Early-on HAZOP (PHAZOP) Advocacy: Best Practices

Building from the past to the future in integrity management

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1. Introduction

• HAZOP origin and use discussed by Trevor Kletz at MKOPSC 2009
  – Structured process to review designs
  – If had to do over again would have the HAZOP earlier in the process
  – More lead time to influence the design
• Earlier recognition of issues
  – Detect issues sooner more time to develop options
  – Longer time to consider the gap exposed and implications for more gaps
• We can never know how much we don’t know.
  – Issues studied identify more areas we didn’t know about
  – Risk mitigations may create more problems not expected
1. Introduction

• Events Define Change; Change expands thought, discipline
  – Piper Alpha
  – Bhopal
  – Chernobyl
  – 3 mile island
  – Flixborough
  – Texas City
  – Deepwater Horizon

• Events Mark Points-in-time
  – Piper Alpha
  – 9/11
  – London 7/7
  – Kennedy Assassination
1. Introduction

- The Trevor Kletz statement comes into view:
  - Find the hazards as early as possible in the design process.
  - When can the PHAZOP be effective as a process?
  - What kinds of design products are available at an early stage?
  - Are PHAZOP goals clear and evident to the participants?
  - Do we have genuine buy-in and commitment to the process?
- Both experiences and less-experienced can contribute
  - Experience draws on lessons learned and workable designs
  - Less-experienced bring a fresh set of eyes to critically review
The process then is a Design Challenge and Execution Challenge:

- Provide thought provoking direction.
- Use of a guideword process to initiate response and call to action to participate.
- Guidewords, experience and fresh thought open the design to discussion of risks by challenges.
- Execution risks and aspects appear early-on.
- Develop KPI’s (Key Performance Indicators)
2. Risk Identification and Gaps

Early-on HAZOP or Preliminary HAZOP (PHAZOP)

- Do we know all that can be known?
- Do we have a full list of hazards and the risk?
- Can we know how much we don’t know about a design and its hazards?
- What is completeness of the process?
- When we consider our process complete is it actually incomplete at the very moment?
- Are identified hazards fully mitigated or is the system now with a new hazard and the same or worse than the original?
- Supposing the contrary, do we think we have discovered all gaps and learned everything in every study?
2. Risk Identification and Gaps

Early-on HAZOP or Preliminary HAZOP (PHAZOP)

- IM approach - Guidewords to support discussions - link experience and knowledge of SMEs to the process to reduce the unknown risk

- PHAZOP Benefits: ensure hazard detectability and thus consideration of the mitigations which can be brought to bear on the design in its early stages before decisions that exclude options are made.
3. PHAZOP as a Tool

Experiences

- Many clients use the PHAZOP as an early tool and include it in the process, but not all.

- A subsea deepwater tie-back used a PHAZOP in FEED. Recent corrosion lessons learned were incorporated and an additional corrosion protection issue was identified. 30 items were detected. PHAZOP was held just 3 months into the project as soon as first rev P&ID’s were available.

- A subsea deepwater tie-back used a PHAZOP and corrosion, and compatibility and materials studies were identified.
3. PHAZOP as a Tool

Experiences

- An offshore drilling platform with well-testing facilities and accommodations held a PHAZOP with early identification of critical design, life safety and environmental issues.

- A subsea deepwater tie-back was in select stage and with numerous options with P&IDs’ developed. End of stage comments were that a PHAZOP would have been a more valuable process. This is a possible example of the point Trevor Kletz made.

- A subsea pipeline system with multiple wells and platforms in FEED was scheduled with the HAZOP at 90% design point. This is a possible example of the point Trevor Kletz made.
Experiences

- A refinery upgrade PHAZOP identified items for system design which included a cold vent for which a recommendation early-on was a new line to the flare header to run to flare.
- A refinery debottlenecking PHAZOP showed the need for an additional relief valve and resulted in the direction of a new heat load study.
- A refinery PHAZOP identified over 100 items for review.

We find that experiences define major problem areas e.g. Corrosion under insulation.
3. PHAZOP as a Tool

Risk Identification Progression
Key Aspects

- Internal corrosion
- External corrosion
- Material degradation
- Flow Assurance
4. Hazard Discussions

Barriers & Mitigations (Corrosion Examples)
Swiss Cheese Model: Macro and Micro elements

- Localized Pitting
- General Corrosion, Poor Inspection data, etc
- Erosion, Cavitation, wear
- Materials Performance, Fracture, Embrittlement, SCC, etc
- Structural Integrity, Mechanical Strength, Loss of Properties, Weld defects, etc
- New Mechanism(s) LME, CUI, 8,10,12 etc
- Operations, Steady State, Out of Envelope, Excursions, Transients, Ergonomics, Human Error, etc
- Management Snafu, Adverse Project Decision,
- Hazards
- Losses
- P.T.W.
- etc

Experience that Delivers
Knowledge Management

- Validation of new applications and step-outs in technology;
- Increased confidence in design inputs for new developments;
- Increased integrity assurance and early warning of potential issues for existing developments;
- Identification of evolving industry practices;
- Improved tracking and application of lessons learned

Brownfield/Greenfield

- Possibility to base Greenfield design requirements on Brownfield available operational parameters - ensure more accurate design and less conservative assumptions
Design Variation / Change Management

- If changes are not properly assessed, catastrophic events may occur:
  - Accelerated degradation of materials can take place if the correct material compatibility assessment has not been undertaken
  - Specification of design limits and identification of suitable materials
  - Insufficient Structural Integrity of hosting facility due to additional hanging off loads from new risers on one side of a facility
  - Detailed review topsides operations and hardware
  - Detailed review of extreme dynamic response & the fatigue life of the risers

Brownfield/Greenfield

- Compilation of histogram of historic operating data from Brownfield to most accurately define the service conditions
### 6. Impact to Hazard Discussions

**Fatigue**

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Benefit</th>
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</thead>
<tbody>
<tr>
<td>Knowledge Management</td>
<td>Validation of numerical assumptions</td>
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</tbody>
</table>
| Change Management             | • Accurate modeling of drag properties  
                              | • Changes in topsides pipework that may be impacted by FIV              |
| Preliminary Design Specification | Base fatigue design based on measured conditions                         |
## Internal Corrosion

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge Management</td>
<td>Calibration of corrosion models with monitored Brownfield data</td>
</tr>
<tr>
<td>Change Management</td>
<td>Fluid composition changes that may impact internal corrosion</td>
</tr>
<tr>
<td>Preliminary Design Specification</td>
<td>Driven by Knowledge Management (No definite industry codes of practice)</td>
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## 6. Impact to Hazard Discussions

### External Corrosion

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Benefit</th>
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</thead>
<tbody>
<tr>
<td>Knowledge Management</td>
<td>Identify best practice from latest DNV, ISO, or NACE standards</td>
</tr>
<tr>
<td>Change Management</td>
<td>Capture changes that may require modification to CP system or coatings</td>
</tr>
<tr>
<td>Preliminary Design Specification</td>
<td>Better understanding of local environment = better assessment of marine growth</td>
</tr>
</tbody>
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### Material Degradation

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Benefit</th>
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</thead>
<tbody>
<tr>
<td>Knowledge Management</td>
<td>Most recent polymer degradation curves</td>
</tr>
<tr>
<td>Change Management</td>
<td>Material or global CP compatibility concerns</td>
</tr>
<tr>
<td>Preliminary Design Specification</td>
<td>Better design basis = Less design iteration</td>
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## 6. Impact to Hazard Discussions

### Flow Assurance/Operability

<table>
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<tbody>
<tr>
<td>Knowledge Management</td>
<td>Identify operating regimes and quantify slug loads on system</td>
</tr>
<tr>
<td>Change Management</td>
<td>Accurate modeling of riser stresses and future slug loads</td>
</tr>
<tr>
<td>Preliminary Design Specification</td>
<td>Better definition of riser behavior during slug events, with potential to revise fatigue life (+ or -)</td>
</tr>
</tbody>
</table>
6. Impact to Integrity Management Plan

- IM Performance Standards
  - Lessons Learned
  - System Data
- HAZID / HAZOP
  - Risk & Reliability Assessment
  - Recommendations
- Schedule / Implementation Trigger
  - Anomaly Limits / KPIs
  - Spares Strategy
- Regulatory Compliance
  - Plan Execution
  - Fitness for Purpose

Knowledge Management

Risk & Reliability Analysis

Changes to System?

Yes

No

Update risk?

Yes

No

IM Plan Specification

IM Plan Implementation

Periodic Review & Fitness Assessment

Action required?

Yes

No
Whole Life Cycle Approach

- Prevention of all failure modes in terms of:
  - Functionality – the system must safely contain fluids in accordance with the service requirements;
  - Reliability – the system must maintain the integrity during normal production & operational conditions, and during non-routine operations.
  - Survivability – the systems must maintain the integrity during foreseeable environment conditions;
  - Dependency/interactions – the system must maintain control process to prevent loss of containment and failures by implementing procedures and instrumented protective functions.
## 6. Impact to Integrity Management Plan

### Risk Analysis & Reduction - ALARP

#### ALARP Risk Triangle

<table>
<thead>
<tr>
<th>Probability Index, P</th>
<th>Consequence Index, C</th>
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<tbody>
<tr>
<td>5</td>
<td>1</td>
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<td>4</td>
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**INSIGNIFICANT RISK**
- Corrosion Events Negligible

**TOLERABLE RISK REGION**
- Corrosion Manageable
- Risk reduction benefits practicable
- Consequences acceptable

**UNACCEPTABLE RISK**
- Consequences too bad
- Material/Corrosion failures not acceptable
- Justifiable only in very exceptional cases
Incidents

- **2002** – During a scheduled platform shutdown a gas release occurred from a flange as flange bolts were removed. Gas alarms sounded and activated the platform deluge system along with the GPA, general platform alarm, and personnel assembled at the muster stations. The gas dispersed by natural ventilation.

- **2005** – Failure to isolate energy source during maintenance allowed gas to migrate through sales gas line back through production equipment and escape. Later activities caused further issues and the evacuation of the platform. The platform was later reboarded when safe and valves closed to stabilize the incident.
Regulatory Environment

• The regulatory environment was changing prior to the April 20, 2010 Deepwater Incident and more so afterward.

• Risk assessment will continue to be a key element in incident prevention with the HAZID, PHAZOP and HAZOP as important tools.

• *Inherently safer design will move to the forefront.* The involvement of the IM disciplines with knowledge, experience and techniques in corrosion prevention, material degradation and risk based solutions is a key asset.
8. Conclusions

• PHAZOP is a valuable early-on risk assessment tool which allows time to influence the design.

• Use PHAZOP as part of a risk assessment progression of several studies across many stages since our knowledge is not complete but an ongoing task.

• Risk assessment strives to decrease the unknown while not introducing new hazards.

• Hazard identification and detection is part of the Integrity Management process which uses subject matter experts from many areas.

• Experience has demonstrated the value of the PHAZOP.

• Get in EARLY. Focus on Integrity from the EARLY project stages and utilize the process to define/discuss/develop KPI’s.
Thank you

Any questions?