Bureau of Safety and Environmental Enforcement

BSEE Domestic and International Standards Workshop: Systems Reliability Evaluations

Joseph Levine

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"To promote safety, protect the environment and conserve resources offshore through vigorous regulatory oversight and enforcement."

Presentation Overview

- BSEE, Systems Reliability Section (SRS)
  - Purpose
  - Evaluations To Date
  - Evaluation Findings
  - Outstanding Issues

SRS – Purpose and Function

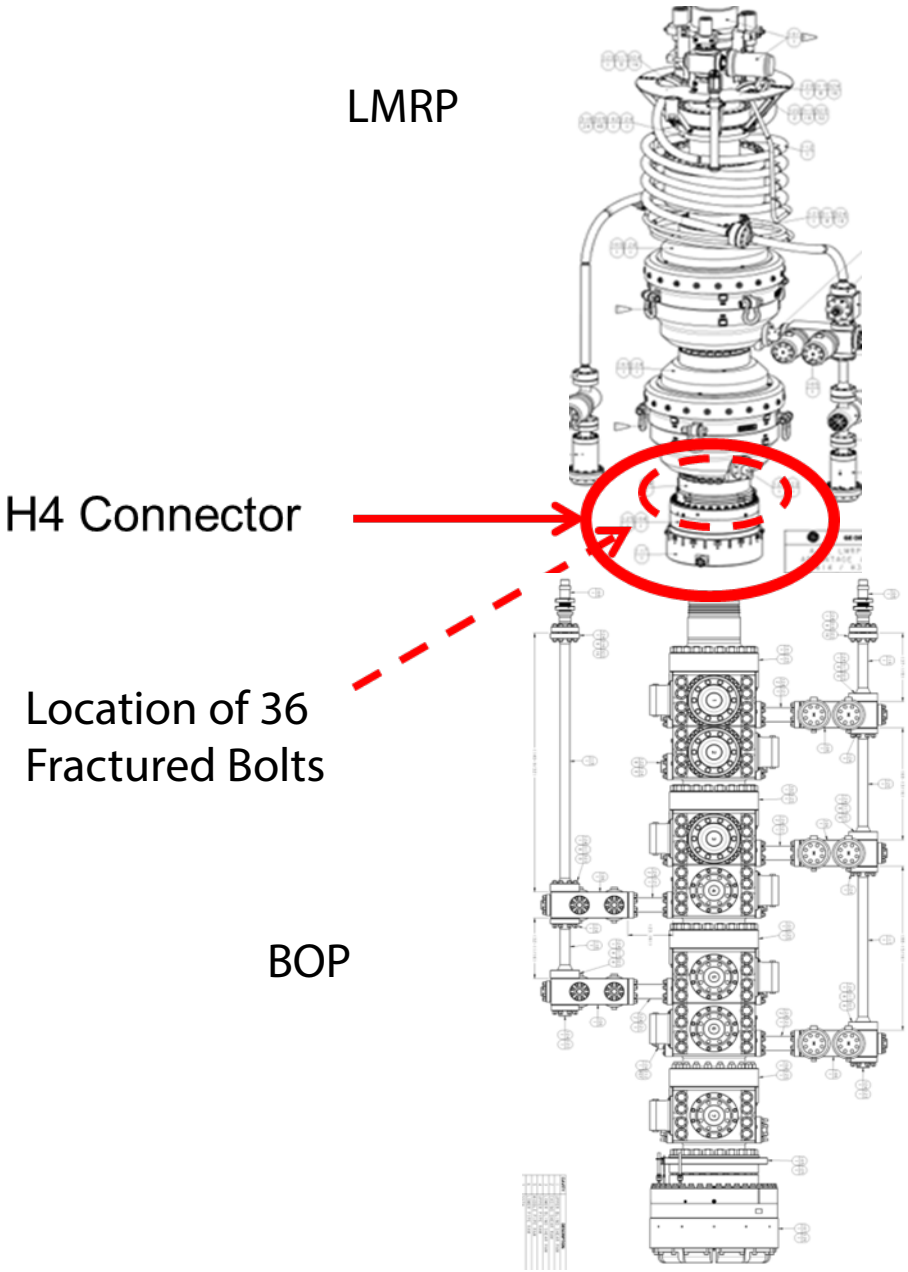
- SRS was formed in 2/2013, located in Herndon, VA.
- Functions
  - Establish meaningful communication with original equipment manufacturer (OEM)
  - Conduct QA/QC evaluations on manufactured equipment
  - Evaluate "Fitness for Service" capabilities of manufactured equipment
  - Identify gaps in industry practices/standards and/or regulations
  - Enhance knowledge base of regulator and industry in regards to evaluation findings
- SRS Technical Evaluations
  - Focus on issues that have potential industry wide (global) impacts
  - Are not the same as traditional BSEE OIR, 2010 or panel report investigations

SRS Evaluations To Date

Five evaluations since 2/2013

- H4 Connector Bolt Failure
  - Completed 8/2014
  - http://www.bsee.gov/uploadedFiles/BSEE/Enforcement/Accidents_and_Incidents/Bolt%20report%20Final%208-4-14.pdf
- Seal Assembly/Cement Failure
  - Completed 12/2014
  - http://www.bsee.gov/uploadedFiles/BSEE/Inspection_and_Enforcement/Accidents_and_Incidents/QC-FIT_Reports/QC-FIT%20Report%20Apache%20Liner%20Seal%20.pdf
- Three evaluations in progress
  - Wing-Valve Assembly
  - HC Connector Bolt Failure
    - May have similar issues as the 8/2014 evaluation
  - Marine riser sub seal assembly

8/2014 BSEE REPORT: H4 CONNECTOR BOLT FAILURE



SCHEMATIC OF LMRP H4 CONNECTOR AND MANDREL INDICATING LOCATION OF 36 CONNECTOR BOLTS

H4 Connector and Bolt Failure Evaluation

- While drilling, the LMRP separated from the subsea BOP (12/2012)
- Separation resulted in a 432 bbl. SBM discharge through the LMRP H4 connector
- Evaluation identified a global issue
  - 10,982 replacement bolts provided by OEM for use on 361 LMRP connectors worldwide
  - 1,318 bolts returned to OEM (494 in the GOM)

OEM Safety Notice and BSEE Safety Alerts issued (1/2013)

H4 Connector and Bolt Failure Causes

- Industry RCA found concerns with bolt
  - Material Properties (Hardness, YS, UTS)
  - Lack of post-bake procedure
- QC-FIT additionally noted Hydrogen Induced Stress Corrosion Cracking may be due to any combination of
  - Bolts' high material hardness, yield strength and ultimate tensile strength
  - Stray voltage
  - Coatings
- Concerns identified with OEM Quality Management System (QMS)

H4 Connector and Bolt Failure Evaluation

- Inconsistent Hardness, YS, and UTS requirements in subsea standards as related to bolts show wide range of values
  - Hardness (22-35 HRC)
  - YS (360-1036 MPa)
  - UTS (1000-1380 MPa)
- Standards with different bolt related material property requirements include
  - API 6A/16A/16F/17A
  - NACE MR0175
  - NORSOK-M001

H4 Connector and Bolt Failure Evaluation

- Coatings
  - Subcontractor relied on an older 1998 edition of ASTM B633 rather than the latest 2007 edition
    - In accordance with the 1998 edition bolts did not receive required post bake electroplating which may have reduced the risk of hydrogen embrittlement
    - 2007 edition requires post bake treatment
  - Standards with different coating requirements include
    - ASTM B633/B849/B850/F1941/F1137

H4 Connector and Bolt Failure Evaluation

- Quality Management System(s) (QMS)
  - OEM's QMS qualified/audited only first-tier suppliers
    - OEM QMS did not require qualification and audit of second/third tier subcontractors
    - Neither operator or contractor detected an issue with the sub-tier supplier during their assessment of OEM
    - Need improved oversight of second and third tier subcontractors

H4 Connector and Bolt Failure Opportunities for Improvement

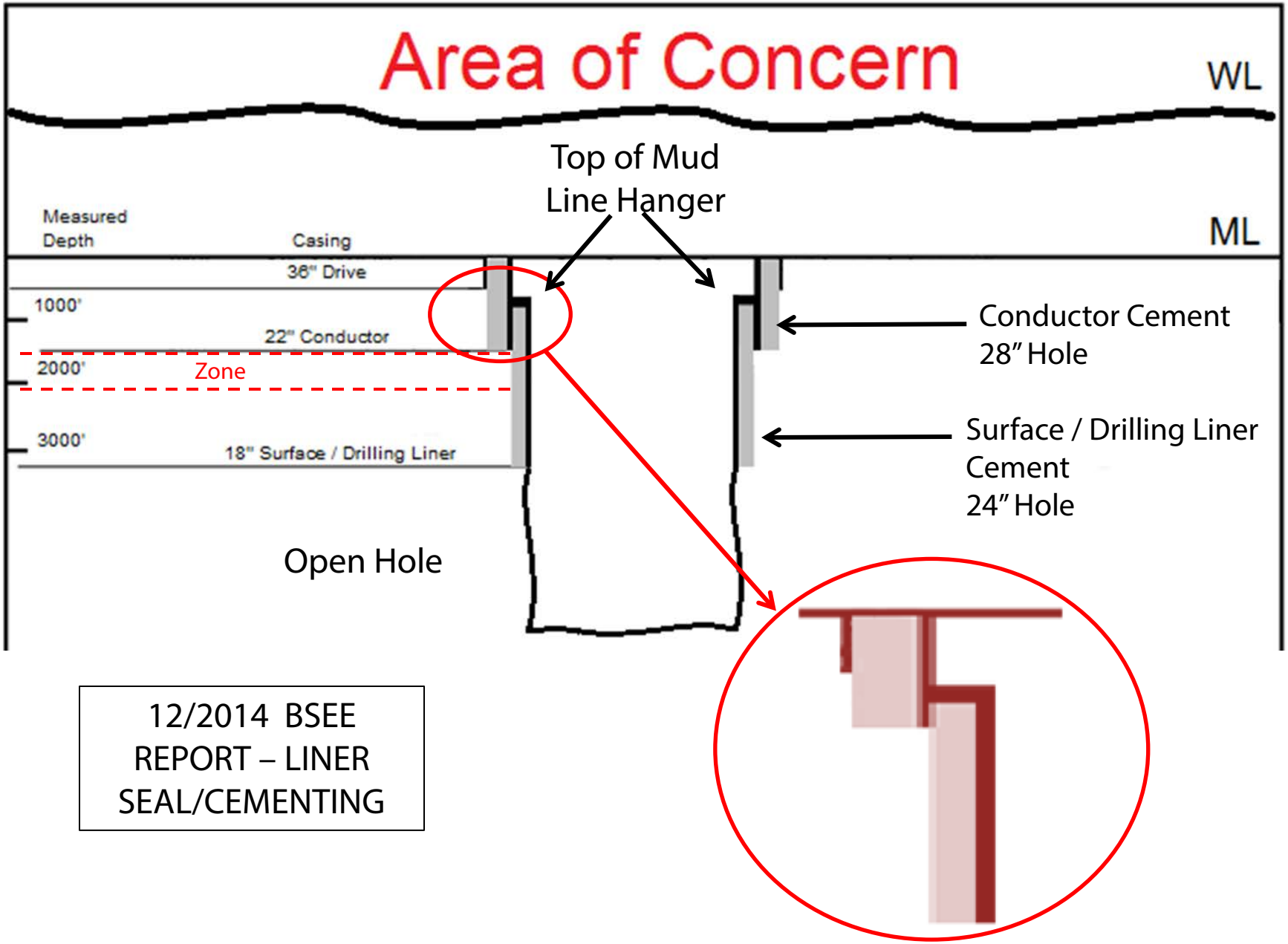
- Harmonization of material property requirements, particularly hardness, for subsea equipment in general and connector bolts specifically
  - Issue was mentioned by BSEE at the 1/2015 API Winter Standards Conference in New Orleans
    - What has been accomplished since then?
- How deep should your (operator, contractor, OEM) management system dig to ensure a quality product?
  - How deep is deep enough to assure a “fit for service” product?
- Research opportunities?

Critical Drill Through Equipment Fastener 2015 Research

- There is a need for an independent assessment of critical drill through equipment fasteners used in offshore oil and gas operations
  - Identify and asses fastener systems currently in use
    - Offshore, domestic and global
    - Onshore, domestic and global
    - Other industries
  - Assess design, manufacture, installation, maintenance, and inspection processes
  - Evaluate the performance of current fastener systems
  - Identify similarities and differences in industry standards and regulations globally

Seal Assembly/Cement Failure Evaluation

- While drilling operator took a gas kick (2/2013)
- Kick resulted in a gas flow into a shallow sand below the conductor casing shoe culminating in an underground blowout
- Event created risk of broaching to the seafloor
- Possible failure points
  - Casing hanger seal
  - Cement column in conductor/surface liner annulus
  - Hole in casing
  - Damaged casing threads



12/2014 BSEE
REPORT – LINER
SEAL/CEMENTING

Seal Assembly/Cement Failure Evaluation

- Major Issues
  - Is the Shallow Liner Seal/Cement Column a single or dual barrier system when it comes to well control?
  - Can cement requirements for shallow sections of the well be improved upon?
  - What criteria need to be evaluated to ensure the Shallow Liner Seal is "Fit for Service"?

Seal Assembly/Cement Failure Evaluation

- Is the Shallow Liner Seal/Cement Column a single or dual barrier?
- If the liner seal is faulty are you actually testing the cement column?
  - How would you know?
- Does a successful liner pressure test mask a poor cement job?
  - How would you know?
- Is the integrity of the cement column behind the liner truly understood?
  - How could you determine the cement integrity?

Seal Assembly/Cement Failure Evaluation

- Surface Drilling Liner Cement Concerns
  - Is the BSEE liner lap/liner pressure test sufficient to prove reliability of the barrier(s)?
    - Can not decline more than 10 percent in a 30-minute test
  - Annular fill at least 200 feet above conductor shoe
  - WOC of 12 hours with cement held under pressure
  - Is there an ideal open hole diameter/surface liner OD ratio?
    - What Annular space is too large/small?

Seal Assembly/Cement Failure Evaluation

What criteria need to be evaluated to ensure Shallow Liner Seals are "Fit for Service"?

- Temperature Rating
  - Seal Assembly was rated to 75°F but was exposed to 90°F during operation
  - Inconsistencies between operator and OEM concerning seal's temperature rating
- Gas vs Liquid Rating
  - Seal design was not qualified for gas, yet gas was "seen" in the well
- Are there other criteria that need to be evaluated?
  - Pressure
  - Axial loads

Seal Assembly/Cement Failure Opportunities for Improvement

- Do existing standards provide adequate design/qualification for seals?
  - API 17D Design & Operation of Subsea Production Systems – Subsea Wellhead & Tree Equipment - Second Edition (2011)
  - API 19LH Liner Hangers – First Edition (Publish 2016)
  - Should they be modified? How?
- Do existing standards provide adequate design/use for cements?
  - RP 65 Cementing Shallow Water Flow Zones in Deepwater Wells – First Edition,
  - RP 65-2 Isolating Potential Flow Zones During Well Construction – Second Edition
  - Should they be modified? How?
- Possible Shallow Liner/Cement Research
  - Best cementing practices for shallow sections of a well
  - Engineering design of shallow liner seals
  - Are existing BSEE regulations on cements and testing of liner adequate?
  - Possible JIP?

Summary

- Connector Bolts
  - Standard Harmonization
  - QMS
  - BSEE research
- Shallow Liner Seal/Cement Systems
  - Barrier
  - Fit For Service
  - Shallow Cementing Practices
  - JIP?

BSEE Website: www.bsee.gov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