Oregon OSHA Online Course 102

Effective Accident Investigation

MODULE 5: DETERMINING SURFACE AND ROOT CAUSES

Introduction

Did you know that most accidents in the workplace result from unsafe work behaviors? According to the latest research, they represent the direct cause for about 95% of all workplace accidents. Hazardous conditions represent the direct cause for only about 3% of workplace accidents. "Acts of God" account for the remaining 2%. All these statistics imply that management system weaknesses account for fully 98% of all workplace accidents. To effectively fulfill our responsibilities as an accident investigator, we must not close the investigation until these root causes have been identified.

It's a common struggle trying to overcome long-held perceptions about safety and how accidents occur. Management perceptions and subsequent actions reflect both traditional and progressive approaches. Let's take a look at old and new thinking.

Old Theory - Worker Error

Old thinking about the causes of accidents assumes that the worker makes a choice to work in an unsafe manner. It implies that there are no outside forces acting upon the worker influencing his actions and that there are simple reasons for the accident. Old thinking also considers accidents as solely resulting from worker error: A lack of "common sense." The employee is the locus of "the problem." To prevent accidents, the employee must work more safely. This thinking results in blaming and short-term fixes: Inefficient, ineffective, and in the long run more expensive to implement and maintain.

New Theory - Systems Approach

The systems approach takes into account the dynamics of systems that interact within the overall safety program. It concludes that accidents are considered defects in the system. People are only one part of a complex system composed of many complicated processes (more than we realize). Accidents are the result of multiple causes or defects in the system. It becomes the investigator's job to uncover the root causes (defects) in the system. Fixing the system, not the employee, is the heart of the investigation. To prevent accidents, the system must work more safely. This thinking results in long-term fixes: Less expensive to implement and maintain.

Time to analyze for cause

We've gathered information and used it to develop an accurate sequence of events. We've got a good mental picture of what happened. Now it's time to conduct an analysis of each event to determine causes. This module will introduce us to the following concepts:

- Injury analysis
- Event analysis
- Systems analysis
- Direct cause of injury
- Surface cause of the accident
- Root cause of the accident

Three levels of cause analysis

As mentioned earlier in the course, accidents are processes that culminate in an injury or illness. An accident may be

the result of many factors (simultaneous, interconnected, crosslinked events) that have interacted in some dynamic way. In an effective accident investigation, the investigator will conduct three levels of of cause analysis:

Injury analysis. At this level of analysis, we do not attempt to determine what caused the accident, but rather we focus on trying to determine how harmful energy transfer caused the injury. Remember, the outcome of the accident process is an injury.

Event Analysis. Here we determine the surface cause(s) for the accident: Those hazardous conditions and unsafe behaviors described throughout all events that dynamically interact to produce the injury. All hazardous conditions and unsafe behaviors are clues pointing to possible system weaknesses. This level of investigation is also called "special cause" analysis because the analyst can point to a specific thing or behavior.

Systems analysis. At this level we're analyzing the root causes contributing to the accident. We can usually trace surface causes to inadequate safety policies, programs, plans, processes, or procedures. Root causes always pre-exist surface causes and may function through poor component design to allow, promote, encourage, or even require systems that result in hazardous conditions and unsafe behaviors. This level of investigation is also called "common cause" analysis because we point to a system component that may contribute to common conditions and behaviors throughout the company.

The direct cause of injury

Whenever an injury occurs, a harmful level of energy is somehow transferred to our body. We should describe the nature of that energy transfer and refer to it as the direct cause of the injury. Here are the various forms of energy that can be harmful:

1. ACOUSTIC ENERGY - Excessive noise and vibration.

2. CHEMICAL ENERGY - Corrosive, toxic, flammable, or reactive substances. Involves a release of energy ranging from "not violent" to "explosive" and "capable of detonation".

3. ELECTRICAL ENERGY - Low voltage (below 440 volts) and high voltage (above 440 volts).

4. KINETIC (IMPACT) ENERGY - Energy from "things in motion" and "impact," and are associated with the collision of objects in relative motion to each other. Includes impact between moving objects, moving object against a stationary object, falling objects, flying objects, and flying particles. Also involves movement resulting from hazards of high pressure pneumatic, hydraulic systems.

5. MECHANICAL ENERGY - Cut, crush, bend, shear, pinch, wrap, pull, and puncture. Such hazards are associated with components that move in circular, transverse (single direction), or reciprocating motion.

6. POTENTIAL (STORED) ENERGY - Involves "stored energy." Includes objects that are under pressure, tension, or compression; or objects that attract or repulse one another. Susceptible to sudden unexpected movement. Includes gravity - potential falling objects, potential falls of persons. Includes forces transferred biomechanically to the human body during lifting.

7. RADIANT ENERGY HAZARDS - Relatively short wavelength energy forms within the electromagnetic spectrum. Includes infra-red, visible, microwave, ultra-violet, x-ray, and ionizing radiation.

8. THERMAL ENERGY - Excessive heat, extreme cold, sources of flame ignition, flame propagation, and heat related explosions.

Let's take a look at some examples describing the direct cause of injury:

- If a harsh acid splashes on our face, we may suffer a chemical burn because our skin has been exposed to a chemical form of energy that destroys tissue. In this instance, the **direct cause of the injury** is harmful a chemical reaction. The related surface cause might be the acid (condition) or working without proper face protection (unsafe behavior).

- If our workload is too strenuous, force requirements on our body may cause a muscle strain. Here, the direct

cause of injury is a harmful level of kinetic energy (energy resulting from motion), causing injury muscle tissue. A related surface cause of the accident might be fatigue (hazardous condition) or improper lifting techniques (unsafe behavior).

The important point to remember here is that the "direct cause of injury" is **not** the same as the surface cause of the accident. To summarize:

- The **direct cause of injury** is the harmful transfer of energy. The direct result is injury.
- The **surface cause of the accident** describes a condition or behavior. The result of the condition and/or behavior is the direct cause of injury...a harmful transfer of energy.

The surface causes of accidents

The surfaces causes of accidents are those specific **hazardous conditions** and **unsafe employee/manager behaviors** that have directly caused or contributed in some way to the accident.

Hazardous conditions:

- are basically **things or objects** that cause injury or illness
- may also be thought to be **defects in a process**
- may **exist at any level** of the organization

Hazardous conditions may exist in any of the following categories:

- Materials
- Machinery
- Equipment
- Tools
- Chemicals
- Environment
- Workstations
- Facilities
- People
- Workload

It's important to know that most hazardous conditions in the workplace are the result of specific unsafe behaviors that produced them.

Unsafe behaviors:

- are **actions we take or don't take** that increase risk of injury or illness.
- may also be thought to be **errors in a process**
- may occur **at any level** of the organization.

Some example of unsafe employee/manager behaviors include:

- Failing to comply with rules
- Using unsafe methods
- Taking shortcuts
- Horseplay
- Failing to report injuries
- Failing to report hazards
- Allowing unsafe behaviors
- Failing to train
- Failing to supervise
- Failing to correct
- Scheduling too much work
- Ignoring worker stress

Event Analysis

In the last module we learned that each event in our sequence **will** include descriptions of actors and their actions that **may** have contributed to the accident.

Our next step is to examine each event to determine the hazardous conditions and unsafe or inappropriate behaviors representing the surface causes for the incident or accident:

1. the actor represents a hazardous condition, and
2. action that represents an unsafe or inappropriate behavior.

What techniques can we use to help us do the event analysis? Let's take a look at one technique that I have found efficient in conducting an event analysis.

I've modified the commonly used "fishbone diagram," used successfully by many as a general problem solving tool, to help conduct an event analysis.

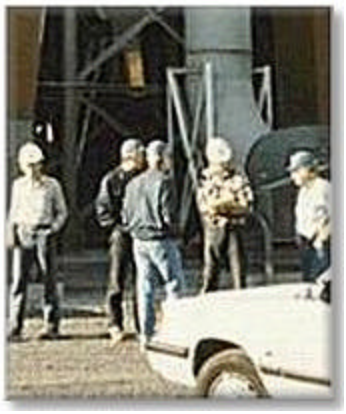
1. Get a sheet of paper.
2. At the top of the sheet write "Accident Analysis". Doing this reminds you that you're breaking down the process into a number of events.
3. At the left side of the sheet, centered, write "The Injury".
4. Extend a horizontal line out from the right of the box.
5. Describe the injury event on the horizontal line.
6. Identify and circle the actors and actions described in the event statement.
7. Start asking **why** questions about the actor and actions to uncover any hazardous conditions or unsafe behaviors.
8. Draw lines either angling up or down from the circled actors and actions and write the answers to your questions.
9. Repeat these steps with each of the new level of answers.

The diagram you produce using this procedure should look something like this. Each level of questioning will get you closer to the root cause(s) that allowed the hazardous condition or unsafe behavior.

System Analysis to determine the root causes of accidents

Once you start identifying inadequate policies, programs, plans, processes, and procedures in the diagram above...you're getting to the real root causes! The **root causes** for accidents are the **underlying safety system weaknesses** that have somehow contributed to the existence of hazardous conditions and unsafe behaviors that represent surfaces causes of accidents. These weaknesses can take two forms:

- **Design root causes.** Inadequate planning and design of the system. The development of formal (written) safety management system policies, plans, processes, procedures is very important to make sure appropriate conditions, activities, behaviors, and practices occur.
- **Implementation root causes.** Inadequate implementation of the system. Failure to



effectively carry out the safety management system is critical to the success of the system. You can develop a wonderfully designed system, yet if it's not implemented correctly, it won't work.

It's important to understand that root causes always pre-exist surface causes. Indeed, inadequately designed and implemented system components have the potential to feed and nurture hazardous conditions and unsafe behaviors. If root causes are left unchecked, surface causes will flourish!

Examples of safety management system functions

Safety systems:

Systems are developed to:

- Promote Commitment/leadership
- Increase employee involvement
- Establish accountability
- Identify and control hazards
- Investigate incidents/accidents
- Educate and train
- Evaluate the safety program

System components:

- Policies
- Programs
- Plans
- Processes
- Procedures
- Budgets
- Reports
- Rules

The biggest challenge to effective accident investigation is to transition from event analysis to systems analysis.

The role of safety engineers and safety coordinators

Safety "engineers" closely analyze all the surface cause categories and attempt to:

- eliminate the harmful energy,
- reduce the harmful energy transfer, or
- reduce exposure to harmful energy transfer.

They do this by designing safety features directly into tools, machinery, equipment, facilities, etc.

Safety coordinators work with safety engineers to eliminate or reduce exposure to hazards through effectively improving safety system components. Because systems design work common throughout the workplace, eliminating any single root cause may simultaneously eliminate many hazardous conditions and unsafe behaviors.

Since root causes reside within safety management systems, upper management -- those who formulate systems, are most likely going to be involved in making the necessary improvements. When analyzing for system weaknesses, it may be beneficial to coordinate closely with those who will be responsible for implementing system improvements.

Last Words

One last important point to make is that most accident processes are far more complex than we might originally think. Some experts believe at least 10 or more factors come together to cause a serious injury. Other experts state that, on average, 27 factors directly and indirectly contribute to serious accidents.

Only by thoroughly conducting all three levels of analysis can we design system improvements that effectively eliminate hazardous conditions and unsafe behaviors at all levels of the organization. The accident investigation can not serve as a proactive safety process unless system improvements effectively prevent future accidents.

Whew! Another great module...only task left is to complete the quiz, so let's go.

Module Review Quiz

21. **All of the following are examples of surface causes except:**

a. Tools
b. Procedures
c. Machinery
d. People

22. **All of the following are examples of root causes except:**

a. Policies
b. Conditions
c. Plans
d. Processes

23. (Fill in the blank) **Surface causes describe hazardous _____ and unsafe _____. Root causes describe inadequate _____.**

a. Systems, behaviors, conditions
b. Behaviors, activities, policies
c. Conditions, behaviors, systems
d. Conditions, systems, accountability

24. **If similar accidents occur repeatedly, what weaknesses in the analysis process is most likely the cause?**

a. It focuses on placing blame
b. It focuses only on root causes
c. It determines only surface causes
d. It focuses on both surface and root causes

25. **If discipline occurs immediately after an accident occurs, what basic process flaw exists?**

a. Blame is based on fact, not feeling
b. The process places blame before considering safety program weaknesses
c. The process determines system flaws before considering personal liability
d. The process neglects to place initial blame.

Congratulations on completing Module 5! Now that we've got cause analysis under our belt, it's time to come up with some solutions. Effective recommendations are important if you want management to "buy" your ideas. Naturally, if you have any questions or comments, just drop me an email at email.

Have a great safe day!