



Guidelines for Investigating Process Safety Incidents

Third Edition, CCPS



Hazards 29 – Incident Investigation
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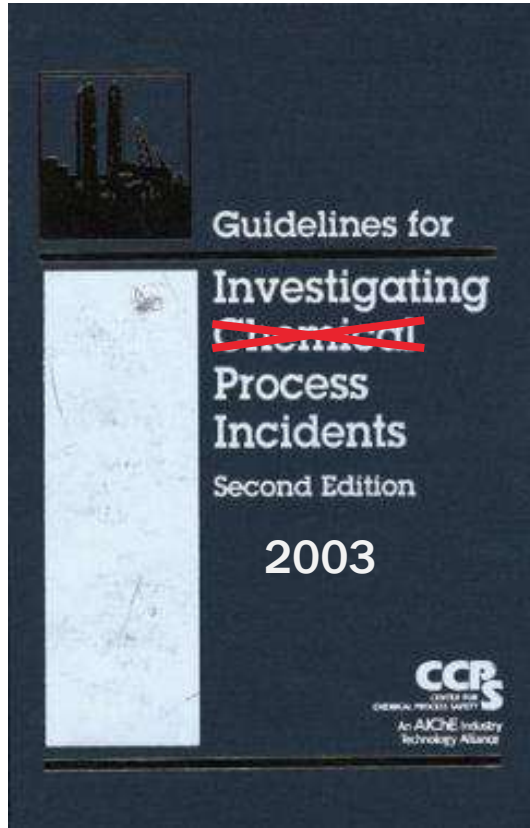
About CCPS

- 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



www.aiche.org/ccps

Evolution



Acknowledgements – CCPS & Subcommittee

- Dan Sliva – CCPS Staff Liaison

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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**
 - Cultures
 - Corporate approaches
 - Experience level
- **Several suggested methodologies for activities including:**
 - Timeline development
 - Causal Factor Determination
 - Root Cause Determination

Target Audiences

- **Company management**
 - Chapters 1 – 4 (Introduction, Incident Causation, Overview of Investigation Methodologies, and Designing an Incident Investigation Management System)
- **Novice investigator**
 - Guide for learning the entire investigation process.
- **Experienced investigators**
 - 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.**

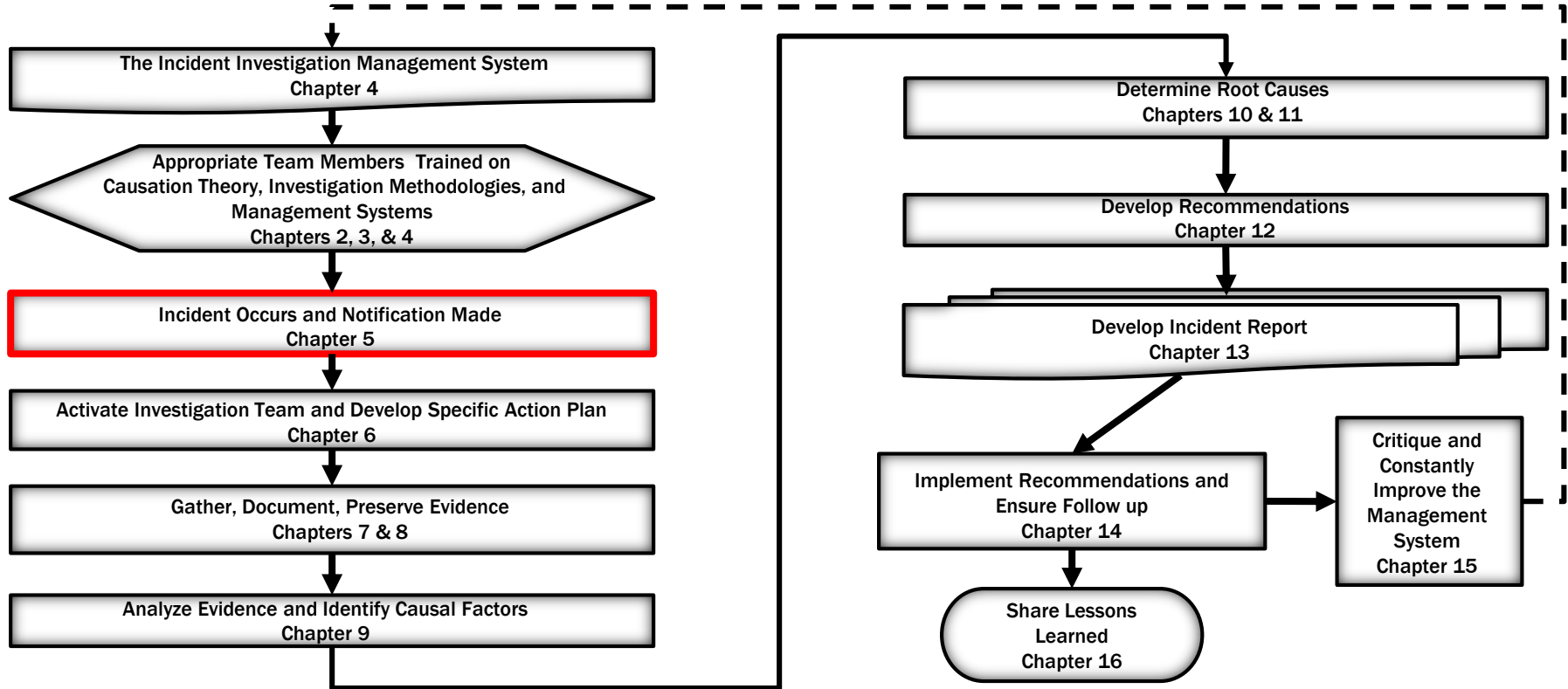
Organisation of the Book

- **Overview of Investigations**
 - Introduction to Investigations
 - Incident Causation
 - Overview of Investigation methodologies
- **Designing an Investigation Management System**
- **Responding to an Incident**
 - Initial notification and classification of an incident
 - Building/ leading an investigation team
 - Witness Management / interviews
 - Evidence identification, collection, and management
 - 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


Book / Incident Flowchart



Notification and Classification

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

Investigation Methodologies

Increasing Structure 

Informal, One-on-one

Traditional, Informal Investigation usually performed by immediate supervision

Brainstorming

Judgment/experience to find credible causes. Structured brainstorming may employ tools such as What-If and 5-Whys.

Process of Elimination

Eliminates potential causes. and the cause(s) not eliminated are concluded to be the final cause(s).

Timeline

Chronological listing of events using a variety of formats from simple sequential list to diagrams showing events/conditions along a straight axis.

Sequence Diagram

Graphical depiction of timeline that allows investigators to exhibit related events and conditions in parallel branches.

Investigation Methodologies

Increasing Structure 

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.

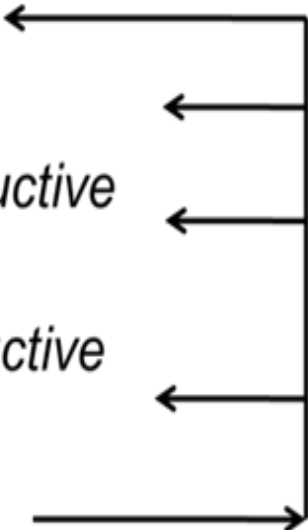
Logic Trees

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

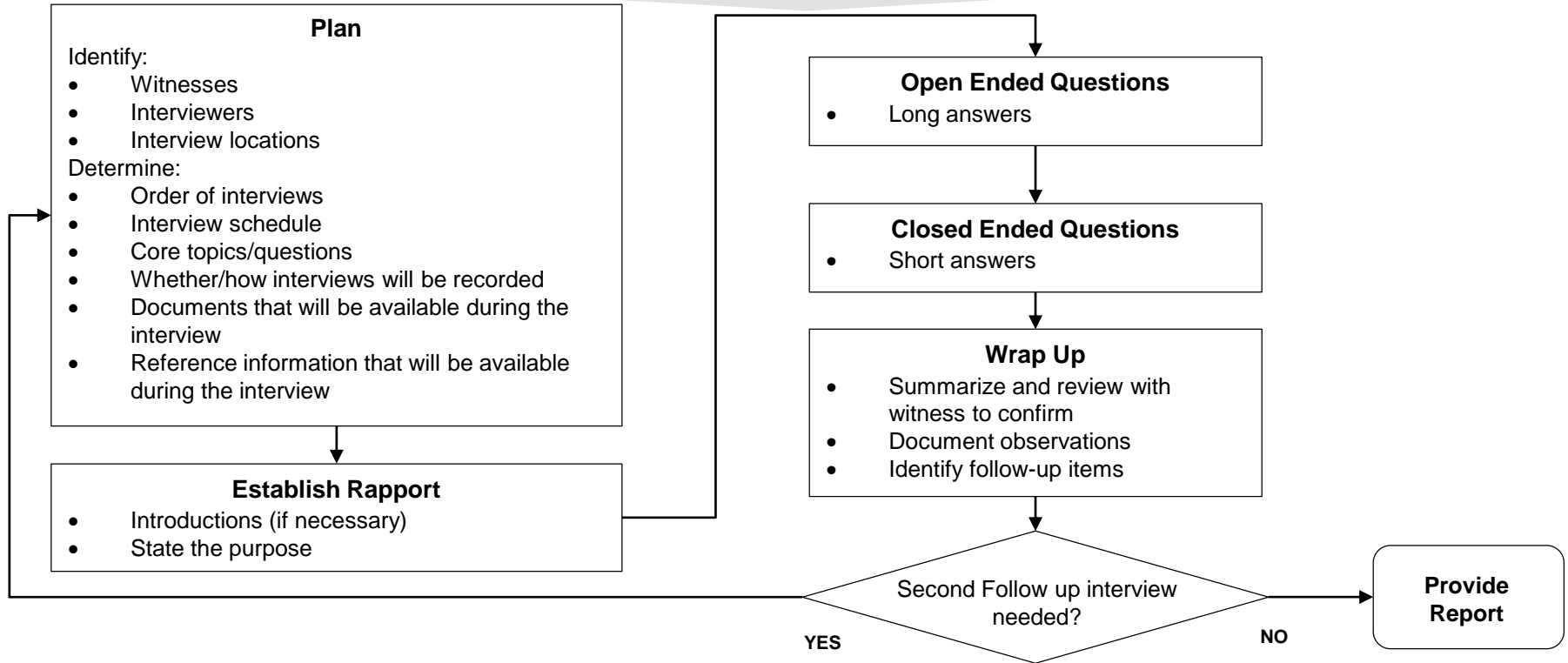
Scientific Method

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
- 
- The diagram illustrates the scientific method as a linear process with feedback loops. A vertical line on the right side of the list connects the steps. Arrows point from this line back to the left, indicating that the process can return to a previous step if needed. Specifically, arrows point from the line back to steps 2, 3, 4, and 5. A final arrow points from the line back to step 6, indicating the completion of the process.

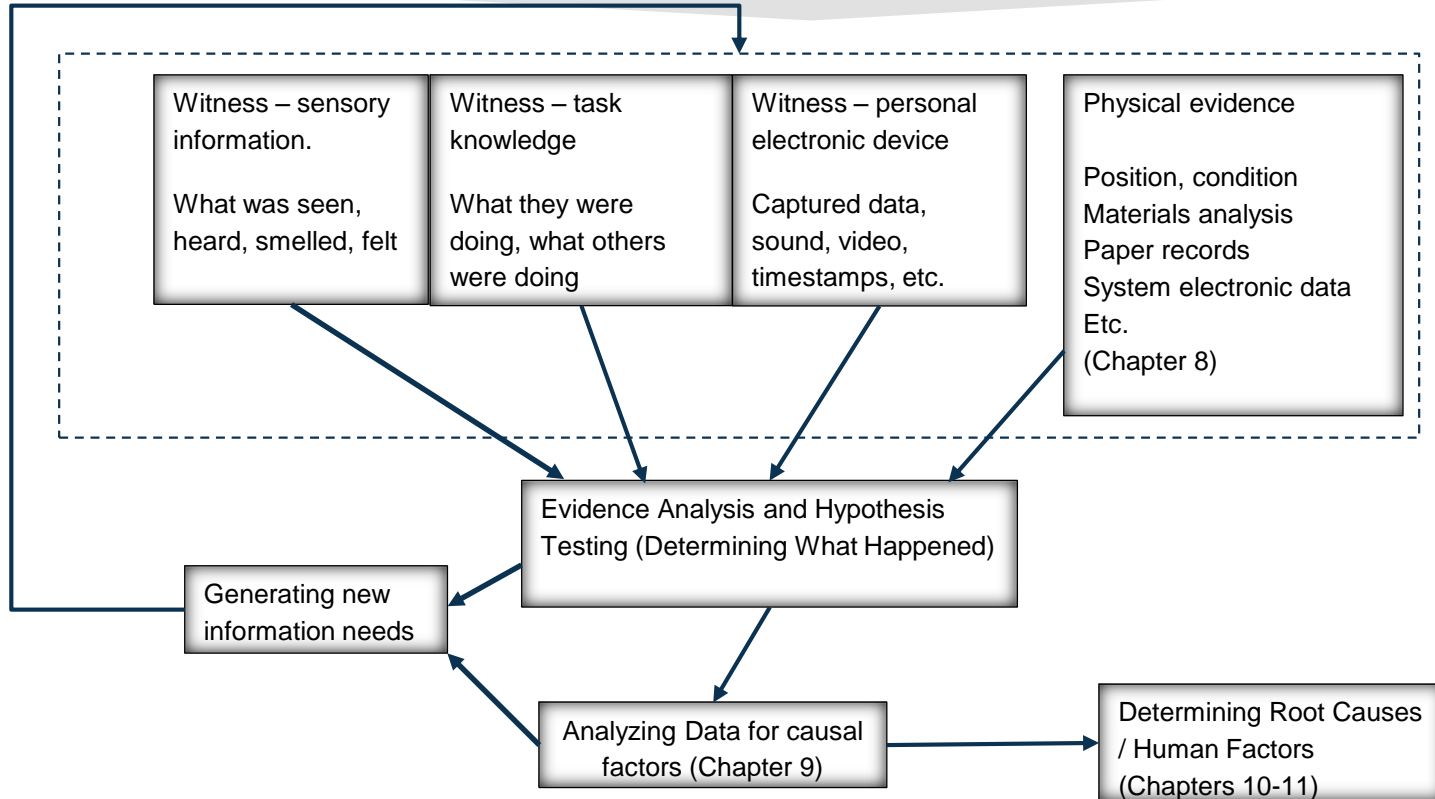
Scientific Method Example – Seal Leak

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

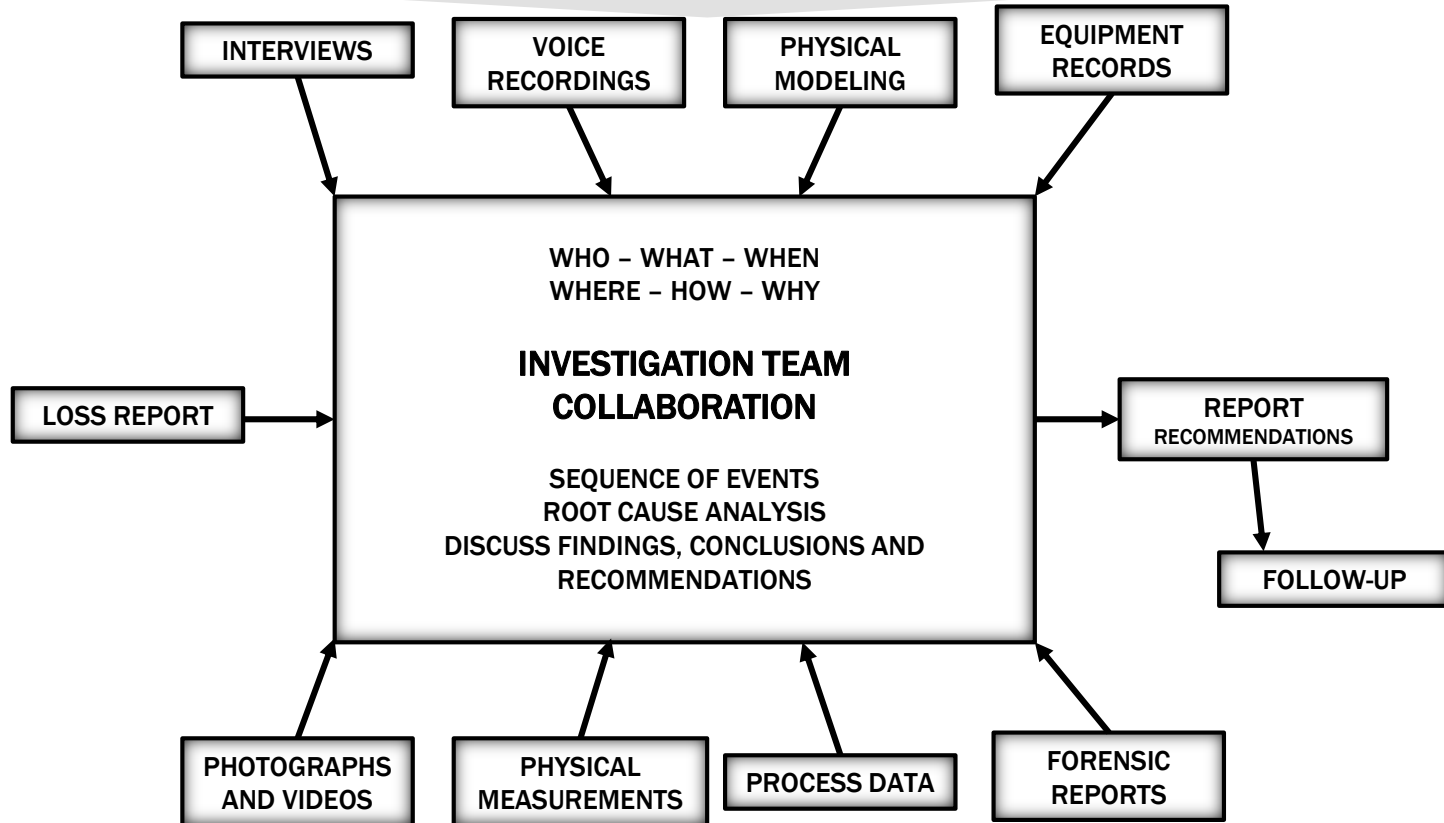
Witnesses and Interviews



Evidence Collection/ Analysis



Investigation Team Activities



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.

Lessons Learned

Expanded to include:

- **Sharing at local level**
- **Sharing more broadly within the company**
- **Sharing with outside industry**
 - Regulatory / litigation issues
- **Receiving lessons from industry**
 - Why we're here

Summary of key developments - Edition 3

- **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**

Conclusions

- **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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Chapters

- 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**

Chapters

- 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**
 - Evidence preservation, the investigators toolkit, evidence preservation, report writing, auditing,