Systems of Safety and Introduction to Logic Tree Diagraming

First Edition

Written and Produced by

The Rutgers Occupational Training and Education Consortium (OTEC)
and New Labor

For the University of Medicine & Dentistry of New Jersey (UMDNJ),
School of Public Health, Office of Public Health Practice

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OTEC/LOSHI

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OTEC partners with unions, employers and other organizations to develop innovative training programs that work toward strengthening the existing systems of safety in the workplace. Relying on participatory educational models, OTEC is committed to building a lasting "culture of safety" in workplaces in New Jersey and around the country.

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LOSHI was established by OTEC and New Labor. Through partnerships with employers, staffing firms, unions and community and faith based organizations LOSHI has developed a series of comprehensive site-specific safety and health training programs, trained over 100 worker-trainers and delivered thousands of hours of training to Latino workers throughout New Jersey.

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New Labor

New Labor is an alternative model of worker organization that combines new and existing strategies to improve working conditions and provide a voice for immigrant workers in central New Jersey. Adapting to changes in the economy, New Labor strategically utilizes worker advocacy, customized training, and grassroots enterprises to leverage members' interests at work and in their communities. Since its founding in January of 2000, New Labor has grown to over 1,400 dues paying members and provides important solutions to the challenges faced by low-wage workers in today's economy.

Visit New Labor's website at www.newlabor.net

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The Small Group Activity Method

Basic Structure
The Small Group Activity Method* is based on activities. An activity can take from 45 minutes to an hour. Each Activity has a common basic structure:

- **Small Group Tasks**
- **Report-Back**
- **Summary**

1. Small Group Tasks: Activities include tasks (problems), or sets of tasks, for the groups to work on. Each task asks that groups use their experience and the factsheets to solve problems and make judgments on key issues.

2. Report-Back: For each task, groups select scribes that take notes on the small group discussions and report back to the class as a whole. During the report-back the scribe informs the entire class as to how his or her group solved the particular problem. The trainer records each scribes report-back on large pads of paper in front of the class so that everyone can refer to them.

3. Summary: Before the discussion drifts too far, the trainer needs to bring it all together during the summary. Here, the trainer highlights the key points of the Activity and brings up any problems or points that may have been overlooked during the report-back.

**The Small Group Activity Method (SGAM) is based on a training procedure developed by England's Trades Union Congress (TUC) in the 1970s. The Labor Institute and Oil, Chemical, and Atomic Workers Union (now part of the United Steelworkers Union) used a similar method around economic and health and safety issues for workers and further developed the procedure into SGAM.*

Three Basic Learning Exchanges
The Small Group Activity Method is based on the idea that every training is a place where learning is shared. With SGAM, learning is not a one-way street that runs from trainer to worker. Rather SGAM is a structured procedure that allows us to share information. It is based on three learning exchanges:

- **Worker-to-Worker**
- **Worker-to-Trainer**
- **Trainer-to-Worker**

Worker-to-Worker: Most of us learn best from each other. SGAM is structured so that the worker-to-worker exchange is a key element of the training. The worker-to-worker exchange allows participants to learn from each other by solving problems in their small groups.

Worker-to-Trainer: Lecture-style training assumes that the trainer knows all the answers. With SGAM it is understood that the trainers also have a lot to learn and this is the purpose of the worker-to-trainer exchange. It occurs during the report-back and it is designed to give the trainer an opportunity to learn from the participants.

Trainer-to-Worker: This is the trainer's opportunity to clear up confusion and make points they think are key. By waiting until the summary section, trainers know better what people need to know.

Activity 1: Hazard Mapping

Purpose

To begin the process of analyzing areas in our facility where the risks of accidents and injuries are greatest.

This Activity has one task.

Task

In your groups choose a scribe and review the factsheets on pages 4-9. The factsheets will help you learn about hazard mapping and how it can be used to help you identify the areas in your facility where the risks of accidents and injuries are greatest.

Then based on your own experience and the factsheets use the sheet of paper and markers and follow steps 1-5 on the next page to help you create your hazard map. Write large and use the entire sheet of paper for your map. Use the factsheets to help you label and describe the specific hazard areas.

Step 1:
Make a drawing on the sheet of paper that shows the basic layout of your facility. (See Factsheet 6, page 9 for an example of what a hazard map looks like.)

Step 2:
Identify the hazards in each area of the facility using a color-coded circle on the map. (See Factsheets 3-4 on pages 6-7.)

Step 3:
Rate each hazard on a scale of 1 to 4 (See Factsheets 3-4 on pages 6-7)

Step 4:
Label each hazard with a name or brief description. (See Factsheets 5-6, on pages 8-9.)

Step 5:
Based on your map make a list of the hazards that concern you the most and be ready to tell us why these hazards are a concern for your group.

1. Use Hazard Mapping to Identify Problems

A Hazard Map is a visual representation of the workplace that identifies where there are hazards that could cause injuries. For example, a hazard map might look at the following:

- Physical hazards
- Frequency of exposures
- Levels of exposures
- A specific chemical
- Specific workers or job classifications most likely to be exposed

Hazard Maps and Worker Experiences

Hazard mapping draws on what workers know from on-the-job experience. The hazard mapping approach works best when conducted by a small group of workers from the same department or work area.

2. Why Hazard Map?

Hazard mapping can help you identify occupational safety and health hazards. If your workplace has other ways or approaches for identifying hazards, they can be included in your hazard map.

The point of hazard mapping is to gather the knowledge about hazards from your co-workers so you can work together to eliminate and/or reduce the risks of accidents and injuries.

Hazard mapping respects the vast array of skill, experience and knowledge that workers have about their jobs. Hazard mapping requires working together to identify, prioritize and solve problems.

3. Labeling

Hazard Code Key		
●	Blue	**Electrical** Hazards
●	Green	**Chemical** Hazards
●	Orange	**Physical** Hazards (heat, noise, air quality, slippery floors, poor lighting, poorly designed work stations, etc.)
●	Brown	**Flammable/Explosive** Hazards
●	Black	Other Hazards (specify)

Level of Hazard	
1	**Low Hazard**
2	**Medium Hazard**
3	**High Hazard**
4	**Very High Hazard**

4. Examples of Hazard Mapping Labels

Hazard Codes and Levels of Hazards		
2	Blue	**Electrical**—Medium Hazard
3	Green	**Chemical**—High Hazard
2	Orange	**Physical**—Medium Hazard
4	Brown	**Flammable/Explosive**—Very High Hazard
1	Black	Other—Low Hazard

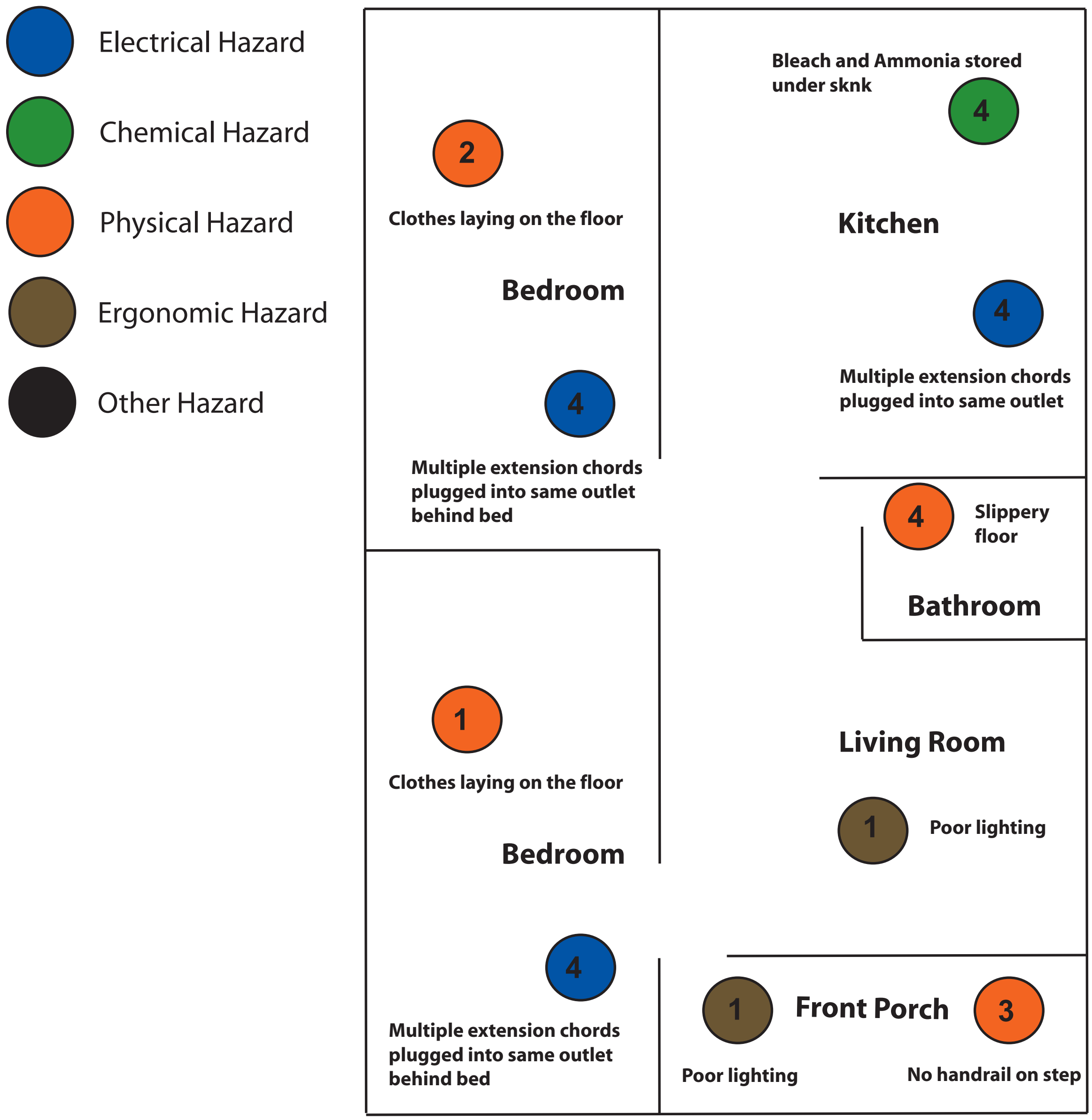
5. Identifying Areas of Concern

Before you begin developing your map, think about where the hazards may exist in your facility.

Potential Facility Hazards	
✓	**Docks:** Injuries happen here when forklifts run off the dock, products fall on employees or equipment strikes a person.
✓	**Forklifts:** About 100 employees are killed and 95,000 injured every year while operating forklifts in all industries. Forklift turnovers account for a significant percentage of these fatalities.
✓	**Conveyors:** Workers can be injured when they are caught in pinch points or in the in-going nip points, are hit by falling products or develop musculoskeletal disorders associated with awkward postures or repetitive motions.
✓	**Materials Storage:** Improperly stored materials may fall and injure workers
✓	**Chemicals:** Chemical burns and/or exposures are possible if spills of hazardous materials occur.
✓	**Forklift Charging Stations:** Fires and explosion risks are possible unless proper guidelines are followed.
✓	**Poor Ergonomics:** improper lifting, repetitive motion or poor design of operations can lead to musculoskeletal disorders in workers.
✓	**Other Hazards:** Inadequate fire safety provisions, improper use of lockout procedures and failure to wear personal protective equipment also create hazards in the workplace.

Source: Occupational Safety and Health Administration (OSHA), *Worker Safety Series, Warehousing*, http://www.osha.gov/Publications/warehousing.html

6. Example of a Home Hazard Map



Summary:

1. A Hazard Map is a visual representation of the workplace where there are hazards that could cause injuries.

2. Hazard mapping can help you identify occupational safety and health hazards.

3. The point of hazard mapping is to gather the knowledge about hazards from your co-workers so you can work together to eliminate and/or reduce the risks of accidents and injuries.

Evaluation

Activity 1: Hazard Mapping

1. How important is this activity for employees at your facility?
Please circle one number.

Activity Is Not Important				**Activity Is Very Important**
1	2	3	4	5

2. Please **put an "X" by the one factsheet** you feel is the most important.

	1. Using Hazard Mapping to Identify Problems		**4.** Examples of Hazard Mapping Labels
	2. Why Hazard Map?		**5.** Identifying Areas of Concern
	3. Labeling		**6.** Example of a Home Hazard Map

3. Which summary point do you feel is most important?
Please circle one number.

Most Important Summary Point				
1.	2.	3.		

4. What would you suggest be done to improve this Activity?

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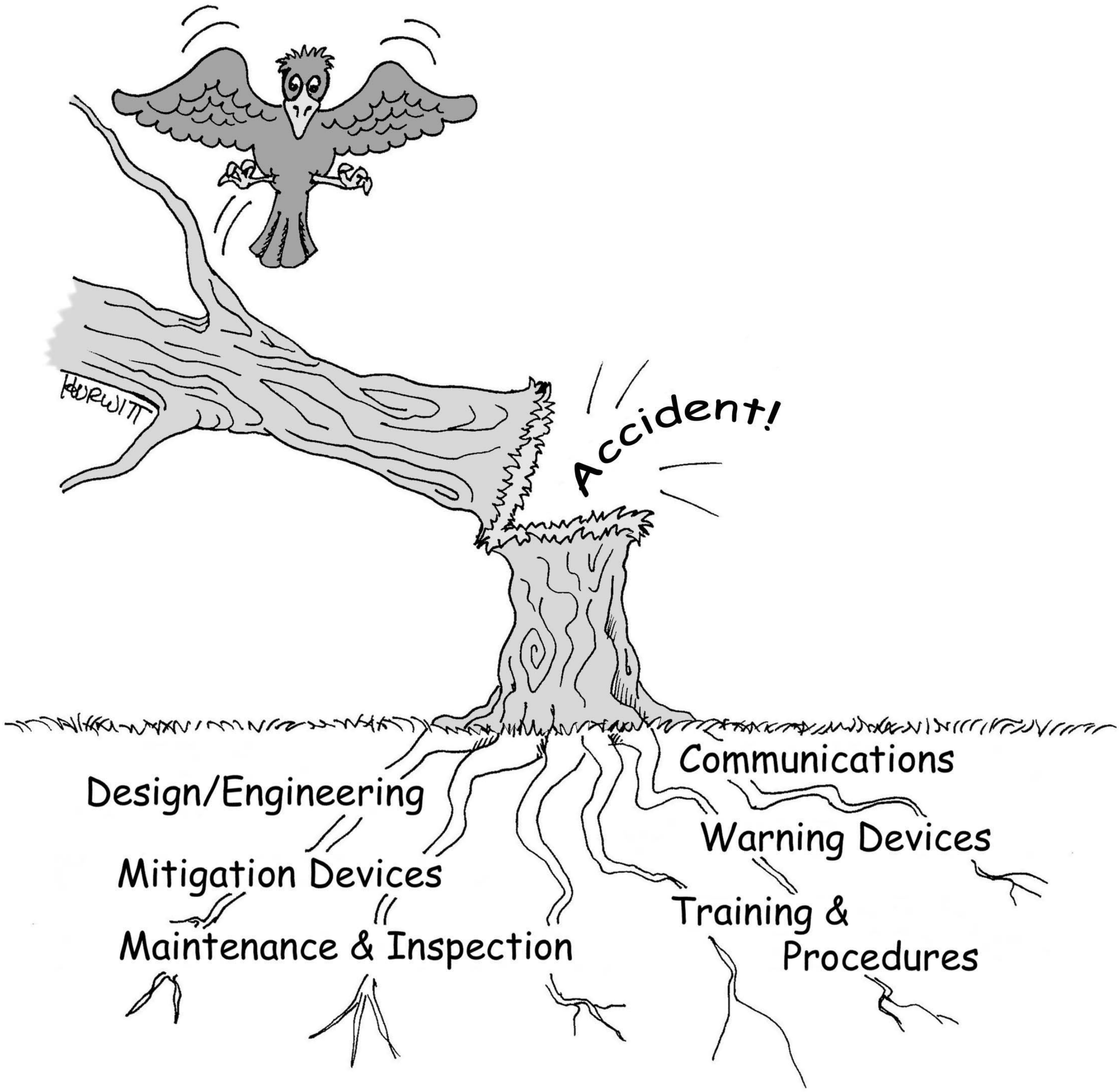
Activity 2: Systems of Safety

Purpose

To introduce the concept of systems of safety and accident prevention.

This Activity has one task.



Systems of Safety is based on an Activity that was originally written by the Labor Institute (a non-profit organization based in New York City) and worker-trainers from the Oil, Chemical and Atomic Workers Union (OCAW).

Task 1

Shortly after midnight on March 24, 1989, the tanker Exxon Valdez ran aground on Bligh Reef in Alaska, spilling 11 million gallons of crude oil. Over 1,500 miles of shoreline were polluted by the spill. Responsibility for the incident was initially placed on the tanker captain, who had been drinking earlier that evening. Captain Hazelwood was disciplined, sued and fired. Further investigation of the accident revealed the following facts:

a. The radar station in the city of Valdez, which was responsible for monitoring the locations of tanker traffic in the treacherous waters of Prince William Sound, had replaced its radar with much less powerful equipment. The location of tankers could not be monitored in the area of Bligh Reef.

b. Congressional approval of the Alaskan oil pipeline and tanker transport network included an agreement by the oil corporations to build and use double-hulled tankers. This would significantly reduce the amount of oil released in an accident. In order to save money, the oil industry generally abandoned the agreement. The Exxon Valdez did not have a double hull.

c. Crew fatigue was typical on the tankers. In 1977, the average oil tanker operating out of Valdez had a crew of 40 people. By 1989, crew size had been cut in half. Crews routinely worked 12- to 14-hour shifts plus extensive amounts of overtime. The Exxon Valdez had arrived in port at 11 p.m. the night before. The crew was rushing to get loaded for departure the next evening.

d. State-of-the-art equipment for monitoring icebergs in shipping lanes was promised by the oil industry, but it was never installed. The Exxon Valdez was traveling outside the normal sea lane in order to avoid icebergs that were thought to be in the area.

e. Although the Coast Guard at Valdez was assigned to conduct safety inspections of the tankers, it did not perform these inspections. Its staff had been cut by one-third.

f. Tanker crews relied on the Coast Guard to plot their location continually. Although the Coast Guard operating manual required this, the area Coast Guard Commander decided it was no longer needed and discontinued tracking the ships all the way out to Bligh Reef. Tanker crews were never informed of the change.

g. Spill response teams and equipment were not maintained. This seriously impaired attempts to contain and recover the spilled oil.

Sources: Fran Locher Freiman and Neil Schlager, *Failed Technology*, Detroit Gale Research Inc., 1994; Art Davidson, *In the Wake of the Exxon Valdez*, San Francisco: Sierra Club Books, 1990.

Task 1 *(continued)*

Review the factsheets on pages 18-26. Then in your groups list the safety systems and sub systems that are flawed in each paragraph above. (Factsheet 1 defines Systems of Safety. Factsheets 2 thru 7 explain each of the systems. Factsheet 8 includes a chart showing all the systems and examples of sub-systems.) **You can list more than one system or flaw for each paragraph.**

Flawed System(s) and Sub-System(s)
a. System(s): Subsystem(s):
b. System(s): Subsystem(s):
c. System(s): Subsystem(s):
d. System(s): Subsystem(s):
e. System(s): Subsystem(s):
f. System(s): Subsystem(s):
g. System(s): Subsystem(s):

1. What Are Systems of Safety?

A efficient systems of safety program outlines in detail how a facility operates safely. It is a proactive program that is designed to prevent injuries from occurring.

Some major systems of safety include :

- Design and Engineering
- Maintenance and Inspection
- Mitigation Devices (i.e., relief valves)
- Warning Devices (i.e., alarms)
- Training and Procedures
- Personal Protective Factors

There are many sub-systems which make up these major systems of safety. For example, refresher training is a sub-system of a facility's training system.

You may have additional systems of safety at your site. They may be organized differently and have different names, but all of our facilities have systems of safety in place.

Source: Adapted in part from Harold Roland and Bian Moriarty, System Safety Engineering and Management, New York: John Wiley and Son, 1983.

2. The Design System

The highest level of hazard prevention is gained by using the Design and Engineering System.

The **organizational side** of Design and Engineering involves how work is organized and the roles people play. It includes:

- Staffing levels
- How resources are used
- How work is assigned and coordinated

The **technical side** of Design and Engineering involves the machinery and processes of work. It includes:

- Process and equipment design and engineering (including redesign)
- Selection of machinery, chemicals and other materials
- Ergonomic design of equipment and control panels
- Reducing the inventory of hazardous materials

Source: Nicholas Ashford, The Encouragement of Technological Change for Preventing Chemical Accidents, Environmental Protection Agency, 1993.

3. The Maintenance and Inspection System

Properly designed equipment can turn into unsafe junk if it isn't appropriately maintained, inspected and repaired. An effective mechanical integrity system should be evaluated by its performance in eliminating the use of breakdown maintenance.

Important elements of the maintenance and inspection system include:

- Keeping spare parts readily available
- Equipment inspections for wear and damage
- Proper training for maintenance employees
- Needed repairs not put off for production requirements
- Use of proper materials, equipment, tools and spare parts including use of a quality control program

4. The Mitigation System

The mitigation system of safety involves the use of equipment that automatically acts to control or reduce the adverse consequences of hazardous incidents. Mitigation devices do not require any action on the part of employees in order for the equipment to function.

The mitigation system provides opportunities for secondary prevention. Mitigation equipment does not eliminate hazards, it only controls the severity of incidents.

Typical examples of mitigation devices include:

- Relief valves
- Automatic shutdown devices
- Mechanical ventilation
- Automatic trip devices
- Machine guards

5. The Warning System

The warning system of safety includes the use of devices that warn employees that a dangerous or potentially dangerous situation is occurring. These warning components require employee intervention to control or mitigate the hazardous situation. Employees must be able to understand the meaning of the warning. They must also be able to respond in a timely manner and understand what actions are necessary.

Examples of warning devices include:

- Fire, spill and evacuation alarms
- Back-up alarms on vehicles

6. The Procedures and Training System

The operation and maintenance of processes that are dangerous require a system of written procedures and training. The greater the hazard of the process, the greater the need for procedures and training.

Parts of an effective procedures and training system include:

- Procedures and training which consistently incorporate the philosophy that safety is more important than production
- Employee involvement in developing and overseeing training and procedures activities
- Methods developed by the technical and manufacturing workforce to certify that training is understood, promotes safety, and is not punitive
- An emergency response plan and training that are in place and are routinely practiced
- Procedures and training which identify all potential hazards, the possible consequences of these hazardous conditions and the actions needed to respond to each hazard or potential hazard

7. Personal Protective Factors

Personal protective factors are the last line of defense among the various systems of safety. They define the traditional roles that employees play in health and safety and generally include obeying the rules (individual behavior) and wearing Personal Protective Equipment (PPE). Unfortunately in far too many situations PPE and behavior are used to compensate for hazards that are built into the work process.

Being Proactive
A better approach is to view the role of employees as proactive and engaged in the process of making the workplace a safe and healthy environment. This perspective requires employees to look critically at the workplace, work together to identify the hazards and then contribute ideas, experience and know-how to correct the system flaws.

Hazards can be eliminated or significantly reduced when employees are actively engaged in the process of identifying systems flaws and correcting them using higher-level solutions such as Design and Engineering.

8. Safety Systems and Sub-Systems

Safety Systems	Design/ Engineering	Maintenance & Inspection	Mitigation Devices	Warning Devices	Training & Procedures	Personal Protective Factors
Type of Prevention	**Primary** *(Goal is to eliminate or prevent hazards)*	**Secondary** *(Enhances prevention and minimizes hazards)*	**Secondary** *(Enhances prevention and minimizes hazards)*	**Secondary** *(Enhances prevention and minimizes hazards)*	**Secondary** *(Enhances prevention and minimizes hazards)*	**Last Line of Defense** *(Protects–to some degree–after other systems fail to control)*
Safety Sub-System	**Technical** Codes Standards Recordkeeping OSHA 300 Log Guidelines that address Design and Engineering Chemical Substitution Design and Engineering of equipment, materials and processes **Organization** Communications Staffing Workload Resource Allocation Shift Schedules	Inspections Preventive Maintenance Parts Quality Control	Shutdown Devices Back-up Generator System and Emergency Outlets Fire Suppression Devices	Monitors Facility Alarms Process Alarms	Operating Manuals Safety Information Emergency Response Refresher Training Communications	Personal Decision Making and Actions Personal Protective Equipment (PPE)

Source: Center for Chemical Process Safety, Guidelines for Technical Management of Chemical Process Safety, New York: American Institute of Chemical Engineers, 1989, pp. 99-103.

9. What Are Root Causes?

The root causes of incidents are the prime factors that underlie the causal factors of an accident. Root causes are sometimes referred to as "basic" causes. There are almost always several root causes involved in an incident, accident or near-miss. For example, the root causes of an electrocution might include improperly designed or maintained equipment, poor lockout procedures or inadequate training. Root causes are always found in safety systems. Effective prevention of similar incidents requires improving the systems.

Examples of Root Causes

- Poor design of process units, machinery and equipment
- Poor layout of work areas
- Difficult access to equipment
- Unsafe sitting and spacing of process units, machinery and equipment
- Lack of preventive maintenance or inspection
- Inadequate procedures or training for both normal and emergency situations
- Excessive overtime
- Inadequate staffing levels

Sources: Mine Safety and Health Administration, Accident Prevent, 1990, pp. 35-38; and Center for Chemical Process Safety, Guidelines for Investigating Chemical Process Incidents, New York: American Institute of Chemical Engineers, 1992, pp. 129-131.

Summary:

1. Creating and maintaining proactive systems of safety are the key to preventing injuries.

2. Major systems of safety include:

    - Design and Engineering
    - Maintenance and Inspection
    - Mitigation Devices (i.e., relief valves)
    - Warning Devices (i.e., alarms)
    - Training and Procedures
    - Personal Protective Factors

3. **The Design and Engineering system can provide primary prevention by eliminating the possibility of a serious accident. The other systems of safety provide secondary prevention by reducing the probability, or severity, of an accident.**

4. Your workplace may have different structures and names for its systems of safety, but all workplaces have systems of safety.

5. **Active management and employee involvement is essential for these systems to be effective.**

6. The root causes of incidents are the prime factors that underlie the causal actors of an accident. Root causes are sometimes referred to as "basic" causes. There are almost always several root causes involved in an incident, accident or near-miss.

Evaluation

Activity 2: Systems of Safety

1. How important is this activity for employees at your facility?
Please circle one number.

Activity Is Not Important				Activity Is Very Important
1	2	3	4	5

2. Please **put an "X" by the one factsheet** you feel is the most important.

	1. Systems of Safety		**6. The Training and Procedures System**
	2. The Design/Engineering System		**7. Personal Protective Factors**
	3. The Maintenance & Inspection System		**8. Systems of Safety and Sub-Systems**
	4. The Mitigation System		**9. What Are Root Causes?**
	5. The Warning System		

3. Which summary point do you feel is most important?
Please circle one number.

Most Important Summary Point				
1.	2.	3.	4.	5.
6.				

4. What would you suggest be done to improve this Activity?

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Activity 3: Investigation Preplanning

Purpose

To examine the issues involved in effective preplanning for a management/employee investigation program.

This Activity has one task.

Task

The Near Miss
As a member of the safety committee at ABC Warehouse, Jane is on the Accident Investigation Team (AIT). In addition to Jane, who is a frontline employee, there are three other members of the safety committee who serve on the AIT including Bill, who is the Assistant Warehouse Manager and two other supervisors.

When Jane punched-in for work on Monday morning, Jim, a co-worker from the night shift informed her that he had nearly fallen off the loading dock the night before. He said the near miss was the result of stepping in a small puddle of fluid or oil and that it was probably coming from one of the forklifts. He said that maybe as a member of the safety committee she could investigate. He also made it clear that he didn't want Jane using his name if she decided to act on the situation because the last time he reported out a near miss management pointed the finger at him.

Later that same morning Jane saw Bill and informed him of the situation. She said that it might be a good opportunity for the AIT to investigate. Bill said that while he thought it was a good idea, it probably wasn't the best time for doing an investigation, especially since no one was injured.

The Accident and Investigation
The following Monday morning Bill was waiting for Jane at the punch-in clock and informed her that on the Friday night graveyard shift Dave, a recently hired employee, had apparently fallen off the dock and was still in the hospital with a broken arm and severely injured back. Bill told Jane to meet him in his office in an hour. When she arrived Jane found Bill scurrying around his office looking for the camera and video equipment. While she was helping him look for the equipment the other two members of the AIT arrived and said that a couple of day shift people told them that Dave had apparently stepped in a puddle of hydraulic fluid, slipped, lost his balance and tumbled off the dock. They noted that if it was a puddle of fluid that he stepped in, it wasn't there anymore because it was already more than 48 hours since the

accident occurred and somebody had obviously cleaned up the mess. At this point Bill gave up looking for the camera and called the warehouse manager. After a short conversation he hung up and told everybody to go back to work and that he would call them later in the week to schedule days when they could interview the employees who witnessed the accident.

It took the AIT nearly a six weeks to complete the interviews and another three months before they issued their report to the safety committee.

A few months after the accident Jim saw Jane at the clock and asked how the investigation was going. Jane stated the following:

> *It's been a very frustrating process. I'm the only member of the AIT that's a frontline employee, everybody else is management so I never have much to say about how the investigation proceeds. And my supervisor rarely lets me go to the meetings.*
>
> *The other problem is that I don't' feel like we really know what we're doing. None of us ever received formal training on how to conduct an investigation. And we aren't organized...Bill still hasn't found the camera!*
>
> *But my greatest concern is that the final report is going to end up sounding like it was Dave's fault because he wasn't watching where he was going and the forklift operator's fault because he didn't realize his forklift was leaking fluid. I think the problems run much deeper than "employee errors." We have real deep seated problems here that nobody wants to confront.*

(continued)

Task *(continued)*

In your groups, review the factsheets on pages 36-45. Then based on your own experience and the factsheets make a list of at least six proposals for improving the incident investigation program at ABC Warehouse.

Proposal for Improving the Incident Investigation Program at ABC Warehouse

1.	
2.	
3.	
4.	
5.	
6.	

1. What to Investigate

Many workplaces have clear policies for investigating injuries, but when it comes to investigating other types of incidents, the policies and procedures are often inconsistent.

All incidents, whether a near miss or an actual injury-related event, should be investigated. Near miss reporting and investigation allows you to identify and control hazards before they cause a more serious incident.

Accident/incident investigations are a tool for uncovering hazards that either were missed earlier or have managed to slip out of the controls planned for them. Investigations are useful when they are conducted with the aim of discovering every contributing factor to the accident/ incident. The goal is to "foolproof" the condition and/or activity and prevent future occurrences.

DEFINITIONS

ACCIDENT - The National Safety Council defines an accident as an undesired event that results in personal injury or property damage.

INCIDENT - An incident is an unplanned, undesired event that adversely affects completion of a task.

NEAR MISS - Near misses describe incidents where no property was damaged and no personal injury sustained, but where, given a slight shift in time or position, damage and/or injury easily could have occurred.

Source: www.osha.gov/SLTC/etools/safetyhealth/mod4_factsheets_accinvest.html

2. Near-Misses: The Disaster Warning Alarms

Real prevention can be gained by investigating the seemingly less serious incidents and accidents that take place in the field. Many of these incidents are commonly called *near-misses*. For example, if someone slipped and fell but was not injured, the fact that they were not injured should not affect the decision to have an investigation. Lessons learned from such a investigation might include improving procedures to ensure that the number of spills or leaks are reduced and when they occur they are promptly cleaned up.

Investigate Near Misses
Near misses are wake-up calls telling us that something is wrong with our safety systems. They represent important opportunities to investigate and correct problems before a serious injury or disaster occurs.

Examples of near-misses that should be investigated include:

- equipment failures
- minor injuries that could have been more serious
- spills and releases of hazardous materials that could have injured people, or the environment

When Not to Investigate
Not all incidents require the convening of an investigation team. This applies to incidents where there was not a potential for a serious injury, exposure, or fire. Examples may include a typical twisted ankle, bruised finger, or a spill or release that was so small that it could not have caused a serious problem.

Your workplace needs to define in writing, as specifically as possible, the types of events that will be investigated.

Sources: www.osha.gov/SLTC/etools/safetyhealth/mod4_factsheets_accinvest.html; Center for Chemical Process Safety, Guidelines for Investigating Chemical Process Incidents, New York: American Institute of Chemical Engineers, 1992, pp. 71-77.

3. When to Investigate

A good investigation begins as soon as possible after the incident has been reported and the situation is controlled and safe. Memories of witnesses fade quickly after an incident. Even a one day delay will usually result in the permanent loss of the accuracy and the details of the event.

The investigators also need to see the incident scene before it is cleaned up. This requires that the area be promptly secured. Physical evidence can easily be lost when investigations do not begin quickly. This can happen because of a rush to get the job done or to clean up the mess or a desire to cover up mistakes.

Management needs to establish formal policies requiring that incident scenes be left undisturbed so that a joint investigation team can better see what happened. Barricade tape may help to keep people out of the area to be investigated.

Source: OSHA Process Safety Management Standard, Appendix B.

4. Creating an Effective Investigation Team

All too often, an investigation team consists of five or six engineers and supervisors and one worker picked by management. When this is the case, employee cooperation in an investigation can be greatly hindered. It will be much harder for the investigation team to uncover all the facts and to determine root causes.

The Trust Factor
Frontline employees have difficulty embracing an investigation program that is solely controlled by upper management. Employee trust in the investigation process is much greater when frontline employees have equitable representation on the investigation team.

Avoid the Common Pitfalls
The following is a list of problems to avoid in selecting members of an investigation team:

- people who “know it all” or think that they are “experts”
- people who are close to the event and could be emotionally involved
- using someone just because they are available
- people who are too busy or think that they are too busy
- people who already “know” the causes of the accident or near-miss

Sources: www.osha.gov/SLTC/etools/safetyhealth/mod4_factsheets_accinvest.html; Center for Chemical Process Safety, Guidelines for Investigating Chemical Process Incidents, New York: American Institute of Chemical Engineers, 1992, pp. 71-77.

5. Making Investigations Job Number One

Investigations may drag on for many weeks or even months before the report is completed. When investigation team members are not released from their regular job duties, the investigation will take a long time to complete. The investigation assignment is piled on a work plate that is already overflowing. Thus, workers may think of an assignment to an investigation team as bad luck or punishment.

The quality of the report also suffers when some of the team members are only able to participate marginally in the investigation because other job duties compete or interfere.

A Successful Program
In a successful investigation program, management makes the prompt completion of the report the number one job duty of investigation team members. This sometimes requires scheduling others to cover the jobs of team members.

The decisions should not be left up to a worker's supervisor or the scheduler. Management should create a formal written facility policy which addresses these important issues.

6. Keeping the Investigation Tool Box Stocked

Conducting timely investigations requires maintaining a dedicated stock of supplies ready for immediate use by the investigation team.

Supplies needed by investigation teams may include:

- camera and film
- video camera
- personal protective equipment
- notebooks and clipboards
- pens, pencils, markers and chalk
- tape measure
- sample bottles, tags, plastic bags and duct tape
- gas detectors
- flashlights and batteries
- latex gloves
- barricade tape
- small tool kit

Source: Mine Safety and Health Administration, *Accident Investigation*, 1987.

7. Employees Need Investigation Training

It is especially important that members of local safety and health committees be trained in the company's Incident Investigation Program. Successful programs often include all employees in some level of training. This improves the quality of investigations by increasing the level of employee cooperation with the investigation team inquiry. This is only possible when the basic procedures and goals of the investigation program are understood by all employees.

Levels of Training

The extent of this training varies with the potential role that different job categories may play in the investigation program. For example, office clerks whose role may be limited to recognizing and reporting an incident may only need a couple of hours of awareness training. People working in the field need to receive more lengthy training. General investigation training topics include:

- the purpose and philosophy of the investigation program
- the importance of reporting and investigating near-misses
- the premise that incidents have multiple causes
- an understanding of safety systems and root causes
- the importance of fact-finding rather than fault-finding
- the responsibilities of management and employees

Source: Center for Chemical Process Safety, Guidelines for Investigating Chemical Process Incidents, New York: American Institute of Chemical Engineers, 1992.

8. Training the Investigation Team

People who serve on investigation teams need to receive additional training for conducting investigations. It is ineffective to try to cram this training in after an incident has already occurred.

In addition to the investigation program training received by plant employees, investigation team members need training in the following:

- investigation methodologies used by the facility
- gathering incident information
- analyzing incident information
- root causes determination
- use of logic tree diagrams
- report preparation
- writing recommendations and investigation follow-up

Source: Center for Chemical Process Safety, Guidelines for Investigating Chemical Process Incidents, New York: American Institute of Chemical Engineers, 1992.

9. Discipline and Blame: Roadblocks to Successful Investigations

Incidents cannot be investigated if they are not reported. If investigations result in placing blame or administering discipline, many incidents and near-misses will go unreported. Even if these events are reported, there is a natural pressure to clean up the incident scene before upper management sees it. Additionally, witnesses will hesitate to be cooperative when they or their friends may receive discipline or blame.

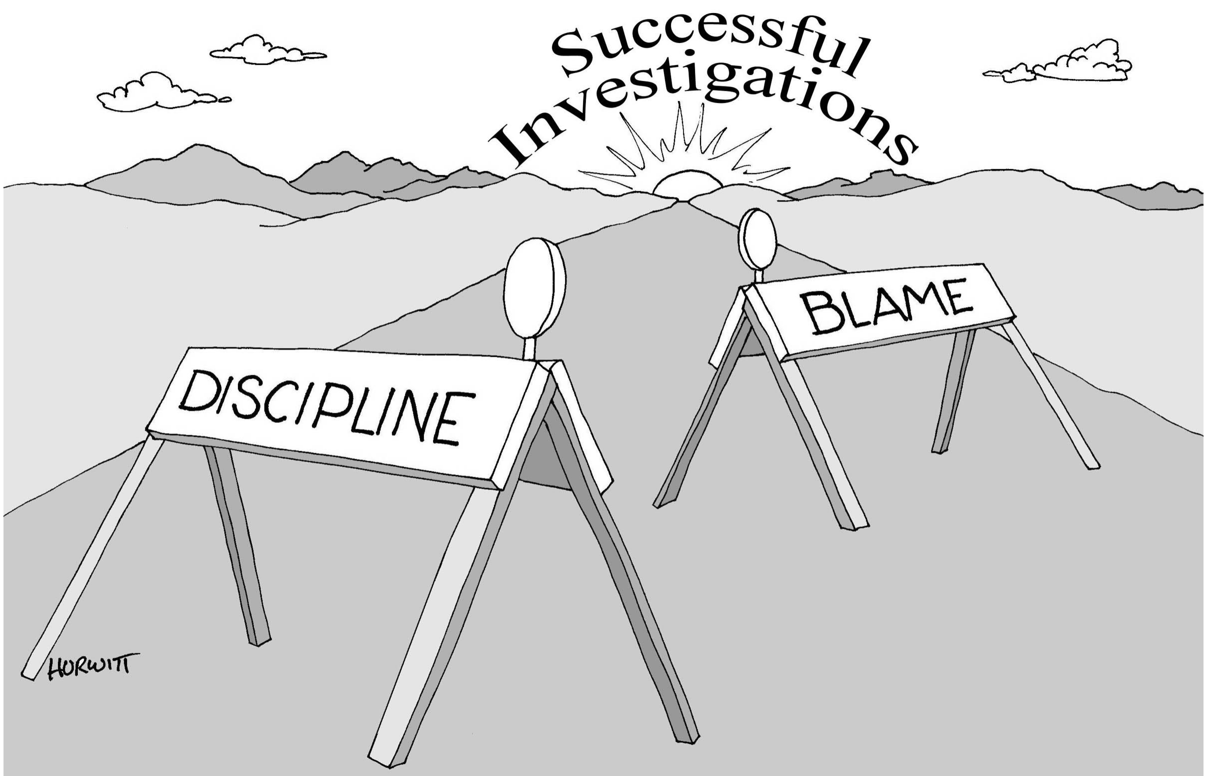
Some companies have their human resource departments hand out discipline rather than the safety department or investigation teams. This arrangement does not remove the discipline roadblock to good investigations. It merely changes the faces of those erecting the roadblocks. In too many facilities discipline is almost always reserved for hourly workers. Engineers and managers do not receive discipline for their actions that cause accidents.

Think Systems!
In facilities that recognize that strong safety systems are the key to a safe workplace, worker errors are understood to be symptoms of problems in management safety programs. An employee not following a procedure is usually not a root cause of an incident. Examining why a procedure was not used at a job site often reveals problems within the procedure system. For example, the procedure may have been outdated, incomplete or unavailable.

Alternatives to the Blame Game
One example of a program that encourages the reporting of incidents and near-misses is NASA's Aviation Safety Reporting System. This program allows pilots, air traffic controllers and others to anonymously report safety problems in the commercial aviation industry.

Trevor Kletz's book "*What Went Wrong?*" offers us some insight into discipline associated with accidents.

> *"...accidents [may be] due to those aberrations that even well-trained and well-motivated persons make from time to time. For example, they forget to close a valve or close the wrong valve. They know what they should do, want to do it, and are physically and mentally capable of doing it.* ***Exhortation, punishment or further training will have no effect.*** *We must either accept an occasional mistake or change the work situation so as to remove the opportunities for error or make errors less likely."*



Sources: T.A. Kletz, *What Went Wrong? Case Histories of Process Plant Disasters, Houston*: Gluf Publishing Company, November 1989; and *Root Cause Network*, Knoxville: System Improvements, Inc., November 1992.

Summary

1. Investigations should begin as soon as possible because memories and evidence are rapidly lost after an accident. This normally means that investigations should begin on the day of the accident or near-miss.

2. It is very important that an investigation program defines as specifically as possible what types of incidents, accidents and near-misses will be investigated.

3. Employee trust in the investigation process is much greater when frontline employees have equitable representation on the investigation team.

4. In a successful investigation program, management makes the prompt completion of the report the number one job duty of investigation team members.

5. Conducting timely investigations requires maintaining a dedicated stock of supplies ready for immediate use by the investigation team.

6. A good investigation preplan ensures full participation of all members of the investigation team. This includes releasing employees and others from their regular assignments as needed so that the investigation is their primary responsibility.

7. An effective safety program includes training in investigation policies, goals and methods for team members and the entire workforce.

8. In facilities that recognize that strong safety systems are the key to a safe workplace, worker errors are understood to be symptoms of problems in management safety programs. An employee not following a procedure is usually not a root cause of an incident. Examining why a procedure was not used at a job site often reveals problems within the procedure system.

Evaluation

Activity 3: Investigation Preplanning

1. How important is this Activity for your facility?
Please circle one number.

Activity Is Not Important				Activity Is Very Important
1	2	3	4	5

2. Please **put an "X"** by the factsheets you feel are the most important.

	1. What to Investigate		**6.** Keeping the Investigation Tool Box Stocked
	2. Near-Misses: The Disaster Warning Alarms		**7.** Employees Need Investigation Training
	3. When to Investigate		**8.** Training the Investigation Team
	4. Creating an Effective Investigation Team		**9.** Discipline and Blame: Roadblocks to Successful Investigations
	5. Making Investigations Job Number One		

3. Which summary point do you feel is most important?
Please circle one number.

Most Important Summary Point				
1.	2.	3.	4.	5.
6.	7.	8.		

4. What would you suggest be done to improve this Activity?

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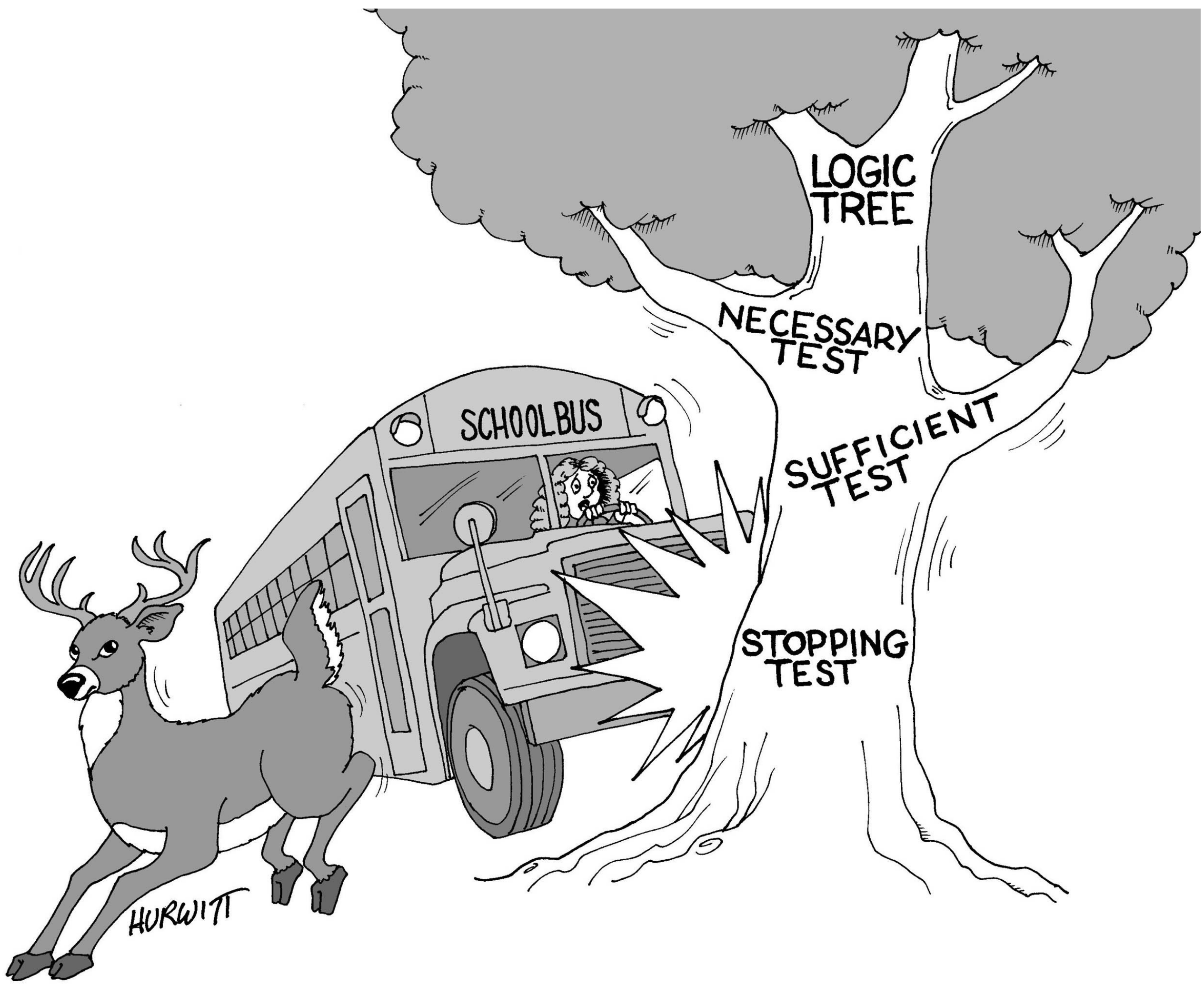
Activity 4: Introduction to Logic Tree Diagramming

Purpose

To learn how to create a logic tree and analyze investigation information.

This Activity has three tasks.



The Introduction to Logic Tree Diagramming is based on an Activity that was originally written by the Labor Institute (a non-profit organization based in New York City), staff members and worker-trainers associated with the Rutgers Occupational Training and Education Consortium, and the Oil, Chemical and Atomic Workers Union (OCAW).

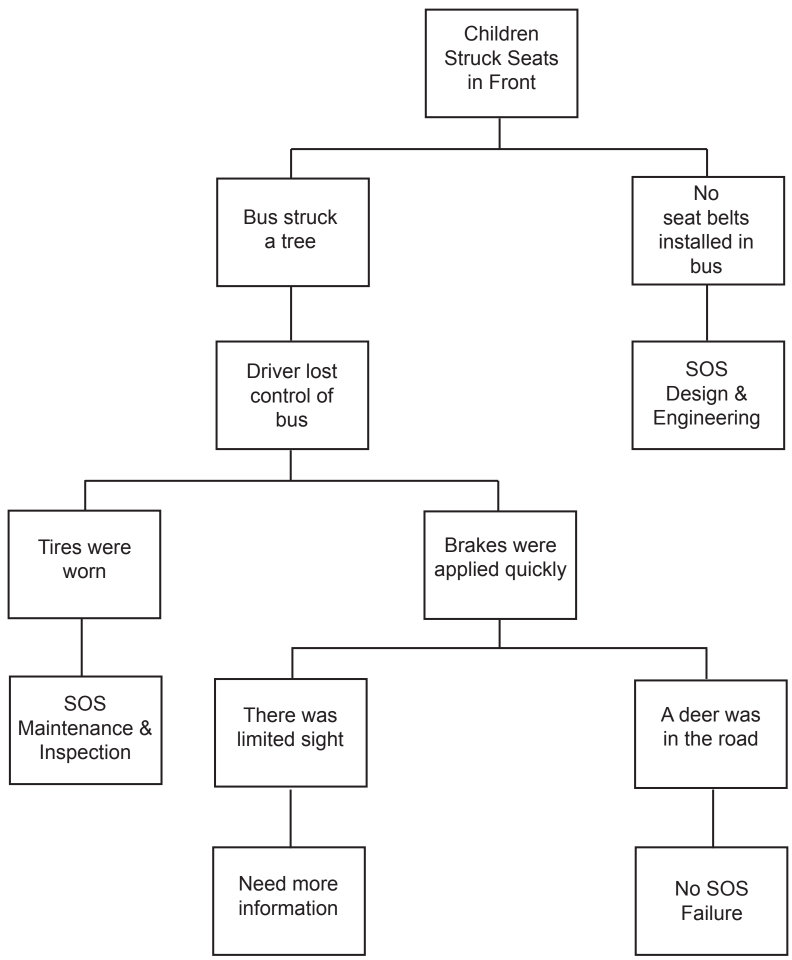
Task 1

The school bus rounded a curve on Highway 35. At the same moment that the bus rounded the sharp curve, a deer ran into the path of the bus. The driver saw the deer and quickly applied the brakes. The bus skidded off the road and struck a tree. Several children slammed into the backs of the seats in front of them. Luckily, none of the children were injured.

The accident investigation revealed the following facts:

- Children struck the seats in front of them
- The bus struck a tree
- There were no seat belts installed in the bus
- The tires were worn
- The brakes were applied quickly
- There was limited sight
- There was a deer in the road

A logic tree is a method used to determine the root causes of incidents, accidents and near misses. The logic tree below uses the scenario and facts from above to identify root causes of the accident. Using Factsheets 1-5 on pages 52-60, we will go over a step by step process for organizing the facts of the accident into a logic tree.



1. Facts and Nothing But the Facts

The first step in making a logic tree diagram is to list all of the facts. Making a list of the facts in an investigation seems like an easy thing to do. In reality it can be challenging. Stating the facts is a special skill which requires following certain rules and lots of practice.

Tips For Stating the Facts	
✓	**List Each Fact Separately** For example, stating that "the children slammed into the seats when the bus struck the tree" actually combines two different facts. The "children striking the seats" and the "bus striking a tree" should be listed as two separate facts. Similarly, stating that "there was a deer in the road and there was limited visions," should also be written as two separate facts.
✓	**Don't Use Subjective or Biased Words In Stating Facts** Do not use words such as the "lazy" operator, the welder "wasn't paying attention" or the worker "refused to follow the procedure. Just state, in precise language, what was done or not done without listing a motive or judgment for each action or condition.
✓	**Don't Assume Facts, Make-up Missing Facts or Jump to Conclusions** Sometimes the cause of an accident may seem obvious. It is important to only list the facts that are determined through gathering actual evidence or from interviews. Statements made in interviews should be considered facts unless the weight of evidence later reveals a different set of facts. Jumping to conclusions can cause you to slant some facts while missing other important facts.
✓	**Don't Discard Any Fact as Unimportant or Irrelevant** Some facts may seem to be trivial or not directly related to the incident under investigation. It is a mistake to try to make these judgments before actually constructing your logic tree diagram. Facts that seemed unimportant at first may prove to be significant when the investigation analysis begins.

2. Constructing a Logic Tree

Step 1: (Define the Top Event)

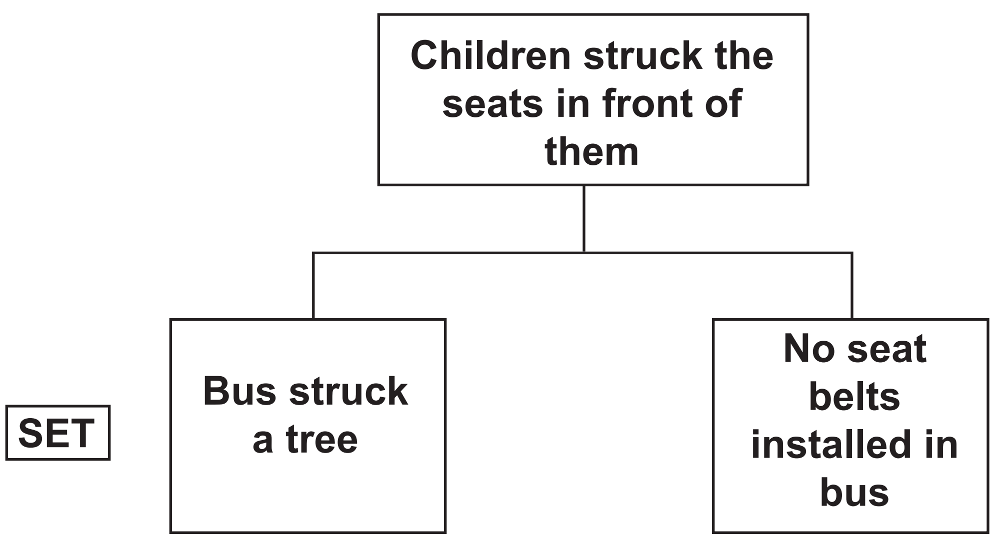
Define the injury, incident or near-miss event that you want to examine and place it at the top of the tree. **This is called <u>the top event</u>.**

In the bus wreck example, the top event is **"Children struck the seats in front of them."**

Step 2: (What Caused or Allowed the Event to Take Place?)

Ask, **"What facts caused or allowed the event to take place?"** This question is repeated for each fact listed in the logic tree.

The group of facts that caused or allowed the event to take place are called a set. The <u>set</u> of facts from the bus accident that caused the children to strike the back of the seats consists of the two facts listed below.



(continued)

2. Constructing a Logic Tree *(continued)*

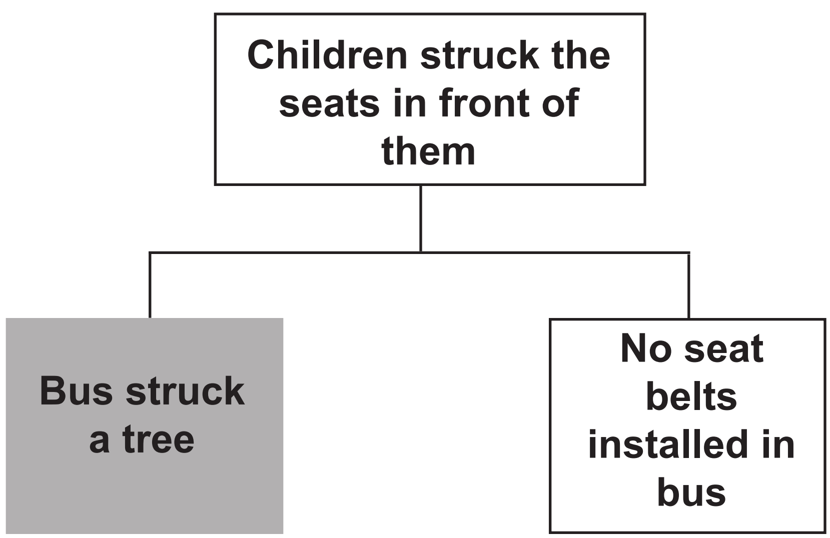
Step 3: (Do the Necessary Test)

Do **the "<u>necessary test</u>"** for each fact listed to ensure that it belongs in the set. This is done as follows:

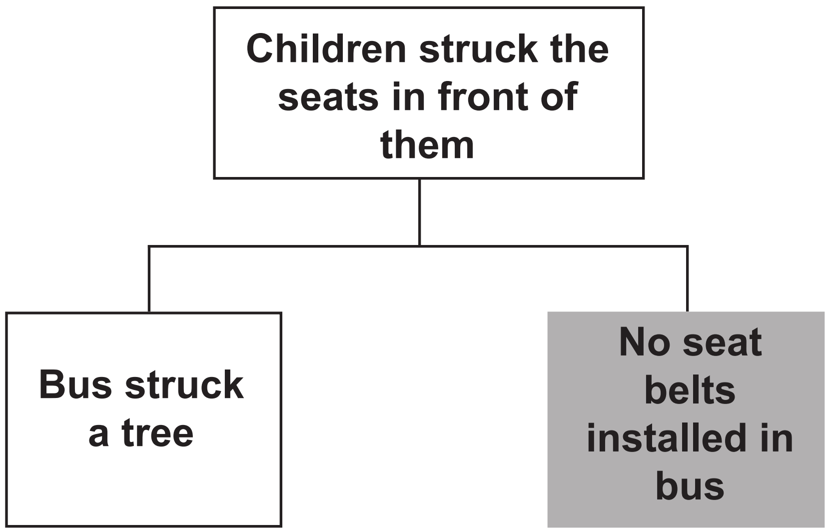
- Reverse the meaning of one fact at a time from the set.
- Then ask if the new set of facts could have still caused or allowed the event or condition being examined to take place.
- It the answer is **"yes,"** the reversed fact is not necessary and does not belong in the set.
- If the answer is **"no,"** the reversed factor belongs in the set.

The **"<u>necessary test</u>"** for **"Children struck the seats in front of them"** is performed as follows:

> Reverse the meaning of the first fact and ask, **"If the bus <u>did not</u> strike a tree and no seat belts were installed, would the children still have struck the seats?"** The answer is **"no,"** so the fact that the **"bus struck a tree"** is needed and stays in the set.



Next ask, **"If seat belts <u>had been installed</u> in the bus and the bus struck a tree,"** would the **"children have struck the seats?"** The answer is "no," so the fact **"no seat belts installed in bus"** ***belongs*** in the set.



Step 4: (Do the Sufficient Test)

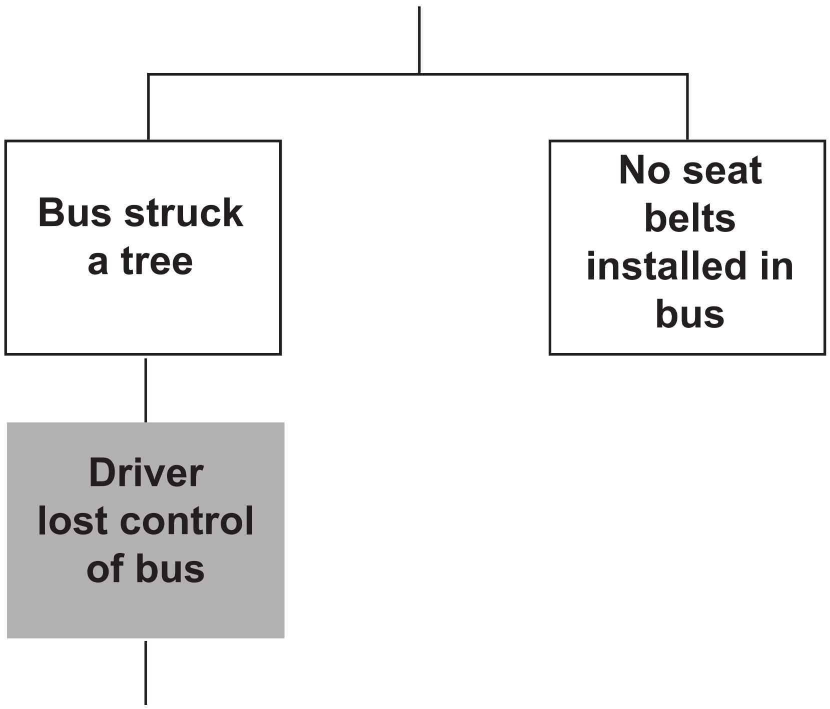
Do the "**<u>sufficient test</u>**" to ensure that you have enough facts. This is done as follows:

- **Is the set of facts sufficient to have caused or allowed the event or condition being examined to have taken place?**
- **If the answer is "<u>yes,</u>"** then the set is complete.
- **If the answer is "<u>no</u>,"** additional facts are needed to complete the set. The investigation team may need to gather more facts.

In the **Bus Accident** example we would ask if the two facts are enough to have caused the **"children to strike the backs of the seats."** The answer is **"yes,"** so the set has enough facts.

3. Extending the Logic Tree

Steps 2, 3, and 4 are repeated **separately** for each fact that needs further examination. In the **"Children striking the back of the seats"** example, **"the bus struck a tree"** and **"no seat belts in stalled in bus"** need to be determined individually.



Step 2: (What Caused or Allowed the Event to Take Place?)

- What facts caused or allowed **the bus to strike the tree**? The answer to the question is the fact that the **"driver lost control of the bus."**

Step 3: (Do the Necessary Test)

- Reverse the meaning of the first fact and ask, **"If the driver did not lose control of the bus would the would the bus have struck the tree?"** The answer is **"no,"** so the fact that the **"driver lost control of the bus"** is needed and stays in the set.

Step 4: (Do the Sufficient Test)

- **Is this one fact enough?** Is the fact that the **"driver lost control of the bus"** **enough** to have caused the "**bus to strike a tree?**" The answer is **"yes."** Therefore the fact is enough by itself.

To extend the first set the procedure is then repeated for **"No seat belts installed in the bus."** The tree continues to extend downward in this manner for every fact on the tree until a stopping point is encountered.

4. The Stopping Points

Step 5: (The Stopping Test)

To know when to stop extending the logic tree, do the "stopping test." There are three types of stopping points in a logic tree:

- **Stop when the fact identifies a problem in a management "System of Safety, (SOS)."**
  Identifying a safety system problem is a minimum stopping point in a logic tree. Sometimes it will make sense to continue the tree to examine what particularly went wrong in the safety system. Further examination might reveal that procedures are being written by people with inadequate knowledge of facility equipment.

- **Stop when the event or condition is "Not a System of Safety Failure (NSOS)."**
  For example, facts such as "it was cold outside," "the unit was running" or "the oil was hot" are conditions that need no further analysis. Facts or conditions of this kind are not Systems of Safety Failures.

- **Stop when you "need more information (NMI)."**
  Sometimes you will not have enough facts to continue the logic tree downward. When this is the case, the investigation team may need to gather additional information.

All three stopping points are included in the **"Children striking the back of the seats"** example.

- **"A deer was in the road"** is **Not a System of Safety Failure (NSOS)**. Thus, you write **"NSOS"** on a blank yellow sheet with a magic marker and place the paper directly below "a deer was in the road" on the logic tree.

- We **"need more information (NMI)"** in order to determine why **"There was limited sight."** There could have been trees or billboards blocking the view of the driver or a curve in the road that limited his sight. Thus, you write **"NMI"** on a yellow sheet and put it below the **"There was limited sight"** fact.

- A good *maintenance and inspection* program identifies worn equipment. Thus, a **System of Safety (SOS)** should be placed under **"Tires were worn."** An **SOS** should also be placed under "**No seat belts installed in the bus."** Buses designed with seat belts could prevent many injuries.

5. Safety Systems and Sub-Systems

Safety Systems	**Design/ Engineering**	**Maintenance & Inspection**	**Mitigation Devices**	**Warning Devices**	**Training & Procedures**	**Personal Protective Factors**
Type of Prevention	**Primary** *(Goal is to eliminate or prevent hazards)*	**Secondary** *(Enhances prevention and minimizes hazards)*	**Secondary** *(Enhances prevention and minimizes hazards)*	**Secondary** *(Enhances prevention and minimizes hazards)*	**Secondary** *(Enhances prevention and minimizes hazards)*	**Last Line of Defense** *(Protects–to some degree–after other systems fail to control)*
Safety Sub-System	**Technical** Codes Standards Recordkeeping OSHA 300 Log Guidelines that address Design and Engineering Chemical Substitution Design and Engineering of equipment, materials and processes **Organization** Communications Staffing Workload Resource Allocation Shift Schedules	Inspections Preventive Maintenance Parts Quality Control	Shutdown Devices Back-up Generator System and Emergency Outlets Fire Suppression Devices	Monitors Facility Alarms Process Alarms	Operating Manuals Safety Information Emergency Response Refresher Training Communications	Personal Decision Making and Actions Personal Protective Equipment (PPE)

Task 2

In the early 1950s, dozens of children died from suffocation as a result of being trapped inside old discarded refrigerators. Double deaths were not uncommon because children naturally enjoy playing together and old refrigerators provided an interesting place to play. But when the doors on the old units slammed shut they became a death trap. Air could not get in and the well-insulated shell prevented cries for help from being heard.

A first response by the industry and consumer groups was to issue warnings about the danger. But that did not solve the problem and as a result Congress passed the Refrigerator Safety Act of 1956. The legislation required refrigerator manufacturers to redesign the door latch so that it could be opened from the inside. The law also required the removal of doors or latches from old discarded units.

At your groups wall station use the sticky pads and markers to reproduce the logic tree on page 64. Then using the facts below and Factsheets 1-5, complete the logic tree. Be sure that you follow all the steps outlined in Factsheets 1-4!

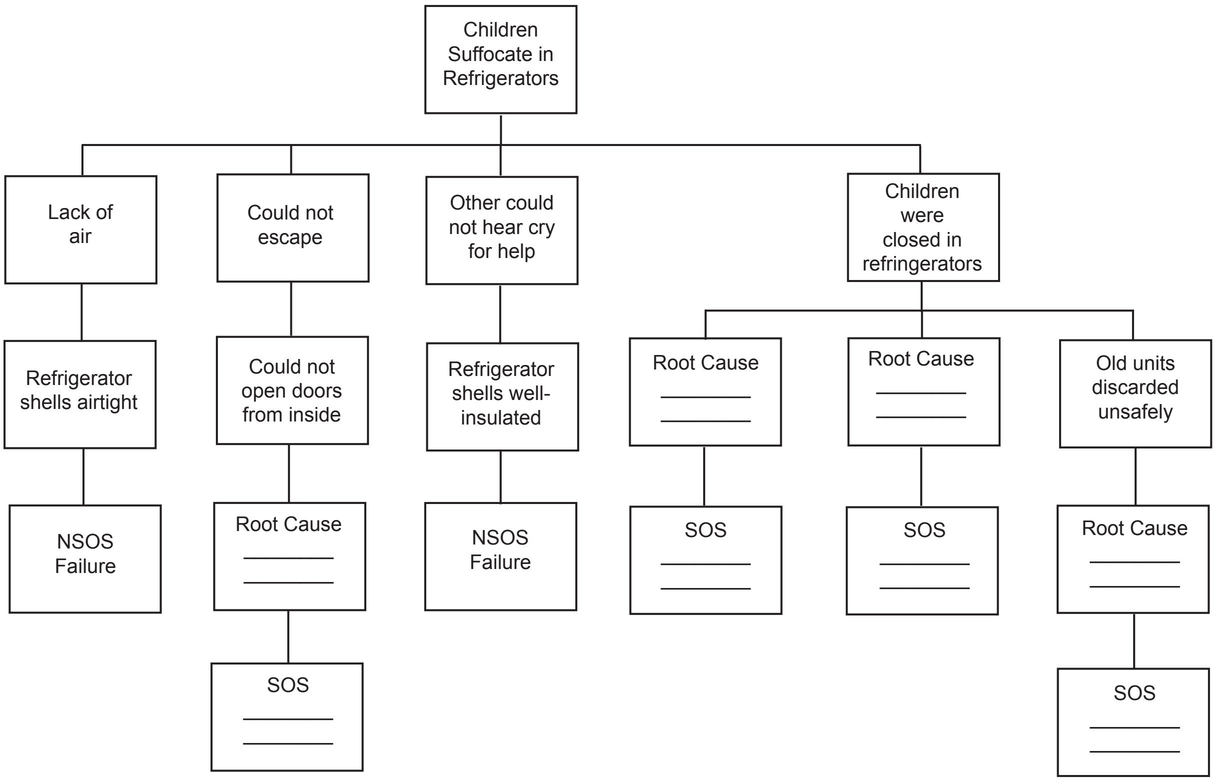
Here are the facts from the scenario.

- Lack of air
- Children could not escape
- Children could not open door from the inside
- Others could not hear their cries for help
- Children were closed inside refrigerators
- Old refrigerators were discarded unsafely
- Refrigerator shells well-insulated
- Refrigerator shells airtight
- **Locking door latches left on refrigerators**
- **Door latches designed that way**
- **Parents unaware of seriousness of hazard**
- **Children unaware of serious of hazard**

(continued)

Task 2 (continued)

Use the bolded facts from page 63 to complete the logic tree and identify the failed Systems of Safety (SOS)



Task 3

Marien was picking goods from a storage bin at the ABC Warehouse when suddenly she slipped and fell. She was rushed to the hospital where it was determined that Marien had broken her arm.

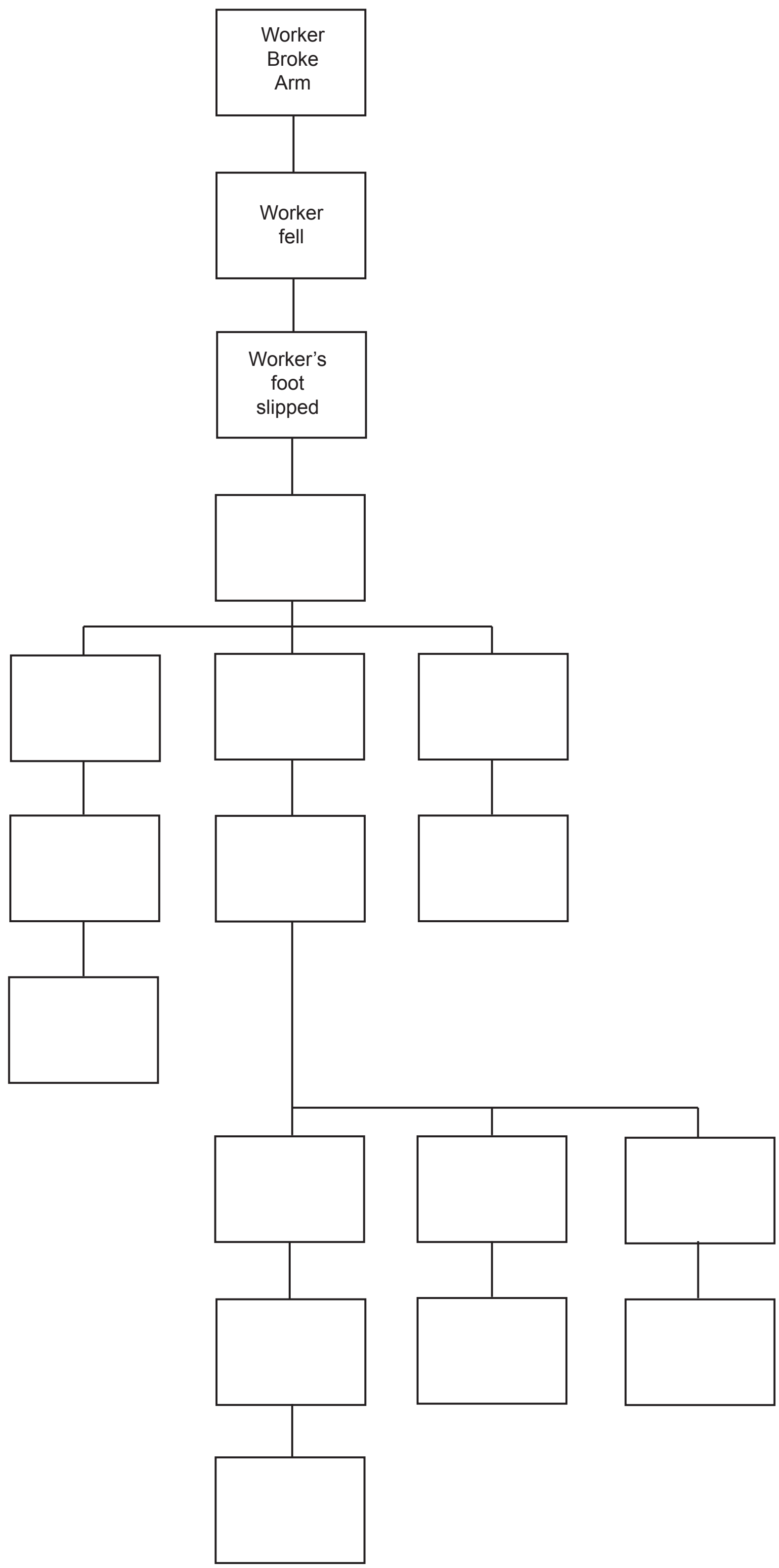
A follow up ABC Warehouse Accident Investigation revealed the following facts:

- Worker broke arm
- **Forklift was leaking hydraulic fluid**
- **There was a bad seal on the forklift hydraulic system**
- **The bad seal was caused by normal wear**
- **Forklift operators do not conduct pre- and post- shift inspections**
- **Preventive maintenance was never performed on the forklift**
- Worker's foot slipped
- **Worker stepped in hydraulic fluid**
- Worker fell
- **Worker did not see the hydraulic fluid**
- **There was poor lighting**
- **Hydraulic fluid was on the floor between the aisle bins**
- **Worker was picking goods from aisle bins**

(continued)

Task 3 (continued)

At your groups wall station use the sticky pads and markers to reproduce the logic tree on page 67. Then using the bolded facts on page 65 and Factsheets 1-5, complete the logic tree. And once again be sure that you follow all the steps outlined in Factsheets 1-4!



Worker Broke Arm
Worker fell
Worker's foot slipped

6. Logic Trees Are a Tool

Good incident investigations use scientific concepts, rules and logic tree diagrams. However, it must be recognized that logic trees are only a tool used by the investigation team. The value of a logic tree is highly dependent on how this tool is used by the members of an investigation team. For example, anyone can go out and buy the fanciest late-model welding machine, but this doesn't make you a welder. The new welding machine will not produce good welds on its own.

Conducting effective investigations as well as the proper use of the logic tree tool depends on the goals, experience and subjectivity of investigation team members. If your goal is to show that an incident was a worker's fault, a logic tree can be designed so that the results will place blame on the worker.

People assigned to an investigation team are encouraged to be objective. In reality, on one enters an investigation with a mind that is like a blank sheet of paper. Everyone on the investigation team is naturally affected by things such as their work experiences, position in the corporation, friendships and personal opinions. "Experts" are equally affected by these subjective factors.

The use of a logic tree diagram does not eliminate the conflicting goals and perspectives of team members. It is a tool to help the team channel attention toward identifying the multiple root causes of an incident.

Sources: Center for Chemical Process Safety, *Guidelines for Investigating Chemical Process Incidents,* New York: American Institute of Chemical Engineers, 1992, Chap. 5; and Mine Safety and Health Administration, "Fault Tree Analysis," *Safety Manual No. 8*, 1986.

7. The DOs and Don'ts of Writing Recommendations

Prevention of incidents and accidents requires that actual changes be made. A hard-hitting investigation can easily be wasted if you sugar-coat the writing in the recommendations. A major problem in writing investigation recommendations is the use of weak words such as "consider." These words make it easy to ignore recommendations. Instead use words like "must," "demand" or "require".

The DON'Ts

- Don't make vague statements.
- Avoid using words such as consider, should, improve review evaluate, examine, increase, investigate.
- Do not recommend discipline.

The DOs

- Address every root cause.
- Recommend changes in management safety systems, remembering that changes in design and engineering provide the highest degree of prevention.
- State the specific actions to be taken.
- Make recommendations that are measurable and tractable.
- Include a time-line for completion of each recommendation.
- Ensure that each recommendation is assigned to an individual to oversee implementation.
- Not all of the recommendations will come directly from your logic tree. Some recommendations will flow from the general findings of the investigation.

Source: Center for Chemical Process Safety, *Guidelines for Investigating Chemical Process Incidents,* New York: American Institute of Chemical Engineers, 1992, Chap. 6.

Summary

1. Logic trees are a powerful tool for graphically depicting and organizing investigation information and establishing cause-and-effect relationships. They help to identify all of the management safety system-based root causes of incidents.

2. The tree is checked by performing the necessary test, the sufficient test and the stopping test.

3. The identification of a problem in a safety system is a minimum stopping point. It may be important to extend the logic tree to determine what things failed in the safety system.

4. The value of a logic tree is highly dependent on how this tool is used by the members of an investigation team. The conclusions and recommendations of the investigation can still depend on the subjective opinions, experiences and goals of investigation team members.

Evaluation

Activity 4: Introduction to Logic Tree Diagramming

1. How important is this Activity for you and your co-workers?
Please circle one number.

Activity Is Not Important				Activity Is Very Important
1	2	3	4	5

2. Please **put an "X"** by the factsheets you feel are the most important.

	1. Facts and Nothing But the Facts		**5.** Safety Systems and Sub-Systems
	2. Constructing a Logic Tree		**6.** Logic Trees Are a Tool
	3. Extending the Logic Tree		**7.** The DOs and DON'Ts of Writing Recommendations
	4. The Stopping Points		

3. Which summary point do you feel is most important?
Please circle one number.

Most Important Summary Point				
1.	2.	3.	4.	

4. What would you suggest be done to improve this Activity?

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Activity 5: Evaluating the Training

Purpose

To evaluate this health and safety training and to spend some time talking about where we go from here.

This Activity has one task.

Task

First take a few minutes and write your answers to the questions below. We will discuss these questions as one large group.

One trainer will ask for the responses to the questions from each table and the other trainer will act as the scribe recording your answers on the flip chart in the front of the room.

1. **Describe the most important things you learned during this training.**

2. **Given your own experience and the things you have learned in this training, what are the health and safety problems at your workplace that need to be addressed right away?**

3. How would you rate the workbook's readability?

- ☐ **Too hard**
- ☐ **Just right**
- ☐ **Too easy**

4. What health and safety topics would you like to learn more about?

5. Of all the activities, which was your favorite? Why?