**Incident Investigation and Reporting**

**Key acronyms**

- **RCA** = root cause analysis
- **SVA** = security vulnerability analysis

**Incident investigation resources**


Chapter 12 • Accident Investigations

- 12.1 Learning from accidents
- 12.2 Layered investigations
- 12.3 Investigation process
- 12.4 Investigation summary
- 12.5 Aids for diagnosis
- 12.6 Aids for recommendations
Chapter 19 • Incident Investigation

1. What is an incident investigation?
2. How does incident investigation fit into PSM?
3. What kinds of incidents are investigated?
4. When is the incident investigation conducted?
5. Who performs the investigations?
6. What are some ways to investigate incidents?
7. How are incident investigations documented?
8. What is done with findings & recommendations?
9. How can incidents be counted and tracked?

An incident investigation is the management process by which underlying causes of undesirable events are uncovered and steps are taken to prevent similar occurrences.

- CCPS 2003

Incident Investigation resources


Chapter 19 • Incident Investigation

19.1 Element Overview
19.2 Key Principles and Essential Features
19.3 Possible Work Activities
19.4 Examples of Ways to Improve Effectiveness
19.5 Element Metrics
19.6 Management Review

Photo credit: U.S. Chemical Safety & Hazard Investigation Board
Learning from incidents

Investigations that will enhance learning
- are fact-finding, not fault-finding
- must get to the root causes
- must be reported, shared and retained.

Definition - Root cause

Root Cause: A fundamental, underlying, system-related reason why an incident occurred that identifies a correctable failure or failures in management systems.

There is typically more than one root cause for every process safety incident.

- CCPS 2003

Incident Investigation and Reporting

1. What is an incident investigation?
2. How does incident investigation fit into PSM?
How does incident investigation fit into PSM?

Risk-Based Process Safety (CCPS 2007a)

<table>
<thead>
<tr>
<th>Commit to Process Safety</th>
<th>Understand Hazards and Risks</th>
<th>Manage Risk</th>
<th>Learn from Experience</th>
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</thead>
<tbody>
<tr>
<td>• Process safety culture</td>
<td>• Process knowledge management</td>
<td>• Operating procedures</td>
<td>• Incident investigation</td>
</tr>
<tr>
<td>• Compliance with standards</td>
<td>• Hazard identification and risk analysis</td>
<td>• Safe work practices</td>
<td>• Measurement and metrics</td>
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<tr>
<td>• Process safety competency</td>
<td></td>
<td>• Asset integrity and reliability</td>
<td></td>
</tr>
<tr>
<td>• Workforce involvement</td>
<td></td>
<td>• Contractor management</td>
<td></td>
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<td>• Stakeholder outreach</td>
<td></td>
<td>• Training and performance assurance</td>
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<td>• Management of change</td>
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<td></td>
<td>• Operational readiness</td>
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<td>• Conduct of operations</td>
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<td>• Emergency management</td>
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Historical

- Codes, Standards, RAGAGEPs

- The historical perspective tells us what to do based on codes, standards and best practices that represent our accumulated experience and lessons learned from previous industry incidents.

Potential

- Hazards, Consequences

- The potentials are what could happen if containment or control of a process hazard was lost or if a security incident occurred.
• The hypothetical, or predictive, perspective looks at what could go wrong, even if it has never happened before. This is a probabilistic perspective, based on hypothetical loss event scenarios.

Hypothetical
What-If, HAZOP, SVA

• The actual or real-time perspective can inform us of previously unrecognized or uncorrected problems, as they are manifested in actual incidents and near misses, as well as by ongoing inspections and tests that can detect incipient problems.

Actual
Incidents, Inspections, Tests

Incident Investigation and Reporting

1. What is an incident investigation?
2. How does incident investigation fit into PSM?
3. What kinds of incidents are investigated?

What kinds of incidents are investigated?

• The first step in an incident investigation is recognizing that an “incident” has occurred!
The first step in an incident investigation is recognizing that an “incident” has occurred!

What kinds of incidents are investigated?

Yes

What kinds of incidents are investigated?

Incident: An unplanned event or sequence of events that either resulted in or had the potential to result in adverse impacts.

Incident sequence: A series of events composed of an initiating cause and intermediate events leading to an undesirable outcome.

Definitions

Incident types

Three categories of incidents, based on outcomes:

- Loss event
- Near miss
- Operational interruption
Incident types

Three categories of incidents, based on outcomes:

- **Loss event**: Actual loss or harm occurs (also termed accident when not related to security).
- **Near miss**: An occurrence in which an accident (i.e., property damage, environmental impact, or human loss) or an operational interruption could have plausibly resulted if circumstances had been slightly different. (Same concept for security incidents also) - CCPS 2003
- **Operational interruption**: Actual impact on production or product quality occurs.

One type of near miss

Give three or four examples of simple near-miss scenarios that would fit the graphic on the previous slide.

Include at least one related to facility security.

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Preventive safeguards revisited

Operational Mode: Abnormal operation
Objective: Regain control or shut down; keep loss events from happening
Examples of Preventive Safeguards:
- Operator response to alarm
- Safety Instrumented System
- Hardwired interlock
- Last-resort dump, quench, blowdown
- Emergency relief system

Incident Investigation and Reporting

1. What is an incident investigation?
2. How does incident investigation fit into PSM?
3. What kinds of incidents are investigated?
4. When is the incident investigation conducted?

When is the incident investigation conducted?

- Basic answer: As soon as possible.
- Reasons:
  - Evidence gets lost or modified
  - Computer control historical data overwritten
  - Outside scene exposed to rain, wind, sunlight
  - Chemical residues oxidize, etc.
  - Witness memories fade or change
  - Other incidents may be avoided
  - Restart may depend on completing actions to prevent recurrence
  - Regulators or others may require it
    - E.g., U.S. OSHA PSM: Start within 48 h

REVIEW

What are the equivalent of preventive safeguards for facility security physical protection systems?

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- 
- 
- 

PREVIEW
When is the incident investigation conducted?

**Challenges** to starting as soon as possible:
- Team must be selected and assembled
- Team may need to be trained
- Team may need to be equipped
- Team members may need to travel to site
- Authorities or others may block access
- Site may be unsafe to approach/enter

DISCUSSION

What might be done to overcome some of the challenges to starting an investigation sooner?

Incident Investigation and Reporting

1. What is an *incident investigation*?
2. How does incident investigation fit into PSM?
3. What kinds of incidents are investigated?
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5. Who performs the investigations?

Who performs the investigations?

**Options:**
- Single investigator
- Team approach
Who performs the investigations?

Options:
- Single investigator
- **Team approach**

**Advantages of team approach:** (CCPS 2003)
- Multiple technical perspectives help analyze findings
- Diverse personal viewpoints enhance objectivity
- Internal peer reviews can enhance quality
- More resources are available to do required tasks
- Regulatory authority may require it

Who performs the investigations?

The “best team” will vary depending on the nature, severity and complexity of the incident.

Some possible team members:
- Team leader / investigation method facilitator
- Area operator
- Process engineer
- Safety/security specialist
- I&E / process control or computer systems support
- Union safety representative
- Contractor representative
- Other specialists (e.g., metallurgist, chemist)

Training site management, potential team members and support personnel ahead of time will speed up the start of the investigation.

- Larger companies may have one or more specially trained persons available for major incident investigations
- All personnel need to be familiar with the basic incident recognition and reporting requirements

Incident Investigation and Reporting

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6. What are some ways to investigate incidents?
### Older investigations

- Only identified obvious causes; e.g.,
  - “The line plugged up”
  - “The operator screwed up”
  - “The whole thing just blew up”
- Recommendations were superficial
  - “Clean out the plugged line”
  - “Re-train the operator”
  - “Build a new one”

### Layered investigations

- Deeper analysis
- Additional layers of recommendations:
  1. Immediate technical recommendations
     - *e.g., replace the carbon steel with stainless steel*
  2. Recommendations to avoid the hazards
     - *e.g., use a noncorrosive process material*
  3. Recommendations to improve the management system
     - *e.g., keep a materials expert on staff*

### Investigation process

1. Choose investigation team
2. Make brief overview survey
3. Set objectives, delegate responsibilities
4. Gather, organize pre-incident facts
5. Investigate, record incident facts
6. Research, analyze unknowns
7. Discuss, conclude, recommend
8. Write clear, concise, accurate report

### Discovery phase

- Develop a plan
- Gather evidence
  - Take safety precautions; use PPE
  - Preserve the physical scene and process data
  - Gather physical evidence, samples
  - Take photographs, videos
  - Interview witnesses
  - Obtain control or computer system charts and data
Analysis of facts

- Develop a timeline
- Analyze physical and/or electronic evidence
  - Chemical analysis
  - Mechanical testing
  - Computer modeling
  - Data logs
  - etc.
- Conduct multiple-root-cause analysis

Some analysis methods

- Five Why’s
- Causal Tree
- RCA (Root Cause Analysis)
- FTA (Fault Tree Analysis)
- MORT (Management Oversight and Risk Tree)
- MCSOII (Multiple Cause, Systems Oriented Incident Investigation)
- TapRooT®

Some analysis methods

General analysis approach:
- Develop, by brainstorming or a more structured approach, possible incident sequences
- Eliminate as many incident sequences as possible based on the available evidence
- Take a closer look at those that remain until the actual incident sequence is discovered (if possible)
- Determine the underlying root causes of the actual incident sequence

Incident sequence questions

Determine, for the incident being investigated:
- What was the cause or attack that changed the situation from “normal” to “abnormal”?
- What was the actual (or potential, if a near miss) loss event?
- What safeguards failed? What did not fail?
"Swiss cheese model" revisited

REMEMBER:
No protective barrier is 100% reliable.

EXERCISE
Conduct “Five Why’s” on the most recent loss event that has happened to you personally.

Why did the loss event happen? Because ____________________________________________

Why? Because ____________________________________________

Why? Because ____________________________________________

Why? Because ____________________________________________

Why? Because ____________________________________________

Discuss, conclude, recommend

• Find the most likely scenario that fits the facts
• Determine the underlying management system failures
• Develop layered recommendations

Aids for diagnosis

• Location of fire ignition?
• Deflagration or detonation?
• Hydraulic or pneumatic failure?
• Pressure required to rupture containment?
• Medical evidence?

See Crowl and Louvar 2001 Section 12.5 for details
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How are incident investigations documented?

A written report documents, as a minimum:

- Date of the incident
- When the investigation began
- Who conducted the investigation
- A description of the incident
- The factors that contributed to the incident
- Any recommendations resulting from the investigation

Typical report format

1. Introduction
2. System description
3. Incident description
4. Investigation results
5. Discussion
6. Conclusions
7. Layered recommendations

Investigation summary

- The investigation report is generally too detailed to share the learnings to most interested persons

- An Investigation Summary can be used for broader dissemination, such as to:
  - Communicate to management
  - Use in safety or security meetings
  - Train new personnel
  - Share lessons learned with sister plants

(See also: Crowl & Louvar 2001, Figure 12-1 and Example 12-2)
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Findings and recommendations

What is the most important product of an incident investigation?
1. The incident report
2. Knowing who to blame for the incident
3. Findings and recommendations from the study

Findings and recommendations

What is the most important product of an incident investigation?
1. The incident report
2. Knowing who to blame for the incident
3. Findings and recommendations from the study
4. The actions taken in response to the findings and recommendations from the study

Findings and recommendations

Example form to document recommendations:

<table>
<thead>
<tr>
<th>ORIGINAL STUDY FINDING / RECOMMENDATION</th>
<th>Source:</th>
<th>PHA</th>
<th>Incident Investigation</th>
<th>Compliance Audit</th>
<th>Self-Assessment</th>
<th>Other</th>
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<tbody>
<tr>
<td>Finding No.</td>
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<td></td>
<td>Risk-Based Priority (A, B, C or N/A)</td>
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<tr>
<td>Finding / Recommendation</td>
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<tr>
<td>Date of Study or Date Finding / Recommendation Made</td>
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</table>

Aids for recommendations

Overriding principles (Crowl and Louvar 2001, p. 528):
- Make safety [and security] investments on cost and performance basis
- Improve management systems
- Improve management and staff support
- Develop layered recommendations, especially to eliminate underlying causes
Aids for recommendations

Overriding principles:

- Make safety [and security] investments on cost and performance basis
- Improve management systems
- Improve management and staff support
- Develop layered recommendations, especially to eliminate underlying causes and hazards

(continued from previous slide)

Did you know?
- Nearly all incidents are the result of more than one failure. Some failures result in more misses that is, they did not cause an incident this time, but could have.
- Almost every month, “The Beacon” receives a number of e-mails pointing out other lessons that can be learned from the incident discussed, which have not been included in the Beacon.
- Because of the limited space available in “The Beacon,” we must pick one of the many lessons from each incident, and focus the Beacon on that lesson. But there are always other lessons.
- Whenever possible, if the reports on the incidents described are publicly available, we will provide a reference in the Beacon cover email note.

What can you do?
- Good – post the Beacon in places where workers will see it and read it, for example, bulletin boards, locker rooms, lunch rooms, control rooms, gate house.
- Better – use the Beacon as the basis for safety meetings or other safety discussions with operatives and other workers.
- Best yet – Develop additional information which relates the topic in the Beacon to the organization as a whole. Consider my similar incidents or near misses in your company, and discuss this information with workers.
- Best – Unit or plant management leads a discussion of the Beacon with workers and translates them to take other lessons in the incident described, beyond those discussed in the Beacon. Challenge plant safety committees to use the Beacon in their work.

Implementation

As for PHA action items, a system must be in place to ensure all incident investigation action items are completed on time and as intended.

- Same system can be used for both
- Include regular status reports to management
- Communicate actions to affected employees
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How can incidents be counted and tracked?

- "Lagging indicators" — actual loss events
  - Major incident counts and monetary losses
  - Injury/illness rates
  - Process safety incident rates

- "Leading indicators" — precursor events
  - Near misses
  - Abnormal situations
    - E.g., Overpressure relief events
    - Safety alarm or shutdown system actuations
    - Flammable gas detector trips
  - Unsafe acts and conditions
  - Other PSM element metrics

Pyramid Principle revisited

Reducing the frequency of precursor events and near misses...
Pyramid Principle revisited

Major Catastrophe: Multiple Fatalities & Loss of Facility

Fatality

Injury; Lost Production Delay

Materiel

Release

Process Excursion; Process Alarm

Unsafe Behavior; Near Miss; First Aid

... will reduce the likelihood of a major loss event

Additional resources

• AIChE Loss Prevention Symposium, Case Histories session (every year)
  • www.csb.gov reports and videos
  • CCPS 2008b, Center for Chemical Process Safety. Incidents that Define Process Safety, NY: American Institute of Chemical Engineers