Well Integrity Failure Analysis

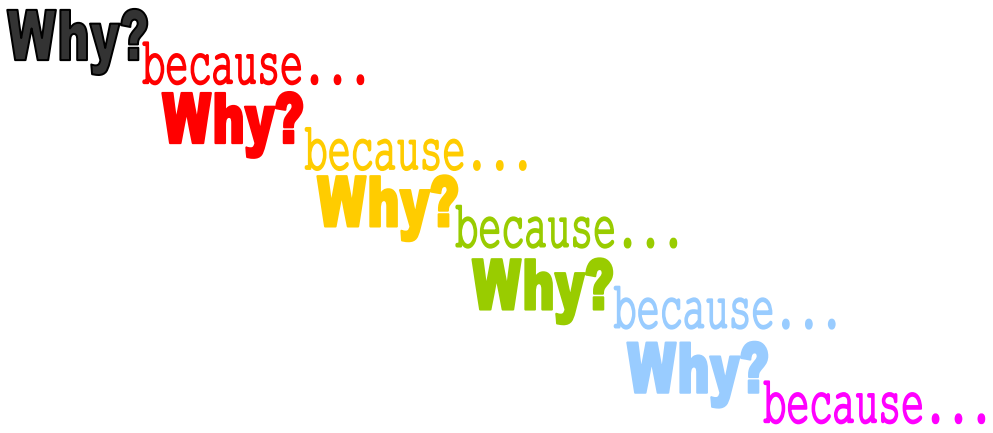
Analysis of wells shutin due to well integrity issues

Well Integrity Forum

May 26, 2011

Purpose of project

- Project Kickoff Oct 2009
  - Report signoff Oct 2010
- Analyze wells shutin due to well integrity issues
  - Identify the root causes
  - Quantify production losses
  - Recommend areas for improvement



  - Investigation of failures assigned by type: DHSV/ASV, XT/WH leaks, Misc failures, tubing leaks, materials
  - Simplified method based on Statoil tool for investigating incidents

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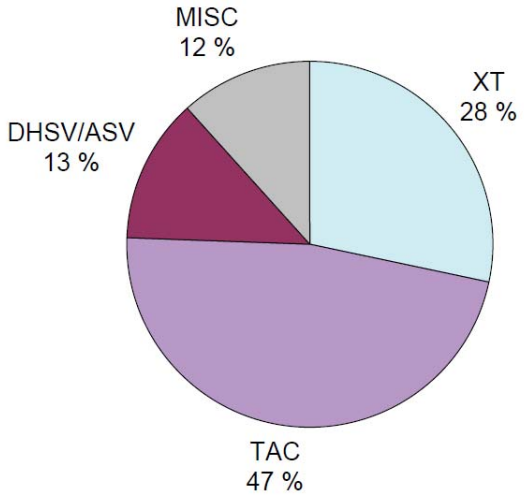
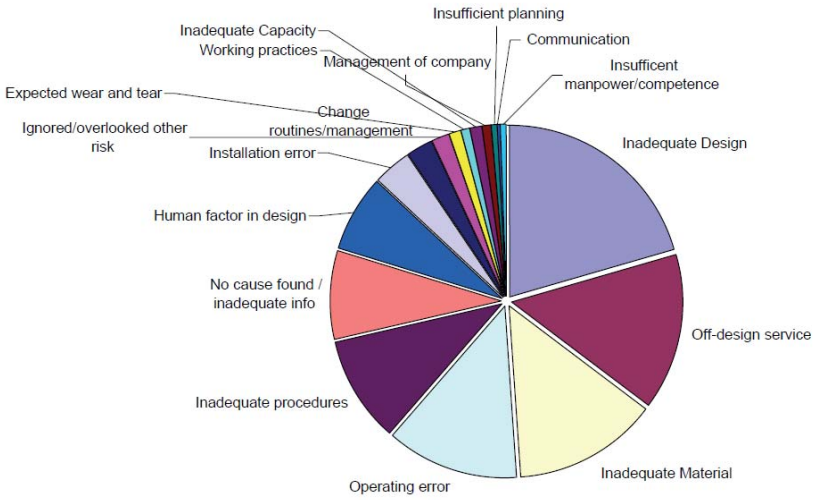
Summary of failures

- Immediate causes
  - Tubing to annulus communication (TAC)
  - XT
  - DHSV
  - Misc



Summary of failures

- Immediate causes
  - TAC, XT, DHSV, Misc
- Underlying causes
  - Each well assessed with general cause codes
  - Multiple cause codes for most wells
  - Single most frequent causes:
    - inadequate design
    - off-design service
    - inadequate materials

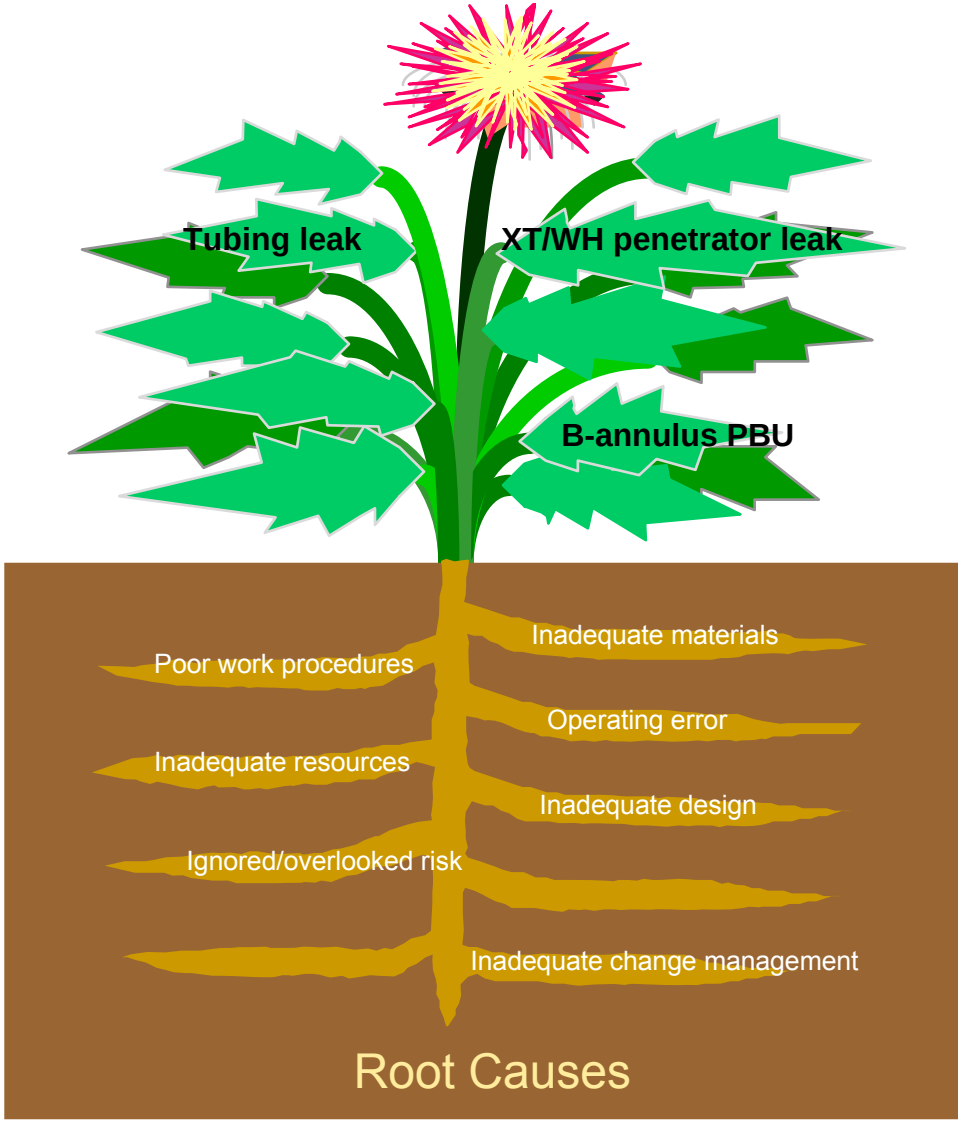


Wells with no production loss

- Reason for no loss was due to:
  - Topside limitations
    - Production line bottleneck
    - Too high gas rate
  - Marketing
    - Injector used when there are export limitations
    - Injector used for banking of gas (flexibility)
  - Drainage strategy
    - Field Water injection shutdown
    - Production is limited due to drainage strategy
  - Sufficient pressure support
    - Injector not required – sufficient pressure support
  - Cuttings injector not required
  - Insufficient production potential
    - Waiting on P&A
    - Low WHP, High water cut

Identifying Root Causes

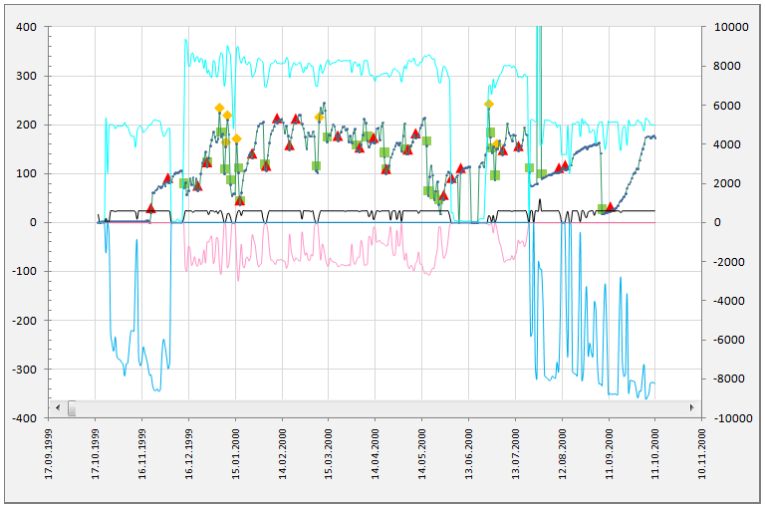
- Findings
  - No systematic capture of root causes. Capturing immediate cause (e.g. tubing leak) is not enough information to find deeper issues
- Recommendations
  - An MTO analysis should be performed on the most common or top well integrity failures
    - Capturing the root causes
    - Prevent the recurrence of similar events.



"Those who cannot remember the past are condemned to repeat it."

Annulus monitoring

- **Findings:**
  - Early detection of leaks is not adequate. There is no onshore engineer looking at long term trends for analysis. Majority of leaks are initially less than the acceptable leak rate criteria.
- **Recommendations**
  - Task of monitoring annuli (pressure and rate over time should be assigned to an onshore engineer)
  - Each asset should include review of pressure trends (in addition to overall integrity status) for all wells at regular intervals (bi-yearly for example).



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D&W Resources

- **Findings**
  - Feedback from the existing and previous well integrity engineer:
    - frustration due to lack of time
    - having many wells with many issues to manage
    - New well integrity requirements to put in place
    - Well integrity engineers are in firefighting mode and do not have the time to take a proactive approach to managing well integrity

- **Recommendations**
  - There should be a provision of dedicated personnel within D&W with sufficient time to manage well integrity.

Corrosion monitoring

- Findings:
  - Lack of overview or assignment of tasks associated with corrosion monitoring within D&W.
    - Rate loss/year
    - Type of corrosion
    - Water quality
    - Material vs fluids injected
- Recommendations
  - Well integrity role should be expanded to include corrosion monitoring tasks
  - Put more focus on leading performance indicators (rather than lagging indicators) wrt water quality and corrosion monitoring.

- **Leading indicator:**
  - Rate/year and total wall loss:
  - O2 and residual chlorine content:
- **Lagging indicator:**
  - Wells shutin due to corrosion

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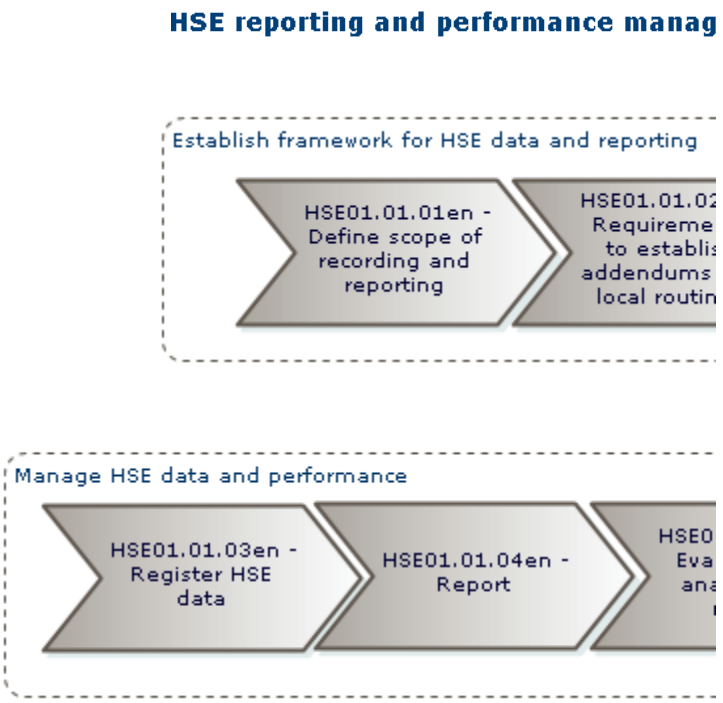
Well Integrity Auditing

- Findings
  - The WIFA report identifies specific and consistent areas for improvement. There is a largely varied method of performing activities between the licenses.
- Recommendations
  - An auditing system for following up well integrity processes should be established. An auditing system will ensure that not only the appropriate well integrity management system is in place but all that the findings from this project have been addressed.

Well Integrity Incident Reporting

- Findings
  - Top steering documentation does not state how reporting should occur and when investigations should take place for well integrity incidents.
- Recommendation:
  - Well integrity incidents in wells in operation should be incorporated into "HSE reporting and performance management“ steering documentation

Done



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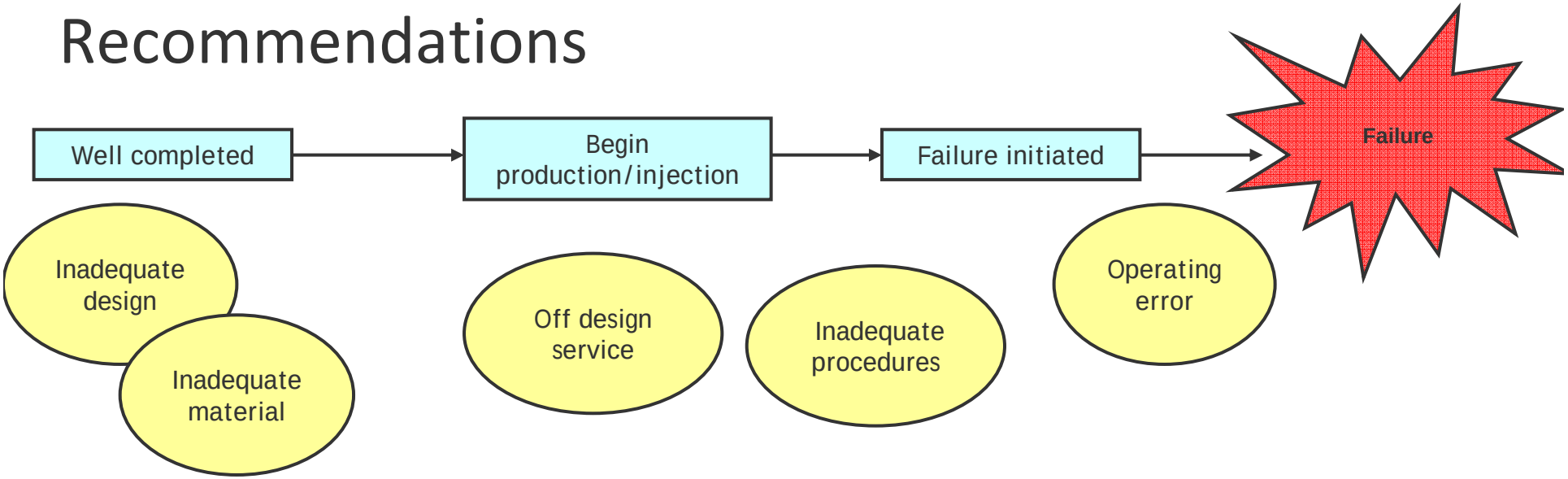
Improvements/Activities

- Courses
  - Elearning – Basic well integrity
  - Elearning – Well Integrity and abandonment
  - Well Integrity course for wells in operation (2 day)
  - Field specific courses – Gullfaks pilot under development (3 day)
  - Yearly Well Integrity Seminar – Wells in operation (1 day)
- Material requirements
  - Robust steering documentation addresses material and design requirements

Recommendations



30 minutes stable pressure test

Focus on QA makeup& testing onshore

Log csg thickness in INJ wells – pkr setting depth area

Improve Corrosion monitoring

Establish Preventative KPI's

Improve monitoring tools (short term)

Well integrity monitoring in IO

Improve annulus monitoring/ early leak detection

Improve failure identification (WLD: leak location)

Improve understanding of gas in water (research). Optimize handling of leaks.

Improved wireline deployment methods/ technology to seal small connection leaks

Eliminate PBR/seals

Improved connections

Improved material selection (GRE)

Improved int casing setting depth & use of gas tight connections

Implement WIMS (underway)

Adequate resources to manage well integrity

Well Integrity reporting, identifying root causes, improved training/competence, Well integrity auditing

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