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ACCIDENT & OPERATIONAL SAFETY ANALYSIS - VOL 2 OF 2 - ACCIDENT INVESTIGATIONS

Main Category:	Project Management
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Course Content:	118 pgs
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OFFICIAL COURSE/EXAM

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PRJ-125 EXAM PREVIEW

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Exam Preview:

1. The Freedom of Information Act (FOIA) and Privacy Act may apply to information generated or obtained during an investigation. These two laws dictate access to and release of government records.
   a. True
   b. False
2. According to the reference material, the appointing official is responsible for briefing all Board members as soon as possible (within ____ days) after their appointment to ensure that they clearly understand their roles and responsibilities.
   a. 3
   b. 5
   c. 7
   d. 14
3. According to the reference material, contributing causes are the causal factors that, if corrected, would prevent recurrence of the same or similar accidents.
   a. True
   b. False
4. Using Figure 2-1: Typical Schedule of Accident Investigation, at what point in the timeline of an accident investigations is the initial analysis completed, and report preparations beginning?
   a. 7
   b. 14
   c. 21
   d. 30

5. 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. Which of the following stages matches the description: The team settles into clear roles, understands the strengths of different members, and begins to work together effectively?
    a. Forming
    b. Storming
    c. Norming
    d. Performing
6. According to the reference material, for Federal investigations, these materials are to be held in storage by the Appointing Official's Program Manager as "permanent" records (__ years) in accordance with DOE O 225.1B.
    a. 50
    b. 75
    c. 100
    d. 25
7. Upon notification of an accident requiring a DOE Federal investigation, the Appointing Official selects the AIB Chairperson. The Appointing Official, with the assistance of the Board Chairperson, selects 5 to 10 other Board members, one of whom must be a trained DOE accident investigator.
    a. True
    b. False
8. Using Table 2-11: Common Human Error Precursor Matrix, which of the following tasks demands (TD) is described by: Inadequate level of mental activity resulting from performance of repeated actions; boring Insufficient information exchange at the job site?
    a. Repetitive actions/Monotony
    b. Interpretation requirements
    c. High workload
    d. Simultaneous, multiple tasks
9. Any non-record materials, such as extraneous information deemed not pertinent to the investigation, or multiple reference copies, or extra drafts & incomplete notes, should be controlled until destroyed.
    a. True
    b. False
10. According to the reference material, lessons learned from the accident investigation are developed and disseminated within __ calendar days of acceptance of the investigation report by the Appointing Official.
    a. 180
    b. 120
    c. 90
    d. 45

ACCIDENT & OPERATIONAL SAFETY ANALYSIS
PART 2: ACCIDENT INVESTIGATIONS

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CHAPTER 2. THE ACCIDENT INVESTIGATION PROCESS

2. THE ACCIDENT INVESTIGATION PROCESS

2.1 Establishing the Federally Led Accident Investigation Board and Its Authority

2.1.1 Accident Investigations' Appointing Official

Section 2.1 primarily deals with the DOE Federal responsibilities under DOE O 225.1B. Upon notification of an accident requiring a DOE Federal investigation, the Appointing Official selects the AIB Chairperson. The Appointing Official, with the assistance of the Board Chairperson, selects three to six other Board members, one of whom must be a trained DOE accident investigator. All of the AIB members are DOE federal employees. To minimize conflicts of interest influences, the Chairperson and the accident investigator must be from a different duty station than the accident location. The Appointing Official for a Federal accident investigation is the Head of Program Element, unless this responsibility is delegated to the Chief Health, Safety and Security Officer (HS-1). The roles and responsibilities of the Appointing Official for Accident Investigations, the Heads of Program Elements for Accident Investigations, and the Heads of Field Elements for establishing and supporting AIBs are defined in the Table 2-1.

Table 2-1: DOE Federal Officials and Board Member Responsibilities

Participants	Major Responsibilities
Appointing Official for Accident Investigations	• Formally appoints the Accident Investigation Board in writing within three days of accident categorization • Establishes the scope of the Board's authority, including the review of management systems, policy, and line management oversight processes as possible causal factors • Briefs Board members within three days of their appointment • Ensures that notification is made to other agencies, if required by memoranda of understanding, law, or regulation • 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 • Accepts the investigation report and the Board's findings • Publishes and distributes the respective investigation report within seven calendar days of report acceptance • Develops lessons learned for dissemination throughout the Department or the organization for or the OSRs • Closes the investigation after the actions in DOE O 225.1B, Paragraph 4d, are completed

Participants	Major Responsibilities
Heads of Program Elements for Accident Investigations	• Serves as Appointing Official for Federal accident investigations for programs, offices and facilities under their authority. • Maintain a staff of trained and qualified personnel to serve in the capacity of Chairperson and DOE Accident Investigators for AIBs and, upon request, provide them to support other AIBs. • Ensure that DOE and contractor organizations are prepared to effectively accomplish initial investigative actions and assist Accident Investigation Boards • Categorize the accident investigation in accordance with the criteria provided in Attachment 2 of DOE O 225.1B • Report accident categorization and initial actions taken by DOE site teams to the Office of Corporate Safety Programs (HS-23) • Serve as the appointing official for Federal accident investigations • Ensure that readiness teams and emergency management personnel coordinate their activities to facilitate an orderly transition of responsibilities for the accident scene • Develop lessons learned for Federal accident investigation • Require submittal of corrective action plans to address the Judgments of Need, approve the implementation of those plans, and track the effective implementation of those plans to closure. • Distribute accident investigation reports to all Heads of Field Elements under their cognizance and direct that extent-of-condition reviews be conducted for issues identified during accident investigations that are applicable to work locations and operations.

Participants	Major Responsibilities
Heads of Field Elements for Accident Investigations	• Maintain a state of readiness to conduct investigations throughout the field element, their operational facilities, and the DOE site teams • Ensure that sufficient numbers of site DOE and contractor staff understand and are trained to conduct or support investigations • Procure appropriate equipment to support investigations • Maintain a current site list of DOE and contractor staff trained in conducting or supporting investigations • Assist in coordinating investigation activities with accident mitigation measures taken by emergency response personnel • Communicate and transfer information on accidents to the head of the Headquarters program elements to whom they report • Communicate and transfer information to the Accident Investigation Board Chairperson before and after his/her arrival on site • Coordinate corrective action planning and follow-up with the head of the Headquarters program element and coordinate comment resolution by reviewing parties • Facilitate distribution of lessons learned identified from accident investigations • Serve as liaison to the HSS AI Program Manager on accident investigation matters • Develop or provide assistance in developing lessons learned for accident investigations. • Require the submittal of contractor corrective action plans to address the Judgments of Need, approve the implementation of those plans, and track the effective implementation of those plans to closure • Conduct extent-of-condition reviews for specific issues resulting from accident investigations that might be applicable to work locations or activities under the Heads of Field Elements' authority, and address applicable lessons learned from investigations conducted at other DOE sites

2.1.2 Appointing the Accident Investigation Board

A list of prospective Chairpersons who meet minimum qualifications is available from the HSS AI Program Manager and 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 Appointing Official, with the help of the HSS AI Program Manager, and the selected AIB Chairperson, assess the potential scope of the investigation and identify other board members needed to conduct the investigation. In selecting these individuals, the chairperson and appointing official follow the criteria defined in DOE O 225.1B, which are shown in Table 2-2.

Table 2-2: DOE Federal Board Members Must Meet These Criteria

Role	Qualifications
Chairperson	• Senior DOE manager • Preferably a member of the Senior Executive Service or at a senior general service grade level deemed appropriate by the appointing official • Demonstrated managerial competence • Knowledgeable of DOE accident investigation techniques • Experienced in conducting accident investigations through participation in at least one Federal investigation, or equivalent experience
Board Members	• DOE Federal employee • Subject matter expertise in areas related to the accident, including knowledge of the Department's safety management system policy and integrated safety management system • Either the Chairperson or, at least one Board member, must be a DOE accident investigator, who has participated in an accident investigation course sponsored by the Office of Corporate Safety Programs
Board Advisor/Consultant	• Knowledgeable in evaluating management systems, the adequacy of policy and its implementation, and the execution of line management oversight • Industry working knowledge in the analytical techniques used to determine accident causal factors

DOE O 225.1B establishes some additional restrictions concerning the selection of Board members and Chairpersons. Members are not permitted to 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 oversight of the facility, area, or activity involved in the accident.
- Both the Chairperson and the DOE Accident Investigator must be selected from a different duty station than the accident location.

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 appoints the Accident Investigation Board within three calendar days after the accident is categorized by issuing an appointment memorandum. The appointment memorandum establishes the Board's authority and releases all members of the AIB from their normal responsibilities/duties for the period of time the Board is convened. The appointment memorandum also 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 appointment memorandum should specify the scope of the investigation which includes:

- Gathering facts;
- Analyzing causes;
- Developing conclusions and,
- Developing Judgments of Need related to DOE and contractor organizations and management systems that could or should have prevented the accident.
- A *Sample Appointment Memorandum* may be found in Appendix D.

2.1.3 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 potential 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 P 450.4A;
- Pertinent accident information and special concerns of the appointing official based on site accident patterns or other considerations.

2.2 Organizing 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 time frame required, the AIB 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 and organizing the investigation.

2.2.1 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.

A tool for the Chairperson, the *Accident Investigation Startup Activities List*, is included in Appendix D. The Chairperson and administrative coordinator can use this list to organize the initial investigative activities.

2.2.2 Collecting Initial Site Information

Following appointment, the Chairperson is responsible for contacting the site/sponsoring organization to obtain as many details on the accident as possible. The sponsoring organization, which could include a DOE field program office, and/or contractor division point-of-contact, 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, sitemaps, and organization charts. The Accident Investigation *Information Request Form* (provided in Appendix D) can be used to document and track these and other information requests throughout the investigation.

2.2.3 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 (CON) and JONs, and report writing. Assigning designated Board members specific responsibilities ensures consistency during the investigation.

2.2.4 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 2-3 shows a list of typical activities to schedule.

Table 2-3: These Activities should be Included in an Accident Investigation Schedule

Interviews/Evidence Collection and Preliminary Analysis
Obtain needed site and/or facility/project background information, policies, procedures, and training records
Assign investigation tasks and writing responsibilities
Initiate and complete first draft of accident chronology and facts
Select analytical methods (preliminary)
Complete interviews
Complete first analyses of facts using selected analytical tools; determine whether additional tools are necessary
Obtain necessary photographs and complete illustrations for report
Internal Review Drafts
Complete first draft of report elements, up to and including facts and analysis section
Complete development and draft of direct, contributing, and root causes
Complete development and draft of Judgments of Need
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 for Quality Assurance review by HSS Office Corporate Safety Programs prior to submission to the Appointing Official
Complete final draft of report
Prepare out-brief materials
Brief relevant site/division and/or field office managers (depending on type of investigation) 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 2-1. The *Accident Investigation Day Planner: a Guide for Accident Investigation Board Chairpersons*, available on the AI Program website, can assist in the development of this schedule. Activities cover nominally 30 days.

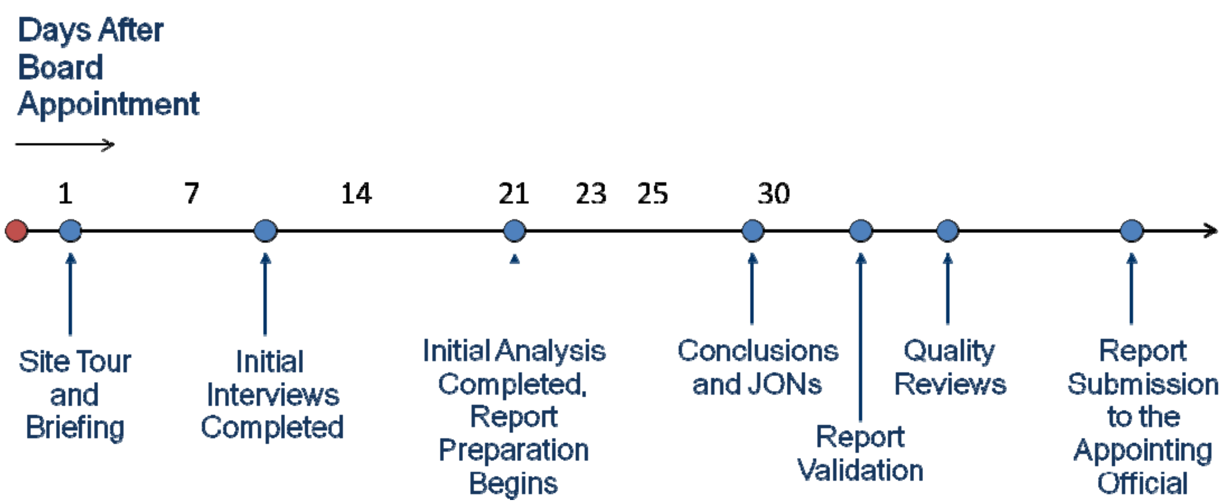


Figure 2-1: Typical Schedule of Accident Investigation

2.2.5 Acquiring Resources

From the first day, the Chairperson begins acquiring resources for the investigation. This includes securing office space, a conference room or "command center", office supplies, and computers through the Field Office Manager (FOM), a secured area for document storage, tools, and personal protective equipment, if necessary. The site's FOM should provide many of these resources. The *Accident Investigation Equipment Checklist* (see Appendix D) is designed to help identify resource needs and track resource status.

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 Appointing Official.

2.2.6 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 *Accident Investigation Individual Conflict of Interest Certification Form* (provided in Appendix D). If the Chairperson or any individual has concern about the potential for or appearance of conflicts of interest, the Chairperson should inform the Appointing Official 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 to the Appointing Official. If the Chairperson relies on the advice of legal counsel, the Chairperson shall seek appropriate legal counsel concurrence through the Appointing Official. The memorandum will become part of the Board's permanent record.

2.2.7 Establishing Information Access and Release Protocols

The Chairperson is responsible for establishing protocols relating to information access and release. These protocols are listed in Table 2-4. 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 may apply to information generated or obtained during an investigation. These two laws dictate access to and release of government records. The Chairperson should obtain guidance from a legal advisor or the FOIA/Privacy Act contact person at the site, field office, or Headquarters regarding question of disclosure, or the applicability of the FOIA or Privacy Act. The 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.

The Board must ensure that the information it generates is accurate, relevant, complete, and up-to-date. For this reason, court reporters may be used in more serious investigations 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, when the Privacy Act is applicable, 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 not 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 *Model Interview Opening Statement* that addresses the provisions of both the FOIA and the Privacy Act and their pertinence to interviews for DOE accident investigations is provided in Appendix D. This statement should be read at the beginning of all applicable interviews. A brief explanatory *Reference Copy of 18USC Sec. 1001 for Information* is provided to the interviewer in Appendix D, in the event questions are raised by the opening statement.

2.2.8 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.

Table 2-4: The Chairperson Establishes Protocols for Controlling Information

Protocol	Considerations
Information Security	Keep all investigative evidence and documents locked in a secure area accessible only to Board members, advisors, and support staff.
Press Releases (if appropriate)	• Board Chairpersons should coordinate with the official authorizing the investigation or their normal chain of command for authority/guidance on Press Releases. • Determine whether there is a designated contact to handle press releases; if so, work with that person. • The Board is not obligated to release any information. However, previous chairpersons have found that issuing an early press release can be helpful. • The initial press release usually contains a general description of the accident and the purpose of the investigation. • The Board chairperson should review and approve all press releases (in addition to whatever review process at the parent organization).

Protocol	Considerations
Lines of Communication	• Establish liaison with field element management and/or with the operating contractor at the site, facility, or area involved in the accident to set up clear lines of communication and responsibility.
Format of Information Releases	• Determine the amount and format of information to be released to the site contractor(s), union advisor, and local DOE office for internal purposes. • Never release verbatim interview transcripts or tapes due to the sensitivity of raw information. • 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. • Consult with the appointing official before releasing any information.
Approvals for Information Releases	• 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.

2.3 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.

2.3.1 Taking Control of the Accident Scene

Before arriving at the site, the Chairperson communicates with the point of contact or the appropriate DOE site 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 DOE site 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.

2.3.2 Initial Meeting of the Accident 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 time frame to conduct the investigation (if applicable);
  - The schedule and plan for completing the investigation; and
  - The need to apply the components of DOE's integrated safety management system during the investigation as the means of evaluating management systems.
- 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; and
- 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 Chairpersons should distribute copies of local phone directories and a list of phone and fax numbers pertinent for the investigation. 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; and

- Accessing the Board's work area after hours.

2.3.3 Promoting Teamwork

The Board must work together as a team to finish the investigation within the time frame 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.

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.

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.
- Consider all ideas and arguments.
- Encourage diverse ideas and opinions.
- Suggest ideas, approaches, and compromises.
- Help keep discussions on track when they start to wander.

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.

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.

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.

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.

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.

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.

2.3.4 Managing Evidence, Information Collection

Upon arrival at the accident site, the Board begins to collect evidence and facts and to conduct interviews. Table 2-5 provides guidelines to assist the Chairperson in monitoring this process.

The Chairperson is responsible for:

- 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 Office of Enforcement, the DOE Site Manager, and the contractor of any potential Price-Anderson enforcement concerns identified during the investigation as soon as practical (Table 2-5 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 Office of Corporate Safety Programs under DOE O 225.1B, Paragraph 4.b.).

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

2.3.5 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), relevant DOE Headquarters/DOE field office 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; and
  - 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 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.
- Providing daily status updates to the Appointing Official.
- Coordinating external communications with the public and media through the field office public relations/media representative to ensure that the Department's interests are not compromised.

Table 2-5: The Chairperson Should Use These Guidelines in Managing Information Collection Activities.

- Review and organize witness statements, facts, and background information provided by the DOE site team or other sources and distribute these to the Board.
- Organize a Board walk-through 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.
- Assign an administrative coordinator to oversee the organization, filing, and security of collected facts and evidence.
- 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.
- 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 in Appendix D of the 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.

2.3.6 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. The responsibility to conduct the analysis is that of the trained DOE Accident Investigator or Analyst.

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.
- Analyses are iterative (i.e., analyses are repeated, each version producing results that approximate 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." Instead, they are linked to causal factors and Judgments of Need.

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.

2.3.7 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; and
- 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) may opt to produce a minority report.

2.3.8 Managing Onsite Closeout Activities

2.3.8.1 Preparing Closeout Briefings

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 conducting the final accuracy review, final editing, production of the report, with assistance from selected Board members and administrative support staff.

A briefing on the investigation's outcome to the Appointing Official and field line management with cognizance over the site of the accident should be conducted. 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.

2.3.8.2 Preparing Investigation Records for Permanent Retention

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:

- **Preparing investigation documents and evidence for long-term storage**: One of the final activities of the Board is to prepare investigation documents and evidence for long-term storage. For Federal investigations, these materials are to be held in storage by the Appointing Official's Program Manager as "permanent" records (75 years) in accordance with DOE O 225.1B. It is recommended that access restriction limitation be designated as "Agency Personnel."

- **All factual material and analysis products are included**, such as logbooks, Board meeting minutes, field notes, sketches, witness statements (including interview tapes or electronic record files, if used), stenographer transcripts, photographs, location and custody of any physical evidence, analysis charts, and the various forms completed during the investigation. Original medical or personnel records subject to the Privacy Act may be returned to their original location.

- Documentation showing that the report was subjected to reviews for classified and Privacy Act information shall be retained in the investigation file.

- If the appointment of an AIB is delayed beyond three calendar days from the time of the categorization of the accident, the rationale for the delay must be documented and maintained in the accident investigation file.

- **Computers used during the accident investigation** that are not to remain in control of the accident board should have all useful records transferred to a storage medium or another computer in the Board's control. All accident investigation or analysis files on the relinquished computers should be purged prior to release from the investigation team. Electronic records should be purged or archived according to DOE CIO procedures.

- If the Heads of the Headquarters Elements delegates the responsibility for an accident investigation to the Heads of a Field Element, or to HSS, a copy of the memorandum of delegation shall be maintained in the accident investigation file.

- **The administrative coordinator arranges for boxing** and for shipping materials to the storage facility identified by Appointing Official's Program Manager during the onsite phase of the investigation. A well maintained AI record system should already be logged, filed, and boxed throughout the investigation for quick close out packaging and transfer. All permanent records should have been screened for classification and stamped accordingly.

- **Destroying non-record materials**: Any non-record materials, such as extraneous information deemed not pertinent to the investigation, or multiple reference copies, or extra drafts & incomplete notes, should be controlled until destroyed. Shredder machines or services should be arranged for throughout the investigation to reduce close out shredding time.

- **Archiving materials**: One of the final activities of the Appointing Official's Program Manager, when immediate reference access is no longer deemed likely after the Post-Investigation Activities, is to arrange for placing investigation permanent records boxes in an archive repository in accordance with 36 CFR 1225.14.

2.3.9 Managing Post-Investigation Activities

The Appointing Official is also responsible for ensuring that there is post-investigation follow through in the form of corrective actions being defined and tracked and lesson learned being documented. These responsibilities are explained below.

2.3.9.1 Corrective Action Plans

The final report is submitted by the Appointing Official to senior managers of organizations identified in the Judgments of Need in the report, with a request for the organizations to prepare corrective action plans. These plans contain actions for addressing Judgments of Need identified in the report and include milestones for completing the actions.

Corrective actions fall into four categories:

- Immediate corrective actions that are taken by the organization managing the site where the accident occurred to prevent a second or related accident.
- Corrective actions required to satisfy Judgments of Need identified by the Board in the final report. These corrective actions are developed by the Heads of Field Elements and/or contractors responsible for the activities resulting in the accident and are designed to prevent recurrence and correct system problems.
- Corrective actions determined by the Appointing Official to be appropriate for DOE-wide application. The Appointing Official recommends these corrective actions when the report is distributed.
- DOE Headquarters corrective actions that result from discussions with senior management. These actions usually address DOE policy.

2.3.9.2 Tracking and Verifying Corrective Actions

Corrective action plans are submitted to the Head of the Program Element which reviews the plans and provides comments.

This review is done to determine the:

- Adequacy of proposed corrective actions in meeting the deficiencies stated in the Judgments of Need.
- Feasibility of the proposed corrective actions.
- Timeliness of the proposed corrective actions.
- Necessity for any interim actions to prevent further accidents, pending permanent.
- Corrective actions.

The Heads of Field Elements whose site, facility, operation, or area was involved in the accident have responsibility for accepting, entering the corrective actions into the appropriate database established by the Head of the Program Element and implementing applicable corrective actions.

However, other DOE/National Nuclear Safety Administration (NNSA) Field Elements may have responsibility for completing actions resulting from the investigation. In these cases, the organization(s) indicated in the corrective action plan as having responsibility for implementation is (are) accountable for completing the requisite actions.

The Heads of Headquarters Elements verifies completion of approved corrective actions and satisfaction of Judgments of Need.

When corrective action plans are completed and corrective actions have been implemented, those Headquarters and field elements having responsibilities for corrective actions notify the Appointing Official, who closes the investigation. Copies of the notification to and closure by the Appointing Official are sent to the Program Manager.

2.3.9.3 Establishing Lessons Learned

Introduction. The purpose of conducting accident investigations is to determine the system deficiencies that allowed the accident to occur so that those deficiencies can be corrected and similar accidents can be prevented. Summaries of deficiencies and the recommended corrective actions are identified as "lessons learned.” In the interest of preventing recurrence of accidents, lessons learned are disseminated DOE-wide to ensure that the results of investigations have the greatest effect for continuous improvement in environment, safety, and health performance.

Responsibilities. The responsibility for developing and disseminating lessons learned arising from accident investigations resides with the Appointing Official as defined in DOE O 225.1B. For accident investigations, the Appointing Official is the Heads of Headquarters Elements. In the event that the responsibility for appointing an AIB is delegated to the Heads of Field Elements, the responsibility for developing and disseminating lessons learned from the accident investigation remains with the Heads of Headquarters Elements Quality Assurance Program.

Developing Lessons Learned. Lessons learned from accident investigations are developed in accordance with DOE O 210.2A, DOE Corporate Operating Experience Program and/or other provisions that govern the DOE Lessons Learned Program. For accident investigations, the Head of the DOE/NNSA Program Element is responsible for to develop and disseminate the lessons learned.

Disseminating Lessons Learned. Lessons learned from the accident investigation are developed and disseminated within 90 calendar days of acceptance of the investigation report by the Appointing Official. Methods for disseminating lessons learned include; hard copy, electronic, and other methods for use both intra-site and across the DOE complex, such as reports, workshops, and newsletters. The DOE Lessons Learned Information System provides for electronic dissemination of lessons-learned information throughout the DOE complex.

2.4 Controlling the Investigation

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.

2.4.1 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.

2.4.2 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 operating within any budget prescribed for the investigation. The Chairperson should prepare a cost estimate for the activities to be conducted during the investigation if needed. 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. 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 scheduled 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 time frame involved, the Chairperson must identify and resolve problems immediately to maintain the schedule, or re-evaluate it with the appointing official as circumstances require.

2.4.3 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. 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 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 2.8 provides further detail on assuring report quality.

Prior to submission of the report to the Appointing Official, the Board Chair, under DOE O 225.1B, needs to submit the report for a quality review to the HSS AI Program Manager.

2.5 Investigate the Accident to Determine "What" Happened

2.5.1 Determining Facts

Immediately following any 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 AI 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 or event.
- Personally conducting a walk-through of the accident scene or, work location.
- Testing or inspecting pertinent components to determine failure modes and physical evidence.
- Obtaining testamentary evidence, and corroborating facts through interviews.
- Challenging "facts" that are inconsistent with other evidence (e.g., physical).

- Reviewing policies, procedures, and work records to determine the level of compliance or implementation.

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 walk-through, 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 is 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 after 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. Analyze Accident to Determine "Why" it happened.

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); and
- Documentary evidence includes paper and electronic information, such as records, reports, procedures, and documentation. A *Checklist of Documentary Evidence* is found in Appendix D.

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.

The process of pursuing evidentiary material involves:

- Collecting human evidence (locating and interviewing witnesses);
- Collecting physical evidence (identifying, documenting, inspecting, and preserving relevant matter);
- Collecting documentary evidence;
- Examining organizational concerns, management systems, and line management oversight; and
- Preserving and controlling evidence. (Examples of *Physical Evidence Log Form* and *Evidence Sign-out Sheet* are included in Appendix D.)

2.5.2 Collect and Catalog Physical Evidence

To ensure consistent documentation, control, and security, it may be useful to designate a single team 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 DOE site team, the team 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
- Operation 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 team to collect and to analyze fluid evidence. If required, expert analysts can be requested to perform tests on the fluids and report results to the investigation team.

When handling potential blood-borne pathogens, universal precautions such as those listed in Table 2-6 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 2-6 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.

In addition to pathogens, any evidence may create a hazard for persons handling it, in ways too numerous to expand upon here. This aspect of any evidence should be considered and addressed before handling it.

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.

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

Table 2-6: Use Precautions when Handling Potential Blood Borne Pathogens

• Personal protective equipment should be worn when exposure to blood borne pathogens is likely.
• Hands and other skin should be washed with soap and water immediately or as soon as feasible after removal of gloves or other personal protective equipment.
• Hand washing facilities should be provided that are readily accessible to employees.
• When provision of hand washing facilities is not feasible, appropriate 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.
• Mucous membranes should be flushed with water immediately or as soon as feasible following contact with blood or other potentially infectious materials.
• Contaminated needles and other contaminated sharps shall not be bent, recapped, or removed except by approved techniques.
• Immediately or as soon as possible after use, contaminated reusable sharps shall be placed in appropriate containers until properly reprocessed.
• Eating, drinking, smoking, applying cosmetics or lip balm, and handling contact lenses are prohibited in work areas where there is a reasonable likelihood of occupational exposure.
• Food and drink shall not be kept in refrigerators, freezers, shelves, cabinets, or on countertops or bench tops where blood or other potentially infectious materials are present.
• All procedures involving blood or other potentially infectious materials shall be performed in such a manner as to minimize splashing, spraying, spattering, and generation of droplets of these substances.
• Mouth pipetting or suctioning of blood or other potentially infectious materials is prohibited.
• Specimens of blood or other potentially infectious materials shall be placed in a container to prevent leakage during collection, handling, processing, storage, transport, or shipping.
• Equipment, which may become contaminated with blood or other potentially infectious materials, shall be examined prior to servicing or shipping and shall be decontaminated as necessary.

2.5.2.1 Document Physical Evidence

Evidence should be carefully documented at the time it is obtained or identified. The *Physical Evidence Log Form* (provided in Appendix D) can help investigators document and track the collection of physical evidence. Additional means of documenting physical evidence include sketches, maps, photographs, corporate files, and video files.

2.5.2.2 Sketch and Map Physical Evidence

Sketching and mapping the position of debris, equipment, tools, and injured persons may be initiated by the DOE site 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 plotting of the position of elements can subsequently be examined to develop and test accident causal theories.

Computer programs or the *Site Sketch*, *Position Mapping Form*, and *Sketch of Physical Evidence Locations and Orientations* (provided in Appendix D) are useful for drawing sketches and maps and recording positions of objects.

2.5.2.3 Photograph and Video 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 investigation. Photos or videos can identify, record, or preserve physical 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. Video should cover the overall accident scene, as well as specific locations or items of significance. A thorough video 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 *Photographic Log Sheet* (provided in Appendix D) can be used to record photograph or video 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 video recording 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 team lead should be to acquire a technical photographer whose work will assist the team.

Five possible sources include:

- DOE site's photo lab, or digital print processor center,
- Commercial photo, or digital print processor center,
- Commercial photographers; industrial, medical, aerial, legal, portrait, and scientific photographers (often the best to assist in accident investigation are forensic/legal, or scientific photographers),

- A member of the investigation team, or
- Security personnel.

Even if photos are taken by a skilled photographer, the investigation team 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, team members may wish to take photos for their own reference. Digital photography facilitates incorporation of the photographs into the investigation 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 *Photographic Log Sheet* can be used for this purpose. The *Sketch of Photography Locations and Orientations* (provided in Appendix D) is helpful when reviewing photos and analyzing information.

2.5.2.4 Inspect 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 voice recorder useful in recording general descriptions of appearance and damage. However, the potential failure of a recorder, inadvertent file erasure, and limitations of verbal description suggest that verbal recorded descriptions should be used in combination with notes, sketches, and photographs.

2.5.2.5 Remove 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 video) 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 team lead and investigators should concur when the parts extraction work can begin, in order to assure that team members have completed all observations requiring an intact accident site.

2.5.3 Collect and Catalog Documentary Evidence

Documentary evidence can provide important data (i.e., proof of "work-as-done") and should be preserved and secured as methodically as physical evidence. This information might be in the form of documents, photos, video, or other electronic media, either at the site or in files at other locations (this information should not be confused with procedures and such).

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

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 incident, they are often overlooked in the preliminary collection of evidence.

Documents often provide important evidence of "work-as-done" for identifying causal factors of an event. This evidence is useful for:

- Indicating the attitudes and actions of people involved in the accident; and
- Revealing evidence that generally is not established in verbal testimony.

Documentary evidence to determine "work-as-done" generally can be grouped into three categories:

- Records that indicate past and present performance and status of the work activities, as well as the people, equipment, and materials involved (examples include log books, security access logs, calls to the operations center, etc);
- Reports that identify the content and results of special studies, analyses, audits, appraisals, inspections, inquiries, and investigations related to work activities (examples include occurrence reports, metrics, management and self assessments, etc.);
- Follow-on documentation that describes actions taken in response to the other types of documentation (examples include corrective action tracking results, lessons learned, etc.).

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

2.5.4 Electronic Files to Organize Evidence and Facilitate the Investigation

To organize the documentary evidence collected and to make it readily accessible to the investigation team, it is strongly recommended that electronic files be set up and populated as evidence becomes available. Examples of evidence to be collected could consist of:

- Work orders, logbooks, training records (certifications/qualifications), forms, time sheets
- Problem evaluation reports
- Occurrence reports
- Nonconformance reports
- Closeout of Corrective Actions from similar events

- Process metrics
- Previous lessons learned
- External reviews or assessments
- Internal assessments (management and self assessments)

The team's lead or the person in charge of collecting the data should organize all information in shared electronic files in pre-established folders as shown in Figure 2-2.

Investigation Electronic File Structure

Assessments
Timeline
DOE's Operational Experience – Lessons Learned
Report – Draft & Final
Extraneous Conditions Adverse to Quality ORPS Reports
Performance Evaluation Requests – Action Tracking
Photographs
Procedures
Statements and Interviews
Training – Qualification
Barrier Analysis
Human Performance Error Precursors
Missed Opportunities
Causal Factors Charts
Extent of Conditions and Causes
JON – Corrective Actions
Lessons to be Learned
Evidence Files (log books, training, etc.)
Tasking Letter
Deep Organizational Issues (culture, etc.)
Housekeeping file for team members

This file structure has been pre-established and populated with the applicable forms and matrices to facilitate data collection and compilation.

The applicable evidence should be collected and placed into the appropriate folder so the entire team has access to all information electronically.

Upon conclusion of the investigation, the electronic file will become part of the investigation record.

Additional folders can be added to adapt to the team and the investigation.

Figure 2-2: Example of Electronic File Records To Keep for the Investigation

2.5.5 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 additional lines of questioning and the need for follow up interviews with persons previously not interviewed.

2.5.6 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 DOE site 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 2-7 lists sources that investigators can use to locate witnesses.

Table 2-7: These Sources are Useful for Locating Witnesses

Site 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).
Staff in nearby facilities (those who may have initially responded to the accident scene; staff at local medical facilities).
News media may have access to witness information and photographs or videos of the post-accident scene.
Maintenance and security personnel may have passed through the facility soon before or just after the accident.

2.5.7 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. Witnesses must be afforded the opportunity to have organized labor or legal representation with them, if they wish.

2.5.7.1 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.

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. The site's point of contact for the Board is responsible for scheduling the selected witnesses, accommodating work shift schedules as necessary and union or legal representation accompanying the witness when requested. Some preparation methods that previous Accident Investigation Boards have found successful are described below.

- **Decide on the Interview Recording Method**. Team note taking using an interviewer and a note taker is the most efficient and expedient method. A formal transcription is not required, but if a more thorough record is desired a court reported can be used. If court recorders are used for multiple witnesses, it may be necessary to have multiple court reporters "tag team" to meet the 48 hour maximum turnaround on delivery of the transcripts to the team. Electronic recording is discouraged due to delays in getting transcribed and the complications archiving the electronic record. Interview notes and transcripts should be reviewed by the witness for accuracy.

  Transcripts - The written transcripts from the court reporter should be obtained as soon as possible after they are taken, considering the cost involved. Each witness should be given a reasonable amount of time to review their transcript for factual accuracy. A record of the accuracy review is made on a *Transcript Review Statement* form and tracked on the *Transcript Receipt & Review Tracking* table (examples provided in Appendix D). Any witness interviewed is afforded the opportunity to review any statements for accuracy and may request a copy of the transcript at the conclusion of the investigation. An example, half page, *Transcript Request* form is provided in Appendix D.

- **Identify all interviewees** using the *Accident Investigation Preliminary Interview List* (provided in Appendix D). 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 in Appendix D). Designate one person, such as the administrative coordinator, to oversee this process.
- **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 walk-through and DOE site team input.
- **Develop a standardized set of interview questions.** Charts may be used to assist in developing questions. The AIB should develop a list of questions for each witness prior to the interview, based on the objectives for that interview. The *Accident Investigation Witness Statement Form, the Accident Investigation Interview Form*, or the *Informal Personal or Telephone Interview Form* (provided in Appendix D.2 - *Forms for Witness Statements and Interviews*) can aid in recording pertinent data.

2.5.7.2 Advantages and Disadvantages of 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 2-8. These considerations should be weighed against the circumstances of the accident when determining which technique to use.

Table 2-8: Group and Individual Interviews have Different Advantages

	Individual Interviews	Group Interviews
Advantages	• Obtain independent stories • Obtain individual perceptions • Establish one-to-one rapport	• More time-efficient • All interviewees supplement story; may get more complete picture • Other people serve as "memory joggers
Disadvantages	• More time-consuming • May be more difficult to schedule all witnesses	• Interviewees will not have independent stories • More vocal members of the group will say more and thus may influence those who are quieter • Group think" may develop; some individual details may get lost • Contradictions in accounts may not be revealed

2.5.7.3 Interviewing Skills

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. Keys to a good start are:

- Identify witnesses as quickly as possible to obtain witness statements. Sources for locating witnesses include DOE site 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.

- While witnesses describe the accident, the investigator: should **not** rush witnesses; should **not** be judgmental, hostile, or argumentative; should **not** display anger, suggest answers, threaten, intimidate, or blame the witness; should **not** make promises of confidentiality, use inflammatory words; and should **not** ask questions that suggest an answer, or omit questions because the investigator presumes to know the answer.

- While not making promises confidentiality, the interviewer can inform the witness that the testimony is not released to site management and the witness' name is not included in the report.
- Management supervision is discouraged from attending witness interview to avoid potential intimidation issues. However, it should be made clear during the scheduling stage that the witness is allowed to invite union or legal representatives to the interview.

Before each interview, interviewees should be apprised of FOIA and Privacy Act concerns as they pertain to their statements and identity. A *Model Interview Opening Statement* that addresses FOIA and Privacy Act provisions can be found in Appendix D. Interviewees should be aware that information provided during the investigation may not be precluded from release under FOIA or the Privacy Act. This model opening statement also addresses the caution against false statements and Appendix D includes a brief explanation in a *Reference Copy of 18 USC Sec. 1001 for Information*.

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 DOE sites have FOIA/Privacy Act specialists who can be consulted for further guidance.

Following the guidelines listed in Table 2-9, will help ensure that witness statements are provided freely and accurately, subsequently improving the quality and validity of the information obtained.

Table 2-9: Guidelines for Conducting Witness Interviews

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.

☐	Use the Model Opening Statement to caution against false testimony and explain 18 U.S. Code 1001 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.

2.5.7.4 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.

Uncooperative witness. If confronted with a witness who refuses to testify, they cannot be forced testify. Emphasize that testimony is voluntary. Reemphasis purpose of the investigation is not to find fault of the individual but to uncover weaknesses in processes and systems. Offer to reschedule the interview if there is anything the witness is uncomfortable with such as time, location, or lack of representation. Ask if the witness is willing to explain reason for refusal to testify. Offer the witness contact information in case they should change their mind. Then, close the interview, noting possible state of mind issues.

2.6 Analyze Accident to Determine "Why" It Happened

2.6.1 Fundamentals of Analysis

Careful and complete analysis of the evidence, 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, and most importantly, re-evaluating and up-dating the events and causal factors chart and analysis the team creates.

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.

Each AIB should utilize the core analytical techniques described in this Handbook. Then, determine which additional analytic techniques are appropriate, 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 O 225.1B and are demonstrably equivalent.

Why an accident happened is based on the search for cause, but the AIB must be judicious in the identification of causes. The identification of an inappropriate or incorrect cause can be harmful to the organization by wasting resources on the wrong corrective actions, needlessly damaging their reputation, or leaving the actual causes unaddressed.

The causal analysis methodologies used in accident investigation are rigorous, logical and help in the understanding of the accident, but the problem is that causality, a cause-effect relationship, can easily be constructed where it does not really exist.

To understand how this happens, investigators need to take a hard look at the accident models and how accidents are investigated; particularly, how the cause and effect relationships are determined and the requirements for a true cause and effect relationship.

Understanding of these concepts can make the difference between a thorough, professional investigation report and one that could best be described as malpractice.

2.6.2 Core Analytical Tools - Determining Cause of the Accident or Event

DOE Accident Investigation Boards need to use, at minimum, five techniques to analyze the 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.

This section of the Handbook describes and provides instructions for using the five core analytic tools:

- Event and Causal Factors Charting and Analysis
- Barrier analysis
- Change analysis
- Root Cause Analysis
- Verification Analysis

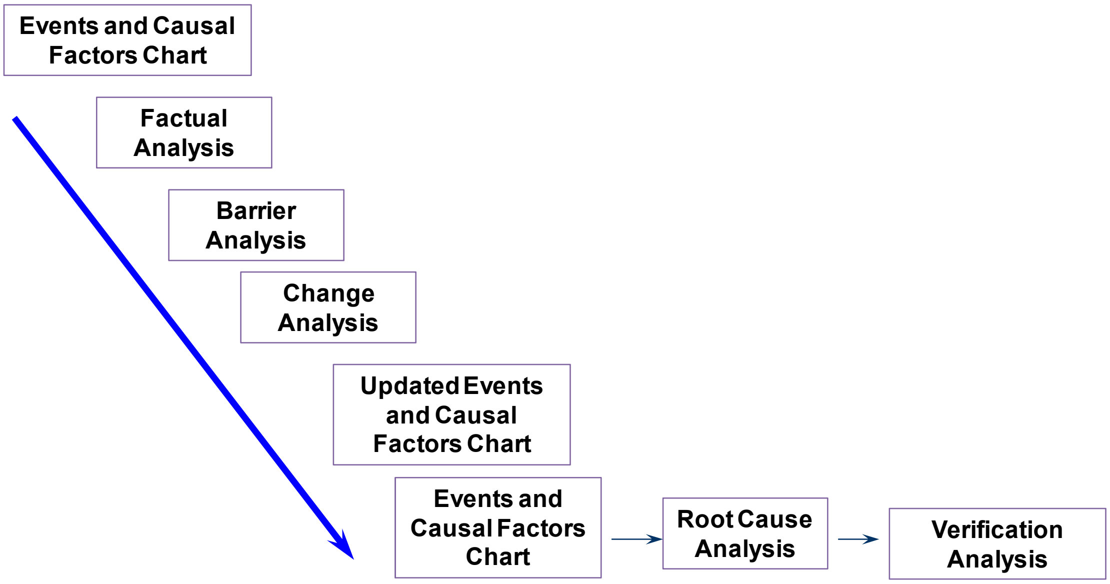


Figure 2-3: Analysis Process Overview

Accident Investigation Terminology
A **causal factor** is an event or condition in the accident sequence that contributes to the unwanted result. There are three types of causal factors: direct cause(s), which is the immediate event(s) or condition(s) that caused the accident; root causes(s), which is the causal factor that, if corrected, would prevent recurrence of the accident; and the contributing causal factors, which are the causal factors that collectively with the other causes increase the likelihood of an accident, but which did not cause the accident. **Event and causal factors analysis** includes charting, which depicts the logical sequence of events and conditions (causal factors that allowed the accident to occur), and the use of deductive reasoning to determine the events or conditions that contributed to the accident. The **direct cause** of an accident is the immediate event(s) or condition(s) that caused the accident. **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. **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 event and, if allowed to persist or re-occur, increase the probability of future events or accidents. **Barrier analysis** review the hazards, the targets (people or objects) of the hazards, and the controls or barriers that management systems put in place to separate the hazards from the targets. Barriers may be physical or administrative. **Change analysis** is a systematic approach that examines planned or unplanned changes in a system that caused the undesirable results related to the accident. **Human Performance analysis** is a method used to identify organizational and human performance factors that combined with human actions that can precipitate undesirable outcomes. **Error precursor analysis** identifies the specific error precursors that were in existence at the time of or prior to the accident. Error precursors are unfavorable factors or conditions embedded in the job environment that increase the chances of error during the performance of a specific task by a particular individual, or group of individuals. Error precursors create an error-likely situation that typically exists when the demands of the task exceed the capabilities of the individual or when work conditions aggravate the limitations of human nature.

2.6.3 The Backbone of the Investigation – Events and Causal Factors Charting

Events and Causal Factors (ECF) Charting has been a core analytic tool since its development at the SSDC in the 1970s. The basic ECF Charting approach has been expanded by DOE, and incorporates HPI by the inclusion decision points and the associated context of the decision. The AIB must develop a sound ECF chart to be able to perform an adequate analysis of the facts, and sound conclusions and Judgments of Need.

Traditionally, worker error is often seen as the cause of the accident and the focus is on what people should have done to avoid the accident. Simply blaming the worker for making a decision that is judged to wrong in hindsight does not, however, explain why the worker took the actions that they did and why those actions made perfect sense to them at the time. Workers come to work the intention to do a good job and the decisions they make, without the benefit of hindsight, must be viewed within the context of the situation at the time.

This is generally referred to as the worker's mindset, which includes the goals that they are trying to accomplish, the knowledge and information available to them at the time, and the resultant focus of their decision. What can seem like an unacceptable shortcut, in hindsight, is often the result of the worker trying to respond to conflicting demands to be efficient, yet thorough at the same time.

ECF charting provides a systematic method to capture the worker mindset by the inclusion of decision points prior to worker actions in the event sequence. Linked to the decision is information on the worker's motivation, goals, knowledge, and focus at the time of the decision.

The ECF chart is a graphically displayed flow chart of the event with the events and decisions plotted on a timeline. As the event timeline is established, the related conditions or information and worker knowledge or focus are linked to the events and decisions. Understanding why workers did what they did and why their decisions and actions made sense to them is an essential goal of the accident investigation.

Unless the context of the decisions is understood, actions to prevent similar events will focus on what are perceived as aberrant worker actions rather than the underlying factors that influenced the decisions. The underlying factors are what need to be identified and addressed to improve the system and prevent similar events in the future.

Event Charting was developed to focus on the decisions and actions that were taken during the event. Instead of just identifying the actions that were taken, ECF Charting requires that the decision to take the action be addressed and information developed about the context of the decisions.

An Event Chart is a graphically displayed flow chart of the event with the events and decisions plotted on a timeline. As the event timeline is established, the related conditions or information and worker knowledge or focus are linked to the events and decisions.

Key to successful use of the causal factors tools introduced in this section is the systematic collection and review of the event facts as captured in the Events and Causal Factors Chart (ECF). The ECF is the workhorse in an event investigation because it provides a systematic tool to separate events in time to allow events that may be critical to determining appropriate causal factors to be seen and acted upon.

The information in the ECF is used to support each follow-on tool available to the investigation team. The ECF collects important information related to human performance challenges, missed opportunities, organizational culture attributes, and potential latent organizational weaknesses. By collecting this important information for each time sequence, biases that the team members may have as they enter the investigation process are removed or at least minimized resulting in a much more objective investigation.

Armed with the information compiled in the ECF, AIBs have numerous causal analysis tools at their disposal to analyze the factual information they have collected, to identify conditions and events that occurred before and immediately following an accident, and to determine the causal factors.

The purpose of any analytic technique in an investigation is to answer the question "WHY" the event happened. That is, why did the organization allow itself to degrade to such a state that the event in question happened? It is the job of the team to apply the appropriate techniques to help them determine the causal factors of an event or accident.

Accidents rarely result from a single cause because, hopefully, many independent systems and barriers were put in place to ensure the catastrophic event did not occur. If an incident occurred, it had to be a result of the breakdown in multiples systems. 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 incident to occur.

Events and causal factors charting is a graphical display of the event and is used primarily for compiling and organizing evidence to portray the sequence of the events and their causal factors that led to the incident. The other analytical techniques (e.g., ECF, process mapping, barrier analysis, and change analysis) are used to inform the team and to support the development of the events and causal factors chart. After the major event facts are fully identified, analysis is performed to identify the causal factors.

Events and causal factors charting is widely used in major event investigations, because it is relatively easy to develop and provides a clear depiction of the information generated by the team. By carefully tracing the events and conditions that allowed the incident to occur, team 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 2-10.

Table 2-10: Benefits of Events and Causal Factors Charting

The **benefits** 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
- Directing the progression of additional data collection and analysis by identifying information gaps
- Linking facts and causal factors to organizational issues and management systems
- Validating the results of other analytic techniques
- Providing a structured method for collecting, organizing, and integrating collected evidence
- Conveying the possibility of multiple causes
- Providing an ongoing method of organizing and presenting data to facilitate communication among the investigators
- Clearly presenting information regarding the accident that can be used to guide report writing
- Providing an effective visual aid that summarizes key information regarding the accident and its causes in the investigation report

Two types of event and causal factors charts will be introduced in this guide:

- Events and Causal Factors Analysis Chart (ECF) and the
- Expanded Events and Causal Factors Analysis (E-ECF) chart, which is an enhanced application of the ECF and may be more applicable to the accident prevention focus of an Operational Safety Review Team in Volume II, Chapter 1 in looking in much greater depth at organizational weaknesses and human performance. The ECF process is described in detail in Section 2.6.3.2.

The team should choose which tool suits their needs.

To identify causal factors, team 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 that provides a mental model of the event such that team can determine the causal factors and make intelligent recommendations

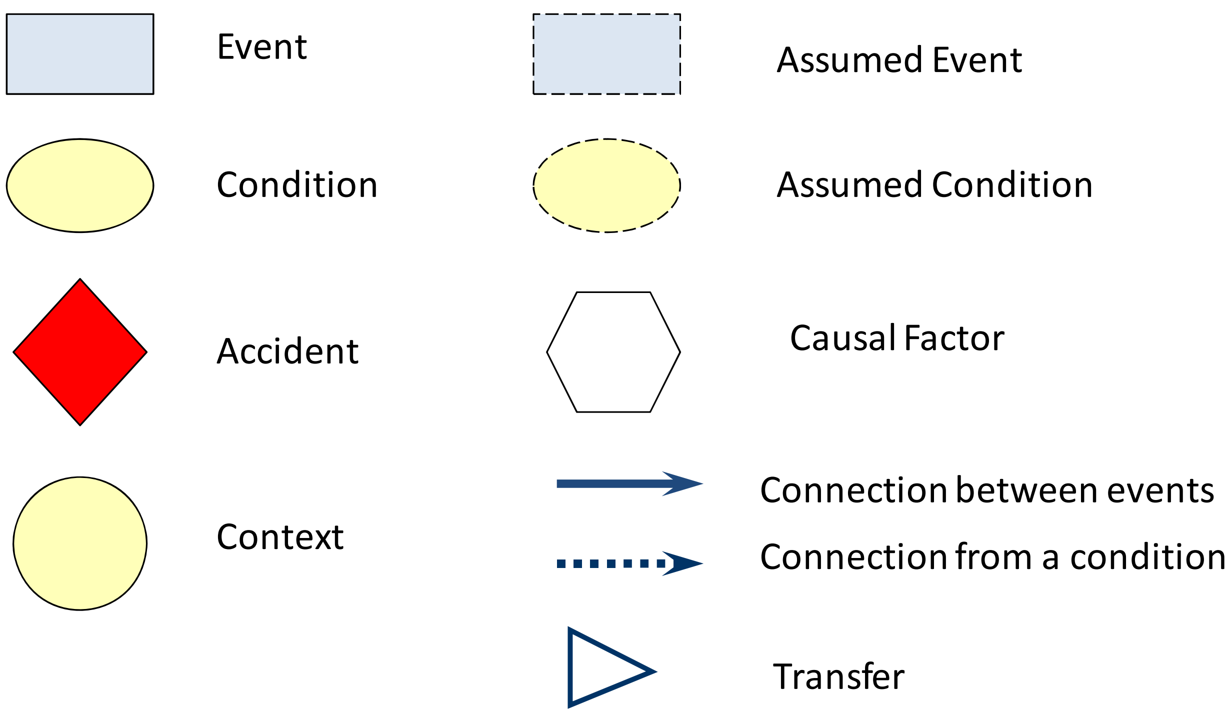
After developing the "initial" ECF, the investigators apply, at minimum, the core analytic techniques of:

- Events and causal factors charting and analysis,
- Barrier Analysis,

- Change Analysis,
- Root Cause Analysis, and
- Verification Analysis.

2.6.3.1 ECF Charting Symbols

The symbols used are as follows:



2.6.3.2 Events and Causal Factors Charting Process Steps

For purposes of this handbook, events and causal factors *charting* and events and causal factors *analysis* (see Section 2.6.8) are considered one technique. They are addressed separately because they are conducted at different stages of the investigation.

This section presents the typical approach to develop the ECF Chart for an accident, where the events have already occurred. In Figure 2-4, a modified form of ECF Chart is presented, and is suggested for use when conducting an Operational Safety Review, of events for the purposes of preventing accidents.

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., barrier analysis and change 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 2-10.

To identify causal factors, Board members must have a clear understanding of the relationships among the events and the conditions, both human performance and management systems, which 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 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 benefits 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.
- Directing the progression of additional data collection and analysis by identifying information gaps.
- Linking facts and causal factors to organizational issues and management systems.
- Validating the results of other analytic techniques.

- Providing a structured method for collecting, organizing, and integrating collected evidence.
- Conveying the possibility of multiple causes.
- Providing an ongoing method of organizing and presenting data to facilitate communication among the investigators.
- Clearly presenting information regarding the accident that can be used to guide report writing.
- Providing an effective visual aid that summarizes key information regarding the accident and its causes in the investigation report.

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. A sample summary events and causal factors chart (Figure 2-4) illustrates the basic format using data from the case study accident. This chart shows how data may become available during an accident investigation, and how a chart would first be constructed and subsequently updated and expanded. Guidelines for constructing the chart are shown in Table 2-10.

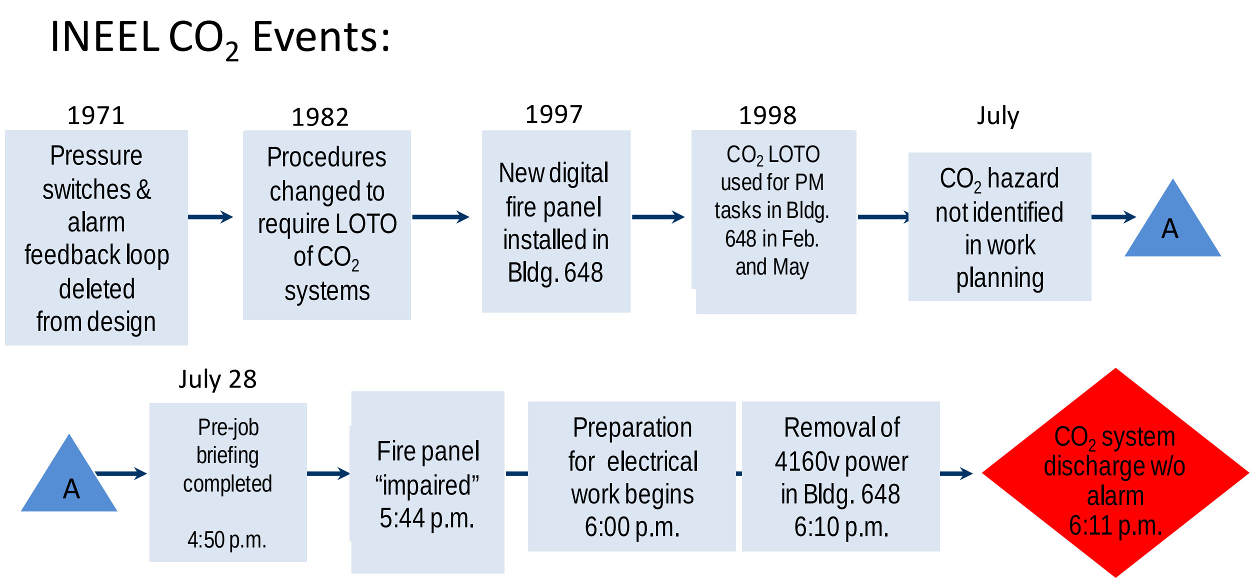


Figure 2-4: Simplified Events and Causal Factors Chart for the July 1998 Idaho Fatality CO2 Release at the Test Reactor Area

Depending on the complexity of the accident, the chart may result in a very large complex sequence of events covering several walls. For the purpose of inclusion in the investigation report and closeout briefings, the chart is generally summarized. Note that "assumed conditions" appear in the final chart. These are conditions the Board believes affected the accident sequence, but the effect could not be substantiated with evidence.

The following steps summarize the construction of the ECF Chart. In practice, this is an iterative process with constant changes and expansion of the chart as information, including context becomes available during the investigation.

Sequence of Events and Actions

First, to initiate the ECF Chart, the investigators begin with a chronological sequence of events, leading up to the accident, then the events immediately after the accident of relevance, such as how the emergency response proceeded. The sequence of events and decisions forms the starting point for reconstructing the accident. The events include observations, actions, and changes in the process or system.

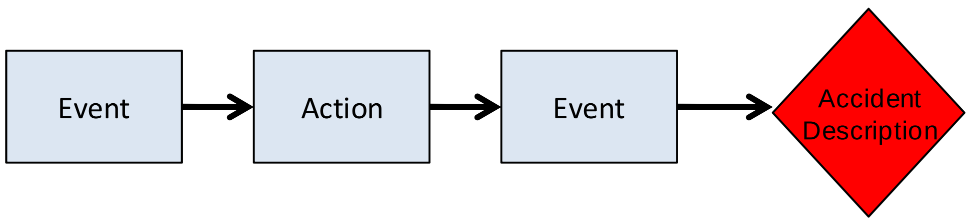


Figure 2-5: Sequence of Events and Actions Flowchart

Decisions before Actions

For each event consider, the decisions (before the actions) to start to establish the mindset of the worker. The goal is to set the framework for how the workers goals, knowledge and focus unfolded in parallel with the situation evolving around them.

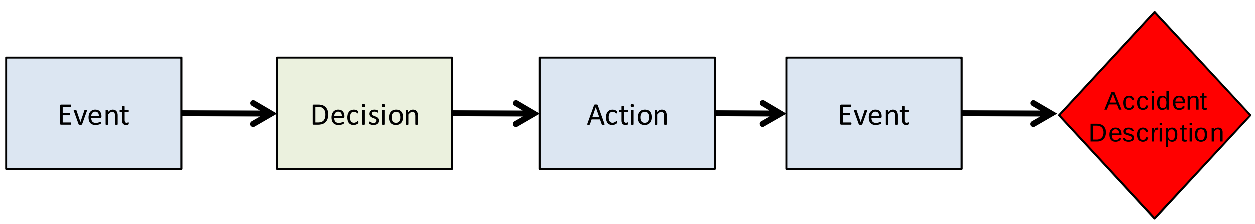


Figure 2-6: Decisions before Actions Flowchart

Conditions and Context of Human Performance and Safety Management Systems

For each event, determine the conditions that existed from the context of the human performance decisions, the actions by individuals, the safety management system, the work environment, and the physical conditions that existed at that specific point of time. This step is about reconstructing the world as it unfolded around the worker. The purpose is to:

- Determine how work was actually being performed;
- Determine what information was available to the worker and decisions that were made; and
- Determine how work was expected to be performed, e.g., procedures, plans, permits.

Reconstruct how the process was changing and how information about the changes was presented to the workers. Use the Human Error Precursor Matrix (Table 2-11), the ISM Seven Guiding Principles (Table 2-13), and the ISM Five Core Functions (Table 1-5) to help identify the context description involved. A more detailed discussion and list of Human Error Precursors will be found in Table 2-11.

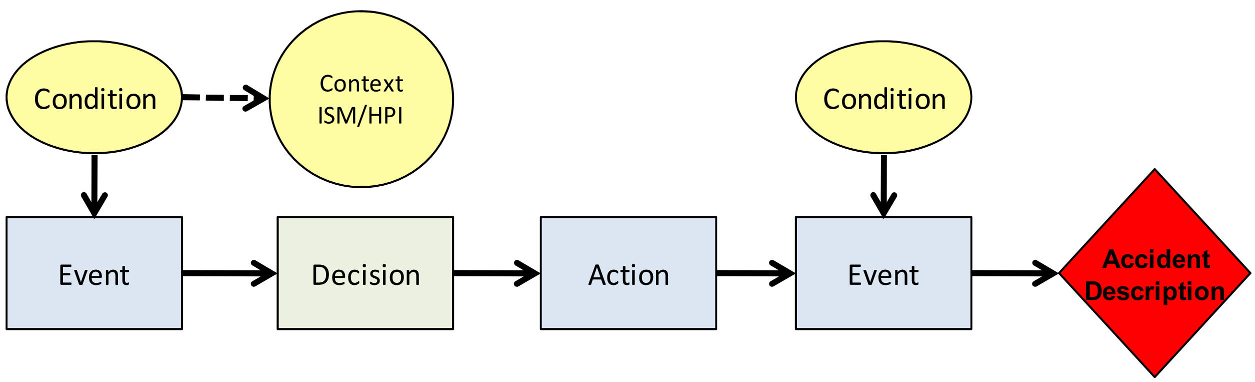


Figure 2-7: Conditions and Context of Human Performance and Safety Management Systems Flowchart

Context of Decisions

Next determine the context by which workers formulated the decisions that lead to their actions at the point of time in the event. Decisions are not made in a vacuum. They are the result of the factors that are influencing the worker at that point in time.

People have goals. Completion of the task is obvious, but there are other, often conflicting, goals present. These can include, but are not limited to:

- Economic considerations, such as safety versus schedule

- Subtle coercions (what boss wants, not what s/he says)
- Response to previous situations (successes OR failures)

People have knowledge, but the application and availability of knowledge is not straight forward. Was it accurate, complete and available?

Goals & knowledge together determine their focus because:

- Workers cannot know and see everything all the time.
- What people are trying to accomplish and what they know drives where they direct their attention.
- Re-constructing their focus of attention will help the investigation to understand the gap between available information and what they saw or used.

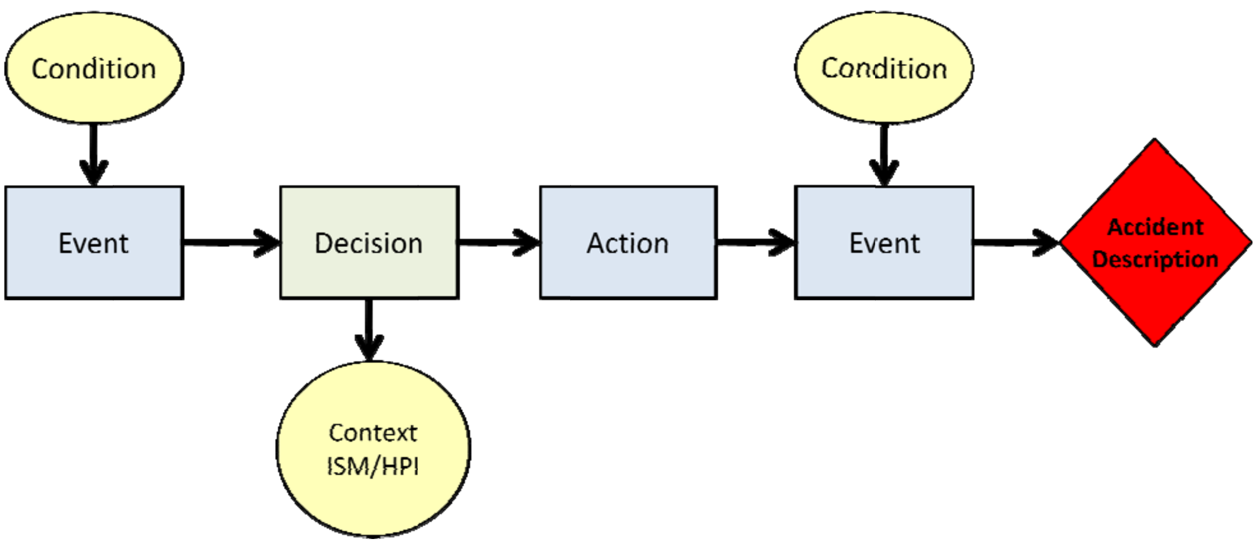


Figure 2-8: Context of Decisions Flowchart

ECF charting provides a graphical display of the event and guides the logic flow on trying to understand the event. The output however is not the chart, but the explanation that of the event that results from the construction of the chart. In particular, it provides an explanation of what the workers did and why they did it. The explanation should address factors such as:

- What was happening with the process?
- What were the workers trying to accomplish and why?

- What did they know at the time?
- Where was their attention focused and why?
- Why what they did made sense to them at the time?

Table 2-11: Common Human Error Precursor Matrix

TASK DEMANDS (TD)
TD #1 Time pressure (in a hurry)
• Urgency or excessive pace required to perform action or task • Manifested by shortcuts, being in a hurry, and an unwillingness to accept additional work or to help others • No spare time
TD #2 High workload (high memory requirements)
• Mental demands on individual to maintain high levels of concentration; for example, scanning, interpreting, deciding, while requiring recall of excessive amounts of information (either from training or earlier in the task)
TD #3 Simultaneous, multiple tasks
• Performance of two or more activities, either mentally or physically, that may result in divided attention, mental overload, or reduced vigilance on one or the other task
TD #4 Repetitive actions / Monotony
• Inadequate level of mental activity resulting from performance of repeated actions; boring Insufficient information exchange at the job site to help individual reach and maintain an acceptable level of alertness

TD #5 Irrecoverable acts
• Action that, once taken, cannot be recovered without some significant delay • No obvious means of reversing an action
TD #6 Interpretation requirements
• Situations requiring "in-field" diagnosis, potentially leading to misunderstanding or application of wrong rule or procedure
TD #7 Unclear goals, roles, and responsibilities
• Unclear work objectives or expectations • Uncertainty about the duties an individual is responsible for in a task that involves other individuals • Duties that are incompatible with other individuals
TD #8 Lack of or unclear standards
• Ambiguity or misunderstanding about acceptable behaviors or results; if unspecified, standards default to those of the front-line worker (good or bad)
WORK ENVIRONMENT (WE)
WE #1 Distractions / Interruptions
• Conditions of either the task or work environment requiring the individual to stop and restart a task sequence, diverting attention to and from the task at hand
WE #2 Changes / Departure from routine
• Departure from a well-established routine • Unfamiliar or unforeseen task or job site conditions that potentially disturb an individual's understanding of a task or equipment status
WE #3 Confusing displays / control

• Characteristics of installed displays and controls that could possibly confuse or exceed working memory capability of an individual
• Examples:
  • missing or vague content (insufficient or irrelevant)
  • lack of indication of specific process parameter
  • illogical organization and/or layout
  • insufficient identification of displayed process information
  • controls placed close together without obvious ways to discriminate conflicts between indications

WE #4 Work-arounds / Out-of-Service instrumentation
• Uncorrected equipment deficiency or programmatic defect requiring compensatory or non-standard action to comply with a requirement; long-term materiel condition problems that place a burden on the individual
WE #5 Hidden system response
• System response invisible to individual after manipulation • Lack of information conveyed to individual that previous action had any influence on the equipment or system
WE #6 Unexpected equipment condition
• System or equipment status not normally encountered creating an unfamiliar situation for the individual
WE #7 Lack of alternative indication
• Inability to compare or confirm information about system or equipment state because of the absence of instrumentation
WE #8 Personality conflict
• Incompatibility between two or more individuals working together on a task causing a distraction from the task because of preoccupation with personal differences
INDIVIDUAL CAPABILITIES (IC)
IC #1 Unfamiliarity with task / First time
• Unawareness of task expectations or performance standards • First time to perform a task (not performed previously; a significant procedure change)
IC #2 Lack of knowledge (mental model)
• Unawareness of factual information necessary for successful completion of task; lack of practical knowledge about the performance of a task
IC #4 New technique not used before
• Lack of knowledge or skill with a specific work method required to perform a task
IC #5 Imprecise communication habits
Communication habits or means that do not enhance accurate understanding by all members involved in an exchange of information
IC #6 Lack of proficiency / Inexperience
• Degradation of knowledge or skill with a task because of infrequent performance of the activity

IC #7	**Indistinct problem-solving skills**
	• Unsystematic response to unfamiliar situations; inability to develop strategies to resolve problem scenarios without excessive use of trial-and-error or reliance on previously successful solutions • Unable to cope with changing facility conditions
IC #8	**"Unsafe" attitude for critical tasks**
	• Personal belief in prevailing importance of accomplishing the task (production) without consciously considering associated hazards • Perception of invulnerability while performing a particular task • Pride; heroic; fatalistic; summit fever; Pollyanna; bald tire
IC #9	**Illness / Fatigue**
	• Degradation of a person's physical or mental abilities caused by a sickness, disease, or debilitating injury • Lack of adequate physical rest to support acceptable mental alertness and function
HUMAN NATURE (HN)	
HN #1	**Stress**
	• Mind's response to the perception of a threat to one's health, safety, self-esteem, or livelihood if task is not performed to standard • Responses may involve anxiety, degradation in attention, reduction in working memory, poor decision-making, transition from accurate to fast • Degree of stress reaction dependent on individual's experience with task
HN #2	**Habit patterns**
	• Ingrained or automated pattern of actions attributable to repetitive nature of a well-practiced task • Inclination formed for particular train/unit because of similarity to past situations or recent work experience
HN #3	**Assumptions**
	• Suppositions made without verification of facts, usually based on perception of recent experience; provoked by inaccurate mental model • Believed to be fact • Stimulated by inability of human mind to perceive all facts pertinent to a decision

HN #4 Complacency / Overconfidence
• A "Pollyanna" effect leading to a presumption that all is well in the world and that everything is ordered as expected • Self-satisfaction or overconfidence, with a situation unaware of actual hazards or dangers; particularly evident after 7-9 years on the job • Underestimating the difficulty or complexity of a task based upon past experiences
HN #5 Mindset
• Tendency to "see" only what the mind is *tuned* to see (intention); preconceived idea • Information that does fit a mind-set may not be noticed and vice versa; may miss information that is not expected or may see something that is not really there; contributes to difficulty in detecting one's own error (s)
HN #6 Inaccurate risk perception
• Personal appraisal of hazards and uncertainty based on either incomplete information or assumptions • Unrecognized or inaccurate understanding of a potential consequence or danger • Degree of risk-taking behavior based on individual's perception of possibility of error and understanding of consequences; more prevalent in males
HN #7 Mental shortcuts (biases)

• Tendency to look for or see patterns in unfamiliar situations; application of thumb rules or "habits of mind" (heuristics) to explain unfamiliar situations:
  • confirmation bias
  • frequency bias
  • similarity bias
  • availability bias

HN #8 Limited short-term memory
• Forgetfulness; inability to accurately attend to more than 2 or 3 channels of information (or 5 to 9 bits of data) simultaneously • The mind's "workbench" for problem-solving and decision-making; the temporary, attention-demanding storeroom we use to remember new information

[Pyszczynski, pp. 117 – 142, 2002][22]

2.6.3.3 Events and Causal Factors Chart Example

The Event

An electrician (E1), working within the basement of the facility was manipulating a stuck trip latch on a spring loaded secondary main air breaker. In order to gain access to the stuck trip latch, E1 decided to partially charge (compress) the large coil closing spring using the manual closing handle and reach into the breaker with his left hand from underneath. As he knelt in front of the breaker, his knee gave out, causing him to lose balance and strike the closing handle with his right hand. This caused the charged closing spring to release and slam the breaker closed, severing the tip of his left middle finger.

Background

The work involved a planned electrical outage for the facility in order to conduct preventive maintenance (PM) on the primary transformer. In order to perform the PM without impact to the facility and its tenants, the work and an outage were scheduled during the weekend. The resident electricians (E1 and E2) were supporting the PM activities by opening and closing seven secondary main breakers as well as several other load breakers. The electricians' work was authorized by an Integrated Work Document (IWD). Per the IWD, their work scope was defined as "assisting the FC in the shutdown and start-up of equipment and to verify proper function."

Air Breakers

The secondary main air breakers were General Electric Type AK-2-75. These breakers are rated for 600 volts and were installed during the construction of the facility in the 1950s and 1960s.

The normal process for closing air breakers is to close the breaker electronically. In this instance, the breaker is closed by turning the knob as shown in Figure 2-9. The breakers do not need to be racked out when closing electronically.

If the breaker does not close electronically, then it is closed manually. The breaker must be racked out and charged using the manual closing handle as shown in Figure 2-9. The air breakers are equipped with a coiled spring that drives the contacts closed. The closing springs are charged by operating the manual closing handle on the front of the breaker. The breaker releases during the 4th cycle of the closing handle.

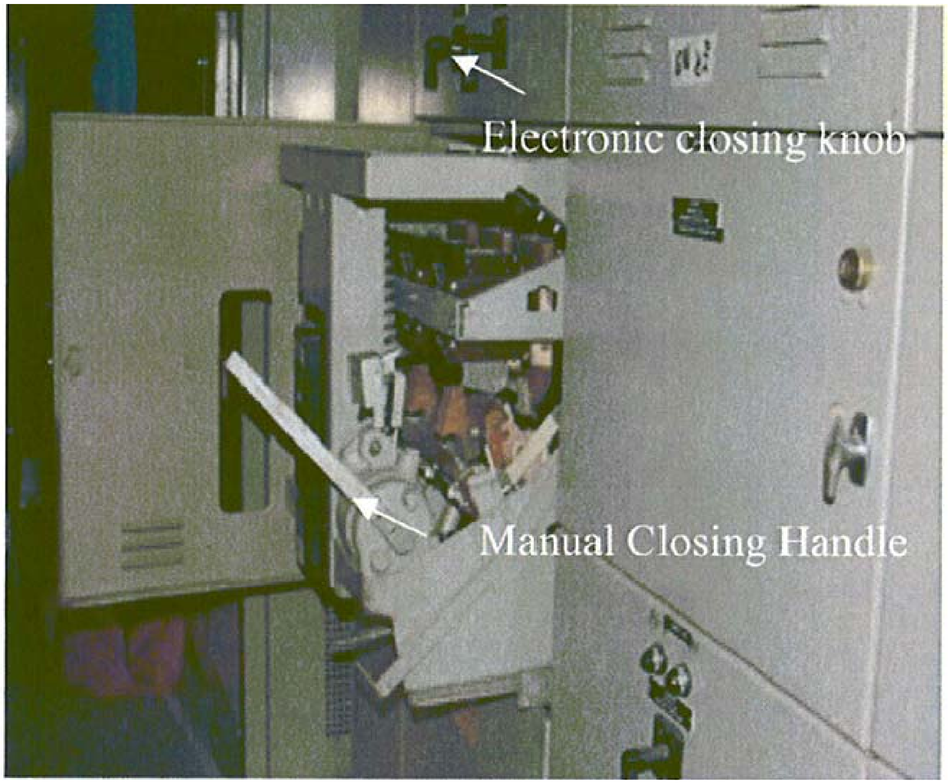


Figure 2-9: Racked Out Air Breaker

Figure 2-10 shows an excerpt from the ECF Chart that addresses the electrician's decision to reach into the breaker:

An explanation of this event might read:

E1 determined that the breakers would not close due to a stuck trip latch based on his previous experience as the foreman of the breaker maintenance crew and having encountered this problem before, including assisting with the repair of the trip latch on one of the other breakers at the facility two months prior. He also knew that these breakers had not been serviced in over 6 years.

E1 and E2 decided to repair the breakers in place rather than send the breakers back to the shop for maintenance. They knew that it could take up to a week to get the breakers serviced and the facility would not be able to reopen the following morning. E1 was motivated to complete the work so that the nuclear facility could reopen on schedule and based on his past experience, he felt he would be "rewarded" for restoring power and that there would be ramifications if the work was not completed by the end of the day.

E1 then decided manipulate the trip latch based on his belief that the latch was stuck due to lack of maintenance that allowed the lubricant to congeal. He had done this before and had learned it from other electricians.

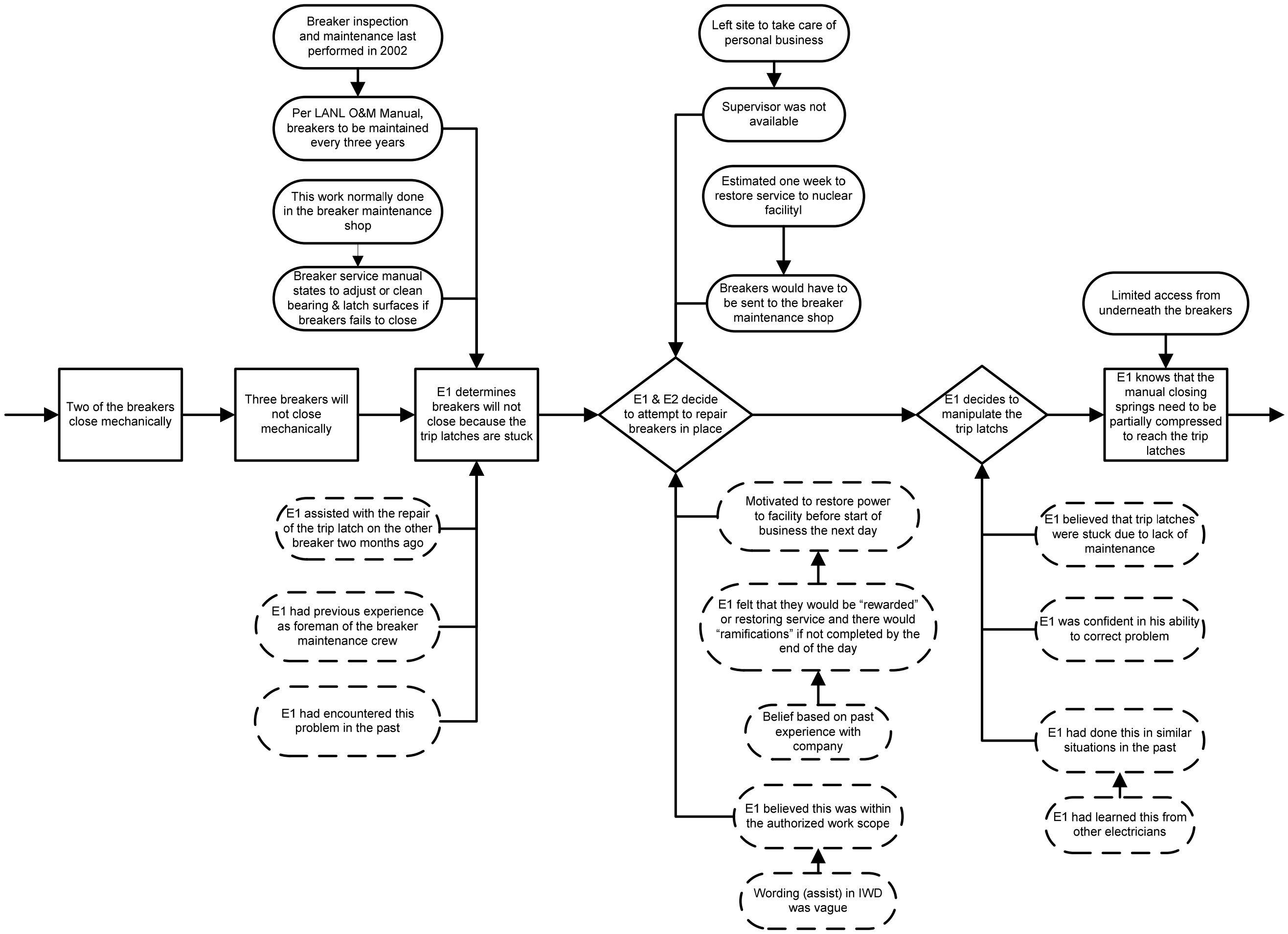


Figure 2-10: Excerpt from the Accident ECF Chart

2.6.4 Barrier Analysis

Once the "initial" ECF is constructed, the team may use the first analysis tool, "Barrier Analysis."

2.6.4.1 Analyzing Barriers

Figure 2-11 shows a summary diagram of the barrier analysis result. As can be seen, there is the potential for a large list of barriers that either did or could have come into play between the hazard and the target. It is user to the analysis if categories are used as much as possible to help recognize the nature of the barrier's performance and the relationship to organizational conditions that either weaken or strengthen the barrier. Fundamental elements of the barrier analysis should identify if the barrier prevents the initiation of accident or mitigates the harm, if the barrier can be passively defeated (ignored) or must it be actively defeated (disabled); and what kinds of latent organizational conditions can influence the barrier reliability.

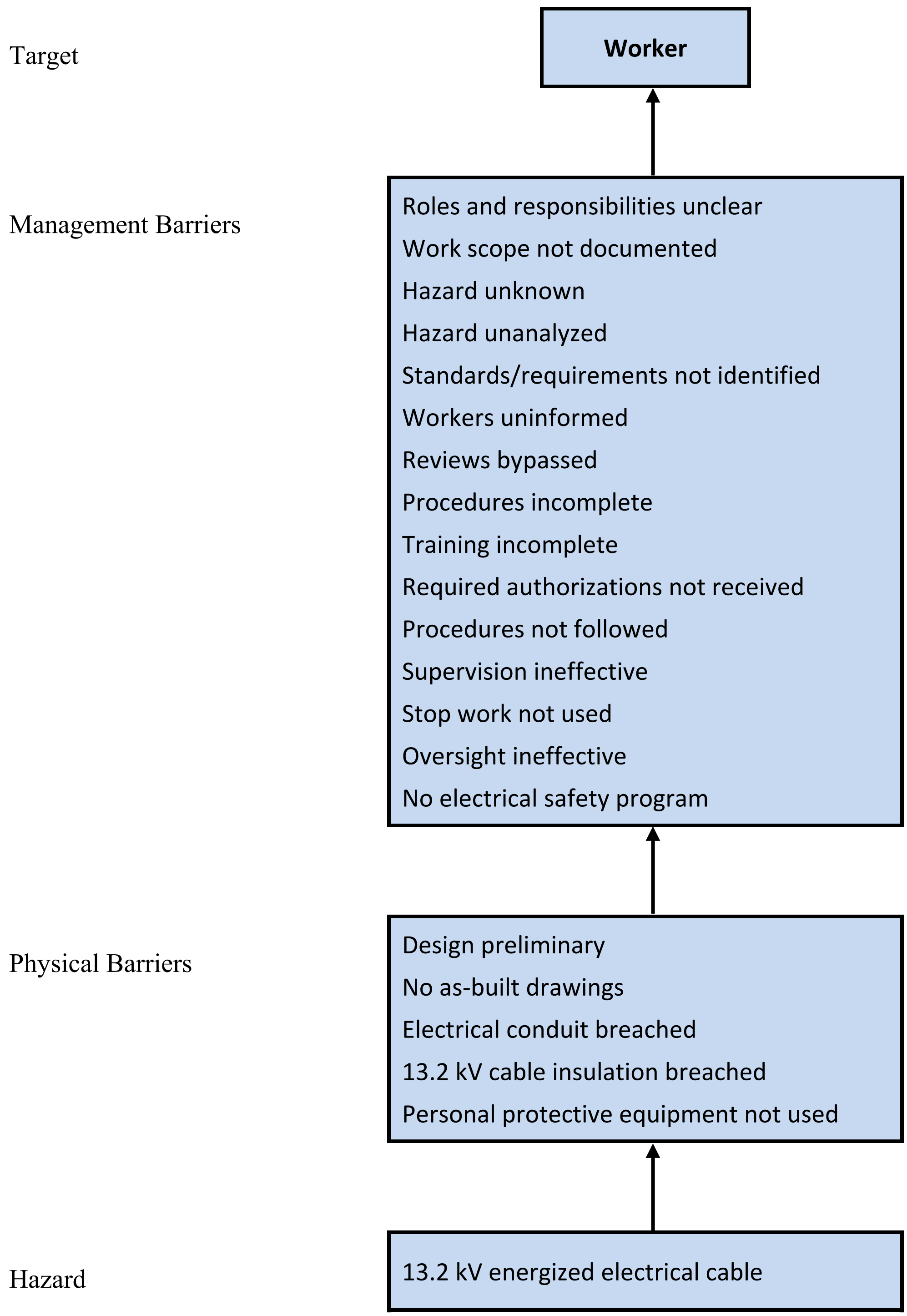


Figure 2-11: Summary Results from a Barrier Analysis Reveal the Types of Barriers Involved

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 the activity, facility, and institutional levels responsible for the work. 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.

At the facility level, the investigator may also need information about safety management systems. 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 (OSHA) 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.

At the institutional level, the investigator may need information about the 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 *Barrier Analysis Worksheet* is provided in Appendix D.4 *Analysis Worksheets*. Table 2-12 illustrates a worksheet that was partially completed using data from the case study. Steps used for completing this worksheet are provided below.

Although a barrier analysis will identify the failures 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.

Table 2-12: Sample Barrier Analysis Worksheet

Hazard: 13.2 kV electrical Cable		Target: Acting pipefitter		
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the accident?**	**Context: HPI/ISM**
Engineering drawings	Drawings were incomplete and did not identify electrical cable at sump location	Engineering drawings and construction specifications were not procured Drawings used were preliminary No as-built drawings were used to identify location of utility lines	Existence of electrical cable unknown	HPI: • **HN #5** - Inaccurate mental picture • **HN #6** - Inaccurate risk perception • **IC #2** - Limited perspective ISM: • **GP #3 & 5** – Hazard Identification
Indoor excavation permit	Indoor excavation permit was not obtained	Pipefitters and utility specialist were unaware of indoor excavation permit requirements	Opportunity to identify existence of cable missed	ISM: • **CF #1** - Define scope of work • **CF #2** - Analyze hazards • **CF #3** - Control hazards

HN – Human Nature (see Table 2-11)
IC – Individual Capabilities (see Table 2-11)
GP – Guiding Principles of ISM (see Table 2-13)
CF – Core Functions of ISM (see Table 1-5)

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.

Table 2-12 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.

Basic Barrier Analysis Steps

Step 1: Identify the hazard and the target. Record them at the top of the worksheet. *"13.2 kV electrical cable. Acting pipefitter."*

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*."

Step 6: Evaluate the context of the consequences of the barrier in terms of both human performance (HPI) AND Integrated Safety Management System (ISMS). Use the Human Error Precursor Matrix (Table 2-11), and Seven Guiding Principles Chart (Table 2-13), and the ISM Five Core Functions (Table 1-5). Record evaluation in column five. A more detailed discussion and list of Human Error Precursors will be found in Table 2-11.

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

DOE O 225.1B 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 O 225.1B requires the board to "evaluate the effectiveness of management systems, as defined by DOE P 450.4A, 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 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 P 450.4A. 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 P 450.4A 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.

There are several readily accessible sources of background information to be used in assessing the safety culture. The DOE maintains databases where accident occurrences, injuries, and lessons learned are recorded for analysis. Some of these databases are:

- Occurrence Reporting and Processing System (ORPS)
- Computerized Accident/Incident Reporting System (CAIRS)
- Lessons Learned and Best Practices
- Operating Experience Summaries
- Electrical Safety

These information sources and onsite corrective action tracking systems can be very good methods for finding past similar incidents and their associated ISM categories. It is, also, useful to investigate past accident investigations for similar types of events to determine if any of the past lessons learned or corrective actions from across the complex were recognized and implemented prior to the present incident. Often, the AI coordinator can be requested to run preliminary search reports from these federal databases as part of the initial background information to the investigation.

In many accidents, deficiencies in implementing the five core safety management functions defined in DOE P 450.4A 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 2-13 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 P 450.4A. 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 2.6.5 will enable the board to determine whether deficiencies found in management systems and line management oversight, are causal factors for the accident.

Table 2-13: 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 integrated safety management policy fully implemented down to the activity level at the time of the accident? • Was DOE line management proactive in assuring timely implementation of integrated safety management by line organizations, contractors, subcontractors, and workers? • Were environment, safety and health (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 site-wide 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 understanding of programs and facilities? • 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? • 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 were kept current and relevant to program needs, and (2) job proficiency was 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 was to 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 the scope of operations ongoing at the time of the accident?

2.6.5 Human Performance, Safety Management Systems and Culture Analysis

In conducting the change and barrier analysis consider the relationship of human performance, and management systems to the conditions that existed along the event change in the team's ECF analysis. This section discusses these relationships between how the organization's people and management system preformed. This analysis is straight forward. For every condition, action a person took, barrier that failed, evaluate it in the context of: Human performance and Management Systems/Culture. The ISM framework and the Error Precursor Matrix, Figure 1-3, at minimum should be used to construct the analysis and statements. Some of these ISM/HPI conditions may later roll up into a causal factor statement.

2.6.6 Change Analysis

Once the Board has completed a barrier analysis, the Board then proceeds to use the next core analytical tool "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.

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?

Change analysis is relatively simple to use. As illustrated in Figure 2-12 it consists of six steps. The last step, in which investigators combine the results of the change analysis 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.

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.

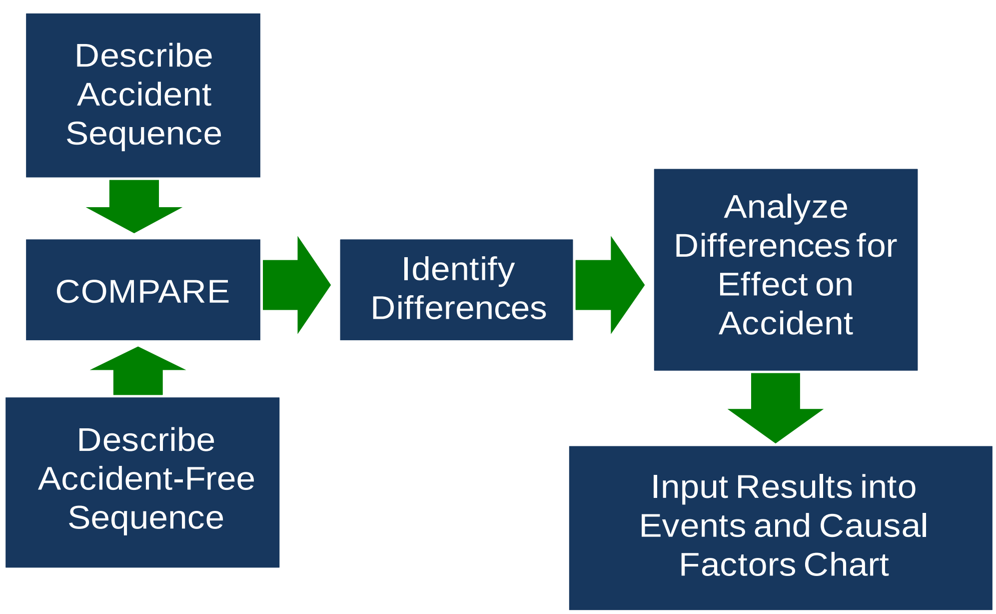


Figure 2-12: The Change Analysis Process

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.

In change analysis, differing events and conditions are systematically reviewed and analyzed to determine potential causes.

Change analysis is most effective under these circumstances:

- A prior "accident-free" or *typical* situation is already documented or can be reconstructed.
- A well-defined *ideal* situation exists.
- Work as is described in procedures versus work as actually done.

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 in Appendix D 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. For example, the Board should determine if the change pertained to 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; and
- **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 2-14 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 2-15, 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.

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-year and five-year baselines with each other can help identify the compounding effects of changes.

Table 2-14: Sample Change Analysis Worksheet

Factors	Accident Situation	Prior, Ideal, or Accident-Free Situation	Difference	Evaluation of Effect
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.	1. Project design and ES&H review are performed by appropriate groups to ensure adequate review and the safety and health of employees. 2. Construction packages are approved by facilities project delivery group. 3. A preliminary hazard analysis is performed on all work.	1 Environmental Group assumed design role and removed ES&H review from task. 2. Environmental Group approved work packages. 3. No preliminary hazard analysis was performed on construction task.	1. Design and ES&H reviews were not performed, contributing to the accident. 2. Construction packages were not approved by facilities group. 3. Hazards were not identified, contributing to the accident.
WHEN Occurred, identified, facility status, schedule				
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 jack-hammering 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				

NOTE: The factors in this worksheet are only guidelines but are useful in directing lines of inquiry and analysis.

Table 2-15: Case Study: Change Analysis Summary

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

2.6.7 The Importance of Causal Factors

The primary purpose of any event investigation is to help prevent recurrence of events/accidents by making worthwhile recommendations based on the event's causal factors. The team 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 responsible for identifying and describing any failures, human performance, and/or management systems that caused the accident. The Board should determine either/and/or the HPI and ISM factors associated with each causal factor statement. This may be accomplished by reviewing and carrying forward the relevant codes you assigned to HPI/ISM when the barrier analysis was constructed.

Modern accident investigation theory indicates that generally the root causes of accidents are found in organizational system failures, not in the most directly related causal factor(s) in terms of time, location, and place.

Generally, the higher in the management and oversight levels a root because is found, the broader the effect is on the scope of the organization's activities. This broader scope impact translates to a larger potential to cause other accidents. Therefore, it is incumbent on a team to ensure that the investigation is not ended until the highest possible root causes are identified. If a team cannot identify root causes, this should be stated clearly in the investigation report, along with an explanation.

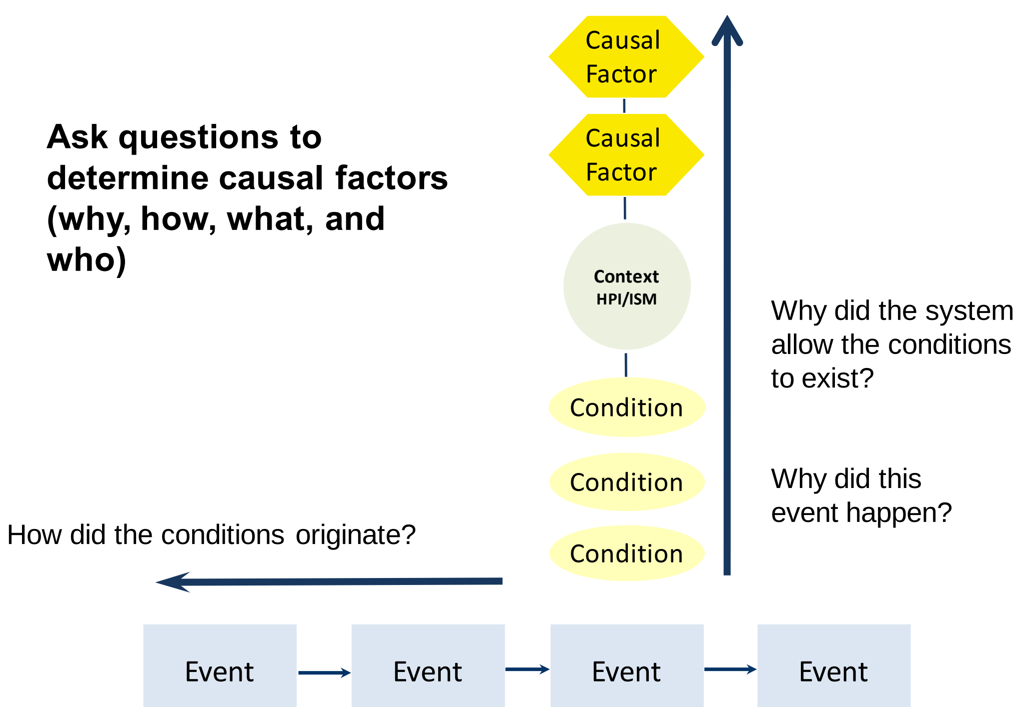


Figure 2-13: Determining Causal Factors

Table 2-16: Case Study Introduction

CASE STUDY
This section on causal analysis begins with a case study of an electrical accident. It is selectively referenced throughout this and subsequent sections to illustrate the process of determining facts and the use of the analytic techniques commonly used in DOE accident investigations. In this workbook, particular emphasis is placed on these techniques because they can be used in most accident investigations. However, for extremely complex accidents, additional, more sophisticated techniques may be needed that require specialized training. Training for these techniques is beyond the scope of this workbook and can be obtained through government, private, and university sources.
EVENT DESCRIPTION
The accident occurred at approximately 9:34 a.m. on January 17, 1996, in Building XX, during the excavation of a sump pit in the floor of the building. Workers were attempting to correct a waste stream outfall deficiency. Two workers arrived at the job site at approximately 8:40 a.m. and resumed the excavation work begun the previous day. The workers were employed by WS, the primary subcontractor for construction and maintenance. They used a jackhammer, pry bar, and shovel to loosen and remove the rubble from the sump pit. At about 9:34 a.m., at a depth of 39 inches, Worker A, who was operating the jackhammer, pierced the conduit containing an energized 13.2 kV electrical cable. He was transported to the local medical center, where cardiac medications were administered.
EVENT FACTS
Using the case study accident, the following three factual statements were derived during the investigation: • The injured worker had not completed safety training prior to the accident, as required by WS Environment, Safety, and Health Manual Procedure 12340. • Design drawings for the project on which the injured employee was working did not comply with the requirements of DOE O 6430.1A, General Design Criteria, and did not show the location of the underground cable. • A standing work order system, without a safety review, was used for non-routine, non-repetitive tasks.

2.6.8 Causal Factors

The core analytical technique of Causal Factor Analysis is applied after the ECF chart is constructed, as completely as possible, and a change analysis and barrier analysis are conducted at minimum.

First, the AIB looks for all potential causal factors then, determine if they are a: contributing; root or, direct causal factor of the accident or event.

The process of determining causal factors seeks to answer the questions; what happened and, why did it happen?

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; and
- Root causes.

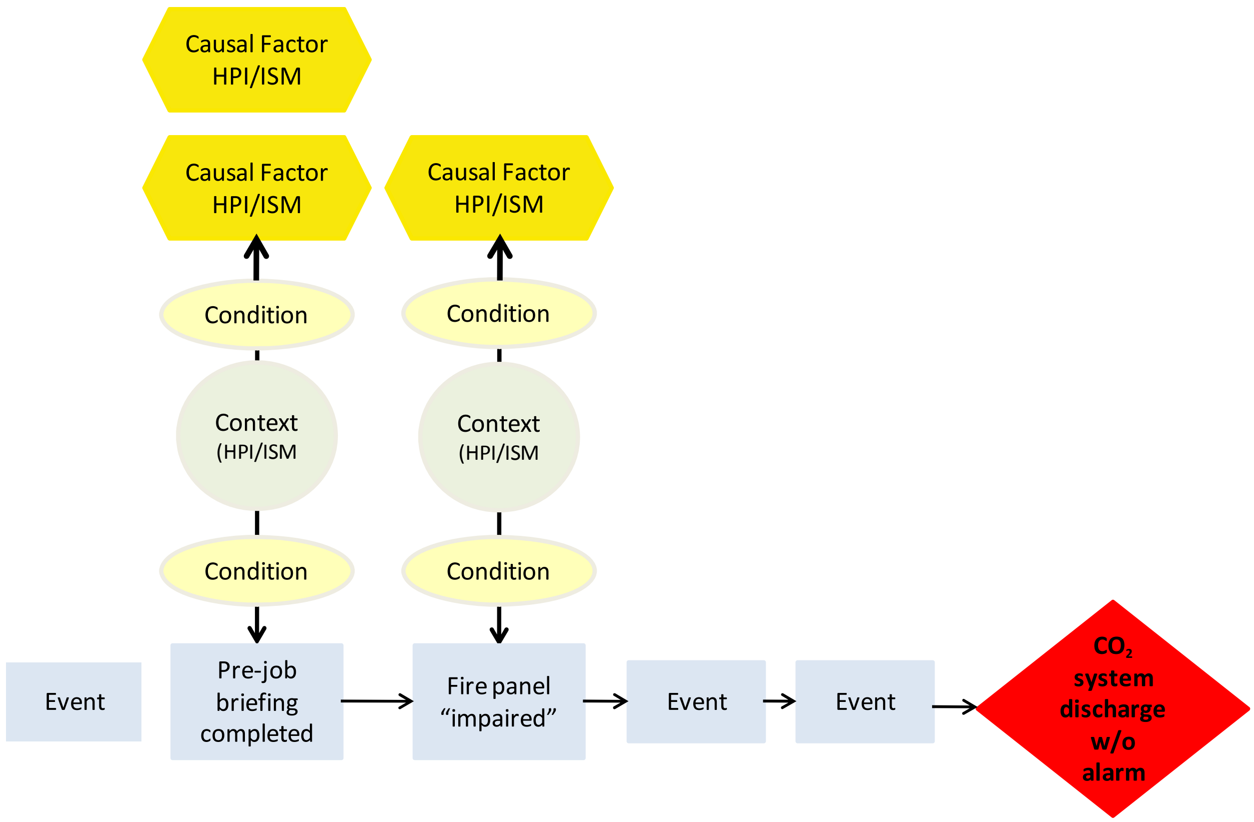


Figure 2-14: Roll Up Conditions to Determine Causal Factors

2.6.8.1 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. Typically, the direct cause of the accident may be constructed or derived from the immediate, proximate event and conditions next to or close by to the accident on the ECF Chart.

EXAMPLES EVENT DIRECT CAUSES

- 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 CO_2 in an occupied space.

2.6.9 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 event and, if allowed to persist or re-occur, increase the probability of future events or accidents.

EXAMPLES EVENT CONTRIBUTING CAUSES

- 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.
- The standing work order process was used by facility personnel as a convenient method of performing work without a job ticket and work package, allowing most work to be field-directed.
- Inadequate illumination in the area of the platform created visibility problems that contributed to the fall from the platform.

2.6.10 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 deficiencies that could cause or contribute to other accidents.

In many cases, root causes are failures to properly implement the principles and core functions of integrated safety management.

For example, 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.

The AIB 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.

EXAMPLES ROOT CAUSES

- 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.
- 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.
- 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.
- 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.

2.6.10.1 Root Cause Analysis

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 deficiencies that could cause or contribute to other accidents. They are identified using root cause analysis. 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.

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.

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 primarily performed to resolve the question, "Why?"

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.

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.

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.

Examples of Root Cause Statements

- 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.

- 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.

- 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.

- 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.

Once several (or all) of the preliminary analytic techniques have been performed, the accident investigation team should have matured in their understanding of the 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. This is done because of the finite resource limitation. The AI team wants to focus the JONs and the subsequent corrective actions on those causal (root cause) factors that provide the biggest return on investment of resources to fix.

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 team 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.

Significance of the causal factors may be determined by the "Nominal Group Technique," during which the team simply votes on the most significant causal factors. By this point in the investigation, the team should be knowledgeable about the event, and their instincts may provide a reliable source of accurate information. The team votes for the causal factors that they feel contributed the most to the event, and the causal factors receiving the most votes win.

Validate each significant or key causal factor by asking the question, "If it was fixed, would it break the chain that caused the event?" Indicate significant causal factors on the CFA Chart using red boxes, and indicate key contributing causal factors with yellow boxes. Many significant factors and causes may be indicated, and each requires a Corrective Action.

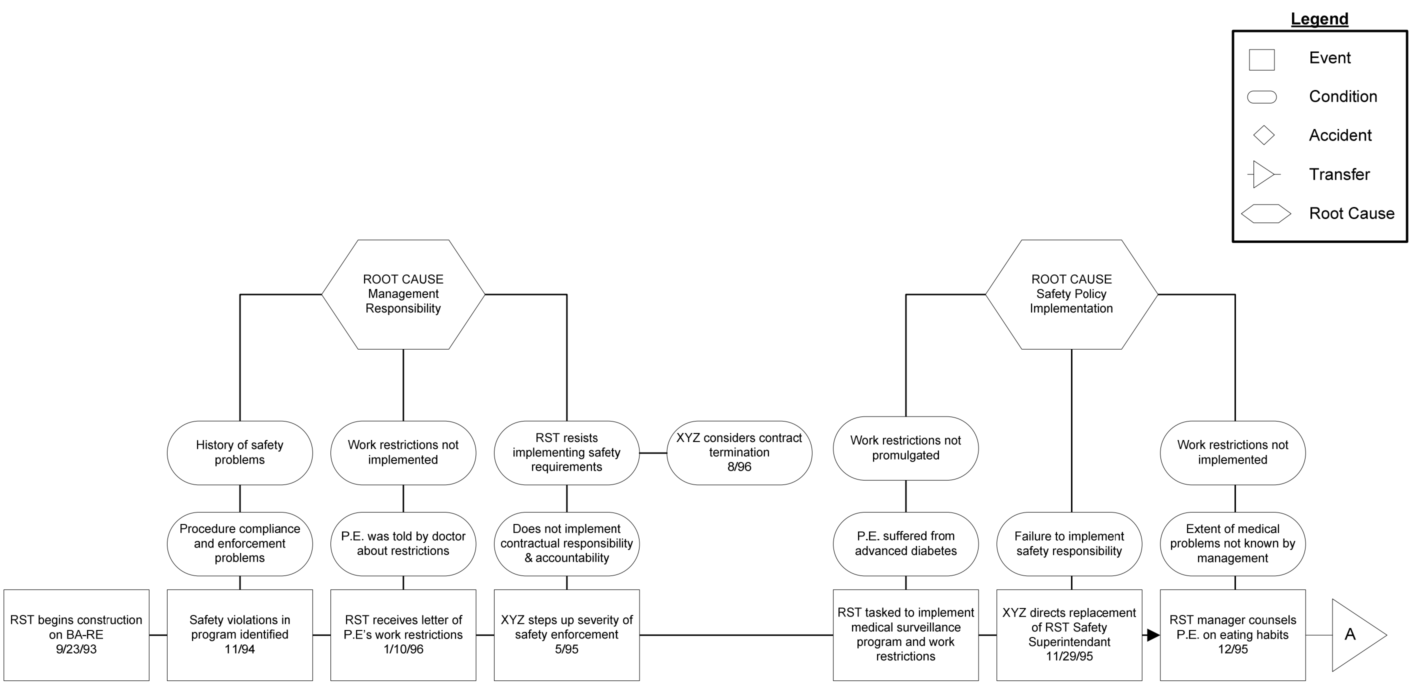


Figure 2-15: Grouping Root Causes on the Events and Causal Factors Chart

2.6.11 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 2-

17, 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.

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 not 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.

Table 2-17: Compliance/Noncompliance Root Cause Model Categories

Don't Know		Can't Comply		Won't Comply	
Never Knew	This is often an indication of poor training or failure in a work system to disseminate guidance to the working level.	Scarce Resources	Lack of funding is a common rebuttal to questions regarding noncompliance. However, resource allocation requires decision-making and priority-setting at some level of management. Boards should consider this line of inquiry when examining root causes pertaining to noncompliance issues.	No Reward	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.
Forgot	This is usually a local, personal error. It does not reflect a systemic deficiency, but may indicate a need to increase frequency of training or to institute refresher training.	Don't Know How	This issue focuses on lack of knowledge (i.e., the know-how to get a job done).	No Penalty	This issue focuses on whether sanctions can force compliance, if enforced.
Tasks Implied	This is often a result of lack of experience or lack of detail in guidance.	Impossibility	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?	Disagree	In some cases, individuals refuse to perform to a standard or comply with a requirement that they disagree with or think is impractical. Investigators will have to consider this in their collection of evidence and determination of root causes.

2.6.12 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 pull-down 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.

Analytical software packages can help the board:

- Remain focused during the investigation
- Identify interrelationships among data
- Eliminate irrelevant data
- Identify causal factors (most significantly, root causes).

The graphics design features of many of these software packages can also be quite useful to the Accident Investigation Board. With a 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.

2.7 Developing Conclusions and Judgments of Need to "Prevent" Accidents in the Future

Conclusions and Judgments of Need are key elements of the investigation that must be developed by the Board.

2.7.1 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.

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

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 cause to the accident.
- Welds did not fail during the steam 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.

2.7.2 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 Office of Corporate Safety Programs.

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.

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.

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 2-12 demonstrates how this information can be arranged to provide an ongoing assessment of linkages among the four elements. Using this diagrammed verification analysis 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.

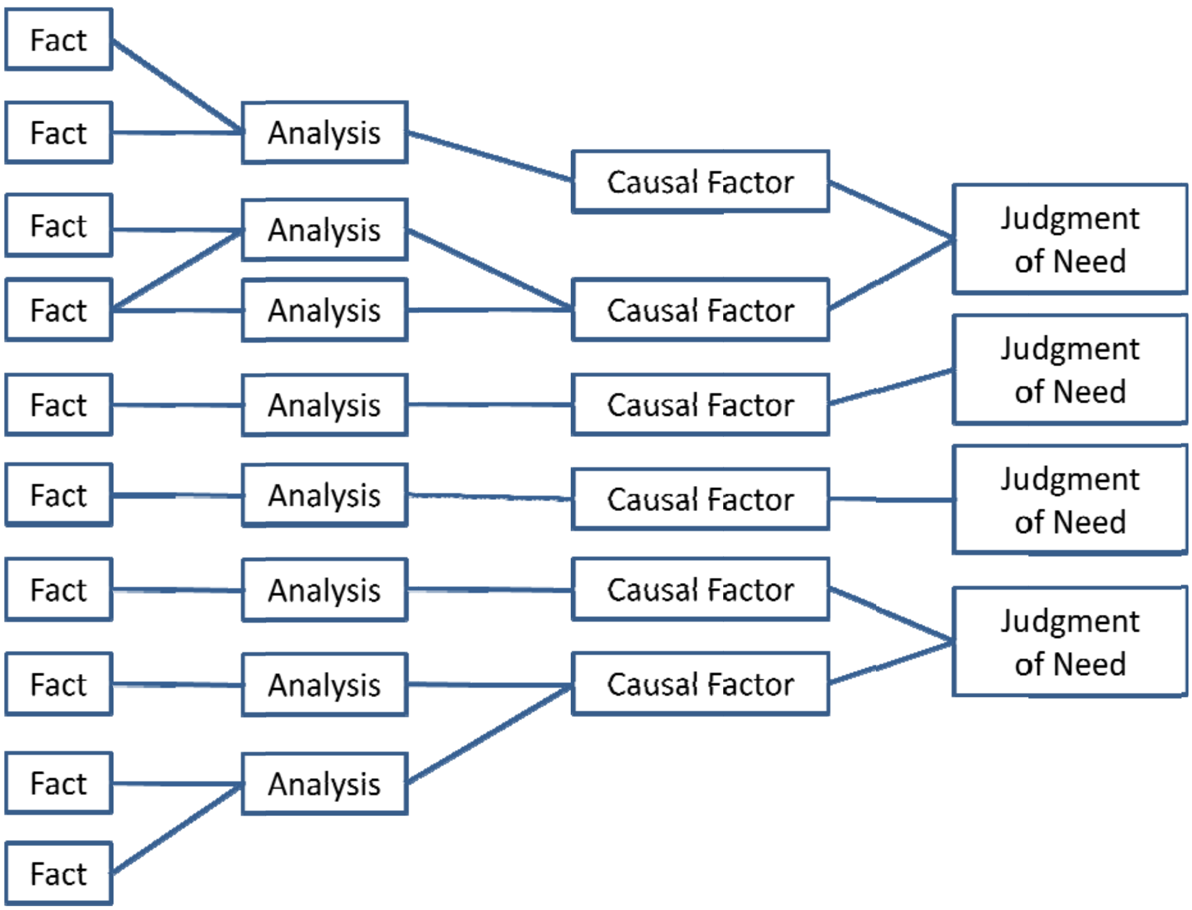


Figure 2-16: Facts, Analyses, and Causal Factors are needed to Support Judgments of Need

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

Once the Board has identified the Judgments of Need derived from their investigation activities, the members can begin writing statements documenting these judgments. Table 2-18 presents guidance on writing these statements.

Table 2-18: 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 2-19 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 2-19: Case Study: Judgments of Need

Significant Facts	Causal Factors	Judgments of Need
Safety training for the accident victim as required by XYZ 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.	XYZ management needs to evaluate the effectiveness of implementation of the training program by observing and measuring workplace performance.

Significant Facts	Causal Factors	Judgments of Need
The standing work order system normally used for non-routine, non-repetitive tasks was used to authorize the work involved in the accident.	Using the standing work order process, normally used for routine tasks, to accomplish non-routine, 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.

2.7.3 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;
- Needs to evaluate the analyses conducted and consider using different analytical techniques; or
- Disagrees on the linkages among facts, analyses and causal factors.

When this disagreement occurs, additional information may be needed to resolve these conflicts. 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 2.8.11.

2.8 Reporting the Results

The purpose of the investigation report is to clearly and concisely convey the results of the investigation. The content should 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.

2.8.1 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 that provides the affected site and the DOE complex as a whole with the basis for developing the corrective actions and lessons learned necessary to prevent or minimize the severity of a recurrence.

Previous Boards have conducted thorough and competent accident investigations, yet failed to effectively communicate the results in the report. As a result, the conclusions, Judgments of Need and lessons learned can appear unsupported or are lost in a mass of detail.

The report writing process is interactive, but must maintain a focused objective. Guidelines for drafting a report, provided in Table 2-20, will help the Board work within the investigation cycle and schedule to maximize their efficiency and effectiveness in developing a useful report.

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

Table 2-20: 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 2.8.2). 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.

2.8.2 Report Format and Content

The investigation report should consist of the elements listed in Table 2-21. Although DOE O 225.1B 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.

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.

Table 2-21: The Accident Investigation Report Should Include these Items

EXAMPLE: TABLE OF CONTENTS

EXAMPLE: EXHIBITS, FIGURES AND TABLES

The following are brief descriptions and acceptable examples of the elements of a typical accident investigation report.

2.8.3 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.

EXAMPLE: DISCLAIMER

This report is an independent product of the Federal Accident Investigation Board appointed by [Name], Chief Health, Safety and Security Officer.

The Board was appointed to perform a Federal investigation of this accident and to prepare an investigation report in accordance with DOE Order 225.1B, *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.

2.8.4 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 O 225.1B 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 Federal 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 analyses, identification of direct, contributing, and root causes, and Judgments of Need reached during the investigation were performed in accordance with DOE Order 225.1B, *Accident Investigations*. I accept the findings of the Board and authorize the release of this report for general distribution.

Signed,

[Name]

Title

Office

2.8.5 Acronyms and Initialisms

The use of acronyms and initialisms is common among DOE staff and contractors. However, to a reader outside the Department, the use of such terms without adequate definition can be frustrating and hinder understanding. Acronyms and initialisms should be kept to a minimum. Proliferation of acronyms makes it difficult, for 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. This element of the report assists readers by identifying, in alphabetical order, terms and acronyms used in the report (see example below). In addition, if necessary, a glossary of technical terms should follow this section.

EXAMPLE: ACRONYMS AND INITIALISMS

CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EM	DOE Office of Environmental Management
ES&H	Environment, Safety and Health
HSS	Office of Health, Safety and Security
M&O	Management and Operating
OSHA	Occupational Safety and Health Administration

2.8.6 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.

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.

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 re-establish 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.

2.8.7 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.

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.

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. In other words, if this was the only part of the report that was read, what are the three or four most important things you want the reader to come away with?

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 450.4A.

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.

EXAMPLE: EXECUTIVE SUMMARY (continued)	
Table 1. Conclusions and Judgments of Need	
Conclusions	**Judgments of Need**
• Comprehensive safety requirements existed, were contractually invoked, and were appropriate for the nature of [Facility] construction work.	None
• [Subcontractor] failed to follow procedures required by its contract and by its ES&H Program Plan, including: • [Subcontractor] failed to adequately implement fall protection requirements contained in its ES&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. • The worker was not wearing any fall protection equipment and did not obtain a direct reading dosimeter before entering the radiological control area.	[Subcontractor] line management and safety personnel need to implement existing safety requirements and procedures.
• [Subcontractor] and [Contractor] did not fully implement the hazard inspection requirements of the [Facility] contract and [Subcontractor's] ES&H Program Plan, and therefore did not sufficiently identify or analyze hazards and institute protective measures necessary due to changing conditions.	[Subcontractor] and [Contractor] need to ensure that an adequate hazard analysis is performed prior to changes in work tasks that affect the safety and health of personnel.

2.8.8 Introduction

The Introduction 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.

Site and facility diagrams and organizational charts for relevant management systems may be appropriate in either the Introduction or the Facts and Analysis section. However, include this information only when it is needed to clarify the accident's context and the role of related organizations.

EXAMPLE:

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 an Accident Investigation Board to investigate the accident, in accordance with DOE Order 225.1B, *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 450.4A.
- 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.

2.8.9 Facts and Analysis

The Facts and Analysis 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. 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. The Facts and Analysis section 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).
- **Accident Description and Chronology subsection.** A subsection describing the accident and chronology of events should be first in the Facts and Analysis section of the report. 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. 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.

Description and Analysis of Facts subsections. 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 2-22 illustrates this distinction.

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.

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 on the next page.

Table 2-22: Facts Differ from Analysis

Facts	Analysis
• At 9:30 a.m. the outside temperature was 36° F and the sky was clear.	• Meteorological conditions at the time of the accident did not contribute to the accident.
• 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.	• The alternate work authorization process was not adequate to assure worker safety.

EXAMPLE: DESCRIPTION AND ANALYSIS OF FACTS

3.0 FACTS AND ANALYSIS

3.3 PHYSICAL HAZARDS, CONTROLS, AND RELATED FACTORS

3.3.1 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.

3.12 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:

3.13 EVENTS AND CAUSAL FACTORS ANALYSIS

3.13.1 Direct Cause of the accident: fall from an unprotected platform. However, there were also contributing causes and root causes.

3.13.2 Contributing causes for the accident:

- 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.

3.13.3 Root Causes of the accident:

- **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 hazard analysis, required by the Industrial Hygiene 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 by 10 C.F.R. 831 and the ES&H 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.

2.8.10 Conclusions and Judgments of Need

The Conclusions and Judgments of Need 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 2.7). 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 in the Example.

EXAMPLE:

4.0 CONCLUSIONS AND JUDGMENTS OF NEED

This section of the report identifies the conclusions and Judgments of Need determined by the Board, as a result of using the analysis methods described in Section 3.0. Conclusions of the Board consider significant facts, causal factors, and pertinent analytical results. Judgments of Need are managerial controls and safety measures believed necessary to prevent or mitigate the probability or severity of a recurrence. They flow from the causal factors and are directed at guiding managers in developing follow-up actions. Table 4-11 identifies the conclusions and the corresponding Judgments of Need identified by the Board.

Table 4-1. Conclusions and Judgments of Need

CONCLUSIONS	JUDGMENTS OF NEED
• Comprehensive safety requirements existed, were contractually invoked, and were appropriate for the nature of construction work.	None
• [Subcontractor] failed to follow procedures required by its contract and by its ES&H Program Plan, including: • [Subcontractor] failed to adequately implement fall protection requirements contained in its ES&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.	[Subcontractor] line management and safety personnel need to implement existing safety requirements and procedures.
• 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. • [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&H Program Plan. • [Contractor] failed to recognize that warning signs and barriers were not in place in the work area near the platform.	[Subcontractor] and [Contractor] need to ensure that safety personnel inspect changing work conditions for previously unidentified safety and health hazards, and implement protective measures.

2.8.11 Minority Report

If used, the Minority Report 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.

2.8.12 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 on the next page. This page also indicates whether each Board member is a DOE accident investigator.

EXAMPLE:

5.0 BOARD SIGNATURES

Signed ______________________ Date Dated ____________

[Name], Board Chairperson
U.S. Department of Energy, HQ

Signed ______________________ Date Dated ____________

[Name], Board Member
DOE Accident Investigator
U.S. Department of Energy, Savannah River Site Office

Signed ______________________ Date Dated ____________

[Name], Board Member
DOE Accident Investigator
U.S. Department of Energy, Oak Ridge Operations Office

Signed ______________________ Date Dated ____________

[Name], Board Member
Accident Investigator
U.S. Department of Energy, Idaho Operations Office

Signed ______________________ Date Dated ____________

[Name], Board Member
U.S. Department of Energy, Idaho Operations Office

2.8.13 Board Members, Advisors, Consultants, and Staff

The investigation team participants section lists the names of the Board members, advisors, and staff, indicating their employers and their positions with respect to the accident investigation.

EXAMPLE:

6.0 BOARD MEMBERS, ADVISORS, CONSULTANTS, AND STAFF

Chairperson [Name], DOE
Member [Name], DOE
Member [Name], DOE
Member [Name], DOE
Member [Name], DOE

Advisor [Name], DOE
Advisor [Name], DOE
Advisor [Name], DOE
Advisor [Name], DOE
Advisor [Name], Consultant

Medical Advisor[Name], M.D., Consultant
Legal Advisor [Name], DOE

Administrative Coordinator [Name], XYZ Corporation

Technical Writer [Name], XYZ Corporation

Technical Writer [Name], XYZ Corporation

Administrative Support [Name], DOE

2.8.14 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.

2.9 Performing Verification Analysis, 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 Board Chairperson should plan and schedule sufficient time for these reviews to maintain the appropriate investigation cycle. The following are further considerations for quality review of the report.

2.9.1 Structure and Format

The report should be reviewed to ensure that it follows the format and contains the information outlined in Section 2.8, which ensures compliance with the intent of Paragraph 4.c. (3) of DOE O 225.1B. 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.

2.9.2 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.

2.9.3 Verification Analysis

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 verification analysis determines whether the flow from facts to analysis to causal factors to JON 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.

One approach to verification analysis is to compare the facts, analysis, causal factors, and JON on an ECF wall chart; and validate the continuity of facts through the analysis and causal factors to the JON. This method also identifies any misplaced facts, insufficient analyses, and unsupported CON or JON.

If a clear, defensible linkage of a CON/JON cannot be supported by the facts and analysis from the ECF chart, consider re-working the CON/JON or dropping it from the report.

2.9.4 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. 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.

2.9.5 Factual Accuracy Review

The facts presented in the Facts and Analysis section of the final draft report should be reviewed and validated for accuracy by the affected DOE and contractor line management before the final report is submitted to the appointing official for acceptance. 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 open review of the facts is consistent with the focus on fixing system deficiencies, rather than fixing blame 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. Forms useful for the implementation of a Factual Accuracy Review such as, *Example Cover Sheet For Facts Section*, *Example Factual Accuracy Room Sign*, and *Example Sign-in Sheet for Factual Accuracy Review*, are included in Appendix D.5 *Factual Accuracy Review*.

Comments and revisions from DOE and contractor management are incorporated into the draft final report, as appropriate.

2.9.6 Review by the Chief Health, Safety and Security Officer

DOE O 225.1B requires review of accident investigation reports by the Chief Health, Safety and Security Officer (HS-1). Federal 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 HSS AI Program Manager.

2.9.7 Document the Reviews in the Records

Documentation that these reviews have been completed should be retained in the permanent investigation file.

Glossary

Accident: An unwanted transfer of energy or an environmental condition that, 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.

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 investigations, with responsibilities as prescribed in DOE O 225.1B.

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.

Critical Process Step: A step in the process where potential threats could interact with the hazard that could be released. For accident analysis, the absence of hazards or threads in a process step makes it a non-critical step.

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 Federal 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 Corporate Safety Programs.

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.