Common Operations Failure Modes in the Process Industries

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Beyond Regulatory Compliance, Making Safety Second Nature

Dr. Peter Bullemer
Human Centered Solutions
Jason Laberge
Honeywell
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• **Dr. Peter Bullemer**
  – Senior partner, North American, human factors consulting group, Human Centered Solutions, LLP
  – Specializes in human performance in process industry operations
  – Technical Contributor to the ASM® Consortium since 1994

• **Jason Laberge**
  – Principal Investigator for the Abnormal Situation Management® (ASM®) Consortium
  – Lead human factors researcher for ASM since 2005
  – Research focuses on understanding the factors that influence performance in complex systems
Founded in 1994

Creating a new paradigm for the operation of complex industrial plants, with solution concepts that improve Operations’ ability to prevent and respond to abnormal situations.

www.asmconsortium.org
• The typical approach to incident analysis does NOT effectively identify the impact of ineffective operations practices
• This paper illustrates a methodology to identify systemic operations practice failure modes
• And improve human reliability associated with plant operations practices
Project Objectives

• Understand relation between ineffective operations practices and process industry incidents
  – Systematically analyze incidents to determine common operational practice failure modes
  – Identify root causes of common operational practice failure modes
  – Why do failures occur ACROSS incidents

This research study was sponsored by the Abnormal Situation Management® (ASM®) Consortium.
• Identified 123 candidate incidents (99 public, 24 site)
• Priority given to recent refining/chemical incidents with severe consequences and detailed reports
• Selected 32 incidents for the study
• **Failure** is any operational practice flaw that, if corrected, could have prevented the incident from occurring or would have significantly mitigated its consequences
  – What went wrong in the specific incident in the investigation team’s own language/terms
  – Example: Supervisor not accessible

• **Common failure modes** are shared operational practice failures across incidents
  – Common problems for the industry (or site)
  – Failures map to ASM *Effective Operations Practices Guidelines*
  – Example: Ineffective first line leadership roles
### Common Failure Modes

<table>
<thead>
<tr>
<th>Top 10 Operations Failures</th>
<th>#</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard analysis/ communication</td>
<td>79</td>
<td>15%</td>
</tr>
<tr>
<td>First-line leadership</td>
<td>65</td>
<td>12%</td>
</tr>
<tr>
<td>Continuous improvement</td>
<td>60</td>
<td>11%</td>
</tr>
<tr>
<td>Safety culture</td>
<td>36</td>
<td>7%</td>
</tr>
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<td>Initial and refresher training</td>
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<td>6%</td>
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<td>Task communications</td>
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<td>Cross functional communication</td>
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<td>Compliance with procedures</td>
<td>15</td>
<td>3%</td>
</tr>
<tr>
<td>Design guidelines and standards</td>
<td>14</td>
<td>3%</td>
</tr>
<tr>
<td>Other failure modes</td>
<td>160</td>
<td>30%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>539</td>
<td></td>
</tr>
</tbody>
</table>

- Top 10 covers 70% of identified operations practice failures
• The explicit focus on operating practice failures identified opportunities to reduce risk to incidents that may not be identified via traditional investigation approaches.
• **BP Texas City incident** (March 23, 2005) **investigation reports** (Baker, CSB, BP) failed to fully identify the following operating practice failures:

  » **Task-oriented collaborative communication** (i.e., team coordination and real-time communication)

  » **Training for situation management** and team collaboration (i.e., CRM-training)

  » Need for a **common console operator interface framework** that supports all operator interaction requirements

• Note: this investigation was not typical in level of detail and scope of coverage
Key Learning from Project

- Typical analyses that focus on just root causes are insufficient for identifying systemic improvement opportunities:
  - Root causes explain ‘why’ something occurred, not ‘what’ occurred in terms of failures
  - Root causes are general and not specific enough to drive continuous improvement – details are buried in incident report
  - No effective methods for aggregating root cause details across incidents for systemic analysis of problems and improvements
Some Definitions

• Incident failure is any operational practice flaw that, if corrected, could have prevented the incident from occurring or would have significantly mitigated its consequences
  – ‘What’ went wrong in the specific incidents and often in the investigation team’s own language/terms
  – In the research project incident failures were identified based on incident reports
  – Example: Supervisor did not check procedure progress
• **Common failure** are shared operational practice failures across incidents
  
  – Common problems for the industry (or site)
  – In the research project common failures map to *ASM Effective Operations Practices Guidelines*
  – Example: *Ineffective first line leadership*
• A **root cause** is the most basic cause (or causes) that can reasonably be identified that management has control to fix and, when fixed, will prevent (or significantly reduce the likelihood of) the failure’s (or factor’s) recurrence
  – ‘Why’ a failure occurred
  – In the research project root causes were based on TapRoot®
  – An operations failure mode may have more than one root cause
  – Example: *No Supervision* and *No communication* may both result in *Ineffective first line leadership* failure mode
Some Definitions

- Root cause **manifestations** are the specific expression or indication of a root cause in an incident
  - ‘How’ operational failure modes are expressed in real operations settings – are the root cause details aggregated across incidents
  - Basis for creating audit checklist to proactively look for operational risks
  - Example: *Supervisor not in control room to discuss problems* is an example manifestation for the *No Supervision common root cause and the Ineffective First Line Leadership Role* common failure mode
Relation of Failures to Root Causes to Manifestations

Incident 1

Failure 1
  - Root Cause
  - Manifestation

Failure 2
  - Root Cause
  - Manifestation

... (omitted for brevity)

Failure N
  - Root Cause
  - Manifestation

Incident 2

Failure 1
  - Root Cause
  - Manifestation

Failure 2
  - Root Cause
  - Manifestation

... (omitted for brevity)

Failure N
  - Root Cause
  - Manifestation
Incident failures are often in the analysts own language so some kind of mapping must occur to determine common failures.

- In the research project, the team mapped the incident failures to the *ASM Effective Operations Practices Guidelines*.
In the research project, Common Root Causes were simply the count and relative frequency of the TapRoot® root causes across the incident sample.
Relation of Failures to Root Causes to Manifestations

Incident 1

Failure 1
  Root Cause
  Manifestation

Failure 2
  Root Cause
  Manifestation

…

Failure N
  Root Cause
  Manifestation

Incident 2

Failure 1
  Root Cause
  Manifestation

Failure 2
  Root Cause
  Manifestation

…

Failure N
  Root Cause
  Manifestation

Common Failures

Common Root Causes

Common Manifestations
• Data at all three levels is needed to:
  – Focus improvement on **common and systemic problems**
  – Understand why problems occur and develop improvement programs and corrective actions to **address real root causes**
## Relation of Failures to Root Causes to Manifestations

<table>
<thead>
<tr>
<th>Incident</th>
<th>Incident Failure</th>
<th>Common Failure</th>
<th>Common Root Cause</th>
<th>Manifestation</th>
<th>Common Manifestation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas City</td>
<td>Shift Supervisor did not ensure procedures were being followed</td>
<td>Effective first line leadership</td>
<td>No Supervision</td>
<td>Supervisor did not check procedure progress before leaving site</td>
<td>Checking procedure progress for area of responsibility</td>
</tr>
<tr>
<td>Texas City</td>
<td>It was not clear who was in charge when supervisor was gone</td>
<td>Effective first line leadership</td>
<td>No Communication</td>
<td>Supervisor did not communicate with personnel that he was leaving the site</td>
<td>Bi-directional communication of status between supervisors and operators</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No policy that outlines responsibilities when supervisor leaves the site</td>
<td>Unclear policy for supervisor requirements and expectations</td>
</tr>
<tr>
<td>Esso Longford</td>
<td>No permit was issued or reviewed for the maintenance work</td>
<td>Effective first line leadership</td>
<td>Standards, Policies, Admin Controls (SPAC) not followed</td>
<td>Presence of field operator was assumed to remove need for permit</td>
<td>Enforcing practices/procedures across the site</td>
</tr>
</tbody>
</table>
ASM Effective Practice
Work Process Description

- Review Incident Reports
  - List of operational failures, root causes

- Site Incident Reports
- Identify Common Failures
  - Cluster list of failures per practice standards
  - List of top practice failure modes (covers at least 50%)

- Identify Common Root Causes
  - List top root causes for each failure mode

- Identify Common Manifestations
  - Cluster manifestations associated by root cause
  - Consolidate list to highlight common elements

- Analyze Gaps in Systems
  - List of weaknesses in management systems and practice standards

- Define Practice Improvements
  - List of prioritized solutions (cost, impact, etc)

- Implement Practice Changes
  - Generate improvement action plan to make changes per priority & resource constraints

- Site Continuous Improvement Program
- Monitor Impact of Changes
  - Use leading/lagging metrics to track
Typical programs look at individual incidents for root causes

Action plans developed to address root causes

Operations practice failure modes are NOT explicitly identified

Manifestations of root causes are NOT captured to help identify gaps in management systems and operations practices

Continuous improvement programs lack input from incident based gap analysis
## Value of Failure Mode Information
### Common Failures vs. Root Causes

#### ASM Approach

<table>
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<td><strong>TOTAL</strong></td>
<td>539</td>
<td></td>
</tr>
</tbody>
</table>

#### Typical Approach

<table>
<thead>
<tr>
<th>Root Causes</th>
<th>#</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No communication</td>
<td>71</td>
<td>8%</td>
</tr>
<tr>
<td>Crew Teamwork Needs Improvement</td>
<td>58</td>
<td>7%</td>
</tr>
<tr>
<td>Hazard Analysis Needs Improvement</td>
<td>46</td>
<td>5%</td>
</tr>
<tr>
<td>Management of Change (MOC) Needs Improvement</td>
<td>40</td>
<td>5%</td>
</tr>
<tr>
<td>Displays Need Improvement</td>
<td>35</td>
<td>4%</td>
</tr>
<tr>
<td>No supervision</td>
<td>34</td>
<td>4%</td>
</tr>
<tr>
<td>Corrective Action Needs Improvement</td>
<td>33</td>
<td>5%</td>
</tr>
<tr>
<td>No Standards, Policy or Administrative Controls (SPAC)</td>
<td>32</td>
<td>4%</td>
</tr>
<tr>
<td>SPAC confusing or incomplete</td>
<td>32</td>
<td>4%</td>
</tr>
<tr>
<td>SPAC not followed</td>
<td>29</td>
<td>3%</td>
</tr>
<tr>
<td>Others</td>
<td>160</td>
<td>51%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>432</td>
<td></td>
</tr>
</tbody>
</table>

- In our analysis, Common Failure Modes correspond to specific ASM Effective Operations Practices
- Moreover, failure modes need to map to a site's operations practice standards, policy and guidelines
Improvement Opportunities for First Line Leadership

- Improvement opportunities are identified by extracting the root cause profiles for each common failure mode
  - Profiles show distribution of common root causes (i.e., “why the failure occurred”) across incidents

<table>
<thead>
<tr>
<th>Root Cause Profile</th>
<th>#</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No supervision</td>
<td>14</td>
<td>18%</td>
</tr>
<tr>
<td>Crew teamwork needs improvement</td>
<td>11</td>
<td>14%</td>
</tr>
<tr>
<td>SPAC[1] not followed</td>
<td>8</td>
<td>10%</td>
</tr>
<tr>
<td>MOC needs improvement</td>
<td>6</td>
<td>8%</td>
</tr>
<tr>
<td>Pre-job briefing needs improvement</td>
<td>5</td>
<td>6%</td>
</tr>
<tr>
<td>Other</td>
<td>36</td>
<td>45%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>80</td>
<td>100%</td>
</tr>
</tbody>
</table>

[1] Standards, policies, administrative controls—standardized work processes, rules, procedures
• Identify the root cause manifestations for each profile
  – Specific reasons the failures occurred across incidents
  – Manifestations are “indicators” of failures
  – Potential candidates for leading indicators of incidents

<table>
<thead>
<tr>
<th>Root Cause (from profile)</th>
<th>Manifestation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No supervision</td>
<td>Checking procedure progress for area of responsibility</td>
</tr>
<tr>
<td></td>
<td>Being at job site and maintaining situation awareness</td>
</tr>
<tr>
<td></td>
<td>Identifying and addressing risk to personnel</td>
</tr>
<tr>
<td></td>
<td>Monitoring high risk activities for problems/issues</td>
</tr>
<tr>
<td>Crew teamwork needs improvement</td>
<td>Enforcing violations of practices/procedures (esp related to safety)</td>
</tr>
<tr>
<td></td>
<td>Ensuring team members (eg ops, maint) stay coordinated</td>
</tr>
<tr>
<td></td>
<td>Not correcting/communicating known problems</td>
</tr>
<tr>
<td></td>
<td>Team members not questioning when evidence of problems</td>
</tr>
<tr>
<td></td>
<td>Team not focusing on critical activities/indicators (tunnel vision)</td>
</tr>
<tr>
<td></td>
<td>Supervisor not keeping track of big picture, losing sight of hazards</td>
</tr>
</tbody>
</table>
ASM Conclusions

• If analysis is limited to individual incident analysis, the tendency is to address root causes specific to the incident.

• A single incident focus may miss the larger management system contributions to safety risk.

• Hence, the improvement may not have the intended positive impact.
Conclusions

• Whereas, if the analysis is based on a sample of incidents (either common failures or root causes)

• Analysts will make assumptions about how to address high-level root causes such as “No supervision”

• Manifestations ground improvement opportunities in the incident data
  – increasing the likelihood of understanding the operations practice or management system vulnerabilities
• Thank You!

• Questions and/or Comments?
• The Abnormal Situation Management® Consortium funded a study to investigate common failure modes and root causes associated with operations practices. The study team analyzed 20 public and 12 private incident reports using the TapRoot® methodology to identify root causes. These root causes were mapped to operations practice failures. This presentation presents the top ten operations failure modes identified in the analysis. Specific recommendations include how to analyze plant incident reports to better understand the sources of systemic failures and improve plant operating practices.

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