Lessons Learned from Real World Application of Bow-tie Method

2010 International Symposium

BEYOND REGULATORY COMPLIANCE, MAKING SAFETY SECOND NATURE

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Purpose of presentation

- Bow-tie method
- Example case study
- Practical uses and benefits
- Tips for successful use
The “bow-tie” diagram

Causes

Preventive controls

Process upset

Recovery preparedness

Consequences
In more detail

Prevention

Threat

Threat

Threat

Mitigation

Hazard

Consequence

Consequence

Consequence

Barriers

Top Event
Example case study

Loss of containment

- Overpressure bullets
- Overfill bullets
- Internal corrosion
- Third-party interference
- LPG storage bullets
- Torch, pool or flash fire
- Unignited VC - buildings
- Unignited VC - neighbors
- BLEVE

Other threats
What are the preventive controls?

- Overpressure bullets
  - Bullets rated 250/operate 179 psi
  - Operator monitors level, P, T & quality. PAH, LAH, TAH
  - HH –P trip (179 psi) S/D feed
  - Two PRVs (250 & 262 psi), sized for fire case

Loss of containment
What are the mitigative measures?

- Gas detection: 10% LEL >> alarm, 40% >> plant ESD feed trip & isolation
- Detect leak & alarm via operator rounds or CCTV. Plant S/D at local ESD buttons or C/R
- Muster & acct for personnel
- Fireproof supports

- Torch, pool or flash fire

- Multiple muster areas on site, plus offsite point

- Muster areas impaired

...8 mitigation measures in total
It’s more than a picture: who’s responsible and what must they do?

- Gas detection
  - 10% LEL
  - >> alarm, 40% >> plant ESD
  - feed trip & isolation
  - Instr. Tech

- Detect leak & alarm via operator rounds or CCTV.
  - Plant S/D at local ESD buttons or C/R
  - Operator

- Muster & acct for personnel
  - Training

- Fireproof supports

- Torch, pool or flash fire

- Muster areas impaired

- Multiple muster areas on site, plus offsite point
  - Safety Eng.

Test and calibrate critical instrumentation, ESDs, P & flow sensors & alarms, F&G detection.
What is the critical documentation?

- Gas detection 10% LEL >> alarm, 40% >> plant ESD feed trip & isolation
- Detect leak & alarm via operator rounds or CCTV. Plant S/D at local ESD buttons or C/R
- Muster & acct for personnel
- Fireproof supports
- Emergency response plan
- Multiple muster areas on site, plus offsite point
- Protective sys. spec. & performance stds.
- Operator schedule & training matrix
- Torch, pool or flash fire
- Instr. Tech
- Operator
- Safety Eng.
- PFP spec. & perf. stnd.
- Muster areas impaired
- Review ER provision
## Catalogue of process safety-critical activities

<table>
<thead>
<tr>
<th>Safety-critical role</th>
<th>Instrument Technician</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Safety-critical activity</strong></td>
<td><strong>Procedure</strong></td>
</tr>
<tr>
<td>Maintain protective instrumentation</td>
<td>SAP work order</td>
</tr>
<tr>
<td>Test (incl. integrity w hazardous area classification) &amp; calibrate critical instrumentation in field locations:</td>
<td></td>
</tr>
<tr>
<td>- ESD systems</td>
<td></td>
</tr>
<tr>
<td>- P &amp; flow sensors/alarms</td>
<td></td>
</tr>
<tr>
<td>- F&amp;G detectors, systems &amp; alarms</td>
<td></td>
</tr>
<tr>
<td>- Corrosion injection system alarms</td>
<td></td>
</tr>
</tbody>
</table>
### How good are the controls?
Example barrier effectiveness rating scheme

<table>
<thead>
<tr>
<th>Barrier Rating</th>
<th>Used?</th>
<th>Does it work/is it effective?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Good</td>
<td>Always</td>
<td>Always (&gt;99%)</td>
</tr>
<tr>
<td>Good</td>
<td>Frequently</td>
<td>Generally (75% - 99%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>Unknown/not guaranteed</td>
<td>Unknown/cannot be guaranteed (50% - 75%)</td>
</tr>
<tr>
<td>Poor</td>
<td>Occasionally</td>
<td>Possibly (25% - 50%)</td>
</tr>
<tr>
<td>Very Poor</td>
<td>Rarely</td>
<td>Currently ineffective (&lt;25%)</td>
</tr>
<tr>
<td>Un-assessed</td>
<td>-</td>
<td>Insufficient information</td>
</tr>
</tbody>
</table>

Every barrier must be **suitable**: (1) independent and (2) competent responsible person undertakes critical activity to provide barrier
How good is each control?

- Gas detection
  - 10% LEL >> alarm, 40% >> plant ESD feed trip & isolation
  - Instr. Tech

- Detect leak & alarm via operator rounds or CCTV.
  - Plant S/D at local ESD buttons or C/R
  - Operator

- Muster & acct for personnel
  - Training

- Fireproof supports

- Torch, pool or flash fire

- Muster areas impaired
  - Multiple muster areas on site, plus offsite point
  - Safety Eng.

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What about overall control?

- **Every** threat and consequence for **every** hazard must have **sufficient** barriers of adequate rating.

- Requires scheme for assessing overall control
  - Avoid counting barriers (scheme should be relative, not absolute)
Overall control?

- Provides a guide for focusing effort on risk reduction, rather than measuring acceptability:
  - What else can we do?
  - Can we improve control effectiveness?
  - Can we add more controls?
  - Is it practical to do so?
Can we improve control effectiveness?

Gas detection 10% LEL >> alarm, 40% >> plant ESD feed trip & isolation

Detect leak & alarm via operator rounds or CCTV. Plant S/D at local ESD buttons or C/R

Muster & acq for personnel

Fireproof supports

Torch, pool or flash fire

Instr. Tech.

Operator

Training


Muster areas impaired

Multiple muster areas on site, plus offsite point

Safety Eng.

Recommendation

Confirm muster pt. locations & arrangements appropriate for all credible major accident scenarios (e.g. outside LFL)
The complete picture

- Display altogether, or one branch at a time
- Strengths and weaknesses in process safety clearly visible
  - Coloring of barriers
  - Coloring of threats & consequences
## How can we use it in practice?

<table>
<thead>
<tr>
<th>Topic</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logical structured approach</td>
<td>Do we have any gaps in risk control?</td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td>How do we engage non-risk specialists?</td>
</tr>
<tr>
<td>Formal demonstration</td>
<td>Can we really demonstrate control?</td>
</tr>
<tr>
<td><strong>Specific risks</strong></td>
<td>Will we be in control?</td>
</tr>
<tr>
<td>Critical roles</td>
<td>Do our people know what is expected of them?</td>
</tr>
<tr>
<td><strong>Competencies</strong></td>
<td>Are competence and control requirements aligned?</td>
</tr>
<tr>
<td>Critical procedures</td>
<td>Are they complete and effective?</td>
</tr>
<tr>
<td><strong>Auditing</strong></td>
<td>How can we focus audits on what really matters?</td>
</tr>
<tr>
<td>Critical systems and performance standards</td>
<td>What are they?</td>
</tr>
</tbody>
</table>
What do bow-ties do for you?

1. Improved understanding
   - Powerful communication tool
   - Readily understood
   - Clear identification of links
   - Keeps sight of big picture
   - Captures previous incidents
2. **Greater ownership**
   - Encourages wide participation
   - Promotes positive ownership
   - Clear identification of roles and responsibilities
What do bow-ties do for you?

3. **Efficiency gains**
   - Less labor intensive
   - Helps focus resources
   - “A picture paints a thousand words”
   - **Targets** critical maintenance, inspection & testing activities
   - **Avoids** reinventing the wheel
Tips for success

1. Pitch at the right level
2. Involve the right people
3. Use method to full potential
4. Avoid barrier counting but do verify quality of controls
5. Focus on risk reduction
Summary

- Improves understanding and encourages ownership of process safety
- Provides missing link between plant, procedures & people (not just a pretty picture)
- Provides structured framework for determining whether current control of process safety is good enough
- Helps to ensure that risks are managed rather than just analyzed