Introducing a New Recommended Practice for Fit for Purpose Well Abandonment
Optimize P&A Using Risk Based Acceptance Criteria

- The total reduction in well P&A costs by using a risk based approach ~ 30-50%
- “Careful planning is the key to success in all operations” -- > potential savings of ~25%
- Improved acceptance criteria -- > could reduce costs for P&A in the future
- New P&A technology could reduce the overall P&A costs by 20-40%

Value Added Proposition
Organized to Maximize Value for our Customers

MARITIME

OIL & GAS

ENERGY

BUSINESS ASSURANCE

SOFTWARE

RESEARCH & INNOVATION
2,200 employees and 75 offices in North America
Global P&A/ Decommissioning Project Experience

<table>
<thead>
<tr>
<th>Area</th>
<th># of Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>9</td>
</tr>
<tr>
<td>Environment</td>
<td>15</td>
</tr>
<tr>
<td>Safety</td>
<td>5</td>
</tr>
<tr>
<td>Technical</td>
<td>25</td>
</tr>
<tr>
<td>MWS</td>
<td>8</td>
</tr>
<tr>
<td>TQ</td>
<td>3</td>
</tr>
<tr>
<td>P&amp;A</td>
<td>7</td>
</tr>
</tbody>
</table>

Over 150,000 Man-Hours to Date
Over 20 Year Period
P&A Reference List

- P&A RP (Basis for Presentation)
  - The method has been applied to several wells at different locations in the North Sea
  - Additional studies for 3 more wells (all different operators) are ongoing
  - Case study to be presented
- Results suggest that alternative plugging solutions with fewer barriers to those prescribed by the standard NORSOK D-010 result in the same, low level of environmental risk.
Technology Qualification Example Project

- Interwell P&A Solution to DNV-RP-A203
DNV GL JIP Decommissioning of Flexible & Rigid Pipelines

**CHALLENGE**
A number of flexible and rigid pipelines are reaching the end of their design life, but there is no best practice available ensuring that decommissioning operations are done efficiently and safely. Offshore operators, contractors, engineering companies, environment regulators and authorities need to establish procedures collecting the best practices to perform decommissioning operations efficiently and safely.

**Solution**
- Development of a guideline for decommissioning of O&G Subsea Installations
- Development of a risk based comparative assessment tool involving options related to subsea system decommissioning.

**Benefit**
- Standardized procedures and practices in conformity with current regulations.
- Better decision making on the removal or abandonment of flexible pipes on the seabed

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**Value**
DNV GL will provide an independent approach & international experience that can lead to potential saving potential through right decision making and standardized processes.

**Region:** South America
Standardization: DNVGL “Standards”, Offshore Removal Activities

– DNV-RP-H101 Risk Management in Marine - and Subsea Operations
– DNV-RP-H102 Marine operations during Removal of Offshore Installations *(Under Revision)*
– DNV-RP-H103 Modelling and Analysis of Marine Operations
– DNV-OSS-300, Risk Based Verification
– DNV Rules for Planning and Execution of Marine Operations, January 2000
Introducing New DNV GL RP

- In May 2016, DNV GL released a new Recommended Practice (RP)

**DNV GL-RP-E103**

*Risk Based Abandonment of Offshore Wells*

- The document (and all previously mentioned) are currently available for free download online at [www.dnvgl.com](http://www.dnvgl.com)
- The RP can be alternative to current practices
Are all P&A Wells the Same?

Moderate flow potential, hydrocarbon-bearing

Limited flow potential, not hydrocarbon-bearing

HPHT reservoir, moderate flow potential

Depleted reservoir, limited flow potential

Primary barrier
Secondary barrier
Surface barrier
Global P&A Barrier Length Requirements

<table>
<thead>
<tr>
<th>Regulator</th>
<th>No of Plugs</th>
<th>Minimum Length (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>UK</td>
<td>2</td>
<td>~30</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>Germany</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>USA (BSEE)</td>
<td>2</td>
<td>~30</td>
</tr>
<tr>
<td>Canada</td>
<td>1</td>
<td>~8</td>
</tr>
<tr>
<td>Russia</td>
<td>1</td>
<td>~24</td>
</tr>
<tr>
<td>Australia</td>
<td>1</td>
<td>~30</td>
</tr>
<tr>
<td>Malaysia</td>
<td>1</td>
<td>~30</td>
</tr>
</tbody>
</table>

“Plugging and Abandonment (P&A) Challenges” The Challenge of Well Integrity in a Subsea Environment, Jules Schoenmakers, Shell 2014
Cost-Saving Comparison Prescriptive Requirements vs. Risk-Based

Hydrocarbon Reservoir
Overburden Zones

10 ¾” x 9 7/8”
13 3/8”
20”
30”
### From Well Parameters to Environmental Risk Metrics

<table>
<thead>
<tr>
<th>Potential inflow of hydrocarbons from overburden formations</th>
<th>Micro-annulus or seepage pathway in outer cement sheath</th>
<th>Potential leakage rate with probabilistic modelling</th>
<th>Oil in water and accumulation of oil in sediment</th>
<th>Measurable impact on organisms?</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="example.com" alt="Diagram" /></td>
<td><img src="example.com" alt="Diagram" /></td>
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<td><img src="example.com" alt="Diagram" /></td>
<td><img src="example.com" alt="Image" /></td>
</tr>
</tbody>
</table>

\[
\frac{dm}{dt} = \text{Sources} - \text{Sinks} = F_{in}^1 + F_{in}^2 + F_{in}^3 + F_{in}^4 - S_f - D_o - S_p - T_{bio} - D_{sed}
\]

**Mass balance water column:**

**Mass balance sediment:**

- Inflow $F_{in}^1$
- Sorption to formation $S_f$
- Vertical flux $S_p$
- Outflow $F_{out}$
- Sorption to particles $D_{sed}$
- Anaerobic biological degradation $T_{bio}$
- Dispersion in water column $D_w$

**PEC/PNEC evaluations**

**Ambient current**

**Oil droplets**

**Porous media**

**Overburden**

**Loss**

**Dispersion modelling ambient conditions**
Elements in Well Abandonment Risk Assessment – Risk Evaluation

- MIRA states that each operating company should define the term *insignificant* in the context of long-term leakage.
- MIRA suggests that long-term leakage that lasts more than 10 years should have an annual likelihood less than \(1 \times 10^{-3}\) if the environment is to be unaffected 99% of the time.
- Example Acceptance Criteria Below (Should Be Site, Operator, and Regulator Specific)

<table>
<thead>
<tr>
<th>THC concentration</th>
<th>5-20 %</th>
<th>20-50%</th>
<th>&gt;50 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5 ppb</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>5-20 ppb</td>
<td>(1 \times 10^{-2})</td>
<td>(1 \times 10^{-2})</td>
<td>(1 \times 10^{-3})</td>
</tr>
<tr>
<td>20-50 ppb</td>
<td>(1 \times 10^{-2})</td>
<td>(1 \times 10^{-3})</td>
<td>(1 \times 10^{-3})</td>
</tr>
</tbody>
</table>
Case Study

- Fit for purpose solutions have been implemented in well P&A in Norway
- Risk assessing the proposed well abandonment designs strengthen the case for alternative solutions
- There is a large savings in well P&A (~$12 Million USD per well)
- “Huldra PP&A project – from five to one double barrier,” PAF Seminar, Stavanger – 29. October 2015
Value Added Proposition – P&A Well Feasibility Assessment

- **Purpose & Objective**
  - Evaluate the feasibility of applying the DNV GL RP on Risk-Based Abandonment of Offshore Wells and its potential cost savings benefits for sample wells for major operators and service providers.
  - Increase the confidence and trust for the methodology beyond the wells that have been utilized as reference cases for developing the methodology.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Deliverable</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workshop – Discussion of Potential Wells w/ Highest Potential for Alternate P&amp;A</td>
<td>Workshop facilitated by DNV GL to Help Select Wells Anticipated to Have Highest Potential</td>
<td>Work In Kind</td>
</tr>
<tr>
<td>Feasibility Evaluation</td>
<td>Preliminary Report on Feasibility for Selected Wells</td>
<td></td>
</tr>
<tr>
<td>Presentation of Evaluation</td>
<td>Presentation of Results</td>
<td></td>
</tr>
<tr>
<td>RP Method – FMECA, Environmental Analysis, Dispersion Modeling, Impact Assessment</td>
<td>Statement of Conformity</td>
<td>Confidential</td>
</tr>
</tbody>
</table>
Advantages to Using the Alternative

- Explicit criteria for environmental protection
- P&A spending focused on higher-risk zones
- Optimize P&A design
- Flexibility – can incorporate new technology
- Site specific considerations.
Summary

• The RP provides the framework for establishing and evaluating P&A wells individually using a risk perspective.
• Considerable savings can be achieved
• DNV GL can evaluate well abandonment designs and help optimize them to be fit-for-purpose
Questions?

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