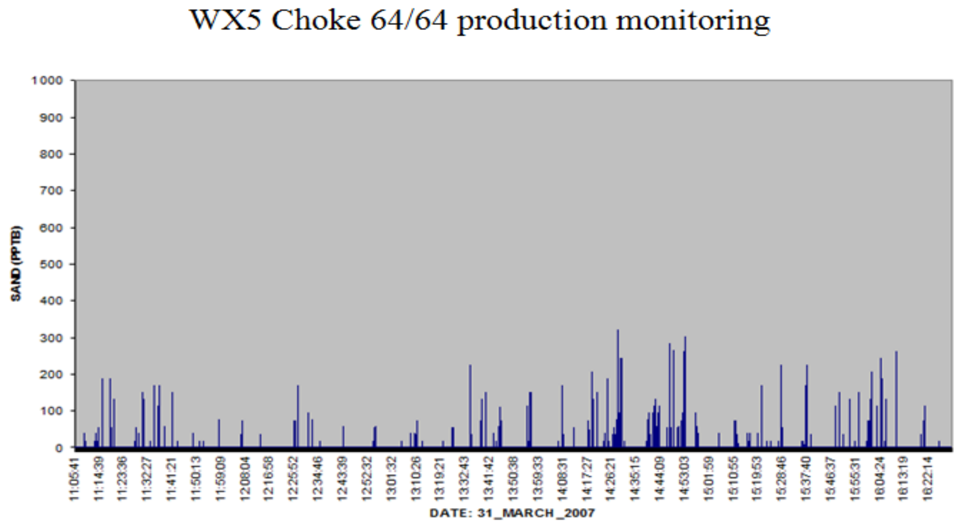


**Figure 11.**WX5 production monitoring.

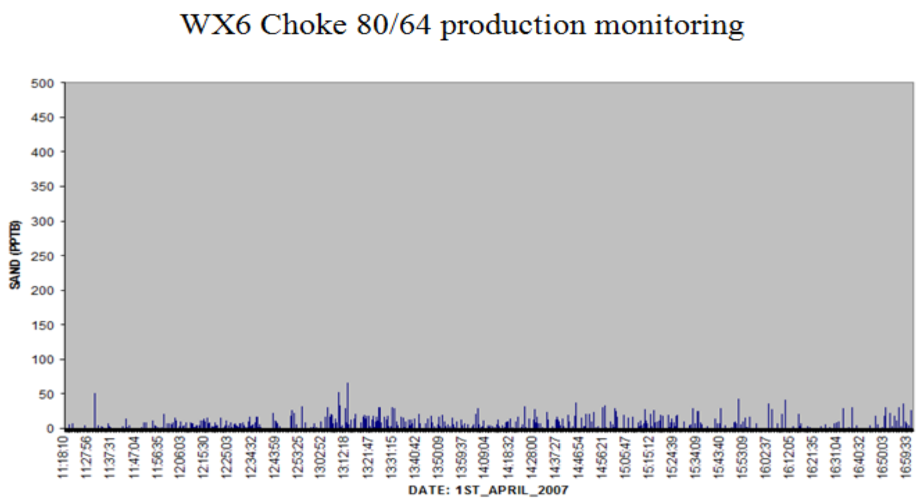


**Figure12.** WX6 production monitoring

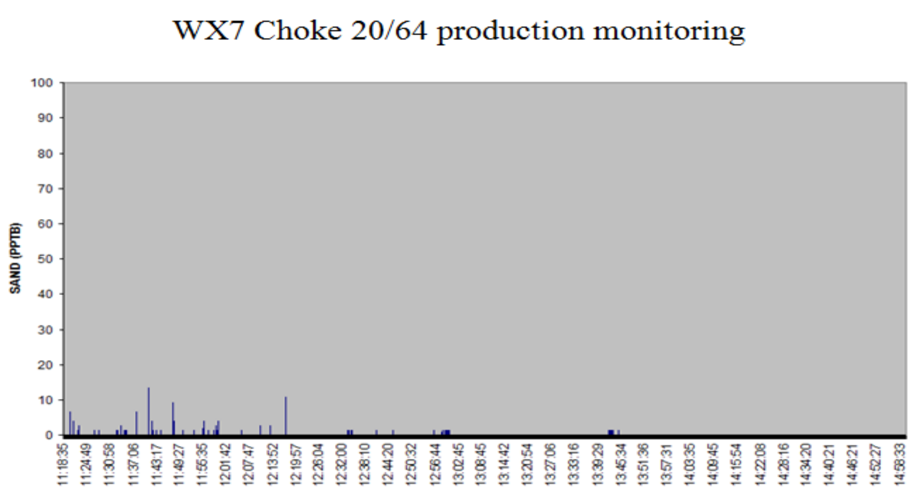


**Figure 13.** WX7 production monitoring