Overpressure Protection Assurance through Management of Change

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Outline

• Premise of paper
• Importance of pressure relief analysis
• Change happens
• New and old data
• Challenges to MOC success
• MOC enhancement for PRA
• PRA/MOC checklist
• Concluding remarks
Premise of paper

1. Pressure relief analysis (PRA) and design basis integrity are paramount to safe operations.
2. Data provides evidence that deficiencies continue to exist in overpressure protection systems.
3. One of the primary reasons for these deficiencies is the shortage of technical personnel with sufficient experience to identify when the overpressure protection design basis must be reviewed and perhaps modified as changes to the process are made.
4. Comprehensive integration of PRA expertise with a facility’s management of change (MOC) program is necessary to establish and preserve overpressure protection integrity.
Setting the stage

• Industry responded with initial PSM element implementation and documentation phase.
• Industry now in maintenance phase.
• Maintenance of PSM program and process safety information is heavily dependent on Management of Change program.
Importance of pressure relief analysis

- PRA safeguards against:
  - Flammability of potential releases
  - Toxicity of potential releases
  - Asphyxiation concerns of potential releases
  - Radiation of potential releases
  - Damage to physical assets
  - Loss of production – quality and volume-wise
Overpressure protection

- Overpressure protection has 3 main constituents:
  1. Protection via physical assets
  2. Protection via knowledge and expertise
  3. Protection via work processes
Changes do occur after initial design

• Identical equipment unavailable when a replacement is needed;
• New raw material or product specifications;
• Operating procedures modified;
• New administration;
• Changes in regulations; and
• Temporary equipment or process modifications.
Examples of changes impacting PRA

1. Unit de-bottlenecking;
2. Liquid level;
3. Pump capacity;
4. Operating pressure;
5. Flare system.
Let’s look at past studies

• CCPS:
  – Study performed in 1998.
  – Of 100 previous largest-loss incidents studied, 25% were result of relief system inadequacy.

• Berwanger study:
  – Study performed in 1999.
  – PHAs ineffective for evaluating pressure relief systems.
  – 35% of equipment evaluated had at least one system deficiency, even though essentially all systems had undergone a PHA (i.e. 65% were concern-free).
  – 12.5% of all equipment studied lacked any overpressure protection, even though equipment had one or more credible overpressure scenarios.

• Both studies indicate a need for improvement that PHAs were not providing.
Let’s look at our data

- Source = 3,000 systems in chemical plants, gas plants, and refineries.
- System is set of equipment, piping, and process that are in open communication with each other.
- Systems were identified as part of revalidations or audits for plants.
High level results

All facilities, all systems
- Deficiencies: 52%
- No deficiencies: 48%

Chemical plants, all systems
- Deficiencies: 18%
- No deficiencies: 82%

Refineries, all systems
- Deficiencies: 47%
- No deficiencies: 53%

Gas plants, all systems
- Deficiencies: 25%
- No deficiencies: 75%
## Deficiency categories and analysis

<table>
<thead>
<tr>
<th>Deficiency category</th>
<th>% of systems with deficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>High inlet pressure drop</td>
<td>6.5</td>
</tr>
<tr>
<td>High back pressure</td>
<td>8.2</td>
</tr>
<tr>
<td>Other installation concern</td>
<td>5.4</td>
</tr>
<tr>
<td>Toxic/Flammable release</td>
<td>5.3</td>
</tr>
<tr>
<td>No data/No calculations</td>
<td>9.3</td>
</tr>
<tr>
<td>Inadequate capacity for Fire</td>
<td>5.1</td>
</tr>
<tr>
<td>Inadequate capacity for Blocked Outlet</td>
<td>5.6</td>
</tr>
</tbody>
</table>

*Note: Only those deficiency categories which exceed 5% are listed*
## Equipment types and deficiencies

<table>
<thead>
<tr>
<th>Equipment type</th>
<th>Number of systems</th>
<th>% of systems with deficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Columns</td>
<td>102</td>
<td>64.7</td>
</tr>
<tr>
<td>Compressors</td>
<td>171</td>
<td>75.4</td>
</tr>
<tr>
<td>Drums</td>
<td>151</td>
<td>49.0</td>
</tr>
<tr>
<td>Filters</td>
<td>130</td>
<td>42.3</td>
</tr>
<tr>
<td>Heat exchangers, fired heaters, and boilers</td>
<td>948</td>
<td>42.3</td>
</tr>
<tr>
<td>Piping</td>
<td>266</td>
<td>17.7</td>
</tr>
<tr>
<td>Pump discharges</td>
<td>647</td>
<td>57.3</td>
</tr>
<tr>
<td>Reactors</td>
<td>50</td>
<td>66.0</td>
</tr>
<tr>
<td>Tanks</td>
<td>127</td>
<td>68.5</td>
</tr>
<tr>
<td>Turbines</td>
<td>56</td>
<td>64.3</td>
</tr>
<tr>
<td>Vessels</td>
<td>514</td>
<td>68.3</td>
</tr>
<tr>
<td>Other</td>
<td>54</td>
<td>38.9</td>
</tr>
</tbody>
</table>
### Common undersized scenarios by facility type

#### Refineries:

<table>
<thead>
<tr>
<th>Undersized scenarios</th>
<th>% of systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blocked outlet</td>
<td>7.9</td>
</tr>
<tr>
<td>Fire</td>
<td>6.2</td>
</tr>
</tbody>
</table>

#### Chemical plants:

<table>
<thead>
<tr>
<th>Undersized scenarios</th>
<th>% of systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inadvertent valve opening</td>
<td>6.2</td>
</tr>
<tr>
<td>Fire</td>
<td>3.6</td>
</tr>
</tbody>
</table>

#### Gas plants:

<table>
<thead>
<tr>
<th>Undersized scenarios</th>
<th>% of systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blocked outlet</td>
<td>4.7</td>
</tr>
<tr>
<td>Fire</td>
<td>4.8</td>
</tr>
</tbody>
</table>
Design, PHA, or MOC?

- Original PRA was performed by reliable engineering companies.
- Most of the systems had previously undergone conventional PHAs.
- So why so many deficiencies?
  - Evolution of design guidelines;
  - Evolution of PHA methodology as well as level of detail (e.g. LOPA, SIL);
  - Non-comprehensive management of change protocols.
MOC challenges

• Change must be reviewed by personnel with appropriate expertise.

• To ensure consistent and effective MOC practices, expertise must be involved in development of MOC protocol as well as evaluation of impact of change.

• Perhaps biggest challenge to successful implementation of MOC program is mindset and evolution of a “safety culture”.
Recommendation: MOC enhancement

1. MOC review must include appropriate integration of PRA expertise.
2. MOC review should identify pressurized systems that may be affected by change – directly or indirectly.
3. MOC review should evaluate common input variables affecting PRA, when necessary.
4. MOC protocol should incorporate use of expertise-specific checklist(s).
5. MOC protocol and checklists must be “learning” entities.
PRA/MOC checklist

- Appendix A of paper.
- Addresses six categories:
  1. Physical assets;
  2. Operating issues (e.g. throughput, operating conditions);
  3. Pressure relief systems;
  4. Regulatory or technical practice changes;
  5. Near-misses;
  6. Mechanical integrity (i.e. maintenance and inspection).
- Positive response to any item on checklist requires PRA expertise to determine impact of change.
Appendix A: PRA/MOC Checklist

A positive response to any item on the checklist requires pressure relief analysis expertise to determine the impact of the change.

1. Physical Assets:
   a. Are you installing, removing, or relocating/repositioning process equipment?
   b. Are you changing the process equipment temperature or pressure ratings (e.g. vessel re-rating)?
   c. Are you changing the internal or external heat transfer rates (e.g. heat transfer area, addition or removal of insulation, change in fire zone or changes that may alter sun exposure)?
   d. Are you changing pump or compressor capacity, including impeller changes?
   e. Are you installing, removing, or modifying fittings, instrumentation, valves or piping on process lines?
   f. Are you installing or removing block valves?
   g. Are you adding/removing any mechanical locking elements on valves, (e.g. chain-lock on a control valve bypass line)?

2. Operating Issues:
   a. Are you changing the process feedstock, intermediate or product composition, process chemical additives or concentrations or catalyst type or concentration?
   b. Is any alternative mode of operation not previously considered for the design of the overpressure protection being added?
Parting thoughts...

1. Deficiencies in overpressure protection exist to a significant extent.
2. There are not enough PRA experts to monitor MOCs for PRA impact.
3. Modify MOC protocol to ensure usage of expertise-specific checklists.
4. Develop/modify MOC checklist with intent of integrating PRA expertise/knowledge into process to identify when PRA experts should be consulted.
5. Maintain expertise-specific checklists via triggers to update checklists based on lessons learned from internal and external incidents (including near-misses).