SPE DISTINGUISHED LECTURER SERIES

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SPE FOUNDATION

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Objectives

- Why is Well Integrity important
- Components of a Well Integrity Management System

Topics

- Environmental & Safety Moments
- Define Well Integrity
- Failure Case History
- Components of a Well Integrity System
- Data Management
- Underground Failure Case Histories
- Program Checklist

Reference Material: www.wellintegrity.net
Any issues with this well?

- Missing tree valves
- Located in populated area?
- Missing lockdown screws
- Missing annulus valves
- Exposed VR plug
- Marsh environment?
- Who is accountable for this well?

Definition of Well Integrity

“Application of technical, operational and organizational solutions to reduce risk of uncontrolled release of formation fluids throughout the life cycle of a well” (NORSOK D-010)
Well Integrity Life Cycle

- Design
- Construct
- Operate
- Maintain
- Abandon

SPE 102524: "Well Integrity Operations at Prudhoe Bay, Alaska"
Bomber Glacier, Alaska

- 50,000 U.S. traffic related fatalities, 130/day
- ~1 airplane/day – would you fly?
- How does the aviation industry safely fly?
Failure Case History
Prudhoe Bay Well A-22

- B annulus pressure increased pressure to 7700 psi during startup
- Surface casing failed at 16 feet
- High pressure fluid flowed up conductor annulus

AOGCC report: "Investigation of Explosion and Fire at Prudhoe Bay Well A-22".
A-22 Surface Casing Failure

- Flooring timbers knocked off
- A annulus needle valve
- 2000 psi gas lift gas vented inside the wellhouse
- Gas ignited
- The Pad Operator was injured by the blast

AOGCC report: "Investigation of Explosion and Fire at Prudhoe Bay Well A-22".
Starting B annulus pressure = 2000 psi

Diesel in annulus

Temperature rises 45F to 115F

Final Pressure = 7,700 psi
Causal Diagram

“Lessons from Longford“, Andrews Hopkins, April 2000
Causal Factors

- Operator training, awareness of potential for annulus pressure buildup
- Startup procedures
- Reporting system for anomalies
- Risk assessment of operating with 2000 psi B annulus pressure
- Amount of responsibility
- Audit processes
- Accountability
Well Integrity Management System

1) Accountability & Responsibility
2) Well Operations
3) Well Interventions
4) Tubing / Annulus Program
5) Wellhead / Tree Maintenance
6) Safety Valve Program

SPE 102524: "Well Integrity Operations at Prudhoe Bay, Alaska"
1) Accountability / Responsibility

**Accountable**
- Makes sure it’s done,
- controls the resources

**Responsible**
- Does the work

**Team approach, involving**
- engineering, drilling,
- operations, regulators

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**Well Integrity**

**RACI Chart**

<table>
<thead>
<tr>
<th>Decisions/Functions</th>
<th>Functional Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Responsibility for implementation of the Well Integrity program</td>
<td>Performance Unit Leader</td>
</tr>
<tr>
<td>Ensure Functional Roles know their RACI status</td>
<td>Delivery Manager</td>
</tr>
<tr>
<td>Maintain the RACI Chart.</td>
<td>Area Manager</td>
</tr>
<tr>
<td>Initiate updates to the WI System Policy</td>
<td>Well Operations Supv.</td>
</tr>
<tr>
<td>Maintain data systems necessary to support WI work processes.</td>
<td>Well Operations Coord.</td>
</tr>
<tr>
<td>Initiate Peer Assists, Audits, etc. to ensure all the tasks on this RACI chart are being conducted.</td>
<td>Lead Operator</td>
</tr>
<tr>
<td>Ensure adequate resources are available to fulfill the RACI chart requirements.</td>
<td>Field Operator</td>
</tr>
</tbody>
</table>

---

**Element 1: Accountability**

<table>
<thead>
<tr>
<th>Performance Unit Leader</th>
<th>Delivery Manager</th>
<th>Area Manager</th>
<th>Well Operations Supv.</th>
<th>Well Operations Coord.</th>
<th>Lead Operator</th>
<th>Field Operator</th>
<th>Wells Manager</th>
<th>Wells Integrity Coord.</th>
<th>Wells PE</th>
<th>GPB Staff Supt</th>
<th>Anch PE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element 2: Well Operating Procedures</td>
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<tr>
<td>Ensure all personnel involved in well operations are competent.</td>
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<tr>
<td>Maintain up-to-date WI training modules</td>
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<td></td>
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<tr>
<td>Ensure operations personnel have completed WI training.</td>
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</tr>
<tr>
<td>Ensure well operating procedures reflect current operating practices.</td>
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<tr>
<td>Initiate changes to procedures.</td>
<td>I</td>
<td>I</td>
<td>C</td>
<td>R</td>
<td>C</td>
<td>C</td>
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</tr>
<tr>
<td>Ensure procedures are being followed by field personnel.</td>
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<td></td>
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</tr>
<tr>
<td>Ensure all operating wells have a pressure gauge. Must be visible, appropriate range, have a stop pin.</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

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SPE 102524: "Well Integrity Operations at Prudhoe Bay, Alaska"
Well Integrity Team

Well Integrity Technical Authority
Wells Manager

Corrosion Engineer Downhole

Well Integrity Team Leader

Well Integrity Coordinator Field Based

Well Integrity Engineer Projects

Well Integrity Engineer DHD Crew

Well Integrity Technician

Wellhead Technician

DHD Crew Foreman

DHD Crew Lead

(7) Downhole Diagnostic Technicians

SPE 102524: "Well Integrity Operations at Prudhoe Bay, Alaska"
2) Well Operations

- Well Ownership & Handover
- Personnel Competency
- Procedures: startup, operating, shutdown
- Corrosion & Erosion Management

SPE 102524: "Well Integrity Operations at Prudhoe Bay, Alaska"
3) Well Interventions

- Well Ownership & Handover
- Personnel Competency
- Procedures
- Records, document well service events
4) Tubing / Annulus Program

- Assigned operating pressure limits
- Report anomalies
- Respond to anomaly reports
- Every well is different – need to understand the risks of continued operation
Barrier System

- NORSOK D-010 has very clear discussion of well barrier systems
- If whatever is holding pressure fails, where will the pressure go, and how will it react?
- Primary and Secondary barrier systems
- Acceptance Criteria – how much can it leak and be okay?
- Can you test the barrier system? How to identify if it has lost competency?
5) Wellhead & Tree Maintenance

- Tree & wellhead valves serviced twice per year
- Wellhead Tech to handle wellhead leaks

SPE 102524: "Well Integrity Operations at Prudhoe Bay, Alaska"
6) Safety Valve Program

✓ Surface safety valves on all producers
✓ Downhole safety valves on gas injectors & offshore wells
✓ Tested 6 months
Data Management

- Data input
- Information retrieval
- Auto generated reports

SPE 95813: "Enhancing Collaboration Between Engineering and Operations"
Well Integrity Diagnostics Report

- Annulus pressure > allowable pressure
- Annulus pressures not entered
- Overdue compliance work
- Injector with Tubing and Annulus pressure within 250 psi

Emailed automatically each morning

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WELL INTEGRITY DIAGNOSTICS REPORT

Report Date: 9/16/2007
Wells Not Operable Showing to be On-Line

<table>
<thead>
<tr>
<th>Well</th>
<th>WI Status</th>
<th>Type</th>
<th>Well Integrity Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>3C-2C</td>
<td>Not Operable</td>
<td>PWI</td>
<td>LT GI, Well safed out per GC Ops Lead Tech</td>
</tr>
</tbody>
</table>

Total Wells: 1

Wells with High IA or OA Pressures:

<table>
<thead>
<tr>
<th>Well</th>
<th>WI Status</th>
<th>On?</th>
<th>Entry Date</th>
<th>FTP</th>
<th>IA</th>
<th>OA</th>
<th>Well Integrity Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-14A</td>
<td>Under Eval</td>
<td>Y</td>
<td>9/14/2007</td>
<td>2150</td>
<td>200 TcLA comm - F to MIT-IA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-39</td>
<td>Operable</td>
<td>Y</td>
<td>9/14/2007</td>
<td>150</td>
<td>2060</td>
<td>560</td>
<td>Careful bleeding OA - will produce sand up OA</td>
</tr>
<tr>
<td>F-43</td>
<td>Operable</td>
<td>Y</td>
<td>9/14/2007</td>
<td>100</td>
<td>2060</td>
<td>60</td>
<td>High IAP is due to A/L, Well is SI - D to TIFL</td>
</tr>
<tr>
<td>N-26</td>
<td>Under Eval</td>
<td>N</td>
<td>9/14/2007</td>
<td>160</td>
<td>2100</td>
<td>0</td>
<td>TcLA comm, S to C/O S/O</td>
</tr>
<tr>
<td>P-00A</td>
<td>Operable</td>
<td>Y</td>
<td>9/14/2007</td>
<td>0</td>
<td>2160</td>
<td>0</td>
<td>D to TIFL</td>
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<tr>
<td>S-103</td>
<td>Operable</td>
<td>Y</td>
<td>9/14/2007</td>
<td>0</td>
<td>2040</td>
<td>400 RWO fixed TcLA comm - D to TIFL</td>
<td></td>
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<tr>
<td>S-12A</td>
<td>Under Eval</td>
<td>N</td>
<td>9/14/2007</td>
<td>0</td>
<td>2100</td>
<td>120</td>
<td>D to TIFL</td>
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<tr>
<td>S-21</td>
<td>Operable</td>
<td>Y</td>
<td>9/14/2007</td>
<td>0</td>
<td>2100</td>
<td>0</td>
<td>D to TIFL</td>
</tr>
<tr>
<td>S-36</td>
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<td>Y</td>
<td>9/14/2007</td>
<td>0</td>
<td>2100</td>
<td>540</td>
<td>D to TIFL</td>
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<tr>
<td>S-37</td>
<td>Operable</td>
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<td>9/14/2007</td>
<td>0</td>
<td>2100</td>
<td>130</td>
<td>D to TIFL</td>
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<tr>
<td>D-113</td>
<td>Under Eval</td>
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<td>9/14/2007</td>
<td>0</td>
<td>2200</td>
<td>200</td>
<td>High IAP to A/L - 3 to change out S/O, set TTP</td>
</tr>
<tr>
<td>W-21A</td>
<td>Operable</td>
<td>Y</td>
<td>9/14/2007</td>
<td>0</td>
<td>2060</td>
<td>0</td>
<td>D to TIFL</td>
</tr>
</tbody>
</table>
Auto Generated Reports

Area Management Report

“What gets measured, gets done”

- Regulatory
- Optimization

SPE 95813: “Enhancing Collaboration Between Engineering and Operations”
Underground Failures

- Algeria Cave Creation
- Indonesia Mud Volcano
BerKaouï Cave Creation, Algeria

- Drilled in late seventies, original hole was lost leaving 700m uncased.
- A cavern formed in the salt formation.
- Collapsed in 1986, created a 200m by and 80m deep depression.
The Result . . .

SPE 94427: "Northern Sahara Aquifers Protection"
Indonesia “Mud Volcano”

ANTARA NEWS 4 September, 2006

- 29 May 2006, flow of hot formation water (“mud”) began
- The East Java Police seized a rig belonging to oil and gas exploration company PT Lapindo Brantas. The seizure was made in order to bring the case to court
- The number of residents displaced by the mud has increased to an estimated 15,000 people after an emergency pond the firm erected to contain the mud collapsed.
- Mud flows cover an estimated 200 hectares (500 acres) of land in the Porong area
- The sinking of the land at 2km from the well is predicted to reach 60 centimeters within a year's time.
Indonesia Mud Volcano
Options?
Why is Well Integrity Important?

- Injury
- Environment
- Cost
- Liability
- Future generations
Well Integrity Checklist

- Assigned accountability & responsibility, team approach
- Audit Verification
- System covers design to abandonment
- Competent personnel
- Operating and well intervention procedures
- Annulus monitoring, engineering support
- Tree, wellhead and safety valve maintenance program

Reference Material: www.wellintegrity.net
Implementing a Well Integrity Management System

Joe Anders, P.E., SPE
BP Exploration (Alaska) Inc.

Prepared for the SPE Distinguished Lecture Program
Wrap up

Shokran!

- References at www.wellintegrity.net
- Questions?