Guidelines for Investigating Process Safety Incidents
Third Edition, CCPS
About CCPS

- Center for Chemical Process Safety
- March 1985, in response to Bhopal, AIChE formed CCPS with seventeen charter member companies.
- A collaborative effort to eliminate catastrophic process incidents by advancing state of the art technology and management practices, serving as the premier resource for information on process safety, supporting process safety in engineering, and promoting process safety as a key industry value
- Now over 100 member companies including most of the world’s leading chemical, petroleum, pharmaceutical and related manufacturing companies.
- Over 100 books and products
Evolution

Guidelines for Investigating Chemical Process Incidents
Second Edition
2003

Guidelines for Investigating Process Incidents
2019
## Acknowledgements – CCPS & Subcommittee

- **Dan Sliva – CCPS Staff Liaison**

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# Acknowledgements – Peer Reviewers

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Major Process Safety Incidents since 2003

- 2003 – Repsol Puertollano Refinery Explosion
- 2004 – Sonatrach Skikda, Algeria Explosion
- 2005 – BP Texas City Explosion
- 2005 – HOSL Buncefield Explosion
- 2008 – Alon Refinery Explosion
- 2009 – Caribbean Petroleum Explosion
- 2010 – BP Macondo/ Deepwater Horizon
- 2011 – TEPCO Fukushima Daiichi
Major Process Safety Incidents since 2003

- 2012 – Chevron Richmond Refinery Fire
- 2013 – Williams Olefins Explosion / West Fertilizer explosion
- 2014 – Shell Moerdijk Explosion
- 2015 – ExxonMobil Torrance Refinery Explosion
- 2016 – BASF Ludwigshafen ethylene pipeline explosion
- 2017 – Grenfell Tower Fire
- 2018 – Bayernoil, Germany Explosion
Incident Investigation Developments 2003-2019

- Methodologies used to investigate process incidents
- Attitudes about investigation focus and practices
- Technological developments
- Regulatory agency expectations
- Legal rulings regarding admissibility of evidence and expert opinions
Focus of Third Edition

- Primarily process safety incidents, but concepts equally applicable to other potentially hazardous industries -
  - Manufacturing / mining
  - Construction
  - Transportation

- Emphasis on investigating near-misses and minor incidents
  - Had the potential for significant damage / injury and should be considered for a higher level of investigation commensurate with the potential consequence.

- Witness management, evidence analysis, the scientific method, and human factors

- To be more global
  - Flexibility in the investigation approach for varying regulatory, industry, cultural, and situational considerations.
Role of Third Edition

• Detailed reference on investigation of process safety incidents in processing facilities

• Guideline
  o Cultures
  o Corporate approaches
  o Experience level

• Several suggested methodologies for activities including:
  o Timeline development
  o Causal Factor Determination
  o Root Cause Determination
Target Audiences

• Company management
  o Chapters 1 – 4 (Introduction, Incident Causation, Overview of Investigation Methodologies, and Designing an Incident Investigation Management System)

• Novice investigator
  o Guide for learning the entire investigation process.

• Experienced investigators
  o Reference when they require information on a specific subject or a refresher on a topic.
Terminology

Incident

• An unusual, unplanned, or unexpected occurrence that either resulted in, or had the potential to result in harm to people, damage to the environment, or asset/business losses, or loss of public trust or stakeholder confidence in a company’s reputation.
Terminology

Near-Miss (Near Hit)

- Follows the lead of HSE Guide 245 and API RP 585 in treating a near-miss as an incident.
- Significant philosophical shift as many companies have treated near-misses as events that did not have to be investigated like accidents.
- The book encourages investigating near-misses with the same rigor as accidents based on potential severity (damage/injury) of the near miss.

- A Free Lesson
Terminology

Causal Factor

• A major unplanned, unintended contributor to an incident (a negative event or undesirable condition), that if eliminated would have either prevented the occurrence of the incident, or reduced its severity or frequency.

Root Cause

• A fundamental, underlying, system-related reason why an incident occurred that identifies a correctable failure(s) in management systems. There is typically more than one root cause for every process safety incident.
Organisation of the Book

• Overview of Investigations
  o Introduction to Investigations
  o Incident Causation
  o Overview of Investigation methodologies

• Designing an Investigation Management System

• Responding to an Incident
  o Initial notification and classification of an incident
  o Building/ leading an investigation team
  o Witness Management / interviews
  o Evidence identification, collection, and management
  o Analysing data
Organisation of the Book

- Determining Causal Factors
- Determining Root Causes
- The Impact of Human Factors
- Developing Recommendations
- Preparing a Report
- Implementing Recommendations
- Sharing and Institutionalising Lessons Learned
- Improving the Investigation Program
- Checklists
  - Evidence preservation, the investigators toolkit, report writing, auditing
The Incident Investigation Management System
Chapter 4

Appropriate Team Members Trained on
Causation Theory, Investigation Methodologies, and
Management Systems
Chapters 2, 3, & 4

Incident Occurs and Notification Made
Chapter 5

Activate Investigation Team and Develop Specific Action Plan
Chapter 6

Gather, Document, Preserve Evidence
Chapters 7 & 8

Analyze Evidence and Identify Causal Factors
Chapter 9

Determine Root Causes
Chapters 10 & 11

Develop Recommendations
Chapter 12

Develop Incident Report
Chapter 13

Implement Recommendations and
Ensure Follow up
Chapter 14

Share Lessons Learned
Chapter 16

Critique and Constantly Improve the Management System
Chapter 15
• Legal / agency / corporate / stakeholder requirements
• Classifying incidents and determining appropriate level of investigation.
  o A near-miss that potentially could have been a severe incident would be investigated in the same way as a major incident
  o Tiered approach (e.g., based on API RP 754 / CCPS metrics & severity categories)
  o Logic Tree
  o Risk Matrix
# Investigation Methodologies

<table>
<thead>
<tr>
<th>Increasing Structure</th>
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<tbody>
<tr>
<td>Informal, One-on-one</td>
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<tr>
<td>Brainstorming</td>
</tr>
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<td>Process of Elimination</td>
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<td>Timeline</td>
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<tr>
<td>Sequence Diagram</td>
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<table>
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<tr>
<th>Informal, One-on-one</th>
<th>Traditional, Informal Investigation usually performed by immediate supervision</th>
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<tbody>
<tr>
<td>Brainstorming</td>
<td>Judgment/experience to find credible causes. Structured brainstorming may employ tools such as What-If and 5 Whys.</td>
</tr>
<tr>
<td>Process of Elimination</td>
<td>Eliminates potential causes. and the cause(s) not eliminated are concluded to be the final cause(s).</td>
</tr>
<tr>
<td>Timeline</td>
<td>Chronological listing of events using a variety of formats from simple sequential list to diagrams showing events/conditions along a straight axis.</td>
</tr>
<tr>
<td>Sequence Diagram</td>
<td>Graphical depiction of timeline that allows investigators to exhibit related events and conditions in parallel branches.</td>
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Investigation Methodologies

Scientific Method
Test hypotheses based on Investigation data, to prove/disprove them, and iteratively resolve to the final hypothesis using scientific approaches.

Causal Factor Identification
Negative events, conditions, and actions that made major contributions to the incident. Tools such as Barrier Analysis and Change Analysis may be used.

Checklists
Review of causal factors against Investigative checklists to determine why that factor existed. A combined what-if/checklist approach may be used.

Pre-Defined Trees
Ready-made tools. Investigators apply causal factors to each branch in turn, disregard those branches that are not relevant to the specific Incident.

Logic Trees
Tools using a multiple cause, system-oriented approach to determine root causes integrated with a PSM program. E.g.: fault tree, event tree, causal tree, why tree.
Objectivity of Investigations

• Scientific method used to objectively, systematically, and scientifically determine the causal factors.

• Supports latest guidance in NFPA 921: *Guide for Fire and Explosion Investigations, 2017*

• Helps to avoid bias
  - Pre-conceptions (confirmation bias) / hindsight bias
Scientific Method

1. Define the problem
2. Collect data
3. Analyze the data
4. Develop a hypothesis (inductive reasoning)
5. Test the hypotheses (deductive reasoning)
6. Select final hypothesis
**Scientific Method Example – Seal Leak**

<table>
<thead>
<tr>
<th>Potential cause</th>
<th>Verification</th>
<th>Finding</th>
<th>Hypothesis</th>
</tr>
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<tbody>
<tr>
<td>Poor installation by one fitter</td>
<td>Review of maintenance history where similar work carried out</td>
<td>Leaks have occurred where other fitters have installed seal</td>
<td>FALSE</td>
</tr>
<tr>
<td>Poor installation by all fitters</td>
<td>Review of maintenance procedures with all fitters concerned</td>
<td>No evidence that the work was being done differently to that in the manual</td>
<td>FALSE</td>
</tr>
<tr>
<td>Overpressure</td>
<td>Review of DCS data</td>
<td>No evidence of overpressure</td>
<td>FALSE</td>
</tr>
<tr>
<td>Generic seal problem</td>
<td>Background gas level measurements</td>
<td>Slight rise in average toxic gas levels for past 18 months (not acted upon)</td>
<td>CONFIRMED</td>
</tr>
<tr>
<td>Component problem</td>
<td>Review spares stock against manufacturer’s specification</td>
<td>Spares supplier changed 2 years previously. Same spec but slight difference in compressibility of O-ring seal</td>
<td>CONFIRMED</td>
</tr>
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Witnesses and Interviews

**Plan**
- Identify:
  - Witnesses
  - Interviewers
  - Interview locations
- Determine:
  - Order of interviews
  - Interview schedule
  - Core topics/questions
  - Whether/how interviews will be recorded
  - Documents that will be available during the interview
  - Reference information that will be available during the interview

**Establish Rapport**
- Introductions (if necessary)
- State the purpose

**Open Ended Questions**
- Long answers

**Closed Ended Questions**
- Short answers

**Wrap Up**
- Summarize and review with witness to confirm
- Document observations
- Identify follow-up items

**Second Follow up interview needed?**

**Provide Report**

**YES**

**NO**
Evidence Collection/Analysis

Witness – sensory information.
What was seen, heard, smelled, felt
Witness – task knowledge
What they were doing, what others were doing
Witness – personal electronic device
Captured data, sound, video, timestamps, etc.

Physical evidence
Position, condition
Materials analysis
Paper records
System electronic data
Etc. (Chapter 8)

Evidence Analysis and Hypothesis Testing (Determining What Happened)

Generating new information needs

Analyzing Data for causal factors (Chapter 9)

Determining Root Causes / Human Factors (Chapters 10-11)
INVESTIGATION TEAM ACTIVITIES

- Interviews
- Voice recordings
- Physical modeling
- Equipment records
- Loss report
- Photographs and videos
- Physical measurements
- Process data
- Forensic reports

WHO - WHAT - WHEN
WHERE - HOW - WHY

INVESTIGATION TEAM COLLABORATION

Sequence of events
Root cause analysis
Discuss findings, conclusions and recommendations

Report recommendations
Follow-up
Recommendations – clarification of roles

- Recommendations developed in collaboration with the management team.
- Implementation of the recommendations - management’s role.
- Decision whether to restart a process - management’s role.
- Decision on partial restart (major incident, lengthy investigations) – management’s role but based on Interim reports / recommendations.
Expanded to include:

• Sharing at local level
• Sharing more broadly within the company
• Sharing with outside industry
  o Regulatory / litigation issues
• Receiving lessons from industry
  o Why we’re here
Treat near-misses as incidents

Decision on the level of investigation based on the potential severity of the incident

Scientific method was added to the book to improve objectivity of investigations

Roles of the investigation team and management in implementing recommendations and deciding on restarting processes were clarified

Methods are suggested on sharing lessons learned both internally and externally as well as institutionalising them
The new book is a comprehensive guide to investigating incidents - not just on chemical/ process plant.

It also guides the reader through the management systems and processes that are required to have an effective incident investigation system.

If you are looking for a comprehensive reference for incident investigation you might find it a useful addition to your library and reading material.

Note: We are not on commission!
Contact Us

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1. Introduction
2. Overview of Causation
3. Overview of Methodologies
4. Design of Incident Investigation Management System
5. Initial Notification, Classification and Investigation of Process Safety Incidents
6. Building and Leading an Incident Investigation Team
7. Witness Management
8. Evidence Identification, Collection and Management
9. Evidence Analysis and Causal Factor Determination
10. Determining Root Causes—Structured Approaches
11. The Impact of Human Factors
12. Developing Effective Recommendations
13. Preparing the Final Report
14. Implementing Recommendations
15. Continuous Improvement for the Incident Investigation System
16. Lessons Learned – Institutional Knowledge

• Numerous Checklists
  o Evidence preservation, the investigators toolkit, evidence preservation, report writing, auditing,