Updated CCPS Investigation Guidelines book

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Abstract

Incident investigation standards and performance criteria continue to improve. In recognition, the Center for Chemical Process Safety (CCPS) undertook a major project to upgrade and update the Incident Investigation Guidelines originally published in 1992. These significantly expanded guidelines provide a practical resource for effective investigation of process-related incidents, and reflect changes in good practices and expectations of regulators.

This paper highlights the content of the new guidelines with special emphasis on what is new and improved. Entirely new chapters address the topics of legal considerations, the near-miss event, and continuous improvement of the investigation system. The objective of the guidelines is to allow chemical process organizations to develop and implement an incident investigation management system that is effective in identifying underlying causes.

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1. Introduction and overview

The Center for Chemical Process Safety (CCPS) recognized the role of effective incident investigation when it published the original *Guidelines for Investigating Chemical Process Incidents* in 1992 [1]. Chemical process incidents are often complex in nature, involve multiple simultaneous failures, and sometimes have catastrophic consequences; Bhopal, Seveso, and Flixborough are three examples [2,3]. A robust root cause incident investigation approach is necessary to understand the event scenario and identify the underlying causes.

The first edition of the guidelines provided a thorough treatment of incident investigation practices at that point in time including:

- the concept of multiple root causes,
- the relationship between root causes and management system deficiencies,
- practical application of several state-of-the-art tools including:
  - iterative loop;
  - logic diagrams;
  - time-line; and
  - fact-hypothesis matrix,
- guidance on implementing an incident investigation management system, and
- worked example cases and a reference section.

Since the CCPS investigation guidelines were originally published, incident investigation performance standards and practices have continued to evolve. In recognition of incident investigation advances during the past 10 years, CCPS decided there was value in updating the investigation guidelines with the goal of retaining the knowledge base provided in the original book while simultaneously updating and expanding it to reflect the latest thinking. A team of CCPS representatives has now developed an updated and expanded version of the investigation guidelines that meets this goal and reflects changes in industry practices and expectations. This updated version ("New" CCPS Incident Investigation Guidelines) is the result of a 3-year project with input of experienced investigators from 15 CCPS member organizations.

This paper details the content of the newly revised CCPS investigation guidelines book with special focus on those items that have been added or significantly modified.

These CCPS investigation guidelines differ from other incident investigative approaches in several important aspects:

- They are specifically designed for use by technical personnel who may not be trained investigators.
- They are designed for use in potentially complex events.
- They are not intended as a substitute for basic accident investigation training.
- They are not intended to replace any of a number of quality investigation methodologies currently in use in the industry.

The value of these CCPS guidelines is maximized when they are used to supplement and improve a fundamentally sound investigation management system. These new guidelines are also intended to reflect and represent current best practices used by high performance investigators.

Like the original edition, the revised guidelines focus primarily on investigating process-related incidents that result in (or easily could have resulted in), catastrophic consequences. However, readers will find that methodologies, tools, and techniques described in the guidelines may also be applied when investigating other types of events such as environmental incidents, operational interruptions, traditional (non-process related) industrial occupational health and safety incidents, and quality assurance issues.

In recognition of the continuing variations in the use of terminology, CCPS designated the following definitions for three key terms: incident, accident, and near-miss:

- *Incident*—an unusual or unexpected event, which either resulted in, or had the potential to result in:

○ injury to personnel,
○ significant damage to property,
○ adverse environmental impact, or
○ a major interruption of process operations.
- *Accident*—an incident in which property damage, detrimental environmental impact, or human loss (either injury or death) occurs.
- *Near miss*—an incident in which property loss, human loss or operational difficulties *could have* plausibly resulted if circumstances had been slightly different.

In other words, an "Incident" can be either an "accident" or a "near miss".
This book focuses on three specific target groups:

- investigation team leaders for process safety incidents,
- investigation team members,
- corporate and site PSM managers and coordinators.

For anyone directly involved in leading or participating on an incident investigation team, the CCPS guidelines provide a valuable reference tool. The guidelines present knowledge, techniques, and examples to support successful investigations. For persons in technical and management roles responsible for implementing the incident investigation element of an integrated PSM system, the book offers a model for success in building or upgrading their program.

The guidelines book is organized as follows:

- Introduction and overview of Incident Investigation.
- Incident Investigation Management System.
- Incident Causation Theories and Investigative Techniques.
- Near-misses.
- Human Factors.
- Building and Leading the Investigation Team.
- Gathering and Analyzing Evidence.
- Determining the Root Causes.
- Developing Recommendations.
- Writing the Reports.
- Legal Concerns.
- Implementation and Follow-up.
- Continuous Improvement.
- Lessons Learned.
- Annotated Appendices (glossary, list of resources for further assistance, examples, samples and case studies, brief discussion of classic chemical process incidents).

2. Chapter descriptions

Note. At the time of publication of this paper, the CCPS Project Team is considering revising the chapter numbers. The final edition of the book may be organized slightly differently than presented here.

2.1. Chapter 1—introduction and overview

The second edition of the CCPS guidelines begins with an overview of process incident investigation and concepts. This chapter discusses the intended user/reader, the importance of management support and participation, and points out the unique features of the second edition. Chapter 1 prepares the reader for the rest of the book and is especially useful to those who need to secure, confirm, or re-enforce the support of line management. The material in this chapter is an excellent source for an overview training session for line managers and employees and could be used to enrich an existing training program.

2.2. Chapter 2—incident investigation management system

In the majority of cases, the investigation will identify weaknesses or defects in a management system as underlying causes of the incident. A management system perspective examines a very broad range of issues and activities that could result in allowing or facilitating an accident to occur. Fig. 1 is a flow chart of an example incident investigation management system.

The *management system* for investigating process safety incidents is examined in Chapter 2. It opens with a review of management responsibilities and presents those important features that an investigation system must address to be effective. It examines systematic approaches that help implement incident investigation teams, root cause determination(s), recommendations, follow-up, and documentation. Specific knowledge, skill, competencies and training needs are examined for the various participants in the incident investigation management system.

Incident investigations produce maximum positive effects when they are conducted in an atmosphere of openness and trust. Management must demonstrate by both word and deed that the primary objective is not to assign blame, but to understand what happened for the sake of preventing future incidents. The CCPS investigation guidelines help organizations define and refine their incident investigation systems to achieve positive results effectively and efficiently.

2.3. Chapter 3—overview of incident causation theories and investigation techniques

This section discusses the basics of determining incident causation and describes the general categories of incidents—from near-miss to major catastrophe. It examines the anatomy of process incidents as related to theoretical models of incident causation and presents the investigation's place in controlling risk. It also discusses the relationship between a hazard, the layers of protection (barriers), and an accident (see Fig. 2) as well as giving an introduction to investigation techniques.

2.4. Chapter 4—the near miss

This is an entirely new chapter that highlights the potential value and benefits of proactively investigating near-miss incidents and taking preventive actions on their root causes. Many major process safety incidents were preceded by precursor events. These precursor
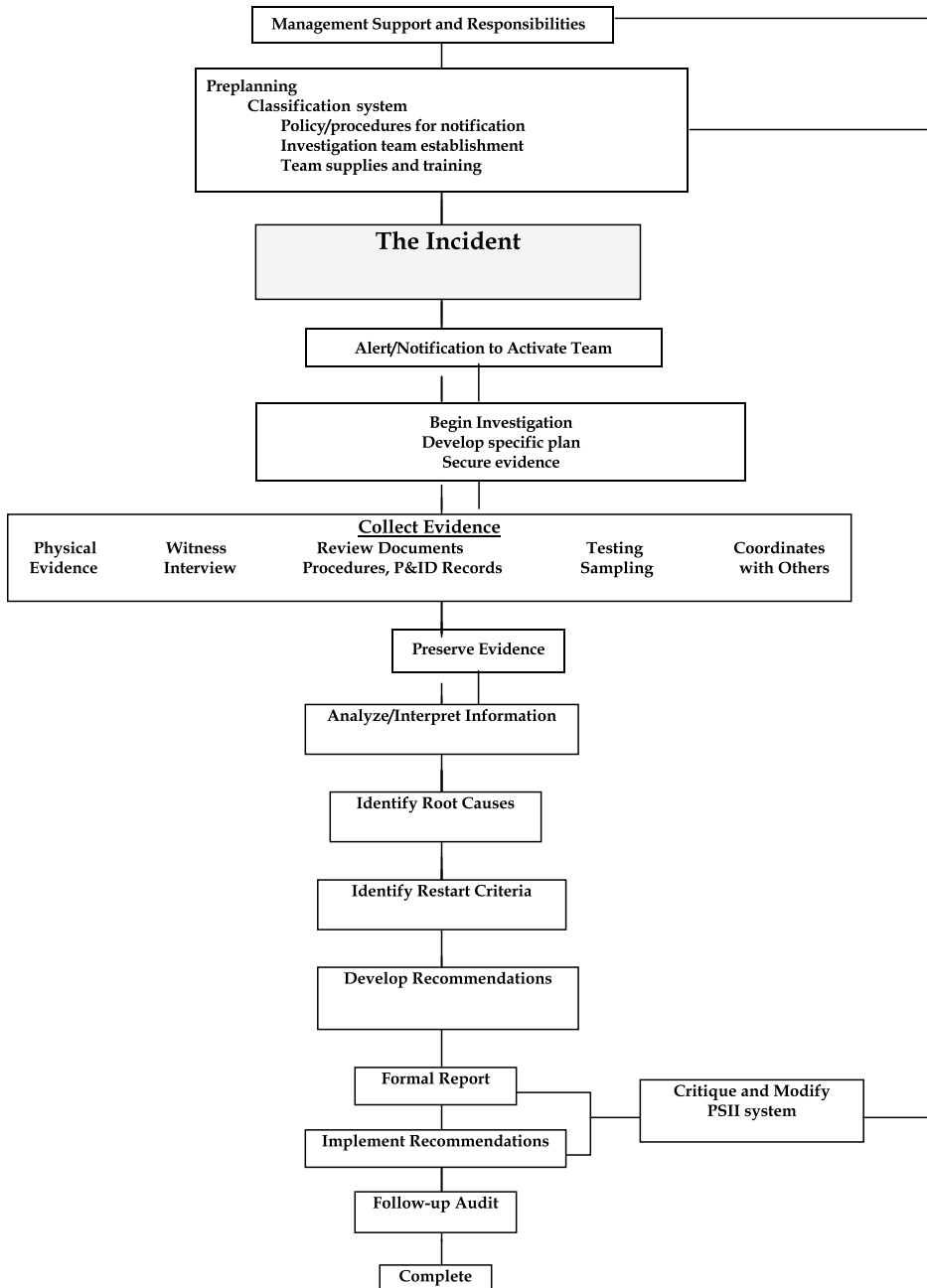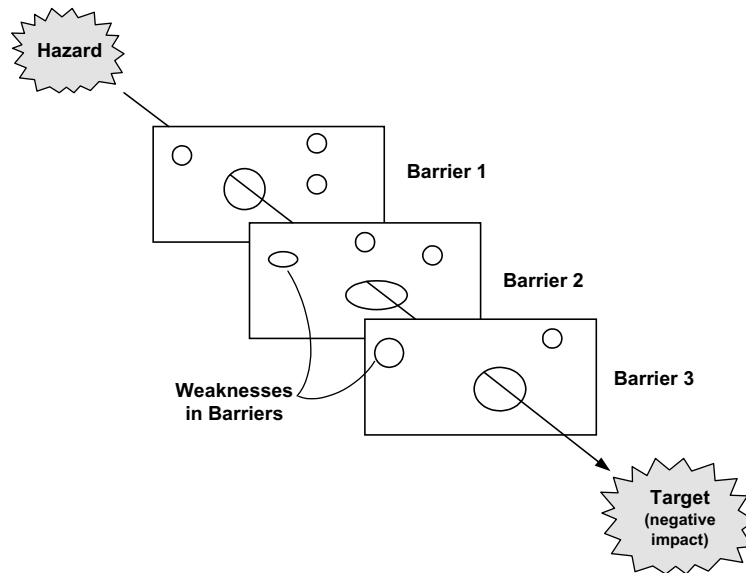
Fig. 1. Management system example.

Fig. 2. Hazard-barrier-target example.

events may have been unrecognized or ignored because "nothing bad" actually happened. Lessons learned from such occurrences, typically referred to as *near-misses*, can be extremely valuable in averting disaster. However, this potential benefit can only be realized when near-miss events are recognized, reported, and investigation techniques are properly applied. This chapter describes near-misses, discusses their importance, and presents methods for helping ensure appropriate near misses are reported. Aggressive proactive near-miss investigation systems are difficult to effectively implement and require sustained and genuine leadership from the organizational management team.

2.5. Chapter 5—human factors

This chapter describes human factors considerations in incident causation. It touches on why humans err and the management systems that influence them to do so. It further discusses the four types of human error—omission, commission, sequence and timing.

2.6. Chapter 6—building and leading an investigation team

Personnel with proper training, skills and experience are critical to the successful outcome of an incident investigation. This chapter describes team composition as a function of incident type and severity. Team training topics and suggestions are included. It also provides team leaders with a high-level overview of the basic team activities typically required in the course of conducting an investigation.

The guidelines address potential safety issues faced by the investigation team members, such as

- Potential respiratory hazard exposures.
- Unstable working–walking surfaces.
- Sharp edges from debris and broken glass.
- Need for specific personal protective equipment.
- Hazwoper OSHA 1910.120 compliance issues.

2.7. Chapter 7—gathering and analyzing evidence

This chapter addresses the practical considerations of data-gathering activities. Facts are the fuel an investigation needs to reach a successful conclusion. The team must undertake selected activities to compile the information needed to determine underlying causes and make sound recommendations for preventive measures. This chapter describes types of data, sources of data, data-gathering tools, and techniques. One key feature of this chapter is the section devoted to witness interviews. Many engineers and technical personnel are not highly skilled or trained in interviewing skills. Process engineers may find themselves in the uncomfortable position of being responsible for conducting effective witness interviews for catastrophic incidents.

The following are examples of effective witness interview techniques addressed in this chapter:

- Establishing initial rapport.
- Conducting the interview in a private and low stress location.
- Promptness (to minimize co-mingling of information between witnesses).
- Use of the *Uninterrupted Narrative* concept.
- Proper timing and application of *Open-Ended questions*.

2.8. Chapter 8—determining root causes—a structured approach

Root cause is the term used by investigators to describe the underlying primary reasons why an incident occurred. In almost every instance, process safety incidents are the result of more than one root cause. This chapter provides a detailed description of some powerful, widely used tools and techniques available to incident investigation teams. It addresses the application of logic trees (event trees, fault trees, and "why" trees), checklists, and fact/hypothesis matrices. See Fig. 3 for a fault tree example.

Three other examples of the tools discussed in this chapter are: time-line, interactive loop, and deductive logic diagrams. Fig. 4 is a simplified time-line example.

2.9. Chapter 9—developing effective recommendations

Effective investigations lead to effective recommendations that can reduce the likelihood of recurrence or mitigate the consequences of similar incidents. A critical step in incident investigation is to generate recommendations that if implemented would eliminate or minimize the root causes of the incident and thereby prevent a repeat incident.

Once the likely causes of an incident have been identified, investigation teams analyze what can be done to help prevent recurrence. The resultants are usually called "Recommendations" or "Action Plans". The incident investigation recommendations are
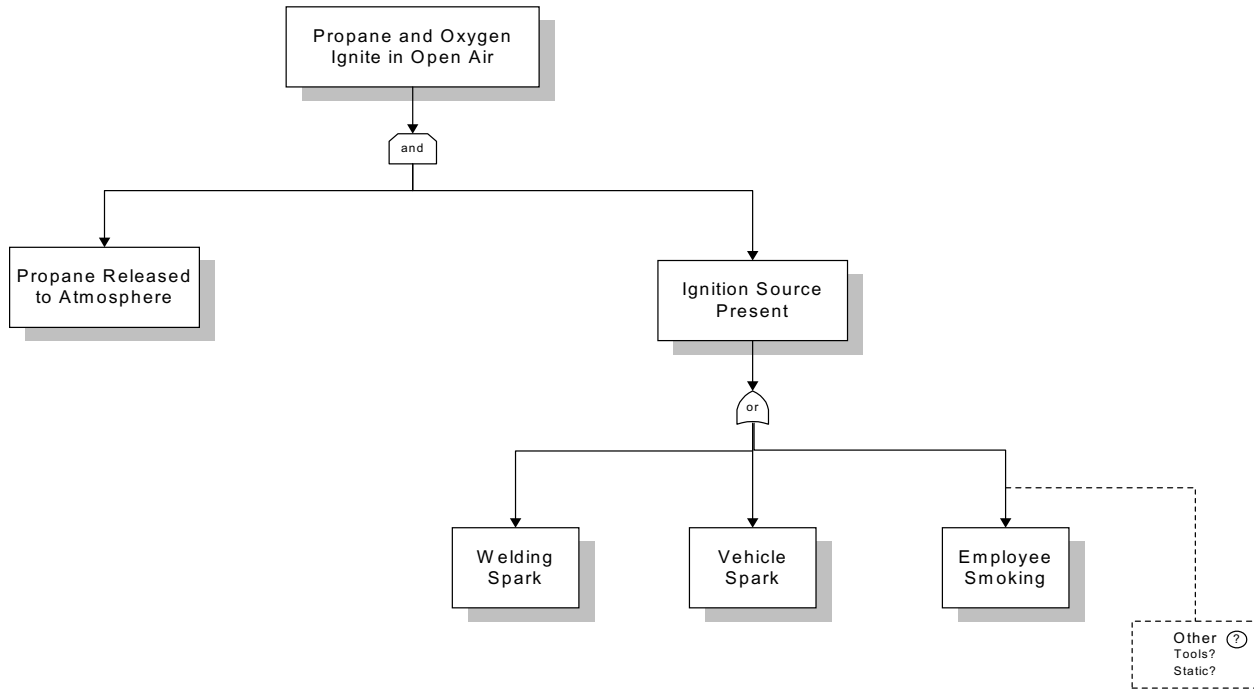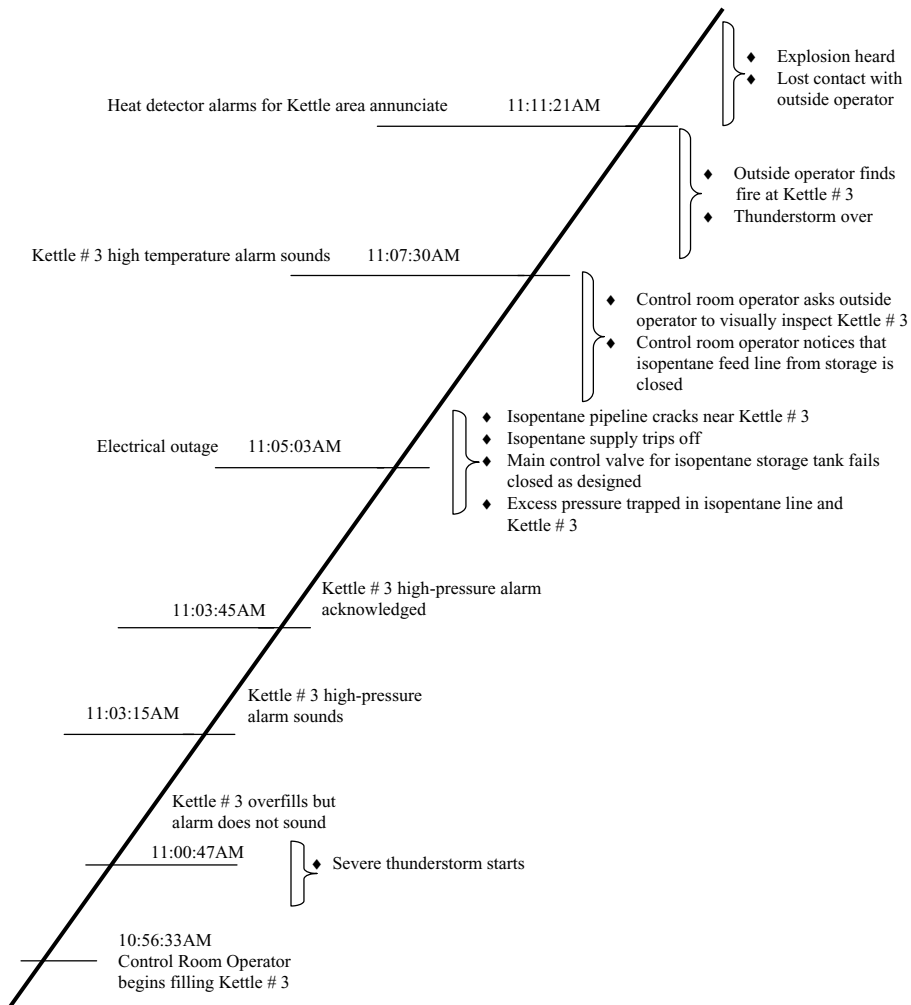
Fig. 3. Fault tree example.

Fig. 4. Time-line example.

the product of this analysis. This chapter addresses types of recommendations, some attributes of good recommendations, methods to document and present recommendations, and management's responsibilities.

Attributes of effective recommendations include:

- addresses a root system cause,
- clearly describes the intended action,
- feasible,
- reduces risk (frequency and/or consequence),
- designated target date,
- identifies a person responsible for ensuring completion.

ABSTRACT	summary of event, consequences, causes and recommendations, 1 page maximum
BACKGROUND	process description, purpose and scope of investigation, conditions preceding the incident.
NARRATIVE	description of the event scenario, sequence, consequences
ROOT CAUSES	identification and discussion of the root system causes of the incident
FINDINGS AND RECOMMENDATIONS	two separate sections, identifying factual findings, and recommended preventive action.
APPENDIX/OTHER	miscellaneous back-up information, discussion of rejected or less-probable scenarios, documents of special interest or value, method of investigation and team membership, photographs, diagrams, calculations, lab reports.

Fig. 5. Investigation report format example.

2.10. Chapter 10—preparing and communicating the incident investigation reports

A major milestone is completed when the final incident investigation report is submitted. The incident report documents the investigation team's findings, conclusions and recommendations. The report itself is a tool for prevention and provides an opportunity to learn and apply insights gained from the investigation. This chapter describes practical considerations for writing formal incident reports, a discussion of the attributes of well-written reports, and the issue of communicating the report findings to affected persons, both internally and externally.

One of the key issues is to identify the intended reader/user of the report. Another critical aspect for process safety incident reports is the review by legal. A plan should be developed for sharing the information learned by the investigation team, and for tracking the implementation of the recommended action items.

A suggested format for reports is included in the guidelines and is displayed in Fig. 5.

2.11. Chapter 11—considering legal issues

The work products of incident investigations are subject to the legal process of discovery. Whether examined by regulatory agencies investigating the cause to further government research on industrial incidents or by attorneys representing parties involved in criminal or civil cases, the incident investigation report becomes a focal point. Because of this, the incident investigation team must keep two purposes in mind:

- First, the ultimate purpose of the incident investigation is to determine what happened, why it happened and how to prevent future occurrences.
- Second, there are important legal issues associated with the conduct, documentation, and follow-up of incident investigations. This chapter provides insight into legal issues and is written for a lay audience.

2.12. Chapter 12—implementing the recommendations

The recommendations generated as a result of an incident investigation should be properly implemented in a timely fashion to minimize the risk associated with repeat occurrences.

This chapter focuses on the critical aspects of implementation and follow through. It addresses initial resolution of the recommendations, their implementation, and sharing lessons learned from the investigation. Until and unless the root causes are actually fixed, the efforts of the investigation remain just an academic exercise. If the investigation team does an excellent job identifying the causes and suggested remedies, and nothing is implemented, the actual risk level remains unchanged.

2.13. Chapter 13—seeking continuous improvement

Every investigation provides an opportunity to identify and apply lessons learned that could contribute to improving the investigation system's effectiveness and therefore improve the next investigation. There are always a few items that the team would do differently given the same circumstances next time. The adage "if it ain't broke, don't fix it" does not apply to process safety management systems. The management system and its constituent elements should be subject to on-going review and improvement efforts. This chapter describes techniques that can help the incident investigation element of PSM remain strong and viable in an ever-changing technical, business, and regulatory environment. It includes considerations for assessing an existing incident investigation program and develops approaches for implementing continuous improvement.

2.14. Chapter 14—lessons learned

This chapter focuses on the value of critically analyzing incident information and discusses the benefits of using databases to evaluate lessons learned. The power of both internal databases and industry-wide incident databases can help organizations improve their performance in process safety and environmental responsibility.

The Concord Air crash of 2000 involved some unapplied lessons learned from previous incidents. And, a recent chemical plant compressor fire in Texas had striking similarities to an almost identical event in the same company at another location. In both instances, the lessons available for learning had not been applied effectively within the organization. With the advent of intra-nets, many organizations have a powerful new tool to help share the word.

2.15. Appendices

The appendices provide a wealth of supplemental information on the subject of incident investigation, including a list of other references and case studies of actual incidents.

References

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