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CONDUCTING ACCIDENT INVESTIGATIONS

REVISION 2

May 1, 1999

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Washington, D.C. 20585
DISTRIBUTION STATEMENT

Approved for public release; distribution is unlimited.
Foreword

As part of its continuing effort to enhance the quality and consistency of oversight activities, the Office of the Deputy Assistant Secretary for Oversight initiated an extensive review of all aspects of the Accident Investigation Program. As a result, this workbook has been revised to improve the Accident Investigation Program.

Substantive Workbook Changes

Section 1

- Section 1.2.4, "Broad Environmental Factors," is retitled "Physical Work Environment," and a new section 1.2.5, "Organizational Work Environment," was added. The seven guiding principles from DOE Policy 450.4, Safety Management System Policy, are summarized and described as characteristics of the organizational work environment that are necessary to prevent accidents.

Section 5

- Added a new Section 5.1.5 entitled, "Addressing Potential Conflicts of Interest." This section describes the steps for resolving and documenting the resolution of any potential conflict of interest concerns regarding board members, advisors, and consultants. Additionally, a new "Conflict of Interest Certification Form" was added to the end of Section 5.

- Section 5.2.5, "Coordinating Internal and External Communication," was revised by adding a bullet at the end of the section regarding the required notifications when a potential Price-Andersen Amendments Act non-compliance is identified during an investigation.

Section 6

- Table 6-4, "Interviewing Do's," was revised by adding a bullet under "Create a Relaxed Atmosphere," which states, "Conduct the interview in a neutral location that was not associated with the accident." This reminder was added based on lessons learned from investigations conducted since the last revision of the workbook.

- Section 6.4, "Examining Organizational Concerns, Management Systems, and Line Management Oversight," was revised to more clearly describe using DOE Policy 450.4 as a framework for investigating management systems. The typical questions for addressing the five core functions in Table 6-7 were revised and Table 6-8, "Typical Questions for Addressing the Seven Guiding Principles of Integrated Safety Management," was added. These tables illustrate how lines of inquiry can be developed that are specific to the accident and involve the principles and core functions of integrated safety management.

Section 7
Moved Section 7.5, "Determining Causal Factors," to the front of Section 7 to become Section 7.2, because it provides definitions of the terms that are used throughout the remainder of the section.

Revised the text of Section 7.2.3, "Root Causes," to more clearly incorporate safety management considerations. The root cause examples in the text and in the text box for this section were revised to more directly pertain to integrated safety management principles and core functions.

Added a new Section 7.2.4, "Importance of Causal Factors." This section emphasizes the importance of identifying causal factors in the management systems failures that lead to the accident. It also stresses the importance of assigning responsibility for the root cause(s) at the appropriate line management and oversight levels.

Extensively revised Section 7.3.2, "Barrier Analysis," to illustrate applying integrated safety management core functions and principles in conducting a barrier analysis. Major changes include:

- Combining administrative and management barriers on Figure 7-4 into one class of barriers entitled, "Management Barriers"
- Adding guidance regarding the types of information that might be needed to analyze safety management barriers at the activity, facility/corporate, and institutional levels
- Simplifying Table 7-4, "Sample Barrier Analysis Worksheet"
- Revising the Basic Barrier Analysis Steps text box to be consistent with revised Table 7-4
- Revising Figure 7-5 to highlight physical vs. management barriers and adding Figure 7-6 to show how the five core functions can be used to organize and present the results of a barrier analysis in the investigation report.

Revised Section 7.3.3, "Change Analysis," by deleting the old Table 7-3, "Considerations for Completing the Change Analysis Worksheet," and adding text to clarify the change analysis process. This includes revising the Note in the last paragraph of the section to incorporate an example of the compounding effects of incremental change.

Revised Section 7.3.5, "Root Cause Analysis," Section 7.3.5.1, "Tier Diagraming," and Table 7-8, "Example Tier Diagram Approach," to emphasize the use of the core functions and guiding principles of integrated safety management as a framework for identifying the underlying management system deficiencies as potential root cause(s).

Section 9.5, "Review by the Assistant Secretary for Environment, Safety and Health" (part of Report Writing), was revised to clarify that Type B accident investigation reports will be reviewed by EH-2, with comments incorporated prior to report publication and distribution by the appointing official.
Introduction

The purpose of this workbook is to provide those responsible for conducting accident investigations with practical, detailed advice on conducting these investigations. The material in this workbook parallels information in the U.S. Department of Energy (DOE) Implementation Guide for Use with DOE Order 225.1A (which explains how to meet the requirements and responsibilities of DOE Order 225.1A, Accident Investigations). The workbook provides more in-depth guidance, as well as specific tools and techniques, that will facilitate the investigation process. It is designed primarily for use by DOE accident investigation boards (board chairpersons and board members) and their support staff (consultants, advisors, and administrative staff). However, field and program office points of contact for accident investigations will also find this workbook useful in preparing for and supporting accident investigations.

This workbook is intended to:

- Provide more detailed information and guidance for the subjects addressed in the Implementation Guide for Use with DOE Order 225.1A
- Serve as a reference source for conducting investigations
- Support training in accident investigation processes.

The workbook does not introduce or impose any requirements not addressed in DOE Order 225.1A. Users have the latitude to choose whether and how to apply the procedures, methodologies, and techniques presented here. Alternative approaches and methods that effectively implement the requirements of DOE Order 225.1A are acceptable.

This workbook is divided into two parts. Part I covers background information those involved in accident investigations need to know before they begin an investigation. Included in Part I are:

- Accidents: General Principles (Section 1)
- DOE's Accident Investigation Program (Section 2).

Part II describes the detailed, step-by-step DOE process for conducting accident investigations, including specific tools and techniques that have proven effective on previous investigations. Part II covers:

- Appointing the Investigation Board (Section 3)
- Implementing Site Readiness (Section 4)
- Managing the Accident Investigation (Section 5)
- Collecting Data (Section 6)
- Analyzing Data (Section 7)
- Developing Conclusions and Judgments of Need (Section 8)
Reporting the Results (*Section 9*).

A glossary and list of references are included in Appendices A and B. Appendices C and D list specific administrative needs and components of DOE's Safety Management System Evaluation Factors. Appendix E is a subject index.
Accidents: General Principles

1.1 The Nature of Accidents

Accidents are unplanned and unintentional events that result in harm or loss to personnel, property, production, or nearly anything that has some inherent value (i.e., targets). These losses increase an organization's operating costs through higher production costs, decreased efficiency, and the long-term effects of decreased employee morale and unfavorable public opinion.

Accidents are rarely simple and almost never result from a single cause. Most accidents involve multiple, interrelated causal factors. Accidents can occur whenever significant deficiencies, oversights, errors, omissions, or unanticipated changes are present. Any one of these conditions can be a precursor for an accident; the only uncertainties are when the accident will occur and how severe its consequences will be.

To conduct a complete accident investigation, the factors contributing to an accident, as well as the means to prevent accidents, must be clearly understood. Management prevents or mitigates accidents by identifying and implementing the appropriate controls and barriers. Controls help to prevent errors or failures that could result in an accident; barriers help to mitigate the consequences of potential errors or failures. Barriers to protect targets against loss can be physical barriers, such as machine guards and railings, or management barriers, such as work procedures, hazard analysis, requirements management, line management oversight, and communications. In a work environment, several barriers may be used in an effort to prevent accidents. Accidents occur when one or more barriers in a work system, including procedures, standards, and requirements intended to control the actions of workers, fail to perform as intended. The barriers may not exist, may not be adhered to, or simply may not be comprehensive enough to be effective. Personal performance and environmental factors may also reduce protection.

A certain level of risk is inherent in every activity. Accepting some level of risk is necessary, but to protect against unwanted loss (e.g., injury, property damage, production downtime), risks must be controlled, transferred, or eliminated. Understanding how to prevent or control accidents requires an understanding of the sequence of events leading to an accident in order to identify and implement countermeasures that contain risks within acceptable limits.
1.2 Human Factors Considerations

Human factors focus on people and their interaction with equipment, facilities, procedures, and environments in work and daily activities and how these considerations affect accidents. The human factors framework can be used by the investigator to:

- Identify the multiple, interrelated factors that may contribute to an accident
- Trace non-human causes back to potential human contributors.

These considerations should be assessed during the data collection process to ensure that they are considered as part of the overall analysis of an accident. Understanding human factors as they relate to accidents requires knowing how the human-machine interface operates in the workplace, the capabilities people bring to a task, and how the primary elements of the work setting affect human performance.

In most accidents, human performance is likely to be a significant causal factor. For example, an accident may be caused by a worker failing to follow safety procedures when operating equipment. In another situation, an accident may occur as a result of an equipment malfunction, which upon further investigation is found to result from a poorly constructed control device. In the first case, human error on the part of the equipment operator is a causal factor in the accident. In the latter case, human error on the part of the equipment designer is a causal factor in the accident. In both cases, human performance is an important causal factor. An investigation of both accidents would involve examining human activities, the equipment or machine, and the environment.

Human factors analysis starts by looking at the immediate context of human-machine performance. It then addresses how human capabilities, equipment considerations, and the environment can affect human-machine performance. The human factors framework consists of five key areas that should be addressed in any accident investigation:

- Human-machine interface
- Human capabilities
- Equipment/design considerations
- Physical work environment
- Organizational work environment.

1.2.1 Human-Machine Interface

In every accident, there is a human consideration, or a human-made object, or both. Generally, any accident can be attributed to a human activity or response. Figure 1-1 shows the relationship among humans and machines. This relationship provides a human-machine "activity model" that can be used to examine the immediate work activity and to examine potential causal factors of the accident.

![Figure 1-1. Human-machine "activity model."](http://tis.eh.doe.gov/oversight/procedures/9905workbook/chpt1/chpt1.htm)

Before examining factors that may contribute to accidents, it is important to understand the process people use to perform a task or activity. As shown in Figure 1-1, humans perform the following activities to complete a task:

- Information perception: Perceiving information means that the human has detected some type of signal; this may be visual, auditory, or tactile. For example, operators perceive information from annunciator panels. The activity of monitoring displays and perceiving information serves as a trigger to an action.
Information processing and decision-making: This activity involves processing the information to determine its meaning and formulating an appropriate response. For example, operators must continually process the meaning of the information provided by machine displays and determine the appropriate action. Often, determining the appropriate action requires effective sharing of information and collective decision-making in order to formulate the most appropriate action.

Action planning and execution: When a decision is made, the human then plans and executes the course of action. In the case of operators, the action might need to be coordinated among many operators. The action is executed by manipulating controls that initiate a change in the status of the machine. The machine, in turn, responds by providing feedback via displays indicating the new status of the plant.

1.2.2 Human Capabilities

Determining whether worker capabilities match work requirements is another human factors consideration. For example, military and commercial aircraft pilots are selected, in part, for their quick response time, problem-solving abilities, and visual acuity. Persons in this occupation who lack high levels of these capabilities have a greater propensity to cause accidents.

Table 1-1 lists human capabilities that contribute to the actions described in the “activity model.” These are only a sample of capabilities that contribute to effective performance. Many other capabilities can affect performance, depending on specific task requirements:

- **Experience, knowledge, and training:** For any task or work activity, human performance is generally enhanced if the person has previous experience in performing the task, has knowledge of the input, and understands the meaning of various indicators and the implications of various actions. This knowledge and experience can be gained through formal training, education, and on-the-job training.

- **Physical aptitude, fitness, and behavior:** A worker's capability to perform effectively may be reduced by: (a) recent injuries or surgery or temporary physical limitations; (b) seasonal allergies or other temporary disorders; (c) changes in visual capacity (e.g., decreased visual acuity due to aging, color vision, and night adaptation) or changes in work that demand greater visual abilities; (d) hearing loss due to noise exposure; and (e) physical and neurological effects due, for example, to exposure to toxic materials.

- **Stress:** Workers may experience stress because of work-related or personal events. Sources of stress may stem from: (a) drug use—which can impair motor and cognitive functions—including taking prescription or over-the-counter medications to alleviate a condition or injury (e.g., taking antihistamines for allergies); (b) alcohol consumption, which can reduce sensory perception resulting in loss of physical coordination; and (c) smoking, which can cause muscular deterioration and weakness among other things.

- **Fatigue:** A worker may become fatigued due to disruptions in sleep patterns resulting from social, familial, or work factors such as an excessive workload for an extended period.

- **Work or shift changes:** Changes in working hours (from day to evening) can alter a worker's effectiveness until he/she has adjusted to the change in schedule.

Table 1-1. Human capabilities contribute to work performance.

<table>
<thead>
<tr>
<th>Work Activity</th>
<th>Human Capability</th>
<th>Specific Examples</th>
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<tbody>
<tr>
<td>Information Perception</td>
<td>Perceptual Processes</td>
<td>Vision, Hearing, Pain</td>
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<tr>
<td>Information Processing and Decision-Making</td>
<td>Cognitive Processes</td>
<td>Short-Term Memory, Long-Term Memory, Problem Solving</td>
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1.2.3 Equipment/Design Considerations

Equipment can also contribute to an accident in two main ways. One way is for an equipment malfunction to directly cause the accident. A second way is for the equipment to contribute to a human error that then causes the accident. Even if equipment malfunction rather than human error appears to be the direct cause of an accident, it is important to trace the equipment malfunction back to potential sources of human error.
There are two main sources of human error: design flaws and improper maintenance. When an accident involves some type of equipment, it is useful to examine the equipment to determine whether the design is compatible with human capabilities and consistent with commonly accepted operating practices and norms. Equipment design features that can impact human-machine interaction are shown in Table 1-2. Accident investigations involving equipment should also include a review of the equipment’s technical manuals to ensure that operation and maintenance are congruent with design specifications.

### Table 1-2. Equipment design can affect human performance.

<table>
<thead>
<tr>
<th>Features</th>
<th>Interaction Characteristics</th>
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<tr>
<td>Large Equipment</td>
<td>■ Equipment to carry or house humans should be designed with specified size, stature, and sitting height limitations.</td>
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<td>■ A proper field of view should be provided.</td>
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<td>Control Placement and Operations</td>
<td>■ Control knobs and dials should be positioned so that an operator can easily reach and operate them.</td>
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<td>■ Controls should be placed in an arrangement that logically reflects the normal sequence of operations.</td>
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<td>■ Control operation should be compatible with widely accepted standards or norms (e.g., knobs turn clockwise to increase power and counterclockwise to decrease power).</td>
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<tr>
<td>Visual Displays</td>
<td>■ Information presented in visual displays should be easy to perceive, process, and interpret.</td>
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<td>■ Coded information should be compatible with widely accepted standards or norms (e.g., color-coded indicators, such as red for danger, yellow for caution).</td>
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<tr>
<td>Audio Indicators</td>
<td>■ Audio alarms should be easily interpreted and distinguishable from other audio indicators.</td>
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<td>■ Audio alarms should be compatible with widely accepted standards or norms, so that high frequency and rates indicate urgency.</td>
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### 1.2.4 Physical Work Environment

Environmental factors can influence human-machine performance and thereby contribute to an accident. The physical work environment is the setting in which the accident occurred.

Many physical work environment requirements are specified in Occupational Safety and Health Administration (OSHA) regulations. Environmental factors that may influence the effective performance of both humans and equipment include:

- **Illumination:** The level of lighting must be sufficient for workers to have a good view of their work environment, the equipment, and the materials they are working with.

- **Noise:** High levels of noise can distract workers from concentrating on the task they are performing. In addition, high levels of extraneous noise can interfere with audio indicators that workers rely on to signal actions or activities.

- **Vibration and motion:** High levels of vibration and motion can interfere with human task performance, especially tasks that require fine motor movement. Vibration can also interfere with equipment performance, causing unexpected performance decrements in equipment that is normally considered highly reliable.

- **Thermal conditions:** Worker performance is influenced by temperature extremes, which can often influence worker concentration (information processing and decision-making). Extreme temperatures may also affect human control responses by requiring additional clothing or gear for protection. In addition, equipment may have limited operating conditions under extreme temperatures. Therefore, it is important to identify the limits of equipment and machines under extreme temperatures.

- **Altitude and depth:** Humans can experience physical functioning problems when performing at high altitudes and extreme depths; in general, humans also experience cognitive functioning decrements under both these conditions.

Humans and equipment are limited in their capacity to perform effectively under extreme or unusual environmental conditions. When investigating an accident, it is important to characterize the environmental conditions at the time of the accident and the potential human or machine performance decrements that could result.

### 1.2.5 Organizational Work Environment

Organizational factors can contribute to accidents. Effective safety management systems are critical to establish a work environment in which safe operations are assured.

Experience in DOE facilities and in other industries in which safe operations are required has enabled DOE to identify the characteristics of organizations that are necessary to prevent accidents. These characteristics are
defined in DOE Policy 450.4, Safety Management System Policy, and include:

■ Line management is directly responsible for the protection of the public, workers, and the environment. Direct responsibility means that senior managers set clear policies that are implemented throughout all levels of the organization and are clearly communicated and understood. Managers create a safety culture by emphasizing safety in each management decision. Workers are empowered to raise issues, design safe work processes, and to stop work or refuse unsafe work assignments.

■ Lines of authority and responsibility for ensuring safety at all organizational levels must be clearly defined. Managers and workers at all levels understand that they are responsible for assuring the safety of any work activities within their span of control. They translate and communicate safety goals to their subordinates. Managers and workers are held accountable for safety performance through a variety of means, such as safety performance evaluation in annual performance appraisals, and establishing meaningful consequences for safety successes and failures.

■ Competence is commensurate with job responsibilities. All personnel in the organization have the experience, knowledge, skills, and abilities to perform their technical work and to perform it safely. Competence to perform work safely means that managers and workers are aware of the hazards associated with the work activities for which they are responsible and of the hazard controls that are necessary to protect the public, workers, and the environment from harm. Training programs are strong and kept current.

■ Priorities must be balanced. Decisions regarding resource investments achieve a balance between mission and safety goals. Schedule pressures are not allowed to compromise safety in work activities. Safety programs and initiatives are not eroded by budget cuts or staff reductions.

■ Safety standards and requirements are implemented. Managers and workers ensure that all safety standards and requirements are met when work is performed. Changes to standards and requirements lead to changes in safety management policies and procedures. Changes in mission, functions, and work activities are analyzed to detect any new hazards. Required hazard controls are identified and implemented.

■ Hazard controls are tailored to the work being performed. The scope and purpose of work activities are defined in advance. Hazards are identified, analyzed, categorized, and then controlled. Workers’ knowledge of any hazards is used in planning for the job, and their experience in performing the work is captured and institutionalized in procedures and training programs.

■ Operations are authorized. Work activities are planned and performed in accordance with the work plan. The scope, purpose, and staffing requirements of work activities are defined in advance. Work is authorized only when the work plan has been reviewed and accepted, and work is then performed within the controls. Hazard controls are implemented and workers are informed of the work to be performed and the hazard controls required.

In addition, safe and efficient organizations use operational experience to improve their performance. Safety performance is evaluated and the results are used to enhance operations. Systems are created to gather safety performance information from systematic measurements, from external and self-assessments, and from analyses of local incidents and near-misses. Any deficiencies in safety management are immediately corrected. Lessons learned at other facilities and in other industries are examined for applicability to the local work environment.

Comparing the organizational work environment in which the accident occurred to these critical organizational characteristics is likely to provide important information for understanding the accident.

Key Points to Remember

Accidents are unplanned and unintentional events that result in harm or loss to personnel, property, production, or anything that has some value. Barriers (physical and management) should exist to prevent accidents or mitigate their consequences. Accidents occur when one or more barriers in a work system fail to perform or do not exist.

Human factors are important in assessing the causes of accidents. Two basic principles are important in assessing the role of human factors in an accident:

■ Nearly every accident has more than one cause.

■ Human error can be identified as a causal factor in nearly every accident.

The major human attributes that affect work performance are:

■ Experience, knowledge, and training

■ Physical aptitude, fitness, and behavior

■ Stress
- Fatigue
- Work or shift changes.

In conducting the investigation, it is helpful to consider how the following factors contributed to the accident.

- **Human-machine interface:** The immediate activity involving the human and the machine/equipment that preceded and continued through the accidental event.
- **Human capabilities:** The capabilities of the worker or person directly involved in the accident.
- **Equipment/design considerations:** Equipment can contribute to accidents by either directly causing the accident or contributing to human errors that cause accidents. Even if equipment malfunction is the direct cause of the accident, equipment malfunctions can often be traced back to human error (poor design or maintenance).
- **Physical work environment:** The environmental conditions at the work site (extreme temperatures, poor lighting, high noise levels, or vibration) can impair human performance.
- **Organizational work environment:** Organizational factors such as line management responsibility for safety, personnel competence, safety prioritization, and hazard analysis and requirements, as well as other management system characteristics, directly impact safe operations.
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2

DOE's Accident Investigation Program

A primary mission of DOE is to operate its programs and facilities with a high level of safety. The accident investigation process has been designed to evaluate management systems and determine causal factors to prevent accident recurrence.

Specifically, the objectives of DOE's accident investigation program are to prescribe requirements for conducting investigations that will:

- Contribute to improved environmental protection and enhanced safety and health of DOE employees, contractors, and the public
- Prevent the recurrence of accidents
- Reduce accident fatality rates and promote a downward trend in the number and severity of accidents.

To accomplish these objectives, the accident investigation process must respond with speed, accuracy, focus, and brevity. The results of accident investigations can help managers eliminate underlying causes, prevent similar accidents, and enhance safety across the DOE complex. To achieve maximum benefit, accident investigations need to be convened rapidly, staffed and supported adequately, focused on pertinent and essential facts and causation, conducted accurately and thoroughly, concluded quickly, and reported clearly and concisely. Analytical techniques used to draw conclusions and to establish causes must be valid, appropriate, and easy to use. Finally, sound judgments of need promote better safety practices, address systemic problems, and when implemented, help prevent future occurrences without determining individual fault or proposing punitive measures.

2.1 Overall Management of the Program

The DOE Accident Investigation Program Manager (referred to throughout the workbook as the "Program Manager") in the Office of Oversight administers the program on behalf of the Assistant Secretary for Environment, Safety and Health (EH-1). The Program Manager is the central focal point for field and program office points of contact for program administration and training coordination.

2.2 Roles and Responsibilities of Key Participants
A number of groups and individuals play important roles in DOE's accident investigation program. These persons include appointing officials, line management, the accident investigation board, advisors and consultants to the board, and administrative support staff.

### 2.2.1 Appointing Officials and Line Management Participants

Table 2-1 lists the primary responsibilities of the appointing official for an accident investigation, heads of field elements, and for field and program office points of contact.

**Table 2-1. Appointing officials and line management participants in accident investigations have clearly defined responsibilities.**

<table>
<thead>
<tr>
<th>Participants</th>
<th>Major Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appointing Official</td>
<td>■ Formally appoints the accident investigation board in writing within three days of accident categorization</td>
</tr>
<tr>
<td></td>
<td>■ Establishes the scope of the board's authority, including the review of management systems, policy, and line management oversight processes as possible causal factors</td>
</tr>
<tr>
<td></td>
<td>■ Briefs board members within three days of their appointment</td>
</tr>
<tr>
<td></td>
<td>■ Ensures that notification is made to other agencies, if required by memoranda of understanding, law, or regulation</td>
</tr>
<tr>
<td></td>
<td>■ Emphasizes the board's authority to investigate the causal roles of organizations, management systems, and line management oversight up to and beyond the level of the appointing official</td>
</tr>
<tr>
<td></td>
<td>■ Accepts the investigation report and the board's findings</td>
</tr>
<tr>
<td></td>
<td>■ Publishes and distributes the accident investigation report within seven calendar days of report acceptance</td>
</tr>
<tr>
<td></td>
<td>■ Develops lessons learned for dissemination throughout the Department</td>
</tr>
<tr>
<td></td>
<td>■ Closes the investigation after the actions in DOE Order 225.1A, Paragraph 4d, are completed</td>
</tr>
<tr>
<td>Heads of Field Elements</td>
<td>■ Maintain a cadre of qualified(^1) accident investigation board chairpersons and DOE accident investigators</td>
</tr>
<tr>
<td></td>
<td>■ Ensure that DOE and contractor organizations are prepared to effectively accomplish initial investigative actions and assist accident investigation boards</td>
</tr>
<tr>
<td></td>
<td>■ Categorize the accident investigation in accordance with the algorithm provided in Attachment 2 of DOE Order 225.1A</td>
</tr>
<tr>
<td></td>
<td>■ Report accident categorization and initial actions taken by site readiness teams to the Office of the Deputy Assistant Secretary for Oversight (EH-2)</td>
</tr>
<tr>
<td></td>
<td>■ Serve as the appointing official for Type B and delegated Type A accident investigations</td>
</tr>
<tr>
<td></td>
<td>■ Ensure that readiness teams and emergency management personnel coordinate their activities to facilitate an orderly transition of responsibilities for the accident scene</td>
</tr>
<tr>
<td></td>
<td>■ Develop lessons learned for Type B accident investigations</td>
</tr>
<tr>
<td></td>
<td>■ Develop and submit (nominally within 30 days of report acceptance by the appointing official) corrective action plans to address judgments of need identified by accident investigation boards to the responsible Secretarial Officer and to the Office of the Deputy Assistant Secretary for Oversight.</td>
</tr>
<tr>
<td></td>
<td>■ Provide biannual status reports of accident investigation corrective actions to the Office of the Deputy Assistant Secretary for Oversight until all corrective actions are completed</td>
</tr>
</tbody>
</table>

\(^1\) Federal employees serving as board chairpersons or DOE accident investigators shall have attended an accident investigation course of instruction that is based on current materials developed by the Office of the Deputy Assistant Secretary for Oversight. This requirement is effective October 1, 1998.

**Table 2-1. Appointing officials and line management participants in accident investigations have clearly defined responsibilities. (Continued)**

<table>
<thead>
<tr>
<th>Participants</th>
<th>Major Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field and Program Office Points of Contact</td>
<td>■ Maintain a state of readiness to conduct investigations throughout the field element, their operational facilities, and the site readiness teams</td>
</tr>
<tr>
<td></td>
<td>■ Ensure that sufficient numbers of site DOE and contractor staff understand and are trained to conduct or support investigations</td>
</tr>
<tr>
<td></td>
<td>■ Procure appropriate equipment to support investigations</td>
</tr>
<tr>
<td></td>
<td>■ Maintain a current list of DOE and contractor staff trained in conducting or supporting investigations</td>
</tr>
<tr>
<td></td>
<td>■ Oversee the activities of the site readiness team</td>
</tr>
<tr>
<td></td>
<td>■ Assist readiness teams in coordinating investigation activities with accident mitigation measures taken by emergency response personnel</td>
</tr>
<tr>
<td></td>
<td>■ Communicate and transfer information on accidents to the head of the field elements, cognizant secretarial officer, or Headquarters element to whom they report</td>
</tr>
<tr>
<td></td>
<td>■ Communicate and transfer information to the accident investigation board chairperson before and after his/her arrival on site</td>
</tr>
<tr>
<td></td>
<td>■ Coordinate corrective action planning and follow-up with the head of the field element and coordinate comment resolution by reviewing parties</td>
</tr>
<tr>
<td></td>
<td>■ Assist heads of field elements in tracking implementation of corrective action plans</td>
</tr>
</tbody>
</table>
2.2.2 The Accident Investigation Board

When an accident occurs, the board must be rapidly assembled to collect the facts, conduct the investigation, reach conclusions, and prepare a report. The board's overall responsibilities are listed in Table 2-2. Responsibilities for those individuals who comprise the investigation board are described below.

Table 2-2. The accident investigation board has these major responsibilities.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Major Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident Investigation Board</td>
<td>■ Conducts a comprehensive investigation within the defined scope and allotted time frame, collects all pertinent information, and determines the facts relevant to the accident</td>
</tr>
<tr>
<td></td>
<td>■ Analyzes facts and determines causal factors</td>
</tr>
<tr>
<td></td>
<td>■ Analyzes the causal role of organizations, management systems, and oversight up to and beyond the level of the appointing official</td>
</tr>
<tr>
<td></td>
<td>■ Identifies judgments of need that must be addressed to prevent recurrence of the accident</td>
</tr>
<tr>
<td></td>
<td>■ Reports the essential facts and results of the investigation in a concise and understandable manner</td>
</tr>
<tr>
<td></td>
<td>■ Maintains appropriate communications with interested organizations throughout the investigation</td>
</tr>
<tr>
<td></td>
<td>■ Ensures the quality and accuracy of its activities</td>
</tr>
<tr>
<td></td>
<td>■ Assists the appointing official in closing the investigation, if requested</td>
</tr>
</tbody>
</table>

2.2.2.1. Board Chairperson

The board chairperson manages the investigation by coordinating the efforts of the board members, advisors/consultants, and support staff. The board chairperson is responsible to the appointing official for all aspects of the investigation. The chairperson maintains control of the accident scene until it is no longer needed for the investigation. The chairperson does not normally conduct investigative activities, but rather directs the overall effort, keeping it focused and on schedule.

If unlawful activity is revealed during the investigation, the chairperson notifies DOE and appropriate Federal, state, or local authorities, or in the case of fraud, waste, or abuse, the DOE Office of the Inspector General. If any potential Price-Anderson enforcement concerns are revealed, the chairperson notifies the Director, Office of Enforcement and Investigation (EH-10), the DOE Site Manager, and the contractor as soon as practical.

The chairperson's specific roles and responsibilities include:

■ Taking control of the investigation from the site readiness team

■ Providing leadership and managing board activities by:
  ■ Establishing and communicating the roles and responsibilities of board members, advisors, consultants, and support staff
  ■ Building effective team relationships with and among board members
  ■ Planning, scheduling, and coordinating activities
  ■ Establishing and meeting deadlines
  ■ Remaining continuously informed of the investigation's progress and status

■ Ensuring that the board is supported by appropriate advisors and consultants with specialized expertise, as needed

■ Resolving potential conflicts of interest for board members, advisors, and consultants

■ Serving as the point of contact with the appointing official and DOE management at the site, facility, or area where the accident occurred, and representing DOE in all matters pertaining to the investigation

■ Coordinating with, and communicating board activities to, interested managers and organizations who are stakeholders with a legitimate interest in the accident

■ Ensuring an effective and efficient investigation that thoroughly examines all potential causal factors, including management systems, within the allotted time frame

■ Generating a quality report of the investigation

■ Following report acceptance by the appointing official, conducting a briefing, together with the head of the field element, to Headquarters and field line management, as well as to the Assistant Secretary for Environment, Safety and Health (for Type A investigations), on the outcome of the investigation.

2.2.2.2 Board Members

Board members are primarily responsible for collecting and analyzing information, reaching conclusions regarding causal factors,
identifying judgments of need, and writing the report. Board members apply investigative and analytical techniques to make these determinations.

2.2.2.3 Advisors and Consultants

Advisors and consultants are used at the discretion of the chairperson whenever the circumstances of an accident require specialized expertise or special knowledge of the accident itself is required. These individuals may include:

- **Legal advisor**—helpful in dealing with legal issues that may arise, including liability issues and concerns related to the Freedom of Information and Privacy Acts. DOE counsel from the operations or field office having cognizance over the site, area, or facility involved generally fulfills this role. If this is not feasible, an attorney from the Office of General Counsel can assist the board.

- **Medical advisor**—a key person in any investigation involving an injury, illness, or fatality. The board may obtain advice from a physician to clarify medical issues early in the investigation.

- **Technical experts**—provide valuable expertise during investigations involving technical information about operations, policy, hazards, failure modes, component testing, and systems.

- **Professional/technical photographer**—critical for providing an accurate photographic record of evidence and the accident scene, using techniques not commonly known to investigators.

- **Site personnel**—may contribute specific knowledge of processes or activities in areas such as metallurgy, chemistry, electrical operations, or conduct of operations.

- **Union advisor**—can provide information on work practices, facilitate interviews with union members, and convey to workers the board's desire to assure that the accident is thoroughly investigated.

2.2.2.4 Support Staff Roles

The investigation board uses support staff to handle administrative functions or to provide expertise not available from members, consultants, and advisors. The following support positions are recommended:

- **Administrative coordinator**. This individual should be familiar with the administrative and logistical needs and processes of an accident investigation and be able to provide daily coordination of these matters. Other functions include tracking and controlling documentation, tracking appointments, assigning administrative tasks and priorities, and coordinating report production (a detailed list of responsibilities is included in Appendix C).

- **Analyst**. An individual trained in and knowledgeable of the various analytical techniques that can be used to support the accident investigation process (see Section 7 of this workbook). Board members have the responsibility for collecting and analyzing information; however, a dedicated analyst can recommend the proper analytical tools based on the type and complexity of the accident and process the information using the tools selected, allowing the board members to concentrate on the results of the analysis.

- **Technical writer/editor**. This person can facilitate the report writing process. While board members have primary writing responsibilities, use of a dedicated writer focuses responsibility for assembling the report, facilitates report preparation, and results in a more cohesive and readable report.

- **Typist/text processor**. A board usually needs at least one typist to perform general secretarial and administrative tasks, such as filing, word processing, and answering telephones. These personnel can often be provided by the facility where the investigation is being conducted.

- **Court reporters**. Using a court reporting service increases the timeliness and accuracy of interview transcripts. The use of court reporters gives all members of the board the opportunity to review interviews in which they did not participate and provides a transcript for reconstructing or developing the chronology of events preceding the accident. When an investigation requires numerous interviews, use of court reporters is essential and can help prevent the investigation from getting behind schedule in its early stages, when most of the interviewing takes place and when the information from interviews is needed. This service is available commercially in most areas.

2.3 Site Readiness

DOE Order 225.1A and its Attachment 1, Contractor Requirements Document, establish requirements and responsibilities for heads of field elements and contractors to:

- Support Type A, Type B, and limited scope accident investigations

- Establish and maintain readiness to respond to accidents.

Site readiness is an important, ongoing part of DOE's accident investigation program. This section addresses responsibilities of points of contact and heads of field elements, as well as activities needed to implement those responsibilities, in meeting site readiness requirements.

2.3.1 Readiness - What Is It?

Readiness to conduct accident investigations means preparing in advance to:

- Respond to and mitigate the consequences of an accident

- Preserve the accident scene and collect and control critical initial evidence—physical, human (given through witness statements or interviews), and documentary (including photographic media)

- Assist the accident investigation board with investigations.

To implement these requirements, the site's point of contact and designated readiness teams normally:
2.3.3 Maintaining Resources to Support Accident Investigations

Sufficient resources to support an onsite accident investigation should be in place or readily available. The specific composition of the site readiness team is determined by the field elements and their contractors. Ideally, the team should be documented in procedures and its performance should be periodically tested.

A well trained readiness team that participates in the initial response to an accident can provide valuable assistance to the accident investigation board when it assembles on site. DOE and contractor managers should ensure that accident responders and readiness teams can complete the immediate and near-term steps that will facilitate the investigation. When an accident occurs, immediate actions include taking charge of the accident scene quickly, initiating any required emergency response, assisting injured parties, ameliorating the accident conditions, and preserving and protecting evidence and the accident scene for later investigation. Each field element is responsible for maintaining a readiness capability to respond to accidents in this manner.

To ensure the capability for the necessary rapid response, heads of field elements and designated points of contact should ensure that:

- Sufficient numbers of readiness team personnel and prospective accident investigation board personnel are trained and available
- Adequate procedures for initial response have been established
- Equipment is available and functional
- The necessary infrastructure can be quickly assembled to respond to the accident and support the accident investigation.

Managers, through points of contact, evaluate the need for site- or organization-specific training to ensure that sufficient numbers of staff are available to perform these functions.

In determining the number and qualifications of potential accident investigation board members, consideration should be given to the need for supporting other Departmental elements by providing chairpersons and board members. Contracts that address accident readiness by contractors should be modified to include these provisions under DOE Order 225.1A, if they are not adequately addressed in existing contracts. The benefits of incorporating initial investigative or investigative support actions into emergency preparedness plans and drills should also be considered. It is important to ensure coordination between readiness teams and emergency management personnel to facilitate an orderly transition of responsibilities for the accident scene.

An important element in establishing site readiness is to ensure that both the DOE field element and contractors work together to ensure that the site has a well coordinated and effective capability for responding to accidents. This capability includes:

- Clearly documented and coordinated procedures, roles, responsibilities, authorities, and accountabilities
- Adequate resources to support investigations
- Focused training for the field or program office points of contact and the site readiness team
- Periodic practice and evaluation.

2.3.2 Establishing Written Procedures and Responsibilities

DOE field elements should have clearly documented and integrated procedures, roles, responsibilities, authorities, and accountabilities in their implementation directives for establishing and maintaining site readiness. In addition, their contractors establish and document their implementation directives for establishing and maintaining site readiness programs should:

- Contain appropriate detail regarding the specific responsibilities and activities that make up the accident response approach
- Provide clearly formulated guidelines that address decisions involving tradeoffs between accident mitigation/restoration of operations and accident scene/evidence preservation
- Be consistent with DOE orders
- Be coordinated with the emergency response program
- Be adequately communicated to the people responsible for taking or directing action in response to accidents.

Site readiness procedures should cover the activities indicated in Section 2.3.1.

2.3.3 Maintaining Resources to Support Accident Investigations

Sufficient resources to support an onsite accident investigation should be in place or readily available.

The specific composition of the site readiness team is determined by the field elements and their contractors. Ideally, the team should

- Assist in reporting events (in accordance with DOE Order 225.1A and DOE Order 232.1, Occurrence Reporting and Processing of Operations Information)
- Assist in restoring operations, if requested
- Document the accident scene through photography or other means
- Provide facilities, equipment, supplies, tools, and general administrative and logistical support for accident investigations
- Conduct initial investigative activities
- Provide sufficient numbers of DOE board chairpersons and accident investigators and, if requested, provide them to other DOE sites
- Transfer control and custody for the accident scene and evidence to the board chairperson when he/she arrives at the site.

Readiness teams coordinate their actions with or are integrated with emergency management personnel. The team's composition, location, equipment, and other characteristics are determined by field elements and their contractors. The operation of equipment for the team should be documented in procedures and its performance should be periodically tested.

An important element in establishing site readiness is to ensure that both the DOE field element and contractors work together to ensure that the site has a well coordinated and effective capability for responding to accidents. This capability includes:

- Sufficient numbers of readiness team personnel and prospective accident investigation board personnel are trained and available
- Adequate procedures for initial response have been established
- Equipment is available and functional
- The necessary infrastructure can be quickly assembled to respond to the accident and support the accident investigation.

Managers, through points of contact, evaluate the need for site- or organization-specific training to ensure that sufficient numbers of staff are available to perform these functions.

In determining the number and qualifications of potential accident investigation board members, consideration should be given to the need for supporting other Departmental elements by providing chairpersons and board members. Contracts that address accident readiness by contractors should be modified to include these provisions under DOE Order 225.1A, if they are not adequately addressed in existing contracts. The benefits of incorporating initial investigative or investigative support actions into emergency preparedness plans and drills should also be considered. It is important to ensure coordination between readiness teams and emergency management personnel to facilitate an orderly transition of responsibilities for the accident scene.

An important element in establishing site readiness is to ensure that both the DOE field element and contractors work together to ensure that the site has a well coordinated and effective capability for responding to accidents. This capability includes:

- Clearly documented and coordinated procedures, roles, responsibilities, authorities, and accountabilities
- Adequate resources to support investigations
- Focused training for the field or program office points of contact and the site readiness team
- Periodic practice and evaluation.
include individuals currently involved in the emergency response function. Field elements are also responsible for assuring that DOE and contractor organizations have mechanisms in place to provide enough qualified personnel to serve as accident investigation board chairpersons and members to support DOE accident investigations at other sites.

They also assure that other resources are readily accessible. These resources include reference documents, site references, office equipment, tools, measurement devices, office supplies, and protective gear. The Accident Investigation Equipment Checklist (provided at the end of this section) is a tool that field elements can use to assure that adequate resources to support accident investigations are readily available at the site.

TIP

To determine the necessary number of trained site readiness personnel, consider both the site's readiness needs and the site's obligation to supply accident investigators and accident investigation chairpersons to other DOE sites.

2.3.4 Training for Site Readiness

Site readiness requires formal training for the points of contact and site readiness team members. In addition, training for emergency response teams should ensure that when they respond to an accident, they consider the need to preserve the accident scene and evidence. Line managers and supervisors also need instruction in accident response; if they are present at an accident scene, these persons can be very useful in providing background about the event (e.g., people involved, witnesses present, equipment involved, material involved, and environmental factors).

The field element is responsible for identifying the minimum site- and organization-specific training requirements to support the site readiness capability.

Managers within affected organizations then develop appropriate training based on these requirements and site-specific needs.

Field elements or program offices are responsible for coordinating with the Program Manager to assure that DOE and contractor staff are trained in accident investigation techniques and readiness. In particular, the field or program office point of contact verifies that site readiness personnel responding immediately following an accident have been trained in:

- Initial reporting and categorization of events (in accordance with DOE Order 225.1A and DOE Order 232.1)
- Photographing and videotaping the accident scene
- Identifying, collecting, controlling, and preserving evidence and information
- Performing other initial investigative functions, such as taking witness statements and determining the fitness-for-duty status of all individuals injured in the accident
- Transferring responsibility for the accident scene, evidence, and documentation to the accident investigation board.

In addition to needing to know how, when, where, and to whom to report an accident and how to summon emergency help, those responding to an accident must know what actions they can take, and what actions require skilled and qualified emergency response professionals. Emergency personnel who direct and coordinate emergency response and rescue operations need to know what equipment, materials, and protective gear are required, how and where they are obtained, and what training or qualifications are required for their use. They also need to know the risks, hazards, or peculiarities of the operation, process, or facility involved, as well as what specialized knowledge, skills, procedures, and equipment are needed to handle them safely. They must know what means are needed and available to control and limit injuries and losses and to prevent emergency teams, rescuers, and investigative readiness teams from causing additional injury or loss or becoming casualties themselves.

Site readiness personnel who are prospective DOE accident investigators and chairpersons, as well as the field or program office point of contact, should attend an accident investigation course of instruction that is based on current materials developed by the Office of the Deputy Assistant Secretary for Oversight and must have the appropriate qualifications through experience in conducting comparable investigations.

2.3.5 Conducting Periodic Practices and Evaluations

To be effective, site readiness plans and procedures should be practiced and evaluated periodically. Because of the need for coordinated efforts, the benefits of incorporating the site readiness actions into emergency preparedness plans/procedures, as well as combining drills for site readiness and emergency preparedness, should be considered. Readiness teams can be evaluated during drills by having appropriate team members demonstrate tasks and functions such as:

- Collecting and storing evidence
- Identifying witnesses and taking statements
- Preparing an information transition plan for a board chairperson.

2.4 Accident Investigation Process Overview

The major activities between the accident and the end of the accident investigation are shown in Figure 2-1. They are discussed in detail in Part II of this workbook.
A nominal 30-calendar-day timeframe, beginning with the date of the board appointment and ending with submission of the accident report, has been established by DOE as a target for completing Type A and Type B accident investigations. The timeline and schedule of activities, illustrated in Table 2-3, is flexible and depends on specific accident circumstances, such as the accident's severity and complexity. The appointing official should attempt to identify any circumstances that may prolong this 30-day timeline and make appropriate adjustments to the completion date. The board chairperson should be aware of potential delays and make adjustments as early as possible. Figure 2-2 demonstrates how the three primary activity phases of an accident investigation overlap during the accident investigation cycle.
2.5 Waivers

In some instances when an accident meets the criteria for a Type A or Type B investigation, it nevertheless may be desirable not to conduct a Type A or Type B investigation if the head of the field element determines that the investigation would lead to no significant lessons learned. In such a case, the head of the field element submits a request for waiver, within five calendar days after the accident is categorized, to the Office of the Deputy Assistant Secretary for Oversight.

Table 2-3. The timeline for a Type A or Type B accident investigation requires conducting multiple simultaneous tasks.*

<table>
<thead>
<tr>
<th>Timeframe</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Collecting evidence, conducting interviews, conducting tests (engineering, chemical, nondestructive, etc.), initiating analysis, and beginning development of the report.</td>
</tr>
<tr>
<td>Week 2</td>
<td>Further collection of data, more in-depth analysis, and report writing by the board.</td>
</tr>
<tr>
<td>Week 3</td>
<td>Additional interviews, data analysis, and report writing. Additional data collection as needed to fill gaps identified in analyses. Factual accuracy check by site DOE and contractor line management. At end of the week, the board briefs site DOE and contractor line management on facts, conclusions, and judgments of need.</td>
</tr>
<tr>
<td>Week 4</td>
<td>Report completion, editing, and formatting; report review by Office of Oversight; report submittal to the appointing official.</td>
</tr>
</tbody>
</table>

* Limited scope investigations are permitted, if no substantial lessons learned would be expected from conducting a full scope investigation. For limited scope investigations, these activities are expected to be completed within 10-14 days, as discussed in Section 2.6 of this workbook.

Figure 2-2. The three primary activity phases in an accident investigation overlap significantly.

The Office of the Deputy Assistant Secretary for Oversight will review waiver requests and either recommend approval or disapproval of the requests in writing to the Assistant Secretary for Environment, Safety and Health, who will make the final determination in writing.

2.6 Limited Scope Accident Investigations

Limited scope investigations may be conducted when chartered by the Assistant Secretary of Environment, Safety and Health, as prescribed in DOE Order 225.1A, when it is determined that a formal but less resource-intensive investigation is warranted.

Limited scope investigation boards consist of a board chairperson and one to three board members. The requirements for selecting board chairpersons and board members are identical to those for Type A and Type B accident investigation boards. Limited scope investigations are expected to be completed within 10 to 14 days of board appointment.

The process for conducting limited scope investigations uses the same principles as those described previously for Type A and Type B accident investigations. The limited scope investigation may have an abbreviated scope, as determined by the charter. Facts are collected and analyzed using the analytical techniques described in Section 7 of this workbook (although the processes for using them are abbreviated); causal factors are identified; judgments of need are developed; and a report is written and submitted to the appointing official.
Key Points to Remember

DOE's accident investigation program provides timely, useful, and needed information regarding the causal factors of accidents in order to prevent future accidents from similar causes.

The Accident Investigation Program Manager in the Office of Oversight administers the accident investigation program. The Program Manager also coordinates accident investigation training.

Each person involved in the accident investigation process plays a specific role:

- **The Assistant Secretary for Environment, Safety and Health (EH-1)** serves as appointing official for Type A accident investigation boards (unless this responsibility is specifically delegated to the head of a field element), reviews all delegated Type A accident investigation reports, grants waivers of the requirement to conduct Type A or Type B accident investigations, and charters limited scope investigations.

- **The appointing official** establishes the board's authority; selects the board chairperson and board members; briefs the board before they begin their investigation activities; accepts the report; and closes the investigation.

- **Heads of field elements** serve as appointing officials for Type B accident investigation boards and ensure that DOE and contractor organizations in the field maintain investigative site readiness and develop and implement corrective action plans.

- **Field or program office points of contact** ensure that sites can effectively respond to, conduct, or assist with accident investigations; serve as a liaison to the Program Manager on accident investigation matters; and assist in distributing lessons learned.

- **Board chairpersons** have overall responsibility for the investigation and are accountable to the appointing official.

- **Board members** perform accident investigation activities—gather information, analyze data, and report findings.

The field or program office point of contact is responsible for ensuring that the site can support accident investigation activities. To prepare for these activities, points of contact should:

- Assure that site readiness personnel are trained to respond to accidents, preserve and collect evidence, and take witness statements
- Periodically verify readiness by conducting drills to practice readiness skills.

The accident investigation cycle has a nominal 30-calendar-day timeline for completion. However, individual investigation schedules may vary, depending on an accident's complexity.

---

**Accident Investigation Equipment Checklist (page 1 of 5)**

<table>
<thead>
<tr>
<th>DOCUMENT PACKET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Checklist</td>
</tr>
<tr>
<td><strong>sm</strong></td>
</tr>
<tr>
<td><strong>nm</strong></td>
</tr>
<tr>
<td><strong>z</strong></td>
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<tr>
<td></td>
</tr>
</tbody>
</table>

**SITE DOCUMENTS**

<table>
<thead>
<tr>
<th></th>
<th>Organization charts</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

- Organization charts
- Facility maps
- Applicable blueprints and as-built drawings
- Policies and procedures manuals
- ES&H manuals
- Training manuals
- Phone books (local, facility, and Headquarters)
<table>
<thead>
<tr>
<th></th>
<th>Checklist</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>OFFICE SUPPLIES</strong></td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>18 In/Out baskets</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>Adhesive notes (assorted sizes &amp; colors)</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>Adhesive flags (assorted colors)</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>Chart paper (1/4&quot; grid)</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>12 hard-bound journals</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>2 boxes suspension folders</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>12 letter-size expandable files</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>3 boxes computer disks</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>1 box full-page dividers</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>8 calendars</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>3 boxes pens, red</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>3 boxes pens, black</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>4 heavy black markers</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>1 box yellow highlighters</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>1 box pencils (hard)</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>12 boxes paper clips</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>12 boxes binder clips (assorted)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Checklist</td>
<td>Notes</td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td></td>
<td>OFFICE SUPPLIES (cont’d)</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>4 scissors</td>
<td>z</td>
</tr>
<tr>
<td>z</td>
<td>2 three-hole punch</td>
<td>z</td>
</tr>
<tr>
<td>z</td>
<td>2 clipboards</td>
<td>z</td>
</tr>
<tr>
<td>z</td>
<td>12 three-ring binders - (1&quot;, 2&quot;, 3&quot;)</td>
<td>z</td>
</tr>
<tr>
<td>z</td>
<td>2 boxes manila file folders</td>
<td>z</td>
</tr>
<tr>
<td>z</td>
<td>Assorted file folder labels</td>
<td>z</td>
</tr>
</tbody>
</table>

**Accident Investigation Equipment Checklist** (page 3 of 5)
| z | Overnight mailing supplies | z |
| z | 12 phone message pads | z |
| z | 6 bottles all-purpose whiteout | z |
| z | Assorted envelopes (9"x12", 5"x7", 10"x13") | z |
| z | DOE-HQ memorandum letterhead | z |
| z | 24 ruled notepads | z |
| z | 12 steno pads | z |
| z | 3" x 5" index cards | z |
| z | Return address labels | z |
| z | Packing boxes | z |
| z | 5 boxes double-pocket portfolio (assorted colors) | z |
| z | Nylon filament tape | z |

**OFFICE EQUIPMENT**

<p>| z | Telephones | z |
| z | Answering machine or voice mail capability | |
| z | Computers/software | Provided by EH-21 for Type A investigations |
| z | Letter-quality printers | Provided by EH-21 for Type A investigations |
| z | Camera with flash | Contained in Type A &quot;Go Kit&quot; |
| z | Film | z |</p>
<table>
<thead>
<tr>
<th>Checklist</th>
<th>Notes</th>
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<tbody>
<tr>
<td><strong>OFFICE EQUIPMENT (cont'd)</strong></td>
<td></td>
</tr>
<tr>
<td>z  Portable cellular phone</td>
<td></td>
</tr>
<tr>
<td>z  50 3.5” formatted diskettes with labels</td>
<td></td>
</tr>
<tr>
<td>z  Pagers (beepers)</td>
<td></td>
</tr>
<tr>
<td>z  Fax machine</td>
<td></td>
</tr>
<tr>
<td>z  Cassette tape recorder, cassettes, and batteries</td>
<td>z</td>
</tr>
<tr>
<td>z  High-speed photocopier (multifunction)</td>
<td></td>
</tr>
<tr>
<td>z  Document shredder</td>
<td></td>
</tr>
<tr>
<td>z  Electric pencil sharpener</td>
<td></td>
</tr>
<tr>
<td><strong>TOOLS</strong></td>
<td></td>
</tr>
<tr>
<td>z  Flashlight or lantern (explosion-proof)</td>
<td></td>
</tr>
<tr>
<td>z  Spare batteries and bulb for flashlight</td>
<td></td>
</tr>
<tr>
<td>z  Steel tape measure - 100-foot</td>
<td></td>
</tr>
<tr>
<td>z  Scale -12-inch ruler</td>
<td></td>
</tr>
<tr>
<td>z  Scissors (heavy-duty)</td>
<td></td>
</tr>
<tr>
<td>z  Compass - professional type (e.g. MILSPEC Lensatic or surveyor's)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Checklist</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------</td>
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<tr>
<td><strong>SPECIAL DEVICES</strong> (cont'd)</td>
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<tr>
<td>z</td>
<td>Calculators</td>
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<tr>
<td>z</td>
<td>Calipers, inside and outside diameter</td>
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<tr>
<td><strong>PERSONAL PROTECTION EQUIPMENT</strong></td>
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<tr>
<td>z</td>
<td>Hard hats</td>
</tr>
<tr>
<td>z</td>
<td>First aid kit</td>
</tr>
<tr>
<td>Description</td>
<td>Quantity</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Glasses, other eye protection</td>
<td>z</td>
</tr>
<tr>
<td>Gloves, leather or canvas</td>
<td>z</td>
</tr>
<tr>
<td>Ear plugs, other hearing protection</td>
<td>z</td>
</tr>
<tr>
<td>Vest, orange flagperson's</td>
<td>z</td>
</tr>
<tr>
<td>Steel-toed boots or shoes</td>
<td>z</td>
</tr>
<tr>
<td>Dust masks, respirators</td>
<td>z</td>
</tr>
</tbody>
</table>

This list is not exhaustive or limiting. Use this checklist as a starting point and add or delete items as needed.

---

**Accident Investigation "Go Kit" Contents**

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SUITCASE 1 OF 3</strong></td>
<td></td>
</tr>
<tr>
<td>Bushnell 10 x 50 Binoculars</td>
<td>1</td>
</tr>
<tr>
<td>Gerber Multi-Plier Tool</td>
<td>1</td>
</tr>
<tr>
<td>30' Steel Tape Measure</td>
<td>1</td>
</tr>
<tr>
<td>100' Steel Tape Measure</td>
<td>1</td>
</tr>
<tr>
<td>Two Wheel Rolatape</td>
<td>1</td>
</tr>
<tr>
<td>NiteTracker Rechargeable Spotlight</td>
<td>1</td>
</tr>
<tr>
<td>Replacement Bulbs for NiteTracker</td>
<td>2</td>
</tr>
<tr>
<td>Kodak DC50 Zoom digital camera (S/N EKA63701001 &amp; EKA62501451)</td>
<td>1</td>
</tr>
<tr>
<td>Energizer Hi Energy Lithium AA batteries (camera)</td>
<td>12</td>
</tr>
<tr>
<td>Film cards for camera</td>
<td>5</td>
</tr>
<tr>
<td>Camera connector cables</td>
<td>2 sets</td>
</tr>
<tr>
<td>AC Adapter (NiteTracker)</td>
<td>1</td>
</tr>
<tr>
<td>Description</td>
<td>Quantity</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>DC Adapter (NiteTracker)</td>
<td>1</td>
</tr>
<tr>
<td>Evidence Tags (packs)</td>
<td>2</td>
</tr>
<tr>
<td>Evidence/Security tape (108')</td>
<td>2</td>
</tr>
<tr>
<td>Inspection Mirror</td>
<td>2</td>
</tr>
<tr>
<td>Tweezer (metal)</td>
<td>2</td>
</tr>
<tr>
<td>Tweezer (metal)</td>
<td>2</td>
</tr>
<tr>
<td>Tweezer (metal)</td>
<td>2</td>
</tr>
<tr>
<td>Tweezer (disposable)</td>
<td>24</td>
</tr>
</tbody>
</table>

**Accident Investigation "Go Kit" Contents (page 2 of 2)**

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Suitcase 2 of 3</strong></td>
<td></td>
</tr>
<tr>
<td>Bushnell 7 x 35 Binoculars</td>
<td>1</td>
</tr>
<tr>
<td>Super Sabrelite Flashlight</td>
<td>10</td>
</tr>
<tr>
<td>&quot;Duracell&quot; size Battery Pack (10-battery pack)</td>
<td>3 packs</td>
</tr>
<tr>
<td>Latex Exam Gloves: Small (box)</td>
<td>1</td>
</tr>
<tr>
<td>Latex Exam Gloves: Medium (box)</td>
<td>1</td>
</tr>
<tr>
<td>Latex Exam Gloves: Large (box)</td>
<td>1</td>
</tr>
<tr>
<td>Latex Exam Gloves: X-Large (box)</td>
<td>1</td>
</tr>
<tr>
<td>Nuisance Odor Masks</td>
<td>10</td>
</tr>
<tr>
<td>Vionex Skin Wipes (50/box)</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Suitcase 3 of 3</strong></td>
<td></td>
</tr>
<tr>
<td>Minolta Freedom Action Zoom Camera</td>
<td>1</td>
</tr>
<tr>
<td>Kodak film 100, 12 exp</td>
<td>2 rolls</td>
</tr>
<tr>
<td>Kodak film 200, 12 exp</td>
<td>2 rolls</td>
</tr>
<tr>
<td>Kodak film 400, 12 exp</td>
<td>1 roll</td>
</tr>
<tr>
<td>Item</td>
<td>Quantity</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Kodak film 400, 24 exp</td>
<td>1 roll</td>
</tr>
<tr>
<td>Camera battery, C123A</td>
<td>3</td>
</tr>
<tr>
<td>Evidence bags - paper, style 86</td>
<td>38</td>
</tr>
<tr>
<td>Evidence bags - paper, style 25</td>
<td>29</td>
</tr>
<tr>
<td>Evidence bags - paper, style 12</td>
<td>25</td>
</tr>
<tr>
<td>Evidence bags - paper, style 4</td>
<td>60</td>
</tr>
<tr>
<td>Evidence bags - zip lock plastic, 9 x 12</td>
<td>50</td>
</tr>
<tr>
<td>Evidence bags - zip lock plastic, 5 x 8</td>
<td>50</td>
</tr>
<tr>
<td>Evidence bags - zip lock plastic, 4 x 6</td>
<td>50</td>
</tr>
<tr>
<td>Evidence bags - zip lock plastic, 3 x 5</td>
<td>50</td>
</tr>
</tbody>
</table>
3

Appointing the Investigation Board

Before an accident investigation can actually begin, the appointing official must conduct a number of activities, including selecting and briefing the investigation board. These activities are discussed below.

3.1 Establishing the Accident Investigation Board and Its Authority

Upon notification of an accident requiring a Type A or Type B investigation, the appointing official selects the accident investigation board chairperson and three to six other board members, one of whom must be a DOE accident investigator. The appointing official for a Type A accident investigation is the Assistant Secretary for Environment, Safety and Health (EH-1), unless this responsibility is delegated to the head of the field element. The appointing official for Type B accident investigations is the head of the field element. Limited scope investigations are chartered by the Assistant Secretary for Environment, Safety and Health. A list of prospective chairpersons who meet minimum qualifications is available from the Program Manager. The Program Manager also maintains a list of qualified board members, consultants, advisors, and support staff, including particular areas of expertise for potential board members or consultants/advisors. The selected chairperson can help identify and select board members and others needed to conduct the investigation. In selecting these individuals, the appointing official follows the criteria defined in DOE Order 225.1A, which are shown in Table 3-1.

DOE Order 225.1A establishes some additional restrictions concerning the selection of board members and chairpersons. No member shall have:

- A supervisor-subordinate relationship with another board member
- Any conflict of interest or direct or line management responsibility for day-to-day operation or management of the facility, area, or activity involved in the accident.

Consultants, advisors, and support staff can be assigned to assist the board where necessary, particularly when DOE employees with necessary skills are not available. For example, advisory staff may be necessary to provide knowledge of management systems or organizational concerns or expertise on specific DOE policies. A dedicated and experienced administrative coordinator (see Appendix C) is recommended. The Program Manager can help identify appropriate personnel to support accident investigation boards.
The appointing official must appoint the accident investigation board within three calendar days after the accident is categorized by issuing an appointment memorandum. If the board appointment is delayed beyond three calendar days, the rationale for the delay must be provided to the Assistant Secretary for Environment, Safety and Health (EH-1).

Table 3-1. Board members must meet these criteria.

<table>
<thead>
<tr>
<th>Role</th>
<th>Qualifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chairperson</td>
<td>■ Senior DOE manager</td>
</tr>
<tr>
<td></td>
<td>■ Preferably a member of the Senior Executive Service or at a senior general service grade level deemed appropriate by the appointing official</td>
</tr>
<tr>
<td></td>
<td>■ Demonstrated managerial competence</td>
</tr>
<tr>
<td></td>
<td>■ Knowledgeable of DOE accident investigation techniques</td>
</tr>
<tr>
<td></td>
<td>■ Experienced in conducting accident investigations through participation in at least one Type A or Type B investigation, or equivalent experience</td>
</tr>
<tr>
<td></td>
<td>■ Effective October 1, 1998, has participated in an accident investigation course sponsored by the Deputy Assistant Secretary for Oversight</td>
</tr>
<tr>
<td>Board Members</td>
<td>■ DOE employee</td>
</tr>
<tr>
<td></td>
<td>■ Subject matter expertise in areas related to the accident, including knowledge of the Department's safety management system policy and integrated safety management system</td>
</tr>
<tr>
<td></td>
<td>■ At least one board member must be a DOE accident investigator, having participated in at least one Type A or Type B accident investigation</td>
</tr>
<tr>
<td>Board Member or Advisor/Consultant</td>
<td>■ Knowledgeable in evaluating management systems, the adequacy of policy and its implementation, and the execution of line management oversight</td>
</tr>
<tr>
<td></td>
<td>■ Industry working knowledge in the analytical techniques used to determine accident causal factors</td>
</tr>
</tbody>
</table>

The appointment memorandum establishes the board’s authority and includes the scope of the investigation, the names of the individuals being appointed to the board, a specified completion date for the final report (nominally 30 calendar days), and any special provisions deemed appropriate.

The scope of the investigation includes:

■ Gathering facts
■ Analyzing facts and evidence
■ Developing conclusions
■ Identifying judgments of need related to DOE and contractor organizations and management systems that could or should have prevented the accident
■ Reviewing all levels of the organization up to and beyond the level of the appointing official.

3.2 Briefing the Board

The appointing official is responsible for briefing all board members as soon as possible (within three days) after their appointment to ensure that they clearly understand their roles and responsibilities. This briefing may be given via videoconference or teleconference. If it is impractical to brief the entire board, at least the board chairperson should receive the briefing and then convey the contents of the briefing to the other board members before starting the investigation. The briefing emphasizes:

■ The scope of the investigation
■ The board’s authority to examine DOE and contractor organizations and management systems,
including line management oversight, as possible root causes of an accident, up to and beyond the level of the appointing official

- The necessity for avoiding conflicts of interest
- Evaluation of the effectiveness of management systems, as defined by DOE Policy 450.4 (Safety Management System Policy)
- Pertinent accident information and special concerns of the appointing official based on site accident patterns or other considerations.

---

**Key Points to Remember**

- Upon notification of an accident requiring an investigation, the appointing official selects the board chairperson and board members and briefs them before they begin the investigation.

- Board chairpersons and members must meet the experience and qualification criteria defined in DOE Order 225.1A.

- The appointing official establishes the board's authority in a written appointment memorandum.

- The scope of the investigation includes identifying causal factors and developing conclusions and judgments of need related to DOE and contractor organizations and management systems, including line management oversight, up to and beyond the level of the appointing official.
Implementing Site Readiness

This section addresses actions to be taken by field element readiness teams immediately following an accident. All of these actions occur before the DOE accident investigation board chairperson arrives on site.

Many immediate post-accident activities are concurrent with emergency actions taken to save lives and limit losses and hazards. Emergency action considerations—particularly lifesaving and life-protecting activities—always take first priority, even if property or evidence is destroyed, distorted, or broken in the process. The adverse effects of tradeoffs that must be made during emergency response can be minimized through advance preparation and planning to ensure proper coordination of emergency actions with initial investigative activities.

It is important, therefore, that the head of the field element ensure that readiness teams and emergency response personnel coordinate their activities for optimal emergency and initial investigative response. Following these initial actions, the field or program office point of contact is responsible for ensuring a smooth transition of initial investigative activities to the accident investigation board chairperson, including transferring evidence and other information relevant to the accident.

4.1 Immediate Post-Accident Actions

Immediately after an accident occurs, the field or program office point of contact is responsible for notifying and providing critical information to the following individuals: the head of the field element; the cognizant secretarial officer or responsible official at the appropriate Headquarters element; the Accident Investigation Program Manager; the board chairperson (after appointment); the emergency operations center; and the emergency response team. The point of contact then:

- Coordinates with the emergency response team to preserve the accident scene
- Begins legal negotiations for temporary control of the area if the accident occurs on public property or on
property owned by a private party

- Establishes an accident investigation "command center" (a large, dedicated conference room to be used exclusively by the accident investigation board)
- Initiates collection and control of evidence and documentation of the accident scene and scenario
- Manages identification of witnesses and collection of witness statements
- Determines which contractor and line organizations are affected by the accident
- Provides input into decisions made by line managers regarding mitigation actions and the restoration of operations, as appropriate.

Each site readiness team member has responsibility for supporting some portion of these activities, particularly those described in the sections that follow.

### 4.2 Preserving and Documenting the Accident Scene

The effectiveness of an accident investigation depends on immediate preservation of the accident scene and the physical, human, and documentary evidence related to the accident. Because the accident investigation board may not arrive until two or three days after the accident, the site readiness team preserves and documents the condition and status of the accident scene. This encompasses assessing the medical condition and fitness-for-duty status of the injured or others involved in the accident (including requesting an autopsy, as appropriate), and preserving and recording the accident scene by means of written documentation, sketches, video, and photographs (including the location of equipment, parts, materials, debris, spills and stains, injured parties and witnesses, and other pertinent items). Procedures to be used by the site readiness team in preserving, collecting, and documenting evidence for the board are discussed below.

#### 4.2.1 Securing and Preserving the Scene

The accident scene should be secured immediately following an accident. This can be achieved in several ways, including:

- Removing and excluding all persons from the accident scene except essential emergency responders
- Cordonning the area with rope, tape, or barricades
- Locking doors and gates
- Posting warning signs
- Posting security personnel to control access
- Taking photographs and narrated videotape recordings of the accident scene, especially of any evidence that easily can be destroyed (e.g., tire tracks, fluids on the ground).

**TIP**

Securing a frequently used or public area may require additional efforts. Security personnel can be posted around the area to help secure the accident scene long enough for the site readiness team to complete a thorough walkthrough and document the scene, if long-term access controls are not feasible.

To effectively preserve the accident scene, the first member of the site readiness team to arrive is responsible for performing a walkthrough to:

- Characterize the accident scene
- Identify key human, physical, and documentary evidence
- Identify changes made to the scene because of accident mitigation activities
- Define the physical characteristics of the accident scene (e.g., "injured person is four feet from equipment, lying face down").

This initial information should be documented through notes or diagrams labeled as "initial walkthrough."

**TIP**

If the accident occurs in an area that makes securing the accident scene difficult, the walkthrough may be the sole opportunity to collect and preserve important evidence.
4.2.2 Documenting the Scene

Designated site readiness team members are responsible for recording the accident scene as it exists after the accident. Effective documentation methods include:

- Photographs
- Videotapes
- Initial position maps
- Sketches.

Because a professional photographer or videographer may not be available, it is important that designated site readiness team members be familiar with these techniques so that they can capture the initial state of the accident scene. Site readiness team members need to be aware of what documentary evidence is needed for successful accident investigations. A sufficient number of qualified readiness team members should be available on site to perform these functions at all times. If necessary, initial photographs and videotapes can be supplemented later with professional photographs and videotapes.

Sketches and position maps can be used to note items removed from the scene prior to photographing and videotaping. These sketches and maps should include measured distances and directions from reference objects that will remain at the scene. The original location of evidence should be marked at the accident scene (using paint, tape, chalk, or other appropriate media) before evidence is removed.

Details on documenting the accident scene using photographs, videotapes, position maps, and sketches are provided in Section 6 of this workbook.

4.3 Collecting, Preserving, and Controlling Evidence

There are three types of evidence: physical, human (given through witness statements or interviews), and documentary (including photographic media). Physical evidence at an accident scene may include solids, liquids, and gases. Documentary evidence includes all the documentation developed by the site readiness team, as well as accident-related paper and electronic information, such as logbooks, instrument charts, as-built drawings, engineering analyses, vendor information, correspondence, and computer software.

Most physical evidence can safely be left intact at a protected accident scene to await examination by the investigation board. However, some evidence may be too perishable to remain safely at the scene, and some may have been removed during emergency response or casualty evacuation. Perishable evidence includes artifacts that may provide information about the accident and are located at the scene, but that may be corrupted, moved, or lost if left at the scene. For example, fluids emanating from equipment or vehicles involved in an accident may quickly evaporate or be absorbed by surrounding materials. Therefore, fluid samples should be taken quickly.

Before any evidence is removed from the accident scene, site readiness team members should preserve its integrity by:

- Recording the exact location and orientation of evidence at the scene, using measurements, logs, sketches, photography, and video
- Establishing secure storage locations for evidence
- Establishing and maintaining a strict chain of custody (documentation showing physical custody) for each item of evidence
- Ensuring that access to evidence is limited only to those who are investigating the accident until transfer of the evidence to the accident investigation board.

Tools to use in collecting, preserving, and controlling evidence are discussed in Section 6 of this workbook.

TIP

Be conservative in determining whether items are evidence. It is easy to discard items that are not needed later on, but it may be difficult or impossible to recover discarded items intact.

4.4 Obtaining Initial Witness Statements

Human evidence (evidence given through witness statements or interviews) also must be immediately preserved by identifying and isolating witnesses. A witness is anyone who either directly observed or was affected by the accident,
or who was directly or indirectly involved in the process, equipment, or system affected. Statements from witnesses must be taken as soon as possible, preferably before they leave the accident scene, to ensure that initial observations and impressions are not lost or altered.

**TIP**

Quickly identify witnesses and take their statements (e.g., from injured parties, eyewitnesses, and other participants) because witnesses' initial statements are more accurate and have greater credibility than those made later.

Other persons, such as emergency response personnel, persons who arrive at the scene shortly after the accident, and anyone else who might be expected to provide material information about the accident, should be identified, located, and asked to provide statements. Early statements form the basis for documenting the accident sequence and identifying potential interviewees for the more extensive and formal interviews to be conducted later by the accident investigation board. Guidance on gathering witness statements is provided below.

If accident circumstances prevent the site readiness team from taking witness statements at the scene, names and contact information for all witnesses should be recorded. The *Accident Investigation Preliminary Interview List* (see end of this section) can be used to record this information. To preserve initial observations, witnesses to the accident should be: (1) informed not to talk about the accident except to accident response and investigative personnel, and (2) isolated to the extent possible before and while giving their initial statements. Usually, witnesses can be categorized as shown in Table 4-1, with initial statements taken in the order in which the categories are listed.

**Table 4-1. Several types of witnesses should provide preliminary statements.**

<table>
<thead>
<tr>
<th>Type of Witness</th>
<th>Relationship to the Accident</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal Witnesses</td>
<td>■ Those directly involved in or who sustained injury from the accident</td>
</tr>
<tr>
<td>Eyewitnesses</td>
<td>■ Participants</td>
</tr>
<tr>
<td>■ Observers of the accident or events immediately preceding, during, or following the accident</td>
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</tr>
<tr>
<td>Emergency Response Personnel and Site Readiness Team Members</td>
<td>■ Those arriving at the scene shortly after the accident</td>
</tr>
<tr>
<td>Other Potential Witnesses</td>
<td>■ Those in the vicinity of the accident</td>
</tr>
<tr>
<td>■ Those with knowledge of preceding events or conditions, such as shift workers on duty prior to the shift during which the accident occurred; the shift change-over team leader; or security personnel who may have conducted a recent walkthrough</td>
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<tr>
<td>■ Persons with work tasks related to the process, equipment, or facility involved</td>
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</tr>
<tr>
<td>■ Equipment and facility designers, operators, procurement specialists, and safety and quality personnel</td>
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</tbody>
</table>

Some witnesses may leave the accident scene before they are identified. To ensure that all witnesses are identified:

■ Ask witnesses to list or recall others at the scene

■ Make a public request for information via local media and site notification and communication systems.

A standardized witness statement form, such as the *Accident Investigation Witness Statement Form* (see the end of this section), may be used for gathering initial witness statements. Using a standard form helps ensure consistency in the type of information obtained from each witness and helps investigators obtain the information in a structured manner. The questions on this form are open-ended to ensure that witnesses are not constrained from conveying their observations and impressions.

Asking witnesses to sketch or diagram the accident setting also may help capture some of this information. The site readiness team should encourage witnesses to revisit the accident scene to help clarify or recall information.
Finally, any behavioral observations that may impact the witness' statement should be noted.

### 4.5 Transferring Information to the Board

The field or program office point of contact ensures the orderly transfer of information by:

- Identifying and reporting the accident to the Program Manager
- Briefing the board chairperson and continuing to transfer important information to the chairperson prior to his/her arrival on site
- Continuing communication with the Program Manager
- Providing a detailed, well-structured briefing to the chairperson upon his/her arrival on site and to the entire board when they are assembled on site
- Transferring documentary evidence, along with the secured accident scene and other evidence, to the accident investigation board.

Information should be summarized and organized in a structured manner to provide a clear description of the accident scene and scenario. The point of contact also conducts verbal briefings and faxes accident documentation materials to both the Program Manager and the chairperson. Early access to information allows these persons to start:

- Identifying information about similar types of accidents
- Identifying and contacting appropriate board members
- Identifying and contacting consultants and advisors
- Scoping and planning the accident investigation before the board arrives on site.

---

### Key Points to Remember

- The site readiness team is responsible for a number of initial investigative activities immediately following an accident, including preserving evidence and documenting the accident scene.
- To facilitate optimal accident response, the site readiness team should maintain close coordination or integration with emergency response personnel and the emergency operations center.
- Emergency response actions take precedence over initial investigative actions. To minimize the loss of evidence, advance planning and coordination with emergency response personnel are necessary.
- The site readiness team should collect, document, and control perishable evidence that cannot remain at the accident scene.
- Initial witness statements should be taken as soon as possible after the accident to ensure maximum accuracy and credibility.
- Procedures should be in place for transferring information collected by the site readiness team to the board chairperson.
## Accident Investigation Preliminary Interview

### List

<table>
<thead>
<tr>
<th>Interviewee/Title</th>
<th>Reason for Interview</th>
<th>Phone Number</th>
<th>Location/Shift/Company Affiliation</th>
<th>Notes</th>
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<tr>
<td>Name:</td>
<td>Job Title:</td>
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<td></td>
<td></td>
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<tr>
<td>Telephone No.</td>
<td>Supervisor:</td>
<td></td>
<td></td>
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</tbody>
</table>

Work Location:

Location of Accident:

Accident Time and Date:

Please fully describe the accident sequence from start to finish (use additional paper as needed):

Please fully describe the work and conditions in progress leading up to the accident (use additional paper as needed):

Note anything unusual you observed before or during the accident (sights, sounds, odors, etc.):
What was your role in the accident sequence?

Accident Investigation Witness Statement Form

What conditions influenced the accident (weather, time of day, equipment malfunctions, etc.)?

What do you think caused the accident?

How could the accident have been prevented?
<table>
<thead>
<tr>
<th>Please list other possible witnesses:</th>
</tr>
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<tbody>
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<td></td>
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</table>

<table>
<thead>
<tr>
<th>Additional comments/observations:</th>
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<tr>
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</table>

<table>
<thead>
<tr>
<th>Signature:</th>
<th>Date/Time:</th>
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<tbody>
<tr>
<td></td>
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</table>
Managing the Accident Investigation

The accident investigation is a complex project that involves a significant workload, time constraints, sensitive issues, cooperation between team members, and dependence on others. To finish the investigation within the timeframe required, the board chairperson must exercise good project management skills and promote teamwork. The chairperson's initial decisions and actions will influence the tone, tempo, and degree of difficulty associated with the entire
investigation. This section provides the board chairperson with techniques and tools for planning, managing, and controlling the investigation.

5.1 Project Planning

Project planning must occur early in the investigation. The chairperson should begin developing a plan for the investigation immediately after his/her appointment. The plan should include a preliminary report outline, specific task assignments, and a schedule for completing the investigation. It should also address the resources, logistical requirements, and protocols that will be needed to conduct the investigation.

The chairperson's initial planning activities are shown in the Accident Investigation Startup Activities List, provided at the end of this section. The chairperson and administrative coordinator can use this list to organize the initial investigative activities.

5.1.1 Collecting Initial Site Information

Following appointment, the chairperson is responsible for contacting the site to obtain as many details on the accident as possible. The field or program office point of contact or the site readiness team leader is usually designated as the liaison with the board. The chairperson needs the details of the accident to determine what resources, board member expertise, and technical specialists will be required. Furthermore, the chairperson should request background information, including site history, site maps, and organization charts. The Accident Investigation Information Request Form (provided at the end of this section) can be used to document and track these and other information requests throughout the investigation.

5.1.2 Determining Task Assignments

A useful strategy for determining and allocating tasks is to develop an outline of the accident investigation report, including content and format, and use it to establish tasks for each board member. This outline helps to organize the investigation around important tasks and facilitates getting the report writing started as early as possible in the investigation process. Board members, advisors, and consultants are given specific assignments and responsibilities based on their expertise in areas such as management systems, work planning and control, occupational safety and health, training, and any other technical areas directly related to the accident. These assignments include specific tasks related to gathering and analyzing facts, conducting interviews, determining causal factors, developing conclusions and judgments of need, and report writing. Assigning designated board members specific responsibilities ensures consistency during the investigation.

5.1.3 Preparing a Schedule

The chairperson also prepares a detailed schedule using the generic four-week accident investigation cycle and any specific direction from the appointing official. The chairperson should establish significant milestones, working back from the appointing official's designated completion date. Table 5-1 shows a list of typical activities to schedule.

Table 5-1. These activities should be included on an accident investigation schedule.

<table>
<thead>
<tr>
<th>Interviews/Evidence Collection and Preliminary Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obtain needed site and facility background information, policies, procedures, and training records</td>
</tr>
<tr>
<td>Assign investigation tasks and writing responsibilities</td>
</tr>
<tr>
<td>Initiate and complete first draft of accident chronology and facts</td>
</tr>
<tr>
<td>Select analytical methods (preliminary)</td>
</tr>
<tr>
<td>Complete interviews</td>
</tr>
<tr>
<td>Complete first analyses of facts using selected analytical tools; determine whether additional tools are necessary</td>
</tr>
<tr>
<td>Obtain necessary photographs and complete illustrations for report</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Internal Review Drafts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete first draft of report elements, up to and including facts and analysis section</td>
</tr>
<tr>
<td>Complete development and draft of direct, contributing, and root causes</td>
</tr>
<tr>
<td>Complete development and draft of judgments of need</td>
</tr>
</tbody>
</table>
Complete first draft of report for internal review
Complete draft analyses
Complete second draft of report for internal review

**External Review Drafts**

Complete Classification/Privacy Act reviews
Conduct factual accuracy review and revise report based on input
Complete report review by Office of Oversight
Complete final draft of report
Prepare outbrief materials
Brief relevant site and field office managers on findings
Leave site
Complete final production of report

The schedule developed by the board chairperson should include the activities to be conducted and milestones for their completion. A sample schedule is included as Figure 5-1. The Accident Investigation Day Planner: A Guide for Accident Investigation Board Chairpersons, available from the Program Manager, can assist in the development of this schedule.

*Figure 5-1. A typical schedule of accident investigation activities covers 30 days.*
5.1.4 Acquiring Resources

From the first day, the chairperson and administrative coordinator begin acquiring resources for the investigation. This includes securing office space, a dedicated conference room or "command center," office supplies, computers (available through the Program Manager for Type A investigations), a secured area for document storage, tools, and personal protective equipment, if necessary. The site’s accident readiness function should provide many of these resources. The Accident Investigation Equipment Checklist (see Section 2) is designed to help identify resource needs and track resource status. The Program Manager retains an investigation “go kit” (see Section 2) containing many of these resources for Type A investigations.

In addition, the board chairperson assures that contracting mechanisms exist and that funding is available for the advisors and consultants required to support the investigation. These activities are coordinated with the Program Manager.

5.1.5 Addressing Potential Conflicts of Interest

The board chairperson is responsible for resolving potential conflicts of interest regarding board members, advisors, and consultants. Each board member, advisor, and consultant should certify that he or she has no conflicts of interest by signing the Individual Conflict of Interest Certification Form (see the end of this section). If the chairperson or any individual has concern about the potential for or appearance of conflicts of interest, the chairperson should inform the Program Manager and seek legal counsel input, if necessary. The decision to allow the individual to participate in the investigation, and any restrictions on his or her participation, shall be documented in a memorandum signed by the board chairperson with written concurrence from the Program Manager. If the chairperson relies on the advice of legal counsel, the chairperson shall seek appropriate legal counsel concurrence through the Program Manager. The memorandum will become part of the board’s permanent record.

5.1.6 Establishing Information Access and Release Protocols

Information access and other control protocols maintain the integrity of the investigation and preserve the privacy and confidentiality of interviewees and other parties. The Freedom of Information Act (FOIA) and Privacy Act apply to information generated or obtained during a DOE accident investigation. These two laws dictate access to and release of government records.
The Freedom of Information Act (FOIA) provides access to Federal agency records except those protected from release by exemptions. Anyone can use the FOIA to request access to government records. Therefore, the board must ensure that the information it generates is accurate, relevant, complete, and up-to-date. For this reason, court reporters should be used to record interviews, and interviewees should be allowed to review and correct transcripts.

The Privacy Act protects government records on citizens and lawfully admitted permanent residents from release without the prior written consent of the individual to whom the records pertain.

Specifically, the board is responsible for:

- Informing interviewees why information about them is being collected and how it will be used
- Ensuring that information subject to the Privacy Act is not disclosed without the consent of the individual, except under the conditions prescribed by law. Information that can normally be disclosed includes name, present and past positions or “grade” (e.g., GS-13), annual salaries, duty station, and position description. Therefore, the board should not request this information unless it is relevant to the investigation.

A sample statement that addresses the provisions of both the FOIA and the Privacy Act and their pertinence to interviews for DOE accident investigations is provided at the end of Section 6. This statement should be read at the beginning of all interviews.

The chairperson should obtain guidance from a legal advisor or the FOIA/Privacy Act contact person at the site, field office, or Headquarters regarding questions of disclosure, or the applicability of the FOIA or Privacy Act.

The chairperson also is responsible for establishing other protocols relating to information access and release. These protocol concerns are listed in Table 5-2.

### Table 5-2. The chairperson establishes protocols for controlling information.

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Security</td>
<td>Keep all investigative evidence and documents locked in a secure area accessible only to board members, advisors, and support staff.</td>
</tr>
<tr>
<td>Press Releases</td>
<td>■ Determine whether there is a DOE-designated contact to handle press releases; if so, work with that person.</td>
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<tr>
<td></td>
<td>■ The board is not obligated to release any information. However, previous chairpersons have found that issuing an early press release can be helpful.</td>
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<tr>
<td></td>
<td>■ The initial press release usually contains a general description of the accident and the purpose of the investigation.</td>
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<tr>
<td></td>
<td>■ The board chairperson should review and approve all press releases.</td>
</tr>
<tr>
<td>Lines of Communication</td>
<td>Establish liaison with field element management and with the operating contractor at the site, facility, or area involved in the accident to set up clear lines of communication and responsibility.</td>
</tr>
<tr>
<td>Format of Information Releases</td>
<td>■ Determine the amount and format of information to be released to the site contractor(s), union advisor, and local DOE office for internal purposes.</td>
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<tr>
<td></td>
<td>■ Never release verbatim interview transcripts or tapes due to the sensitivity of raw information.</td>
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<tr>
<td></td>
<td>■ Do not release preliminary results of analyses. These results can be taken out of context and lead to premature conclusions by the site and the media.</td>
</tr>
<tr>
<td></td>
<td>■ Consult with the appointing official before releasing any information.</td>
</tr>
<tr>
<td>Approvals for Information Release</td>
<td>Assure that board members, site contractors, and the local DOE office do not disseminate information concerning the board’s activities, findings, or products before obtaining the chairperson’s approval. Brief the board on what they can reveal to others.</td>
</tr>
</tbody>
</table>

### 5.2 Managing the Investigation Process

As an investigation proceeds, the chairperson uses a variety of management techniques, including guiding and directing, monitoring performance, providing feedback on performance, and making decisions and changes required to meet the investigation’s objectives and schedule. Because these activities are crucial, the chairperson may
designate an individual to oversee management activities in case the chairperson is not always immediately available.

5.2.1 Taking Control of the Accident Scene

Before arriving at the site, the chairperson communicates with the point of contact or the appropriate site readiness designee to assure that the scene and evidence are properly secured, preserved, and documented and that preliminary witness information has been gathered. At the accident scene, the chairperson should:

- Obtain briefings from all persons involved in managing the accident response
- Obtain all information and evidence gathered by the site readiness team
- Make a decision about how secure the accident scene must remain during the initial phases of the investigation. If there are any concerns about loss or contamination of evidence, play it safe and keep the scene restricted from use.
- Assume responsibility only for activities directly related to the accident and investigation. The chairperson and board members should not take responsibility for approving site activities or procedures, or for recovery, rehabilitation, or mitigation activities. These functions are the responsibility of line management.

5.2.2 Initial Meeting of the Investigation Board

The chairperson is responsible for ensuring that all board members work as a team and share a common approach to the investigation. As one of the board's first onsite activities, the chairperson typically holds a meeting to provide all board members, advisors, consultants, and support staff with an opportunity to introduce themselves and to give the chairperson an opportunity to brief the board members on:

- The scope of the investigation, including all levels of the organizations involved up to and beyond the level of the appointing official
- An overview of the accident investigation process, with emphasis on:
  - Streamlined process and limited timeframe to conduct the investigation (if applicable)
  - The schedule and plan for completing the investigation
  - The need to apply the components of DOE’s integrated safety management system during the investigation as the means of evaluating management systems
  - Report-writing process.
- Potential analytical and testing techniques to be used
- The roles, responsibilities, and assignments for the chairperson, the board members, and other participants
- Information control and release protocols
- Administrative processes and logistics.

At the meeting, the chairperson clearly communicates expectations and provides direction and guidance for the investigation. In addition, at the meeting the chairperson should distribute copies of local phone directories and a list of phone and fax numbers for pertinent individuals at DOE Headquarters. The board should also be briefed on procedures for:

- Handling potential conflicts of interest resulting from using contractor-provided support and obtaining support from other sources
- Storing investigative materials in a secured location and disposing of unneeded yet sensitive materials
- Using logbooks, inventory, checkout lists, or other methods to maintain control and accountability of physical evidence, documents, photographs, and other material pertinent to the investigation
- Recording and tracking incoming and outgoing correspondence
- Accessing the board’s work area after hours.

5.2.3 Promoting Teamwork

The board must work together as a team to finish the investigation within the timeframe established by the appointing official. To make this happen, the board chairperson should ensure that strong-willed personalities do not dominate and influence the objectivity of the investigation and that all viewpoints are heard and analyzed.

The chairperson must capitalize on the synergy of the team’s collective skills and talents (i.e., the team is likely to make better decisions and provide a higher quality investigation than the same group working individually), while allowing individual actions and decisions. It is important that the chairperson set the ground rules and provide guidance to the board members and other participants in:
Member relationships: Friendship is not required, but poor relationships can impede the board's ability to conduct a high-quality investigation. The chairperson can encourage positive relationships by focusing attention on each member's strengths and downplaying weaknesses. The chairperson can facilitate this by arranging time to allow team members to get to know one another and learn about each other's credentials, strengths, and preferences. Effective interpersonal relationships can save time and promote high-quality performance.

Communication processes: It is the chairperson's responsibility to make sure that all members get a chance to speak and that no one member dominates conversations. The chairperson should establish communication guidelines and serve as an effective role model in terms of the following:

- Be clear and concise; minimize the tendency to think out loud or tell "war stories"
- Be direct and make your perspective clear
- Use active listening techniques, such as focusing attention on the speaker, paraphrasing, questioning, and refraining from interrupting
- Pay attention to non-verbal messages and attempt to verbalize what you observe
- Attempt to understand each speaker's perspective
- Seek information and opinions from others, especially the less talkative members
- Postpone evaluation until all ideas and arguments have been heard
- Encourage diverse ideas and opinions
- Suggest ideas, approaches, and compromises
- Help keep discussions on track when they start to wander.

Decision processes: The chairperson should gain agreement in advance regarding how particular decisions will be made. Decisions can be made by consensus, by vote, by the chairperson, or by an expert. Each method has strengths and weaknesses, and the method used should be the one that makes the most sense for the particular decision and situation. Team members should be aware of which method will be used.

Roles and responsibilities: Team members should clearly understand both the formal and informal roles and responsibilities of each board member, consultant, and support person. Clarifying these roles helps avoid duplication of effort and omission of critical tasks, and reduces power struggles and other conflicts. Board chairpersons should avoid the temptation to reassign tasks when team members encounter problems.

Group processes: For an effective investigation, group processes must be efficient. Time and energy may be needed to develop these processes. The chairperson should pay attention to and note processes that seem to work well, and ask the group to suggest alternatives to processes that are unsatisfactory.

TIP
Teams are more effective than individuals, because team members have a clear purpose, capitalize on each other's strengths, coordinate their efforts, and help each other. Teamwork promotes a higher quality investigation.

To control team dynamics, the chairperson needs to be aware that groups go through predictable stages as they progress from meeting one another to becoming a high-performance team:

- Forming: At this stage, team members get acquainted, understand their purposes, and define their roles and responsibilities. Members are typically very polite at this stage, and conflict is rare. Little work is accomplished during this stage, as the team is still in the planning phase. The chairperson can speed this stage by formally organizing the group; by defining goals, roles, and responsibilities; and by encouraging members to become comfortable with one another.

- Storming: Team members begin to realize the sheer amount of work to be done and may get into conflict regarding roles, planned tasks, and processes for accomplishing the work. There may be power struggles. The team focuses energy on redefining work processes. The chairperson can speed this phase by encouraging open discussion of methods and responsibilities and promoting non-defensive, solution-focused communication.

- Norming: The team develops norms about roles, planned tasks, and processes for working together. Power issues are settled. Team members start to become productive and assist one another. The chairperson can speed this stage by formalizing new norms, methods, and responsibilities and by encouraging relationship development.

- Performing: The team settles into clear roles, understands the strengths of different members, and begins to work together effectively. The chairperson can help maintain this stage by encouraging open communication, a "learning from mistakes" philosophy, and recognizing progress.
TIP
Understanding the four typical stages of team development can help the chairperson manage team interactions and promote team processes throughout the accident investigation.

The chairperson sets the stage for effective teamwork at the very first board meeting. At this meeting, the chairperson should encourage the team to define their goals and tasks, clarify their roles and responsibilities, agree on team processes, and become acquainted with each other's strengths.

TIP
Many board members may have never worked on an effective team. The chairperson needs to focus on effective team activities, because the members may not immediately see the value of teamwork or may be caught up in their own tasks to the exclusion of the team.

5.2.4 Managing Information Collection

Upon arrival at the accident site, the board begins to collect evidence and facts and to conduct interviews. Table 5-3 provides guidelines to assist the chairperson in monitoring this process.

5.2.5 Coordinating Internal and External Communication

The board chairperson is responsible for coordinating communication both internally (with the appointing official, board members, advisors, consultants, and support staff) and externally (relevant DOE Headquarters managers, local DOE field office site managers, site contractor(s), the media and the public).

Maintaining effective communications includes:

- Conducting daily board meetings to:
  - Review and share the latest information and evidence
  - Discuss how new information may contribute to analyses
  - Review latest analytical findings and potential causal factors and discuss how new information may affect these analyses
  - Note information gaps and prioritize directions to pursue
  - Serve as a checkpoint to ensure that board members are completing their tasks, acting within scope, and not pursuing factual leads of limited potential value.

- Obtaining regular verbal or written progress reports from board members and identifying solutions to potential problems

- Using a centralized, visible location for posting assignments and progress reports to keep everyone informed and up-to-date

- Conducting meetings with site managers and contractor(s) to exchange information and to summarize investigation status

- Conducting weekly conference calls with managers from Headquarters, the local field office, and contractors; calling the appointing official on a predetermined basis; and providing written status reports to the appointing official

- For Type A investigations, providing daily status updates to the Deputy Assistant Secretary for Oversight

- Coordinating external communications with the public and media through the field office public relations/media representative to ensure the Department's interests are not compromised

Table 5-3. The chairperson should use these guidelines in managing information collection activities.

<table>
<thead>
<tr>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review and organize witness statements, facts, and background information provided by the site readiness team or other sources and distribute these to the board.</td>
</tr>
<tr>
<td>Organize a board walkthrough of the accident scene, depicting events according to the best understanding of the accident chronology available at the time. This can help the board visualize the events of the accident.</td>
</tr>
<tr>
<td>Assign an administrative coordinator to oversee the organization, filing, and security of collected facts and evidence.</td>
</tr>
<tr>
<td>Develop draft of objectives and topical areas to be covered in initial interviews and oversee development of a standardized list of initial interview questions to save interviewing time and promote effective and efficient interviews.</td>
</tr>
</tbody>
</table>
If deemed appropriate, issue a site or public announcement soliciting information concerning the accident.

Ensure that witnesses are identified and interviews scheduled.

Ensure that board members preserve and document all evidence from the accident scene.

Make sure all board members enlist the aid of technical experts when making decisions about handling or altering physical evidence.

Establish a protocol agreeable to the board for analyzing and testing physical evidence.

Identify and initiate any necessary physical tests to be conducted on evidence.

Assess and reassess the need for documents, including medical records, training records, policies, and procedures, and direct their collection. Use the Accident Investigation Information Request Form provided at the end of the section to document and track information requests.

Emphasize to board members that to complete the investigation on schedule, they must prioritize and may not have time to pursue every factual lead of medium to low significance. The board chairperson must emphasize pursuits that will lead to the development of causal factors and judgments of need.

Ensuring that in both internal and external communications (press conferences, briefings), the facts presented are sufficiently developed and validated, and that no speculation, hypotheses, or conjecture is expressed; consulting with the appointing official prior to disseminating any information about the investigation.

Notifying DOE and appropriate Federal, state, or local authorities of unlawful activities, or in the case of fraud, waste, or abuse, the DOE Office of the Inspector General.

Notifying the Director, Office of Enforcement and Investigation (EH-10), the DOE Site Manager, and the contractor of any potential Price-Anderson enforcement concerns identified during the investigation as soon as practical. Table 5-4 provides additional detail;

Coordinating board activities with all organizations having an interest in the accident (e.g., agencies notified by the appointing official or the Deputy Assistant Secretary for Oversight under DOE Order 225.1A, Paragraph 4.b.).

### Table 5-4. The Price-Anderson Amendments Act of 1988.

The Price-Anderson Amendments Act of 1988 provides indemnification (government acts as an insurer against findings of liability from nuclear activities of contractors acting within the scope of their contracts) to DOE contractors who manage and operate nuclear facilities for DOE. The Act subjects DOE indemnified contractors, subcontractors, and suppliers to potential civil and criminal penalties for violations of DOE rules, regulations, and orders relating to nuclear safety requirements. DOE’s enforcement procedural rules and policy are published in 10 CFR Part 820.

Some examples of nuclear safety noncompliances that should be reported as potential enforcement items are:

- Any single unplanned occupational exposure to an individual that exceeds 100 millirem Total Effective Dose Equivalent
- Any single occurrence of personal contamination of clothing (excluding personal protective clothing) that is greater than 100 times the levels specified in 10 CFR Part 835, Appendix D
- An aggregate of related nuclear safety noncompliances indicative of a programmatic breakdown
- A number of nuclear safety-related noncompliances with common root causes occurring at the same site
- Intentional violations involving the failure to perform activities that fulfill nuclear safety requirements, coupled with alteration, concealment, or destruction of documents pertaining to those activities.

For further information, review DOE Handbook 1089, Guidance for Identifying, Reporting, and Tracking Nuclear Safety Noncompliances, contact the Field Office Price-Anderson Coordinator, or contact the DOE Office of Enforcement and Investigation (EH-10).

### TIP

Meetings that maximize efficiency have a set length of time and follow a planned, well focused agenda.

### 5.2.6 Managing the Analysis

The chairperson is responsible for ensuring that events and causal factors charting and application of the core analytical techniques begin as soon as initial facts are available. This will help to identify information gaps early, drive the fact collection process, and identify questions for interviews. The use of accident investigation analysis software can be a helpful tool for identifying information gaps and organizing causal factors during the analyses.
Another technique is to use multicolored adhesive notes on a wall to portray elements of the events and causal factors chart. A wall-size chart makes it easier for all board members to observe progress, provide input, and make changes.

As the board proceeds with the analyses, the chairperson should monitor and discuss progress to ensure that:

- Several board members and/or advisors work collectively (not one person in isolation) to produce a quality result

**TIP**

Delegating responsibility for complex analyses to a single individual can produce inferior results. Analyses are strengthened by input from the entire board and its advisors.

- If analysis and information-gathering functions (e.g., interviewing) are assigned to separate groups of board members, these groups should interact regularly to improve coordination, strengthen the analytical process, and maintain appropriate focus
- Analyses are iterative (i.e., analyses are repeated, each version producing results that approximates the end result more closely). Several iterations of analyses will be needed as new information becomes available
- The analyses address organizational concerns, management systems, and line management oversight functions that may have contributed to the accident's causes
- The causal factors, conclusions, and judgments of need are supported by the facts and analysis
- Significant facts and analyses do not result in a "dead end"; rather, they are linked to causal factors and judgments of need.

### 5.2.7 Managing Report Writing

Many investigation boards have found report writing to be the most difficult part of the investigation, often requiring several iterations. Report quality is crucial, because the report is the official record of the investigation. Efforts to conduct a quality investigation lose integrity if the report is poorly written or fails to adequately convey a convincing set of supporting facts and clear conclusions. To manage the reporting process, the chairperson should:

- Develop a report outline as soon as possible to facilitate writing assignments and minimize overlap in content between sections
- Begin writing the accident chronology, background information, and facts as soon as information becomes available
- Continuously identify where sections should be added, moved, or deleted
- Adhere to required format guidelines and promote ongoing clarification of format, content, and writing styles
- Quickly identify strong and weak writers and pair them, when possible, to avoid report writing delays
- Encourage authors to consult with one another frequently to become familiar with the content of each section and to reduce redundancy
- If possible, use a technical writer to evaluate grammar, format, technical content, and linkages among facts, analyses, causes, and judgments of need. This is important when several authors have contributed to the report. The technical writer focuses on producing a clear, concise, logical, and well-supported report and ensures that the report reads as if one person wrote it.

It is possible to have serious disagreements among board members regarding the interpretation of facts, causal factors, conclusions, and judgments of need. The board chairperson should make a concerted effort to reach consensus among board members on accident causes, conclusions, and judgments of need. When board members cannot reach agreement and the chairperson cannot resolve the difference, the dissenting board member(s) has (have) the option to produce a minority report.

### 5.2.8 Managing Onsite Closeout Activities

The investigative portion of the process is considered complete and board members are released when the appointing official formally accepts the final report. The chairperson is responsible for final editing and production of the report, with assistance from selected board members and administrative support staff. In the case of Type A investigations, the chairperson must coordinate with the Program Manager for final report production (e.g., graphics, duplicating, binding).

A briefing on the investigation's outcome to DOE Headquarters (including the Assistant Secretary for Environment, Safety and Health for Type A accident investigations) and field line management with cognizance over the site of the accident is required by DOE Order 225.1A. This briefing is conducted by the board chairperson and the head of the field element of the site at which the accident occurred. Accident investigation participants (chairperson, board
members, and any consultants and advisors deemed appropriate by the chairperson) may attend the briefing. The briefing covers:

- The scope of the investigation, as provided in the appointment letter
- The investigation's participants, including any subject matter experts or other consultants
- A brief summary of the accident (what happened)
- Causal factors (why it happened)
- Judgments of need (what needs to be corrected)
- Organizations that should be responsible for corrective actions.

Other briefings may be provided by the board chairperson and board members, as deemed appropriate by the appointing official. These may include briefing DOE and contractor line management at the site of the accident.

5.2.9 Managing Post-Investigation Activities

The chairperson is also responsible for ensuring that all information resulting from the investigation is carefully managed and controlled. To this end, the chairperson takes the following actions:

- Controlling the release of information to the public: The chairperson should instruct board members not to communicate with the press or other external organizations regarding the investigation. External communications are the responsibility of the board chairperson until the final report is released. The board chairperson should work closely with a person designated by the site to release other information, such as statements to site employees and the public.

- Archiving materials: One of the final activities of the board is to place investigation documents and evidence in long-term storage. For Type A investigations, these materials are archived by the Program Manager. All factual material and analysis products are included, such as logbooks, board meeting minutes, field notes, sketches, witness statements (including interview tapes, if used), photographs, location and custody of any physical evidence, analysis charts, and the various forms completed during the investigation. Medical or personnel records subject to the Privacy Act may be returned to their original location. The administrative coordinator arranges for archiving and for shipping materials to the archive repository during the onsite phase of the investigation.

5.3 Controlling the Investigation Process

Throughout the investigation, the board chairperson is responsible for controlling board performance, cost, schedule, and quality of work. Techniques for implementing these controls are described below.

5.3.1 Monitoring Performance and Providing Feedback

The chairperson uses daily meetings to monitor progress and to measure performance against the schedule of activity milestones. Board members are given specific functions or activities to perform and milestones for completion. The chairperson assesses the progress and status of the investigation periodically by asking such questions as:

- Is the investigation on schedule?
- Is the investigation within scope?
- Are board members, advisors, consultants, and support staff focused and effective?
- Are additional resources needed?
- Are daily board meetings still necessary and productive, or should the interval between them be increased?

The chairperson must be informed on the status of the accident investigation and must be prepared to make decisions and provide timely feedback to board members, site personnel, and other parties affected by the accident. Frequently, decisions must be made when there is not time to reach consensus among the board members. When this occurs, the chairperson informs the board members of the decision and the reason for the urgency. Intermediate milestone revisions can then be made, if events or practical considerations so dictate.

5.3.2 Controlling Cost and Schedule

Cost and schedule must be controlled to ensure that planning and execution activities are within the established budget and milestones.

- Cost Control: The board chairperson is responsible for preparing a cost estimate for the activities to be conducted during the investigation and assuring that funds are available to support the investigation process, including costs associated with travel, advisors, and consultants. If necessary, the chairperson may issue a memo authorizing costs incurred by board members, including additional travel expenses, hotel rates over per
diem, and incidental expenses. Control can be exercised over costs by using advisors and consultants only when required and by limiting travel (such as trips home for the weekend) during the onsite investigation. During Type B investigations, the board chairperson should coordinate with the appropriate designee of the head of the field element to ensure that the costs are being tracked. The Program Manager is the point of contact for these concerns during Type A investigations. A method for estimating costs should be agreed upon early in the investigation, and the estimate should be reviewed each week to ensure that the cost of the work is not exceeding the estimate, or that any cost growth is justified and can be funded.

- **Schedule Control:** Progress against the schedule milestones can be assessed during daily progress meetings with the board and its staff. As problems arise, the schedule may be adjusted or resources applied to offset variances. Because of the relatively short timeframe involved, the chairperson must identify and resolve problems immediately to maintain the schedule, or reevaluate it with the appointing official as circumstances require.

### 5.3.3 Assuring Quality

Formal quality control measures are necessary because of the seriousness and sensitivity of the accident investigation board’s work and because of the need for accuracy, thoroughness, and perspective. The chairperson has the prerogative to implement any quality assurance measures deemed necessary. At a minimum, the chairperson must ensure that the report is technically accurate, complete, and internally consistent. When analytical results are developed into conclusions, all verified facts, the results of analyses of those facts, and the resulting conclusions must be both consistent and logical.

When essential portions of the draft report are complete, the chairperson conducts a requirements verification analysis to ensure that the facts are consistent with the best information available, that all report sections are consistent, and that analyses, causes, and judgments of need logically flow from the facts. Section 9 provides further detail on assuring report quality.

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**Key Points to Remember**

During the accident investigation, the board chairperson is responsible for managing all aspects of the process, including planning, organizing, directing, and controlling the investigative process:

- Completing initial activities prior to arriving on site are critical to ensuring an efficient and effective investigation.
- Planning and organizing includes using project management techniques to organize the process and team; establish a schedule, plan, and assign specific tasks and completion milestones; acquire resources; and establish information access and release protocols.
- Directing the investigative process involves developing the board into a team, leading communications, conducting feedback and decision-making activities, evaluating and modifying group processes, and managing investigative activities.
- Controlling the investigative process includes monitoring performance, providing feedback, controlling costs and schedule, and providing quality assurance.

Teamwork is important in assuring that the investigation is completed on schedule with high quality. By understanding the four stages of team development (forming, storming, norming, and performing) the chairperson can facilitate quick progression to the fourth stage. The chairperson promotes effective teamwork by assuring a clear understanding of roles and responsibilities, encouraging effective communications, providing clear explanations of expectations, obtaining agreement on decision-making methods and group processes, and working with board members to resolve potential problems.

The board chairperson has responsibility for representing DOE on all matters pertaining to board activities and the investigation by communicating with other DOE organizations and individuals, as well as external parties. These include the appointing official, DOE Headquarters managers, field managers, site managers, contractors, the media, unions, and other stakeholders with legitimate interests.

External communications should be coordinated through a field office public relations/media representative to preserve the interests of the Department. Moreover, prior to any public address, facts pertaining to the investigation must be sufficiently developed and validated.

For all Type A investigations, the board chairperson provides daily status updates to the Deputy Assistant Secretary for Oversight.

Information must be controlled to maintain the integrity of the investigation and preserve the privacy of those involved. Consequently, evidence, interview transcripts, personnel records, analytical and test results, and other material should be locked in a secured area to which only the board has access. Freedom of Information Act and Privacy Act restrictions apply to most investigative materials. Coordinating press releases, developing protocols for access to and release of information, and presenting awareness briefings to the board are common ways to help control sensitive investigation information.

The onsite phase of the investigation is considered complete when:
The board has reviewed the draft report for internal consistency, and site management and contractors have reviewed it for factual accuracy.

The appointing official accepts the report.

The typical contents of a closeout briefing include:

- The scope of the investigation
- The investigation's participants
- A summary of what happened
- The accident's causal factors
- Judgments of need
- Organizations that should be responsible for corrective actions.

The chairperson is responsible for ensuring that certain post-investigation activities are completed. These include final editing and distribution of the report, briefings requested by Department officials, and archiving investigative files.

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**Accident Investigation Startup Activities List** (page 1 of 3)

<table>
<thead>
<tr>
<th>Description of Activity</th>
<th>Name of Designated Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HQ</td>
</tr>
<tr>
<td><strong>Board Chairperson Responsibilities:</strong></td>
<td></td>
</tr>
<tr>
<td>Attend briefing by appointing official</td>
<td></td>
</tr>
<tr>
<td>Assist in selecting, notifying, and briefing board members and consultants/advisors</td>
<td></td>
</tr>
<tr>
<td>Identify all appropriate site authorities</td>
<td></td>
</tr>
<tr>
<td>Obtain details of accident from site readiness team leader and other site parties</td>
<td></td>
</tr>
<tr>
<td>Ensure that adequate evidence preservation and collection activities were initiated</td>
<td></td>
</tr>
<tr>
<td>Begin identifying and collecting background and factual information</td>
<td></td>
</tr>
<tr>
<td>Ask the Program Manager to search for information about similar accidents</td>
<td></td>
</tr>
<tr>
<td>Review all forwarded site and board member information</td>
<td></td>
</tr>
<tr>
<td>Reassign normal business commitments</td>
<td></td>
</tr>
<tr>
<td>Description of Activity</td>
<td>Name of Designated Lead</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Establish a preliminary accident investigation schedule, including milestones and deadlines</td>
<td>HQ Site Other</td>
</tr>
<tr>
<td>Contact selected board members, consultants/advisors, and site personnel</td>
<td>HQ Site Other</td>
</tr>
<tr>
<td>Arrange travel for self and expedite board travel arrangements</td>
<td>HQ Site Other</td>
</tr>
<tr>
<td>Establish administrative support</td>
<td>HQ Site Other</td>
</tr>
<tr>
<td>Determine that logistical support for the accident investigation is established</td>
<td>HQ Site Other</td>
</tr>
<tr>
<td>Travel to site</td>
<td>HQ Site Other</td>
</tr>
</tbody>
</table>

**Accident Investigation Startup Activities List (page 2 of 3)**

<table>
<thead>
<tr>
<th>Administrative Coordinator Responsibilities:</th>
<th>HQ Site Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make hotel selection and reserve a block of rooms for the accident investigation board</td>
<td>HQ Site Other</td>
</tr>
<tr>
<td>Determine site/field office points of contact for administrative and logistical support</td>
<td>HQ Site Other</td>
</tr>
<tr>
<td>Arrange for local court reporter support for interviews</td>
<td>HQ Site Other</td>
</tr>
<tr>
<td>Arrange for office/work space and furnishings for the accident investigation board</td>
<td>HQ Site Other</td>
</tr>
<tr>
<td>Arrange for a large, dedicated conference room that can be locked when not in use by the accident investigation board</td>
<td>HQ Site Other</td>
</tr>
<tr>
<td>Arrange for several small, hard-walled offices to be used when conducting interviews</td>
<td>HQ Site Other</td>
</tr>
<tr>
<td>Arrange for security badges/passes for members of the accident investigation board</td>
<td>HQ Site Other</td>
</tr>
<tr>
<td>Arrange for property permits for personal equipment (cameras, laptops, etc.) for members of the accident investigation board</td>
<td>HQ Site Other</td>
</tr>
<tr>
<td>Arrange for specific security, access, safety, and health training, as required</td>
<td>HQ Site Other</td>
</tr>
<tr>
<td>Description of Activity</td>
<td>Name of Designated Lead</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------------</td>
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<tr>
<td>____________________________________________________________________________________</td>
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<tr>
<td>Arrange for dedicated telephone services and a fax machine</td>
<td>a</td>
</tr>
<tr>
<td>Arrange for a dedicated, high-speed copy machine that has collating and stapling capability</td>
<td>a</td>
</tr>
<tr>
<td>Obtain office supplies and consumables for use by the accident investigation board</td>
<td>a</td>
</tr>
<tr>
<td>Arrange after-hours access to site and work space, and assume responsibility for all keys/cards provided by the site</td>
<td>a</td>
</tr>
</tbody>
</table>

**Accident Investigation Startup Activities List (page 3 of 3)**

**Accident Investigation Information Request Form**

<table>
<thead>
<tr>
<th>Date of Request</th>
<th>Page</th>
<th>Information Requested</th>
<th>How Transmitted</th>
<th>Date Received</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Requested From:  
Requested By:  
Contact Person:  
Location:  
Phone Number:  
Fax Number:  
Information Requested:  
How Transmitted:  
Date Received:  

Accident Investigation Individual Conflict of Interest Certification Form

I certify that all work to be performed by me in support of the DOE accident investigation identified as:

__________________________________________
(include the accident site name and date)

I have no past, present, or currently planned interests that either directly or indirectly may relate to the subject matter of the work to be performed that may diminish my capacity to give impartial, technically sound, objective assistance and advice. Additionally, I have performed no services that might bias my judgment in relation to the work to be performed, or which could be perceived to impair my objectivity in performing the subject work.

__________________________________________
(Print name)  

(Signature)

BOARD POSITION:  

Member  

Advisor  

Consultant  

(Federal employee)

CONTRACT NO. (if applicable): ____________________________________________________________

DATE: ________________________________________________________________________________

The original of this form remains with the accident investigation files. One copy will be sent to the:

DOE Accident Investigation Program Manager
Office of Oversight
Environment, Safety & Health
Department of Energy
(phone) 301-903-5605
(fax) 301-903-4120

NOTE: Statements or entries generally:

Whoever, in any matter within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals or covers up by any trick, scheme, or device a material fact, or makes any false, fictitious, or fraudulent statements or representations, or makes or uses any false writing or document knowing the same to contain any false, fictitious, or fraudulent statement or entry, shall be fined not more than $10,000 or imprisoned not more than five years, or both. (18 USC 1001)
6

Collecting Data

Collecting data is a critical part of the investigation. Although initial information is collected by the site readiness team, the detailed information collected by the accident investigation board is the foundation for the entire investigation, including the analyses and conclusions. These in turn become the basis for identifying preventive measures to preclude recurrences. Consequently, it is important to ensure that all relevant information is collected and that the information is accurate.

Gathering and analyzing information is an interdependent process that takes place throughout the first three weeks of the investigation cycle. As preliminary analysis is conducted on the initial evidence, gaps will become apparent, requiring the board to collect additional evidence. Generally, many data collection and analysis iterations occur before the board can be certain that all pertinent evidence has been gathered and analyses are finalized.

Upon arrival of the accident investigation board, the point of contact briefs the board members on all actions taken by the site readiness team and other emergency response personnel. It is important that the board become familiar with the initial investigative actions conducted prior to their arrival. At this time, all evidence the site readiness team has collected, including lists of witnesses, witness statements, and other important documents, are also turned over to the board.

Three key types of evidence are collected during the investigation:

- **Human or testamentary evidence** includes witness statements and observations
- **Physical evidence** is matter related to the accident (e.g., equipment, parts, debris, hardware, and other physical items)


**Documentary evidence** includes paper and electronic information, such as records, reports, procedures, and documentation.

The investigation board expands and builds on results from the site readiness team's initial activities. Therefore, the board chairperson must obtain a timely assessment of what has been done and determine the board's immediate actions. It may be helpful for the board chairperson to designate one board member to oversee evidence collection.

Collecting evidence can be a lengthy, time-consuming, and piecemeal process. Witnesses may provide sketchy or conflicting accounts of the accident. Physical evidence may be badly damaged or completely destroyed. Documentary evidence may be minimal or difficult to access. Thorough investigation requires that board members be diligent in pursuing evidence and adequately explore leads, lines of inquiry, and potential causal factors until they gain a sufficiently complete understanding of the accident.

The process of collecting data is iterative. Preliminary analysis of the initial evidence identifies gaps that will direct subsequent data collection. Generally, many data collection and analysis iterations occur before the board can be certain that all analyses can be finalized. The process of data collection also requires a tightly coordinated, interdependent set of activities on the part of several investigators.

### 6.1 Collecting Human Evidence

Human evidence is often the most insightful and also the most fragile. Witness recollection declines rapidly in the first 24 hours following an accident or traumatic event. Therefore, witnesses should be located and interviewed immediately and with high priority. As physical and documentary evidence is gathered and analyzed throughout the investigation, this new information will often prompt follow-up interviews with persons previously not interviewed, and additional lines of questioning.

#### 6.1.1 Locating Witnesses

Principal witnesses and eyewitnesses are identified and interviewed as soon as possible. Principal witnesses are persons who were actually involved in the accident; eyewitnesses are persons who directly observed the accident or the conditions immediately preceding or following the accident. General witnesses are those with knowledge about the activities prior to or immediately after the accident (the previous shift supervisor or work controller, for example). One responsibility of the site readiness team and other initial responders is to identify witnesses, record initial statements, and provide this information to the investigation board upon their arrival. Prompt arrival by board members and expeditious interviewing of witnesses helps ensure that witness statements are as accurate, detailed, and authentic as possible.

Table 6-1 lists sources that investigators can use to locate witnesses.

#### 6.1.2 Conducting Interviews

Witness testimony is an important element in determining facts that reveal causal factors. It is best to interview principal witnesses and eyewitnesses first, because they often provide the most useful details regarding what happened. If not questioned promptly, they may forget important details.

| Site readiness team members and emergency response personnel | can name the person who provided notification of the incident and those present on their arrival, as well as the most complete list available of witnesses and all involved parties. |
| Principal witnesses and eyewitnesses | are the most intimately involved in the accident and may be able to help develop a list of others directly or indirectly involved in the accident. |
| First-line supervisors | are often the first to arrive at an accident scene and may be able to recall precisely who was present at that time or immediately before the accident. Supervisors can also provide the names and phone numbers of safety representatives, facility designers, and others who may have pertinent information. |
| Local or state police, firefighters, or paramedics, if applicable. | |
| Nurses or doctors | at the site first aid center or medical care facility (if applicable). |

Table 6-1. These sources are useful for locating witnesses.
6.1.2.1 Preparing for Interviews

Much of the investigation's fact-finding occurs in interviews. Therefore, to elicit the most useful information possible from interviewees, interviewers must be well prepared and have clear objectives for each interview. Interviews can be conducted after the board has established the topical areas to be covered in the interviews and after the board chairperson has reviewed with the board the objectives of the interviews and strategies for obtaining useful information. Table 6-2 provides guidelines for interview preparation.

| Identify all interviewees using the Accident Investigation Preliminary Interview List (provided in Section 4). Record each witness’ name, job title, reason for interview, phone, work schedule, and company affiliation; take a brief statement of his or her involvement in the accident. |
| Schedule an interview with each witness using the Accident Investigation Interview Schedule Form (provided at the end of this section). Designate one person to oversee this process. Previous boards have found it useful to make the administrative coordinator responsible for scheduling initial and follow-up interviews and written statement verifications. |
| Assign a lead interviewer from the board for each interviewee. Having a lead interviewer can help establish consistency in depth and focus of interviews. |
| Develop sketches and diagrams to pinpoint locations of witnesses, equipment, etc., based on the initial walkthrough and site readiness team input. |
| Develop a standardized set of interview questions. Charts may be used to assist in developing questions. The Accident Investigation Interview Form (provided at the end of this section) can aid in recording pertinent data. |
| Discuss interviewing objectives and plan strategies to ensure that all board members use consistent interviewing methods. To enhance the quality of information obtained, everyone should have some training on correct interviewing techniques. |
| Determine the appropriate means of documenting interviews (handwritten notes, court reporter, etc.) in light of the circumstances. Experience indicates that a court reporter generally is preferable. |

**Table 6-2.** It is important to prepare for interviews.

People's memories, as well as their willingness to assist an investigative board, can be affected by the way they are questioned. Based on the availability of witnesses, board members' time, and the nature and complexity of the accident, the board chairperson and members must determine who to interview, in what order, and what interviewing techniques to employ. Some methods that previous accident investigation boards have found successful are described below.

**TIP**

A witness interview is not an interrogation. Investigators should convey the sense of a cooperative, informal meeting.

**Individual Vs. Group Interviews.** Depending on the specific circumstances and schedule of an accident investigation, investigators may choose to hold either individual or group interviews. Generally, principal witnesses and eyewitnesses are interviewed individually to gain independent accounts of the event. However, a group interview may be beneficial in situations where a work crew was either involved in or witness to the accident. Moreover, time may not permit interviewing every witness individually, and the potential for gaining new information from every witness may be small. Sometimes, group interviews can corroborate testimony given by an individual, but not provide additional details. The board should use their collective judgment to determine which technique is appropriate. Advantages and disadvantages of both techniques are listed in Table 6-3. These considerations should be weighed against the circumstances of the accident when determining which technique to use.

**Interviewing: Do's and Don'ts.** Table 6-4 lists actions that promote effective interviews, and Table 6-5 lists actions to avoid while conducting interviews.

It is important to create a comfortable atmosphere in which interviewees are not rushed to recall their observations. Interviewees should be told that they are a part of the investigation effort and that their input will be used to prevent future accidents and not to assign blame. Before and after questioning, interviewees should be notified that follow-up interviews are a normal part of the investigation process and that further interviews do not mean that their initial statements are suspect. Also, they should be encouraged to contact the board whenever they can provide additional information or have any concerns.
Table 6-3. Group and individual interviews have different advantages.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Individual Interviews</th>
<th>Group Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obtain independent stories</td>
<td></td>
<td>More time-efficient</td>
</tr>
<tr>
<td>Obtain individual perceptions</td>
<td></td>
<td>All interviewees supplement story; may get more complete picture</td>
</tr>
<tr>
<td>Establish one-to-one rapport</td>
<td></td>
<td>Other people serve as “memory joggers”</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disadvantages</th>
<th>Individual Interviews</th>
<th>Group Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>More time-consuming</td>
<td></td>
<td>Interviewees will not have independent stories</td>
</tr>
<tr>
<td>May be more difficult to schedule all witnesses</td>
<td></td>
<td>More vocal members of the group will say more and thus may influence those who are quieter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“Group think” may develop; some individual details may get lost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contradictions in accounts may not be revealed</td>
</tr>
</tbody>
</table>

Table 6-4. Interviewing do’s.

**Create a Relaxed Atmosphere**

- Conduct the interview in a neutral location that was not associated with the accident.
- Introduce yourself and shake hands.
- Be polite, patient, and friendly.
- Treat witnesses with respect.

**Prepare the Witness**

- Describe the investigation’s purpose: to prevent accidents, not to assign blame.
- Explain that witnesses may be interviewed more than once.
- Use the Model Opening Statement to address FOIA and Privacy Act concerns.
- Stress how important the facts given during interviews are to the overall investigative process.

**Record Information**

- Rely on a court reporter to provide a detailed record of the interview.
- Note crucial information immediately in order to ask meaningful follow-up questions.

**Ask Questions**

- Establish a line of questioning and stay on track during the interview.
- Ask the witness to describe the accident in full before asking a structured set of questions.
- Let witnesses tell things in their own way; start the interview with a statement such as “Would you please tell me about...?”
- Ask several witnesses similar questions to corroborate facts.
- Aid the interviewee with reference points; e.g., “How did the lighting compare to the lighting in this room?”
- Keep an open mind; ask questions that explore what has already been stated by others in addition to probing for missing information.
- Use visual aids, such as photos, drawings, maps, and graphs to assist witnesses.
- Be an active listener, and give the witness feedback; restate and rephrase key points.
- Ask open-ended questions that generally require more than a “yes” or “no” answer.
Observe and note how replies are conveyed (voice inflections, gestures, expressions, etc.).

Close the Interview

End on a positive note; thank the witness for his/her time and effort.

Allow the witness to read the interview transcript and comment if necessary.

Encourage the witness to contact the board with additional information or concerns.

Remind the witness that a follow-up interview may be conducted.

Table 6-5. Interviewing don'ts.

- DO NOT rush the witness while he/she is describing the accident or answering questions.
- DO NOT judge, display anger, refute, threaten, intimidate, or blame the witness.
- DO NOT suggest answers.
- DO NOT make promises that cannot be kept (for example, unrestricted confidentiality).
- DO NOT use inflammatory words ("violate," "kill," "lie," "stupid," etc.).
- DO NOT omit questions during the interview because you think you already know the answer.
- DO NOT ask questions that suggest an answer, such as "Was the odor like rotten eggs?"

Before each interview, interviewees should be apprised of Freedom of Information Act (FOIA) and Privacy Act concerns as they pertain to their statements and identity. A model opening statement that addresses FOIA and Privacy Act provisions can be found at the end of this section. Interviewees should be aware that information provided during the investigation may not be precluded from release under FOIA or the Privacy Act. For further information consult Section IV, Paragraph 2.2.5.7 of the Implementation Guide for Use with DOE Order 225.1A (DOE G225.1-1). If any questions arise concerning the disclosure of accident investigation records or the applicability of the FOIA or the Privacy Act, guidance should be obtained from the FOIA/Privacy Act attorney at either Headquarters or the field. Most sites have FOIA/Privacy Act specialists who can be consulted for further guidance.

Following these guidelines will help ensure that witness statements are provided freely and accurately, subsequently improving the quality and validity of the information obtained.

6.1.2.2 Evaluating the Witness’s State of Mind

Occasionally, a witness's state of mind may affect the accuracy or validity of testimony provided. In conducting witness interviews, investigators should consider:

- The amount of time between the accident and the interview. People normally forget 50 to 80 percent of the details in just 24 hours.
- Contact between this witness and others who may have influenced how this witness recalls the events.
- Signs of stress, shock, amnesia, or other trauma resulting from the accident. Details of unpleasant experiences are frequently blanked from one's memory.

Investigators should note whether an interviewee displays any apparent mental or physical distress or unusual behavior; it may have a bearing on the interview results. These observations can be discussed and their impact assessed with other members of the board.

6.2 Collecting Physical Evidence

TIP

To ensure consistent documentation, control, and security, it may be useful to designate a single board member or the administrative coordinator to be in charge of handling evidence.

Following the leads and preliminary evidence provided by the initial findings of the site readiness team, the board proceeds in gathering, cataloging, and storing physical evidence from all sources as soon as it becomes available. The most obvious physical evidence related to an accident or accident scene often includes solids such as:

- Equipment
- Tools
Materials
Hardware
Plant facilities
Pre- and post-accident positions of accident-related elements
Scattered debris
Patterns, parts, and properties of physical items associated with the accident.

Less obvious but potentially important physical evidence includes fluids (liquids and gases). Many DOE facilities use a multitude of fluids, including chemicals, fuels, hydraulic control or actuating fluids, and lubricants. Analyzing such evidence can reveal much about the operability of equipment and other potentially relevant conditions or causal factors.

Care should be taken if there is the potential for pathogenic contamination of physical evidence (e.g., blood); such material may require autoclaving or other sterilization. Specialized technicians experienced in fluid sampling should be employed to help the board collect and analyze fluid evidence. If required, expert analysts can be requested to perform tests on the fluids and report results to the board.

When handling potential bloodborne pathogens, universal precautions such as those listed in Table 6-6 should be observed to minimize potential exposure. All human blood and body fluids should be treated as if they are infectious. The precautions in Table 6-6 should be implemented for all potential exposures. Exposure is defined as reasonable anticipated skin, eye, mucous membrane, or parenteral contact with blood or other potentially infectious materials.

### TIP
Significant physical evidence is often found in obscure and seemingly insignificant places, such as hinges and supports.

Physical evidence should be systematically collected, protected, preserved, evaluated, and recorded to ultimately determine how and why failures occurred and whether use, abuse, misuse, or nonuse was a causal factor.

#### Table 6-6. Use these universal precautions when handling potential bloodborne pathogens.

<table>
<thead>
<tr>
<th>Precaution</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal protective equipment</strong></td>
<td>Should be worn when exposure to bloodborne pathogens is likely.</td>
</tr>
<tr>
<td>Hands and other skin</td>
<td>Should be washed with soap and water immediately or as soon as feasible after removal of gloves or other personal protective equipment.</td>
</tr>
<tr>
<td>Handwashing facilities</td>
<td>Should be provided that are readily accessible to employees.</td>
</tr>
<tr>
<td>When provision of handwashing facilities is not feasible, appropriate</td>
<td>Antiseptic hand cleanser in conjunction with clean cloth, paper towels, or antiseptic towelettes should be used. Hands should be washed with soap and water as soon as possible thereafter.</td>
</tr>
<tr>
<td>Contaminated needles and other contaminated sharps shall not be bent, recapped, or removed except by approved techniques.</td>
<td></td>
</tr>
<tr>
<td>Immediately or as soon as possible after use, contaminated reusable sharps</td>
<td>Shall be placed in appropriate containers until properly reprocessed.</td>
</tr>
<tr>
<td>Eating, drinking, smoking, applying cosmetics or lip balm, and handling</td>
<td>Contact lenses are prohibited in work areas where there is a reasonable likelihood of occupational exposure.</td>
</tr>
<tr>
<td>Food and drink</td>
<td>Shall not be kept in refrigerators, freezers, shelves, cabinets, or on countertops or benchtops where blood or other potentially infectious materials are present.</td>
</tr>
<tr>
<td>All procedures involving blood or other potentially infectious materials</td>
<td>Shall be performed in such a manner as to minimize splashing, spraying, spattering, and generation of droplets of these substances.</td>
</tr>
<tr>
<td>Mouth pipetting or suctioning of blood or other potentially infectious</td>
<td>Materials is prohibited.</td>
</tr>
<tr>
<td>Specimens of blood or other potentially infectious materials shall be placed</td>
<td>In a container to prevent leakage during collection, handling, processing, storage, transport, or shipping.</td>
</tr>
<tr>
<td>Equipment, which may become contaminated with blood or other potentially</td>
<td>shall be examined prior to servicing or shipping and shall be decontaminated as necessary.</td>
</tr>
<tr>
<td>6.2.1 Documenting Physical Evidence</td>
<td></td>
</tr>
</tbody>
</table>
Evidence should be carefully documented at the time it is obtained or identified. The Accident Investigation Physical Evidence Log Form (provided at the end of this section) can help investigators document and track the collection of physical evidence. Additional means of documenting physical evidence include sketches, maps, photographs, and videotape.

6.2.1 Sketching and Mapping Physical Evidence

Sketching and mapping the position of debris, equipment, tools, and injured persons may be initiated by the site readiness team and expanded on by the accident investigation board. Position maps convey a visual representation of the scene immediately after an accident. Evidence may be inadvertently moved, removed, or destroyed, especially if the accident scene can only be partially secured. Therefore, sketching and mapping should be conducted immediately after recording initial witness statements.

Precise scale plottings of the position of elements can subsequently be examined to develop and test accident causal theories.

The Accident Investigation Site Sketch, Accident Investigation Site Map, Accident Investigation Position Mapping Form, and Accident Investigation Sketch of Physical Evidence Locations and Orientations (provided at the end of this section) are useful for drawing sketches and maps and recording positions of objects.

6.2.1.2 Photographing and Videotaping Physical Evidence

Photography and videography can be used in a variety of ways to emphasize areas or items of interest and display them for better understanding. These are best performed by specialists, but should be supervised and directed by an investigator.

Photography is a valuable and versatile tool in accident investigation. Photos or videos can identify, record, or preserve physical accident evidence that cannot be effectively conveyed by words or collected by any other means.

Photographic coverage should be detailed and complete, including standard references to help establish distance and perspective. Videotapes should cover the overall accident scene, as well as specific locations or items of significance. A thorough videotape allows the board to minimize trips to the accident scene. This may be important if the scene is difficult to access or if it presents hazards. The Accident Investigation Photographic Log Sheet (provided at the end of this section) can be used to record photograph or videotape subjects, dates, times, and equipment settings and positions.

Good photographic coverage of the accident is essential, even if photographs or video stills will not be used in the investigation report. However, if not taken properly, photographs and videos can easily misrepresent a scene and lead to false conclusions or findings about an accident. Therefore, whenever possible, accident photography and videotaping should be performed by professionals. Photographic techniques that avoid misrepresentation, such as the inclusion of rulers and particular lighting, may be unknown to amateurs but are common knowledge among professional photographers and videographers.

One of the first responsibilities of the board chairperson should be to acquire a technical photographer whose work will assist the board. Five possible sources include:

- In-plant photo lab
- Other DOE or DOE contractor photo labs
- Commercial photographers; industrial, medical, aerial, legal, portrait, and scientific photographers (perhaps the best to assist in accident investigation are industrial, legal, or scientific photographers)
- A member of the investigation board
- Security personnel.

Even if photos are taken by a skilled photographer, the investigation board should be prepared to direct the photographer in capturing certain important perspectives or parts of the accident scene. Photographs of evidence and of the scene itself should be taken from many angles to illustrate the perspectives of witnesses and injured persons. In addition, board members may wish to take photos for their own reference.

If available, digital photography will facilitate incorporation of the photographs into the investigation report. However, if this is not practical, high-quality 35mm photographs can be scanned for incorporation in the report.

As photos are taken, a log should be completed noting the scene/subject, date, time, direction, and orientation of photos, as well as the photographer's name. The Accident Investigation Photographic Log Sheet can be used for this purpose. The Accident Investigation Sketch of Physical Evidence Locations and Orientations (provided at the end of this section) is helpful when reviewing photos and analyzing information.

6.2.2 Inspecting Physical Evidence

Following initial mapping and photographic recording, a systematic inspection of physical evidence can begin. The inspection involves:

- Surveying the involved equipment, vehicles, structures, etc., to ascertain whether there is any indication that component parts were missing or out of place before the accident
- Noting the absence of any parts of guards, controls, or operating indicators (instruments, position indicators, etc.) among the damaged or remaining parts at the scene
- Identifying as soon as possible any equipment or parts that must be cleaned prior to examination or testing and transferring them to a laboratory or to the care of an expert experienced in appropriate testing methodologies
- Noting the routing or movements of records that can later be traced to find missing components
- Preparing a checklist of complex equipment components to help ensure a thorough survey.

These observations should be recorded in notes and photographs so that investigators avoid relying on their memories. Some investigators find a small cassette tape recorder useful in recording general descriptions of appearance and damage; however, the potential failure of a
6.2.3 Removing Physical Evidence

Following the initial inspection of the scene, investigators may need to remove items of physical evidence. To ensure the integrity of evidence for later examination, the extraction of parts must be controlled and methodical. The process may involve simply picking up components or pieces of damaged equipment, removing bolts and fittings, cutting through major structures, or even recovering evidence from beneath piles of debris. Before evidence is removed from the accident scene, it should be carefully packaged and clearly identified. The readiness team or a pre-assembled investigator's kit can provide general-purpose cardboard tags or adhesive labels for this purpose.

Equipment or parts thought to be defective, damaged, or improperly assembled should be removed from the accident scene for technical examination. The removal should be documented using position maps and photos to display the part in its final, post-accident position and condition. If improper assembly is suspected, investigators should direct that the part or equipment be photographed and otherwise documented as each subassembly is removed.

Items that have been fractured or otherwise damaged should be packaged carefully to preserve surface detail. Delicate parts should be padded and boxed. Both the part and the outside of the package should be labeled. Greasy or dirty parts can be wrapped in foil and placed in polyethylene bags or other nonabsorbent materials for transport to a testing laboratory, command center, or evidence storage facility. If uncertainties arise, subject matter experts can advise the board regarding effective methods for preserving and packaging evidence and specimens that must be transported for testing.

When preparing to remove physical evidence, these guidelines should be followed:

- Normally, extraction should not start until witnesses have been interviewed, since visual reference to the accident site can stimulate one's memory.
- Extraction and removal or movement of parts should not be started until position records (measurements for maps, photographs and videotape) have been made.
- Be aware that the accident site may be unsafe due to dangerous materials or weakened structures.
- Locations of removed parts can be marked with orange spray paint or wire-staffed marking flags; the marking flags can be annotated to identify the part removed and to allow later measurement.
- Care during extraction and preliminary examination is necessary to avoid defacing or distorting impact marks and fracture surfaces.
- The board chairperson and investigators should concur when the parts extraction work can begin, in order to assure that board members have completed all observations requiring an intact accident site.

6.3 Collecting Documentary Evidence

Documentary evidence can provide important data and should be preserved and secured as methodically as physical evidence. This information might be in the form of paper, photos, videotape, magnetic tape, or electronic media, either at the site or in files at other locations.

Some work/process/system records are retained only for the workday or the week. Once an accident has occurred, the board must work quickly to collect and preserve these records so they can be examined and considered in the analysis.

Accident investigation preplanning should include procedures for identifying records to be collected, as well as the people responsible for their collection. Because records are usually not located at the scene of the accident, they are often overlooked in the preliminary collection of evidence.

Documents often provide important evidence for identifying causal factors of an accident. This evidence is useful for:

- Thoroughly examining the policies, standards, and specifications that molded the environment in which the accident occurred.
- Indicating the attitudes and actions of people involved in the accident.
- Revealing evidence that generally is not established in verbal testimony.

Documentary evidence generally can be grouped into four categories:

- Management control documents that communicate management expectations of how, when, where, and by whom work activities are to be performed.
- Records that indicate past and present performance and status of the work activities, as well as the people, equipment, and materials involved.
- Reports that identify the content and results of special studies, analyses, audits, appraisals, inspections, inquiries, and investigations related to work activities.
- Follow-on documentation that describes actions taken in response to the other types of documentation.

Collectively, this evidence gives important clues to possible underlying causes of errors, malfunctions, and failures that led to the accident.

6.4 Examining Organizational Concerns, Management Systems, and Line Management Oversight

DOE Order 225.1A requires that the investigation board "examine policies, standards, and requirements that are applicable to the accident being investigated, as well as management and safety systems at Headquarters and in the field that could have contributed to or prevented the accident." Additionally, DOE Order 225.1A, Paragraph 4.c.(2)(b) and (d), requires the board to "evaluate the effectiveness of management systems, as defined by DOE Policy 450.4 (Safety Management System Policy), the adequacy of policy and policy implementation, and the effectiveness of line management oversight as they relate to the accident." Therefore, accident investigations must thoroughly examine organizational concerns, management systems, and line management oversight processes to determine whether...
deficiencies in these areas contributed to causes of the accident. The investigation board should consider the full range of management systems from the first-line supervisor level, up to and including site and Headquarters, as appropriate. It is important to note that this focus should not be directed toward individuals.

In determining sources and causes of management system inadequacies and the failure to anticipate and prevent the conditions leading to the accident, investigators should use the framework of DOE's integrated safety management system established by the Department in DOE Policy 450.4. This policy lists the objective, guiding principles, core functions, mechanisms, responsibilities, and implementation means of an effective safety management system.

The safety management system elements described in DOE Policy 450.4 should be considered when deciding who to interview, what questions to ask, what documents to collect, and what facts to consider pertinent to the investigation. Even more importantly, these elements should be considered when analyzing the facts to determine their significance to the causal factors of the accident.

In many accidents, deficiencies in implementing the five core safety management functions defined in DOE Policy 450.4 cause or contribute to the accident. The five core functions are: (1) define the scope of work; (2) identify and analyze the hazards associated with the work; (3) develop and implement hazard controls; (4) perform work safely within the controls; and (5) provide feedback on adequacy of the controls and continuous improvement in defining and planning the work. Table 6-7 contains a list of typical questions board members may ask to determine whether any deficiencies in the implementation of the core functions affected the accident sequence.

Table 6-8 contains a list of typical questions board members may ask to determine whether line management deficiencies affected the accident. These questions are based on the seven guiding principles of DOE Policy 450.4.

The questions in Tables 6-7 and 6-8 are provided in Appendix D to facilitate use by the board. These are not intended to be exhaustive. Board members should adapt these questions or develop new ones based on the specific characteristics of the accident. The answers to the questions may be used to determine the facts of the accident, which, along with the analytical tools described in Section 7, will enable the board to determine whether deficiencies found in management systems and line management oversight are causal factors for the accident.

Table 6-7. These are typical questions for addressing the five core functions of integrated safety management.

<table>
<thead>
<tr>
<th>Function #1: Define the scope of work.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Were the purpose and scope of the work to be performed clearly defined so that workers could identify any unanticipated conditions and actions that would be outside the authorized work scope?</td>
</tr>
<tr>
<td>• Were expectations regarding the removal or control of hazards clearly defined and communicated to the workers?</td>
</tr>
<tr>
<td>• Were the required safety support activities identified?</td>
</tr>
<tr>
<td>• Were roles, responsibilities, and authorities for the work activity defined and executed appropriately?</td>
</tr>
<tr>
<td>• Were the worker qualifications required to safely perform the work identified?</td>
</tr>
<tr>
<td>• Were the design, operation, and configuration of equipment known and considered in work planning?</td>
</tr>
<tr>
<td>• Were the characteristics of the work environment known and considered in work planning?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Function #2: Identify and analyze the hazards.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Were the type and magnitude of all possible hazards clearly understood by line management, supervisors, and workers?</td>
</tr>
<tr>
<td>• Were the hazards analyzed and potential consequences documented?</td>
</tr>
<tr>
<td>• Did the workers provide input to the hazard analysis?</td>
</tr>
<tr>
<td>• Did the workers receive any feedback regarding their input?</td>
</tr>
<tr>
<td>• Were the standards and requirements associated with the hazards identified?</td>
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</table>

<table>
<thead>
<tr>
<th>Function #3: Develop and implement hazard controls.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Were required physical and engineering hazard controls evaluated for likely effectiveness under the expected work conditions?</td>
</tr>
<tr>
<td>• Were the required administrative controls, such as technical procedures and safety support personnel, in place?</td>
</tr>
<tr>
<td>• Were the workers qualified and given hazard- or activity-specific training?</td>
</tr>
<tr>
<td>• Was a proper review, approval, and configuration control process in place?</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Function #4: Perform work within controls.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Was the readiness to perform the work checked and confirmed prior to starting work?</td>
</tr>
<tr>
<td>• Was appropriate authorization received to start work?</td>
</tr>
<tr>
<td>• Was the work performed as planned (i.e., by the intended workers using the pre-approved procedures with the required level of supervision and safety support present with effective hazard controls in place)?</td>
</tr>
<tr>
<td>• Were the workers empowered to stop work if unanticipated or unsafe conditions arose?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Function #5: Provide feedback and continuous improvement.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Was there a system to collect and use feedback from workers on workplace hazards?</td>
</tr>
<tr>
<td>• Were workers aware of any hazards affecting the work activity that were not addressed in planning for it?</td>
</tr>
<tr>
<td>• Was management aware of the hazard(s) identified by the workers?</td>
</tr>
<tr>
<td>• Were there any lessons learned locally, from audit or evaluation results or from external operating experience, that applied to the work activity but were not addressed in planning for it?</td>
</tr>
</tbody>
</table>
Table 6-8. These are typical questions for addressing the seven guiding principles of integrated safety management.

<table>
<thead>
<tr>
<th>Guiding Principle #1: Line management is directly responsible for the protection of the public, workers, and the environment.</th>
</tr>
</thead>
<tbody>
<tr>
<td>■ Did DOE assure and contractor line management establish documented safety policies and goals?</td>
</tr>
<tr>
<td>■ Was integrated safety management policy fully implemented down to the activity level at the time of the accident?</td>
</tr>
<tr>
<td>■ Was DOE line management proactive in assuring timely implementation of integrated safety management by line organizations, contractors, subcontractors, and workers?</td>
</tr>
<tr>
<td>■ Were environment, safety and health (ES&amp;H) performance expectations for DOE and contractor organizations clearly communicated and understood?</td>
</tr>
<tr>
<td>■ Did line managers elicit and empower active participation by workers in safety management?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Guiding Principle #2: Clear lines of authority and responsibility for ensuring safety shall be established and maintained at all organizational levels within the Department and its contractors.</th>
</tr>
</thead>
<tbody>
<tr>
<td>■ Did line management define and maintain clearly delineated roles and responsibilities for ES&amp;H to effectively integrate safety into sitewide operations?</td>
</tr>
<tr>
<td>■ Was a process established to ensure that safety responsibilities were assigned to each person (employees, subcontractors, temporary employees, visiting researchers, vendor representatives, lessees, etc.) performing work?</td>
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<tr>
<td>■ Did line management establish communication systems to inform the organization, other facilities, and the public of potential ES&amp;H impacts of specific work processes?</td>
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<tr>
<td>■ Were managers and workers at all levels aware of their specific responsibilities and accountability for ensuring safe facility operations and work practices?</td>
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<tr>
<td>■ Were individuals held accountable for safety performance through performance objectives, appraisal systems, and visible and meaningful consequences?</td>
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<tr>
<td>■ Did DOE line management and oversight hold contractors and subcontractors accountable for ES&amp;H through appropriate contractual and appraisal mechanisms?</td>
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<thead>
<tr>
<th>Guiding Principle #3: Personnel shall possess the experience, knowledge, skills, and abilities that are necessary to discharge their responsibilities.</th>
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<tr>
<td>■ Did line managers demonstrate a high degree of technical competence and understanding of programs and facilities?</td>
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<td>■ Did line management have a documented process for assuring that DOE personnel, contractors, and subcontractors were adequately trained and qualified on job tasks, hazards, risks, and Departmental and contractor policies and requirements?</td>
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<tr>
<td>■ Were mechanisms in place to assure that only qualified and competent personnel were assigned to specific work activities, commensurate with the associated hazards?</td>
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<tr>
<td>■ Were mechanisms in place to assure understanding, awareness, and competence in response to significant changes in procedures, hazards, system design, facility mission, or life cycle status?</td>
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<tr>
<td>■ Did line management establish and implement processes to ensure that ES&amp;H training programs effectively measure and improve performance and identify training needs?</td>
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<tr>
<td>■ Was a process established to ensure that (1) training program elements were kept current and relevant to program needs, and (2) job proficiency was maintained?</td>
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<tr>
<th>Guiding Principle #4: Resources shall be effectively allocated to address safety, programmatic, and operational considerations. Protecting the public, the workers and the environment shall be a priority whenever activities are planned and performed.</th>
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<tr>
<td>■ Did line management demonstrate a commitment to ensuring that ES&amp;H programs had sufficient resources and priority within the line organization?</td>
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<tr>
<td>■ Did line management clearly establish that integrated safety management was to be applied to all types of work and address all types of hazards?</td>
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<tr>
<td>■ Did line management institute a safety management system that provided for integration of ES&amp;H management processes, procedures, and/or programs into site, facility, and work activities in accordance with the Department of Energy Acquisition Regulation (DEAR) ES&amp;H clause (48 CFR 970.5204-2)?</td>
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<td>■ Were prioritization processes effective in balancing and reasonably limiting the negative impact of resource reductions and unanticipated events on ES&amp;H funding?</td>
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<tr>
<th>Guiding Principle #5: Before work is performed, the associated hazards shall be evaluated and an agreed-upon set of safety standards shall be established that, if properly implemented, will provide adequate assurance that the public, the workers, and the environment are protected from adverse consequences.</th>
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<tr>
<td>■ Was there a process for managing requirements, including the translation of standards and requirements into policies, programs, and procedures, and the development of processes to tailor requirements to specific work activities?</td>
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<td>■ Were requirements established commensurate with the hazards, vulnerabilities, and risks encountered in the current life cycle stage of the site and/or facility?</td>
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<tr>
<td>■ Were policies and procedures, consistent with current DOE policy, formally established and approved by appropriate authorities?</td>
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<tr>
<td>■ Did communication systems assure that managers and staff were cognizant of all standards and requirements applicable to their positions, work, and associated hazards?</td>
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Guiding Principle #6: Administrative and engineering controls to prevent and mitigate hazards shall be tailored to the work performed and associated hazards.

- Were the hazards associated with the work activity identified, analyzed, and categorized so that appropriate administrative and engineering controls could be put in place to prevent or mitigate the hazards?
- Were hazard controls established for all stages of work to be performed (e.g., normal operations, surveillance, maintenance, facility modifications, decontamination, and decommissioning)?
- Were hazard controls established that were adequately protective and tailored to the type and magnitude of the work and hazards and related factors that impact the work environment?
- Were processes established for ensuring that DOE contractors and subcontractors test, implement, manage, maintain, and revise controls as circumstances change?
- Were personnel qualified and knowledgeable of their responsibilities as they relate to work controls and work performance for each activity?

Guiding Principle #7: The conditions and requirements to be satisfied for operations to be initiated and conducted shall be clearly established and agreed upon.

- Were processes in place to assure the availability of safety systems and equipment necessary to respond to hazards, vulnerabilities, and risks present in the work environment?
- Did DOE and contractor line management establish and agree upon conditions and requirements that must be satisfied for operations to be initiated?
- Was a management process established to confirm that the scope and authorization documentation is adequately defined and directly corresponds to the scope and complexity of the operations being authorized?
- Was a change control process established to assess, approve, and reauthorize any changes to the scope of operations ongoing at the time of the accident?

6.5 Preserving and Controlling Evidence

Preserving and controlling evidence are essential to the integrity and credibility of the investigation. Security and custody of evidence are necessary to prevent its alteration or loss and to establish the accuracy and validity of all evidence collected.

The point of contact is responsible for assuring that a chain of custody is established for all evidence removed from the accident scene before the board arrives.

The board chairperson is responsible for establishing an evidentiary custody protocol to ensure that all evidence is well documented at the accident scene and carefully controlled when it is removed and stored after the board arrives. Evidence control procedures similar to the following guidelines will help assure that evidence is not adulterated, corrupted, or lost and that subsequent engineering tests, if conducted, and other analytical results are valid.

- Evidence should be photographed and/or videotaped in its original location immediately following the accident, provided it does not interfere with rescue or amelioration activities.
- A log should be maintained stating the location, date, and time that photos and videos are taken. The Accident Investigation Photographic Log Sheet can be used for this purpose. Avoid using photographic attachments that digitally record the date and time on the negative because these images become a permanent part of the photo and may obscure evidence or important details in the photo or video. The computerized/printed date on the back of photos provided by film processors should be used in conjunction with, not in lieu of, a photo log, because the date on photos gives the day the film was processed, not the day the photos were taken.
- Board members should prepare and sign an inventory of all evidentiary items collected, including statements regarding:
  - Items removed from the scene
  - Date and time items were removed
  - Person who removed items
  - Location where those items will be stored.
- Evidence should be controlled by signature transfer (signatures of the recipient and the person relinquishing custody) and made available only to those who need to examine and use the evidence during the accident investigation. The Accident Investigation Physical Evidence Log Form may be used for this purpose.
- Secure storage should be obtained immediately, and access to evidence controlled throughout the investigation.
- Access to the room or suite of offices used by the investigation board should be restricted. No one other than board members, advisors, and support staff should have access to the board's office space; this includes janitorial staff.
- The board chairperson should determine the disposition of evidence at the conclusion of the investigation.

Documentary evidence can easily be overlooked, misplaced, or taken. Documents can be altered, disfigured, misinterpreted, or electronically corrupted. Computer software and disks can be erased by exposure to magnetic fields. As with other evidence collected during the investigation, documentary evidence should be collected, inventoried, controlled, and secured (in locked containers, if necessary).

TIP

Protect all records relating to the accident until investigation activities or analysis of those records determines that they are not relevant to the accident.
Key Points to Remember

- Gather as much evidence as quickly as possible. It is easier to discount an item later than to capture or reconstruct it later.

- Assess initial response activities performed by the site readiness team to determine any gaps or immediate concerns. Formulate initial plans for evidence collection based on this assessment.

- Three types of evidence are gathered during accident investigations:
  - Human or testamentary evidence (witness statements and observations)
  - Physical evidence (matter related to the accident such as equipment, parts, fluids, debris, hardware, and other physical items)
  - Documentary evidence (paper and electronic information).

- Develop and implement effective procedures to preserve and control evidence because they are necessary to ensure the accuracy and validity of the evidence and essential to the integrity and credibility of the investigation.

- The five major steps in gathering evidence are:
  - Collecting human evidence (locating and interviewing witnesses)
  - Collecting physical evidence
  - Collecting documentary evidence
  - Examining organizational concerns, management systems, and line management oversight
  - Preserving and controlling evidence.

- Identify witnesses as quickly as possible to obtain witness statements. Sources for locating witnesses include site readiness and emergency response personnel, principal witnesses, eyewitnesses, first line supervisors, police, firefighters, paramedics, nurses or doctors, news media, and maintenance and security personnel.

- Promoting effective interviews includes careful preparation, creating a relaxed atmosphere, preparing the witness for the interview, recording the interview (preferably by using a court reporter to document the interview), asking open-ended questions, and evaluating the witness's state of mind.

- Do not rush witnesses while they are describing the accident; do not be judgmental, hostile, or argumentative; do not display anger, suggest answers, threaten, intimidate, or blame the witness; do not make promises of confidentiality, use inflammatory words, ask questions that suggest an answer, or omit questions because you think you know the answer.

- Make position maps of the accident scene, noting the position of all relevant evidence. Use professionals to capture high-quality photographic evidence.

- Mapping and photographing the accident scene are important, because precise visual representations of the accident scene and pinpointing the location of evidence before it is moved are necessary to ensure that the board has the means to develop and test causal theories.

- Remove evidence carefully, tagging and packaging it to preserve its integrity.

- Before removing evidence from the accident scene, follow these guidelines:
  - If possible, removal should not begin until witnesses have been interviewed
  - Extraction and removal or movement should not be started until the scene and the location of evidence has been documented
  - Exercise caution and be alert for unsafe conditions or weakened structures
  - The location of removed material can be marked with paint or flags
  - Avoid defacing or distorting impact marks and fracture surfaces
  - The board should concur on removal
  - Follow precautions when handling potential bloodborne pathogens.

- Documentary evidence is generally grouped into four categories:
  - Management control documents
  - Records that indicate past and present status of work activities
  - Reports of studies, analyses, audits, etc.
  - Follow-on documentation that describes actions taken in response to other types of documentation.

- Consider the role of management systems when collecting and reviewing evidence, and gather all evidence that could reveal deficiencies in safety management.

- Use the guiding principles and core functions of the integrated safety management system to form questions that will guide evidence collection and analysis of all levels of management systems, from the first line
supervisor up to and including Headquarters.

- Establish a chain of custody for evidence and ensure that it is strictly maintained throughout the investigation.

### Accident Investigation Interview Schedule Form

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<th>Individual to be interviewed</th>
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## Accident Investigation Interview Form

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<th>Interviewer: Title/Position:</th>
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MODEL OPENING STATEMENT

[To be recorded]

Let the record reflect that this interview has commenced at (time, date, and place).

I'm (state interviewer's name(s) and employment affiliation(s), i.e., I'm Joe Smith of the Idaho Operations Office of the Department of Energy. With me are (name and organization of other Department personnel). For the record, please state your full name, company affiliation, job title or position.

Read into record the names and employment of any additional persons present (other than the recorder).

The Department has established an accident investigation board to determine the facts that led to the (accident date) accident at (place of accident). The principal purpose of this investigation is to determine the facts surrounding the accident so that proper remedial measures can be instituted to prevent the recurrence of accidents. We have authority to conduct this investigation under the Department of Energy Organization Act, which incorporates provisions of the Atomic Energy Act of 1954 authorizing investigations of this type.

Your appearance here to provide information is entirely voluntary, and you may stop testifying and leave at any time. However, you should understand that giving false testimony in this investigation would be a felony under 18 U.S. Code Section 1001. Do you understand that?

You have the right to be accompanied by an attorney or a union representative. (If witness has attorney or a union representative, put the name of such person into the record.) "Let the record reflect that Mr./Mrs./Ms. is accompanied by " (as his/her attorney or union representative).

We would like to record this interview to ensure an accurate record of your statements. A transcript of this discussion will be produced, and you will have an opportunity to review the transcript for factual accuracy and corrections. If you do not wish to have the session recorded, we will not do so. Do you have any objection to having the session recorded?

We will attempt to keep your testimony confidential but we cannot guarantee it. At a later date, we may have to release your testimony pursuant to a request made under the Freedom of Information Act, a court order, or in the course of litigation concerning the accident, should such litigation arise. Do you want your testimony to be considered confidential? (wait for answer--if answer to preceding question is affirmative).

Accident Investigation Physical Evidence Log Form

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<th>Evidence Description</th>
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### Attach copy of Accident Investigation Sketch of Physical Evidence Locations

**Accident Investigation Site Sketch**

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### Attach copy of Accident Investigation Position Mapping Form

**Accident Investigation Site Map**

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### Attach copy of Accident Investigation Position Mapping Form

**Accident Investigation Position Mapping Form**

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Attach copy of Accident Investigation Site Map and Accident Investigation Site Sketch

**Accident Investigation Sketch of Physical Evidence Locations and Orientations**

Board Member:  
Title:  

[Blank space for sketch]

Attach copy of Accident Investigation Physical Evidence Log Form
### Accident Investigation Photographic Log Sheet

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### Accident Investigation Sketch of Photography Locations and Orientations

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Attach copy of Accident Investigation Position Mapping Form
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- 7.2 Determining Causal Factors
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  - 7.2.2 Contributing Causes
  - 7.2.3 Root Causes
  - 7.2.4 The Importance of Causal Factors
- 7.3 Using the Core Analytical Techniques
  - 7.3.1 Events and Causal Factors Charting
  - 7.3.2 Barrier Analysis
  - 7.3.3 Change Analysis
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Analyzing Data

Careful and complete analysis of the data collected following an accident is critical to the accurate determination of an accident's causal factors. The results of comprehensive analyses provide the basis for corrective and preventive measures.

The analysis portion of the accident investigation is not a single, distinct part of the investigation. Instead, it is the central part of the iterative process that includes collecting facts and determining causal factors. Well chosen and carefully performed analytical methods are important for providing results that can aid investigators in developing an investigation report that has sound judgments of need.

Caution must be taken in applying analytic methods. First, no single method will provide all the analyses required to completely determine the multiple causal factors of an accident. Several techniques that can complement and cross-validate one another should be used to yield optimal results. Second, analytic techniques cannot be used mechanically and without thought. The best analytic tools can become cumbersome and ineffective if they are not applied to an accident's specific circumstances and adapted accordingly.

**TIP**
Each board should determine which analytic techniques to use based on the accident’s complexity and severity. Alternative approaches and methods to those presented in this workbook are acceptable, provided that they meet the requirements of DOE Order 225.1A and are demonstrably equivalent.

### 7.1 Determining Facts

Immediately following any serious accident, much of the available information may be conflicting and erroneous. The volume of data expands rapidly as witness statements are taken, emergency response actions are completed, evidence is collected, and the accident scene is observed by more individuals.

The principal challenge of the investigation board is to distinguish between accurate and erroneous information in order to focus on areas that will lead to identifying the accident's causal factors. This can be accomplished by:

- Understanding the activity that was being performed at the time of the accident
- Personally conducting a walkthrough of the accident scene
- Challenging ‘facts’ that are inconsistent with other evidence (e.g. physical)
- Corroborating facts through interviews
- Testing or inspecting pertinent components to determine failure modes and physical evidence
- Reviewing policies, procedures, and work records to determine the level of compliance or implementation.

**TIP**
Prevention is at the heart of the entire investigation process; therefore, any accident investigation must focus on fact-finding, not fault-finding.

Fact-finding begins during the collection of evidence. All sources of evidence (e.g., accident site walkthroughs, witness interviews, physical evidence, policy or procedure documentation) contain facts that, when linked, create a chronological depiction of the events leading to an accident. Facts are not hypotheses, opinions, analysis, or conjecture. However, not all facts can be determined with complete certainty, and such facts are referred to as assumptions. Assumptions should be reflected as such in the investigation report and in any closeout briefings.

Board members should immediately begin developing a chronology of events as facts and evidence are collected. Facts should be reviewed on an ongoing basis to ensure relevance and accuracy. Facts and evidence later determined to be irrelevant should be removed from the accident chronology but retained in the official investigation file for future consideration.

Contradictory facts can be resolved in closed board meetings, recognizing that the determination of significant facts is an iterative process that evolves as gaps in information are closed and questions resolved. The board revisits the prescribed scope and depth of their investigation often during the fact-finding and analysis process. Doing so ensures that the investigation adheres to the parameters prescribed in the board’s appointment memorandum.

Causal factors of an accident are identified by analyzing the facts. Judgments of need, and the subsequent corrective actions, are based on the identified causes of the accident. Therefore, the facts are the foundation of all other parts of the investigative process.

Table 7-1. Case study introduction.
7.2 Determining Causal Factors

Causal factors are the events and conditions that produced or contributed to the occurrence of the accident. There are three types of causal factors:

- Direct cause
- Contributing causes
- Root causes.

7.2.1 Direct Cause

The direct cause of an accident is the immediate events or conditions that caused the accident. The direct cause should be stated in one sentence, as illustrated in the examples below.

**EXAMPLES:**
- The direct cause of the accident was contact between the chisel bit of the air-powered jackhammer and the 13.2 kV energized electrical cable in the sump pit being excavated.
- The direct cause of the accident was the inadvertent activation of electrical circuits that initiated the release of CO2 in an occupied space.

Identifying the direct cause of an accident is optional. While it may not be necessary to identify the direct cause in order to complete the causal factors analysis, the direct cause should be identified when it facilitates understanding why the accident occurred or when it is useful in developing lessons learned from the accident.

7.2.2 Contributing Causes

Contributing causes are events or conditions that collectively with other causes increased the likelihood of an accident but that individually did not cause the accident. Contributing causes may be longstanding conditions or a series of prior events that, alone, were not sufficient to cause the accident, but were necessary for it to occur. Contributing causes are the events and conditions that “set the stage” for the accident and, if allowed to persist or reoccur, increase the probability of future accidents.

**EXAMPLES:**
- Failure to implement safety procedures in effect for the project contributed to the accident.
- Failure to erect barriers or post warning signs contributed to the accident.
- Inadequate illumination in the area of the platform created visibility problems that contributed to the fall from the platform.

7.2.3 Root Causes

Root causes are the causal factors that, if corrected, would prevent recurrence of the same or similar accidents. Root causes may be derived from or encompass several contributing causes. They are higher-order, fundamental causal factors that address classes of deficiencies, rather than single problems or faults. Correcting root causes would not only prevent the same accident from recurring, but would also solve line management, oversight, and management system issues.
deficiencies that could cause or contribute to other accidents. They are identified using root cause analysis (see Section 7.3.5).

In many cases, root causes are failures to properly implement the principles and core functions of integrated safety management. Root causes can include failures in management systems to:

- Define clear roles and responsibilities for safety
- Ensure that staff are competent to perform their responsibilities
- Ensure that resource use is balanced to meet critical mission and safety goals
- Ensure that safety standards and requirements are known and applied to work activities
- Ensure that hazard controls are tailored to the work being performed
- Ensure that work is properly reviewed and authorized.

**TIP**

Even though the board should avoid placing individual blame for an accident, the board has an obligation to seek out and report all causal factors, including deficiencies in management, safety, or line management oversight systems.

Root cause statements, as shown in the examples below, should identify the DOE and contractor line organizations responsible for the safety management failures. Root cause statements should also identify the specific management system(s) that failed.

<table>
<thead>
<tr>
<th>EXAMPLES: ACCIDENT ROOT CAUSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractor management and the DOE field office failed to clearly define responsibilities for safety reviews of planned work. The lack of clarity in roles and responsibilities for safety reviews was a root cause of the accident.</td>
</tr>
<tr>
<td>Contractor management allowed the standing work order process, intended for routine work, to be used to accomplish non-routine, complex modification and construction work. DOE field office oversight failed to detect and ensure correction of this practice. Misuse of the standing work order process was a root cause of the accident.</td>
</tr>
<tr>
<td>Contractor management systems were ineffective in translating lessons learned from past occurrences into safer day-to-day operations at the facility. The failure to implement lessons learned was a root cause of the accident.</td>
</tr>
<tr>
<td>Assessments performed by the DOE program office failed to identify that some safety standards were not addressed by contractor safety management systems. Implementation of these requirements would have prevented the accident.</td>
</tr>
</tbody>
</table>

### 7.2.4 The Importance of Causal Factors

The primary purpose of any accident investigation is to help line management prevent recurrence of accidents by identifying all of an accident’s causal factors. The board is responsible for identifying the local causal factors that, if corrected, would prevent another accident from occurring when the same work activity is performed again. However, more is required than simply detecting and removing immediate hazards. The board is also responsible for identifying and describing any failures in management systems and oversight processes that allow hazards to exist that could lead to other accidents at other facilities and DOE sites. Modern accident investigation theory indicates that generally the root causes of accidents are found in management system failures, not in the most directly related causal factor(s) in terms of time, location, and place.

Generally, the higher the level in the management and oversight chain at which a root cause is found, the broader the scope of the activities that the root cause can affect. Because these higher-level root causes, if not corrected, have the largest potential to cause other accidents, it is incumbent on a board to ensure that the investigation is not ended until the root causes are identified. If a board cannot identify root causes, this should be stated clearly in the investigation report, along with an explanation.

### 7.3 Using the Core Analytical Techniques

**TIP**

The purpose of any analytic technique in an accident investigation is to answer the question — “How did it happen?” It is the job of the board to apply whatever techniques can help them determine the causal factors of an accident.

Accident investigation boards commonly use four techniques to analyze the factual information they have collected, to identify conditions and events that occurred before and immediately following an accident, and to determine an accident’s causal factors.

Following are descriptions of and instructions for using these four core analytic techniques:

- Events and causal factors charting and analysis
- Barrier analysis
- Change analysis
- Root cause analysis.

#### 7.3.1 Events and Causal Factors Charting

Accidents rarely result from a single cause. Events and causal factors charting is useful in identifying the multiple causes and graphically depicting the triggering conditions and events necessary and sufficient for an accident to occur.

For purposes of this workbook, events and causal factors charting and events and causal factors analysis (see Section 7.3.4) are considered one technique. They are addressed separately because they are conducted at different stages of the investigation. Events and causal factors charting is a graphical display of the accident’s chronology and is used primarily for compiling and organizing evidence to portray the sequence of the accident’s events. It is a continuous process performed throughout the investigation. Events and causal factors analysis is the application of analysis to determine causal factors by identifying significant events and conditions that led to the accident. As the results of other analytical techniques (e.g., change analysis and barrier analysis) are completed, they are incorporated into the events and causal factors chart. After the chart is fully developed, the analysis is performed to identify causal factors.

Events and causal factors charting is possibly the most widely used analytic technique in DOE accident investigations, because the events and causal factors chart...
is easy to develop and provides a clear depiction of the data. By carefully tracing the events and conditions that allowed the accident to occur, board members can pinpoint specific events and conditions that, if addressed through corrective actions, would prevent a recurrence. The benefits of this technique are highlighted in Table 7-2.

### Table 7-2. Benefits of events and causal factors charting.

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illustrating and validating the sequence of events and the conditions affecting these events</td>
<td>By carefully tracing the events and conditions that allowed the accident to occur, board members can pinpoint specific events and conditions that, if addressed through corrective actions, would prevent a recurrence.</td>
</tr>
<tr>
<td>Showing the relationship of immediately relevant events and conditions to those that are associated but less apparent — portraying the relationships of organizations and individuals involved in the accident</td>
<td>The benefit of events and causal factors charting include: Illustrating and validating the sequence of events leading to the accident and the conditions affecting these events; showing the relationship of immediately relevant events and conditions to those that are associated but less apparent — portraying the relationships of organizations and individuals involved in the accident.</td>
</tr>
<tr>
<td>Directing the progression of additional data collection and analysis by identifying information gaps</td>
<td>The benefit of events and causal factors charting include: Illustrating and validating the sequence of events leading to the accident and the conditions affecting these events; showing the relationship of immediately relevant events and conditions to those that are associated but less apparent — portraying the relationships of organizations and individuals involved in the accident.</td>
</tr>
<tr>
<td>Linking facts and causal factors to organizational issues and management systems</td>
<td>The benefit of events and causal factors charting include: Illustrating and validating the sequence of events leading to the accident and the conditions affecting these events; showing the relationship of immediately relevant events and conditions to those that are associated but less apparent — portraying the relationships of organizations and individuals involved in the accident.</td>
</tr>
<tr>
<td>Validating the results of other analytic techniques</td>
<td>The benefit of events and causal factors charting include: Illustrating and validating the sequence of events leading to the accident and the conditions affecting these events; showing the relationship of immediately relevant events and conditions to those that are associated but less apparent — portraying the relationships of organizations and individuals involved in the accident.</td>
</tr>
<tr>
<td>Providing a structured method for collecting, organizing, and integrating collected evidence</td>
<td>The benefit of events and causal factors charting include: Illustrating and validating the sequence of events leading to the accident and the conditions affecting these events; showing the relationship of immediately relevant events and conditions to those that are associated but less apparent — portraying the relationships of organizations and individuals involved in the accident.</td>
</tr>
<tr>
<td>Conveying the possibility of multiple causes</td>
<td>The benefit of events and causal factors charting include: Illustrating and validating the sequence of events leading to the accident and the conditions affecting these events; showing the relationship of immediately relevant events and conditions to those that are associated but less apparent — portraying the relationships of organizations and individuals involved in the accident.</td>
</tr>
<tr>
<td>Providing an ongoing method of organizing and presenting data to facilitate communication among the investigators</td>
<td>The benefit of events and causal factors charting include: Illustrating and validating the sequence of events leading to the accident and the conditions affecting these events; showing the relationship of immediately relevant events and conditions to those that are associated but less apparent — portraying the relationships of organizations and individuals involved in the accident.</td>
</tr>
<tr>
<td>Clearly presenting information regarding the accident that can be used to guide report writing</td>
<td>The benefit of events and causal factors charting include: Illustrating and validating the sequence of events leading to the accident and the conditions affecting these events; showing the relationship of immediately relevant events and conditions to those that are associated but less apparent — portraying the relationships of organizations and individuals involved in the accident.</td>
</tr>
<tr>
<td>Providing an effective visual aid that summarizes key information regarding the accident and its causes in the investigation report.</td>
<td>The benefit of events and causal factors charting include: Illustrating and validating the sequence of events leading to the accident and the conditions affecting these events; showing the relationship of immediately relevant events and conditions to those that are associated but less apparent — portraying the relationships of organizations and individuals involved in the accident.</td>
</tr>
</tbody>
</table>

**TIP**

To identify causal factors, board members must have a clear understanding of the relationships among the events and the conditions that allowed the accident to occur. Events and causal factors charting provides a graphical representation of these relationships.

### Constructing the Chart.

Constructing the events and causal factors chart should begin immediately. However, the initial chart will be only a skeleton of the final product. Many events and conditions will be discovered in a short amount of time, and therefore, the chart should be updated almost daily throughout the investigative data collection phase. Keeping the chart up to date helps ensure that the investigation proceeds smoothly, that gaps in information are identified, and that the investigators have a clear representation of accident chronology for use in evidence collection and witness interviewing.

Investigators and analysts can construct an events and causal factors chart using either a manual or computerized method. Accident investigation boards often use both techniques during the course of the investigation, developing the initial chart manually and then transferring the resulting data into computer programs.

The manual method employs removable adhesive notes to chronologically depict events and the conditions affecting these events. The chart is generally constructed on a large conference room wall or many sheets of poster paper. Accident events and conditions are recorded on removable adhesive notes and affixed sequentially to the wall in the board’s conference room or “command center.” Because the exact chronology of the information is not yet known, using removable adhesive notes allows investigators to easily change the sequence of this information and to add information as it becomes available. Different colored notes or inks can be used to distinguish between events and conditions in this initial manual construction of the events and causal factors chart.

If the information becomes too unwieldy to manipulate manually, the data can be entered into a computerized analysis program. Using specialized analytical software, investigators can produce an events and causal factors graphic, as well as other analytical trees or accident models.

Whether using a manual or a computerized approach, the process begins by chronologically constructing, from left to right, the primary chain of events that led to an accident. Secondary and miscellaneous events are then added to the events and causal factors chart, inserted where appropriate in a line above the primary sequence line. Conditions that affect either the primary or secondary events are then placed above or below these events. Figure 7-1 illustrates the basic format of the events and causal factors chart. Guidelines for constructing the chart are shown in Table 7-3.

A sample summary events and causal factors chart (Figure 7-2) uses data from the case study accident. It illustrates how data may become available during an accident investigation, and how a chart would first be constructed and subsequently updated and expanded.

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**Figure 7-1. Simplified events and causal factors chart.**

![Event and Causal Factors Chart](http://tis.eh doe.gov/oversight/procedures/9905workbook/chpt7/chapt7.htm (5 of 32) [1/29/2002 9:11:12 AM])

**Table 7-3. Guidelines and symbols for preparing an events and causal factors chart.**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event 1</td>
<td>Primary event</td>
</tr>
<tr>
<td>Event 2</td>
<td>Secondary event</td>
</tr>
<tr>
<td>Condition</td>
<td>Conditions affecting the events</td>
</tr>
<tr>
<td>Sequence</td>
<td>Sequence of events and conditions</td>
</tr>
<tr>
<td>Arrow</td>
<td>Direction of sequence</td>
</tr>
</tbody>
</table>

---
Symbols
- Events
- Accidents
- Conditions
- Presumptive events
- Presumptive conditions or assumptions
- Connect events
- Connect conditions
- Transfers one line to another
- LTA - Less than adequate; a judgment of the board

Events
- Are active (e.g., "crane strikes building")
- Should be stated using one noun and one active verb
- Should be quantified as much as possible and where applicable (e.g., "the worker fell 26 feet," rather than, "the worker fell off the platform")
- Should indicate the date and time of the event, when they are known
- Should be derived from the event or events and conditions immediately preceding it.

Conditions
- Are passive (e.g., "fog in the area")
- Describe states or circumstances rather than occurrences or events
- As practical, should be quantified
- Should indicate date and time if practical/applicable
- Are associated with the corresponding event.

Primary Event Sequence
- Encompasses the main events of the accident and those that form the main events line of the chart.

Secondary Event Sequence
- Encompasses the events that are secondary or contributing events and those that form the secondary line of the chart.

Figure 7.2. Sample of an events and causal factors chart (in progress).

Stage 1:
(Facts available at the time of board's arrival on site)

Stage 2:
(Facts and conditions known after reviewing witness statements and conducting walk-through)

Stage 3:
(Additional facts obtained from interviews and document reviews. Note few conditions have been determined thus far.)
Stage 4:
(Facts and conditions known after interviews, reviews of documentary evidence)

Legend
- Event
- Condition
- Accident
- Transfer
- LTA Less Than Adequate
7.3.2 Barrier Analysis

Barrier analysis is based on the premise that hazards are associated with all accidents. Barriers are developed and integrated into a system or work process to protect personnel and equipment from hazards (see Figure 7-3 below). For an accident to occur, there must be:

- A hazard, which comes into contact with
- A target, because
- Barriers or controls were not in place, unused or failed

Figure 7-3. Barriers are intended to protect personnel and property against hazards.
A **hazard** is the potential for an energy flow to result in an accident or other adverse consequence. Energy flow is the transfer of energy from its source to another destination. This transfer of energy can be either wanted or unwanted. For example, the flow of electricity through an electrical cable to a piece of equipment is a desired energy flow. A worker coming into contact with that electricity is an undesired energy transfer. As used here, energy is defined broadly as the capacity to do work. Energy could be, for example, kinetic, biological, acoustical, chemical, electrical, mechanical, potential, electromagnetic, thermal, or radiation.

A **target** is a person or object that a hazard may damage, injure, or fatally harm.

A **barrier** is any means used to control, prevent, or impede the hazard from reaching the target.

Investigators use barrier analysis to identify hazards associated with an accident and the barriers that should have been in place to prevent it. This analysis addresses:

- Barriers that were in place and how they performed
  - Barriers that were in place but not used
  - Barriers that were not in place but were required
- The barrier(s) that, if present or strengthened, would prevent the same or a similar accident from occurring in the future.

Figure 7-4 shows types of barriers that may be in place to protect workers from hazards.

When analyzing barriers, investigators should first consider how the hazard and target could come together and what was in place or was required to keep them apart. Obvious physical barriers are those placed directly on the hazard (e.g., a guard on a grinding wheel); those placed between a hazard and target (e.g., a railing on a second-story platform);
or those located on the target (e.g., a welding helmet). Management system barriers may be less obvious, such as the exposure limits required to minimize harm to personnel or the role of supervision in ensuring that work is performed safely. The investigator must understand each barrier's intended function and location, and how it failed to prevent the accident.

To analyze the performance of physical barriers, investigators may need several different types of data, including:

- Plans and specifications for the equipment or system
- Procurement and vendor technical documentation
- Installation and testing records
- Photographs or drawings
- Maintenance histories.

To analyze management barriers, investigators may need to obtain information about barriers at three organizational levels responsible for the work: the activity, facility, and institutional levels. For example, at the activity level, the investigator will need information about the work planning and control processes that governed the work activity, as well as the relevant safety management systems. This information could include:

- Organizational charts defining supervisory and contractor management roles and responsibilities for safety
- Training and qualification records for those involved in the accident
- Hazard analysis documentation
- Hazard control plans
- Work permits
- The work package and procedures that were used during the activity.

The investigator may also need information about safety management systems at the facility level. This kind of information might include:

- The standards and requirements that applied to the work activity, such as occupational exposure limits or relevant Occupational Safety and Health Administration regulations
- The facility technical safety requirements and safety analysis report
- Safety management documentation that defines how work is to be planned and performed safely at the facility
- The status of integrated safety management implementation.

The third type of information the investigator may need would be information about the institutional-level safety management direction and oversight provided by senior line management organizations. This kind of information might include:

- Policy, orders, and directives
- Budgeting priorities
- Resource commitments.

The investigator should use barrier analysis to ensure that all failed, unused, or uninstalled barriers are identified and that their impact on the accident is understood. However, the investigator must cross-validate the results with the results of other core analytic techniques to identify which barrier failures were contributory or root causes of the accident.

**Constructing a Worksheet.** A barrier analysis worksheet is a useful tool in conducting a barrier analysis. A blank worksheet is provided at the end of this section. Table 7-4 illustrates a worksheet that was partially completed using data from the case study. Steps used for completing this worksheet are provided below.

<table>
<thead>
<tr>
<th>Table 7-4. Sample barrier analysis worksheet.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hazard:</strong> 13.2 kV electrical cable</td>
</tr>
<tr>
<td><strong>What were the barriers?</strong></td>
</tr>
<tr>
<td>Engineering drawings</td>
</tr>
<tr>
<td>Indoor excavation permit</td>
</tr>
<tr>
<td>Personal protective equipment</td>
</tr>
</tbody>
</table>
Basic Barrier Analysis Steps

Step 1: Identify the hazard and the target. Record them at the top of the worksheet.

1.3.2 kV electrical cable. Acting pipetter.

Step 2: Identify each barrier. Record in column one.

Engineering drawings. Indoor excavation permit. Personal protective equipment.

Step 3: Identify how the barrier performed (What was the barrier's purpose? Was the barrier in place or not in place? Did the barrier fail? Was the barrier used if it was in place?) Record in column two.

Drawings were incomplete and did not identify electrical cable at sump location. Indoor excavation permit was not obtained. Personal protective equipment was not used.

Step 4: Identify and consider probable causes of the barrier failure. Record in column three.

Engineering drawings and construction specifications were not procured. Drawings used were preliminary, etc.

Step 5: Evaluate the consequences of the failure in this accident. Record evaluation in column four.

Existence of electrical cable unknown.

TIP
Although a barrier analysis will identify the failure in an accident scenario, the failures may not all be causal factors. The barrier analysis results directly feed into the events and causal factors chart and subsequent causal factors determination.

Analyzing the Results. The results of barrier analysis are first derived and portrayed in tabular form, then summarized graphically to illustrate, in a linear manner, the barriers that were unused or that failed to prevent an accident. Results from this method can also reveal what barriers should have or could have prevented an accident.

In the tabular format, individual barriers and their purposes are defined. Each is considered for its effectiveness in isolating, shielding, and controlling an undesired path of energy.

Figure 7-5 provides an example of a barrier analysis summary. This format is particularly useful for illustrating the results of the analysis in a clear and concise form. Figure 7-6 provides an example of a barrier analysis summary that highlights the five core functions of integrated safety management. These summary charts are an effective graphic in closeout briefings and in the final report.

Figure 7-5. Summary results from a barrier analysis reveal the types of barriers involved.

Figure 7-6. Summary results from a barrier analysis can highlight the role of the core functions in an accident.
7.3.3 Change Analysis

Change is anything that disturbs the "balance" of a system operating as planned. Change is often the source of deviations in system operations. Change can be planned, anticipated, and desired, or it can be unintentional and unwanted. Workplace change can cause accidents, although change is an integral and necessary part of daily business. For example, changes to standards or directives may require facility policies and procedures to change, or turnover/retirement of an aging workforce will change the workers who perform certain tasks. Change can be desirable, for example, to improve equipment reliability or to enhance the efficiency and safety of operations. Uncontrolled or inadequately analyzed change can have unintended consequences, however, and result in errors or accidents.

TIP

Change analysis is particularly useful in identifying obscure contributing causes of accidents that result from changes in a system.

Change analysis examines planned or unplanned changes that caused undesired outcomes. In an accident investigation, this technique is used to examine an accident by analyzing the difference between what has occurred before or was expected and the actual sequence of events. The investigator performing the change analysis identifies specific differences between the accident-free situation and the accident scenario. These differences are evaluated to determine whether the differences caused or contributed to the accident. For example, why would a system that operates correctly 99 times out of 100 fail to operate as expected one time?

Conducting Change Analysis. Change analysis is relatively simple to use. As illustrated in Figure 7-7, it consists of six steps. The last step, in which investigators combine the results of the change analyses with the results from other techniques, is critical to developing a comprehensive understanding of the accident.

When conducting a change analysis, investigators identify changes as well as the results of those changes. The distinction is important, because identifying only the results of change may not prompt investigators to identify all causal factors of an accident.

Figure 7-7. The change analysis process is relatively simple.
The results of a change analysis can stand alone, but are most useful when they are combined with results from other techniques. For example, entering change analysis results into the events and causal factors chart helps to identify potential causal factors.

To conduct a change analysis, the analyst needs to have a baseline situation. This baseline situation can be:
- The same situation but before the accident (e.g., previous shift, last week, or last month)
- A model or ideal situation (i.e., as designed or engineered).

Generally, it is recommended that boards compare the accident sequence to the same situation in an accident-free state—the operation prior to the accident—to determine differences and thereby identify accident causal factors. In order for the comparison to be effective, investigators must have sufficient information regarding this baseline situation.

The following data sources can be a starting point for acquiring a good working knowledge of the system, facility, or process under study prior to the accident or event; however, the list of input requirements should be tailored to fit the specific circumstances and needs of the investigation:
- Blueprints
- Equipment description documents
- Drawings
- Schematics
- Operating and maintenance procedures
- Roles and responsibilities
- Job/task descriptions
- Personnel qualifications
- Results of hazard analysis
- Performance indicators
- Personnel turnover statistics.

A sample change analysis worksheet is presented at the end of this section for reference. This worksheet may be modified as necessary to meet specific requirements.

To develop the information needed to conduct a change analysis, it is useful for the board to list any changes they identify from their information-gathering activities on a poster board set up in the board's common meeting room. At the beginning of the investigation, the board members should simply note the changes they identify as they find them and not worry about analyzing the significance of the changes. Often, in the early stages of an investigation, there is insufficient information to determine whether a change is important or not.

As the investigation progresses, it will become clear that some of the changes noted on the poster board are insignificant and can be crossed off the list. The remaining changes that seem to be important for understanding the accident can then be organized by entering them into the change analysis worksheet.

Board members should first categorize the changes according to the questions shown in the left-hand column of the worksheet. That is, the board should determine if the change pertained to, for example, a difference in:
- **What** events, conditions, activities, or equipment were present in the accident situation that were not present in the baseline (accident-free, prior, or ideal) situation (or vice versa)
- **When** an event or condition occurred or was detected in the accident situation versus the baseline situation
- **Where** an event or condition occurred in the accident situation versus where an event or condition occurred in the baseline situation
- **Who** was involved in planning, reviewing, authorizing, performing, and supervising the work activity in the accident versus the accident-free situation
- **How** the work was managed and controlled in the accident versus the accident-free situation.

Reviewing the worksheet may also prompt the investigators to identify additional changes that were not originally listed.

To complete the remainder of the worksheet, first describe each event or condition of interest in the column labeled, "Accident Situation." Then describe the related event or condition that occurred (or should have occurred) in the baseline situation in the column labeled, "Prior, Ideal, or Accident-Free Situation." The difference between the events and conditions in the accident and the baseline situations should be briefly described in the column labeled, "Difference." As a group, the board should then discuss the effect that each change had on the accident and record the evaluation in the final column of the worksheet.

Table 7-5 below shows a partially completed change analysis worksheet containing information from the case study to demonstrate the change analysis approach. The worksheet allows the user to compare the "accident situation" with the "accident-free situation" and evaluate the differences to determine each item's effect on the accident.

A change analysis summary, as shown in Table 7-6, is generally included in the accident investigation report. It contains a subset of the information listed in the change analysis worksheet. The differences or changes identified can generally be described as causal factors and should be noted on the events and causal factors chart and used in the root cause analysis, as appropriate.

| Table 7-5. Sample change analysis worksheet. |
### Factors

**WHAT**  Conditions, occurrences, activities, equipment

1. Design and ES&H reviews were not performed.
2. Established review process was bypassed.
3. Hazards associated with the work being performed were not identified. No review of as-built drawings. No excavation permit. No underground utility survey.

**WHEN** Occurred, identified, facility status, schedule

- C

**WHERE** Physical location, environmental conditions

- Sump location was placed above a 13.2 kV electrical line.
- Sump is placed in a non-hazardous location.
- Inadequate design allowed sump to be located above a 13.2 kV line.
- Sump location was placed above an electrical line, which was contacted by a worker jackhammering in the area.

**WHO** Staff involved, training, qualification, supervision

- Environmental Group assumed line responsibility for project.
- Environmental Group serves as an oversight/support organization to assist line management in project.
- Support organization took responsibility of line function for project management.
- Lack of oversight on project.

**HOW** Control chain, hazard analysis monitoring

- Management allowed Environmental Group to oversee construction tasks.
- Management assures that work is performed by qualified groups.
- Hazards analysis was not conducted.
- Hazards were not identified, contributing to the accident.

**OTHER**

- C

**Evaluation of Effect**

<table>
<thead>
<tr>
<th>WHAT</th>
<th>Accident Situation</th>
<th>Prior, Ideal, or Accident-Free Situation</th>
<th>Difference</th>
<th>Evaluation of Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard analyses were not performed, contributing to the accident.</td>
<td>1. Project design and ES&amp;H review were performed by appropriate groups to ensure adequate review and the safety and health of employees.</td>
<td>2. Construction packages are approved by facilities project delivery group.</td>
<td>No preliminary hazard analysis was performed on construction task.</td>
<td>Design and ES&amp;H reviews were not performed, contributing to the accident.</td>
</tr>
</tbody>
</table>

**Table 7-6. Case Study: Change analysis summary.**

<table>
<thead>
<tr>
<th>Prior or Ideal Condition</th>
<th>Present Condition</th>
<th>Difference (Change)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Group serves as an oversight/support organization to assist line management in project.</td>
<td>Environmental Group assumed line responsibility for project.</td>
<td>Support organization takes responsibility for a line function.</td>
</tr>
<tr>
<td>Project design and ES&amp;H reviews were performed by appropriate groups to ensure adequate review and the safety and health of employees.</td>
<td>Environmental Group assumed design role and removed ES&amp;H review from task.</td>
<td>Design and ES&amp;H reviews were not performed.</td>
</tr>
<tr>
<td>Work is stopped when unexpected conditions are found.</td>
<td>Work continued.</td>
<td>No opportunity to analyze and control hazards of changed work conditions.</td>
</tr>
<tr>
<td>A preliminary hazard analysis is performed on all work.</td>
<td>No preliminary hazard analysis was performed on maintenance task.</td>
<td>Hazards associated with the work were not identified. No review of as-built drawings. No excavation permit. No underground utility survey.</td>
</tr>
<tr>
<td>Sump is placed in a non-hazardous designated location.</td>
<td>Sump was located above a 13.2 kV electrical line.</td>
<td>Inadequate design allowed sump to be located above a 13.2 kV line.</td>
</tr>
</tbody>
</table>

**Note:** A potential weakness of change analysis is that it does not consider the compounding effects of incremental change (for example, a change that was instituted several years earlier coupled with a more recent change). To overcome this weakness, investigators may choose more than one baseline situation against which to compare the accident scenario. For example, decreasing funding levels for safety training and equipment may incrementally erode safety. Comparing the accident scenario to more than one baseline situation (for example, one year ago and five years ago and then comparing the one- and five-year baselines with each other) can help identify the compounding effects of changes.

### 7.3.4 Events and Causal Factors Analysis

The following describes the process for using the events and causal factors chart to determine the causal factors of an accident. This process is an important first step in later determining the root causes of an accident. The results of this analysis can be used with a tier diagram (see Section 7.3.5.1) if desired. The quality and accuracy of root cause analysis depends on the results of the events and causal factors analysis. Therefore, the events and causal factors analysis must be complete and thorough.

Events and causal factors analysis requires deductive reasoning to determine which events and/or conditions contributed to the accident.

**Getting Started.** Before starting to analyze the events and conditions noted on the chart, the board must first ensure that the chart contains adequate detail. Both change and barrier analyses should be conducted and the results incorporated into the chart before the analysis begins. Also, the board must resolve any obvious gaps in data before this analysis begins.

By the time the board is ready to conduct a preliminary analysis of the chart, a great deal of time will have been devoted to adding, removing, and rearranging events and conditions on the chart. In all likelihood, the chart will be lengthy, possibly containing 100 events or more. Given the magnitude of data, one can become overwhelmed with where to begin identifying causal factors. It is easiest and most efficient to begin with the event on the chart that immediately precedes the accident and work backwards.

**Conducting the Analysis.** Examine the first event that immediately precedes the accident. Evaluate its significance in the accident sequence by asking, "If this event had not occurred, would the accident have occurred?" If the answer is, "The accident would have occurred whether this event happened or not" (e.g., worker punched in to work at
If the answer to the evaluation question is, "The accident would not have occurred without this event," then determine whether the event represented normal activities with the expected consequences. If the event was intended and had the expected outcomes, then it is not significant. However, if the event deviated from what was intended or had unwanted consequences, then it is a significant event.

Carefully examine the events and conditions associated with the significant event by asking a series of questions about this event chain, such as:

- Why did this event happen?
- What events and conditions led to the occurrence of the event?
- What went wrong that allowed the event to occur?
- Why did these conditions exist?
- How did these conditions originate?
- Who had responsibility for the conditions?
- Are there any relationships between what went wrong in this event chain and other events or conditions in the accident sequence?
- Is the significant event linked to other events or conditions that may indicate a more general or larger deficiency?

The significant events, and the events and conditions that allowed the significant events to occur, are the accident's causal factors.

Repeat this questioning process for every event in the chart. As a causal factor is identified, write a summary statement that describes the causal factor on an adhesive note of a unique color and place the note above the event chain from which it was derived, as shown in Figure 7-8 below, when constructing the chart manually. If a computer graphics program is used to construct the chart, use a hexagon to represent causal factors.

Figure 7-8. Events and causal factors analysis; driving events to causal factors.

Sometimes events and conditions from several different event chains are related and suggest a larger, more significant causal factor. For example, in two side-by-side event chains, the conditions "procedure did not address electrical hazard" and "electrical hazard not discussed in pre-job brief" may indicate that the electrical hazard was not identified in the hazard analysis for the activity. In such a case, the board can write a causal factor concerning the hazard analysis, place it on the chart, and connect it with an arrow to the two event chains from which it was derived (see Figure 7-9 below). Alternatively, the board can record the same causal factor twice and place it above each of the applicable event chains.

Figure 7-9. Grouping root causes on the events and causal factor chart.
TIP
Not all event chains will produce causal factors. However, it is important to prepare a complete set of events in order to understand the circumstances leading up to the accident and to assure that all significant events have been identified.

After these steps have been completed for each event on the chart, the process should be repeated with all board members to ensure that nothing has been overlooked and that consensus has been reached.

When the board is satisfied that all causal factors have been identified on the chart, efforts can then be focused on initiating the root cause analysis.

7.3.5 Root Cause Analysis

TIP
Root cause analysis should be conducted for every occurrence, regardless of severity or complexity. Minor incidents often foreshadow more serious events.

Accidents are symptoms of larger problems within a safety management system. Although accidents generally stem from multiple causal factors, correcting only the local causes of an accident is analogous to treating only symptoms and ignoring the "disease." To identify and treat the true ailments in a system, the root causes of an accident must be identified. Root cause analysis is any technique that identifies the underlying deficiencies in a safety management system that, if corrected, would prevent the same and similar accidents from occurring.

Root cause analysis is a systematic process that uses the facts and results of the core analytic techniques to determine the most important reasons for the accident. Root cause analysis is not an exact science and therefore requires a certain amount of judgment. The intent of the analysis is to identify and address only those root causes that can be controlled within the system being investigated, excluding events or conditions that cannot be reasonably anticipated and controlled, such as some natural disasters. The core analytic techniques—events, and causal factors analysis, barrier analysis, and change analysis—provide answers to an investigator's questions regarding what, when, where, who, and how. Root cause analysis is performed to resolve the question, "Why?"

Once several (or all) of the recommended core analytic techniques have been performed, the accident investigation board should have a broad understanding of the accident's events and conditions, along with a fairly extensive list of suspected causal factors. A root cause analysis is performed to refine the list of causal factors and categorize each according to its significance and impact on the accident.

Refining causal factors entails identifying any commonality or linkages that suggest more fundamental causal factors. The core functions and guiding principles of integrated safety management provide a useful framework for grouping causal factors and identifying the underlying safety management deficiencies that caused the accident. For example, causal factors in an accident might include "failure to follow procedures," "failure to establish a fire watch," and "failure to stop work when unanticipated conditions arose." By reviewing the five core functions of integrated safety management, it becomes clear that each of these causal factors reflects an underlying failure to perform work within controls, which is core function #4. Other causal factors in an accident may demonstrate similar relationships with the other core functions and guiding principles. The underlying management system deficiency, as defined by the related causal factors, is a candidate root cause.

There may be more than one root cause of a particular accident, but probably not more than three or four. If more are thought to exist at the conclusion of the analysis, the board should re-examine the list of causal factors to determine which causes can be further combined to reflect more fundamental (root) causes. This section provides some examples of root cause analysis and discusses analytical tools that can help accident investigators determine the root causes of an accident.

TIP
In any accident, there may be a series of causal factors, one leading to another. One of the most important responsibilities of the investigation board is to pursue each factor in the series until the board is assured that actual root causes are identified.

Conducting the Analysis. To initiate a root cause analysis, the facts surrounding the accident must be known. In addition, the facts must be analyzed using other analytic methods to ascertain an initial list of causal factors. A rather exhaustive list of causal factors must be developed prior to the application of root cause analysis to ensure that final root causes are accurate and comprehensive.

TIP
If a root cause analysis is attempted before all the significant facts are known or the full spectrum of causal factors is determined, it is likely that the systemic root causes will not be discovered.

The board should examine the evidence collected from the accident scene, witness statements, interviews, and facility documents. It should then determine whether additional information will be needed for the particular root cause technique they are performing.
It is important that the accident investigation board work together to determine the root causes of an accident. One of the board's primary responsibilities is to identify an accident's causal factors so that judgments of need can be prepared and appropriate corrective measures can be developed and implemented. Therefore, all board members must participate in the root cause analysis; it cannot be left solely to a single member of the board.

Root cause analysis can be performed using computerized or manual techniques. Regardless of the method, the intent is to use a systematic process for identifying root causes. Manual root cause analysis methods include tier diagramming and compliance/noncompliance. Each is effective as a systematic method for identifying root causes. However, the compliance/noncompliance method reflects the limited applicability of certain techniques and underscores the need for the board to select analytic methods commensurate with the accident's scope, complexity, and severity.

Computerized techniques can be somewhat more sophisticated and generally speed the process of root cause identification. It is important to note, however, that computerized techniques are dependent on the quality and quantity of data input. Moreover, at least one member of the board should be very familiar with the software package, including its limitations. An overview of these methods is provided below.

### 7.3.5.1 Tier Diagramming

Tier diagramming is a technique used to identify both the root causes of an accident and the levels of line management that have the responsibility and authority to correct the accident’s causal factors.

The board uses tier diagrams to hierarchically categorize the causal factors derived from the events and causal factors analysis. A different diagram is developed for each organization responsible for the work activities associated with the accident. Each diagram is divided into several tiers, depending on the number of management levels in the organization under consideration.

The first diagram should focus on the organization to which the persons (or equipment) directly involved in the accident belonged, usually a contractor or subcontractor organization. The tiers for the first diagram should represent levels of organizational responsibility ranging from the worker level to senior management, as shown in the example tier diagram worksheet in Table 7-7 below. If the accident occurred during subcontractor activities, the first diagram would be composed of the tiers within the subcontractor's organization. A second diagram should then be developed to represent the contractor organization for which the subcontractor was working. A third diagram should be developed to represent the DOE line and oversight organizations responsible for the contractor's (and subcontractor's) activities.

#### Table 7-7. Tier diagram worksheet for a contractor organization

<table>
<thead>
<tr>
<th>Tier</th>
<th>Causal Factors</th>
<th>Root Causes (optional column)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 5: Senior Management</td>
<td>e</td>
<td>e</td>
</tr>
<tr>
<td>Tier 4: Middle Management</td>
<td>e</td>
<td>e</td>
</tr>
<tr>
<td>Tier 3: Lower Management</td>
<td>e</td>
<td>e</td>
</tr>
<tr>
<td>Tier 2: Supervision</td>
<td>e</td>
<td>e</td>
</tr>
<tr>
<td>Tier 1: Worker Actions</td>
<td>e</td>
<td>e</td>
</tr>
<tr>
<td>Tier 0: Direct Cause</td>
<td>e</td>
<td>e</td>
</tr>
</tbody>
</table>

In a series of steps, causal factors from the events and causal factors chart are evaluated. Each causal factor is assigned to a level of management responsibility in the tier diagram(s). Linkages among causal factors are then identified and possible root causes are developed. Review of the integrated safety management core functions and guiding principles assists in this synthesis.

Tier diagraming is helpful in identifying and analyzing root causes because it:

- Helps the board organize and categorize the causal factors identified on the events and causal factors chart
- Provides a structured method for linking causal factors into higher-level, fundamental organizational deficiencies (root causes)
- Provides a structured and repeatable approach for assigning management or oversight responsibility for each causal factor
- Requires the board to assign responsibility for causal factors, from which appropriate judgments of need can later be developed
- Assists the board in visually and physically organizing significant causal factor data.

Before initiating a root cause analysis using the tier diagram method, the board should be satisfied with the results of the events and causal factors analysis. In addition, the board must have a solid understanding of the line and oversight organizations responsible for the activities associated with the accident.

#### Getting Started

Once the events and causal factors analysis is complete, a number of causal factors are noted on the events and causal factors chart. These will be the input to the tier diagrams and root cause analysis. Provided below are step-by-step instructions for completing the root cause analysis using tier diagramming. Guidelines and other reminders follow the instructions.

**Step 1. Identify significant events/conditions.** Review the causal factors listed on the events and causal factors chart to focus only on significant events or conditions (i.e., causal factors).
Step 2. Assign letter designators. Starting at the beginning of the chart, assign a letter to each causal factor (A, B, C,...) on an adhesive note. Place the same letter designator on the actual chart where that causal factor is affixed.

Later, the analyst will remove the adhesive notes and place them on the tier diagram. By noting where the causal factor originated, the analyst can easily return to the event chain if a question arises during the root cause analysis.

Step 3. Develop tier diagram framework. Using Table 7-7 as a model, create a tier diagram with the number of tiers commensurate with the line organization being examined. The grid can be drawn on large butcher paper, a white board, or any other large surface for displaying to the board members. For the purposes of this section, a typical contractor organization with six tiers (0-5) is assumed. A review of organizational charts, work control logs, and other such documentary evidence may be helpful in completing this step.

Step 4. Begin with Tier 0. Remove the “direct cause statement” adhesive note and place it in Tier 0, “direct cause.” Remove all other causal factor adhesive notes and place them in Tier 1, “worker actions.”

Step 5. Evaluate Tier 1. Beginning with causal factor “A,” ask whether the “worker actions—Tier 1” is the organizational level responsible for this causal factor; that is, can this causal factor be attributed to the worker(s) involved in the accident? Use the sample questions listed in Table 7-8 as guidance in completing this step. These questions were derived from the integrated safety management framework and reflect the typical responsibilities for developing and implementing safety management systems that are associated with each of the management levels.

Step 6. Evaluate Tier 2. If the causal factor can be attributed to the worker, ask whether the causal factor is solely attributable to the “worker actions” tier. Did the worker’s supervisor have any responsibility for this causal factor? If not, leave the causal factor in Tier 1. If the supervisor had any responsibility for this causal factor, write a letter “A”; in Tier 1 and physically move the causal factor adhesive note to Tier 2.

Step 7. Evaluate other tiers. Continue a similar line of inquiry about the causal factor at each successive tier until satisfied that the causal factor is placed in the tier commensurate with the highest level of responsibility or authority for it. Again, as a causal factor is moved to higher tiers, note the letter designations in the tier from which it is moved. For example, if responsibility for causal factor “A” is found to reside with upper management, the letter “A” should appear in Tiers 1 through 4, with the actual adhesive note placed in Tier 5. If responsibility for the causal factor lies with DOE line management or oversight, move the adhesive note to the tier diagram(s) for the DOE organizations involved.

Table 7-8. Categories and questions for completing root cause analysis tier diagram.

<table>
<thead>
<tr>
<th>Tier</th>
<th>Typical Integrated Safety Management Responsibilities</th>
<th>Sample Questions for Consideration in Assigning Causal Factors to Management Levels</th>
</tr>
</thead>
</table>
| Tier 5: Senior Management | - Develop safety policy  
- Communicate policy and expectations  
- Prioritize activities and allocate resources  
- Overseer compliance with contract terms and conditions  
- Monitor safety performance | - Did senior management establish documented safety policies and goals?  
- Were ES&H performance expectations for subcontractor organizations clearly communicated and understood?  
- Was senior management proactive in assuring timely implementation of integrated safety management by line organizations, subcontractors, and workers?  
- Did senior management define and maintain clearly delineated roles and responsibilities for ES&H to effectively integrate safety into sitewide operations?  
- Was senior management involved in the sitewide prioritization of work?  
- Was a process established to ensure that safety responsibilities were assigned to each person (employees, subcontractors, temporary employees, visiting researchers, vendor representatives, lessees, etc.) performing work?  
- Did senior management hold line managers accountable for safety performance through performance objectives, appraisal systems, and visible and meaningful consequences?  
- Did senior management institutionalize the stop-work authority philosophy? |
| Tier 4: Middle Management | - Same as Senior Management with smaller span of control, e.g., a facility, rather than an entire site  
- Develop plans and programs to implement policy  
- Overseer problem identification/corrective action processes  
- Solicit and respond to feedback and lessons learned | - Did management implement policy through plans and programs developed?  
- Was management aware of the status of plans and program implementation?  
- When problems occurred, did management request feedback on the nature of problems?  
- Did management have a system for monitoring and measuring organizational performance?  
- Was a stop-work authority communicated to the organization?  
- Was management involved in the development and implementation of corrective actions? |

Table 7-8. Example tier diagram approach. (Continued)

<table>
<thead>
<tr>
<th>Tier</th>
<th>Typical Integrated Safety Management Responsibilities</th>
<th>Sample Questions for Consideration in Assigning Causal Factors to Management Levels</th>
</tr>
</thead>
</table>
| Tier 3: Lower Management | - Develop procedures to implement plans and programs  
- Ensure hazard awareness and communication  
- Overseer work planning and execution  
- Solicit and use worker input  
- Implement corrective actions | - Were required procedures developed and kept current to assure a safe worker environment?  
- Did management implement required programs for worker safety?  
- Was management aware of problems regarding procedure implementation and compliance?  
- Was management involved in the work planning, control, and execution process?  
- Did management have a system for eliciting feedback on work-related hazards?  
- Did management take timely corrective actions when problems occurred or were identified?  
- Did management have a system for identifying and disseminating work process lessons learned?  
- Was stop-work authority defined for first line supervisors and their staff? |
| Tier 2: Supervision | - Control the work scope  
- Identify hazards  
- Implement hazard controls  
- Authorize job/tasks  
- Provide feedback and lessons learned | - Were supervisor's work instructions adequate to allow the work to be performed safely?  
- Was the work environment safe?  
- Were required procedures provided or communicated to the worker by supervision?  
- Did the supervisor provide feedback to management on prior incidents and/or safety concerns?  
- Did the supervisor discuss job hazards with the worker prior to starting work?  
- Did the supervisor implement timely corrective actions based on previous incidents?  
- Did the supervisor confirm the readiness to perform work prior to the execution of work?  
- Did the supervisor provide the worker with the proper tools and equipment to perform the work safely?  
- Did the supervisor define stop-work authority for workers? |
Step 8. Repeat for each causal factor. Repeat steps 5 through 7 for each causal factor previously placed in Tier 1 of the diagram.

Step 9. Identify linkages. After arranging all the causal factors on the tier diagrams, examine the causal factors to determine whether there is linkage between two or more of them. For example, are two or three causal factors similar enough to indicate poor conduct of operations? Or perhaps several causal factors are related to a lack of worker training. If linkages exist, group the adhesive notes at the highest level where a linkage occurs (see Figure 7-10 below). For example, if causal factors “B” and “F” in Tier 3 are related to causal factor “H” in Tier 4, remove “B” and “F” (noting their location), and affix them to “H” in Tier 4. Next, if one of the causal factors accurately describes the commonality among the grouped causal factors, let that causal factor represent the grouping. If not, write a causal factor statement that captures the common theme of all the causal factors in that particular grouping. This statement becomes a potential root cause.

Figure 7-10. Identifying the linkages on the tier diagram.

Step 10. Identify root causes. Evaluate each of the causal factor statements that now appear on the charts. Compare each statement to the definition of a root cause to determine whether it appears to be a root cause of the accident. This step will generally involve a great deal of discussion among board members.

TIP
If a causal factor does not meet the criteria for a root cause, do nothing; it remains a contributing cause of the accident.

If a causal factor (singly or representing a group) meets the criteria for a root cause, denote it as such either using the letters “RC” (root cause) or some other means. You may find that you need to create a root cause statement based on one or more causal factors. If so, write a summary causal factor statement and place it on the appropriate tier. The board may choose to add a third column, “Root Causes,” to the tier diagram (Figure 7-10). The advantage of adding this column is that moving the root cause statements makes them stand out, along with the associated level of management responsibility.

The root cause analysis may reveal causal factors that are not on the events and causal factors chart. These should be added to both the events and causal factors chart and the tier diagram to assure that they are consistent and reflect all of the causal factors as a basis for root cause analysis.

Step 11. Simplify root cause statements. There may be more than one root cause of a particular accident, but probably not more than three. If there are more than that at the end of the tier diagram analysis, the board should re-examine the list of root causes to determine which ones can be further combined to reflect more fundamental deficiencies.

When the board is satisfied that the root causes have been accurately identified and the number of root causes is not excessive, the root cause analysis is complete. The board should capture the essence of the root cause analysis for the accident investigation report, noting the direct, contributing, and root causes of the accident in order to develop judgments of need.

Guidelines and Reminders:
- Root causes may be found in any tiers of any diagrams. However, they are generally found in higher tiers because that is where managers are most responsible for directing and overseeing activities.
The root cause of an accident can be found at the worker level of the tier diagram if, and only if, the following conditions are found to exist:
- Management systems were in place and functioning, and provided management with feedback on system implementation and performance
- Management took appropriate actions based on the feedback
- Management, including supervision, could not reasonably have been expected to take additional actions based on their responsibilities and authorities.

Root causes can be found at more than one level of an organization. For example, one root cause may be attributable to Tier 3, while two other root causes are attributable to Tier 5.

Root causes are generally attributable to an action or lack of action by a particular group or individual in the line organization.

Each “corporate” organization is considered separately for its responsibility in the accident. For example, in DOE, a management and operating (M&O) contractor would be considered as one organization, and DOE would be considered as a second organization. Consequently, the results of one tier diagram may be the input of another. For example, if the upper management of an M&O contractor was responsible for a particular root cause, DOE may share responsibility for that particular root cause—there may be a deficiency in the directives given from DOE, insufficient oversight, or some other DOE responsibility that was inadequately fulfilled.

7.3.5.2 Compliance/Noncompliance

The compliance/noncompliance technique is useful when investigators suspect noncompliance to be a causal factor. This technique compares evidence collected against three categories of noncompliance to determine the root cause of a noncompliance issue. As illustrated in Table 7-9 below, these are: “Don’t Know,” “Can’t Comply,” and “Won’t Comply.” Examining only these three areas limits the application of this technique; however, in some circumstances, an accident investigation board may find the technique useful.

Table 7-9. Compliance/noncompliance root cause model categories.

<table>
<thead>
<tr>
<th></th>
<th>Don’t Know</th>
<th>Can’t Comply</th>
<th>Won’t Comply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never know</td>
<td>Scarce resources</td>
<td>Lack of funding is a common rebuttal to questions regarding noncompliance.</td>
<td>An investigator may have to determine whether there is a benefit in complying with requirements or doing a job correctly. Perhaps there is no incentive to comply.</td>
</tr>
<tr>
<td>Forgot</td>
<td>Don’t know how</td>
<td>This issue focuses on lack of knowledge (i.e., the know-how to get a job done).</td>
<td>No penalty</td>
</tr>
<tr>
<td>Tasks implied</td>
<td>Impossibility</td>
<td>This issue requires investigators to determine whether a task can be executed. Given adequate resources, knowledge, and willingness, is a worker or group able to meet a certain requirement?</td>
<td>Disagree</td>
</tr>
</tbody>
</table>

The basic steps for applying the compliance/noncompliance technique are:
- Have a complete understanding of the facts relevant to the event
- Broadly categorize the noncompliance event
- Determine why the noncompliance occurred (i.e., the subcategory or underlying cause).

For example, investigators may use this technique to determine whether an injured worker was aware of particular safety requirements, and if not, why he or she was not (e.g., the worker didn’t know the requirements, forgot, or lacked experience). If the worker was aware but was not able to comply, a second line of questioning can be pursued. Perhaps the worker could not comply because the facility did not supply personal protective equipment. Perhaps the worker would not comply in that he or she refused to wear the safety equipment. Lines of inquiry are pursued until investigators are assured that a root cause is identified.

Lines of questioning pertaining to the three compliance/noncompliance categories follow. However, it should be noted that these are merely guides; an accident investigation board should tailor the lines of inquiry to meet the specific needs and circumstances of the accident under investigation.
- Don’t Know: Questions focus on whether an individual was aware of or had reason to be aware of certain procedures, policies, or requirements that were not complied with.
- Can’t Comply: This category focuses on what the necessary resources are, where they come from, what it takes to get them, and whether personnel know what to do with the resources when they have them.
- Won’t Comply: This line of inquiry focuses on conscious decisions to not follow specific guidance or perform to a certain standard.

By reviewing collected evidence, such as procedures, witness statements, and interview transcripts, against these three categories, investigators can pursue suspected compliance/noncompliance issues as causal factors.

Although the compliance/noncompliance technique is limited in applicability, by systematically following these or similar lines of inquiry, investigators may identify causal factors and judgments of need.

7.3.5.3 Automated Techniques

Several root cause analysis software packages are available for use in accident investigations. Generally, these methods prompt the investigator to systematically review investigation evidence and record data in the software package. These software packages use the entered data to construct a tree model of events and causes surrounding the accident. In comparison to the manual methods of root cause analysis and tree or other graphics construction, the computerized techniques are quite time-efficient. However, as with any software tool, the output is only as good as the input; therefore, a thorough understanding of the accident is required in order to use the software effectively.

Many of the software packages currently available can be initiated from both PC-based and Macintosh platforms. The Windows-based software packages contain pulldown menus and employ the same use of icons and symbols found in many other computer programs. In a step-by-step process, the investigator is prompted to collect and enter data in the templates provided by the software. For example, an investigator may be prompted to select whether a problem (accident or component of an accident) to be solved is an event or condition that has existed over time. In selecting the “condition” option, he or she would be prompted through a series of questions designed to prevent a mishap occurrence; the “event” option would initiate a process of investigating an accident that has already occurred.
The graphics design features of many of these software packages can also be quite useful to the accident investigation board. With little input, these software packages allow the user to construct preliminary trees or charts, when reviewed by investigators, these charts can illustrate gaps in information and guide them in collecting additional evidence.

It is worth underscoring the importance of solid facts collection. While useful, an analytic software package cannot replace the investigative efforts of the board. The quality of the results obtained from a software package is highly dependent on the skill, knowledge, and input of the user.

### 7.4 Using Advanced Analytic Methods

The four core techniques can be effectively applied to many investigations, but the analysis of more complex accidents may have to be supplemented with more sophisticated techniques. These techniques require in-depth knowledge and specialized expertise beyond the scope of this workbook. However, several are discussed briefly here to ensure awareness of their applicability to the accident investigation process. The chairperson, board members, and any subject matter experts should determine which methods to employ, based on their familiarity with various methods and the severity and complexity of the accident.

#### 7.4.1 Analytic Trees

Analytic tree analyses are well defined, useful methods that graphically depict, from beginning to end, the events and conditions preceding and immediately following an accident. An analytic tree is a means of organizing information that helps the investigator conduct a deductive analysis of any system (human, equipment, or environmental) to determine critical paths of success and failure. Results from this analysis identify the details and interrelationships that must be considered to prevent the oversights, errors, and omissions that lead to failures. In accident investigations, this type of analysis can consist of both failure paths and success paths, and can lead to neutral, negative, or positive conclusions regarding accident severity.

The analytic tree process begins by clearly defining the accident; “branches” of the tree are constructed using logic symbology. Following is a summary overview of the approach to constructing an analytic tree, which is illustrated in Figure 7-11 below. It should not be inferred that this is the only way to construct or use analytic trees, since a variety of analytic tree methods is available.

**Figure 7-11.** The analytic tree process begins with the accident as the top event.
As the events at the bottom branches of the tree become more specific, the causal factors of the accident are developed. When the event at the bottom contains no other events that allowed it to occur, a decision must be made regarding whether the event is a causal factor or is not relevant to the outcome of the accident (top event). When processed through the logic gate, each bottom tier should be necessary and sufficient to lead directly to the failure or success of the event on the next higher tier.

The steps required to prepare an analytic tree are described below.

**Step 1.** Define the top event as the accident. As in events and causal factors analysis, the event should be defined as a single, discrete event, such as "worker strikes 13.2 kV primary feeder cable."

**Step 2.** Acquire a working knowledge of the accident effects, the work situation, and the upstream processes that preceded them. A comprehensive understanding of the management system is also needed to develop the tree.

**Step 3.** Based on the facts, postulate the possible scenarios by which the accident occurred. All accidents are complex events that become interrelated to produce the unwanted event (accident). This step should force the investigator to analyze the facts of the accident and try to visualize all possible scenarios. As the investigation continues and as new evidence is introduced, a different scenario could develop. Before the tree is constructed, it is important to visualize it using different possible scenarios consistent with the facts.

**Step 4.** Construct the analytic tree, starting with the top event and using the proper logic gates and symbols. The tiers beneath the top event should explain the reason for failure or success of that event. The proper use of symbols and transfers is crucial to understanding this graphic model.

**Step 5.** It is important for each board member to validate the analytical tree for completeness, logic, and accuracy. As new facts and evidence are discovered, the tree must be updated to reflect these changes. The validation process should begin as soon as the tree is constructed. The purpose of this validation review is to confirm that:

- The tree meets its intended objectives
- The management systems are fully and clearly described
- Inputs to logic gates are necessary and sufficient to logically produce the stated output events.

**Step 6.** Each relationship between events should be evaluated to determine the causal factors of the accident (top event). As these tiers flow down to the end events, the specific events of the analytic tree will be developed and will help describe why the top event occurred, by organizing the accident's evidence in a way that helps the board identify the accident's causal factors. Though the chart is highly structured, identifying root causes is not a mechanical process. Considerable reasoning and judgment are required from the board to determine root and contributing causes.

**Step 7.** Add to the analytic tree as new evidence is acquired and new possible scenarios are developed. The tree must be a working analytical tool that will have several iterations before the final tree is developed. If new possible scenarios are introduced, do not reject the scenario if it does not fit the tree. It might be necessary to construct a new tree for a new scenario. It is important that all possible scenarios be considered, they should be rejected only because they do not fit the facts, not because they are improbable.

**Step 8.** Through the iterative process of fact-finding and analysis identify the causal factors.

The basic conventions for constructing an analytic tree are to:

- Use common and accepted graphic symbols for events, logic gates, and transfers. (Figure 7-12 below displays the symbols used in analytic trees.)

---

**Figure 7-12.** Analytic trees are constructed using symbols.

- **Rectangle (General Basic Event)** - The primary building block for analytic trees. Event resulting from the combination of more basic events acting through logic gates.

- **Circle (Basic Event)** - The symbol used for the bottom tier of the tree to indicate development is complete. Event is not dependent on other events.

- **Diamond (Undeveloped Event)** - An event that is not further developed either because it is of insufficient consequence or because information is unavailable.

- **House or Scroll (External event)** - An event that is normally expected to occur. The house is used for analytic trees, and the scroll is used for MORT.
The analytic tree should be constructed as simply as the accident allows. The tree should flow logically from the top event to the more specific events. If an event occurs that has no relevance to the accident, a diamond symbol should note that there is no further development of this event.

- Keep the tree logical. The tree should be validated at each level to ensure that each contributing event logically proceeds to the top event. The lower-tier input events should be only those that are necessary and sufficient to produce the next tier event. It is important for events to logically flow to other events that are supported by the facts.
- Use the proper logic gate that describes the relationship between the events. The proper selection and use of the logic gates will identify the interaction between lower-tier events and the top event.
- The event descriptions should be simple, clear, and concise. The descriptions should be sufficiently detailed and logical that they can be understood without referring to another section.
- The final analytic tree should be limited in the number of tiers placed on a single page. For legibility and readability, it is best that only four or five tiers be placed on a single page.
- Use a common numbering system for the events. Each event is identified by the decimal numbering system. The number of digits in the decimal event numbering system should correspond to the tier on which the event is located. (For example, the fourth tier will contain four digits.) This system for numbering will uniquely describe an event and systematically trace its development through subbranches and branches to the first-tier event. Each successively higher-level event can be identified by dropping the last digit from the number. For example:

<table>
<thead>
<tr>
<th>Top Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>1.1</td>
</tr>
<tr>
<td>1.1.1</td>
</tr>
<tr>
<td>1.1.1.1</td>
</tr>
<tr>
<td>1.1.1.1.1</td>
</tr>
</tbody>
</table>

- A modified decimal system for numbering events can be adapted for transfer symbols, beginning with the letter designation for the transfer. If the transfer letter is A, then the corresponding numbers could be A.1.3.2. The numbering system is the same as the decimal system, with an alphabetic symbol as the first digit corresponding to the transfer. The fourth subtier that is transferred would be labeled as shown below:

<table>
<thead>
<tr>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.2</td>
</tr>
<tr>
<td>D.2.2</td>
</tr>
<tr>
<td>D.2.2.1</td>
</tr>
<tr>
<td>D.2.2.1.2</td>
</tr>
</tbody>
</table>

- Use transfers to avoid duplication of identical branches or segments of the tree and to reduce single-page tree complexity. Whenever two or more gate output events have identical details in the substructures contributing to their occurrence, that substructure should be constructed under only one of the output events; it should then be transferred to the others through the use of transfer symbols. Transfers should also be used below the bottom-tier events on a page to indicate continuance of subbranches of those events on other pages. Whenever there is insufficient space on a page to develop a branch below an event at any level, a transfer immediately below that event indicates that the branch is developed on another page.
- Do not number or letter logic gates; use numeric and alphanumeric decimal identification designations only for events.
- Follow the left-to-right convention of indicating time sequencing or order of performance for related events on a single tier. It should also be apparent that a higher-tier event has greater significance (more impact on the top event) and occurs later than the more detailed contributory events located on lower tiers within its branch.

Below, Figure 7-13 shows an example format for the layout of an analytic tree. Although each accident will dictate its own shape, this example displays all elements in an analytic tree. Figure 7-14 is an example of a completed analytic tree for a grinding wheel accident. The lowest tier shows that the tool rest was not set correctly, the operator did not wear goggles, and the machine guard was removed for convenience. This example displays how the lower-tier elements contribute (flow) to the top event.

Figure 7-13. The layout of an analytic tree shows logical relationships.
Figure 7-14. A completed analytic tree shows the flow of lower-tier elements to top event.

Wheel Fragment Impacts Operator's Eye

AND

Abrasive Wheel Disintegrated

Grinder Operating

Operator's Eye Exposed

Wheel Struck by Object

Stress Limit Exceeded

Operator's Eye Not Protected

Operator in Front of Wheel

Tool Impressed At Excessive Angle

Wheel Overspeed

Did Not Wear Goggles

Machine Eye Shield Removed
7.4.2 Management Oversight and Risk Tree Analysis (MORT)

MORT—a comprehensive analytical tree technique—was originally developed for DOE to help conduct nuclear criticality and hardware analysis. It was later adapted for use in accident investigations and risk assessments. Basically, MORT is a graphical checklist, but unlike the events and causal factors chart, which must be filled in by investigators, the MORT chart contains generic questions that investigators attempt to answer using available factual data. This enables the investigator to focus on potential key causal factors. The MORT chart's size can make it difficult to learn and use effectively. For complex accidents involving multiple systems, such as nuclear systems failures, MORT can be a valuable tool but may be inappropriate for relatively simple accidents. MORT requires extensive training to effectively perform an in-depth causal analysis of complex accidents. If needed, the MORT analysis is usually performed by board members with substantial previous experience in using the MORT techniques.

In evaluating accidents, MORT provides a systematic method (analytic tree) for planning, organizing, and conducting a comprehensive accident investigation. Through MORT analysis, investigators identify deficiencies in specific control factors and in management system factors. These factors are evaluated and analyzed to identify the causal factors of the accident.

Detailed knowledge and understanding of management and operating systems is a prerequisite to a comprehensive MORT analysis. Therefore, it is most effective if investigators have collected substantial evidence before initiating the MORT process. The management system data required include procedures, policies, implementation plans, risk assessment program, and personnel. Information about the facility, operating systems, and equipment is also needed. This information can be obtained through reviews of physical evidence, interview transcripts, management systems, and policies and procedures.

The symbols used on the MORT chart are similar to those used for other analytical trees. The symbols that differ for the MORT chart are the scroll normally used to follow the tree's logic. The symbols used are similar to those used for other analytical trees. The symbols that differ for the MORT chart are the scroll normally used to follow the tree's logic. The symbols used are similar to those used for other analytical trees. The symbols that differ for the MORT chart are the scroll normally used to follow the tree's logic.

The first step of the process is to obtain the MORT charts and select the MORT chart for the safety program area of interest evaluating each event. Next, the investigators work their way down through the tree, level by level, proceeding from known to unknown. Events should be coded in a specific color relative to the significance of the event (accident). The color-coding system used in MORT analysis is shown in Table 7-10 below. An event that is deficient, or less than expected event) and the oval satisfactory event). The event distinguishes events that are typically a part of any system, such as functional (part of the system) and people or objects in the energy channel. In addition to using the traditional transfer symbol (triangle), the MORT chart includes capital letters as drafting breaks and small ovals as risk transfers.

The benefits of MORT are that it:

- Uses the analytic tree method to systematically dissect an accident
- Permits the simultaneous evaluation of multiple accident causes
- Serves as a detailed road map by requiring investigators to examine all possible causal factors (e.g., assumed risk, management controls, or lack of controls, and operator error)
- Looks beyond immediate causes of an accident and instead stresses close scrutiny of management systems that allowed the accident to occur
- Provides a systematic method (analytic tree) for planning, organizing, and conducting a comprehensive accident investigation
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- Permits the simultaneous evaluation of multiple accident causes
- Serves as a detailed road map by requiring investigators to examine all possible causal factors (e.g., assumed risk, management controls, or lack of controls, and operator error)
- Looks beyond immediate causes of an accident and instead stresses close scrutiny of management systems that allowed the accident to occur
- Provides a systematic method (analytic tree) for planning, organizing, and conducting a comprehensive accident investigation
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TIP

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- Serves as a detailed road map by requiring investigators to examine all possible causal factors (e.g., assumed risk, management controls, or lack of controls, and operator error)
- Looks beyond immediate causes of an accident and instead stresses close scrutiny of management systems that allowed the accident to occur
- Provides a systematic method (analytic tree) for planning, organizing, and conducting a comprehensive accident investigation

Table 7-10. MORT color coding system.

<table>
<thead>
<tr>
<th>Color Code</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>The event is less than adequate. Corrective actions are needed. All events colored red must be documented and supported with facts and analyzed as potential causal factors of the accident.</td>
</tr>
<tr>
<td>Green</td>
<td>The event is satisfactory and adequate. Credible evidence must support this event to ensure that no corrective actions need to be identified for this event.</td>
</tr>
<tr>
<td>Blue</td>
<td>The event has insufficient evidence or information to evaluate. Additional facts or evidence must be collected to analyze this event.</td>
</tr>
<tr>
<td>Black</td>
<td>The event is not applicable or relevant to the accident. The event does not need any further investigation.</td>
</tr>
</tbody>
</table>

When the appropriate segments of the tree have been completed, the path of cause and effect (from lack of control by management, to basic causes, contributory causes, and root causes) can easily be traced back through the tree. This becomes a matter of following the red events through the various logic gates. The tree highlights quite clearly where controls and corrective actions are needed and can be effective in preventing recurrence of the accident.

Figures 7-15 through 7-17 show three MORT charts. Below, Figure 7-15 displays the injury, damage, other costs, performance lost, or degraded event. Figure 7-16 describes the incident, barriers, and persons or objects. Figure 7-17 is an evaluation of the management system factors.
Figure 7-16. The accident description can be shown on a MORT chart.
7.4.3 Project Evaluation Tree (PET) Analysis

PET is an efficient means of performing an in-depth analysis of an operation, project, or system. This analytical tree method is best suited for performing hazard
and accident analyses, but it can also be used to identify preventive measures. PET was developed to capture the philosophy and methodology of MORT, but eliminate the complexity of the more than 1,500 logic gates in MORT.

Using PET in an accident investigation requires detailed information regarding the various components of the system, operation, or accident situation, such as procedures, personnel, facilities, and equipment. Using logic symbology, an analyst traces each component of a system through the tree’s branches to evaluate each element as a potential causal factor.

TIP
The key benefits of the PET analysis are that it:
- Provides a simplified approach that applies the tenets of MORT
- Categorizes information into three main branches—procedures, personnel, and plant or hardware—enabling investigators to examine the factors that impact an accident relatively simply and quickly.

PET is structured for evaluation and analysis of procedures, personnel, and facilities/hardware. (An example of a PET chart used to analyze procedures is shown in Figure 7-18 below.) PET analysis requires detailed information on these three dimensions. Evaluation of procedures requires procedural instructions, reviews and safety evaluations, work plans, work package instructions, and other data. Personnel evaluation requires job descriptions, organizational charts, training records, course curricula, course materials, interviews, and other data. If the accident was facility- or hardware-related, then drawings, procurement documents, specifications, test plans, system safety plans, hazard analyses, and budget data are required to conduct a comprehensive PET analysis. The scope and depth of the accident investigation dictate the input requirements.

The first step is to organize the data into procedures, personnel, and facilities/hardware. These data are then systematically evaluated using the appropriate PET chart. The next step is to color-code the events. Red is used for events that are less than adequate (LTA), green for events that are satisfactory (adequate), black for events that are not relevant to the accident, and blue for areas that need additional investigation or analysis to reach a decision. (This color-coding system is the same system used for MORT.)

After the chart is completed and the events are color-coded, PET worksheets should be used to evaluate each red item. A PET analysis worksheet is provided at the end of this section. This worksheet is similar to the barrier analysis and change analysis worksheets. It provides the basis for the narrative summary of the analysis.

Figure 7-18. This branch of the PET chart deals with procedures.

7.5 Other Analytic Techniques
Other analytic techniques may be used for specific investigations, depending on the nature and complexity of the accident. Ultimately, the analytic techniques
used in any investigation should be determined by the board chairperson with input from the board members and advisors/consultants. To conduct an effective and timely investigation, the choice normally should be limited to the techniques discussed above. However, if warranted by the circumstances of the accident investigation, experts in various analytic methods may be called upon to use other analytic techniques. It is also important for investigators to understand that many of these analytical processes may have been completed prior to the accident and may be included in authorization basis documentation (e.g., safety analysis reports). This information is useful to the board in developing and understanding its own analysis of the accident. Following are brief descriptions of additional analytic techniques that might be used.

The list of techniques provided in this workbook is not exhaustive. Other analytic techniques that may yield important results for a particular investigation may be necessary and used at the board's discretion.

7.5.1 Time Loss Analysis

Time loss analysis evaluates emergency response performance. The basic assumption of this technique is that every accident sequence has a natural progression that would occur without outside intervention by emergency response personnel (e.g., a fire would eventually burn out without the aid of firefighters).

With this technique, the natural course of accident events is plotted graphically against time. A second line is plotted that shows the positive effect of emergency responders on the natural course of events (i.e., decreasing the end-time of the accident). A second line also can be plotted that displays emergency response actions that made the natural course of events worse or prolonged the end-time of the accident (for example, by contributing to additional injuries). This technique begins with the accident, compares actual events and processes with an ideal response process, and continues until loss ceases.

Time loss analysis is not widely used in accident investigations; however, it can be useful in cases where additional response activities could have decreased the severity of the accident or where investigators suspect that emergency response actions were less than sufficient. Figure 7-19 below displays a time loss analysis chart.

![Figure 7-19. Time loss analysis can be used when emergency response is in question.](image)

7.5.2 Human Factors Analysis

Human factors analysis identifies elements that influence task performance, focusing on operability, work environment, and management elements. Humans are often the weakest link in a system and can be the system component most likely to fail. Often machines are not optimally designed for operators, thereby increasing the risk of error. High-stress situations can cause personnel fatigue and increase the likelihood of error and failure. Therefore, methods that focus on human factors are useful when human error is determined to be a direct or contributing cause of an accident.

7.5.3 Integrated Accident Event Matrix

An integrated accident event matrix illustrates the time-based interaction between the victim and other key personnel prior to the accident and between the emergency responders and the victim after the accident. It analyzes at what time key personnel performed certain tasks both before and after the accident. This technique complements the events and causal factors chart, but is more specific about the timing of accident events; it is a simple and effective way to develop the accident scenario around the facts related to key personnel and appropriate tasks.

7.5.4 Failure Modes and Effects Analysis

This method is most often used in the hazard analysis of systems and subsystems; it is primarily concerned with evaluating single-point failures, probability of accidents or occurrences, and reliability of systems and subsystems. This technique examines a system's individual subsystems, assemblies, and components to determine the variety of ways each component could fail and the effect of a particular failure on other equipment components or subsystems. If possible, the analysis should include quantified reliability data.

7.5.5 Software Hazards Analysis

This analytic technique is used to locate software-based failures that could have contributed to an accident. This technique may be increasingly important in the future as more operations and systems associated with an accident become computerized and therefore dependent on software.

7.5.6 Common Cause Failure Analysis

Common cause failure analysis evaluates multiple failures that may be caused by a single event shared by multiple components. Common causes of failures in redundant systems are analyzed to determine whether the same failure contributed to the accident. The general approach to common cause failure analysis is to identify critical systems or components and then use barrier analysis to evaluate the vulnerability to common environmental hazards, unwanted energy flows, and barrier failures. This method is useful for accidents in which multiple barriers failed and a common cause failure contributed to the accident.

7.5.7 Sneak Circuit Analysis
A sneak circuit is an unanticipated energy path that can enable a failure, prevent a wanted function, or produce a mistiming of system functions. Sneak circuit analysis is mainly performed on electronic circuitry, but it can also be used in situations involving hydraulic, pneumatic, mechanical, and software systems. It identifies ways in which built-in design characteristics enable an undesired function to occur or prevent desired functions from occurring. Its importance lies in the distinction from component failure. Sneak circuit failure results from circuit design. Sneak circuit analysis generally employs inductive reasoning and is difficult to employ without the appropriate proprietary software.

### 7.5.8 Materials and Structural Analysis

Materials and structural analysis is used to test and analyze physical evidence. This technique has made significant contributions to developing credible scenarios and determining the cause of several accidents. It is used whenever hardware, material failure, or structural integrity is a possible issue, but the cause of the failure is unknown.

### 7.5.9 Design Criteria Analysis

This method involves the systematic review of standards, codes, design specifications, procedures, and policies relevant to the accident. This tool is useful in identifying whether codes exist, how standards or codes were circumvented, and codes or standards that should be in place to prevent recurrence. It can be used similarly to change analysis to examine the accident to determine whether work processes deviated from existing standards, codes, or procedures (i.e., was a piece of equipment used properly as designed and specified?).

### 7.5.10 Accident Reconstruction

Although not widely used in DOE accident investigations, accident reconstruction may be useful when accident scenes yield sketchy, inconclusive evidence. This method uses modeling to reconstruct the accident-related equipment or systems (i.e., from accident to pre-accident state). Good reconstruction can be more accurate than witness statements, because it applies the laws of physics and engineering.

### 7.5.11 Scientific Modeling

Scientific modeling models the behavior of a physical process or phenomenon. The methods, which range from simple hand calculations to complex and highly specialized computer models, cover a wide spectrum of physical processes (e.g., nuclear criticality, atmospheric dispersion, groundwater and surface water transport/dispersion, nuclear reactor physics, fire modeling, chemical reaction modeling, explosive modeling). For example, several computer models have been developed to predict the concentrations of hazardous materials in the air at downwind locations from a release. Such modeling is useful in characterizing the consequences of an accidental release of a hazardous material to the atmosphere. Similarly, nuclear criticality models (e.g., the SCALE package or the KENO code) can analyze scenarios that could lead to a critical configuration. In the event of a nuclear criticality, such models could be useful in understanding how the event occurred and what factors were important to the accident scenario (e.g., the presence of "moderating" or "reflecting" materials, such as water, can be very important).

Although useful in some circumstances, scientific modeling is not necessary for most accident investigations. It is only performed for accident scenarios involving complex physical processes (e.g., nuclear criticality, fires, "runaway" chemical reactions and explosions) and is not normally needed for typical occupational and industrial accidents. When scientific modeling is deemed appropriate, it should be performed at the direction of technically competent personnel (e.g., specialists, consultants, or board members who have the requisite technical backgrounds and familiarity with the models being used).

All scientific models have inherent assumptions and uncertainties that limit their accuracy. The board should recognize such limitations when considering the results of scientific models during the accident investigation process. Sometimes the facility in which an accident occurred may choose to perform scientific modeling and may provide those results to the board. In reviewing such results, the board should validate whether it is appropriate to obtain independent expertise to interpret the results and determine the validity of the modeling assumptions.

### Key Points to Remember

#### Determining Facts
- Begin defining facts early in the collection of evidence.
- Develop an accident chronology (e.g., events and causal factors chart) while collecting evidence.
- Set aside preconceived notions and speculation.
- Allow the discovery of facts to guide the investigative process.
- Consider all information for relevance and possible causation.
- Continually review facts to verify accuracy and relevance.
- Retain all information gathered, even that which is removed from the accident chronology.
- Establish a clear description of the accident.

Analytical techniques are used to determine the causes of an accident. There are three types of causal factors: the direct cause, contributing causes, and root causes.

#### Conducting the Analysis

Four core analytic techniques are generally used in DOE accident investigations:
- **Events and causal factors charting and analysis:** used to trace the sequence of events and conditions surrounding an accident, as well as to determine the causal factors.
- **Barrier analysis:** used to examine the effectiveness of barriers (management and physical) intended to protect persons, property, and the environment from unwanted energy transfers.
- **Change analysis:** used to examine planned or unplanned changes in a system and determine their significance as causal factors in an accident.
- **Root cause analysis:** used to identify the causal factors, including management systems, that, if corrected, would prevent recurrence of the accident.

Each of these techniques has strengths and limitations that should be reviewed before applying it to any given accident. However, the use of the core analytical techniques should be sufficient for most accident investigations. Other techniques are available for complex accidents or when there are special circumstances or considerations. Some of these techniques are MORT, PET, materials and structural analysis, design criteria analysis, integrated accident event matrix, and scientific modeling. Other techniques are available for complex accidents or special accident circumstances.

The following should be considered when performing analyses:
- Chart events in chronological order, developing an events and causal factors chart as initial facts become available.
- Stress aspects of the accident that may be causal factors.
Establish accurate, complete, and substantive information that can be used to support the analysis and determine the causal factors of the accident.

- Stress aspects of the accident that may be the foundation for judgments of need and future preventive measures.
- Resolve matters of speculation and disputed facts through board discussions.
- Document methodologies used in analysis; use several techniques to explore various components of an accident.
- Qualify facts and subsequent analysis that cannot be determined with relative certainty.
- Conduct preliminary analyses; use results to guide additional collection of evidence.
- Analyze relationships of event causes.
- Clearly identify all causal factors.
- Examine management systems as potential causal factors.
- Consider the use of analytic software to assist in evidence analysis.

### Barrier Analysis Worksheet

<table>
<thead>
<tr>
<th>Hazard:</th>
<th>Target:</th>
</tr>
</thead>
<tbody>
<tr>
<td>What were the barriers?</td>
<td>How did each barrier perform?</td>
</tr>
<tr>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>a</td>
<td>a</td>
</tr>
</tbody>
</table>

### Change Analysis Worksheet

<table>
<thead>
<tr>
<th>Factors</th>
<th>Accident Situation</th>
<th>Prior, Ideal, or Accident-Free Situation</th>
<th>Difference</th>
<th>Evaluation of Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHAT</td>
<td>Conditions, occurrences, activities, equipment</td>
<td>a</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>WHEN</td>
<td>Occurred, identified, facility status, schedule</td>
<td>a</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>WHERE</td>
<td>Physical location, environmental conditions</td>
<td>a</td>
<td>a</td>
<td>a</td>
</tr>
</tbody>
</table>
### WHO
Staff involved, training, qualification, supervision

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Evaluated</th>
<th>PET Event</th>
<th>Color</th>
<th>Problem/Comments</th>
<th>Responsible Person/Agency</th>
<th>Status</th>
<th>Final Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>a</td>
<td>a</td>
<td>a</td>
<td>a</td>
<td>a</td>
<td>a</td>
<td>a</td>
</tr>
</tbody>
</table>

### HOW
Control chain, hazard analysis monitoring

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Evaluated</th>
<th>PET Event</th>
<th>Color</th>
<th>Problem/Comments</th>
<th>Responsible Person/Agency</th>
<th>Status</th>
<th>Final Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>a</td>
<td>a</td>
<td>a</td>
<td>a</td>
<td>a</td>
<td>a</td>
<td>a</td>
</tr>
</tbody>
</table>

### Other

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Evaluated</th>
<th>PET Event</th>
<th>Color</th>
<th>Problem/Comments</th>
<th>Responsible Person/Agency</th>
<th>Status</th>
<th>Final Completion Date</th>
</tr>
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</tbody>
</table>

Note: The factors in this worksheet are only guidelines but are useful in directing lines of inquiry and analysis.
Developing Conclusions and Judgments of Need

Conclusions and judgments of need are key elements of the investigation that must be developed by the board.

8.1 Conclusions

Conclusions are significant deductions derived from the investigation's analytical results. They are derived from and must be supported by the facts plus the results of testing and the various analyses conducted.

Conclusions may:
- Include concise statements of the causal factors of the accident determined by analysis of facts
- Be statements that alleviate potential confusion on issues that were originally suspected causes
- Address significant concerns arising out of the accident that are unsubstantiated or inconclusive
- Be used to highlight positive aspects of performance revealed during the investigation, where appropriate.

When developing conclusions, the board should:
- Organize conclusions sequentially, preferably in chronological order, or in logical sets (e.g., hardware, procedures, people, organizations)
- Base conclusions on the facts and the subsequent analysis of the facts
- Include only substantive conclusions that bear directly on the accident, and that reiterate significant facts and pertinent analytical results leading to the accident's causes
- Keep conclusions as short as possible and, to the extent possible, limit reference citations (if used) to one per conclusion.
Example: Conclusions

- XYZ contractor failed to adequately implement a medical surveillance program, thereby allowing an individual with medical restrictions to work in violation of those restrictions. This was a contributing factor to the accident.
- Welds did not fail during the stam line rupture.
- Blood tests on the injured worker did not conclusively establish his blood alcohol content at the time of the accident.
- The implementation of comprehensive response procedures prevented the fire from spreading to areas containing dispersible radioactive materials, averting a significant escalation in the consequences of the fire.

TIP
The process of determining conclusions seeks to answer the questions—what happened and why did it happen?

8.2 Judgments of Need

Judgments of need are the managerial controls and safety measures determined by the board to be necessary to prevent or minimize the probability or severity of a recurrence. Judgments of need should be linked to causal factors and logically flow from the conclusions. They should be:

- Stated in a clear, concise, and direct manner
- Based on the facts/evidence
- Stated so that they can be the basis for corrective action plans.

Judgments of need:

- Should not be prescriptive corrective action plans or recommendations, nor should they suggest punitive actions
- Should not include process issues (e.g., evidence control, preservation of the accident scene, readiness) unless these issues have a direct impact on the accident. These concerns should be noted in a separate memorandum to the appointing official, with a copy to site management and the Assistant Secretary for Environment, Safety and Health.

An interactive process is the preferred approach for generating judgments of need. That is, board members should work together to review causal factors and then begin generating a list of judgments of need. These judgments should be linked directly to causal factors, which are derived from facts and analyses.

TIP
Board members should work together to derive judgments of need to assure that the merits and validity of each are openly discussed and that each one flows from the facts and analyses.

One method for ensuring that all significant facts and analytical results are addressed in the judgments of need is to develop displays linking judgments of need with facts, analyses, and causal factors. Previous boards have found it useful to display these elements on the walls of the board's conference room. Figure 8-1 below demonstrates how this information can be arranged to provide an ongoing assessment of linkages among the four elements. It portrays the concept of requirements verification analysis described in Section 9 of this workbook. Using this approach, the board can identify gaps in the data where a clear, logical flow among the four elements is missing. The board can use this information to determine whether judgments of need are supported by linkages connecting the facts, results from analyses, and causal factors.

TIP
If a judgment of need cannot be clearly linked to causal factors derived from analysis of facts, exclude it from the report.

Figure 8-1. Facts, analyses, and causal factors are needed to support judgments of need
Once the board has identified the judgments of need derived from their investigation activities, the members can begin writing statements documenting these judgments. Table 8-1 below presents guidance on writing these statements.

Table 8-2 provides samples of well-written judgments of need for the case study electrical accident. Information in this table demonstrates the relationships among significant facts, analysis, causal factors, and judgments of need.

Judgments of need form the basis for corrective action plans, which are the responsibility of line management and should not be directed by the board. If the board finds a need to make specific recommendations, they should appear in a separate communication and not in the body of the report or in the transmittal letter to the appointing official.

**Table 8-1. These guidelines are useful for writing judgments of need**

- Clearly identify organizations that need to implement actions to prevent recurrence of the accident. Where applicable, specify whether the judgment of need applies to a DOE Headquarters or field element, contractor, subcontractor, or some combination of these.
- Avoid generic statements and focus on processes and systems, not individuals.
- Focus on causal factors.
- Be specific and concise; avoid vague, generalized, broad-brush, sweeping solutions introduced by "should."
- Do not tell management how to do something; simply identify the need.
- Present judgments of need in a manner that allows a specific organization to translate them into corrective actions sufficient to prevent recurrence.

**Table 8-2. Case Study: Judgments of need**

<table>
<thead>
<tr>
<th>Significant Facts</th>
<th>Causal Factors</th>
<th>Judgments of Need</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Safety training for the accident victim as required by WS ES&H Manual Procedure 1234 was not completed prior to the accident. Training implementation was informal and was not based on appropriate structured development and measurement of learning. This programmatic deficiency was a contributing cause to the accident. WS management needs to evaluate the effectiveness of implementation of the training program by observing and measuring workplace performance.

The standing work order system normally used for nonroutine, nonrepetitive tasks was used to authorize the work involved in the accident. Using the standing work order process, normally used for routine tasks, to accomplish nonroutine, complex modification and construction work, was a root cause of the accident. XYZ management needs to assure that the standing work order system is used only on routine, repetitive, and noncomplex tasks where no significant risks or hazards have been identified or could reasonably be encountered.

### 8.3 Minority Opinions

During the process of identifying judgments of need, board members may find that they disagree on the interpretation of facts, analytical results, causal factors, conclusions, or judgments of need. This disagreement can occur because the board:

- Has too few facts or has conflicting information from different sources; when this occurs, additional information may be needed to resolve these conflicts
- Needs to evaluate the analyses conducted and consider using different analytical techniques
- Disagrees on the linkages among facts, analyses and causal factors.

Even when new facts are collected and new analyses are conducted, board members may still strongly disagree on the interpretation of facts, the conclusions, or the judgments of need. Board members should make these differences known to the chairperson as soon as they arise.

Every effort should be made to resolve a board member's dissenting opinion by collecting additional facts, if possible, and conducting additional analyses.

When board members still disagree, it is recommended that the chairperson:

- Obtain a detailed briefing from those not in agreement and consider the facts, analyses, causal factors, and conclusions that each used.
- Monitor the differences between those not in agreement by holding meetings to discuss any new information collected or new analyses conducted; more common ground may be found as this information emerges.
- Work with the board to identify areas of mutual agreement and areas of disagreement as the end of the investigation approaches.
- Openly discuss his or her position concerning the causal factors, conclusions, and judgments of need with the board and achieve consensus. At this point, board members who disagree with the consensus should describe their position and indicate whether there is a need to present a minority opinion in the accident investigation report.

Note that the board is not required to reach consensus, but is encouraged to work diligently to resolve differences of opinion. However, if one or more board members disagree with the interpretation of facts, causal factors, conclusions, or judgments of need endorsed by the remainder of the board, the minority board member or members should document their differences in a minority report. This report is described in Section 9.

### Key Points to Remember

Conclusions are significant deductions derived from the investigation’s analytical results. They are derived from and supported by the facts plus the results of testing and various analyses conducted.

- Judgments of need are the managerial controls and safety measures necessary to prevent or minimize the probability or severity of an accident’s recurrence.
- To ensure that a clear and comprehensive list of judgments of need is presented, the board should link each judgment of need with causal factors, analyses, and facts. If the linkage is weak at any point, the judgment of need should be excluded from the list.
- As the board generates the judgments of need, differing opinions may emerge. If these differences cannot be resolved at the end of the investigation, the board member(s) whose opinion(s) differs from the majority should prepare a report describing those differences (i.e., the minority report). This circumstance generally arises as a result of: (1) insufficient or conflicting factual information, (2) inconclusive or conflicting analytical results, (3) disagreement as to the interpretation of facts, causal factors, conclusions, or judgments of need, or (4) unclear linkage among facts, analyses, and causal
factors.
9 Reporting the Results

The purpose of the investigation report is to clearly and concisely convey the results of the investigation in a manner that will help the reader understand what happened (the accident description and chronology), why it happened (the causal factors), and what can be done to prevent a recurrence (the judgments of need). Investigation results are reported without attributing individual fault or proposing punitive measures.

The investigation report constitutes an accurate and objective record of the accident and provides complete and accurate details and explicit statements of:

- The board's investigation process
- Facts pertaining to the accident, including relevant management systems involved
- Analytical methods used and their results
- Conclusions of the board, including the causal factors of the accident
- Judgments of need for corrective actions to prevent recurrence of the accident.

When completed, this report is submitted to the appointing official for acceptance and dissemination.

9.1 Writing the Report
The investigation report is the official record of the investigation; its importance cannot be overemphasized. The quality of the investigation will be judged primarily by the report, which will provide the affected site and the DOE complex as a whole with the basis for developing the corrective actions necessary to prevent or minimize the severity of a recurrence, as well as lessons learned.

TIP

Many previous boards have conducted thorough and competent accident investigations, yet failed to communicate the results effectively in the report. As a result, the causes, judgments of need, and lessons learned often appear unsupported or are lost in a mass of detail.

The report writing process is interactive, yet focused. Guidelines for drafting a report, provided in Table 9-1 below, will help the board work within the investigation cycle and schedule to maximize their efficiency and effectiveness in developing a useful report.

Table 9-1. Useful strategies for drafting the investigation report.

- Establish clear responsibilities for writing each section of the report.
- Establish deadlines for writing, quality review, and production, working back from the scheduled final draft report due date.
- Use an established format (as described in Section 9.2). Devise a consistent method for referencing titles, acronyms, appendices, and footnotes to avoid last-minute production problems.
- Use a single point of contact, such as the administrative coordinator, to control all electronic versions of the report, including editing input, and to coordinate overall report production.
- Start writing as soon as possible. Write the facts as bulleted statements as they are documented. Write the accident chronology as soon as possible to minimize the potential for forgetting the events and to save time when generating the first draft.
- Begin developing illustrations and photograph captions early. These processes take more time than generally anticipated.
- Allow time for regular editorial and board member review and input. Don't wait until the last few days on site for the board to review each other's writing and the entire draft report. This step is important for assuring that primary issues are addressed and the investigation remains focused and within scope.
- Use a zip drive to save the report during text processing — the file is extremely large.
- Use a technical writer or editor early in the process to edit the draft report for readability, grammar, content, logic, and flow.
- Share information with other board members.
- Plan for several revisions.

Senior DOE management is placing increasingly greater emphasis on generating concise (nominally less than 50 pages), yet thorough investigation reports. This approach requires board members to communicate the significant facts, analyses, causal factors, conclusions, and judgments of need with as little extraneous narrative as possible. Inherent in this approach is the need for reports to provide helpful and useful information to line managers to assist them in enhancing their safety programs.

9.2 Report Format and Content

The investigation report should consist of the elements listed in Table 9-2 below. Although DOE Order 225.1A does not specifically require some of these elements or prescribe any specific order of presentation within the report, a certain level of consistency in content and format among reports facilitates extraction and dissemination of facts, conclusions, judgments of need, and lessons learned.

Table 9-2. The accident investigation report should include these items.
The following are brief descriptions and acceptable examples of the elements of a typical accident investigation report.

9.2.1 Disclaimer

The accident investigation report disclaimer should appear on the back of the title page of the report. The disclaimer is a statement that the report neither determines nor implies liability. It should be worded exactly as the example below, with the substitution of the appointing official and designated type of accident investigation (i.e., A or B) relevant to the given accident (these items are shaded in the example).

**EXAMPLE: DISCLAIMER**

This report is an independent product of the Type A accident investigation board appointed by [Name], Assistant Secretary for Environment, Safety and Health (EH-1).

The board was appointed to perform a Type A Investigation of this accident and to prepare an investigation report in accordance with DOE Order 225.1A, Accident Investigations.

The discussion of facts, as determined by the board, and the views expressed in the report do not assume and are not intended to establish the existence of any duty at law on the part of the U.S. Government, its employees or agents, contractors, their employees or agents, or subcontractors at any tier, or any other party.

This report neither determines nor implies liability.

9.2.2 Appointing Official's Statement of Report Acceptance

After reviewing the draft final report, the appointing official signs and dates a statement indicating that the investigation has been completed in accordance with procedures specified in DOE Order 225.1A and that the findings of the accident investigation board have been accepted. An example of this statement is provided below.

**EXAMPLE: APPOINTING OFFICIAL’S ACCEPTANCE STATEMENT**

On [Date], I established a Type [A] Accident Investigation Board to investigate the [Fall] at the [Facility] at the [Site] that resulted in the [Fatality of a construction worker]. The Board’s responsibilities have been completed with respect to this investigation. The analysis, identification of direct, contributing, and root causes, and judgments of need reached during the investigation were performed in accordance with DOE Order 225.1A, Accident Investigations. I accept the findings of the Board and authorize the release of this report for general distribution.

Signed

[Name]
Assistant Secretary for Environment, Safety and Health
9.2.3 Table of Contents

In addition to a table of contents for the report body, a list of exhibits, figures, and tables and a list of appendices should be included. Typically, the table of contents lists the headings within the report down to the third level. An example is provided below for reference.

<table>
<thead>
<tr>
<th>EXAMPLE: TABLE OF CONTENTS</th>
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</tr>
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<td>PROLOGUE</td>
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<td>EXECUTIVE SUMMARY</td>
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<td>1.3 SCOPE, CONDUCT, AND METHODOLOGY</td>
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<td>2.0 FACTS AND ANALYSIS</td>
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<tr>
<td>2.1 ACCIDENT DESCRIPTION AND CHRONOLOGY</td>
</tr>
<tr>
<td>2.1.1 Background and Accident Description</td>
</tr>
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<td>2.1.2 Chronology of Events</td>
</tr>
<tr>
<td>2.1.3 Accident Response and Investigative Readiness</td>
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<tr>
<td>2.2 PHYSICAL HAZARDS, CONTROLS, AND RELATED FACTORS</td>
</tr>
<tr>
<td>2.2.1 Work Controls</td>
</tr>
<tr>
<td>2.2.2 Personnel Performance</td>
</tr>
<tr>
<td>2.2.3 Management Systems</td>
</tr>
<tr>
<td>2.3 BARRIER ANALYSIS</td>
</tr>
<tr>
<td>2.4 CHANGE ANALYSIS</td>
</tr>
<tr>
<td>2.5 CAUSAL FACTORS ANALYSIS</td>
</tr>
<tr>
<td>3.0 CONCLUSIONS AND JUDGMENTS OF NEED</td>
</tr>
<tr>
<td>4.0 BOARD SIGNATURES</td>
</tr>
<tr>
<td>5.0 BOARD MEMBERS, ADVISORS, CONSULTANTS, AND STAFF</td>
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</table>

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| Appendix B. Performance of Barriers | B-1 |
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<th>EXHIBITS, FIGURES AND TABLES</th>
</tr>
</thead>
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<tr>
<td>Exhibit 2-1 View Looking South</td>
</tr>
<tr>
<td>Figure 2-1 Summary Events Chart and Accident Chronology</td>
</tr>
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<td>Figure 2-2 Barrier Analysis Summary</td>
</tr>
<tr>
<td>Figure 2-3 Events and Causal Factors Chart</td>
</tr>
<tr>
<td>Table 3-1 Conclusions and Judgments of Need</td>
</tr>
</tbody>
</table>

9.2.4 Acronyms and Initialisms

Use of acronyms and initialisms is common among DOE staff and contractors; however, to people outside the Department who may read the report, use of such terms without adequate definition can be frustrating and hinder understanding. This element of the report assists readers by identifying, in alphabetical order, terms and acronyms used in the report. Acronyms and initialisms should be kept to a minimum (see example below). Proliferation of acronyms makes it difficult for managers and those unfamiliar with the site, facility, or area involved to read and comprehend the report. Acronyms or initialisms should not be used for organizational elements in the field or position titles. If necessary, a glossary of technical terms should follow this section.
**9.2.5 Prologue—Interpretation of Significance**

The prologue is a one-page synopsis of the significance of the accident with respect to management concerns and the primary lessons learned from the accident.

**EXAMPLE: PROLOGUE**

**INTERPRETATION OF SIGNIFICANCE**

The fatality at the [Site] on [Date] resulted from failures of Department of Energy (DOE), contractor, and subcontractor management, and the fatally injured worker. The subcontractor, the employer of the fatally injured worker, had a poor record of serious safety deficiencies and had never accepted the higher levels of safety performance required by the Department's safe work ethic.

Although all the appropriate contractual and procedural requirements were in place, the subcontractor failed to implement them and continued to allow violations of Occupational Safety and Health Administration regulations invoked by DOE orders. These serious deficiencies were recognized by the prime contractor, which was instituting progressively stronger sanctions against the subcontractor. However, because of the subcontractor's recalcitrance and the imminent danger conditions represented by the subcontractor's frequent violations of fall protection requirements, more aggressive measures, such as contract cancellation, could have been taken earlier.

The prime contractor's oversight was narrowly focused on selected aspects of the subcontractor's safety performance and did not identify the subcontractor's failure to implement its own procedures, or institute appropriate fall protection measures. Thus, the implications and frequency of imminent danger hazards were not fully appreciated. Departmental oversight focused on the subcontractor's performance and did not identify the gaps in the prime contractor's oversight focus. As a result, hazards were not identified and barriers were not in place to prevent the accident, which could have been avoided.

This fatality highlights the importance of a complete approach to safety that stresses individual and line management responsibility and accountability, implementation of requirements and procedures, and thorough and systematic oversight by contractor and Department line management. All levels of line management must be involved. Contractual requirements and procedures, implementation of these requirements, and line management oversight are all necessary to mitigate the dangers of hazards that arise in the workplace. Particular attention must be paid to individual performance and changes in the workplace. Sound judgment, constant vigilance, and attention to detail are necessary to deal with hazards of immediate concern. When serious performance deficiencies are identified, there must be strong, aggressive action to mitigate the hazards and reestablish a safe working environment. Aggressive actions, up to and including swift removal of organizations that exhibit truculence toward safety, are appropriate and should be taken.

**TIP**

The prologue should interpret the accident's significance as it relates to the affected site, other relevant sites, field offices within the DOE complex, and DOE Headquarters.

**9.2.6 Executive Summary**

The purpose of the executive summary is to convey to the reader a reasonable understanding of the accident, its causes, and the actions necessary to prevent recurrence. Typical executive summaries are two to five pages, depending on the
complexity of the accident.

The executive summary should include a brief account of:

- Essential facts pertaining to the occurrence and major consequences (what happened)
- Conclusions that identify the causal factors, including organizational, management systems, and line management oversight deficiencies, that allowed the accident to happen (why it happened)
- Judgments of need to prevent recurrence (what must be done to correct the problem and prevent it from recurring at the affected facility and elsewhere in the DOE complex).

The executive summary should be written for the senior manager or general reader who may be relatively unfamiliar with the subject matter. It should contain only information discussed in the report, but should not include the facts and analyses in their entirety.

### EXAMPLE: EXECUTIVE SUMMARY

#### INTRODUCTION

A fatality was investigated in which a construction subcontractor fell from a temporary platform in the [Facility] at the [Site]. In conducting its investigation, the accident investigation board used various analysis techniques, including events and causal factors charting and analysis, barrier analysis, change analysis, and root cause analysis. The board inspected and videotaped the accident site, reviewed events surrounding the accident, conducted extensive interviews and document reviews, and performed analyses to determine the causal factors that contributed to the accident, including any management system deficiencies. Relevant management systems and factors that could have contributed to the accident were evaluated using with the components of the Department's integrated safety management system, as described in DOE Policy 450.4.

#### ACCIDENT DESCRIPTION

The accident occurred at approximately [Time] on [Date] at the [Facility], when a construction worker, employed by [Subcontractor], fell from a temporary platform. The platform had been installed to catch falling tools and parts, but it was also used as a work platform for personnel activities when 100 percent fall protection was used. The worker was transported by helicopter to the medical center, where he died at [Time] from severe head and neck injuries.

#### DIRECT AND ROOT CAUSES

The direct cause of the accident was the fall from an unprotected platform.

The contributing causes of the accident were: (1) the absence of signs and barricades in the vicinity of the platform, (2) visibility problems created by poor illumination in the area of the platform, and (3) lack of implementation of job safety analysis, work controls, and the medical surveillance program.

The root causes of the accident were: (1) failure by [Subcontractor] to implement requirements and procedures that would have mitigated the hazards, and (2) failure by [Subcontractor] to effectively implement components of the Department's integrated safety management policy mandating line management responsibility and accountability for safety performance.

#### CONCLUSIONS AND JUDGMENTS OF NEED

Conclusions of the board and judgments of need as to managerial controls and safety measures necessary to prevent or mitigate the probability of a recurrence are summarized in Table 1.

<table>
<thead>
<tr>
<th>Conclusions</th>
<th>Judgments of Need</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Subcontractor] failed to follow procedures required by its contract and by its ES&amp;H Program Plan, including:</td>
<td>[Subcontractor] line management and safety personnel need to implement existing safety requirements and procedures.</td>
</tr>
<tr>
<td>✔ [Subcontractor] failed to adequately implement fall protection requirements contained in its ES&amp;H Program Plan for the [Facility] project, including enforcement of a three-tiered approach to fall protection. The third tier (choice of last resort) requires anchor points, lanyards, shock absorbers, and full-body harness.</td>
<td></td>
</tr>
<tr>
<td>☐ The worker was not wearing any fall protection equipment and did not obtain a direct reading dosimeter before entering the radiological control area.</td>
<td></td>
</tr>
<tr>
<td>[Subcontractor] and [Contractor] did not fully implement the hazard inspection requirements of the [Facility] contract and [Subcontractor’s] ES&amp;H Program Plan, and therefore did not sufficiently identify or analyze hazards and institute protective measures necessary due to changing conditions.</td>
<td>[Subcontractor] and [Contractor] need to ensure that an adequate hazards analysis is performed prior to changes in work tasks that affect the safety and health of personnel.</td>
</tr>
</tbody>
</table>
TIP
The Executive Summary should not include a laundry list of all the facts, conclusions, and judgments of need. Rather, to be effective, it should summarize the important facts; causal factors; conclusions; and judgments of need.

9.2.7 Introduction
This section of the report, illustrated in the example that follows, normally contains three major subsections:

- A brief background description of the accident and its results, and a statement regarding the authority to conduct the investigation
- A facility description defining the area or site and the principal organizations involved, to help the reader understand the context of the accident and the information that follows
- Descriptions of the scope of the investigation, its purpose, and the methodology employed in conducting the investigation.

EXAMPLE: INTRODUCTION

1.0 INTRODUCTION

1.1 BACKGROUND
On [Date], at approximately [Time], a construction subcontractor working at the [Site] fell approximately 17 feet from a temporary platform. The platform was built to catch falling tools and parts in the [Facility]. The worker was transported by helicopter to the medical center, where he died from severe head and neck injuries.

On [Date], [Appointing Official Name and Title] appointed a Type A accident investigation board to investigate the accident, in accordance with DOE Order 225.1A, Accident Investigations.

1.2 FACILITY DESCRIPTION
Contractor activities at [Site] are managed by the DOE XXX Operations Office. The facility in which this accident occurred is under the programmatic direction of the Office of Environmental Management (EM).

[Provide a brief discussion of site, facility, or area operations and descriptive background that sheds light on the environment or location where the accident occurred.]

1.3 SCOPE, CONDUCT, AND METHODOLOGY
The board commenced its investigation on [Date], completed the investigation on [Date], and submitted its findings to the Assistant Secretary for Environment, Safety and Health on [Date].

The scope of the board's investigation was to review and analyze the circumstances to determine the accident's causes. During the investigation, the board inspected and videotaped the accident site, reviewed events surrounding the accident, conducted interviews and document reviews, and performed analyses to determine causes.

The purposes of this investigation were to determine the nature, extent, and causation of the accident and any programmatic impact, and to assist in the improvement of policies and practices, with emphasis on safety management systems.

The board conducted its investigation, focusing on management systems at all levels, using the following methodology:

- Facts relevant to the accident were gathered
- Relevant management systems and factors that could have contributed to the accident were evaluated in accordance with the components of DOE's integrated safety management system, as described in DOE Policy 450.4
- Events and causal factors charting and analysis, along with barrier analysis and change analysis, was used to provide supportive correlation and identification of the causes of the accident.
9.2.8 Facts and Analysis

This section of the report states the facts related to the accident and the analysis of those facts. It focuses on the events connected to the accident; the factors that allowed those events to occur; and the results of the various analytical techniques used to determine the direct, contributing, and root causes of the accident, including the role of management and safety system deficiencies. This section should logically lead the reader to the conclusions and judgments of need. It includes subsections dealing with:

- **Accident description and chronology**, including a description of the responses to the accident
- **Hazards, controls, and management systems pertinent to the accident**
- **Brief descriptions of and results from analyses** that were conducted (e.g., barrier analysis, change analysis, events and causal factors analysis, and root cause analysis).

Photographs, evidence position maps, and diagrams, which may provide perspectives that written narrative cannot capture, should be included in the Facts and Analysis section, as determined by the board.

**Accident Description and Chronology.** A subsection describing the accident and chronology of events should be first in the Facts and Analysis section of the report. This section includes:

- Background information about systems and any activities and events preceding the accident, including scheduled maintenance and system safety analysis
- Chronological description of the events leading up to and including the accident itself
- A summary events chart, identifying the major events from the events and causal factors chart.

This is typically one of the first sections written, as soon as evidence is collected and pertinent information is documented. It is reasonable for the board to begin preparing a draft of the accident description and chronology during the first few days on site. As additional information is collected, new findings can be used to augment the initial writing.

**Description and Analysis of Facts.** Subsections on the facts surrounding the accident, and the analysis of those facts, should follow the accident description and chronology subsection. These sections must provide the full basis for stating the accident's causes and judgments of need.

In writing the report, it is important to clearly distinguish facts from analysis. **Facts** are objective statements that can be verified by physical evidence, by direct observation, through documentation, or from statements corroborated by at least one witness or interviewee other than the one making the statement. **Analysis** is a critical review and discussion of the implications of the facts, leading to a logical interpretation of those facts and supportable conclusions. The analysis should include a brief statement of the impact of the factual circumstances on the accident. Table 9-3 illustrates this distinction.

### Table 9-3. Facts differ from analysis.

<table>
<thead>
<tr>
<th>Facts</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>At 9:30 a.m., the outside temperature was 36° F and the sky was clear.</td>
<td>Meteorological conditions at the time of the accident did not contribute to the accident.</td>
</tr>
<tr>
<td>In September 1995, the Environmental Group implemented its own alternate work authorization process. This process did not include a job hazards analysis prior to construction activities.</td>
<td>The alternate work authorization process was not adequate to assure worker safety.</td>
</tr>
</tbody>
</table>

Following are some guidelines for developing this portion of the report:

- The subsections should be organized logically according to relevant investigation topics, such as:
  - Physical hazards
  - Conduct of operations
  - Training
  - Work planning and control
Organizational concerns
- Management systems
- Maintenance
- Personnel performance
- Other topics specific and relevant to the investigation.

For each subsection, list relevant facts in the form of bulleted statements.

For each subsection, provide an analysis of what the facts mean in terms of their impact on the accident and its causes. This narrative should be as concise as possible and may reference the more detailed analyses discussed later in the report (e.g., barrier analysis, change analysis, events and causal factors charting and analysis, and root cause analysis). All facts included in the report should be addressed.

TIP
Avoid lengthy narratives. It is more important to lay out the facts in a clear, concise manner that is understandable to the reader. Precede the bulleted facts with a statement identifying them as facts. Include only facts—not conjecture, assumptions, analysis, or opinions.

Generally the facts are presented as short statements, and the analysis of the facts provides a direct link between the facts and causal factors. See the example below.

Brief Descriptions and Results from Analyses. Subsections in the Facts and Analysis section should describe the formal analytical methods used during the investigation, as well as the results. For example, if barrier analysis, change analysis, and events and causal factors analysis were performed during an investigation, each of these methods and the results are briefly summarized. There always should be a subsection that includes a discussion of the root cause analysis. If necessary, detailed supporting documentation for analyses performed during the investigation is included in one or more appendices.

EXAMPLE: DESCRIPTION AND ANALYSIS OF FACTS

2.0 FACTS AND ANALYSIS
2.2 PHYSICAL HAZARDS, CONTROLS, AND RELATED FACTORS
2.2.1 Physical Barriers

Facts related to physical barriers on the day of the accident are as follows:
- There were no general barriers, warning lines, or signs to alert personnel on top of the construction materials to the fall hazards in the area. There were no other safety barriers for the platform.
- The platform was intended to catch falling tools or parts, but it was also used as a work platform for personnel with 100 percent fall protection.
- There were no static lines or designated (i.e., engineered) anchor points for personnel to connect fall protection equipment in the vicinity of the platform.
- Lighting in the area of the platform was measured at 2 foot-candles.

Following is the analysis of these facts.

Occupational Safety and Health Standards for the Construction Industry (29 CFR 1926) requires that, when working from an area greater than six feet in height or near unprotected edges or sides, personal protection in the form of a fall protection system be in place during all stages of active work. Violations of fall protection requirements usually constitute an imminent danger situation. Lighting in the area was less than the minimum of 5 foot-candles prescribed by the OSHA standards (29 CFR 1925.56). This level of illumination may have contributed to the accident, taking into consideration the visual adjustment when moving from a brighter area to a progressively darker area, as was the case in the area where the accident occurred.

There were no permanently installed fall protection systems, barriers, or warnings; each sub-tier contractor was expected to identify the fall hazards and provide its own fall protection system as they saw fit. The combination of these circumstances was a contributing cause of the accident.

Causal Factors Analysis. Three types of causal factors are identified using analytic methods: direct cause, contributing causes, and root causes. A narrative showing how these are presented in the report is provided below. A figure (a summary events and causal factor chart) showing the logical sequence of the events and causal factors for the accident is included in the report. Each causal factor is generally a brief, explicit statement that summarizes the cause and any of its contributing factors. The causal factors that are identified in the report must be fully supported by the facts and analysis described in the report. If they are not, the board risks reaching erroneous conclusions and producing insufficient or unnecessary judgments of need that will affect the report's credibility.
EXAMPLE: DESCRIPTION AND RESULTS FROM ANALYSES

2.0 FACTS AND ANALYSIS
2.3 CHANGE ANALYSIS

Change analysis was performed to determine points where changes are needed to correct deficiencies in the safety management system and to pinpoint changes and differences that may have had an effect on the accident.

Changes directly contributing to the accident were failure to execute established procedures for fall protection, signs and barricades, and Job Safety Analysis/Construction Safe Work Permit; unsafe use of the temporary platform; insufficient lighting in the platform area; and unenforced work restrictions for the construction worker. No job safety analysis was performed and/or Construction Safe Work Permit obtained for work on the platform, leading to a failure in the hazard analysis process and unidentified and uncorrected hazards in the workplace. Deficiencies in the management of the safety program within [Subcontractor] are also related to failures in the medical surveillance program.

Changes brought about by [Subcontractor] management failures resulted in a deficient worker safety program. Management failed to implement the contractual safety requirements necessary to prevent the accident and avoid deficiencies in the worker safety program.

[Contractor's] progressive approach to improving [Subcontractor's] compliance with safety requirements was successful to a degree, but failed to prevent recurrence of imminent danger situations.

EXAMPLE: CAUSAL FACTORS ANALYSIS

2.5 CAUSAL FACTORS ANALYSIS

The direct cause of the accident was the fall from an unprotected platform. However, there were also contributing causes and root causes.

Contributing causes for the accident were:
- Job safety analysis, work controls, and medical surveillance program not implemented
- Insufficient illumination in the area of the temporary platform
- Failure to remove the temporary platform
- Absence of warning signs and barricades.

Another possible contributing factor was impaired judgment of the worker who fell from the platform. This cause could not be substantiated.

Root causes of the accident were:
- Failure by [Subcontractor] to implement requirements and procedures that would have mitigated the hazards. The implementation of comprehensive and appropriate requirements is part of the third of DOE's safety management principles. [Subcontractor] failed to implement its medical surveillance program and to enforce work restrictions for the worker. A hazards analysis, required by DOE Order 5480.9A and the ES&H Program Plan, was not conducted; consequently, the hazards associated with the platform were not identified, and no countermeasures were implemented. The absence of fall protection, physical barriers, and warning signs in the vicinity of the platform, along with inadequate lighting, violated DOE requirements that invoke Federal safety standards. Finally, failure to ensure that comprehensive requirements are fully implemented represents a fundamental flaw in the safety management program of [Subcontractor] and exhibits failure to meet part of the management requisites for the fifth of DOE's safety management principles requiring that comprehensive and appropriate requirements be established and effectively implemented to counteract hazards and assure safety.
- Failure by [Subcontractor] to implement the principle of line management responsibility and accountability for safety. Line management responsibility and accountability for safety is the first of DOE's safety management principles. [Subcontractor] has clear safety policies and well defined responsibilities and authorities for safety. However, [Subcontractor] line management failed to appropriately analyze and manage hazard mitigation and, when faced with adverse consequences for poor safety performance, has refused to accept accountability. [Subcontractor] consistently failed to implement effective safety policies and practices as reflected in DOE policies and industry standards. [Subcontractor] did not meet contractual requirements for safety and its own safety policy. Finally, [subcontractor] failed to ensure that findings resulting from reviews, monitoring activities, and audits were resolved in a timely manner. [Subcontractor's] approach and numerous safety program failures reflect less than full commitment to safety and directly led to the accident.
9.2.9 Conclusions and Judgments of Need

This section of the report lists the board's conclusions in the form of concise statements, as well as the board's judgments of need (discussed in Section 8 of this workbook). The conclusions can be listed using bulleted statements, tables, or diagrams with limited narrative, as long as the meaning is clear. Judgments of need may be presented in the same manner.

Judgments of need are identified actions required to prevent future accidents. Examples of well-written judgments of need are shown below.

**EXAMPLE: CONCLUSIONS AND JUDGMENTS OF NEED**

<table>
<thead>
<tr>
<th>CONCLUSIONS</th>
<th>JUDGMENTS OF NEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehensive safety requirements existed, were contractually invoked, and were appropriate for the nature of construction work.</td>
<td>None</td>
</tr>
<tr>
<td>[Subcontractor] failed to follow procedures required by its contract and by its ES&amp;H Program Plan, including:</td>
<td>[Subcontractor] line management and safety personnel need to implement existing safety requirements and procedures.</td>
</tr>
<tr>
<td>[Subcontractor] failed to adequately implement fall protection requirements contained in its ES&amp;H Program Plan for the project, including enforcement of a three-tiered approach to fall protection. The third tier (choice of last resort) requires anchor points, lanyards, shock absorbers, and full-body harness.</td>
<td></td>
</tr>
<tr>
<td>A temporary platform, used as a work surface for personnel activities when employing 100 percent fall protection, did not have guardrails and was left in place without barriers or other warning devices.</td>
<td></td>
</tr>
<tr>
<td>❍ [Subcontractor] failed to post adequate warning signs and establish barriers on the stack to warn personnel that they were approaching within six feet of the edge of a fall hazard, as required by OSHA regulations and [Subcontractor's] ES&amp;H Program Plan.</td>
<td></td>
</tr>
<tr>
<td>❍ [Contractor] failed to recognize that warning signs and barriers were not in place in the work area near the platform.</td>
<td></td>
</tr>
</tbody>
</table>

9.2.10 Minority Report

If used, this section contains the opinions of any board member(s) that differ from the majority of the board. The minority report should:

- Address only those sections of the overall report that warrant the dissenting opinion
- Follow the same format as the overall report, addressing only the points of variance
- Not be a complete rewrite of the overall report.

9.2.11 Board Signatures

The accident investigation board chairperson and members must sign and date the report, even if there is a minority opinion. The signature page identifies the name and position of each board member and the accident investigation board chairperson, as shown below. It also indicates whether each board member is a DOE accident investigator.

**EXAMPLE: BOARD SIGNATURES**
4.0 BOARD SIGNATURES

Signed
[Name], Board Chairperson
DOE Accident Investigator
U.S. Department of Energy, EH-21

Signed
[Name], Board Member
DOE Accident Investigator
U.S. Department of Energy, Rocky Flats Field Office

Signed
[Name], Board Member
DOE Accident Investigator
U.S. Department of Energy, Oak Ridge Operations Office

Signed
[Name], Board Member
OSHA Accident Investigator

Signed
[Name], Board Member

9.2.12 Board Members, Advisors, Consultants, and Staff

This section lists the names of the board members, advisors, and staff, indicating their employers and their positions with respect to the accident investigation.

<table>
<thead>
<tr>
<th>EXAMPLE: PARTICIPANTS</th>
</tr>
</thead>
</table>

5.0 BOARD MEMBERS, ADVISORS, CONSULTANTS, AND STAFF

<table>
<thead>
<tr>
<th>Chairperson</th>
<th>[Name], DOE (EH-21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member</td>
<td>[Name], DOE-Oak Ridge Operations Office</td>
</tr>
<tr>
<td>Member</td>
<td>[Name], DOE-Rocky Flats Field Office</td>
</tr>
<tr>
<td>Member</td>
<td>[Name], DOE-Idaho Operations Office</td>
</tr>
<tr>
<td>Advisor</td>
<td>[Name], DOE (EH-21)</td>
</tr>
<tr>
<td>Advisor</td>
<td>[Name], DOE (EH-21)</td>
</tr>
<tr>
<td>Advisor</td>
<td>[Name], DOE-Albuquerque Operations Office</td>
</tr>
<tr>
<td>Advisor</td>
<td>[Name], DOE-Idaho Operations Office</td>
</tr>
<tr>
<td>Advisor</td>
<td>[Name], Consultant</td>
</tr>
<tr>
<td>Medical Advisor</td>
<td>[Name], M.D., Consultant</td>
</tr>
<tr>
<td>Legal Advisor</td>
<td>[Name], DOE-Idaho Operations Office</td>
</tr>
<tr>
<td>Administrative Coordinator</td>
<td>[Name], DOE (EH-21)</td>
</tr>
<tr>
<td>Technical Writer</td>
<td>[Name], XYZ Corporation</td>
</tr>
<tr>
<td>Technical Editor</td>
<td>[Name], XYZ Corporation</td>
</tr>
<tr>
<td>Administrative Support</td>
<td>[Name], DOE-Rocky Flats Field Office</td>
</tr>
<tr>
<td></td>
<td>[Name], DOE-Idaho Operations Office</td>
</tr>
</tbody>
</table>

9.2.13 Appendices

Appendices are added, as appropriate, to provide supporting information, such as the accident investigation board's
appointment letter and results from detailed analyses conducted during the investigation.

Generally, the amount of documentation in the appendices should be limited. If there is any doubt about the benefit of including material as an appendix, it should probably be omitted. All appendices should be referenced in the report.

### 9.3 Performing Quality Review and Validation of Conclusions

Before releasing the report outside the investigation team, the board reviews it to ensure its technical accuracy, thoroughness, and consistency, and to ensure that organizational concerns, safety management systems, and line management oversight processes are properly analyzed as possible causes of the accident. The following are further considerations for quality review of the report.

**Structure and Format**—The report should be reviewed to ensure that it follows the format and contains the information outlined in Section 9.2, which ensures compliance with the intent of Paragraph 4.c(3) of DOE Order 225.1A. Variation in the format is acceptable, as long as it does not affect the report's quality or conflict with the requirements of the order.

**Technical and Policy Issues**—All technical requirements applicable to the investigation should be reviewed by appropriate subject matter experts to assure their accuracy. Likewise, a knowledgeable board member or advisor should review whether policy, requirements, and procedures were followed. A board member or advisor knowledgeable in such policy and requirements should also review the report to determine whether these requirements were adequately considered.

**Requirements Verification Analysis**—Requirements verification analysis should be conducted on the draft report after all the analytical techniques are completed. This analysis ensures that all portions of the report are accurate and consistent, and verifies that the conclusions are consistent with the facts, analyses, and judgments of need. The requirements verification analysis determines whether the flow from facts to analysis to causal factors to judgments of need is logical. That is, the judgments of need are traced back to the supporting facts. The goal is to eliminate any material that is not based on facts.

**TIP**

One approach to requirements verification is to cut a copy of the draft report apart; compare the facts, analysis, causal factors, and judgments of need on a wall chart; and validate the continuity of facts through the analysis and causal factors to the judgments of need. This method also identifies any misplaced facts, insufficient analyses, and unsupported conclusions or judgments of need.

**Classification and Privacy Review**—A review should be completed by an authorized derivative classifier to ensure that the report does not contain classified or unclassified controlled nuclear information (UCNI). An attorney should also review the report for privacy concerns. These reviews are conducted before the report is distributed for the factual accuracy review. Documentation that these reviews have been completed should be retained in the permanent investigation file.

### 9.4 Conducting the Factual Accuracy Review

When the accident investigation report has been drafted in its final form, but before it is submitted to the appointing official for acceptance, the facts presented in the Facts and Analysis section of the report should be reviewed by affected DOE and contractor line management to validate the factual accuracy of the report contents. Generally, only the “facts” portion should be distributed for this review, in order to protect the integrity of the investigation and prevent a premature reaction to preliminary analyses. However, other portions of the report may be provided at the discretion of the board chairperson. The review is important for ensuring an accurate report and verifying that all affected parties agree on the facts surrounding the accident. This is consistent with the approach of identifying system deficiencies so that corrective actions can be taken, rather than fixing blame. It also supports and is consistent with the DOE management philosophy of openness in the oversight process.

Some boards have conducted this review in the board’s dedicated conference room. This allows representatives of affected organizations to review the draft description of the facts and to ask follow-up questions of board members, while ensuring that dissemination of the draft document remains closely controlled.

Comments and revisions from DOE and contractor management are incorporated into the draft final report, as appropriate.

### 9.5 Review by the Assistant Secretary for Environment, Safety and Health

DOE Order 225.1A requires review of Type A, limited scope, and Type B accident investigation reports by the Assistant Secretary. Type A and limited scope accident investigation reports are reviewed by the Assistant Secretary as the appointing official. Responsibility for review of delegated Type A and Type B accident investigation reports has been delegated to the Deputy Assistant Secretary for Oversight (EH-2). Delegated Type A and Type B accident investigation reports are reviewed prior to acceptance by the appointing official. Comments are provided to the appointing official for
incorporation prior to report publication and distribution. Coordination for these reviews should be made with the Program Manager. Board chairpersons should plan and schedule sufficient time for this review to maintain the appropriate investigation cycle.

9.6 Submitting the Report

Once the report has been finalized, the accident investigation board chairperson provides the draft final report to the appointing official for acceptance. If the appointing official determines that the board has met its obligation to conduct a thorough investigation of the accident, that the report fully describes the accident and its causal factors, and that it provides judgments of need sufficient to prevent recurrence, the report is formally accepted. The statement of report acceptance from the appointing official is included in the final report (see Section 9.2.2).

Key Points to Remember

- Begin writing the report as soon as initial evidence is collected.
- Keep pace with writing as the investigation proceeds to avoid having to do all the writing during the third and fourth weeks.
- The primary portions of the report include:
  - Prologue—Interpretation of Significance
  - Executive Summary
  - Introduction
  - Facts and Analysis
  - Conclusions and Judgments of Need
  - Minority Report (if applicable)
  - Board Signatures
  - Appendices.
- Provide a concise, yet clear discussion of the facts and analyses of the investigation.
- Clearly distinguish between facts and analysis.
- Ensure that the facts and analyses logically lead the reader to the conclusions and judgments of need determined by the board.
- Describe judgments of need so that they can be translated into corrective actions.
- Include appendices as needed, but do not bury important facts in appendices.
- Quality reviews of the report prior to finalization include processes for reviewing structure and format, technical and policy issues, and a requirements verification analysis.
- The factual accuracy of the report is reviewed by submitting it to affected DOE and contractor line management to validate the factual content. This ensures an accurate report and that all affected parties agree on the facts surrounding the accident. Comments and revisions are incorporated as appropriate.
- Requirements verification analysis is conducted on the draft report to ensure that all portions of the report are accurate and consistent. It also verifies that the conclusions are consistent with the facts, analyses, and judgments of need and that the flow from facts to analysis to causal factors to judgments of need is logical. Judgments of need are traced back to the supporting facts. One method of doing this is to create a wall chart using the applicable portions of the report to depict the flow visually.
- Submit the draft report for review and comment to the Office of Oversight before submitting it to the appointing official for acceptance in Type A investigations.
- Submit the draft report for review and comment to the Office of Oversight prior to report publication and dissemination for Type B and delegated Type A investigations.
A Glossary

Accident: An unwanted transfer of energy or an environmental condition which, due to the absence or failure of barriers or controls, produces injury to persons, damage to property, or reduction in process output.

Accident Investigation: The systematic appraisal of unwanted events for the purpose of determining causal factors, subsequent corrective actions, and preventive measures.

Accident or Emergency Response Team: A team or teams of emergency and accident response personnel for a particular site. This team may be composed of a number of teams from the site, such as local police and firefighter units, emergency medical personnel, and hazardous material teams.

Analysis: The use of methods and techniques for arranging data to: (a) assist in determining what additional data are required; (b) establish consistency, validity, and logic; (c) establish necessary and sufficient events for causes; and (d) guide and support inferences and judgments. ¹

Analytical Tree: Graphical representation of an accident in a deductive approach (general to specific). The structure resembles a tree—that is, narrow at the top with a single event (accident) and then branching out as the tree is developed, and identifying root causes at the bottom branches.

Appointing Official: A designated authority responsible for assigning accident investigation boards for Type A and Type B investigations, with responsibilities as prescribed in DOE Order 225.1A, Paragraph 5.d.

Barrier:Anything used to control, prevent, or impede energy flows. Common types of barriers include equipment, administrative procedures and processes, supervision/management, warning devices, knowledge and skills, and physical objects.

Barrier Analysis: An analytical technique used to identify energy sources and the failed or deficient barriers and controls that contributed to an accident.

Board Chairperson: The leader who manages the accident investigation process, represents DOE in all matters regarding the accident investigation, and reports to the appointing official for purposes of the accident investigation.

Board Members: A group of three to six DOE staff assigned to investigate an accident. This group reports to the board chairperson during the accident investigation.

Causal Factor: An event or condition in the accident sequence necessary and sufficient to produce or contribute to the unwanted result. Causal factors fall into three categories:

- Direct cause
- Contributing cause
- Root cause

**Cause:** Anything that contributes to an accident or incident. In an investigation, the use of the word "cause" as a singular term should be avoided. It is preferable to use it in the plural sense, such as "causal factors," rather than identifying "the cause."

**Chain of Custody:** The process of documenting, controlling, securing, and accounting for physical possession of evidence, from initial collection through final disposition.

**Change:** Stress on a system that was previously in a state of equilibrium, or anything that disturbs the planned or normal functioning of a system.

**Change Analysis:** An analytical technique used for accident investigations, wherein accident-free reference bases are established, and changes relevant to accident causes and situations are systematically identified. In change analysis, all changes are considered, including those initially considered trivial or obscure.

**Conclusions:** Significant deductions derived from analytical results. Conclusions are derived from and must be supported by the facts, plus results from testing and analyses conducted. Conclusions are statements that answer two questions the accident investigation addresses: what happened and why did it happen? Conclusions include concise recapitulations of the causal factors (direct, contributing, and root causes) of the accident determined by analysis of facts.

**Contributing Cause:** An event or condition that collectively with other causes increases the likelihood of an accident but that individually did not cause the accident.

**Controls:** Those barriers used to control wanted energy flows, such as the insulation on an electrical cord, a stop sign, a procedure, or a safe work permit.

**Direct Cause:** The immediate events or conditions that caused the accident.

**DOE Accident Investigator:** An individual who understands DOE accident investigation techniques and has experience in conducting investigations through participation in at least one Type A or Type B investigation. Effective October 1, 1998, DOE accident investigators must have attended an accident investigation course of instruction that is based on current materials developed by the Office of Deputy Assistant Secretary for Oversight.

**DOE Operations:** Activities funded by DOE for which DOE has authority to enforce environmental protection, safety, and health protection requirements.

**DOE Site:** A tract either owned by DOE, leased, or otherwise made available to the Federal government under terms that afford DOE rights of access and control substantially equal to those it would possess if it held the fee (or pertinent interest therein) as agent of and on behalf of the government. One or more DOE operations/program activities carried out within the boundaries of the described tract.
Energy: The capacity to do work and overcome resistance. Energy exists in many forms, including acoustic, potential, electrical, kinetic, thermal, biological, chemical, and radiation (both ionizing and non-ionizing).

Energy Flow: The transfer of energy from its source to some other point. There are two types of energy flows: wanted (controlled—able to do work) and unwanted (uncontrolled—able to do harm).

Event: An occurrence; something significant and real-time that happens. An accident involves a sequence of events occurring in the course of work activity and culminating in unintentional injury or damage.

Events and Causal Factors Chart: Graphical depiction of a logical series of events and related conditions that precede the accident.

Eyewitness: A person who directly observed the accident or the conditions immediately preceding or following the accident.

Fatal Injury: Any injury that results in death within 30 calendar days of the accident.

Field Element: A general term for all DOE sites (excluding individual duty stations) located outside the Washington, D.C. metropolitan area.

General Witness: A person with knowledge about the activities prior to or immediately after the accident (the previous shift supervisor or work controller, for example).

Hazard: The potential for energy flow(s) to result in an accident or otherwise adverse consequence.

Heads of Field Elements: First-tier field managers of the operations offices, the field offices, and the power marketing administrations (Administrators).

Human Factors: The study of human interactions with products, equipment, facilities, procedures, and environments used in work and everyday living. The emphasis is on human beings and how the design of equipment influences people.

Investigation: A detailed, systematic search to uncover the "who, what, when, where, why, and how" of an occurrence and to determine what corrective actions are needed to prevent a recurrence.

Investigation Report: A clear and concise written account of the investigation results.

Judgments of Need: Managerial controls and safety measures necessary to prevent or minimize the probability or severity of a recurrence of an accident.

Lessons Learned: A "good work practice" or innovative approach that is captured and shared to promote its repeated application. A lesson learned may also be an adverse work practice or experience that is captured and shared to avoid recurrence.

Limited Scope Investigation: An accident investigation chartered by the Assistant Secretary for Environment, Safety and Health that is reduced in
scope, duration, and resources from that normally associated with a Type A or Type B investigation.

**Occurrence:** An event or condition that adversely affects or may adversely affect DOE or contractor personnel, the public, property, the environment, or DOE mission.

**Occurrence Reporting and Processing System (ORPS):** The reporting system established and maintained for reporting occurrences related to the operation of DOE facilities.

**Point of Contact:** A DOE staff member who is assigned the role of liaison with the Accident Investigation Program Manager in the Office of Security Evaluations (EH-21), who administers the accident investigation program. In this role, the point of contact ensures that site readiness teams are trained in collecting and maintaining initial accident investigation evidence and that their activities are coordinated with accident and emergency response teams.

**Principal Witness:** A person who was actually involved in the accident.

**Readiness Team:** Trained personnel who are available to perform initial investigative response activities immediately following an accident. They are responsible for initiating the accident investigation, maintaining the integrity of evidence before the accident investigation board arrives, and supporting the board after its arrival.

**Requirements Verification Analysis:** A validation technique that determines whether the logical flow of data from analysis to conclusions and judgments of need is based on facts. This technique is conducted after all the analyses are completed.

**Root Cause:** The causal factor(s) that, if corrected, would prevent recurrence of the accident.

**Root Cause Analysis:** Any methodology that identifies the causal factors that, if corrected, would prevent recurrence of the accident.

**Target:** A person, object, or animal upon which an unwanted energy flow may act to cause damage, injury, or death.

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References

a. DOE Order 225.1A, Accident Investigations.


e. DOE Policy 450.4, Safety Management System Policy, October 15, 1996.


g. DOE Policy 450.6, Secretarial Policy Statement Environment, Safety and Health, April 14, 1998.

h. General Technical Qualification Standard, Section 5.1, August 26, 1994.


C Specific Administrative Needs

Roles and Responsibilities of The Administrative Coordinator

The onsite administrative coordinator assists the board chairperson and board members in the day-to-day activities of the accident investigation. This includes serving as a central point of contact for the board, making arrangements for office facilities and equipment, managing report production, and maintaining investigation records.

Generally, the administrative coordinator (working closely with the board chairperson) is responsible for:

- Arranging for appropriate onsite office/work space and furnishings (including a large conference room that can be locked when not in use by the board, several small, hard-walled offices for conducting interviews, a central area to locate a library of documents collected, and several lockable file cabinets)
- Arranging for local court reporter(s)
- Arranging for security badges/passes for board members and property permits for personal equipment (cameras, computers, etc.)
- Arranging for specific security, access, safety, and health training, as required
- Arranging for telephone service and dedicated fax machine
- Arranging for a dedicated, high-speed copy machine that has collating and stapling capability
- Selecting a hotel and reserving a block of rooms
- Obtaining office supplies and consumables for use by board members and support staff
- Arranging for after-hours access to the site and work space
- Serving as the custodian for all keys provided by the site
- Determining site/field office contact for administrative and logistical support
- Preparing and maintaining interview schedules (if requested by board chairperson)
- Creating and maintaining onsite accident investigation files
- Maintaining chain of custody for evidence (if requested by board chairperson)
- Attending daily board meetings and taking notes to assist the chairperson
- Tracking action items and follow-up activities to completion
- Coordinating report preparation and production activities on site and at Headquarters
- Arranging for shipment of files and records to Headquarters for archiving at the end of the investigation.
Safety Management System

Board members should use the framework of DOE’s integrated safety management system, contained in DOE Policy 450.4, to determine the effectiveness of management systems, the adequacy of policy and policy implementation, and the effectiveness of line management oversight as they relate to the accident. The following two tables contain typical questions board members may ask to evaluate the core functions and guiding principles of integrated safety management.

Table D-1. These are typical questions for addressing the five core functions of integrated safety management.

<table>
<thead>
<tr>
<th>Function #1: Define the scope of work.</th>
</tr>
</thead>
<tbody>
<tr>
<td>■ Were the purpose and scope of the work to be performed clearly defined so that workers could identify any unanticipated conditions and actions that would be outside the authorized work scope?</td>
</tr>
<tr>
<td>■ Were expectations regarding the removal or control of hazards clearly defined and communicated to the workers?</td>
</tr>
<tr>
<td>■ Were the required safety support activities identified?</td>
</tr>
<tr>
<td>■ Were roles, responsibilities, and authorities for the work activity defined and executed appropriately?</td>
</tr>
<tr>
<td>■ Were the worker qualifications required to safely perform the work identified?</td>
</tr>
<tr>
<td>■ Were the design, operation, and configuration of equipment known and considered in work planning?</td>
</tr>
<tr>
<td>■ Were the characteristics of the work environment known and considered in work planning?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Function #2: Identify and analyze the hazards.</th>
</tr>
</thead>
<tbody>
<tr>
<td>■ Were the type and magnitude of all possible hazards clearly understood?</td>
</tr>
<tr>
<td>■ Was the accident potential analyzed?</td>
</tr>
<tr>
<td>■ Were the consequences of potential accidents described and understood by line management, supervisors, and workers?</td>
</tr>
<tr>
<td>■ Did the workers provide input to the hazard analysis?</td>
</tr>
<tr>
<td>■ Did the workers receive any feedback regarding their input?</td>
</tr>
<tr>
<td>■ Were the standards and requirements associated with the hazards identified?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Function #3: Develop and implement hazard controls.</th>
</tr>
</thead>
<tbody>
<tr>
<td>■ Were required physical and engineering hazard controls evaluated for likely effectiveness under the expected work conditions?</td>
</tr>
<tr>
<td>■ Were the required administrative controls, such as technical procedures and safety support personnel, in place?</td>
</tr>
<tr>
<td>■ Were the workers qualified and given hazard- or activity-specific training?</td>
</tr>
<tr>
<td>■ Was a proper review, approval, and configuration control process in place?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Function #4: Perform work within controls.</th>
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<tbody>
<tr>
<td>■ Was the readiness to perform the work checked and confirmed prior to starting work?</td>
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<tr>
<td>■ Was appropriate authorization received to start work?</td>
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<td>■ Was the work performed as planned (i.e., by the intended workers using the pre-approved procedures with the required level of supervision and safety support present with effective hazard controls in place)?</td>
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<tr>
<td>■ Were the workers empowered to stop work if unanticipated or unsafe conditions arose?</td>
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<th>Function #5: Provide feedback and continuous improvement.</th>
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Table D-2. These are typical questions for addressing the seven guiding principles of integrated safety management.

**Guiding Principle #1: Line management is directly responsible for the protection of the public, workers, and the environment.**

- Did DOE assure and contractor line management establish documented safety policies and goals?
- Was ISM fully implemented down to the activity level at the time of the accident?
- Was DOE line management proactive in assuring timely implementation of ISM by line organizations, contractors, subcontractors, and workers?
- Were ES&H performance expectations for DOE and contractor organizations clearly communicated and understood?
- Did line managers elicit and empower active participation by workers in safety management?

**Guiding Principle #2: Clear lines of authority and responsibility for ensuring safety shall be established and maintained at all organizational levels within the Department and its contractors.**

- Did line management define and maintain clearly delineated roles and responsibilities for ES&H to effectively integrate safety into sitewide operations?
- Was a process established to ensure that safety responsibilities were assigned to each person (employees, subcontractors, temporary employees, visiting researchers, vendor representatives, lessees, etc.) performing work?
- Did line management establish communication systems to inform the organization, other facilities, and the public of potential ES&H impacts of specific work processes?
- Were managers and workers at all levels aware of their specific responsibilities and accountability for ensuring safe facility operations and work practices?
- Were individuals held accountable for safety performance through performance objectives, appraisal systems, and visible and meaningful consequences?
- Did DOE line management and oversight hold contractors and subcontractors accountable for ES&H through appropriate contractual and appraisal mechanisms?

**Guiding Principle #3: Personnel shall possess the experience, knowledge, skills, and abilities that are necessary to discharge their responsibilities.**

- Did line managers demonstrate a high degree of technical competence and a good understanding of programs and facilities?
- Did line management have a documented process for assuring that DOE personnel, contractors, and subcontractors are adequately trained and qualified on job tasks, hazards, risks, and Departmental and contractor policies and requirements?
- Were mechanisms in place to assure that only qualified and competent personnel were assigned to specific work activities, commensurate with the associated hazards?
- Were mechanisms in place to assure understanding, awareness, and competence in response to significant changes in procedures, hazards, system design, facility mission, or life cycle status?
- Did line management establish and implement processes to ensure that ES&H training programs effectively measure and improve performance and identify training needs?
- Was a process established to ensure that (1) training program elements are kept current and relevant to program needs, and (2) job proficiency is maintained?
Guiding Principle #4: Resources shall be effectively allocated to address safety, programmatic, and operational considerations. Protecting the public, the workers, and the environment shall be a priority whenever activities are planned and performed.

- Did line management demonstrate a commitment to ensuring that ES&H programs had sufficient resources and priority within the line organization?
- Did line management clearly establish that integrated safety management will be applied to all types of work and address all types of hazards?
- Did line management institute a safety management system that provided for integration of ES&H management processes, procedures, and/or programs into site, facility, and work activities in accordance with the Department of Energy Acquisition Regulation (DEAR) ES&H clause (48 CFR 970.5204-2)?
- Were prioritization processes effective in balancing and reasonably limiting the negative impact of resource reductions and unanticipated events on ES&H funding?

Guiding Principle #5: Before work is performed, the associated hazards shall be evaluated and an agreed-upon set of safety standards shall be established that, if properly implemented, will provide adequate assurance that the public, the workers, and the environment are protected from adverse consequences.

- Was there a process for managing requirements, including the translation of standards and requirements into policies, programs, and procedures, and the development of processes to tailor requirements to specific work activities?
- Were requirements established commensurate with the hazards, vulnerabilities, and risks encountered in the current life cycle stage of the site and/or facility?
- Were policies and procedures, consistent with current DOE policy, formally established and approved by appropriate authorities?
- Did communication systems assure that managers and staff were cognizant of all standards and requirements applicable to their positions, work, and associated hazards?

Guiding Principle #6: Administrative and engineering controls to prevent and mitigate hazards shall be tailored to the work performed and associated hazards.

- Were the hazards associated with the work activity identified, analyzed, and categorized so that appropriate administrative and engineering controls could be put in place to prevent or mitigate the hazards?
- Were hazard controls established for all stages of work to be performed (e.g., normal operations, surveillance, maintenance, facility modifications, decontamination, and decommissioning)?
- Were hazard controls established that were adequately protective and tailored to the type and magnitude of the work and hazards and related factors that impact the work environment?
- Were processes established for ensuring that DOE contractors and subcontractors test, implement, manage, maintain, and revise controls as circumstances change?
- Were personnel qualified and knowledgeable of their responsibilities as they relate to work controls and work performance for each activity?

Guiding Principle #7: The conditions and requirements to be satisfied for operations to be initiated and conducted shall be clearly established and agreed upon.

- Were processes in place to assure the availability of safety systems and equipment necessary to respond to hazards, vulnerabilities, and risks present in the work environment?
- Did DOE and contractor line management establish and agree upon conditions and requirements that must be satisfied for operations to be initiated?
- Was a management process established to confirm that the scope and authorization documentation is adequately defined and directly corresponds to the scope and complexity of the operations being authorized?
- Was a change control process established to assess, approve, and reauthorize any changes to operations scope ongoing at the time of the accident?
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