Accident Investigation

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INTRODUCTION

Thousands of accidents occur throughout the United States every day. The failure of people, equipment, supplies, or surroundings to behave or react as expected cause most of the accidents. Accident investigations determine how and why these failures occur. By using the information gained through an investigation, a similar or perhaps more disastrous accident may be prevented. Conduct accident investigations with accident prevention in mind. Investigations are NOT to place blame.

An accident is any unplanned event that results in personal injury or in property damage. When the personal injury requires little or no treatment, it is minor. If it results in a fatality or in a permanent total, permanent partial, or temporary total (lost-time) disability, it is serious. Similarly, property damage may be minor or serious. Investigate all accidents regardless of the extent of injury or damage.

Accidents are part of a broad group of events that adversely affect the completion of a task. These events are incidents. For simplicity, the procedures discussed in later sections refer only to accidents. They are, however, also applicable to incidents.

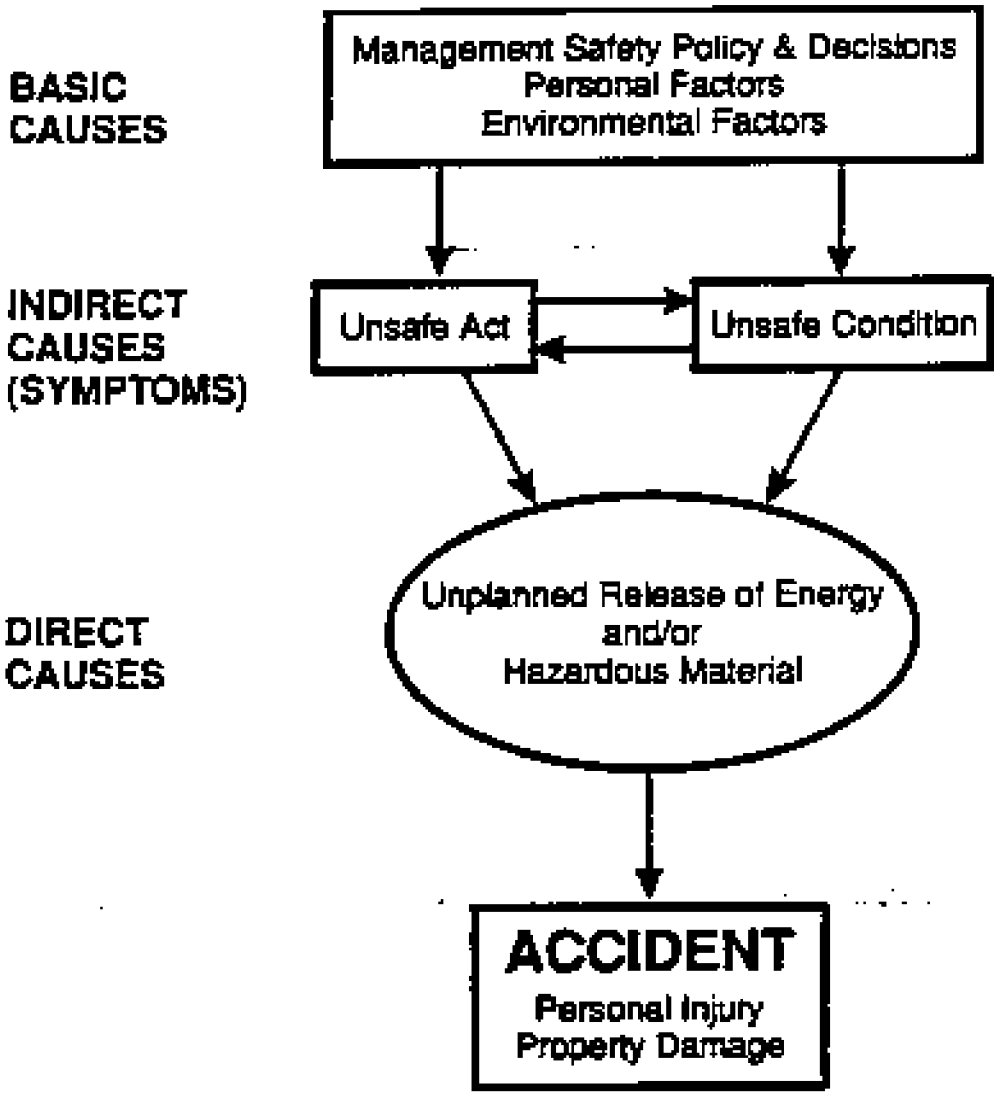
This discussion introduces the reader to basic accident investigation procedures and describes accident analysis techniques.

ACCIDENT PREVENTION

Accidents are usually complex. An accident may have 10 or more events that can be causes. A detailed analysis of an accident will normally reveal three cause levels: basic, indirect, and direct. At the lowest level, an accident results only when a person or object receives an amount of energy or hazardous material that cannot be absorbed safely. This energy or hazardous material is the DIRECT CAUSE of the accident. The direct cause is usually the result of one or more unsafe acts or unsafe conditions, or both. Unsafe acts and conditions are the INDIRECT CAUSES or symptoms. In turn, indirect causes are usually traceable to poor management policies and decisions, or to personal or environmental factors. These are the BASIC CAUSES.

In spite of their complexity, most accidents are preventable by eliminating one or more causes. Accident investigations determine not only what happened, but also how and why. The information gained from these investigations can prevent recurrence of similar or perhaps more disastrous accidents. Accident investigators are interested in each event as well as in the sequence of events that led to an

accident. The accident type is also important to the investigator. The recurrence of accidents of a particular type or those with common causes shows areas needing special accident prevention emphasis.



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INVESTIGATIVE PROCEDURES

The actual procedures used in a particular investigation depend on the nature and results of the accident. The agency having jurisdiction over the location determines the administrative procedures. In general, responsible officials will appoint an individual to be in charge of the investigation. The investigator uses most of the following steps:

1. Define the scope of the investigation.

2. Select the investigators. Assign specific tasks to each (preferably in writing).

3. Present a preliminary briefing to the investigating team, including:

    a. Description of the accident, with damage estimates.

    b. Normal operating procedures.

    c. Maps (local and general).

    d. Location of the accident site.

    e. List of witnesses.

    f. Events that preceded the accident.

4. Visit the accident site to get updated information.

5. Inspect the accident site.

    a. Secure the area. Do not disturb the scene unless a hazard exists.

    b. Prepare the necessary sketches and photographs. Label each carefully and keep accurate records.

6. Interview each victim and witness. Also interview those who were present before the accident and those who arrived at the site shortly after the accident. Keep accurate records of each interview. Use a tape recorder if desired and if approved.

7. Determine
    a. What was not normal before the accident.
    b. Where the abnormality occurred.

c. When it was first noted.
d. How it occurred.

8. Analyze the data obtained in step 7. Repeat any of the prior steps, if necessary.

9. Determine
   a. Why the accident occurred.
   b. A likely sequence of events and probable causes (direct, indirect, basic).
   c. Alternative sequences.

10. Check each sequence against the data from step 7.

11. Determine the most likely sequence of events and the most probable causes.

12. Conduct a post-investigation briefing.

13. Prepare a summary report, including the recommended actions to prevent a recurrence. Distribute the report according to applicable instructions.

An investigation is not complete until all data are analyzed and a final report is completed. In practice, the investigative work, data analysis, and report preparation proceed simultaneously over much of the time spent on the investigation.

FACT-FINDING

Gather evidence from many sources during an investigation. Get information from witnesses and reports as well as by observation. Interview witnesses as soon as possible after an accident. Inspect the accident site before any changes occur. Make photographs and sketches of the accident scene. Record all pertinent data on maps. Get copies of all reports. Documents containing normal operating procedures, flow diagrams, maintenance charts, or reports of difficulties or abnormalities are particularly useful. Keep complete and accurate notes in a bound notebook. Record pre-accident conditions, the accident sequence, and post-accident conditions. In addition, document the location of victims, witnesses, machinery, energy sources, and hazardous materials.

In some investigations, a particular physical or chemical law, principle, or property may explain a sequence of events. Include laws in the notes taken during the investigation or in the later analysis of data. In addition, gather data during the investigation that may lend itself to analysis by these laws, principles, or properties. An appendix in the final report can include an extended discussion.

INTERVIEWS

In general, experienced personnel should conduct interviews. If possible, the team assigned to this task should include an individual with a legal background. In conducting interviews, the team should:

1. Appoint a speaker for the group.

2. Get preliminary statements as soon as possible from all witnesses.

3. Locate the position of each witness on a master chart (including the direction of view).

4. Arrange for a convenient time and place to talk to each witness.

5. Explain the purpose of the investigation (accident prevention) and put each witness at ease.

6. Listen, let each witness speak freely, and be courteous and considerate.

7. Take notes without distracting the witness. Use a tape recorder only with consent of the witness.

8. Use sketches and diagrams to help the witness.

9. Emphasize areas of direct observation. Label hearsay accordingly.

10. Be sincere and do not argue with the witness.

11. Record the exact words used by the witness to describe each observation. Do not "put words into a witness' mouth."

12. Word each question carefully and be sure the witness understands.

13. Identify the qualifications of each witness (name, address, occupation, years of experience, etc.).

14. Supply each witness with a copy of his or her statements. Signed statements are desirable.

After interviewing all witnesses, the team should analyze each witness' statement. They may wish to re-interview one or more witnesses to confirm or clarify key points. While there may be inconsistencies in witnesses' statements, investigators should assemble the available testimony into a logical order. Analyze this information along with data from the accident site.

Not all people react in the same manner to a particular stimulus. For example, a witness within close proximity to the accident may have an entirely different story from one who saw it at a distance. Some witnesses may also change their stories after they have discussed it with others. The reason for the change may be additional clues.

A witness who has had a traumatic experience may not be able to recall the details of the accident. A witness who has a vested interest in the results of the investigation may offer biased testimony. Finally, eyesight, hearing, reaction time, and the general condition of each witness may affect his or her powers of observation. A witness may omit entire sequences because of a failure to observe them or because their importance was not realized.

PROBLEM SOLVING TECHNIQUES

Accidents represent problems that must be solved through investigations. Several formal procedures solve problems of any degree of complexity. This section considers these problem solving procedures.

The Scientific Method

The scientific method forms the basis of nearly all problem solving techniques. It is used for conducting research. In its simplest form, it involves the following sequence: making observations, developing hypotheses, and testing the hypotheses.

Even a simple research project may involve many observations. A researcher records all observations immediately. A good investigator must do the same thing. Where possible, the observations should involve quantitative measurements. Quantitative data are often important in later development and testing of the hypotheses. Such measurements may require the use of many instruments in the field as well as in the laboratory.

When making observations, the investigator develops one or more hypotheses that explain the observations. The hypothesis may explain only a few of the observations or it may try to explain all of them. At this stage, the hypothesis is merely a preliminary idea. Even if rejected later, the investigator has a goal toward which to proceed.

Test the hypothesis against the original observations. A series of controlled experiments is often useful in performing this evaluation. If the hypothesis explains all of the observations, testing may be a simple process. If not, either make additional observations, change the hypothesis, or develop additional hypotheses.

As with scientific research, the most difficult part of any investigation is the formulation of worthwhile hypotheses. Use the following three principles to simplify this step:

1. The principle of agreement.

An investigator uses this principle to find one factor that associates with each observation.

2. The principle of differences.
This principle is based on the idea that variations in observations are due only to differences in one or more factors.

3. The principle of concomitant variation.
This principle is the most important because it combines the ideas of both of the preceding principles. In using this principle, the investigator is interested in the factors that are common as well as those that are different in the observations.

In using the scientific method, the investigator must be careful to eliminate personal bias. The investigator must be willing to consider a range of alternatives. Finally, he or she must recognize that accidents often result from the chance occurrence of factors that are too numerous to evaluate fully.

Change Analysis

As its name implies, this technique emphasizes change. To solve a problem, an investigator must look for deviations from the norm. As with the scientific method, change analysis also follows a logical sequence. It is based on the principle of differences described in the discussion of the scientific method. Consider all problems to result from some unanticipated change. Make an analysis of the change to determine its causes. Use the following steps in this method:

1. Define the problem (What happened?).

2. Establish the norm (What should have happened?).

3. Identify, locate, and describe the change (What, where, when, to what extent).

4. Specify what was and what was not affected.

5. Identify the distinctive features of the change.

6. List the possible causes.

7. Select the most likely causes.

Sequence Diagrams

Gantt charts are sequence diagrams. Use them for scheduling investigative procedures. They can also aid in the development of the most probable sequence of events that led to the accident. Such a chart is especially useful in depicting events that occurred simultaneously.

Gross Hazard Analysis

Perform a gross hazard analysis (GHA) to get a rough assessment of the risks involved in performing a task. It is "gross" because it requires further study. It is particularly useful in the early stages of an accident investigation in developing hypotheses. A GHA will usually take the form of a logic diagram or table. In either case, it will contain a brief description of the problem or accident and a list of the situations that can lead to the problem. In some cases, analysis goes a step further to determine how the problem could occur. A GHA diagram or table thus shows at a glance the potential causes of an accident. One of the following analysis techniques can then expand upon a GHA.

Job Safety Analysis

Job safety analysis (JSA) is part of many existing accident prevention programs. In general, JSA breaks a job into basic steps, and identifies the hazards associated with each step. The JSA also prescribes controls for each hazard. A JSA is a chart listing these steps, hazards, and controls. Review the JSA during the investigation if a JSA has been conducted for the job involved in an accident. Perform a JSA if one is not available. Perform a JSA as a part of the investigation to determine the events and conditions that led to the accident.

Failure Mode and Effect Analysis

Failure mode and effect analysis (FMEA) determines where failures occurred. Consider all items used in the task involved in the accident. These items include people, equipment, machine parts, materials, etc. In the usual procedure, FMEA lists each item on a chart. The chart lists the manner or mode in which each item can fail and determines the effects of each failure. Included in the analysis are the effects on other items and on overall task performance. In addition, make evaluations about the risks associated with each failure. That is, project the chance of each failure and the severity of its effects. Determine the most likely failures that led to the accident. This is done by comparing these projected effects and risks with actual accident results.

Fault Tree Analysis

Fault tree analysis (FTA) is a logic diagram. It shows all the potential causes of an accident or other undesired event. The undesired event is at the top of a "tree." Reasoning backward from this event, determine the circumstances that can lead to the problem. These circumstances are then broken down into the events that can lead to them, and so on. Continue the process until the identification of all events can produce the undesired event. Use a logic tree to describe each

of these events and the manner in which they combine. This information determines the most probable sequence of events that led to the accident.

REPORT OF INVESTIGATION

As noted earlier, an accident investigation is not complete until a report is prepared and submitted to proper authorities. Special report forms are available in many cases. Other instances may require a more extended report. Such reports are often very elaborate and may include a cover page, a title page, an abstract, a table of contents, a commentary or narrative portion, a discussion of probable causes, and a section on conclusions and recommendations.

The following outline has been found especially useful in developing the information to be included in the formal report:

1. Background Information
    a. Where and when the accident occurred
    b. Who and what were involved
    c. Operating personnel and other witnesses
2. Account of the Accident (What happened?)
    a. Sequence of events
    b. Extent of damage
    c. Accident type
    d. Agency or source (of energy or hazardous material)
3. Discussion (Analysis of the Accident - **HOW; WHY**)
    a. Direct causes (energy sources; hazardous materials)
    b. Indirect causes (unsafe acts and conditions)
    c. Basic causes (management policies; personal or environmental factors)
4. Recommendations (to prevent a recurrence) for immediate and long-range action to remedy:

a. Basic causes

b. Indirect causes

c. Direct causes (such as reduced quantities or protective equipment or structures)

SUMMARY

Thousands of accidents occur daily throughout the United States. These result from a failure of people, equipment, supplies, or surroundings to behave as expected. A successful accident investigation determines not only what happened, but also finds how and why the accident occurred. Investigations are an effort to prevent a similar or perhaps more disastrous sequence of events.

Most accident investigations follow a research technique called the scientific method. This method involves gathering and analyzing facts, and developing hypotheses to explain these facts. Each hypothesis must be tested against the facts, and the most probable explanation of the accident needs to be selected. Any one of several problem solving techniques based on this approach may be used. An investigation is not complete however, until completion of a final report. Responsible officials can then use the resulting information and recommendations to prevent future accidents.