SPE WA

Sand Control in Challenging Reservoirs

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Perth

Advanced Ceramic Technology

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3M Germany

Slide Template courtesy of SOCIETY OF PETROLEUM ENGINEERS
The petroleum Industry spends millions of dollars each year to prevent and repair down-hole sand control failures which reduce hydrocarbon production rates
– Source, Halliburton

“With a good quality completion in place, the analysis of screen failures indicated that screen erosion was by far the most common screen failure mechanism. Fluid that flowed through the screen with a small amount of fine sand particles greatly accelerated the screen erosion.” Sand control completions using flux analysis
– Oil and Gas Journal based on SPE 84495 -M.H. Stein, BP America; A.A. Chitale, Quiline Software Inc.; G. Asher, APA; and H. Vaziri, Y. Sun, J.R. Colbert, and F.A. Gonzalez, BP America -2005
Oil/gas production challenges:
Ultradeep wells
HP/HT wells
Sand erosion, corrosion

Why requirement for new solutions
Long life time
Increased MTBF

3M / Maersk development:
Patented Ceramic sand screen solution
Stack of ceramic rings
Defined gap width for sand retention and laminar flow
Why Ceramic Sand Screens

- A proven track record of 18 installations attribute to the success of this innovation
- SPE papers document Installation performance
- Ceramic Screen earned the „CEO innovation award“ from BG Group in 2013 for deploying ceramic sand screens in a gas well in Bolivia
Material Characteristics

EXTREME HARDNESS
- Diamond
- Cubic Boron Nitride
- Boron Carbide
- Silicon Carbide

EXCEPTIONAL RESISTANCE TO WEAR
- The higher the hardness, the lower the erosion

CORROSION STABILITY
- Corrosion resistant against chlorides, hydrogen sulfide or hot sulfuric acid

EXTREME TEMPERATURE RANGE
- Temperature range: -196°C (-320.8°F) to 1800°C (3270°F)
- Low ceramic thermal expansion
- Extreme thermal cycling
90 years experience of particle analysis and its facilities to perform state of the art sand analysis

- Particle Size Distribution (PSD) Analysis
  - Dry sieve analysis
  - Laser particle size analysis (LPSA)
- Sand retention testing
- Erosion testing
- Corrosion testing
- Scanning Electron Microscope (SEM)
**Test conditions:** 20/40 mesh sand, high loaded in air, blasting with 30 – 50 m/s (90 – 150 ft/s)

**Ceramic Longevity Test Duration:** 4 hours with no erosion (no change in mass)
Testing comparison with metals

Corrosion investigations Sintered SiC comparing SS & Tantalum in H2SO4 (96%)

- Stainless steel 1.4562
- Tantalum
- SiC

Material loss [mm/a]

Temperature [°C]
<table>
<thead>
<tr>
<th>DATE OF INSTALLATION</th>
<th>LOCATION</th>
<th>APPLICATION TYPE</th>
<th>NUMBER OF JOINTS/MODULES</th>
<th>PRODUCTION DATA (after installation)</th>
<th>WHY 3M™ Ceramic Sand Screen Technology?</th>
<th>POSITION/PERFORATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAY 2010 North Sea</td>
<td>SSD PROTECTOR</td>
<td>3 Joints/9ft</td>
<td>2,000 BBL/D (30% WATER CUT)</td>
<td>New oil well. Precaution to avoid erosion of Sliding sleeve due to proppant flow back.</td>
<td>Across</td>
<td></td>
</tr>
<tr>
<td>FEBRUARY 2011 North Sea</td>
<td>CTT</td>
<td>1 Joint/16ft</td>
<td>6MMSCF/D (LEVELLED AT 2MMSCF/D)</td>
<td>Remedial screen for gas well. Production was stopped for over 2 years because of sand production prior to ceramic install.</td>
<td>Above</td>
<td></td>
</tr>
<tr>
<td>JUNE 2011 North Sea</td>
<td>SSD PROTECTOR</td>
<td>15 Joints/45ft</td>
<td>6,000 BBL/D</td>
<td>New oil well. Precaution to avoid erosion of Sliding sleeve due to proppant flow back.</td>
<td>Across</td>
<td></td>
</tr>
<tr>
<td>DATE UNKNOWN North Sea</td>
<td>SSD PROTECTOR</td>
<td>13 Joints/39ft</td>
<td>n/a</td>
<td>New oil well. Precaution to avoid erosion of Sliding sleeve due to proppant flow back.</td>
<td>Across</td>
<td></td>
</tr>
<tr>
<td>SEPTEMBER 2011 North Sea</td>
<td>CTT</td>
<td>1 Joint/36ft</td>
<td>n/a</td>
<td>Remedial screen for gas well. Successful deployment. 4”BP with 5 ⅛” OD, 250 micron</td>
<td>Across</td>
<td></td>
</tr>
<tr>
<td>DECEMBER 2011 Austria</td>
<td>SAS</td>
<td>1 Joint/21ft</td>
<td>CASE STUDIES</td>
<td>Remedial screen for a oil well, that replaced Gravel-Pack successfully.</td>
<td>Across</td>
<td></td>
</tr>
<tr>
<td>DATE UNKNOWN North Sea</td>
<td>SSD PROTECTOR</td>
<td>11 Joints/33ft</td>
<td>n/a</td>
<td>New oil well. Precaution to avoid erosion of Sliding sleeve due to proppant flow back.</td>
<td>Across</td>
<td></td>
</tr>
<tr>
<td>JANUARY 2012 North Sea</td>
<td>SSD PROTECTOR</td>
<td>14 Joints/42ft</td>
<td>n/a</td>
<td>New oil well. Precaution to avoid erosion of Sliding sleeve due to proppant flow back.</td>
<td>Across</td>
<td></td>
</tr>
<tr>
<td>TBC North Sea</td>
<td>SAS</td>
<td>1 Joint/55ft</td>
<td>Installation to be scheduled</td>
<td>Trial well for ceramic sand screen</td>
<td>Across</td>
<td></td>
</tr>
<tr>
<td>SEPTEMBER 2012 Bolivia</td>
<td>SAS &amp; SSD PROTECTOR</td>
<td>2 Joints/110ft 2 Joints/22ft</td>
<td>8MMSCFD</td>
<td>Workover for gas well, previous stand alone screens failed just after 2 months. 3M Ceramic Sand Screen was an alternative to GP.</td>
<td>Across</td>
<td></td>
</tr>
<tr>
<td>NOVEMBER 2012 AUSTRIA</td>
<td>SAS</td>
<td>1 Joint/27ft</td>
<td>Screen deployed.</td>
<td>Workover for gas storage, application to test the screens.</td>
<td>Across</td>
<td></td>
</tr>
<tr>
<td>TBC North Sea</td>
<td>CTT</td>
<td>2 Joints/36ft</td>
<td>Installation to be scheduled</td>
<td>Unexpected sand production with potential erosion</td>
<td>Across</td>
<td></td>
</tr>
<tr>
<td>DECEMBER 2013 South America</td>
<td>SAS</td>
<td>1 Joint/20ft</td>
<td>Screen deployed</td>
<td>Replacement of a Gravel pack</td>
<td>Across</td>
<td></td>
</tr>
<tr>
<td>MAI 2014 Indonesia</td>
<td>SAS</td>
<td>1 Joint/5ft</td>
<td>3 MM SCFD</td>
<td>Erosion/Hotspotting issue, Production rates below expectations with conventional screen, Improve MTBF</td>
<td>Above</td>
<td></td>
</tr>
<tr>
<td>MAI 2014 Indonesia</td>
<td>SAS</td>
<td>1 Joint/5ft</td>
<td>2 MMSCFD</td>
<td>DST, Ceramic Sand screen performance test, Improve MTBF</td>
<td>Above</td>
<td></td>
</tr>
<tr>
<td>JUNE 2014 North Sea</td>
<td>SAS</td>
<td>3 Joints/54ft</td>
<td>27 MMSCFD</td>
<td>Proppant flowback causing erosion</td>
<td>Across</td>
<td></td>
</tr>
<tr>
<td>SEPTEMBER 2014 North Sea</td>
<td>SAS</td>
<td>3 Joints/54ft</td>
<td>35 MMSCFD</td>
<td>Proppant flowback causing erosion</td>
<td>Across</td>
<td></td>
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<tr>
<td>SEPTEMBER 2014 Indonesia</td>
<td>SAS</td>
<td>1 Joint/19ft</td>
<td>2.4 MMSCFD</td>
<td>Cased hole Test well. Replacement of IGP. Pilot well for sand screens</td>
<td>Across</td>
<td></td>
</tr>
<tr>
<td>NOVEMBER 2014 Indonesia</td>
<td>SAS</td>
<td>2 Joints/38ft</td>
<td>2 MMSCFD</td>
<td>Cased hole Test well. Replacement of IGP. Pilot well for sand screens</td>
<td>Across</td>
<td></td>
</tr>
<tr>
<td>JANUARY 2015 Indonesia</td>
<td>SAS</td>
<td>1 Joint/19ft</td>
<td>Well clean-up</td>
<td>Cased hole Test well. Replacement of IGP. Pilot well for sand screens</td>
<td>Across</td>
<td></td>
</tr>
<tr>
<td>TBC South America</td>
<td>CTT</td>
<td>20 Joints/400ft</td>
<td>Installation Scheduled in March 15</td>
<td>Failed Gravel pack system offshore well</td>
<td>Across</td>
<td></td>
</tr>
<tr>
<td>TBC North Sea</td>
<td>CTT</td>
<td>1 Joint/20ft</td>
<td>Installation to be scheduled</td>
<td>Failed sand control system</td>
<td>TBD</td>
<td></td>
</tr>
<tr>
<td>TBC North Sea</td>
<td>CTT</td>
<td>4 Joints/108ft</td>
<td>Installation to be scheduled</td>
<td>Oil well with unexpected sand production</td>
<td>Across</td>
<td></td>
</tr>
</tbody>
</table>
Challenge:
Gas Producer in the North Sea (Maersk Oil):
• Old gas well, started in 1983
• Several well treatments and work-overs
• 2009: well was shut in. Unmanageable at 1,250 psi flowing pressure

Enabling Technology:
3M Ceramic Thru Tubing Sand Screen

Success:
Re-gain sand free production with new tubing head pressure of 650psi

Production rate leveled in at 2 MMscf/d

No further Intervention required

* Based on US avg gas import price (Sept 14) $3.95 per 1000 cubic feet
SAS Installation Success – Lower CAPEX / OPEX & Higher Production Rate

Challenge:
Gas producer in Bolivia (onshore):
Metallic screens failed after 2 months
Remote location
Complex work over

Enabling Technology:
3M Ceramic Sand Screen without IGP
SAS Installation Success – Lower CAPEX / OPEX & Higher Production Rate

Success: “Approval of Ceramic Sand Screens as the recommended standard sand control method within the whole BG group”
Reduced work over complexity
Lower CAPEX
Lower OPEX

25% Higher Production Rate
- from expected 6MMscf/d to 8MMscf/d – 52MMscf/Month extra to present
- ($xxxK EXTRA per Month*)
Continuous Production from November 2012 to present

* Based on US avg gas import price (Sept 14) $3.95 per 1000 cubic feet

X17 Longevity increase to date compared to conventional premium metallic screen life

“......All operational costs including re-completion have been recouped (17 days for the ceramic screens and 100 days for the entire work over).”

Source: Extracts of BG abstract for the ATCE, (SPE 166092)
Customer Challenge:

- Client wants to fracture the new drilled wells in order to reach better production rates
- Issue with proppant flow back. Erosion of the well Jewelry.
- Frac pack was unfavourable in this well as this could damage the PI of the Well
- Erosion risk not totally mitigated via Frack pack
- No Sand management facilities on this platform
- 3M ceramic sand screen can be considered because of high erosion resistance properties
Results:

Well 1

- on line since 13th of August 2014
- 35 MMSCFD during 'Bean Up'
- Now 27 MMSCFD @ 2044 psi PDHG; THP 107 bar
- Proppant flow back before the installation of the screen: 1Kg/MMSCFD
- Proppant flow after the installation of the screens: none

Well 2

- Completed on 25th of September 2014
- Bean-up 46 MMSCFD
- Now 35 MMSCFD @ 2354 psi PDHG; THP 120 Bar since 31 October
- No proppant flow back topside
- SPE paper to follow
OTC-25106-MS: An Innovative Approach of Revival for Damaged Wells in High Erosive Environment Using Ceramic Sand Screens – BG Group

SPE 146721: An innovative milestone in Sand Control – Maersk Oil & Gas

SPE 160327: Ceramic sand Screens for Sand Control in unconsolidated Resevoirs (with fines content) – RAG

SPE 166092-MS: Ceramic Sand Screen : Ceramic Sand Screen – An innovative Downhole Sand Control Solutions for Old & Challenging Cased Holes – BG Group