Society of Petroleum Engineers
Aberdeen Section
www.spe-uk.org

‘Sand Management Simplified’

Neil Meldrum – Business Development Manager
FourPhase

Thanks to 2016 Sponsors

EXPRO

GE Oil & Gas

Diary Dates 2016

Society of Petroleum Engineers
Aberdeen Section
www.spe-uk.org

17 March	**Offshore Achievement Awards** AECC Aberdeen Tables of 10 or individual tickets available. Contact Mearns & Gill, oaa@mearns-gill.com
23 March	**Aberdeen Presentation & Networking Dinner** 'Making better appraisal & development decisions: using decision risk analysis & value of information' Pete Naylor, SPE Distinguished Lecturer, Shell
TBC March	**SPE YP– Switch Screening** Venue - TBC
30-31 March	**SPE SMN 7th Sand Management Euroforum 2016** Book your company's exhibition stand or sponsorship.
6 April	**SPE YP Simplified Series** Expro - TBC

Society of Petroleum Engineers
Aberdeen Section
www.spe-uk.org

Start the conversation ...

Society of Petroleum Engineers
Aberdeen Section

@SPE_Aberdeen

Society of Petroleum Engineers
Aberdeen Section

CONTINUOUS PRODUCTION

SPE Aberdeen YP Simplified Series Presentation
Jurys Inn, Aberdeen

Sand Management Simplified

Neil Meldrum – Business Development Manager

2 March 2016

www.FourPhase.com

FOUR PHASE

PRESENTER – NEIL MELDRUM, FOURPHASE

Neil Meldrum, Business Development Manager, FourPhase

- Field and operations experience in land seismic, permanent downhole monitoring and well testing - primarily in North & West Africa and the North Sea.
- MSc. Technology & Management in the Oil & Gas Industry from the University of Aberdeen.
- Member of SPE and EAGE.

CONTENT

- Introduction to FourPhase
- Challenges & Opportunities related to sand management
- Producing sand vs. keeping sand downhole
- Key decision factors for sand management
- Sand Monitoring, handling and disposal
- Case Study – Statoil Gullfaks
- Questions/discussion

FOURPHASE IS GROWING

- FourPhase formed in 2012
- Cyclonic surface solids separation
- 50+ staff (onshore and offshore)
- Facilities and offices in Bergen, Aberdeen, Saudi Arabia, UAE & Oman
- Intervention & Production Operations

Applications:

- Well Test Clean-up
- Milled Scale Clean-up
- Frac proppant flowback
- Drilling mud clean-up
- Interventionless kick-starting wells
- Long-term production Multiwell hook-up

FOURPHASE – SOLIDS EXPERTS

- Next Generation cyclone technology
- Design & innovation since 1997

- A Safety & Quality focused culture
- A passion for delivering excellence

- Team has 100+ years of combined technical, solution driven expertise
- Strong IP

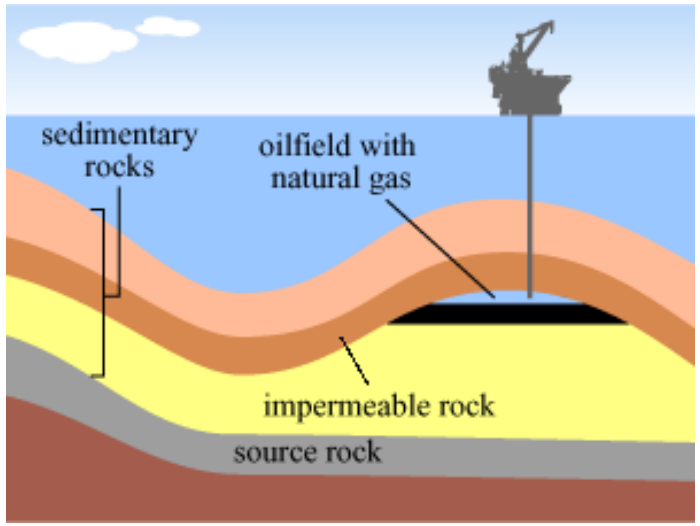
- FourPhase has the leading cyclone engineers
- Specialist field crews

Continuous Production Systems

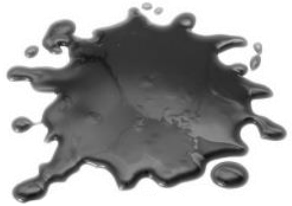
Intervention Clean-up Systems

IMPORTANCE OF SAND MANAGEMENT

According to SPE, 70% of the world's oil and gas reserves are contained in reservoirs where sand production will become a problem at some point during the life of the field.



4 elements are present in the production stream

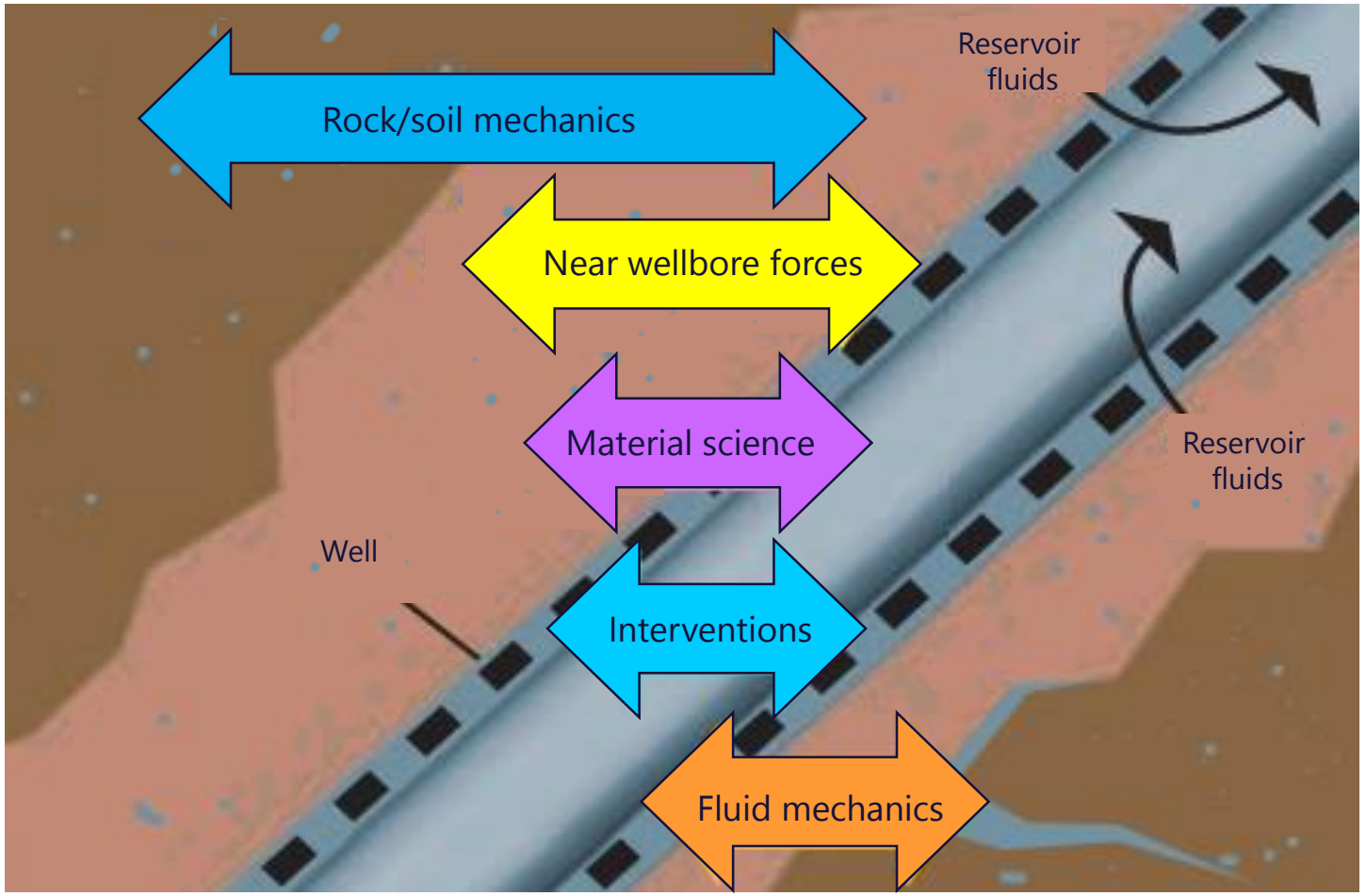
SAND MANAGEMENT - SAND PRODUCTION POTENTIAL

The potential for producing sand to the wellbore is determined by a number of factors:

- **RESERVOIR DEPLETION**: **Reduced reservoir pore pressure** increases the potential for formation of sand grains i.e. rock failure.
- **ROCK STRENGTH**: Different formations have different mechanical strength. The rock strength is characterised in terms of the **level of sand consolidation**
- **WATER BREAKTHROUGH:** Water production **increases sand mobility** to the well bore due to **reduced surface tension** between sand and water - compared to sand and oil.
- **DRAWDOWN:** Drawdown links to the Productivity Index (PI) of the well and production rate, hence the correlation between production rate and sand production. For wells with downhole sand control **too high a drawdown** may lead to **sand screen failure** and **increased sand production.**

SAND MANAGEMENT – KEY AREAS DOWNHOLE

Key areas to help understand the fundamental nature of sand in the reservoir and the wellbore.



Saving Sand Dollars – BP *Frontiers*

SAND MANAGEMENT – COLLAPSE OF THE FORMATION

Collapse of the formation

Collapse of the formation around the well occurs when **large volumes of sand** are produced. **Compaction of the reservoir rock** may occur as a result of **reduced pore pressure** leading to surface subsidence. Examples of subsidence, caused by withdrawals of fluids and reduced pore pressure, are found in:

- Venezuela, Lake Maracaibo
- Long Beach, California
- Gulf Coast of Texas
- Ekofisk Field, where the platforms sank 20 ft

SAND MANAGEMENT - CHALLENGES

The major challenges for operators in the development of fields with sanding problems:

- Predict if, when and **how much sand** the wells will produce
- **Design** of the **subsea** and **topsides** in order to accommodate sand handling equipment
- Optimise the **well design**
- **Maximise** the **individual well's production**
- Effectively **manage** the sand production in regards to the **facility integrity**
- Deploy an appropriate **sand management strategy**
- **Minimise operational cost** and non-productive time
- Manage sand **disposal**

Consequences of sand production:

- Sand accumulation in wellbore leading to sanding-in and **loss of well**
- **Damage** to well components
- **Erosion** in piping system and blow-down (Flare) systems
- Accumulation of sand in separators leading to **unplanned shut-downs**
- **Increased maintenance** due to damage of rotating equipment such as PWRI (produced water reinjection) pumps (impellers) and compressors.
- Sand production may reduce sweep efficiency because of fines in **produced water**

Sand in separator on Gullfaks C prior to implementation of next generation cyclone technology from **FourPhase**

SAND MANAGEMENT – PRODUCING VS KEEPING DOWNHOLE

Sand accumulation downhole

Sand accumulation in surface equipment

Erosion of downhole and surface equipment

Collapse of the formation

SAND MANAGEMENT - OPPORTUNITIES

- Safely and effectively **managing sand production** will positively impact **operational efficiency** & significantly **increase production** capacity.

- The **production capacity** can only be **maximised** as long as the ***consequences*** are properly managed.

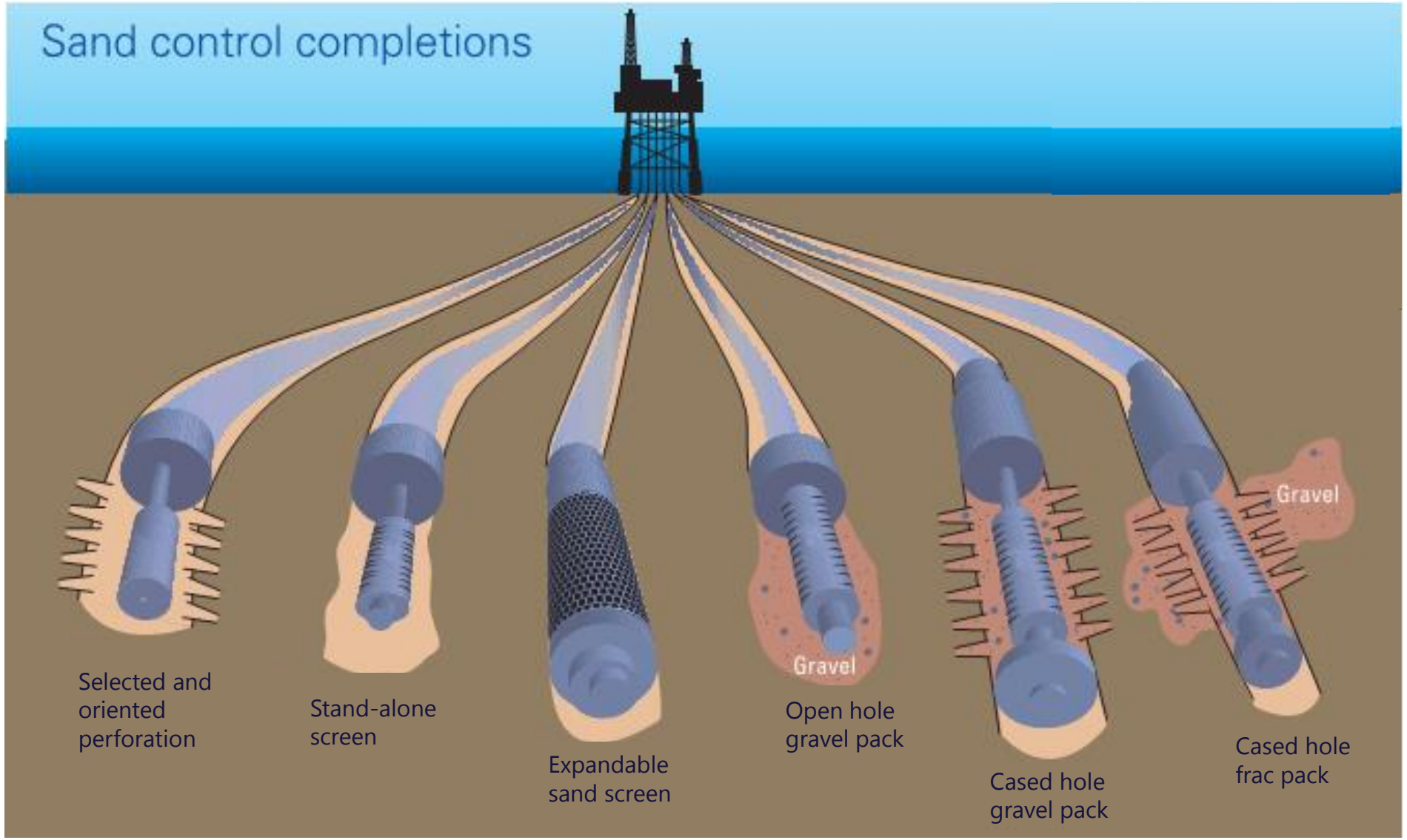
- **Effective sand management** encompasses the **full *sand chain*** from the **reservoir face** to the ultimate disposal of **sand at the surface**.

SAND CONTROL TECHNIQUES

Several techniques are available for controlling sand production. The sand control method selected depends on site-specific conditions, operating practices and economic considerations.

- **Plastic consolidation** – resin system is injected into an unconsolidated sand & cures to a plastic
- **Resin coated gravel** – highly permeable artificial sandstone gravel pack
- **Screenless Completion** – combines consolidation, perforating, fracturing & proppant flowback control
- **Gravel packing**
- **Stand-alone slotted liners or screens**
- **Selective completion practices**
- **Maintenance and workover**
- **Rate restriction**
- **Surface sand control**

SAND CONTROL COMPLETIONS



Saving Sand Dollars – BP *Frontiers*

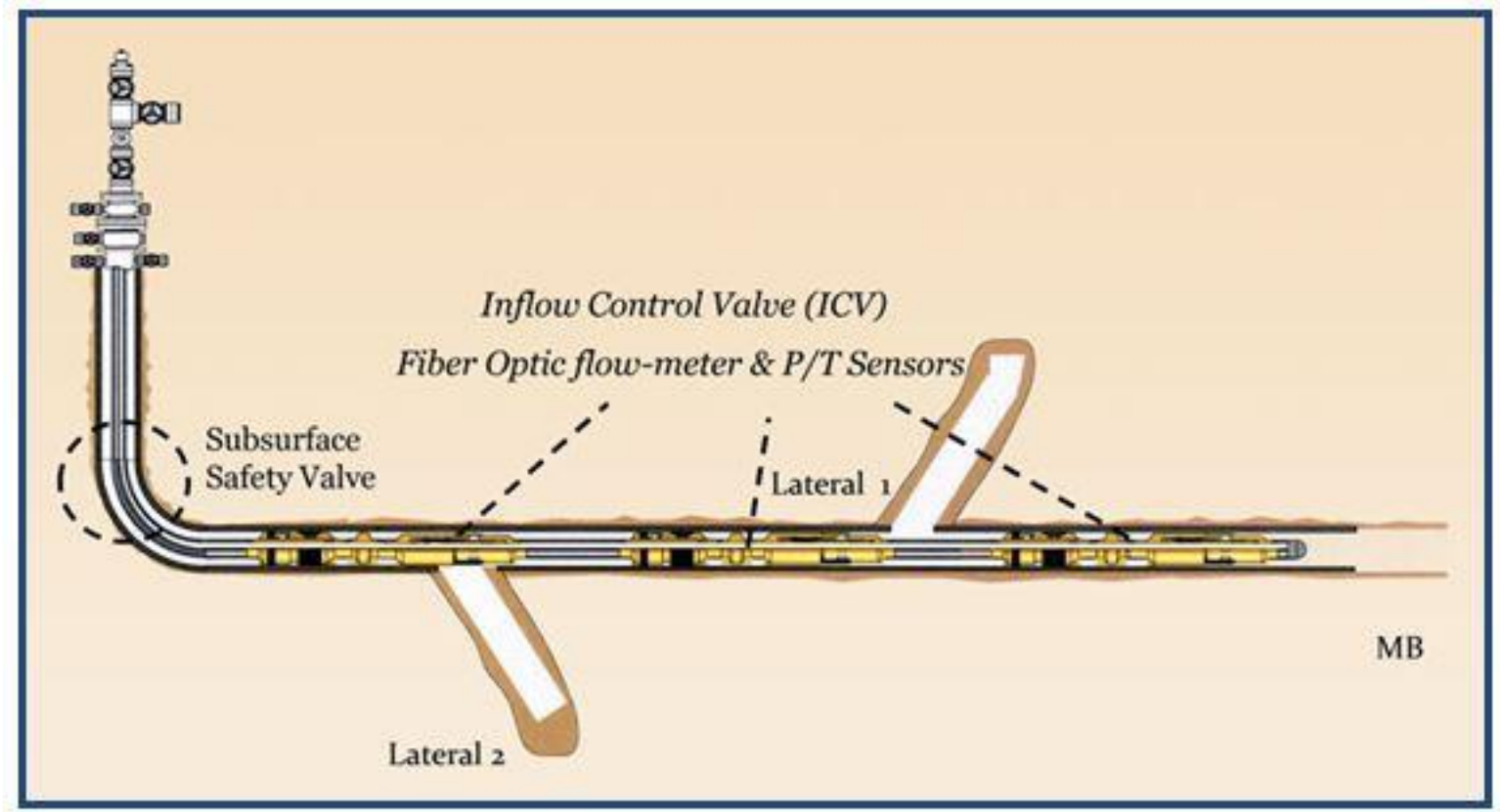
SAND CONTROL TECHNIQUES – SLOTTED LINERS OR SCREENS

Slotted liners or screens have been used as the sole means of controlling formation sand production.

In this service, they function as a **filter. Unless** the formation is a **well-sorted clean sand**, with a large grain size, this type of completion may have an unacceptably short producing life before the **slotted liner or screen plugs** with formation material.

INTELLIGENT WELL COMPLETION - SELECTIVE

Different zones of the reservoir can be remotely closed or opened to the wellbore, to achieve selective hydrocarbon production or, conversely, water injection.

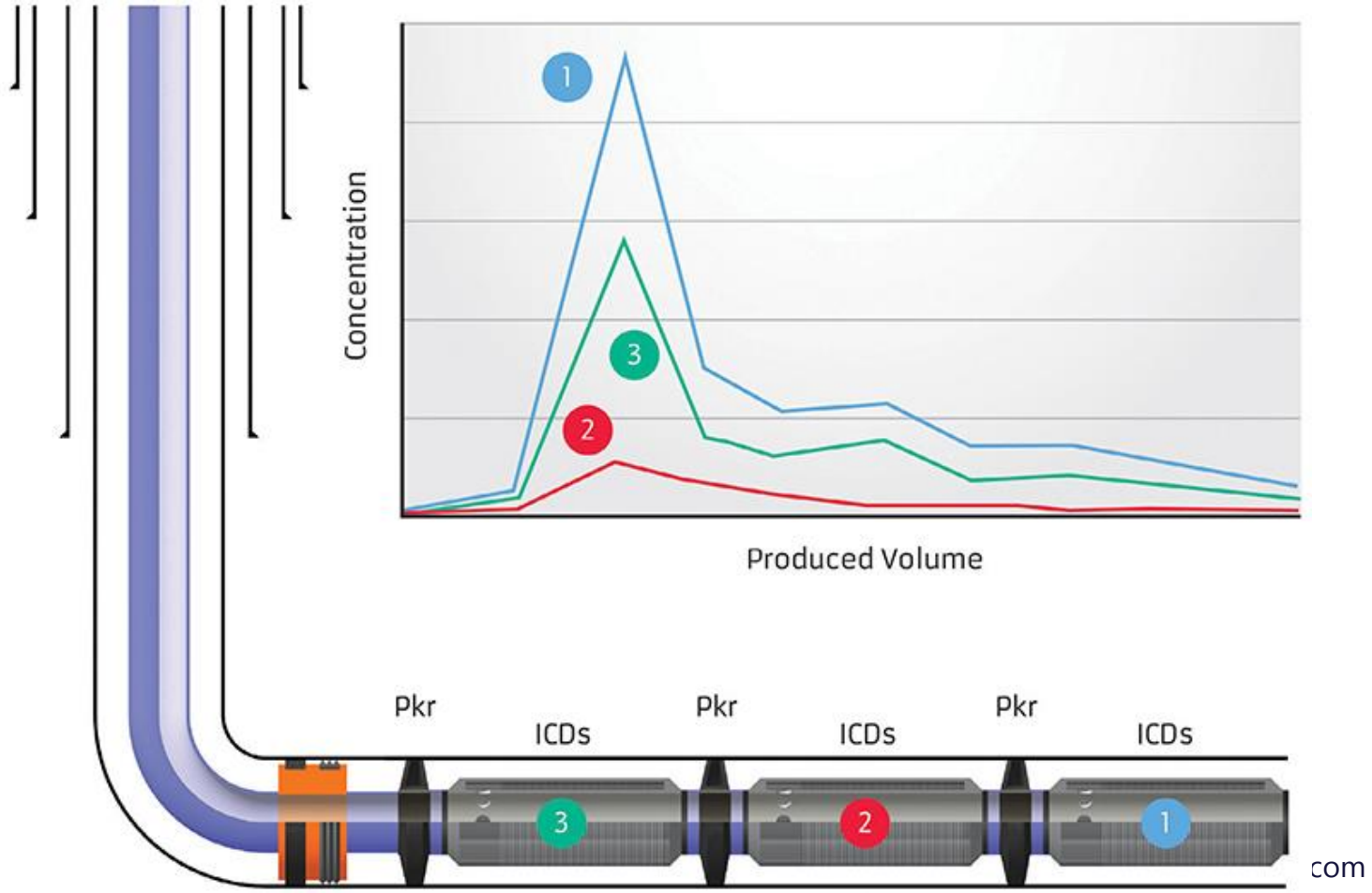


www.oilgasportal.com

INFLOW (INJECTION) CONTROL DEVICES (ICD)

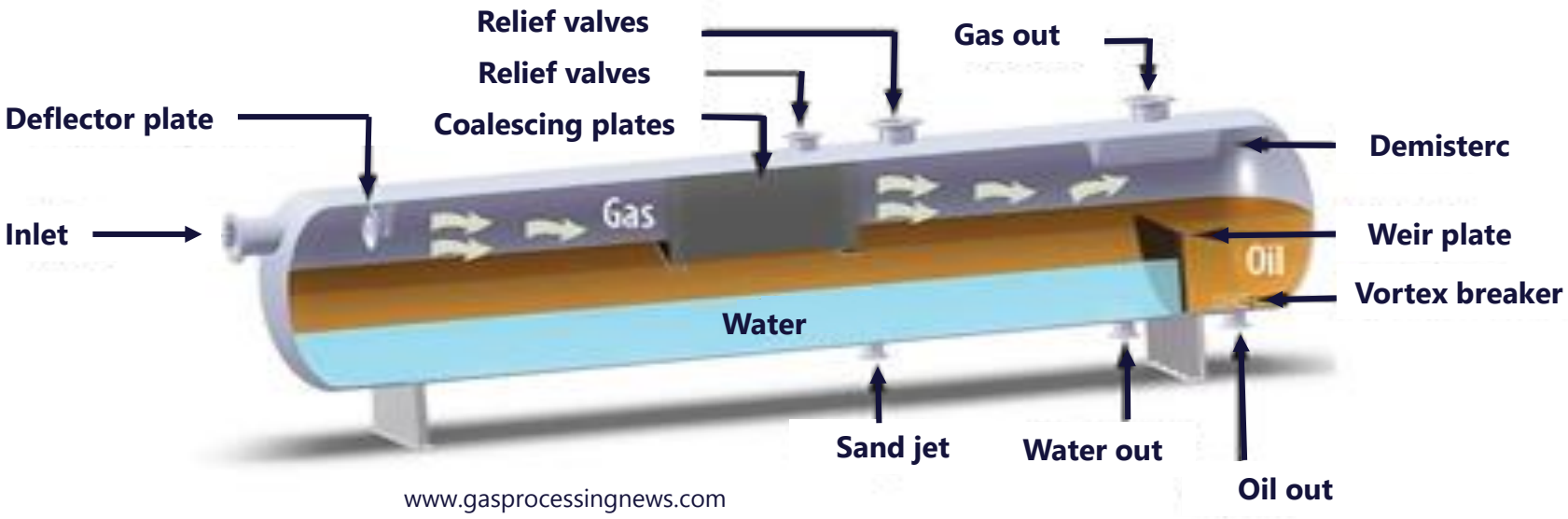
ICDs help maintain **uniform inflow** and injection rates, along the **complete length** of the lateral, helping to minimise sand, and water, production.

An example with Chemical Tracers



SPE – Journal of Petroleum Technology

TOPSIDES - 3 PHASE SEPARATOR



- Separators are **designed to work** efficiently **at a certain production** rate.
- If they start to fill up with sand the **effective volume of the separator is reduced** and **separation efficiency** can be greatly reduced.
- If this happens, **production** must be **slowed down**, or even **halted**, while the sand is removed.

SOLIDS MANAGEMENT – ACCUMULATION IN SURFACE

Accumulation in surface equipment

If the production **velocity is sufficient** to transport sand to the **surface**, the sand may still become **trapped** in the separator, heater treater, or production flowline.

The on-board separator **jetting system** can be overwhelmed by high sand production.

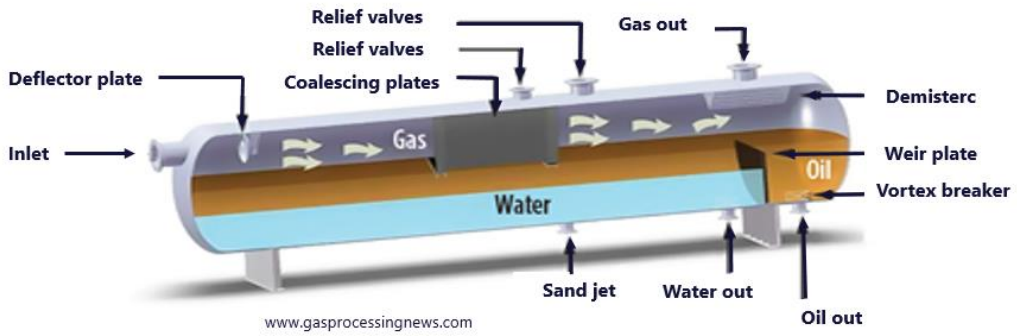
Separator filled with sand – Gullfaks C

SAND CONTROL TECHNIQUES - MAINTENANCE AND WORKOVER

Maintenance and workover is a **passive approach** to sand control. This method basically involves **tolerating** the sand production and **dealing with its effects**, if and when necessary.

The **maintenance and workover method** is primarily used where there is:

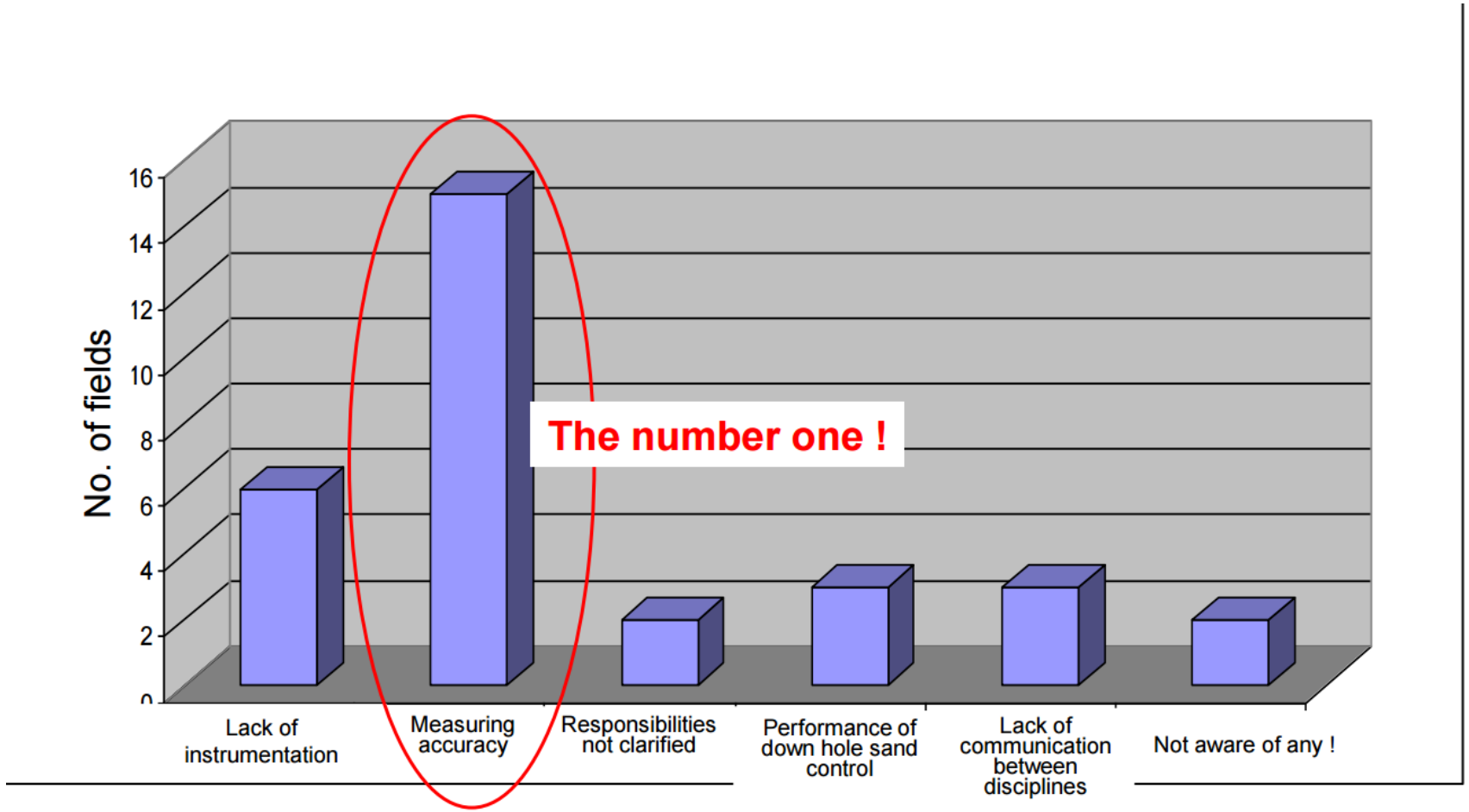
- Minimal sand production
- Low production rates
- Economically viable well service



SAND MANAGEMENT – MANAGING UNCERTAINTIES

What are the biggest uncertainties related to sand production / sand handling ?

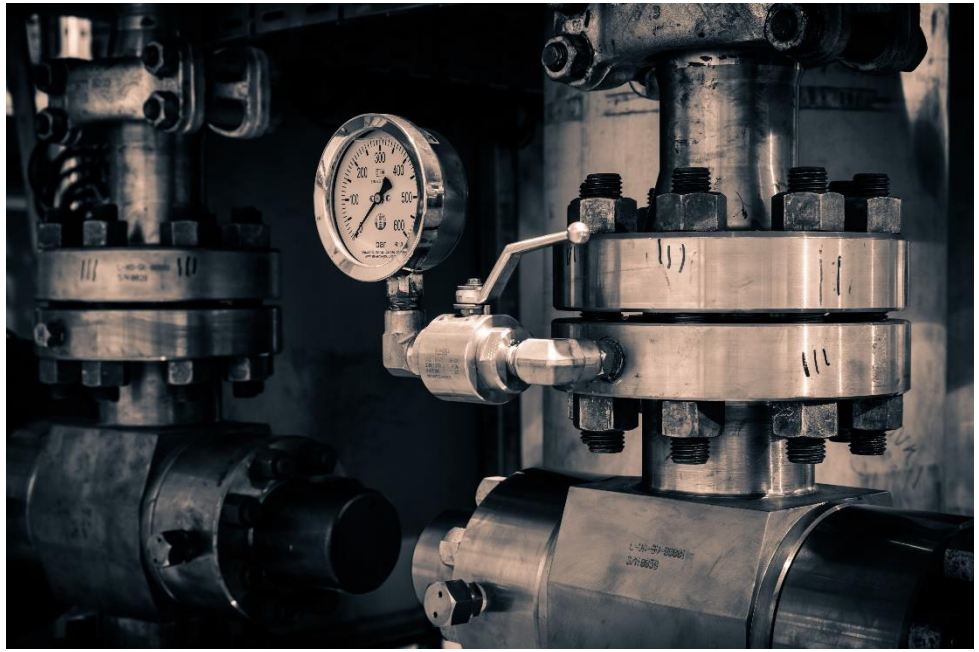
Source: Statoil Sand management workshop March 2007



SAND MANAGEMENT – MEASURING AND MONITORING

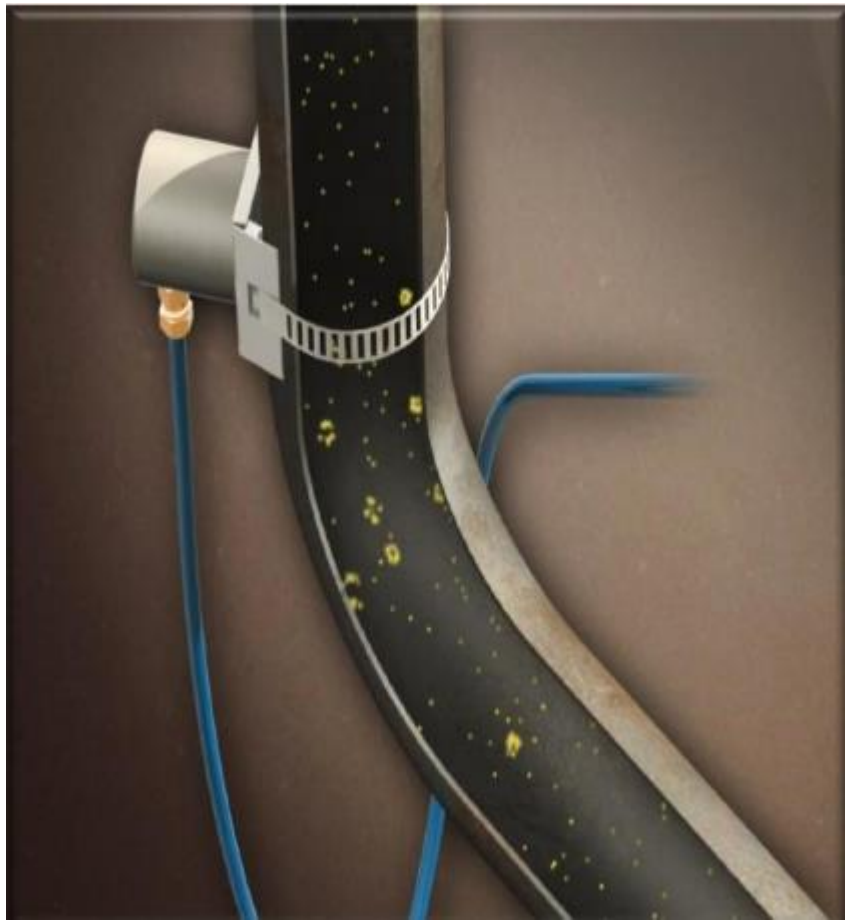
Most common tools for measuring and monitoring sand production:

- **Acoustic sand detectors**
- **Electric resistance erosion probes**
- **Surface or flow line sand sampling**



SAND MANAGEMENT - ACOUSTIC SAND DETECTORS

Acoustic sand detectors



- Passive microphone transducer
- Detects noise of particles impacting on pipe wall
- Also detects flow noise and mechanical noise

Source: Sand Monitoring Services

Erosion probes

- Sand erosion monitor is based on measuring the erosive effect of sand particles hitting the sensing elements on the intrusive probe

Source: Sand Monitoring Services

SAND MANAGEMENT – SURFACE OR FLOWLINE SAND SAMPLING

- Used to collect physical samples of sand from the flow line of a well.
- Quantifies, & corroborates particle size distribution (PSD)

SOLIDS MANAGEMENT - EROSION

Erosion of downhole and surface equipment

If the erosion is severe, or occurs for long enough, complete failure of surface and/or downhole equipment may occur, resulting in critical safety and environmental problems as well as deferred production.

SAND CONTROL TECHNIQUES – TRADITIONAL TOPSIDE EQUIPMENT

Wellhead Sand Filter

Utilises removable filtration cartridges to filter sand – typically 100 – 800 micron (8,000 bpd).

www.offshore-technology.com

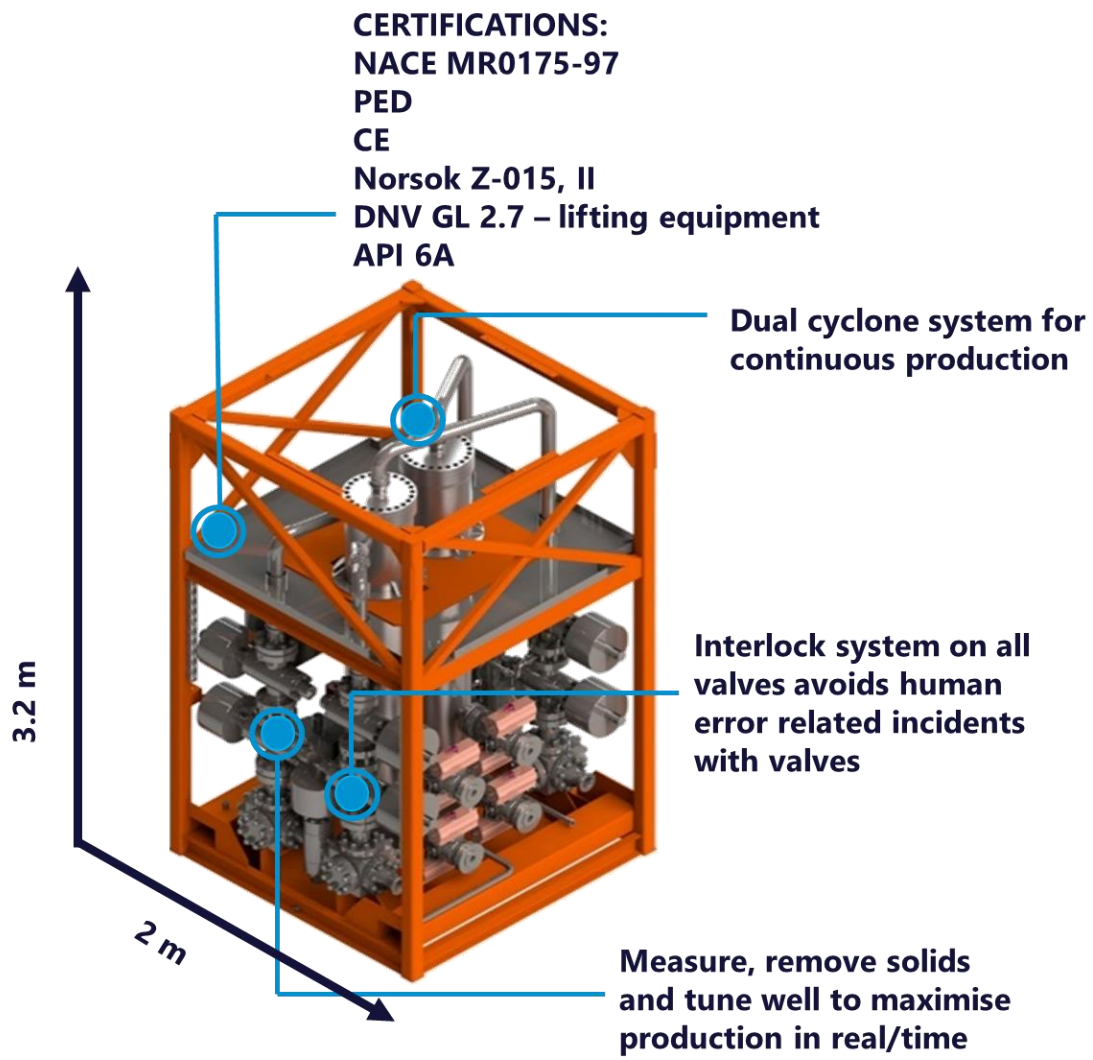
Cyclonic Sand Separator (Desander)

multiphase solid-fluid cyclone designed to treat full wellstream flow 2.5m x 3.7m x 6.5m (26 Tonnes)

www.eprocess.com

DualFlow - Cyclonic Sand Separator

- Large flow range – **0.7k bbls to 30k bbls/day** (fluid), 30MSCUFD (gas)
- Removes solids down to **20 Micron** (µm) with **>98%** efficiency
- Easily installed **2m x 2m x 3.2m (8.5 tonnes)**
- Online **solids weighing** system (0.1kg accuracy)
- Alternate flushing of cyclone vessels (no halt in production)
- Valve **interlock system** – eliminates accidental v/v actuation
- Multi-well hook-up flexibility (production, or test, manifold)
- 100% separation (no underflow management)



SAND CONTROL TECHNIQUES – RATE RESTRICTION

Produce according to an Acceptable Sand Rate (ASR) strategy

ASR: Allow for sand **production** within certain limits to **maximise production** without **compromising** process & personal safety.

Operational requirements underpinning the ASR:

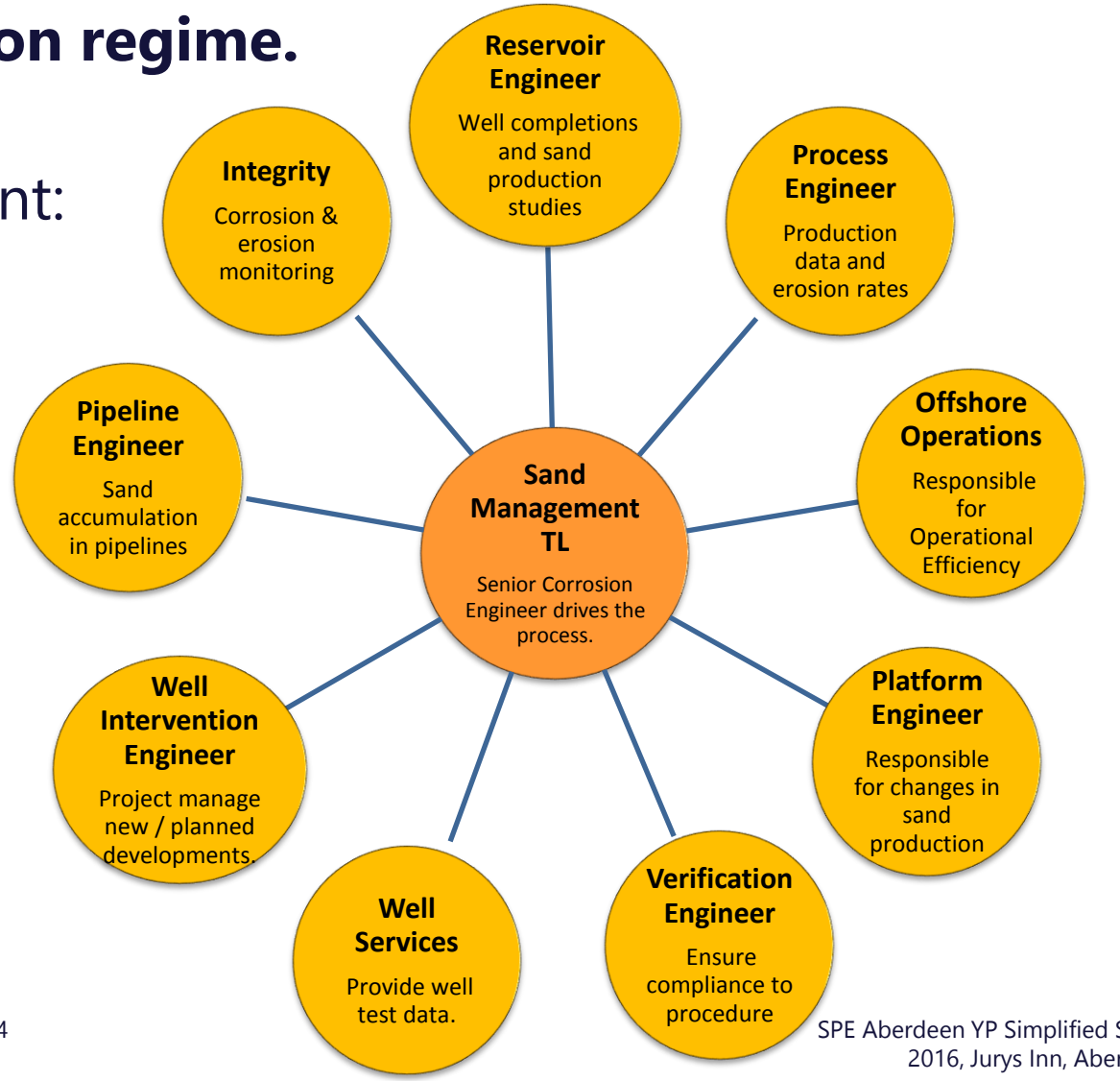
- Produce the well, with **gradually increasing rates**, until sand is produced – "bean-up" technique
- Be able to handle sand at topside, to an **agreed maximum level**, conducive to optimum operational efficiency
- Be able to control, measure and monitor **erosive wear throughout the facilities**

SAND MANAGEMENT – INTEGRATED APPROACH

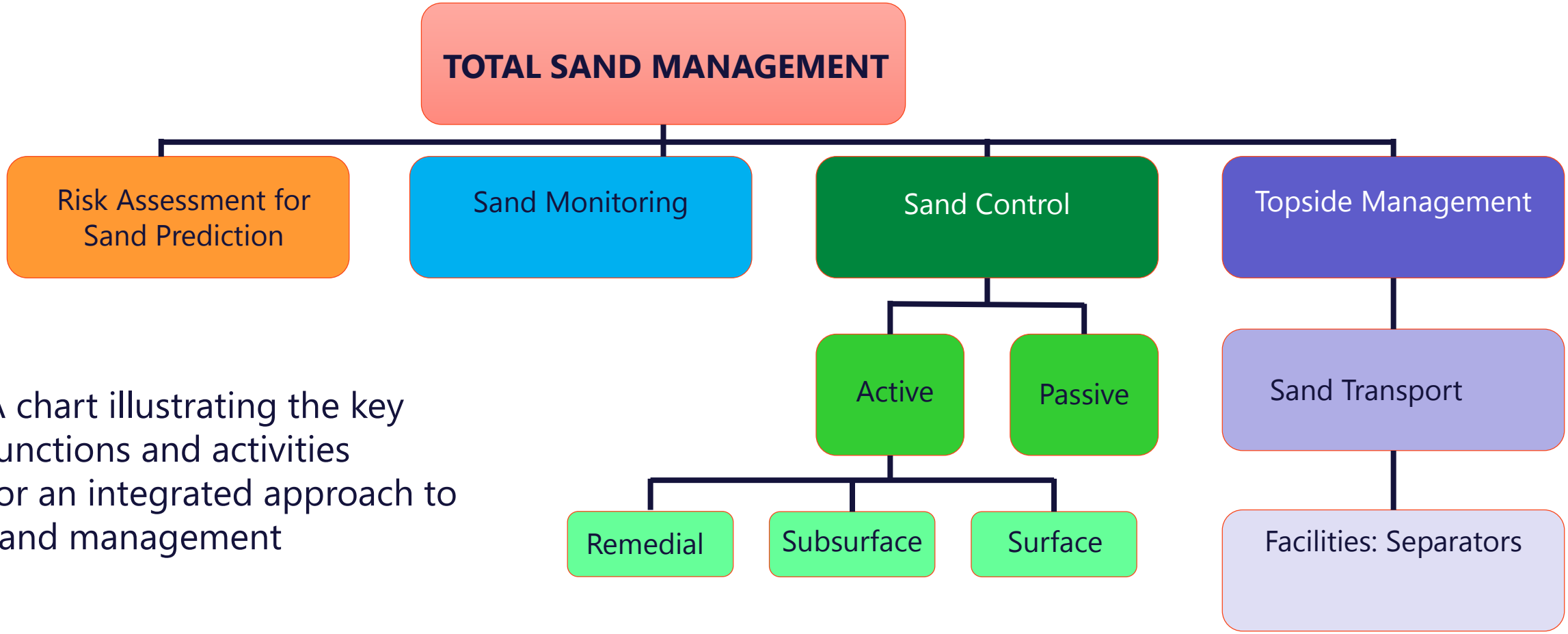
Managing sand production is multidiscipline and a balance between maximising production and ensuring a safe production regime.

The following needs to be taken into account:

- Well and production knowledge
- Inspection strategy
- Training and competence
- Sand monitoring systems
- Process handling
- Erosion monitoring
- Cooperation and communication



INTEGRATED SAND MANAGEMENT



A chart illustrating the key functions and activities for an integrated approach to sand management

Source: Integrated Sand Management For Effective Hydrocarbon Flow Assurance, 2015

INTEGRATED SAND MANAGEMENT

Ask the following questions:

- Will the reservoir produce sand?
- When, how much and from where?
- What type of sand?
- Is sand being transported topside?
- What level of sand production can the asset live with?
- Extent and consequences of erosion?
- What are the contingencies for sand handling?
- **How to maximise production without compromising safety?**

APPLYING SAND MANAGEMENT RP – STATOIL GULLFAKS C

Lars Even Torbergsen, senior principal specialist in DNV GL – Oil & Gas said,

"Statoil's Gullfaks development applied DNV's sand management RP's principles a few years ago. Due to potential sand production, about **50% of the Gullfaks wells** had to be **choked back**. The new sand management strategy reduced this by about 50%, adding a significant amount to the revenue stream.

With an oil price of about $50/bbl, this is equivalent to around $269 million (£175 million) per year. "

(source: World Oil online 9/10/2015)

SAND MANAGEMENT – DELIVERING A STRATEGY

DNV GL revised a new strategy for effective sand management with an updated Recommended Practice (RP) {DNV GL RP-0501} - August 2015

‘’ 2.5 Goals and success factors

— no loss of product to environment due to failures caused by erosion

— no erosion damages causing unplanned shut-down or maintenance/repair/replacements

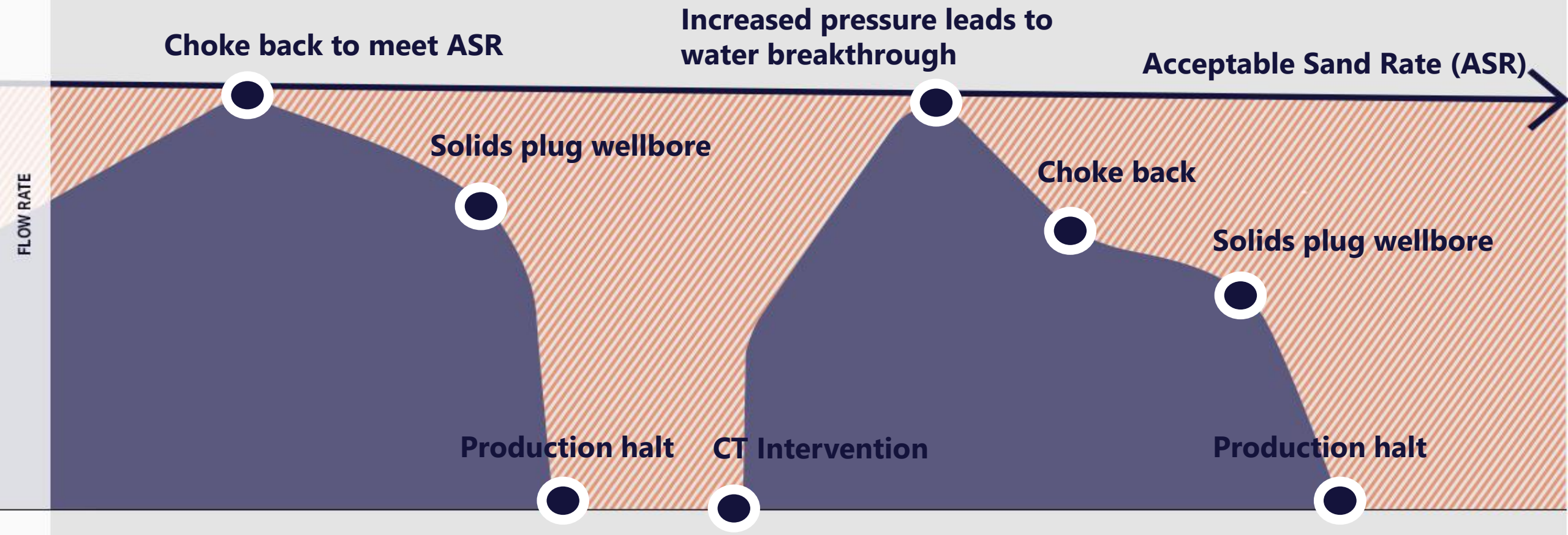
— limited (acceptable) process upsets due to sand production, accumulation, cleaning and disposal

— quality of disposed produced water/sand in compliance with operator and authority requirements

— **maximised production potential (no unnecessary restrictions due to sand)**.”

SOLIDS MANAGEMENT – ACCUMULATION DOWNHOLE

Accumulation downhole – typical production cycle

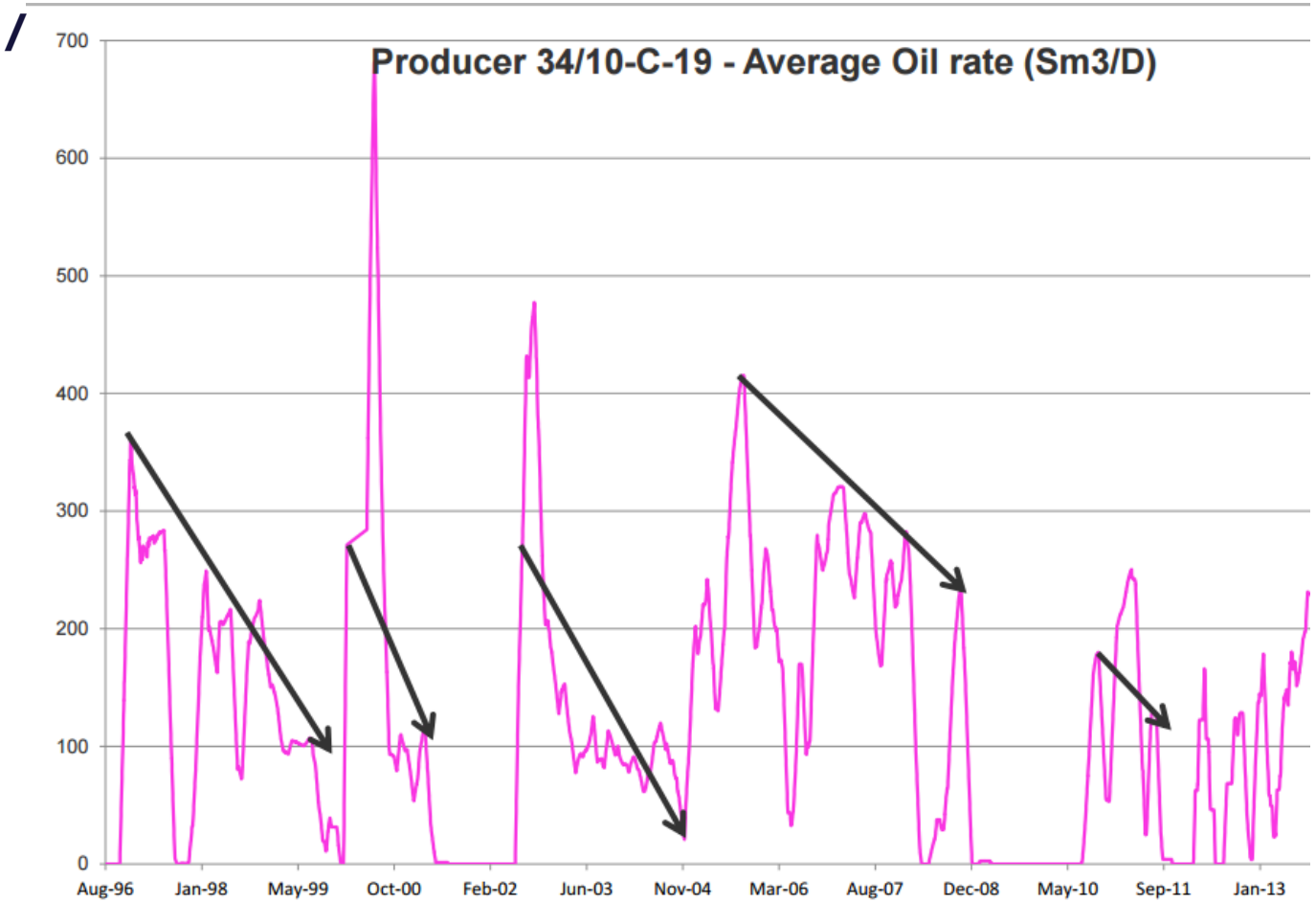


CASE STUDY – PRODUCTION ENHANCEMENT ON GULLFAKS C

Production of C-19 came to a halt in September / October 2014 and was shut in due to high sand production.

What happened?

- Sand rate rapidly exceeded ASR criteria after sand clean-up
- Costly Coil Tubing (CT) operations to clean-up C-19 occurred almost every 2nd year
- Historical CT desander package:
  - poor sand separation
  - well shut-in in order to empty CT desander
  - big footprint
- Need for a better solution for wellbore cleanout and separation of solids



Optimization of well performance by use of a semi-permanent dynamic desander (*By Asle Sandven / Ted Brueren MSc. SPE SMN European Sand Management Forum 26-27 March 2014)*

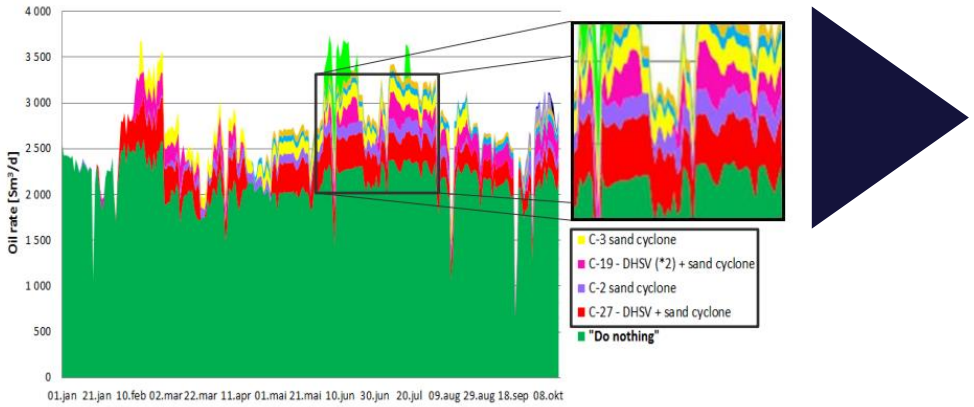
CASE STUDY – PRODUCTION ENHANCEMENT ON GULLFAKS C

SOLUTION

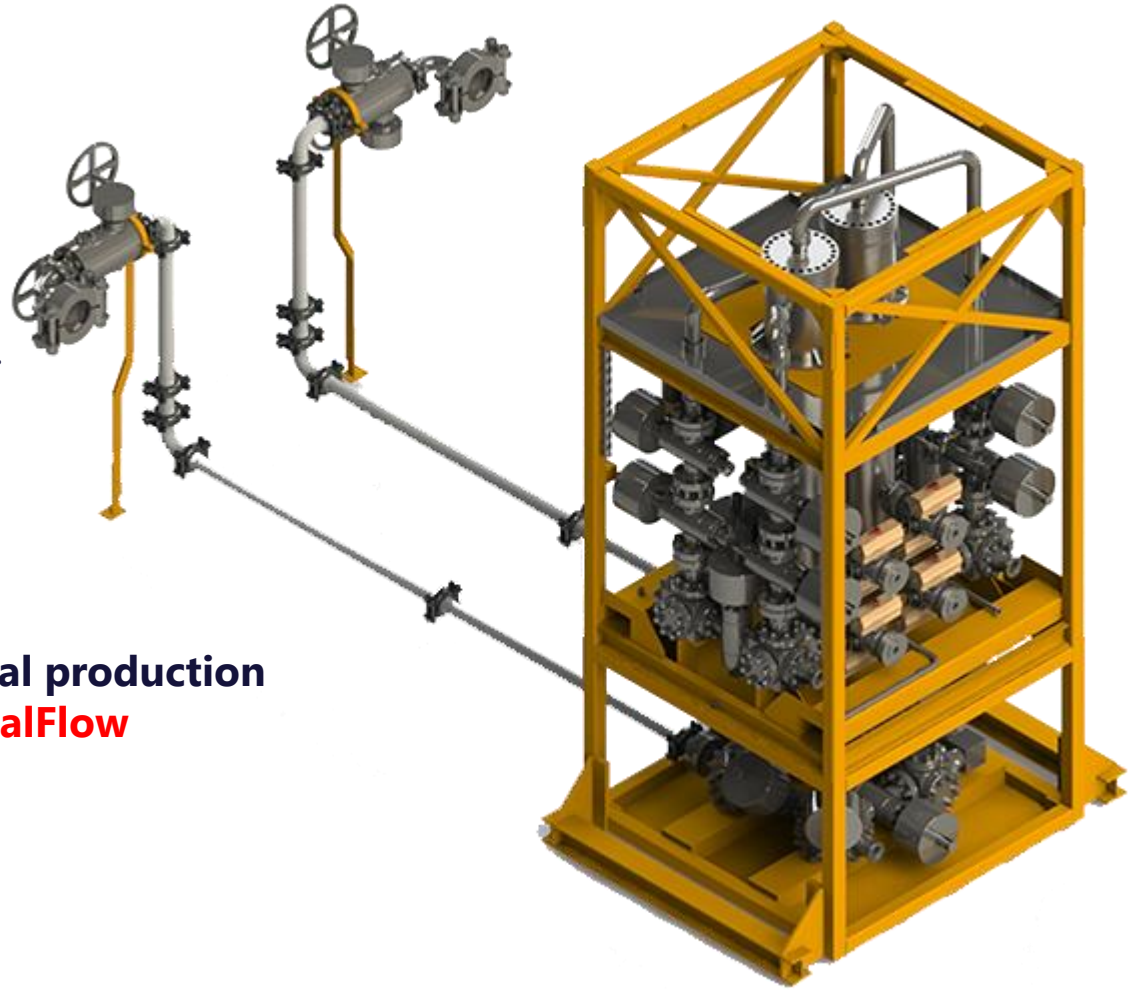
A DualFlow 5K unit combined with X-Flow Choke Manifold

Two solids removal vessels in one frame address space limitations on the Gullfaks C platform and effectively addressing years of solids production challenges in the field.

Result: Optimized well performance



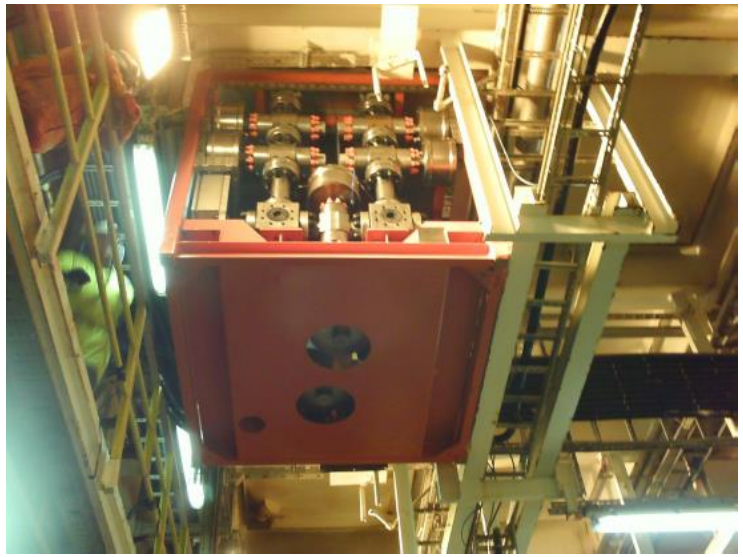
Additional production using DualFlow



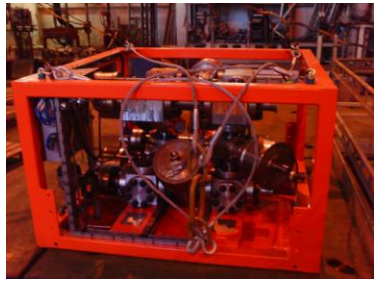
INSTALLATION ON GULLFAKS C

DualFlow 5k Unit

Lowering the DualFlow Unit



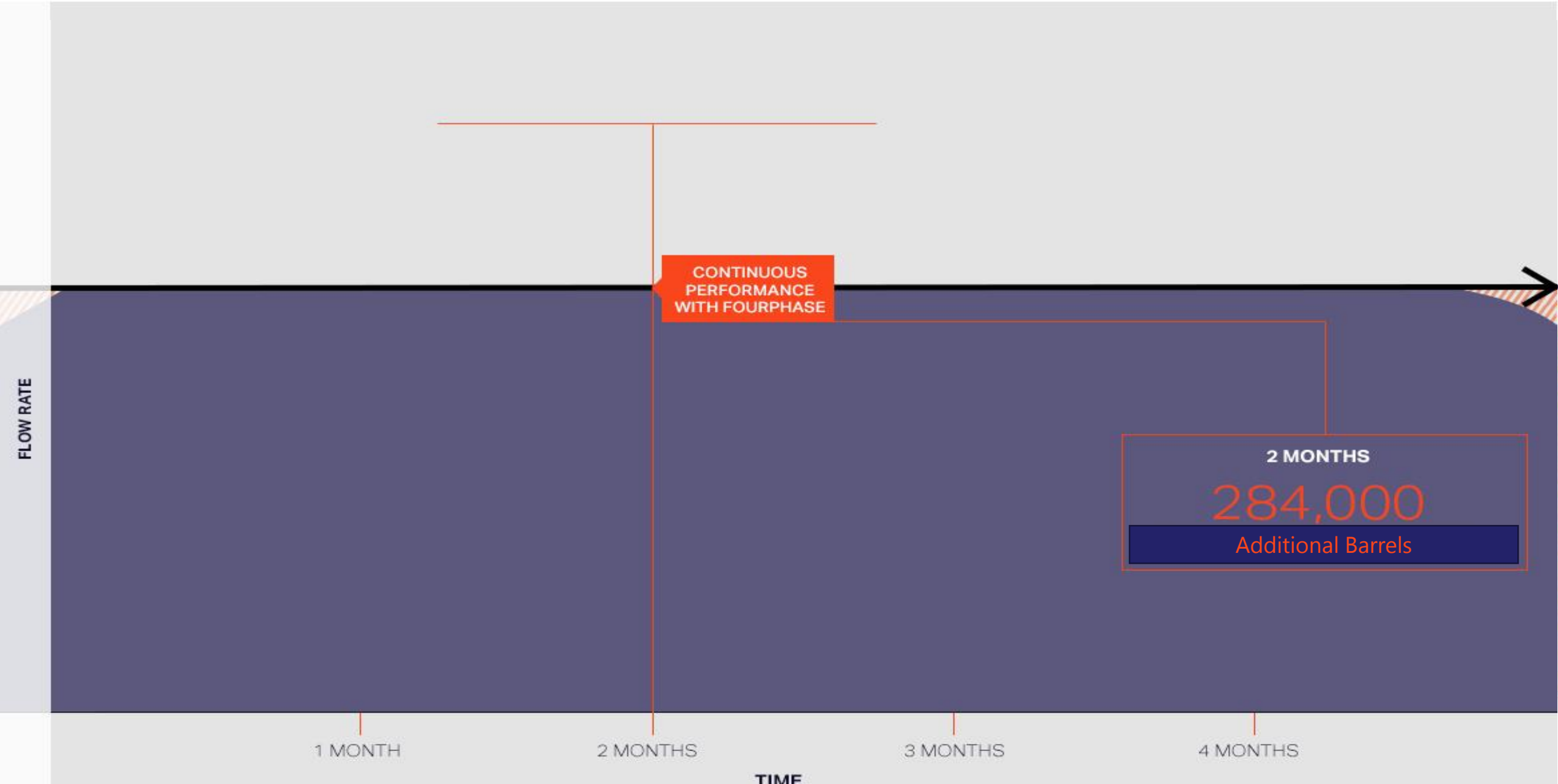
DualFlow Unit installed on top of X-Flow Choke



X-Flow Choke

Lowering the X-Flow Choke

SOLIDS CHALLENGES – OPPORTUNITIES WITH FOURPHASE



SUMMARY

- Actively managing sand production will positively impact **operational efficiency**
- Effective sand management encompasses the **full sand chain** – from reservoir face to surface disposal.
- An integrated approach can significantly **increase production** capacity.

2nd
PHASE

3rd
PHASE

THANK YOU

1st
PHASE

FOUR
PHASE