Sand & Erosive Solids Management
Safety Enhancer & Enabler to Production Optimisation

Sand Management is a much vaunted piece of terminology used in the Oil & Gas Industry but what is Sand Management and what use is the practice to operators in the North Sea and moreover in a global context. Well let's start with some definitions and statistics.

"Sand - A detrital grain between 0.0625 mm and 2 mm in diameter. Sand is larger than silt but smaller than a granule according to the Udden-Wentworth scale. Sand is also a term used for quartz grains or for sandstone." Furthermore (harking back to Geology undergrad days) on Mohs Scale of Hardness (range of 1-10) the major mineral constituents of sand fall in the hardness range of 7, therefore we are dealing with a hard and (dependant on a variety of additional physical characteristics such as grain size and degree of angularity / sphericity) abrasive material.

Therefore it's maybe not so much of a surprise that since 1993 in the UKCS alone there have been at least eighteen (18) dangerous occurrences have been directly attributed to produced sand during operations. These occurrences are mainly related to flowline failures however a significant number are also associated with production vessel and control valve failure. Figure 1 displays an example from the UKCS of the significant erosion that can occur due to sand production.

Figure 1 North Sea UKCS Example - Ball Valve exhibiting severe sand cut erosion

In addition to the attributed dangerous occurrences sand poses additional risks through vessel deposition affecting plant performance, requiring vessel entry to dig out the accumulated sand. Furthermore sand deposition can decrease corrosion inhibitor efficiency thereby increasing corrosion / erosion effects.

So what can be done to deal with sand / erosive solids production especially as we move into a new era of technological challenges? At what point in the field operational life cycle does sand / solids production become an issue? The answer to these questions comes in the form of Sand Management.

So what is Sand Management? Broadly speaking Sand Management covers a wide range of disciplines and services that under current wisdom is subdivided into four areas of specialisation – Prediction (geo-mechanical studies) Prevention (sand control – e.g. sand screens) Monitoring (e.g. real time detection) & Handling (online sand removal from vessels). Personally I'd like to see more input from a couple of additional groups into the 'sand network' as the consequences of sand / solids production has a direct impact on their workscopes. Firstly input from integrity management and corrosion specialists and secondly from well services professionals.

If I were to propose a definition (as I couldn't find a single encompassing definition) this is what I'd go for:

"Sand Management – The process of identifying, evaluating and mitigating against reservoir sand production (and solids –e.g. scale & proppant) and its associated problems" So there you go Sand Management can be refined down to a simple holistic moniker that under one banner brings together a disparate group of technologies and professional to find solutions to sanding tendencies.

So we've mentioned the term Sand Management rather extensively so far, however in practical terms we really should be looking – as stated in the previous paragraph - to extend the process to encompass all forms of erosive solids production from the well bore throughout the life cycle of the well. This is why in essence I'd like to get a broader spectrum of specialists brought into the forum. Therefore maybe we should be looking to 're-brand' our terminology to the slightly less catchy but more meaningful Erosive Solids Management (ESM).

Ok then I'm going to stick with Erosive Solids Management (ESM) - on the principal of increased accuracy - is this all about safety critical operations and offsetting production against integrity? Not exactly, historically this may have been the case however when utilised correctly ESM can be used as an active component in Production Optimisation processes. The ESM Strategy (the documentation relating to the overall Erosive Solids Management philosophy) provides a safe operating envelope in which to increase production via a controlled mechanism of Sand Risk Assessments and active monitoring including monitoring technology and inspection data.

Within the oil & gas industry it is widely accepted that certain well service operations - for example well tests – require active solids management such as solds handling systems (cyclones or sand traps) and solids monitoring. However until recently what has been less acknowledged is that in terms of erosive solids it's not just sand that can be problematic. Indeed if we look at production enhancement in tight formations, these intervention techniques such as Fracture Stimulation, utilize proppant to hold or 'prop' open the newly created flow paths. However if the proppant becomes dislodged or the pack becomes unstable proppant returns to surface are inevitable. These sized spherical solids entrained in the flow can cause extensive damage to flowline components. Figures 2 & 3 highlight examples from a deep water installation off West

Africa. Figure 2 displays proppant induced erosion to installed flowline components, whilst Figure 3 displays a field example of produced proppant.

Figure 2 West Africa - Corrosion monitoring weight loss strip coupon displaying significant proppant induced erosion

Figure 3 West Africa - Proppant can severely damage oilfield components

Certainly applying basic ESM principals of Solids Handling and Solids Monitoring would have prevented such incidents of highly erosive fluid streams. The technology is readily available and can be effectively implemented to practicably reduce the risk posed from the solids highlighted in Figures 2 & 3.

Produced solids can be effectively detected by acoustic or intrusive solids monitors; for example Figure 4 displays a data set from the UKCS of a Frac / Clean Up operation utilising a combined Intrusive – Acoustic Real Time (I-ART) monitoring package. This constitutes an erosion probe - for indicative system metal loss- combined with an acoustic sensor - for instant response to solids production.

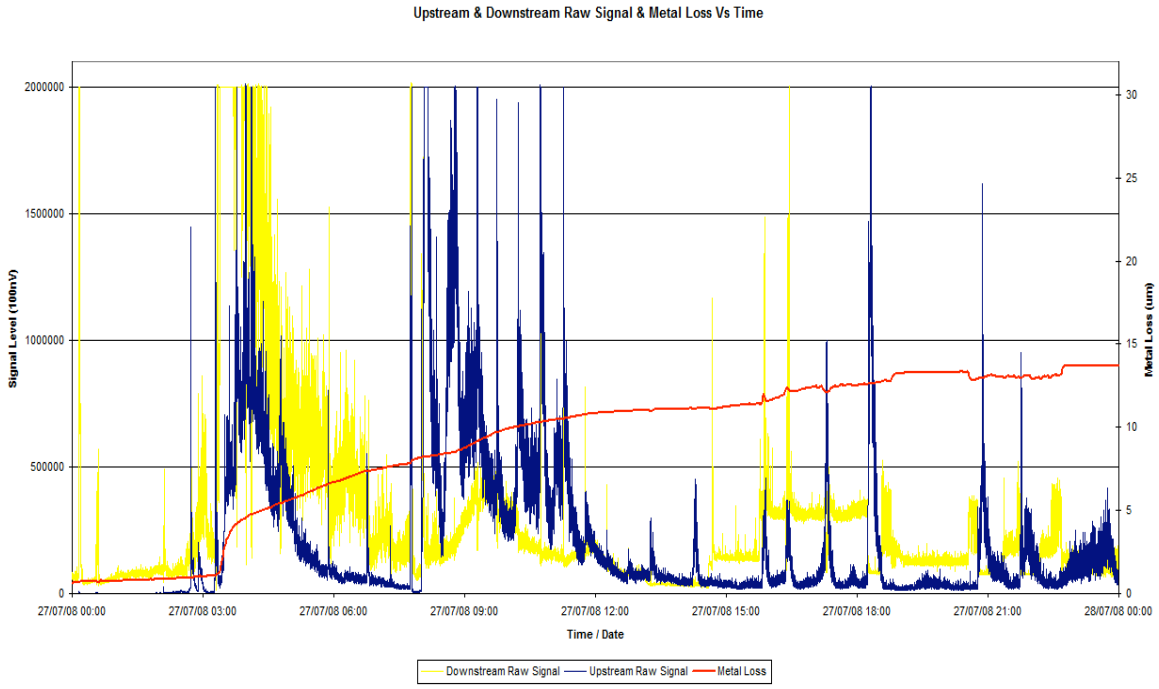

Figure 4 Solids Monitoring during Frac Operations

The data acquired from these monitoring systems can be extremely valuable and greatly enhances the operational safety case. However if we want to get to the next step in the process – an Erosive Solids Monitoring (ESM) Strategy - we need to take into consideration a greater range of information. The solids monitoring data is not sufficient to implement a strategic production optimisation process based within an ESM Strategy; it is an enabler and a key component, but requires correlation of the solids monitoring data with production, inspection, integrity and modeling details to add value through system integration. When this data has been analyzed, informed decisions can then be made to implement the production optimisation process.

If we concentrate a little more within two areas of ESM practice; Prevention and Production, it has been clearly demonstrated that within this genre not only can

operators increase safety with greater confidence, they can also – with the effective usage of ESM principles - make significant gains in terms of production output. It may be noted that the change to adopting a proactive ESM system requires a dedicated engineer / team within the operator environment to facilitate the process, if you will a "Sand Champion" to act as a focal point to gather and assimilate the data necessary for the optimisation process within the control envelope of the ESM Strategy.

An example of the application from the UKCS sees operators utilising a Sand Risk Assessments (SRA's) matrix as a pre-requisite for the Production Optimisation Groups drive for production uplift through planned pressure drop programmes. The SRA comprises of data inputs from a variety of sources e.g. current production conditions, UT wall thickness integrity data, erosion probe data and erosion models. The net result of these data inputs is the prediction of solids production and erosion rates at the proposed Tubing Head Pressure (THP). Evidently the SRA's represent a safety critical feature and provide a Go/No Go stop point for the operational process. The SRA can not be issued without each criteria being met and satisfied through due process control. The key element of the SRA is the integration of data into a single process to systematically control operations. The solids monitoring specialist is responsible for the SRA production with designated area managers being responsible for issuing of the SRA. It may be noted that on completion of any testing activity the resultant data is analysed and correlated with production, probe and sampling data. From these inputs the level of risk posed from solids production levels at the tested THP is assessed and evaluated. If the substantiated risk level is within accepted values, then the Well Operating Guidelines can be amended to reflect the increased production uplift conditions.

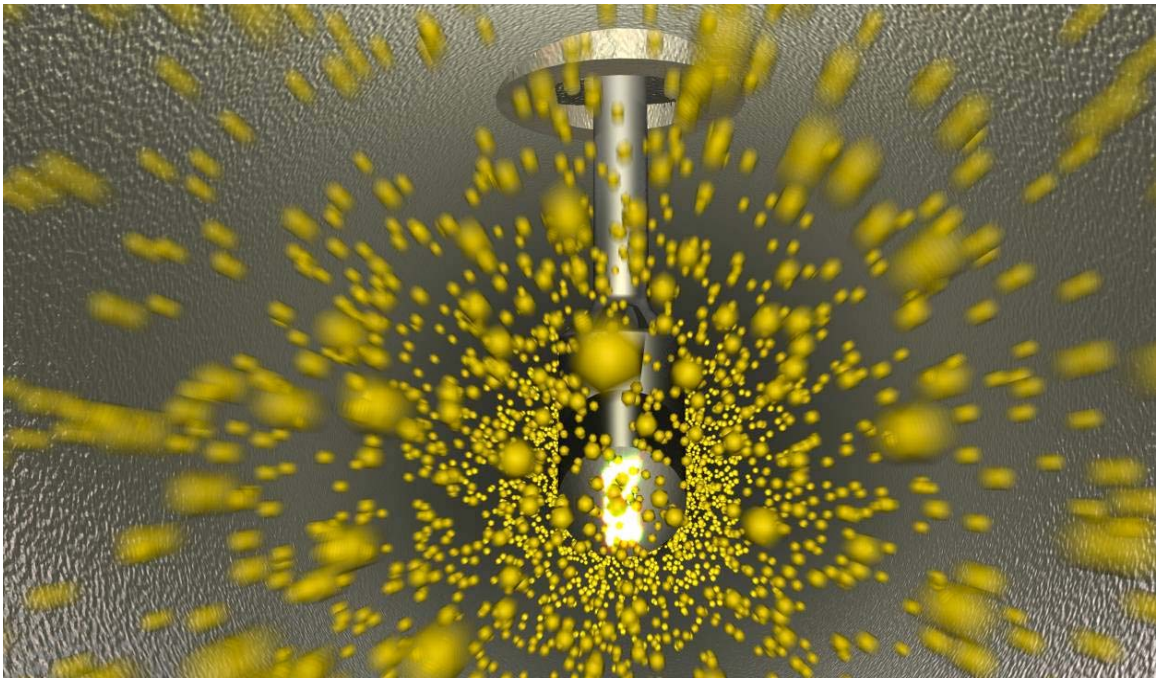

Figure 5 Model of Intrusive Erosion Probe

So it is clear that safe production uplift can be achieved in this new era of technological challenge and change. By enabling a group (or an individual dependant on scale) to facilitate the implementation of ESM - in essence "Sand / Solids Champions" to acts as

focal points can make a real step change improvement in safe production uplift. The end benefits of this active ESM process are not achieved through unique or unrepeatable process but rather through sound engineering practices and the use of a formulaic approach.

There is a common thread running throughout this article, and it's a point I'd consistently stress going forward; for Erosive Solids Management and Sand Control in general to move forward there is a strong need for increased integration / correlation between disciplines. Only through this integration will we be able to grow our knowledge and improve our systems to get a real handle on issues relating to erosive solids production. Thankfully for once the answer to our quest can be met by a mix of good old fashioned "proper" engineering, dedication and a modicum of technological input