SUBSEA DROPPED OBJECTS

New GoM requirements for 2016 and their wider implications

Engineering Services
Feb 2017
Contents

- 2 minute Introduction to Wild Well Control
  - Engineering services
- The BSEE 2016 dropped object rule
- Dropped object analysis method
- Conclusion
Wild Well Control

- Founded in 1975
- Joe Bowden Sr
- First competition to Red Adair Company
- Well Control / Blowout services

- Modern services now include
  - Firefighting
  - Well control
  - Engineering
  - Marine
  - WellCONTAINED
  - CSI

- 350 employees worldwide
## Response Jobs

![80% of all well control incidents worldwide are resolved by Wild Well](image)

### 2016 Well Control Jobs

<table>
<thead>
<tr>
<th></th>
<th>Onshore</th>
<th>Offshore</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Blowout with Fire</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Surface Blowout</td>
<td>16</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>Underground Blowout</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pressure Control</td>
<td>20</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Others</td>
<td>34</td>
<td>14</td>
<td>48</td>
</tr>
<tr>
<td><strong>Total Well Control Jobs</strong></td>
<td><strong>73</strong></td>
<td><strong>21</strong></td>
<td><strong>94</strong></td>
</tr>
<tr>
<td><strong>Total Engineering Jobs</strong></td>
<td><strong>111</strong></td>
<td><strong>127</strong></td>
<td><strong>238</strong></td>
</tr>
</tbody>
</table>

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Wild Well Control
Wild Well Engineering
Prevention rather than cure….
What makes Wild Well stand out?

Operations

Integrated Services

Engineering Services
Integrated Services – everything “in-house”

- WELL CONTROL TRAINING
  - IADC/IWC/ISO Well Control Certification
  - Tailored Courses
  - Well Control Equipment Surveys
  - Rig Site Assessment/Kick Drills
  - Well Specific Readiness Training

- WELL CONTROL ENGINEERING
  - Well Control Modeling
  - Relief Well Planning
  - Blowout / Dynamic Kill Design
  - Well Evaluation / Risk Assessment
  - Advanced Seminars
  - Special Studies

- OPERATIONS
  - Emergency Response
  - Firefighting
  - Well Control
  - Pressure Control
  - Hot Tap
  - Valve Drilling
  - Freeze Services

- TECHNICAL SERVICES
  - Well Control Technical Advisory and Project Management
    - Drilling
    - Well Integrity
    - Workover
    - Field Abandonment

- MARINE WELL SERVICES
  - Project Management / Engineering
  - Decommissioning
  - Unconventional P&A
  - Platform and Wrack Removal
  - Platform Disaster Recovery
  - WellCONTAINED
    - WCERP/BCP
    - Source Control Plans / Training
    - Logistica Plans
    - Drill / Exercise
    - 18 3/4” Capping Stacks
    - Casing Removal
    - Dispersant Equipment
  - Riserless Well Intervention
    - 3 Series
    - 7 Series

SERVICES IN YELLOW ARE OUTSOURCED BY THE COMPETITION.
Capabilities

- Provide engineering insight

- Use engineering analysis to model:
  - Well control events
  - Gas dispersion
  - Structural engineering
  - Heat transfer and radiant heat
  - Fire and Explosion
  - Marine dynamics
BSEE Dropped object rule
Rule Background

- Bureau of Safety and Environmental Enforcement (BSEE)
- US Government agency formed in 2011
  - enhance operational safety and environmental protection for the exploration and development of offshore oil and natural gas on the U.S. Outer Continental Shelf (OCS).
- In the aftermath of Deepwater Horizon incident, BSEE looked to update and consolidate well-control rules
- Consolidate into one part the equipment and operational requirements
- BSEE participated in meetings, training and workshops with industry experts and stakeholders
- List of recommendations and improvements
- Final rule became effective on July 28 2016

- One inclusion was CFR 250.714 and the point concerned dropped objects

- This rule is not enforced in the UK at the minute, but operators may start asking for it as per best practice – may be enforced in the future
Do I have to develop a dropped objects plan?

- If you use a floating rig unit in an area with subsea infrastructure, you must develop a dropped objects plan and make it available to BSEE upon request. This plan must be updated as the infrastructure on the seafloor changes. Your plan must include:

  (a) A description and plot of the path the rig will take while running and pulling the riser;

  (b) A plot showing the location of any subsea wells, production equipment, pipelines, and any other identified debris;

  (c) Modelling of a dropped object’s path with consideration given to metocean conditions for various material forms, such as a tubular (e.g., riser or casing) and box (e.g., BOP or tree);

  (d) Communications, procedures, and delegated authorities established with the production host facility to shut-in any active subsea wells, equipment, or pipelines in the event of a dropped object; and

  (e) Any additional information required by the District Manager as appropriate to clarify, update, or evaluate your dropped objects plan.
CFR 250.714 (c) Interpretation

- Vague description
- Method left for interpretation
- Plan must include modelling of a dropped objects path considering:
  - Metocean conditions
  - Material form
  - What are the likely points where the object will land
  - Must include the influence of the current, water depth, object shape and material
  - Consider site specific subsea infrastructure

- Wild Well Available tools
  - First principals calculation
  - DNV RP
  - Detailed computational analysis
- Risk Assessment of Pipeline Protection October 2010
- Probability calculation approach
- Process is to:
  - Classify objects into classes (7 options)
    - Weight of objects
    - Shape of objects
  - Define the number of lifts for each object over a specified life cycle
    - Common items such as scaffolding, drill pipe have a high frequency
    - Less common items such as BOP, Subsea Tree, have a low lift frequency
  - Define the probability of an accidental drop to sea from DNV RP 107
    - based on industry figures
  - Divide the subsea map into a series of rings

<table>
<thead>
<tr>
<th>Type of lift</th>
<th>Frequency of dropped object into the sea (per lift)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinary lift to/from supply vessel with platform crane &lt; 20 tonnes</td>
<td>$1.2 \times 10^5$</td>
</tr>
<tr>
<td>Heavy lift to/from supply vessel with the platform crane &gt; 20 tonnes</td>
<td>$1.6 \times 10^5$</td>
</tr>
<tr>
<td>Handling of load &lt; 100 tonnes with the lifting system in the drilling derrick</td>
<td>$2.2 \times 10^5$</td>
</tr>
<tr>
<td>Handling of BOP/load &gt; 100 tonnes with the lifting system in the drilling derrick</td>
<td>$1.5 \times 10^3$</td>
</tr>
</tbody>
</table>
Determine the probable impact energy, which depends on:
- Velocity at the time of impact
- Impact type (direct, glancing etc.)
- Seafloor energy absorption

The frequency of hit within each ring can then be estimated based on the number of lifts, the drop frequency per lift and the probability of hit and plotted vs impact energy.

The final risk assessment consists of coupling the relevant frequency rankings with the consequence rankings and then comparing the result against the acceptance criteria.

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Annual frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (low)</td>
<td>So low frequency that event considered negligible.</td>
<td>$&lt;10^{-3}$</td>
</tr>
<tr>
<td>2</td>
<td>Event rarely expected to occur.</td>
<td>$10^{-4} &gt; 10^{-3}$</td>
</tr>
<tr>
<td>3 (medium)</td>
<td>Event individually not expected to happen, but when summarised over a large number of pipelines have the credibility to happen once a year.</td>
<td>$10^{-3} &gt; 10^{-4}$</td>
</tr>
<tr>
<td>4</td>
<td>Event individually may be expected to occur during the lifetime of the pipeline. (Typically a 100 year storm)</td>
<td>$10^{-2} &gt; 10^{-3}$</td>
</tr>
<tr>
<td>5 (high)</td>
<td>Event individually may be expected to occur more than once during lifetime.</td>
<td>$&gt;10^{-2}$</td>
</tr>
</tbody>
</table>
Advantages
- DNV-RP logically lays out the steps and influencing factors
- Considers different shapes or material form as required by BSEE CFR 250.714 (c)
- Considers the effects of the ocean, as required by BSEE CFR 250.714 (c)
- Models the object path in a probabilistic manner, as required by BSEE CFR 250.714 (c)
- Real inputs for the failure frequency data from past history
- Quantifies impact energy allowing a frequency vs consequence risk to be calculated
- Quick calculation, large number of lifts (1000s) can be considered

Disadvantages
- Limited number of object categories (7)
- Generalised coefficients for Cd and Ca
- Path is not explicitly considered, only likely landing locations
- Risk assessment may show a concern where in reality it is physically impossible for there to be an impact

<table>
<thead>
<tr>
<th>Cat. no.</th>
<th>Description</th>
<th>Cd</th>
<th>Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2,3</td>
<td>Slender shape</td>
<td>0.7 – 1.5</td>
<td>0.1 – 1.0</td>
</tr>
<tr>
<td>4,5,6,7</td>
<td>Box shaped</td>
<td>1.2 – 1.3</td>
<td>0.6 – 1.5</td>
</tr>
<tr>
<td>All</td>
<td>Misc. shapes (spherical to complex)</td>
<td>0.6 – 2.0</td>
<td>1.0 – 2.0</td>
</tr>
</tbody>
</table>
Detailed Analysis Workflow

- Predict where the object will land using specific Cd and Ca coefficients
- Explicitly model the objects path in each simulation
- No rings with frequency
  - Find the exact object path for a given condition, and run sensitivity
  - Develop probability distribution around the most likely location

- Computational fluid dynamics
  - Determine accurate Cd and Ca for complex shapes
  - Computationally expensive compared to other analysis methods, not practical to simulate trajectory for cases with a large water depths using CFD

- Wild Well propose a one way coupling approach
  - using CFD to determine hydrodynamic coefficients
  - passing to marine dynamics package

- Ability to run 1000s of drops and generate data through Monte Carlo simulation
Detailed Analysis Case Study

- Single object considered - Pipeline recovery basket
- Steel mesh sided, considered as solid in DNV?
- Some simplifications
  - No loads inside, this would be chaotic in reality
  - Sides modelled implicitly as a porous baffle
  - Some features such as nuts and bolts removed
CFD Hydrodynamics

- Computational Fluid Dynamics
- CFD simulates fluid flow
- Measure the forces on the object and establish the hydrodynamic coefficients

\[ F_{\text{drag}} = \frac{1}{2} \rho v^2 A C_D \]

- Dependent on orientation
- Real life, don’t know the failure mode
- Solution to run multiple configurations and bound the problem
- Cover range of uncertainty in \( F_{\text{drag}} \)
- Pass to Monte Carlo simulation

- Emergence of moving mesh simulations simplifies the calculation of hydrodynamic coefficients
CFD Hydrodynamics

- First step – test the accuracy of the approach
- Known drag and added mass coefficients
- Basket assembly – no empirical data
- Instead used a simple shape
- 3D cube
- Aligned frontal area
- Expected $C_d$ 1.05
- Expected $C_a$ 0.68

- CFD calculated $C_d$ 1.03 ($\text{error <2%}$)
- Overset mesh used for added mass
- CFD calculated $C_a = 0.68$ ($\text{error <1%}$)
CFD Hydrodynamics

- Applied same method to pipeline recovery basket
- Mesh independence achieved
  - 24 Million cells
  - Two layer K-Epsilon Turbulence
  - Hybrid wall function
  - $30 < Y+ < 150$
- Some transient effects in the flow
  - Complex shape
  - Time averaged Cd
- Moving mesh techniques used to find the hydrodynamic coefficients
Explicit path simulations

- Hydrodynamic coefficients handed over to marine dynamics software
- Very fast run time compared to CFD
  - Allows the full water depth to be modelled
  - Allows 10,000s of simulations to be run

- Monte Carlo Simulation approach
  - Define factors with uncertainty
  - Assign range of uncertainty
  - Use Python scripting to generate random inputs within the possible range
Monte Carlo Findings

- Automated process to handle the post processing
- Generate 10,000s of data points
- Data analysis
- Form a probability distribution

- Visualise the data on subsea map
Detailed analysis summary

- Advantages
  - Complex shapes can be considered in detail
  - Hydrodynamic coefficients are explicitly modelled
  - Object mass and force coefficients used to simulate exact path
  - Defines exact landing location for each case
  - Monte Carlo Simulation considers variables to give +/- on the mean landing prediction

- Disadvantages
  - Explicit analysis, and in particular CFD takes significantly longer to solve, very computationally expensive
  - Range of software and hardware resources required

- But disadvantages overcome by selective approach – only use detailed analysis approach when simplified methods not sufficient
Suggested workflow in response to BSEE Rule

- Increasing tiers of complexity
- DNV method, excellent screening tool
- Fulfils BSEE requirements
- More detailed analysis available as required
- If there is still an issue, consider alternatives to the operation
Further work
Consequence analysis

- Determined there is a likelihood of impact
  - Subsea equipment function?
  - Equipment reparable?
  - Loss of containment?
Summary

- BSEE have introduced a new rule in 2016
- If you use a floating rig unit in the U.S. Outer Continental Shelf (OCS) over an area with subsea infrastructure, you must develop a dropped objects plan
  - The plan must include a model which considers a dropped object’s path
- The model must be specific
  - Use site metocean conditions
  - Use material forms for the installation
- Wild Well Control have developed a method which allows clients to demonstrate BSEE compliance
  - Wild Well propose to use DNV-RP to quantify the risk
  - If issues are highlighted, Wild Well propose the use of in-house detailed analysis methods to research further
    - CFD – Marine dynamics – Monte Carlo Simulation – Consequence analysis
- Although not yet enforced in the UK legislation, companies may consider adopting the approach especially those which are US based
- May become part of north sea legislation in the near future
Thankyou for listening. Questions?

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