Lack of Maintenance and Postponing Inspections Kills Worker

Lessons Learned

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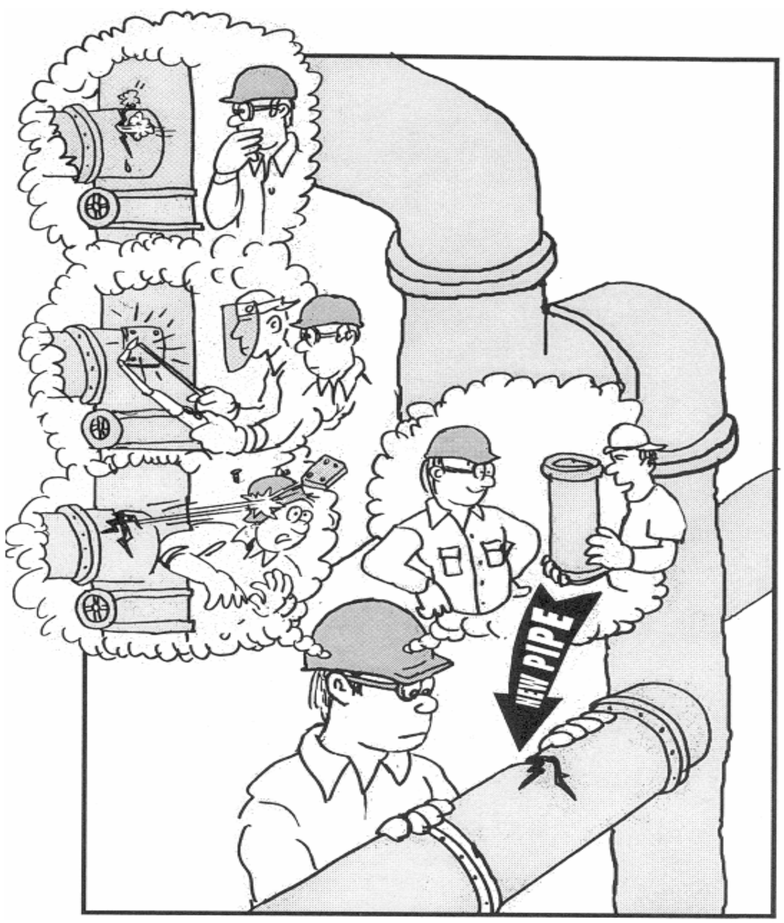
Lack of Maintenance and Postponing Inspections Kills Worker

Purpose

To conduct a small group “lessons learned” activity to share information gained from incident investigations.

To understand “lessons learned” through a systems of safety viewpoint.



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The incident and recommendations made are from an actual USW represented facility. These recommendations are a product of the site’s analysis of the incident and not meant to represent the USW official view on the topic(s). In fact, one of the goals of this exercise is evaluate the recommendations made and to suggest improvements.

Introduction

One Hour "Lessons Learned" Safety Training Activity

This is a Small Group Activity Method (SGAM) exercise. It is designed for use in toolbox style meetings where a group of craft persons, operators, or other small group is assembled for a safety training session. The whole group should be further divided into smaller discussion groups of four to six people.

The tone of the meetings should be informal to create as much discussion as possible within the groups and among the groups. Active participation by group members is essential for this exercise to be successful.

If you plan to present a Lessons Learned Activity and have not been trained in the USW worker trainer program, you should contact the USW Health, Safety & Environment Department:
Phone (412) 562-2581
email: safety@steelworkers-usw.org for trainer information.

For this exercise, each person in the group should have their own copy of this activity printed in its entirety. The exercise consists of three tasks. Each task is designed to provoke thought and generate discussion about the incident at hand. Each discussion group should designate a scribe to keep notes and report back to the facilitator and class after each task. When the exercise is completed, review the Summary on page 13.

Definitions of terms used in this exercise are provided throughout the activity. A glossary of terms is also provided in the appendix.

The incident(s) depicted in this activity are based upon real occurrences. The names of persons and corporations are fictitious.

Task 1

Please read the following scenario:

A worker was killed and several injured when a large acid storage tank in an oil refinery exploded, releasing its entire contents. The explosion also damaged other storage tanks nearby causing them to release their contents as well. Additionally, a large quantity of sulfuric acid breached the containment dike and found its way to a nearby river causing major environmental damage.

Several large storage tanks containing sulfuric acid (H_2SO_4) for a sulfuric acid alkylation unit were located within a common containment dike. Some tanks contained fresh full strength H_2SO_4 while others contained spent or used acid which by its very nature, contains a quantity of light hydrocarbon. Tank 1 had been converted from a fresh acid storage tank to a spent acid storage tank within the past few years.

A catwalk that allowed access to the tops of the tanks had suffered severe corrosion due to acid vapors in the area and required repairs. Holes had also occurred in Tank 1 and most had been patched but several other holes in the tank's roof had not been repaired. Several leaks had been found on this tank in the previous three years but, although the refinery's tank inspectors had repeatedly recommended an internal tank inspection and the tank was emptied several times, the inspection was postponed for six years. The inspection delay was due to process priorities and cuts in the maintenance budget.

The repairs to the catwalk had been initiated several times previous to the incident and at least two times, the hot work permit had been denied due to high sulfur dioxide (SO_2) levels and elevated combustible gas readings in the area. The operator also noted a hole in the roof of Tank 1 and submitted an unsafe condition report three weeks prior to the incident. Management had investigated the report but did not correct the deficiencies.

Modifications made to Tank1 when it was converted to spent acid service included a flame arrestor on the tank's vent and a carbon dioxide (CO_2) inerting system that consisted of a hose dropped into the tank through a hole in the tank's roof. No engineering resources were used to determine if the inerting system was adequate.

As the catwalk repair work was being performed, sparks from an air arc ignited vapors issuing from Tank 1 causing an explosion within the tank. The tank separated from its floor, flew over the tank dike wall and instantly released its contents of approximately a quarter million gallons of acid. Other acid tanks also released their contents as a result of the explosion. The total acid release was estimated at over a million gallons. The acid crash against the tank dike wall and splashed outside the wall and the dike diversion system was overwhelmed allowing the acid to flow through the grating on the streets outside the dike. Nearly 100,000 gallons of acid flowed down the street, into the storm sewer system and eventually flowed into the river causing major environmental damage.

Due to the leaks in the other tanks within the dike, entry to the dike area could not be performed for over a month. Several workers received acid burns to their face, hands and legs and the remains of the welder working on the catwalk were never found.

Task 1 *(continued)*

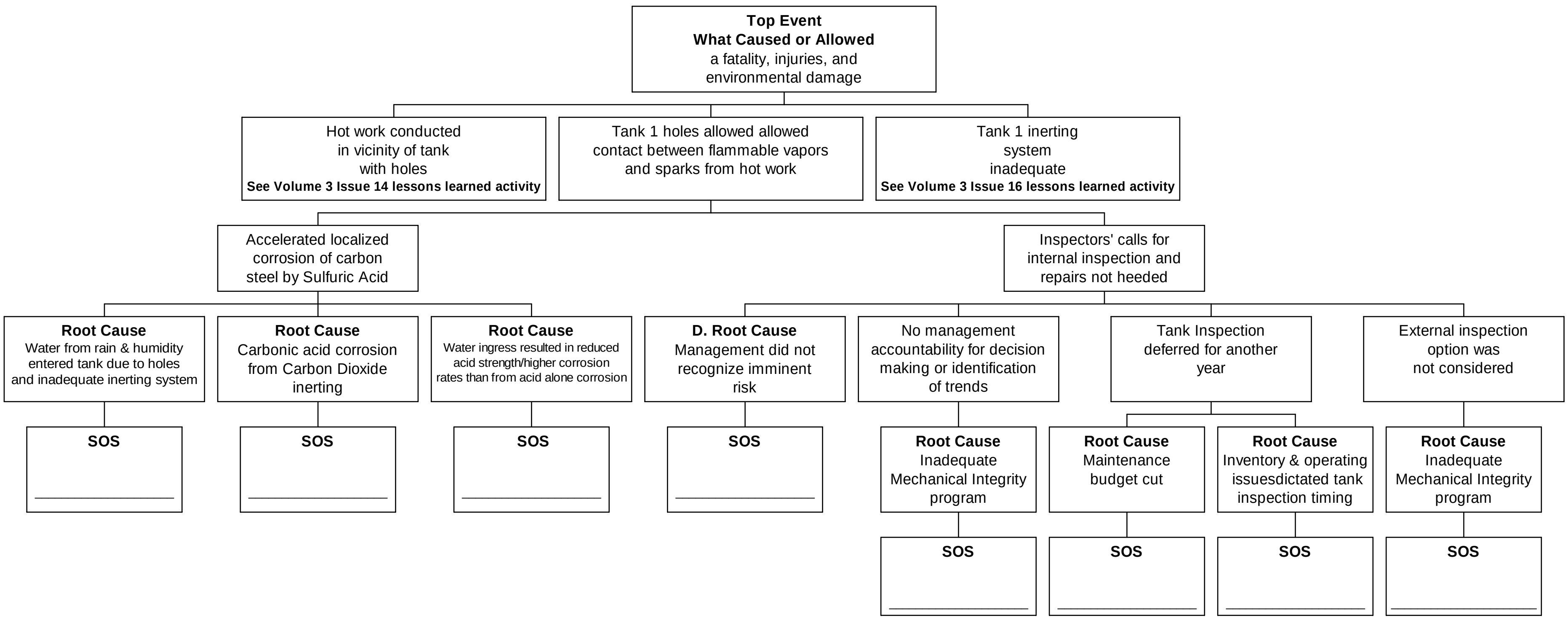
On the next page you will find a logic tree that shows how the investigators at this site linked the incident that occurred (the top event) to the facts described in the scenario and the incident's root causes. Below each root cause in the logic tree you will find a block with the title "SOS" (System of Safety).

Find the boxes marked SOS. Directly above those boxes will be a root cause of the incident. Your task is to complete the logic tree by identifying the *major* system of safety affected where the root cause failure occurred and list it in the box. These "systems" are listed in a chart on page 9. *Note: some of the SOS boxes may already be completed for you.*

Please select someone in your group to act as scribe to report back your answers.

A **Logic Tree** is a pictorial representation of a logical process that maps an incident from its occurrence to the root causes of the incident.

***The logic tree presented here was created by the Chemical Safety Board and does not follow the TOP method exactly. Due to the catastrophic nature of this incident, the logic tree depicted below is one branch of three presented here as lessons learned activities. The other two branches are presented as separate lessons learned activities.



Task 2

A. Below you will find two lists. On the left are the root causes from the logic tree on the previous page. On the right are recommendations made by the team that investigated this incident. On the chart below identify which of the "recommendations" would eliminate or reduce each "root cause" by placing the number of the recommendation(s) on the line provided. More than one recommendation can apply to a root cause.

	Root Causes	Recommendations
______	A. Water from rain & humidity entered tank due to holes and inadequate inerting system.	1. Implement a system to ensure accountability for Maintenance & Inspection decision making.
______	B. Carbonic acid corrosion from carbon dioxide inerting.	2. Review inspection reports by subject area experts, such as metallurgists or equipment design engineers to ensure adequate analysis of failure trends and suitability for intended service.
______	C. Water ingress resulted in reduced acid strength/higher corrosion rates than from acid alone corrosion.	3. Establishment of a planning system to ensure the timely repair of equipment.
______	D. Management did not recognize imminent risk.	4. Review the design of existing tankage that contains or has the potential to contain flammables to ensure that inerting systems are installed where appropriate and are adequately sized and constructed and that emergency venting is provided.
______	E. Inadequate Maintenance & Inspection program.	5. Ensure that management of change reviews are conducted for changes to tank equipment and operating conditions such as tank service and contents as well as tank peripherals, such as inerting and venting.
______	F. Maintenance budget cut.	6. Conduct periodic audits of storage tank Maintenance & Inspection and design, unsafe condition reports, ot work, management of change, and accountability systems at all the company refineries.
______	G. Inventory & operating issues dictated tank inspection timing.	7. Ensure that all audit recommendations are tracked and implemented.
______	H. Inadequate Maintenance & Inspection program	8. Communicate findings & recommendations to the workforce and contractors at all refineries.

B. Use the concepts found on the factsheets on pages 9 through 12 and evaluate the recommendations from Question A. How would you strengthen or add to the list?

Task 3

Discuss ways in which the "Lessons Learned"(listed below) from this incident can be applied at your workplace. Please explain.

Lessons Learned

- Across the board cuts in maintenance budgets without thoughtful consideration of consequences is false economics.
- "Field engineering" ensures that all variables will NOT be considered. Engineering resources should be utilized.
- Management of change is a powerful tool that would probably have discovered the flaws in this operation and probably prevented this fatality.
- Failure to repair equipment is a recipe for disaster.
- A quality Maintenance & Inspection program prevents incidents, deaths, and property losses.
- Production should not dictate equipment inspection timing.

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Systems of Safety
And
Subsystems

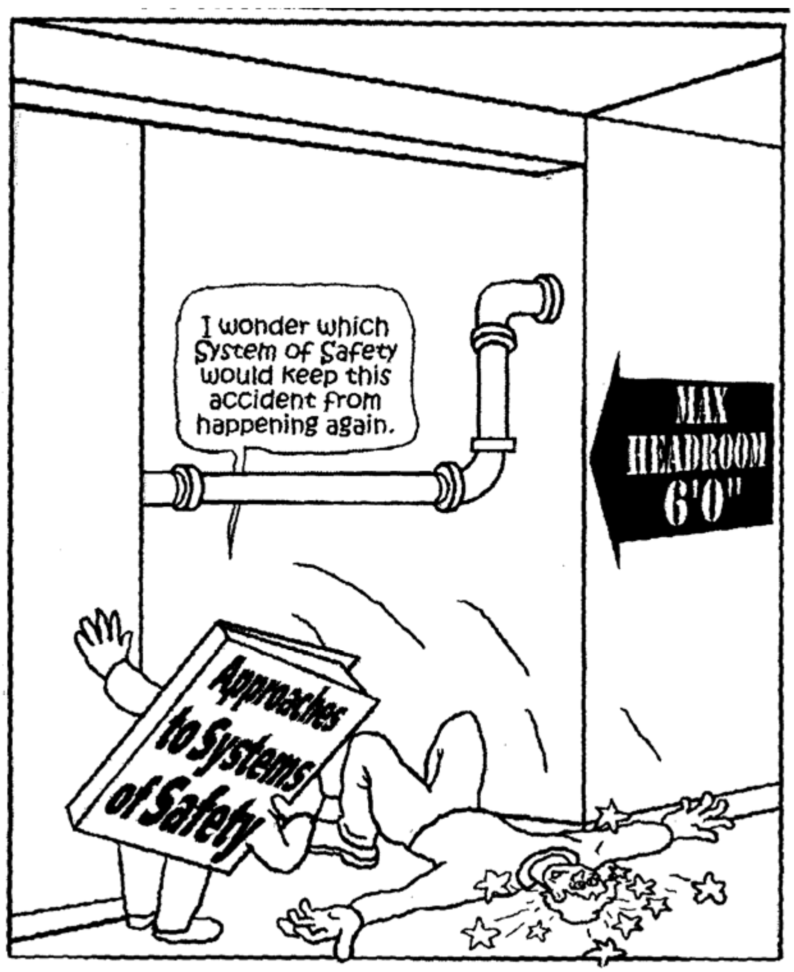
Major Safety Systems	**Design & Engineering**	**Maintenance & Inspection**	**Mitigation Devices**	**Warning Devices**	**Training & Procedures**	**Personal Protective Factors**
Level of Prevention	**Highest—the first line of defense**	**Middle—the second line of defense**				**Lowest—the last line of defense**
Effectiveness	**Most Effective**					**Least Effective**
Goal	***To eliminate hazards.***	***To further minimize and control hazards.***				***To protect when higher level systems fail.***
Examples of Safety Sub-Systems*	**Technical** Design and Engineering of Equipment, Processes and Software Management of Change (MOC)** Chemical Selection and Substitution Safe Siting Work Environment HF **Organizational** Staffing HF Skills and Qualifications HF Management of Personnel Change (MOPC) Work Organization and Scheduling HF Allocation of Resources Codes, Standards and Policies**	Inspection and Testing Maintenance Quality Control Turnarounds and Overhauls Mechanical Integrity	Enclosures, Barriers and Containment Relief and Check Valves Shutdown and Isolation Devices Fire and Chemical Suppression Devices	Monitors Process Alarms Facility Alarms Community Alarms Emergency Notification Systems	Operating Manuals and Procedures Process Safety Information Process, Job and Other Types of Hazard Assessment and Analysis Permit Programs Emergency Preparedness and Response Training Information Resources Communications Investigations and Lessons Learned	Personal Decision-making and Actions HF Personal Protective Equipment and Devices HF Stop Work Authority

HF – Indicates that this sub-system is often included in a category called **Human Factors.**

* There may be additional subsystems that are not included in this chart. Also, in the workplace many subsystems are interrelated. It may not always be clear that an issue belongs to one subsystem rather than another.

** The Codes, Standards and Policies and Management of Change sub-systems listed here are related to Design and Engineering. These subsystems may also be relevant to other systems, for example, Mitigation Devices. When these sub-systems relate to systems other than Design and Engineering they should be considered as part of those other systems, not Design and Engineering.

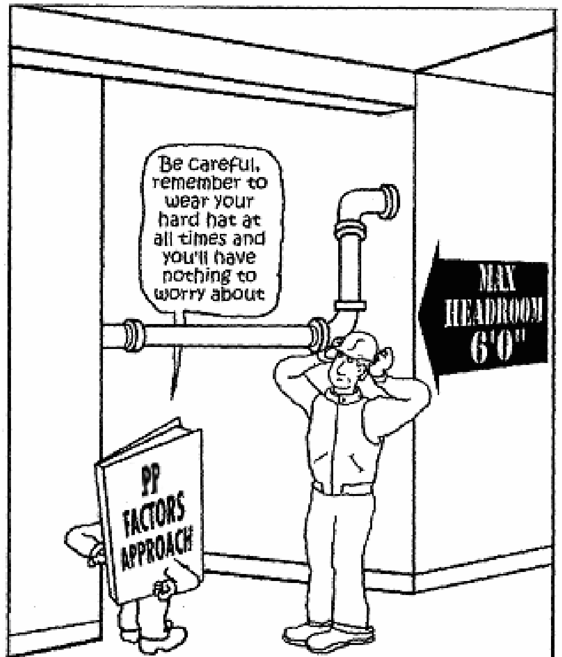
All Systems of Safety Are Not Created Equal!



Surprisingly, the same hazard can often be addressed in more than one system. Take the low pipe in the doorway above, on the next two pages you'll see how this same problem could be handled by each of the major Systems of Safety.

Which is the best approach? Well, if you look at the Systems of Safety Chart on the previous page, you will find the SOS's arranged in order of strength: the most powerful – Design – on down to the least powerful – Personal Protective Factors.

A good investigation team will consider the full range of recommendations for each root cause.



Personal Protective Factors

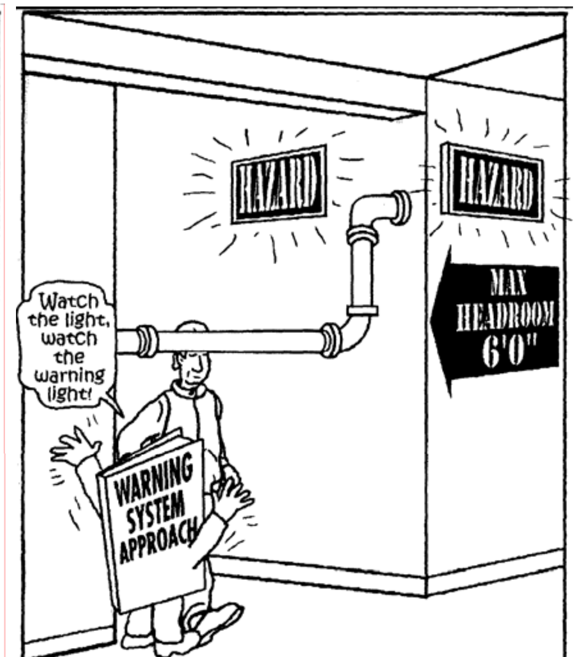
Sub-systems that include a broad range of working conditions and situations that affect workers.

- Weakest system
- Controls the hazard directly at the individual's level

Procedures and Training

The instructions and knowledge necessary to maintain and operate equipment or processes

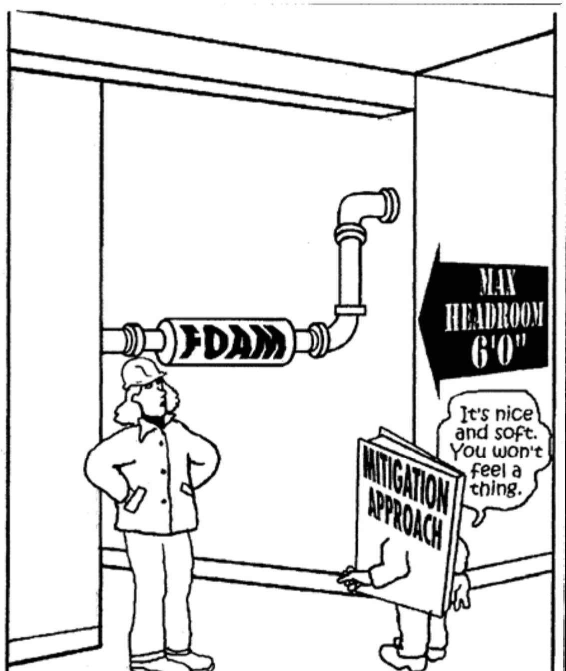
- Easier to affect groups of workers.
- Dependent on individuals' memories and lack of distraction



The Warning System

Devices that warn of a dangerous or potentially dangerous situation.

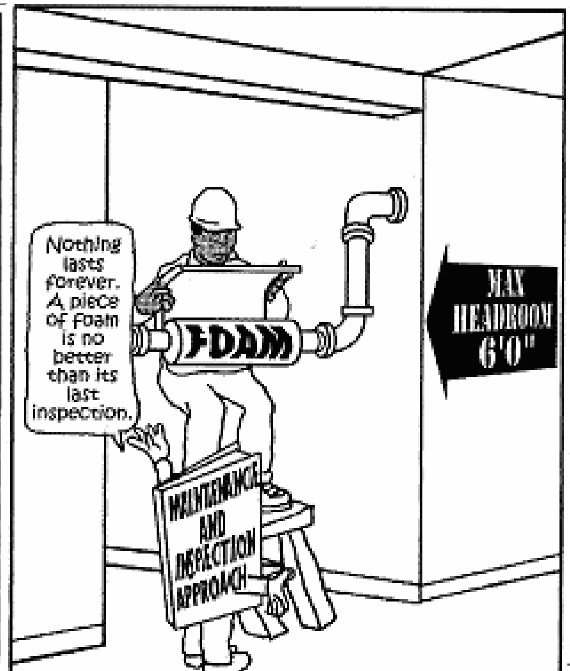
- Draws attention
- May be missed or ignored



The Mitigation System

Sub-systems that automatically act to control or reduce the effect of hazards.

- Workers protected automatically



Maintenance & Inspection

The system responsible for maintaining, repairing and inspecting equipment and processes.

- Vital to make sure even the best designed system continues to function safely

Design and Engineering

The primary (highest level) system that designs the hazard out of the process.

- Strongest system
- Hazard eliminated

Summary: Lessons Learned

1. The objective of "lessons learned" is to prevent accidents through identifying and correcting underlying defects in systems of safety. To achieve maximum prevention, all recommended changes should be made.

2. Corrective action resulting from lessons learned is one of the best methods for achieving proactive health and safety. Maximum prevention is achieved by correcting the conditions that led to the incident at other sites in the plant and at other sites.

3. Systems of safety-based analysis help identify the underlying causes of incidents and are valuable for determining what corrective measures should be taken as a result of the lessons learned.

4. Many times the result of an incident investigation is that worker error is identified as the main contributing factor. When a systems of safety-based analysis is used, multiple root causes are usually uncovered.

5. The most effective controls of health and safety hazards are those which are integrated or designed into the process, such as engineering controls. The least effective controls involve personal protective equipment and procedures that merely acknowledge the hazard and do nothing to eliminate it.

6. All work-related hazards must be evaluated before work begins to eliminate or reduce worker exposure to hazards and to prevent injuries.

Glossary of Terms (Appendix)

Several unique terms are used while doing the "Lessons Learned" exercises. Their definitions are listed below.

Contributing Factor—something that actively contributes to the production of a result, an ingredient.

Fact—a piece of information presented as having objective reality, an actual occurrence or event.

Hierarchy of Systems of Safety—the ranking of systems of safety as to their relative effectiveness in providing accident prevention. This hierarchy is represented by the "Fulcrum" with the most effective system of safety residing on the left side of the lever. Less effective systems reside further to the right on the lever.

Lessons Learned—A summation of an investigation that describes safety hazards or conditions with general educational recommendations to identify and correct similar conditions. These differ from investigation recommendations as illustrated below:

> ***Investigation recommendation:*** Replace the carbon steel gate valve on the vacuum tower bottoms line with a chrome valve. The valve failed due to corrosion.
>
> ***Lessons Learned:*** Verify that carbon steel valves and piping are not used in vacuum tower bottoms service because corrosion can cause them to fail.

Logic Tree—a pictorial representation of a logical process that maps an incident from its occurrence to the root causes of the incident.

Recommendations—calls for specific changes that address each root cause of an incident or accident to prevent its reoccurrence.

Root Cause—basic cause of an accident found in management safety systems.

Glossary of Terms *(continued)*

Supports and Barriers—"supports" are conditions that promote or render assistance to implementing recommendations while "barriers" are conditions that obstruct the implementation of recommendations.

Systems of Safety—management systems that actively seek to identify and control hazards before they result in an incident or injury.

- Design and Engineering
- Maintenance & Inspection
- Mitigation Devices
- Warning Systems
- Procedures and Training
- Personal Protective Factors

Conducting a "Lessons Learned" Activity

Circle the number that best shows your response to each of the following questions.

1. How easy was it for you to understand the "systems of safety" approach presented in this activity?

4	3	2	1
Very easy	**Somewhat easy**	**Somewhat hard**	**Very hard**

2. How useful do you think this "systems of safety" way of thinking could be for tackling safety and health problems at your workplace?

4	3	2	1
Very useful	**Somewhat useful**	**Not very useful**	**Of no use**

3. How much do you agree or disagree with the following statement:

   The logic tree diagram approach can be helpful for analyzing the root causes of safety and health incidents.

4	3	2	1
Strongly agree	**Agree**	**Disagree**	**Strongly disagree**

4. Overall, how useful was this "lessons learned activity" for considering safety and health problems at your workplace?

4	3	2	1
Very useful	**Somewhat useful**	**Not very useful**	**Of no use**