Module 2: Managing Safety and Health

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Module Description

This module begins with an overview of accident costs, direct and indirect. Then we explore the elements and processes of safety programs and worksite analysis. The job hazard analysis is commonly used for training workers as to how to perform a job in the safest manner possible. Hazard recognition and the hierarchy of hazard control are also discussed.

Next, the module explains how to understand accident causation and the various accident theories. If you learn the cause and effect relationship of accident causation and the human element, then you can reduce injuries and illnesses. The final lesson concludes with an overview of incident investigation techniques.

Module Learning Objectives

At the conclusion of this module, you will be able to:

- Examine the direct cost of an accident
- Evaluate the indirect cost of an accident
- Describe the true cost of an accident related to human error factors
- Summarize the components of a safety program
- Explain how hazards are identified, prevented, and controlled
- Discuss safety training and program improvement
- Analyze worksites and tasks and identify hazards
- Identify the hierarchy of hazard control
- Introduce accident causation theories
- Explain how unsafe behaviors contribute to accidents
- Examine the role of a safety management system in preventing accidents and incidents
- Identify incident investigation techniques to find a root cause of an event

Lesson 1: Accident Costs and Prevention

Lesson Focus

This lesson focuses on the following topics:

- Accident Costs
- Safety Programs
- Worksite Analysis
- Hazard Recognition
- Hierarchy of Hazard Control

Accident Costs

Many accidents are expensive when considering lost time events. However, there are many more cost factors related to accidents that can be direct or indirect. To evaluate the total cost of the accident, you must combine both of these costs.

In order for the cost to be paid, the organization must use the profits of the company. All profits are derived after the operational costs of the company have been calculated. Accidents affect the organization's profitability because the costs of the accidents must be paid from increased revenue. A company's profit margin is calculated by **Profit Margin=Total Profits/Total Sales**. The revenue required for funds to offset an injury are: **Revenue Required=Total Cost of Incident/Profit Margin**.

Additionally, the Business Roundtable publication, Improving Construction Safety Performance, published a study conducted by Stanford University Department of Civil Engineering that provides an indirect cost estimator for accidents as it relates to direct costs of an accident.

Direct Cost of an Accident

The direct costs of an accident are directly associated with the event and are easily quantifiable. Most direct costs are paid by the insurance company of the employer. Examples of some of these costs are:

- Physical therapy
- Medical expenses
- Repair fees for damaged equipment
- Increase in workers' compensation premium

- Continuation of pay
- Compensatory damages

Indirect Cost of an Accident

The indirect costs of an accident are not paid through the insurance and therefore are unrecoverable. While the direct costs are easy to quantify, the indirect costs are often unseen or impossible to quantify. The relationship between direct cost and indirect cost is the indirect cost is greater than the direct cost for the company. Examples of indirect cost are:

- Wages paid to injured workers for absences not covered by Worker's Compensation;
- Lost wages and work stoppage associated with the worker injury;
- Over time due to the accident;
- Administrative costs and time spent by safety personnel, clerical workers, and other employees after the injury;
- Training for replacement workers;
- Lost productivity due to the work unit separation from the injury;
- New employee learning curve;
- Accommodation of the injured employee within the organization:
- Clean up, preparation and replacement cost of damaged material, machinery, and property.

The National Council Compensation Insurance, Inc. (NCCI) collected statistics and data from insurance claims between policy periods 2011 through 2013. This data was incorporated by OSHA in the Safety Pays cost estimator for accidents. The NCCI manages the nation's largest database of workers compensation insurance information.

Indirect costs have a measurable relationship to the direct cost of accidents, which was discovered by the business Roundtable publication, improving construction safety performance, and the Stanford University Department of civil engineering. The magnitude of indirect costs is inversely related to the severity of an accident. Using these numbers, OSHA created the **Safety Pays Cost Calculator**.

Cost Estimate Calculator

The following chart will give the relationship between direct costs and indirect costs in a ratio that is used to calculate the total accident cost.

Direct Costs	Indirect Cost Ratio
$0-$2,999	4.5
$3000-$4,999	1.6
$5,000-$9,999	1.2
$10,000 or more	1.1

To use the cost estimate calculator, you need to know either the injury type or the workers compensation direct cost of an accident and the company's profit margin. However, if the profit margin is not known to the officer using the cost estimator then OSHA will give a default 3% profit margin for calculation of the direct and indirect costs in relation to the additional sales needed to pay total cost of the accident.

As an example of this calculator, if you select an amputation from the entry type menu and give the company a profit margin of 10%, the calculator will give you the following information:

- Amputation: (1) Instance
- Direct Cost: $77,995
- Indirect Cost: $85,794
- Total Cost: $163,789
- Additional Sales needed to recuperate cost (Indirect Cost): $857,945
- Additional Sales needed to recuperate cost (Total Cost); $1,637,890

Therefore, this example illustrates that just one instance of an amputation through most likely an at-risk behavior has historically cost $77,995 of direct costs and $85,794 of indirect costs yielding a total injury cost of $163,789.

Organizations will have to use funds from the profits to cover both direct and indirect cost of the accident. However, up to $77,995 can be recoupable through workers' compensation; then sales must increase $2,859,816 to cover the indirect costs of the injury that they cannot get reimbursed at a 3% profit margin.

Safety Programs

The components for an injury and illness program include:

- Management Leadership
- Worker Participation
- Hazard Identification & Assessment
- Hazard Prevention & Control
- Education & Training

- Program Evaluation & Improvement
- Communication & Coordination for Host Employers, Contractors, and Staffing Agencies

Management Leadership

Leaders are all considered managers in some form or fashion. A committed management unit provides clearly defined objectives and goals for organizational safety behavior. They finance the safety activities through purchases and resource allocations. Every level of management value safety practices and accomplishments as much as regulatory compliance and water quality.

Steps to implement leadership commitment to safety are:

- Writing or personally signing a clearly defined safety policy that acknowledges safety and health as important as productivity, water quality, regulatory compliance, and customer service.
- Communicating the policy and values to all levels of the organization
- Visually set examples of safety behavior and demonstrate actions consistent with a safety culture.
- Allocate resources for safety and health
- Hold all levels of the organization accountable for safety performance

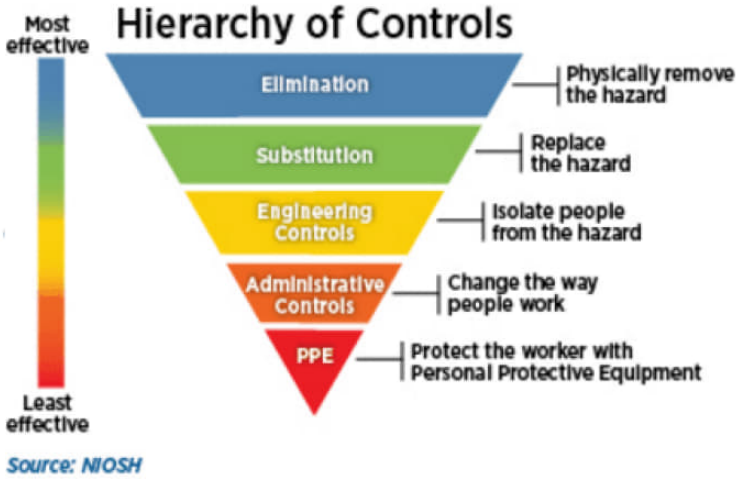
Hazard Identification & Assessment

A hazard is any condition or action that can cause an organizational loss. An organizational loss can come in the form of an injury, illness, damaged equipment, or even worker turnover. When a loss occurs, the organization must determine the root cause of the loss and not just the symptoms leading to the loss event. The assessment process must be structured, detailed, and deliver actionable measures to address the root cause. Hazard identification and assessment can be accomplished by:

- Worksite analysis of past, present, and predictive data from reports, instrumentation and maintenance logs, even worker injury and illness records
- Worksite inspections for safety hazards
- Investigate each accident until the root cause is completely disclosed
- Identify hazards that may arise outside of normal operating conditions including emergencies, start-up, or shut-down operations.

- Characterize the true composition of a hazard, give a priority value to them, and identify appropriate hazard controls

Hazard Prevention & Control



The prevention and control of hazards protect the worker from injury and illness, but also give employees a clear sign that the company cares about their wellbeing.

Elimination of hazards is the best way to avoid an organizational lose. However, that may not be possible in all situations. Therefore, hazard control is appropriate for some hazards that are still present when workers are performing their daily tasks. Although some worksites are practicing substitution of highly hazardous chemicals such as gas chlorine to liquid chlorine, it is mostly because they are trying to avoid the Risk Management Program, regulated by the EPA, and not primarily worker safety.

The hierarchy of hazard controls after elimination and substitution are:

1. Engineering (Physical barrier or device such as a machine guard)
2. Administrative (Work rule such as work rotation)
3. PPE (Protection worn by workers as a barrier to hazards such as a hardhat)

Tips for implementing hazard prevention and controls are as follows:

- Identifying what controls are available for each type of hazard

- Selecting the proper controls by doing a detailed hazard assessment
- Develop, maintain, and update a hazard control plan
- Select controls that are applicable for all aspects of the organization and conditions
- Implement the selected hazard controls with a priority on elimination and substitution of hazards
- Follow up on all hazard controls for each task to make sure they are protective enough

Education & Training

Education and training can be thought of as a tool that binds each step together to keep the efforts cohesive. Some companies have relied on safety training from organizations or even video tapes with outdated material. The role of education and training must be a factor in developing both management and workers to meet the overall safety culture. General workers should have safety awareness training with regular operations or maintenance training. However, if they work in a specialized area that exposes them to unique hazards, then training must be applicable to that hazard. Effective training can be done peer-to-peer, formal classrooms, online, or at the worksite. Some **actions items OSHA suggests** are:

- Provide program awareness training
- Train employers, managers, supervisors on their individual safety roles
- Train workers on their specific role in the safety program
- Train workers on hazard identification and controls

Program Evaluation & Improvement

Every program in an organization must be vetted and improved in order to stay viable and productive; safety programs are no different. Program evaluation must be done at given intervals by a competent group. If there are deficiencies found in a program, then the corrections must be made in a systematic way by high risk issues being fixed first then lower risk areas lastly.

Probability

Risk can be calculated as Probability x Severity=Risk. The probability of a loss event occurring can be broken down into 5 categories:

1. Improbable
2. Unlikely
3. Probable
4. Likely
5. Frequent

Severity

Severity speaks of the consequence of a loss event when it does occur:

1. Minor
2. Marginal
3. Serious
4. Catastrophic

If your risk assessment tells you that a task is a P4 x S3=R12, then it should get your attention over a R3 item.

Program evaluation and improvement must include the following areas:

- Monitoring performance and progress
- Verifying the program is implemented and is operating
- Correct program shortcomings and identify opportunities to improve (**OSHA, 2016**)

Many safety and health program have a significant deficiency in the written programs that are both OSHA regulations and procedures for safe work. The written safety program is used to keep workers from having to guess what is required for the task at hand. These programs must be periodically evaluated to determine if they are creating a hazardous condition by being vague, old information, or just not applicable to current working operations.
There are many OSHA required written programs, which are based on what the employees are exposed to in the work environment. Some common programs are:

- Emergency Action Plan (EAP)
    - The emergency action plan (EAP) is a created to help the workers understand what is the procedures to follow during an emergency situation at the facility.
    - Workers must know who is responsible for making sure that everyone is out of the facility. There must be a mechanism to check for employees that are left to perform critical activities and have to be evacuated after the shutdown process.
    - This plan will detail what emergency service will be called and who is making the call. The numbers must be kept up to date at all times.
    - Workers must be trained as to their roles in an emergency and all aspects of the EAP
- Fire Prevention Plan (FPP)
    - The FPP is regulated in the same vein of the EAP, because these two concepts are complementary in nature. The workers must be able to know what to do to prevent a fire at the facility.
    - In the FPP, the workplace has a person that is in charge of maintaining the combustible material separate from flammable materials.
    - Flammable materials must not be accumulated in such a way that is can cause a fire.
    - This plan also requires workers to be trained as to its contents and what to do to prevent fires, including understanding the use of a fire extinguisher.
- Control of Hazardous Energy Program
    - The control of hazardous program is commonly known as Lockout/Tagout or LOTO because that is the mechanism that is used to be an engineering control for the energy source.
    - This program will detail the interaction of a worker that must perform a task on heavy machinery that can cause amputations, crushing injuries, or even fatalities.
    - LOTO includes a detailed procedure to identify all energy sources of an equipment, release of latent energy, placing a locking device on the energy source, and placing a tag on the locking device or equipment detailing that the equipment is being serviced and not to energize the equipment.
    - The heart of the program is to have individualized lockout procedures for each unique piece of equipment and annual audits to make sure the procedures are still applicable.

- Fall Protection Program
    - Both General Industry and Construction have detailed information that are required for workers that are exposed to a fall hazard. Falls in construction are the #1 killer of workers in that industry.
    - A fall protection plan will uniquely identify the source of the fall hazard then match the most protective and practical fall prevention or fall arrest system for that job.
    - In some cases, it is not feasible to have traditional fall protection, which is, Personal Fall Arrest System, safety net, or guardrails, so an alternate procedure plan is put in place to protect the workers.
    - Training on the components of the fall protection system, fall hazards, and other fall related material is mandatory for employers that have workers that are exposed to fall hazards.
    - The standard does have different fall protection criteria for each industry such as:
        - 4 ft for General Industry
        - 6 ft for Construction
        - 10 ft for Scaffolds
        - 15 ft for Steel Erection work
- Hazard Communication (HazCom)
    - Hazard communication is the top cited standard for General Industry each year. Because to the lack of understanding of the regulation.
    - A worker has the right to know of any hazardous chemical that they are exposed to in the work environment.
    - Often the workers are exposing themselves to hazardous chemicals by putting substances in the wrong secondary container and not putting a proper label on the new bottle. Then the worker will forget or place the chemical in the mislabeled or unlabeled bottle in the general working environment. This can prove to be fatal if a worker consumes chemicals, thinking it is a beverage.
    - The Hazard Communication standard give details on what to place on the label for proper communication of the liquid and its hazard potential. In recent years, OSHA has adapted the Globally Harmonized System for the Classification and Labeling of chemical (GHS). The GHS is a UN initiative that has recommendation for all countries that ship and use chemical for their product.

There are many more written programs that are used to give detailed guidance to the worker for protecting them from unique hazards. To evaluate the written program, the

safety committee must think of the Maturity of the program and how Critical the program is to the overall operations of the facility.
A Maturity/Criticality assessment will give a quantifiable number as to where the current state of the written program is for the company. This will also help the program evaluation team to see where the needed changes must be and how to prioritize what written program gets changed first.

The determining of the maturity and criticality of a written program will align to the overall corporate vision and objectives. Once the program is aligned in such a fashion then it becomes easier to get the budgetary funding for the programs and all activities related to the written program including training and equipment for the workers.
First, the program must be analyzed for the current phase of maturity or immaturity using the following scale (Steinbacher & Smith):

Maturity Score	Maturity Level	Description
4	Introduction	The program may not have elements that are necessary or only covers the basic information with significant gaps in the vision or current state of the program
3	Informal	Program is just getting off the ground with moderate gaps in the vision and current state of the existence
2	Functional	The program is established with almost no gaps or very little gaps between the vision of the program and how it is currently administered
1	Model	The program is a benchmark for other entities. There are no gaps in the execution of the program or functions.

After the Maturity number is assigned then the Criticality is assessed through the following method and numbering system:

Criticality Score	Criticality Level	Description
3	Business Critical	This program is required for the business operations. There will be noncompliance of regulatory requirements, major injury and illness potential, This activity may have an impact on the community and public relations.
2	Core	Key element for the complete Safety Management System of the organization
1	Improvement Oriented	Elements of ongoing process to get a better overall Safety Management System

The Maturity/Criticality Ranking is determined by M x C=MC Rank

Element	M	C	MC	Opportunities
Ergonomics	3	2	6	BBS observation for Ergonomics should be scheduled
LOTO	2	3	6	Get some more training and tools for program success
Driver Safety	3	3	9	Have all drivers go through a safety training program semi-annually through our insurance company

The information that is gathered can be utilized for many components of the over Safety Management System or even the organization as a whole. The message of the score can be used in a color-coded chart to give a visual as to what is priority for the company and what can wait.

MC Decision Matrix			
Model (1)	3	2	1
Functional (2)	6	4	2
Informal (3)	9	6	3
Introduction (4)	12	8	4
	Critical (3)	Essential (2)	Improvement (1)
	High Priority	Medium Priority	Low Priority

Using the M/C scoring system is a great way to visualize and prioritize the activities of the evaluation team as they review the written programs of the organization. Having a written program is only the first stage of keeping the works safe. The plan must be enforced, monitored for completeness, and adjusted as needed to hit its target.

Communication & Coordination for Host Employers, Contractors, and Staffing Agencies

The host company must take responsibility for all workers including contract and staffing agency workers. Many public sector businesses are not under the jurisdiction of federal OSHA or even a state OSHA, but the contract companies are under an occupational safety agency that will regulate and cite them for violations. However, local government officials have a moral obligation to make sure that workers of all types who do business with them are protected from hazards. To keep the workers safe, the company should:

- Communicate with all outside contractors the importance of worker safety
- Coordinate with supervisors, owners, and workers throughout the project to make sure the worksite is safe
- Hold all workers and agencies accountable for operating a safe worksite
- Verify that the bids and contracts specify that safe work practices are a must for working with the company

A safety culture will protect the workers from injury and illness because the company places a value on the lives of the workers. This is a deposit into the “good will” bank of the worker and will be rewarded with loyalty. A deep commitment to a safety culture will lead to worker retention and organizational benefits far beyond regulatory compliance.

Worksite Analysis

Hazard prevention and control comes from all levels of the organization including the chief executive officer all the way down to individual working at the tasks themselves. A safety management system is built on the foundation that not only is everyone responsible for their own safety, but a system can be incorporated in all task that will protect workers from contacting the hazard.

One of the most common ways for workers to visualize hazards in a job prior to doing the job is through a Job Hazard Analysis (JHA).

What is a JHA?

A job hazard analysis is a tool that is used throughout organizations to help the workers visualize a job that needs to be done and break it into steps. It is different than the standard operating procedure because each step will have an identified hazard and an identified control.

The job hazard analysis is commonly used for training workers as to how to perform a job in the safest manner possible. A standard operating procedure will only show the person how to do the job by breaking down its components. The components of any job are usually communicated through instructions by people who have done it in the past. These can be frontline supervisors or the manufacturers of the equipment.

Using the manufacturer's recommendation, you will see how the equipment is supposed to work, but it may not detail the safety requirements of the job. In a standard operating procedure (SOP), the task is detailed from the beginning to the end of the activity.

Many JHA can be started by using the SOP to get the steps outlined in chronological order as to the way it should be done. Then the safety committee with a good selection of the working crew will dissect the steps to see if and where a hazard may present itself.

Once the hazard or hazards for a step are identified, then the workers will look to the hierarchy of hazard control to see if they can either eliminate the hazard, substitute it, engineer out a control, use existing or new work rules as an administrative control, or finally wear personal protective equipment during that step.

The workers can go back and forth reviewing the JHA to determine completeness of tasks and total identification of hazards. The JHA is also formalized by writing on a JHA worksheet and kept for the review of the employees prior to doing the task.

Some JHA's can be done in advance for jobs that are routine, while others are done onsite prior to the beginning of the task. However, even JHA's that are done prior

should be revisited by the work team before any work begins. If there is any doubt as to the steps, hazards, or hazard control, then the work should not progress until all questions have been answered.

Job Hazard Analysis Form

JOB TITLE: DATE OF ANALYSIS:

JOB LOCATION:

STEP	HAZARD	NEW PROCEDURE OR PROTECTION

Hazard Recognition

To understand the behavior-based safety program, it is necessary to understand what a hazard is first. A hazard is anything that can injure or hurt an individual. While you know a workplace can have various hazards that does not mean that there will be an injury. Hazards must have exposure in order for there to be an injury or an incident. Hazard identification is primary to understanding how an accident can happen. Later in this program, we will review accident causation from a few different models.

The hazard itself may be the issue for workers when it comes to safety or it may be the exposure to that hazard that is the issue for the employer. For instance, if there is a cave-in hazard for trenching and excavation the cave-in is possible even without the workers being present. The hazard becomes an accident or incident when workers are present, meaning exposure.

Hazard recognition should be first and foremost taught to the front-line supervisors. If the front-line supervisors, who control their work conditions, are aware of hazards then they will protect themselves and the people they supervise. Hazard recognition secondarily must be taught at the level of each worker as they become employed at the facility.

There are obvious hazards such as working at heights, but there are also hazards that may not be as obvious. Workers may be exposed to an odorless toxic fume, so they are not aware that they are being poisoned. This may be the case in many permit-required confined spaces because they often have hazardous atmospheres.

Hazard Types

Hazard types are ways to classify what specifically the hazard is to the worker. Examples of hazard types are:

- ergonomics
- caught in
- contact with
- chemical exposure
- flammable liquids
- laceration
- Falls to below
- Falls to the same level
- mechanical hazards
- engulfment

There are many more hazard types that are job specific, so the worker must be trained to recognize these hazards from the first day of work. Once the hazards are identified, the next stage is to learn how to control the hazard and prevent it from injuring a worker.

Hierarchy of Hazard Control

There is a hierarchy of hazard control beginning with:

1. **Elimination** is the primary way to protect the worker from any hazard. If workers do not have any exposure to that hazard because it is not present, then they will not be injured or harmed.
2. **Substitution** is a secondary way to protect the worker from injury or illness. If there is work with the gas Chlorine and the workplace decides to go to liquid bleach, that substitution would protect the workers from exposure to a hazardous gas.
3. **Risk Transfer:** Another type of hazard control would be to transfer exposure using a contractor. When the contractor is used to perform jobs that your workers would have been doing, then the exposure will go to the contractor and not to your employees. Many companies decide to use this method when the hire specialist such as mold remediation companies, asbestos removal companies, or private fire rescue companies.
4. **Engineering controls:** An engineering control is one that creates a physical barrier between the worker and the hazard point. This physical barrier is not something that can easily be removed or bypassed without worker intervention. There are several types of engineering controls; they should be used primarily for keeping the worker protected.
    a. An example of engineering control is a machine guard on a table saw. If the workers want to use the table saw without the machine guard, they would have to physically take off that guard and then operate the machinery. The behavior would be an at-risk behavior creating exposure to a low hazard that can cause a laceration or amputation.
5. **Administrative controls**: An administrative control is a work rule set by the employer to protect workers from injuries or illnesses. A work rule, policies, procedures, and employer's safety culture are company norms that will translate into absolutes. An example of an administrative control is to have workers read the procedure on how to safely do a task. This procedure would be detailed, identify the hazards, and help the worker select the appropriate control to that hazard.
6. **Personal Protective Equipment (PPE)**: PPE is the very last line of defense for worker safety and health because they are still exposed to that hazard. If an engineering control is being manufactured and the worker must still be exposed to the hazard, then the PPE should be selected for protection.

a. In general industry, personal protective equipment must be accompanied with a PPE hazard assessment. The PPE hazard assessment is the workplace choosing the right protective equipment to match the hazard that the workers are exposed to. For instance, disposable gloves can be worn to protect against biological hazards. If a worker is cleaning up a blood-borne pathogen spill from human fluids, then he or she would use gloves. The PPE hazard assessment would tell him or her what types of gloves to use. It could be latex gloves, nitrile gloves, or even thicker gloves depending on if there is also a needlestick hazard.

Lesson Summary

There are many cost factors related to accidents that can be direct or indirect. The direct costs of an accident are directly associated with the event and are easily quantifiable. Most direct costs are paid by the insurance company of the employer. The indirect costs of an accident are not paid through the insurance and therefore are unrecoverable.
The components for an injury and illness program include:

- Management Leadership
- Worker Participation
- Hazard Identification & Assessment
- Hazard Prevention & Control
- Education & Training
- Program Evaluation & Improvement
- Communication & Coordination for Host Employers, Contractors, and Staffing Agencies

One of the most common ways for workers to visualize hazards in a job prior to doing the job is through a Job Hazard Analysis (JHA). The job hazard analysis is commonly used for training workers as to how to perform a job in the safest manner possible.

A hazard is anything that can injure or hurt an individual. Hazard identification is primary to understanding how an accident can happen. Hazard types are ways to classify what specifically the hazard is to the worker.

Once the hazards are identified, the next stage is to learn how to control the hazard and prevent it from injuring a worker.
There is a hierarchy of hazard control:

- Elimination
- Substitution

- Risk transfer
- Engineering controls
- Administrative controls
- Personal Protective Equipment (PPE)

Lesson 2: Accident Causation and Investigation

Lesson Focus

This lesson focuses on the following topics:

- Understanding Accident Causation
- Accident Theories
- Incident Investigation Techniques

Understanding Accident Causation

To understand accident causation, investigation relies on the idea that most accidents are caused by human error. Therefore, if you learn the cause and effect relationship of accident causation and the human element, then you can reduce injuries and illnesses. Although, there are additional factors that cause accidents, the human aspect is a leading cause of incidents.

The difference between and accident and an incident are slight but worth noting. Accidents denote a loss-producing, unintended event, and an incident denotes an unintended event that possibly doesn't result in a loss (Friend & Kohn, London). In this session, we will refer to incidents and accidents as interchangeable because, the outcome, in this context, is not as relevant as the causes.

In order for an accident to happen, there must be two factors present: the hazard and exposure to the hazard. The hazard is anything that will hurt harm you through contact. Exposure is how susceptible you are to an injury or illness due to being near to the hazardous substance or material. Accident causation models deal with controlling/eliminating exposure or eliminating, substituting, or controlling the hazard itself.

Types of Hazards

There are several different types of hazards, including but not limited to:

- Chemical
- Caught in between
- Contact by
- Electrical
- Ergonomics
- Excavation

- Slips, trips, and falls
- Mechanical
- Overexertion
- Struck by
- Struck against

Hazardous Control Techniques

If safety professionals do not have the option to eliminate or substitute hazard, then they must control the hazard to which their employees are exposed. There are three types of hazardous control techniques:

1. Engineering controls are the most preferred way to control hazards from affecting a worker. The engineering control is a physical device or barrier that prevents the worker from coming into contact with a point of operation or uncontrolled energy. An example of engineering controls are machine guards, locking devices, and the fume exhaust systems.
2. Administrative controls (or work rules) are controls that create a policy and procedure to protect worker from the hazard. Examples include the safety management system, lockout tag out policies, and job hazard analysis.
3. Personal protective equipment is the last line of defense because the worker is still exposed to the hazard. Some examples of personal protective equipment are hardhats, close, and primary eye protectors.

These hazard controls are set up in the hierarchy scenario, therefore hazardous material must be controlled through engineering controls first, then administrative controls, and finally personal protective equipment. However, in most scenarios one or more of these controls are used to protect the worker from the hazardous condition or material.

Hazard Analysis

Hazard analysis is a way to understand the nature and complexity of a hazardous condition. A proper analysis is done through assessing the risk involved for the workers when confronted with this hazard. Usually hazard analysis includes the probability of the hazard creating an accident and the likelihood that the incident will result in an injury or illness to a certain degree. Therefore, a calculation of probability times severity equals risk.

Probability categories are often delineated into five cases improbable, remote, occasional, probable, and frequent. In most risk analyses, each probability category can be assigned a number beginning with the lowest category improbable being assigned one and the highest category frequent being assigned to five.

The severity factors also are delineated by the characteristics negligible, marginal, critical, and catastrophic. Similar to the probability factor, numbers are assigned to the severity factors beginning with negligible as a one and catastrophic events as a four.
With this understanding of risk, an assessment can be performed using the number system of probability times severity and give a class of hazard. The higher the hazard the more probable that there will be an accident. Combined with the human error factor, the probability and severity may both increase any hazard that is a high risk.

An example of conducting a risk analysis is as follows:
Risk = Probability x Severity

Frequency of Occurrence-Probability	Catastrophic (Fatality) (4)	Critical (OSHA Recordable) (3)	Marginal (First-Aid) (2)	Negligible (Near Miss) (1)
Frequent (5)				
Probable (4)				
Occasional (3)				
Remote (2)				
Improbable (1)				

Example:
A worker working in a laboratory is using acid without any hand protection.

The probability of a chemical burn is high enough to warrant the top level of likelihood of an event occurring, which is a 5. The consequence of a chemical burn will yield a severity of 3. In calculating this risk, the use of acid in a laboratory without hand protection is a risk factor 15. Using the maximum scale of 20, the highest probability 5 and the highest severity as 4, then this action by the worker is a high-risk activity.

In this example, the use of chemicals without proper personal protective equipment has an element of behavioral deficiency. This at-risk behavior can be identified through a behavioral-based safety inspection and coached. Although, the worker did not have gloves on when handling the chemical, it is unlikely that an accident will be the cause of the single factor.

Accident Theories

Single Factor Theory

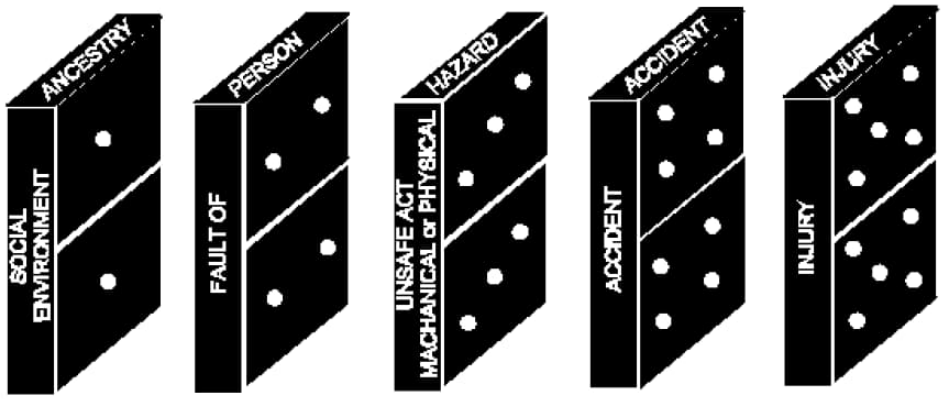
The Single Factor Theory for accident investigation is the most basic of the accident causation models. In the single factor theory, it is thought that there is one event solely responsible for an accident or incident. It is akin to the “pilot error syndrome” that states that the cause of the accident was solely due to an error caused by the pilot. In modern accident causation models, the single factor theory has little to no value.

H.W. Heinrich’s Domino Theory

In 1931, HW Heinrich presented a theory called the axiom of industrial safety. The first axiom dealt with accident causation, which states “the occurrence of the injury invariably results from the complicated sequences of factor, the last one of which being the accident itself” (Heinrich et al, 1980). The model that was used to illustrate this point was a lineup of dominoes, which became known as the domino theory. In all the domino theories, there are 3 phases that are influencers of an accident. These phases are:

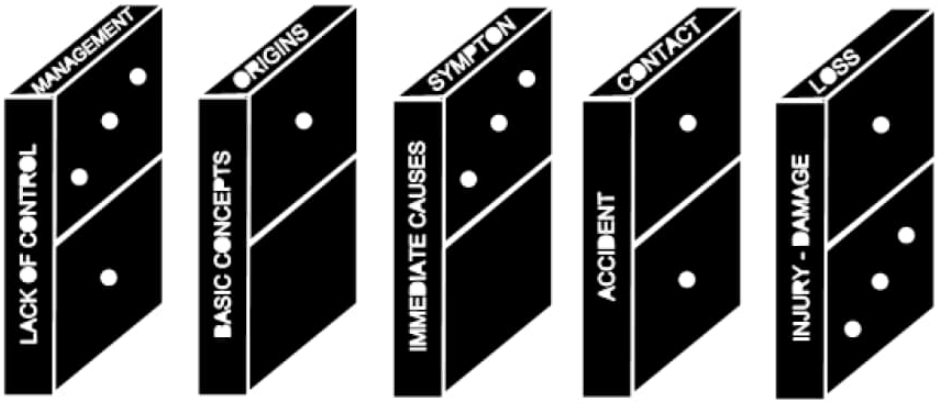
1. Pre-Contact phase prior to the event happening
2. Contact phase, which refers to the event as it’s happening.
3. Post contact phase, which refers to after the release of unplanned energy, the product downtime, or the injury or illness

The domino theory is summarized as an injury is caused by an accident due to an unsaved act and/or mechanical or physical hazards due to the fault of the person, caused by their ancestry and social environment. (Heinrich et al, 1980)



(Heinrich, D, & Roos, 1980)

In this model, Heinrich states that by removing one of the dominoes, preferably the middle unsaved act domino, then the accident would have never occurred. The later model of the Domino, Bird and Loftus added managerial influence and managerial error dominoes. In the later model, loss was organizational loss as opposed to just an accident. An example of organizational loss could be property damage, loss of public trust, as well as an illness or injury.



(Heinrich, D, & Roos, 1980)

A point of contention of the Domino theories was that they don't glean your nature of the incidents. As the accident theories developed, more dimensional approaches became common, indicating that the cause of an incident may be multi-factual with events happening in a nonlinear format.

Multiple Factor Theory

The multiple factor theory looks at not just the 3 phases in the domino theory of pre-contact -- contact -- post contact, it analyzes other factors that influence an accident. Multiple factor theories analyze other things such as management, the machines, the media, and the man. The role of management would be to create the organizational structures, the policy, and procedures. The machinery includes the design, shape, size, and the type of energy sources of the equipment. The role of media can be described as environmental factors. The factor of the man includes gender, age, mentality, fatigue factors, height, weight, etc.

In analyzing all these factors, it becomes apparent that your model does not include just the influencers. Unlike previous theories, management's role is more concrete in the multiple factor theories. Strong management that respects the role of occupational safety will support and lead the safety effort of the organization.

Human Factor Theory

The human factor theory states that the accident is caused by human error. This theory analyzes the factors that lead to the human error. Such factors are overload, inappropriate activities, and inappropriate responses.

Overload doesn't always mean that the worker is overburdened, but the job itself may have excess stressors such as noise, heat, or unclear instructions. Workers can often feel overloaded when given too many tasks at a time or work instructions do not clearly define the goals. Front-line supervisors are charged with making sure that the workers understand the steps of each task.

There are two types of failures that cause human errors: active failures and latent failures (Reason J. , 1990). An active failure is usually caused by the worker or person engaged in an activity. The actions give an immediate consequence, which is the direct cause of the accident. Latent failures lay the foundation of an active failure due to such issues as:

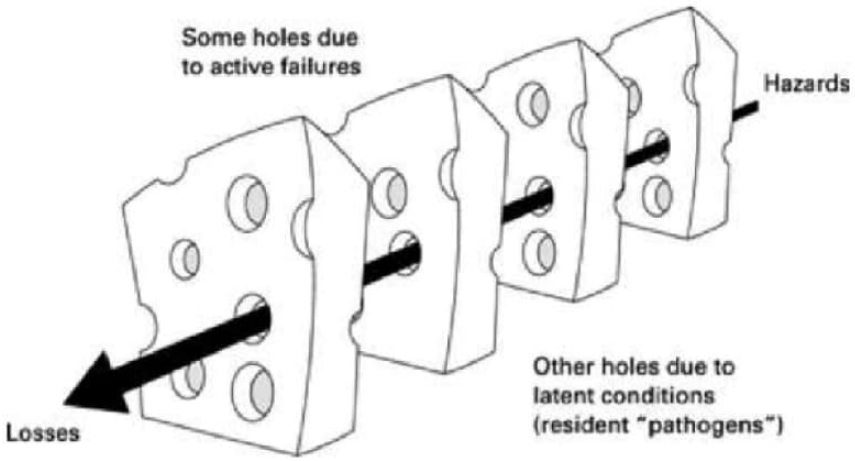
- Ineffective training
- Poor engineering of the equipment or location
- Poor or inadequate supervision
- Ineffective communication
- Unclear roles for the worker

The observation of the human factor theory through a behavioral-based safety analysis can help improve the safety system. The BBS is designed to highlight the behavior of the worker that is causing the accident and to address them systematically. The key to systematic intervention is having a well-planned and thought out BBS program.

James Reason's Swiss Cheese Theory

In recent years, a professor from Manchester University in the United Kingdom, James Reason, developed an accident causation model based on the analogy of holes in Swiss cheese. In his analysis of an accident, he uses a visualization of a complete system with no holes. In a complete system, management is involved, employees are motivated, there is a safety management system in place, and a safety culture exists in the organization.

Fig. (1): The Swiss Cheese Model by James Reason published in 2000. Adopted from Perneger BMC Health ServicesResearch 2005 5:71.



https://www.researchgate.net/figure/Fig-1-The-Swiss-Cheese-Model-by-James-Reason-published-in-2000-Adopted-from-Perneger_fig1_324280519

A breakdown of any one of these components, the blanks, will create a whole similar to the hole in a slice of Swiss cheese. As mortals developed, the system becomes less than ideal and dysfunctional. Eventually each one of the systems will have their holes line up and allow a release of unplanned energy to create an accident condition. In this model, it does have a linear component, but it also includes multiple factors that influence the accident.

An example of how each one of the blanks can develop holes can be found in the following scenario:

Upper management has a change in leadership with the new ownership group. The ownership group values production more than safety. Therefore, the workers are not given adequate time for safety briefings in the morning. Production becomes the main factor for the organization. Quality and safety may suffer due to the production quotas. Eventually workers will become fatigued, equipment fails, or safety training is omitted entirely.

During a busy shift when the worker is trying to meet production quota, he decides not to report a broken guard on a piece of equipment and comes in contact with the unguarded point of operation. The worker sustains a laceration that could have easily been an amputation.

Incident Investigation Techniques

Root Cause Analysis

A root cause analysis is a detailed procedure used by safety professionals to look beyond the initial knee-jerk reaction to assign blame for an incident. First, the investigator will notice direct causes to any accident, but he or she cannot see indirect causes or latent causes that became activated to create the accident.

A root cause analysis must be conducted to determine all factors and variables responsible for an incident. Most of these types of analysis will require a team of trained professionals alert to accident causation models, as well as good investigators and critical thinkers. There are many types of root cause analysis, but they all seek to do the same thing: address the source cause of any accident.

The 5 Whys

The 5 Whys is an accident investigation technique used by safety professionals in developing the root cause analysis. This technique will help the data entry investigator pass simple questions to date beyond the superficial yes or no answer. They are quantifiable questions that build one upon the next. As each question gets answered, the investigator will uncover more reasons for an accident. Although this technique is called the 5 Whys, it often takes more questionings to get to the root cause.

An example of the 5Y technique for incident investigation is as follows:

A worker receives a laceration from touching unguarded blade on a handfed ripsaw. Using the 5 Whys technique for questioning, the investigator can begin with these questions:

1. Why did the worker receive a laceration? -- Because, he touched unguarded blade.
2. Why did the worker touch the unguarded blade? --Because the guard was not placed on the saw.
3. Why was the guard not on the saw? --Because the worker believed he can work faster without the guard.
4. Why did the worker believe it is better to work faster and not safer? --Because the worker gets paid on a quota basis.
5. Why is management placing a greater importance on production quotas over safety? --Because management receives a bonus for achieving production quotas.

In this brief example, the use of production quotas indirectly led to the worker valuing speed over safety. There may be many other factors related to why the worker received a laceration in the scenario. Such factors can include but are not limited to:

- Poor organizational safety culture
- Untrained worker
- Management and supervision has unfair expectation of production quotas
- Worker fears retribution for slowing down production to address safety concerns
- Upper management has condoned and/or rewarded production goals over safety concerns.

When conducting a 5 Whys accident analysis, the investigator will dig deeper to uncover an accident causation. This new revelation may lead the organization to address gaps in their safety management system. The value of operating safely to reduce or eliminate injury and illness must be made apparent to management in order for them to value safety equal with production.

Lesson Summary

Managing safety and health is a key part of keeping workers free from injury and illness. The company will save money by investing in the safety needs of the employees. An organization that values low risk will have a safety culture that will promote safe behaviors in all level of the organization. Additionally, through accident investigations, the company will get a good understanding of what hazards created the incident and how to stop it from hurting future workers.

To understand accident causation, investigation relies on the idea that most accidents are caused by human error. Therefore, if you learn the cause and effect relationship of accident causation and the human element, then you can reduce injuries and illnesses. In order for an accident to happen, there must be two factors present: the hazard and exposure to the hazard.

Accident theories include:

- Single Factor Theory
- H.W. Heinrich's Domino Theory
- Multiple Factor Theory
- Human Factor Theory
- James Reason's Swiss Cheese Theory

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The 5 Whys is an accident investigation technique used by safety professionals in developing the root cause analysis by asking questions. As each question gets answered, the investigator will uncover more reasons for an accident.