Step Change in Safety – Asset Integrity Perspectives Event
Wednesday 8 May 2013; 08:00 – 13:30

Hydrocarbon Release Reduction Project
on Norwegian Continental Shelf
Summary of period 2008 – 2012

Jan Erik Vinnem
jev@preventor.no
Overview

• Brief history
• About the project
• Trends
• Circumstances when leaks occur
• Operational errors
• Verification errors
• Night shift
• Conclusions
• Motivation & awareness
HISTORY AND PREVIOUS PROJECTS (IN BRIEF)

- A dedicated project (GaLeRe) was conducted 2002 to 2008
  - Phase 1: 2002 – 2005
  - Phase 2: 2005 – 2008
    - Goal Phase 2 (10) reached in 2007
    - Subsequent increase to ~15

Number of HC leaks > 0.1 kg/s in the process area on Norwegian offshore installations
NEW PROJECT INITIATED IN 2011

- Started in 2011 based on PSA request
- Presentation the main results from the report: Vinnem & Røed: “Analysis of causes of hydrocarbon leaks in 08-11”

Study basis
- Excluding diesel, lube oil, seal oil etc.
- Accident investigation reports
- In-depth studies
- Information from Synergi

Not only based upon Synergi classifications (such an approach would be insufficient)
Leaks per 100 installation years, 2006 – Q1/2013
12 months rolling average

Average no of leaks per 100 installation years

GaLeRe

HC reduction project
Emphasis

• GaLeRe project focused on:
  – Technical causes
  – Execution of maintenance work by contractor personnel

• Present project focused on:
  – Lack of operational barriers during manual intervention (organisational errors)
  – Leadership, supervision, management of change, learning from incidents, best practice
  – Work outside Work Permit system
  – Experience transfer to design
  – Motivation & awareness
Emphasis

• Focus on operational barriers during manual intervention
  – Consistent with recent accidents & incidents, including Macondo, Montara, Gullfaks C, etc.

• Comparison with UKCS would have been interesting
  – Has not been possible to achieve so far
Approach

- Detailed analysis of leaks in HOF context in order to determine
  - Circumstances of operations when leaks occur
  - Special emphasis on
    - Work permits
    - Isolation plans, implementation & reinstatement
    - Operational controls (barriers)
    - Verification as operational barriers
  - Significant differences between how companies carry out isolations
  - Best practice for isolation and splitting
  - Work outside WP system (normal process operations)

- Developed questionnaire for identification of isolation errors
  - Increased focus during incident investigation

- Focus has for too long been too heavily on equipment alone
LEAK CATEGORIZATION

Main categories reflecting circumstances when leak occurred:

Technical degradation of system (Cat. A)
   - Introducing delayed release (Cat. B)
   - Causing immediate release (Cat. C)

Human intervention

Process disturbance (Cat. D)

Inherent design errors (Cat. E)

External events (Cat. F)

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Degradation of valve sealing</td>
</tr>
<tr>
<td>A2</td>
<td>Degradation of flange gasket</td>
</tr>
<tr>
<td>A3</td>
<td>Loss of bolt tensioning</td>
</tr>
<tr>
<td>A4</td>
<td>Fatigue</td>
</tr>
<tr>
<td>A5</td>
<td>Internal corrosion</td>
</tr>
<tr>
<td>A6</td>
<td>External corrosion</td>
</tr>
<tr>
<td>A7</td>
<td>Erosion</td>
</tr>
<tr>
<td>A8</td>
<td>Other</td>
</tr>
<tr>
<td>B1</td>
<td>Incorrect blinding/isolation</td>
</tr>
<tr>
<td>B2</td>
<td>Incorrect fitting of flanges or bolts during maintenance</td>
</tr>
<tr>
<td>B3</td>
<td>Valve(s) in incorrect position after maintenance</td>
</tr>
<tr>
<td>B4</td>
<td>Erroneous choice of installations of sealing device</td>
</tr>
<tr>
<td>B5</td>
<td>Maloperation of valve(s) during manual operations</td>
</tr>
<tr>
<td>B6</td>
<td>Maloperation of temporary hoses</td>
</tr>
<tr>
<td>C1</td>
<td>Break-down of isolation system during maintenance (technical)</td>
</tr>
<tr>
<td>C2</td>
<td>Maloperation of valve(s) during manual operation</td>
</tr>
<tr>
<td>C3</td>
<td>Work on wrong equipment (not known to be pressurised)</td>
</tr>
<tr>
<td>D1</td>
<td>Overpressure</td>
</tr>
<tr>
<td>D2</td>
<td>Overflow/over filling</td>
</tr>
<tr>
<td>E1</td>
<td>Design related failures</td>
</tr>
<tr>
<td>F1</td>
<td>Impact from falling object</td>
</tr>
<tr>
<td>F2</td>
<td>Impact from bumping/collision</td>
</tr>
</tbody>
</table>
The majority of the HC leaks are associated with human intervention (60%)
Comparison UK vs Norway

Leaks 2001 - 2005

• Gas/condensate/2phase leaks

• > 0.1 kg/s (mass flow)
Main «human intervention» failures resulting in hydrocarbon leaks:
- Incorrect fitting of flanges or bolts during maintenance
- Valves in incorrect position after maintenance
- Break-down of isolation system during maintenance

DISTRIBUTION OF HUMAN INTERVENTION ASSOCIATED LEAKS (CAT. B AND C)

<table>
<thead>
<tr>
<th>Category</th>
<th>Bar Graph</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1. Incorrect blinding/isolation</td>
<td>1</td>
</tr>
<tr>
<td>B2. Incorrect fitting of flanges or bolts during maintenance</td>
<td>10</td>
</tr>
<tr>
<td>B3. Valves(s) in incorrect position after maintenance</td>
<td>7</td>
</tr>
<tr>
<td>B4. Erroneous choice or installations of sealing device</td>
<td>3</td>
</tr>
<tr>
<td>B5. Maloperation of valve(s) during manual operation</td>
<td>2</td>
</tr>
<tr>
<td>B6. Maloperation of temporary hoses</td>
<td>1</td>
</tr>
<tr>
<td>C1. Break-down of isolation system during maintenance</td>
<td>7</td>
</tr>
<tr>
<td>C2. Maloperation of valve(s) during manual operation</td>
<td>2</td>
</tr>
<tr>
<td>C3. Work on equipment not known to be pressurised</td>
<td>1</td>
</tr>
</tbody>
</table>

Delayed leak
Immediate leak

n=36
“Execution” is not the largest category. Activities carried out before and after the execution of the intervention is crucial: Correct isolation and reinstatement.

For a leak to occur in the isolation and reinstatement phases, there must be an error both during isolation/reinstatement and during verification of the isolation/reinstatement.
In more than 2/3 of the verification failures, the verification was not performed at all.
Many hydrocarbon leaks occurred during the night shift, in particular from midnight until start of the day shift. Lack of verification essential aspect
Risk influencing factors (from investigations)

Risk Influencing Factors

- Work practice
- Compliance with steering documents
- Communication
- Handover
- Experience transfer
- Competence
- Work planning
- Procedures
- Supervision
- Time pressure
- Management of change
- Design/fabrication
- New equipment
- Technical quality
- Identification of relevant requirements
- Maintenance program
- Inspection program
- QA
- Logging
- Mustering

Number of leaks:
- Work practice: 20
- Compliance with steering documents: 16
- Communication: 35
- Handover: 20
- Experience transfer: 15
- Competence: 10
- Work planning: 5
- Procedures: 5
- Supervision: 5
- Time pressure: 0
- Management of change: 0
- Design/fabrication: 0
- New equipment: 0
- Technical quality: 0
- Identification of relevant requirements: 0
- Maintenance program: 10
- Inspection program: 10
- QA: 10
- Logging: 5
- Mustering: 5

n=48

PREVENTOR
Risk management research and development
Age influence – leaks due to technical degradation

![Diagram showing the relationship between age of installation and leak frequency. The x-axis represents the age of installation with leaks, ranging from 1 to 32 years. The y-axis represents the leak frequency per installation year, ranging from 0 to 0.14. There are two peaks at ages 19 and 30, indicating higher frequency of leaks at these ages. The number of observations, n=13, is noted at the bottom right of the chart.]

Same installations

n=13
Age influence – leaks due to technical degradation

Two installations removed
Conclusion – technical degradation

- Not possible to demonstrate correlation between leak frequency and age of installation
- Similar conclusions made by other studies
CONCLUDING REMARKS

Key findings:

→ Majority of leaks are associated with human intervention (maintenance & inspection)

→ Challenge in particular during normal operational activities (no WP)

→ Technical degradation does not represent a majority of leaks (21%)

→ Human intervention failures may also have root causes in design sphere, which may be important input for design of new installations
CONCLUDING REMARKS

Key findings:

→ Less than 1/3 of manual intervention failures causing leak occurred during execution of the intervention

→ Many HC leaks are associated with **implementation and reinstatement of isolation plans**

→ **Verification** of implementation and reinstatement of isolation plan are **crucial** barriers

→ 2/3 of verification failures are failure to perform the verification (**silent deviations?**)

→ Several leaks can be traced back to **work being performed during night shift**, especially for the period after midnight until start of day shift
KONSEKVENSER AV EN GASSLEKKASJE

Gaslekkasjer kan ha store følger. Norsk olje og gass har fått laget en presentasjonspakke, som viser hvilke konsekvenser en lekkasje med en rate på 1 kg/s kan få.

Klikk på bildet for å gå gjennom animasjonen (åpner seg i nytt vindu).

Link: http://www.norskoljeoggass.no/no/Hydrokarbonlekkasjer/Delprosjekter/Konsekvenser-av-en-gasslekkasje/
REFERENCES

• Vinnem, J.E. and Røed, W. (2013) Norwegian Oil and Gas Industry Project to Reduce the Number of Hydrocarbon Leaks with emphasis on Operational Barriers Improvement, presented at SPE Europe HSE Conference and Exhibition, London, UK, 16–18 April 2013