DNV GL Joint Industry Project: Decision Support for Dynamic Barrier Management

IADC/DEC Tech Forum “Data Acquisition & Cybersecurity”

Bill Nelson
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DNV GL Joint Industry Project: Decision Support for Dynamic Barrier Management

Challenge

- Knowing the continuous status of barriers and confidence that they will function when needed
- Lack of common risk language for communication
- Lack of practical decision support tools for operations

Benefits

- Continuous knowledge of barrier health status
- Real time decision support and risk management
- Common language for communication and consensus among engineering, operations, maintenance, and management

Delivery

- The JIP participants will develop and test:
  - Methods, best practices, data sources, and tools
  - Standardized bow tie diagrams, response trees, and decision protocols
  - Pilot-scale decision support systems

Contact:

Bill.Nelson@dnvgl.com
+1 832 766-0514

Region:
United States
Background situation

- Continued occurrence and recurrence of major accidents across many industries
  - Three Mile Island
  - Columbia
  - Macondo
  - Fukushima
  - Pipeline spills

- Effective decision support is needed to continuously manage the barriers for preventing and mitigating accidents
Background for the DNV GL research on decision support for dynamic barrier management

- Critical safety functions and success paths
- Information requirements analysis
- Simulator testing of decision support
- Mission success framework

Nuclear Power and Aerospace Concepts

2011 Offshore Technology Conference
- Combine critical safety functions with barrier management
- Identify Post-Macondo human factors issues

2012 DNV Internal Research Project
- Decision support for well control and blowout prevention
- Development of industry partnerships

2013-2016 Projects with Industry Partners
- Erosion integrity management for offshore production installation
- Barrier management for well control

- The approach has also been applied in other projects for offshore operators, pipeline companies and a major nuclear utility.

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Insights for managing risks of offshore operations

- Offshore operators need two types of information - (1) condition of barriers and success paths and (2) practical decision guidance - to effectively manage risk.
  - **Barrier**: Physical or non-physical means to prevent the occurrence of an accident or mitigate its consequences
  - **Success Path**: Combination of equipment and processes (hardware, software, and human actions) necessary for the barrier to perform its intended function

- An intuitive “common language” is needed to combine information for effective decision support

**Proposed Solution** - Combine barriers and success paths to:

- Systematically identify information and instrumentation requirements
- Provide **decision guidance** to restore degraded barriers or implement alternate success paths
- Develop an information architecture for communication, consensus, and action among:
  - Offshore operators
  - Industry groups
  - Regulatory bodies
  - External stakeholders
Some key questions are...

- Do you know the current status of your barriers and success paths?

- Are you able to continuously monitor and assess barrier and success path performance?

- Are you able manage your operational risks by providing clear guidance and decision support for restoring degraded or failed barriers?

- Are you aware of multiple success paths and actions required to restore barriers so as to continue operations?

- Do all involved parties have a common understanding and language for risk communication?
Bow tie diagrams and response trees form the foundation for decision support for dynamic barrier management.
Simplified response tree for the fluid column barrier

Barrier

Success Objective

Success Strategy

- Fluid Column
  - Maintain Positive Hydrostatic Pressure by maintaining MW > PP
    - Maintain Adequate Kick Margin
      - Pore Pressure Estimation
        - Real time downhole information via LWD tool
        - Seismic Interpretation
      - Add weighting material & verify quantity
        - Barite
      - Monitor & Record Fluid Volumes
        - Other Equivalent material e.g. CaCO3, Hematite
        - Flow meter/Pressure Sensor 1
        - Flow meter/Pressure Sensor 2
Simplified response tree for the BOP barrier

Barrier

Success Objective

Success Strategy

Success Path

BOP

Function BOP ram to maintain well integrity

Yellow Pod

Rigid Conduit 1

Surface Accumulators

Success Path 1

Blue Pod

Rigid Conduit 1 Crossover to Blue

Surface Accumulators

Success Path 2

Blue Pod

Rigid Conduit 2

Surface Accumulators

Success Path 3

Yellow Pod

Rigid Conduit 2 Crossover to Yellow

Surface Accumulators

Success Path 4

Subsea Accumulators

Success Path 5

Ungraded
Application of dynamic barrier management: If the fluid column barrier is degraded or fails...

Bow Tie Diagram

Response Tree

Ungraded
If the fluid column barrier is degraded or fails, then the BOP barrier is activated using an available success path.
# Framework for defining information needs and decision guidance for dynamic barrier management

<table>
<thead>
<tr>
<th>Elements of the Bow Tie Diagram and Response Tree</th>
<th>Information Requirements</th>
<th>Source of Information</th>
<th>Decision Criteria (IF)</th>
<th>Response Guidance (THEN)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consequence</strong>: Oil Spill</td>
<td>Occurrence of oil spill</td>
<td>Visual observation</td>
<td>Oil on surface confirmed</td>
<td>Implement Emergency Response Plan</td>
</tr>
<tr>
<td><strong>Mitigation Barrier Success Path:</strong> Inject kill fluid</td>
<td>Initiation criteria for kill fluid injection</td>
<td>- Volume and pressure of kill fluid source&lt;br&gt;- Availability and position of valves in flow path</td>
<td>Uncontrolled well flow</td>
<td>Inject kill fluid</td>
</tr>
<tr>
<td><strong>Mitigation Barrier</strong>: Kill Fluid</td>
<td>Functionality and Availability of Kill Fluid Flow Paths</td>
<td>- Availability of kill fluid source&lt;br&gt;- Availability and position of valves in flow path</td>
<td>Loss of containment has occurred</td>
<td>Implement kill fluid success path</td>
</tr>
<tr>
<td><strong>Top Event</strong>: Loss of Containment</td>
<td>Uncontrolled well flow</td>
<td>- Mud pit levels&lt;br&gt;- Wellbore flow conditions</td>
<td>Uncontrolled well flow</td>
<td>- Function BOP ram to control flow if possible&lt;br&gt;- Inject kill fluid</td>
</tr>
<tr>
<td><strong>Prevention Barrier Success Path:</strong> Function BOP ram to shear pipe and close well</td>
<td>Initiation criteria for BOP activation to shear pipe and close well</td>
<td>- Wellbore conditions&lt;br&gt;- Kick margin</td>
<td>Underbalanced fluid column</td>
<td>Function BOP ram to shear pipe and close well</td>
</tr>
<tr>
<td><strong>Prevention Barrier</strong>: BOP</td>
<td>Availability of hydraulic fluid pathways to function BOP rams</td>
<td>- Volume and pressure of hydraulic fluid source&lt;br&gt;- Availability and position of valves in flow path</td>
<td>Availability of hydraulic fluid pathways does not meet operational and regulatory requirements</td>
<td>- Suspend drilling operations&lt;br&gt;- Maintain BOP control system to restore required capability</td>
</tr>
<tr>
<td><strong>Threat</strong>: Underbalanced fluid column</td>
<td>Hydrostatic pressure</td>
<td>Comparison of fluid column pressure to formation pressure</td>
<td>Inadequate kick margin</td>
<td>Restore kick margin</td>
</tr>
</tbody>
</table>
Visualization concepts for application of dynamic barrier management to well integrity

Dynamic Well Barrier Schematic

Barrier Status

Success Path Status

Compliance Level

- Minimum of One Annular Preventer
- Minimum of Two Pipe Rams
- Minimum of Two Sets of Shear Rams, at least one of which is capable of sealing

Unlatch the LMRP Connector

Maintain Pathways for Hydraulic Fluid to Each Critical Function

Maintain Availability of Safety Functions

Maintain Availability of ROV Functions

Unlatched Upper and Lower Blind Shear Rams

Primary Unlock of LMRP Connector

Secondary Unlock of LMRP Connector

Pull/no pull decision
### Decision support for dynamic barrier management addresses the entire spectrum of offshore operations

<table>
<thead>
<tr>
<th>Progression of the event →</th>
<th>Standby Conditions</th>
<th>Event Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elements of the bow tie diagram ↓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consequence</td>
<td>Consequence Precursors</td>
<td></td>
</tr>
<tr>
<td>Mitigation Barriers</td>
<td>Mitigation Barrier and Success Path Health</td>
<td>Restore Mitigation Barriers</td>
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<tr>
<td>Top Event</td>
<td>Top Event Precursors</td>
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<td>Threat Precursors</td>
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</table>

**Consequence Assessment and Response**
Long-range vision: Dynamic barrier management supports communication and decision making at all levels of operation and across the industry.
Steps for Forming the Decision Support for Dynamic Barrier Management Joint Industry Project

- Obtain feedback from potential industry partners, BSEE, and industry groups
  - Focus on human decision making for well integrity barriers
- Identify Phase 1 sponsor organization and establish contract
- Convene launch meeting of potential JIP participants - Spring 2016
- Conduct case study workshop with a “core group” of industry SMEs as a “laboratory” for developing an application and assessing the value of the approach
  - Identify success paths
  - Identify information requirements for barrier and success path health
  - Identify decision criteria and decision guidance
  - Identify visualization concepts
- Conduct case study reporting meeting to brief JIP participants on lessons learned by the workshop core group and their assessment of value of the approach
- Develop formal plans for JIP Phase 2 and beyond
Questions?

Bill Nelson
Bill.Nelson@dnvgl.com
832-766-0514

www.dnvgl.com

SAFER, SMARTER, GREENER

Ungraded