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## SCHOOL OF MECHANICAL ENGINEERING

## DEPARTMENT OF MECHANICAL ENGINEERING

## COURSE MATERIAL

**Program : M.E - CAD** **Course: Industrial Safety Engineering**
**Course code: SPRA7011** **Semester: III**

## UNIT 1 - INTRODUCTION - SPRA7011

Evaluation of modern safety concepts - Safety management functions - safety organization, safety department - safety committee, safety audit - performance measurements and motivation - employee participation in safety - safety and productivity.

# UNIT 1 - INTRODUCTION - SPRA7011

## HISTORICAL DEVELOPMENT OF INDUSTRIAL SAFETY MANAGEMENT

Industrial Safety Management (ISM) could be traced to the period of Industrial Revolution. The Industrial Revolution was a period from 1750 to 1850 where changes in agriculture, manufacturing, mining, transportation, and technology had a profound effect on social, economic and cultural conditions of the times. It began in the United Kingdom, then subsequently spread throughout Western Europe, North America, Japan, and eventually the rest of the world. However, Hoppit (2011) posited that Great Britain provided the legal and cultural foundations that enable entrepreneurs to pioneer the Industrial Revolution. According to Anonymous the key factors fostering this environment were;

i. The period of peace and stability which followed the unification of England and Scotland,
ii. No trade barrier between England and Scotland,
iii. the rule of law (respecting the sanctity of contractors),
iv. A straight forward legal system which allowed the formation of Joint Stock Companies (Corporations), and
v. A free market (capitalism).

In the 18$^{th}$ century there began a transition in parts of Great Britain's were previous manual labor and draft animal-based economy towards machine-based manufacturing. It started with the mechanization of the textile industries, the development of iron making techniques and the increase use of refined coal (Roger, 1999). Consequently, the critical manufacturing change that marks the Industrial Revolution is the production of interchangeable parts. Some of the machines used in the era of Industrial Revolution include;

i. Watt Steam Engine
ii. Spinning Mule
iii. Spinning Jenny
iv. Reverberator Furnace
v. Savory Engine (the world first commercially useful steam engine)
vi. Newcomen's Steam Powered Atmospheric Engine
vii. Blast Furnace

The introduction of machines changes the process of production which brought various forms of risk in the process of production due to lack of experience in the use of these machines. According to Umunadi (2010), the industrial development of motors, conveyors, pumps and appliances came with risks that are inherent in their use. During the early introduction of machines to replace the domestic process, various forms of accidents occur which led to the loss of life and deformation of workers. The fatality rate was very high then. Golden (1967) in Umunadi (2010) opined that, in the United State of America (U.S.A.), industries pay a substantial bill each year for the treatment and cure of workmen disabled by on the job accidents. Moreso, in the United Kingdom, 256,930 accidents of which 479 were fatal was reported to the factory inspectorate in 1974 and that in the same year in Nigeria, 1,132 accidents and 11 fatalities were notified to the factory inspectorate while 804 accidents, 12 of which resulted in death were reported in 1975, due to the various accidents, risks, fatalities, death, loss of properties; and decline in organization's repute, associated with industrialization. However, the sharp rise in accident cost that resulted from compensation laws and tighter employer's liability initiated the modern concern with work safety and initiated the long-term decline in work accidents and injuries, large firms in railroading, mining, and manufacturing and elsewhere suddenly became interested in safety. Also, companies began to guard machines and power sources while machinery makers began to look for hidden danger at work, and to require that workers wear hard hats and safety glasses, they also set up safety departments run by engineers and safety committees that included both workers and managers. In 1913, companies founded the National Safety Council to pool information. Government agencies such as the Bureau of Mines and National Bureau of Standards provided scientific support while universities also researched safety problems for firms and industries (Aldrich, 1997). Hence, safety education became crucial and important which lead to the introduction of Industrial Safety Management (ISM).

**Industrial Safety Management (IMS)**

Safety is the act of been free from harm and danger. According to Umunadi (2010) it simply means being safe or completely free form dangerous situation or situations that can cause havoc, disaster, harm, injury and death. On the other hand, management is a social or international and economic process involving a sequence of coordinated events (planning,

organizing, coordinating, and controlling) in order to use the available resources to achieve a desired goal in the fastest and most efficient way. From the foregoing, Industrial Safety Management (ISM) is all the steps taken by employers, employees, safety officers, supervisors, and government to ensure safe work or production process in industries which main objectives is to promote safety, practice among employers and employees and to reduce and eliminate risk in industries.

**Personnel in Industrial Safety Management**

In the industries, three main personnel are involved in the production process. These are:

a. The employer: This is the owner of the company.

b. The Employees; This simply means the workers in the company

c. The supervisor: This can be referred to as the foreman in the company.

**The Safety Officer:** This is an employee in an industry that is charged with the responsibilities of preventing accident.

**Goals of Industrial Safety Management (ISM)**

The following are goals of ISM;

i. ISM helps to reduce and prevent accident.

ii. ISM helps to reduce unprecedented financial cost of compensation and treatment of disabled workers.

iii. ISM helps to improve the corporate image of the company.

iv. ISM helps to educate workers and employers on the best safety practice across the world.

v. ISM helps to reduce heavy burden of insurance on the company.

ISM helps to reduce injury, sickness and death caused by accident and exposure to hazardous substance.

**EVALUATION OF SAFETY CONCEPT**

Safety is a state in which hazards and conditions leading to physical, psychological or material harm are controlled in order to preserve the health and well-being of individuals and the community.

Safety engineering concepts provide the structure for both safety and industrial design engineers to develop intrinsically safe equipment, systems, processes and facilities. When employed early in a design process, safety engineers provide insight into how people will interface with the equipment and facility design. Ideally, early on safety design will ensure not only safe design for people, but also, a safe operational concept that will carry

over into capabilities for the facility to handle industrial and non-industrial incidents and minimize the cause-effect. Engineered safety includes fail safe process equipment, fault-tolerant equipment, fire safety features and enclosed hazardous systems that prevent exposure to both workers and the environment.

Safe engineered design concepts include all environmental aspects of the workplace such as lighting, noise levels, atmospheric contaminants, ambient and localized temperature extremes, slip resistance of flooring materials, emergency escape routes and fire suppression and alarm systems.

Safety engineering also is the key component for eliminating hazards that would otherwise be controlled by either administrative controls or use of personal protective equipment as a barrier between a hazard and a worker. These engineered safeguards include machine guards, selection of less hazardous equipment, development of maintenance schedules to ensure equipment safety, audit and inspection procedures, selection of safer tools, safety review of new equipment, employee maintenance training, safe design of the flow of material and people through a facility and risk analysis for both possible man-made and natural incidents.

Safety evaluation of in-coming utilities includes ensuring backup supplies for process critical systems for both power and water. Electrical systems are evaluated to prevent additional facility expansion or equipment from creating stresses to the electrical distribution system.

Human resources practices are important to project and safety management. These include: giving out incentives based on an individual's safety performance; meting out punishment; providing safety training; maintaining close communication and feedback; allowing workers to participate in safety matters; management commitment; evaluating workers based on their safety performance; and providing welfare benefits.

## SAFETY MANAGEMENT FUNCTIONS

If risk minimization cannot be achieved through design measures alone, then the use of safety-relevant control parts and a corresponding definition of safety functions is required. The appropriate safety functions are selected according to the application and required safeguard.

### Safety Functions: Risk and Safety Category Assessments

**(1) Ensure Safety**

The responsible machine or process designer no longer considers the production requirements and adds safety systems later, but addresses the two issues as a whole.

Legislation demands that the machine or process design meets the necessary safety standards and regulations it is a legal requirement. Different types of machines will have different levels of associated risk. These risk levels need to be addressed for the whole machine life span. In particular the requirements at commissioning, application/usage and decommissioning of the machine must be considered.
Risk assessment according to ISO14121 is a series of logical steps that enables designers and safety engineers to examine in a systematic way the hazards arising from the use of machinery so that appropriate safety measures can be selected.

**(2) Risk Assessment**

ISO14121 - Safety of Machinery - Principles for Risk Assessment The main objective is to describe a systematic procedure for risk assessment so that adequate and constant safety measures can be adopted. These are appropriate during the design, construction, modification, use and decommissioning of the machine.

The safety of machines can be determined in 5 steps.

Documentation of the risk assessment process must be kept.

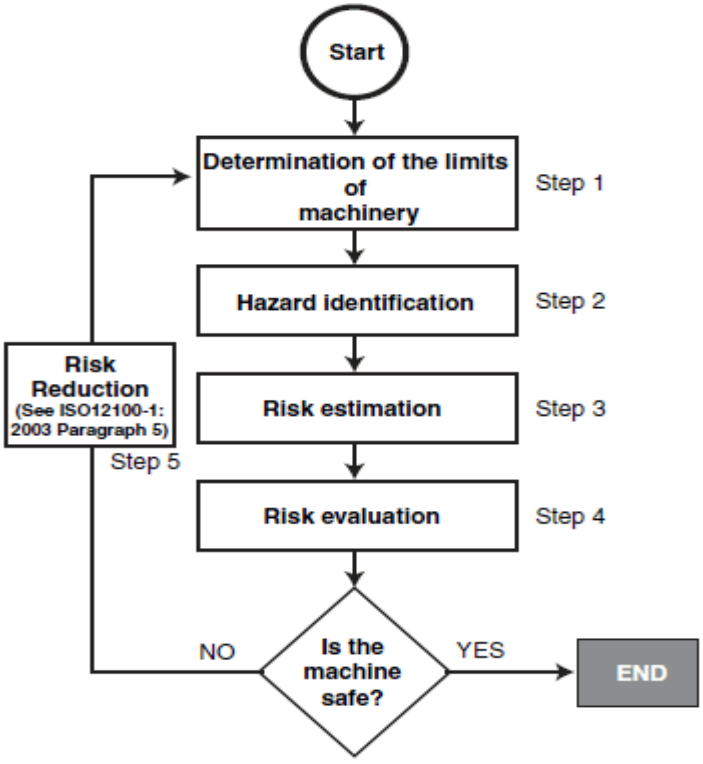


**Fig.1.1**

**● Step 1 Determination of the limits of machinery**

Defining machine limits requires the following points to be considered when assessing risk.

Determining requirements for all phases of the machine's life

Defining the intended use and operation and the foreseeable misuse and malfunction

Defining the machine's range of use as limited by factors such as the operator's gender, age, dominant hand, and physical abilities (e.g., impaired eyesight or hearing, size, and strength)

Expected user training, experience, and competence

Possibility that people may be exposed to machine hazards

Possibility that people may be exposed to machine hazards if a foreseeable machine hazard occurs

**● Step 2 Hazard Identification**

Hazard identification means checking for all the hazardous conditions and hazardous events associated with the machine. This involves predicting hazards that may be caused by the machine, such as the following: Mechanical hazards: Severing, entanglement, crushing, etc. Electrical hazards: Contact with live parts, static electricity, etc. Thermal hazards: Health disorders due to contact with high-temperature parts or working in a high-temperature or low-temperature environment

Methods for clarifying hazards include the following:

- Check lists
- Hazard and Operability Study (HAZOP)
- Failure Mode and Effect Analysis (FMEA)
- Fault Tree Analysis (FTA)
- "What-if" method

**● Step 3 Risk Estimation**

After checking for hazardous conditions and hazardous events, the risk factors are determined and the risks are estimated from the degree or possible harm and the probability of the hazard occurring.

**● Step 4 Risk Evaluation**

After estimating the risk, the risks are evaluated to determine whether the level of risk must be reduced. If the level of risk must be reduced, safety measures, such as changing the design or providing safeguards, are taken.

**● Step 5 Risk Reduction**

The following actions are taken.

Eliminate or reduce exposure to hazard as far as practical.

Reduce the probability and severity.

Use safeguards and safety devices.

Determine that the performance and functional characteristics of the safety measures are suitable for the machine and its use.

**● Risk Reduction under ISO12100**

ISO 12100 (-1/-2) has been formed into JIS standard JISB9700 (-1/-2). The main purpose of this standard is to set out a framework and directions for general machine safety, so that designers can design safe machines. The introduction of ISO12100-1:2003 states that "The concept of safety of machinery considers the ability of a machine to perform its intended function(s) during its lifecycle where risk has been adequately reduced". The 3-step method, which is an expression of this risk reduction methodology, has been further implemented into the **"Risk Reduction Process"** illustrated on the following page, but it does not yet seem to have been fully recognized in actual applications.

**WORKERS PARTICIPATION IN SAFETY**

Employers are the major work force working under hazards. Some know the hazards and some do not. It is of great importance that they must realize that they would be the first victim of any accident, their safety awareness and all accident prevention work is in their interest and therefore their active **EMPLOYEE/WORKER PARTICIPATION IN SAFETY** in showing hazards and helping in removing them by the joint efforts of management and all employees is most desirable.

**Functions & duties:**

1. Co-operation to implement health and safety policy.
2. All matters of health, safety and environment and solutions to problems in that regard.
3. Creation of safety awareness amongst workers.
4. To conduct educational, training and promotional activities.
5. To discuss reports on safety, health and environmental surveys, safety audits, risk assessment, emergency plans and implementation of the recommendations of the reports.
6. To carry out health and safety surveys and identify causes of accidents.
7. To look into complaints of imminent danger and suggest corrective measures.
8. To review the implementation of its own recommendations.
9. To from sub-committee if necessary.

## SAFETY DEPARTMENT

The Safety department is responsible for the overall arrangements and for ensuring that the company's operations are executed at all times in such a manner as to ensure, so far as is reasonably practicable, the health, safety and welfare of all employees and others who may be affected by its operations.

In particular the Safety department will:

1. Ensure there is an effective company policy for health and safety and that all employees, contractors and temporary workers are made aware of their individual responsibility.
2. To understand and ensure, through the appointment of competent persons, that the company's responsibilities as employers under the Health and Safety at Work etc. Act 1974 and any relevant Acts of Parliament and Statutory Instruments are met.
3. To appoint a Director responsible for safety.
4. To ensure that all Directors and Managers understand and fulfil their responsibilities with regard to health and safety.
5. Arrange for funds and facilities to meet the requirements of company policy and legislation.
6. Make provision for adequate and appropriate training to be given to all employees.
7. To ensure that notification and reporting procedures to the relevant statutory authorities are carried out.

## SAFELY AUDIT

A safety audit is a general term used to describe an activity where a facility gathers information about one or more aspects of the workplace in order to evaluate the risk levels for health or safety issues.

During this audit one or more people will gather data related to the efficiency, reliability, and effectiveness of their health and safety systems. When done properly, a safety audit will help determine if a company's day to day activities are in conformity with their safety efforts. This means a safety audit is typically only done after a safety plan for the facility is already in place. A safety audit can, however, be used as part of the process in the creation of a full safety plan for a facility.

**Why Are Safety Audits Done?**

Safety audits are performed for a variety of reasons. Each company will have their own specific list of reasons for completing a safety audit. The following are just a few of the most common reasons:

- Legislative Requirements - There are many local, state, and federal laws in place that require facilities meet certain safety standards. A safety audit can help ensure those standards are met.
- Safety Concern - Keeping employees and the workplace safe is ethically very important.
- Injuries - If someone has been injured in a specific area of the workplace, it is often necessary to perform a safety audit of that area to determine whether the injury was a one-time occurrence or there is a risk of it happening to someone else.
- Bottom Line - While safety improvement in the workplace is often looked at as an expenditure, in the long run it can positively improve a company's bottom line.
- Safety Culture - Employers that want to promote a safety-focused culture need to set the tone by engaging in safety-related activities such as a safety audit.

**PERFORMANCE MEASUREMENTS AND MOTIVATION**

The purpose of your work in the governing body is to protect and promote efforts to achieve the mission of your organization. In order to yield significant and sustained results in pursuit of this mission, however, you must lead the work of the governing body to strategies and investments that maximize organizational performance and vitality. The drive for ever-higher levels of organizational performance is motivated by external events and stakeholders, as well as by internal stakeholders, plans, and motivations.

In contrast, an environment or organizational culture that enables positive performance should do the following 10 things.

1. Clearly define what winning looks like: Look across the entire organization and define what it looks like from a variety of perspectives, such as quality of services and outcomes; beneficiary and health worker satisfaction; procurement; and finance.

2. Spell out your “preferred culture:” In the same way that leaders shape and communicate a vision, they also spell out a picture of the culture they are striving for. This can often be just a set of guiding principles or values, but the best seems to go further by establishing preferred behaviors that support these values with answers to these questions: (1) Which aspects of our current culture are we happy/unhappy with? (2) What behaviors are needed to

create the culture we want? (3) What behaviors are actually rewarded? (4) Which unacceptable behaviors are tolerated? (5) How do we measure up against each of our preferred behaviors?

3. Set stretch targets: Employees tend to rise to the standard set for them. The more you expect, the more they will achieve. But there is a fine line between good stretch targets, which can energize an organization, and bad ones, which can dampen morale.

4. Connect to the big picture: The majority of employees want to be a part of a compelling future. They want to know what is most important at work and what excellence looks like. For targets to be meaningful and effective in motivating employees, they must be tied to larger organizational ambitions. Employees who don't understand the roles they play in company success are more likely to become disengaged. Employees at every level should be able to articulate exactly how their efforts feed into the broader company strategy.

5. Develop an ownership mentality: When individuals understand the boundaries within which they can operate and where the company wants to go, they feel empowered to make decisions. They most often make the right choices as they begin to think and act like "owners."

6. Improving performance through transparency: By sharing financial information with employees, you can increase employees' sense of ownership.

However, being open is not enough. Employees should be trained to understand financial statements. But they should also have an understanding of how their own jobs affect the numbers. Focus on additional metrics besides the financial ones. Employees who are not in the financial world will be able to relate better to the results and will feel more included in the process.

7. Increase performance through employee engagement: Employees who are engaged are motivated to give more than is required of their jobs. Engaged employees are committed and loyal to the organization.

8. Use storytelling: Storytelling can be a powerful tool when you want to drive organizational change and performance improvement. Leaders must be able use stories to motivate their employees to achieve more than they thought possible.

9. Communicate with employees: Internal communication to promote understanding needs to be at the top of the agenda. Have employees heard the message leaders are trying to convey? Do they believe it? Do they know what it means? Have they interpreted it for themselves, and have they internalized it?

10. Take the time to celebrate: Celebrate milestones once they have been reached. Taking the time to celebrate is important because it acknowledges people's hard work, boosts morale, and keeps up the momentum.

**SAFETY AND PRODUCTIVITY**

Realize the connection between productivity and safety. As an overall result of a healthier work environment, businesses have seen, according to the MBIE report, more productivity and reduced sick pay costs, reduced injury costs as well as less production delays which often translates into more profits for the company.

A key aspect of finding a balance between **productivity** and **safety** is with the enforcement of safety culture. A study by Lockheed Martin of their Paducah Plant found that by developing a safety culture, they were able to increase employee productivity by 24% and reduce factory costs by 20%.

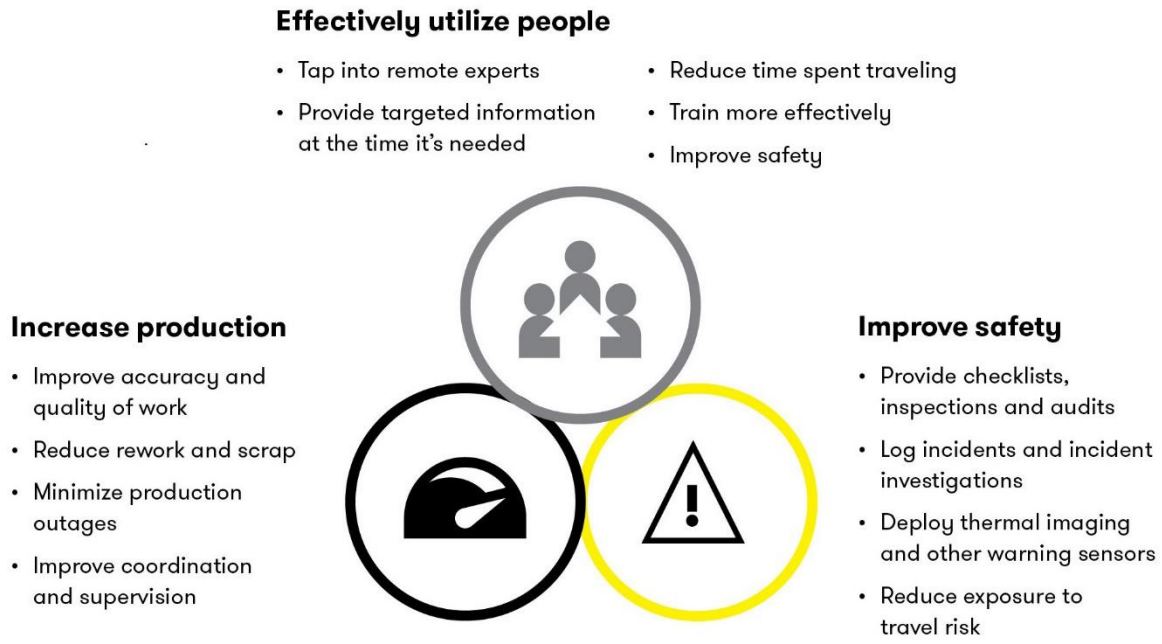


**Fig.1.2**

To successfully complete a modern construction project, managers must ensure that the facility is delivered on time and under budget while meeting specified quality requirements and acceptable safety standards. Productivity is one of the most important factors affecting the overall performance of any organization, large or small.

It must be known that construction accidents are the major element of many human tragedies, demotivate workers, disrupt site activities, delay project progress and

adversely affect the overall cost, productivity and reputation of the construction industry. The relationship between safety and productivity is clear. If the workplace is poor in health and safety, it will affect the individual, the workplace and the community. It will reduce productivity.

Safety training gives employees opportunity to identify hazards and the best practices to avoid such hazards at work-place. Safety training programs should be offered to meet the current demand of the construction industry. There was a clarification from the companies that do not provide a safety training program for staff by saying that most projects do planning for safety means that project employees and workers will be less exposed to expected hazards and thus accidents and its inherent compensations will decrease.

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**Program : M.E - CAD** **Course: Industrial Safety Engineering**
**Course code: SPRA7011** **Semester: III**

## UNIT 2 - OPERATIONAL SAFETY - SPRA7011

Hot metal operation – safety in Cutting – safety in welding – safety in Boilers- Pressure vessels – Furnace (all types) – Heat treatment processes shops – electroplating – grinding – forming processes- rolling – forging - surface hardening – casting –Moulding – coiling. Operational safety (cold metal operation), Safety in Machine shop - Cold bending and chamfering of pipes - metal cutting - shot blasting, grinding, painting - power press and other machines.

# UNIT 2 - OPERATIONAL SAFETY - SPRA7011

**Safety in Welding:**

1. **Hot Work Areas:** Hot Work areas should be properly designated and prepared. The area should not pose a hazard to others in nearby areas. If possible, such work should be confined to properly designed shop areas equipped with necessary controls and proper ventilation.
2. **Combustible and Flammable Materials:** Combustible and flammable materials should be placed at least 3 feet from the work site, but if this is not possible, metal guards or flame-proof curtains or other appropriate covers should be used to create a barrier and protect them.
3. **Welding Machine Operators:** Employees operating welding equipment should be restricted to authorized and properly trained employees.
4. **Floor Covers:** Floor covers within 35 feet of the work area should be sufficient to prevent sparks from falling beneath the floor or to a lower level.
5. **PPE:** Personal protective equipment such as tinted shields be used to protect operators from burns and ultra-violet light exposure. Other PPE may also be necessary, depending on the exact nature of the work. They might include an apron, leggings, safety shoes, protective helmet, ear protection, eye protection and respiratory protection. When working above ground, use a platform with toe boards and standard railings or a safety harness and life line.
6. **Stone and Cement Surfaces:** Never aim a welding torch at a cement or stone surface, because moisture in the material could cause them to explode when they reach a certain temperature.
7. **Inspect Equipment Before Using:** Equipment found to have bare conductors or damaged regulators, torches, electrode holders, or other defective components should not be used.
8. **Warnings:** When finished welding or cutting, warn other workers of hot metal by marking or putting up a clearly visible sign.
9. **Electrode and Rod Stubs:** These should not be left on the floor, but collected up.
10. **Tools:** Tools should be stored safely when work is completed.

**Safety in Cutting**

**Always wear eye protection.**

1. Always be sure that the pilot drill extends beyond the cutting edge of the saw by at least 1/8″.
2. Be sure to secure the material to be cut to keep it from spinning or slipping.
3. Be sure to start the cutting process with the saw square to the material being cut. This will ensure that all teeth begin to cut at the same time and will help prevent premature wear and damage to the saw.
4. Be sure to follow the recommended operating speed for the saw size and the material being cut.
5. Operator should feed the saw in and out to allow the material shavings to clear out of the hole being cut.
6. Cutting oils or lubricants should be used to extend the life of the saw, except when cutting wood or cast iron.
7. Occasionally check the mandrel's drive pins to be sure they are still fully engaged in the saw and that they have not vibrated out of the drive holes in the saw.
8. When sawing in wood, finish the hole from the opposite side to prevent splintering. Once the pilot drill has broken through the other side, you can use this hole to guarantee you are in line with where you have already started cutting.

**Boilers:**

**Precautions to be carried out regularly:**

- Never operate **boiler** above the design pressure and check for the safe operation of **Safety valves** as well as fusible plugs.
- Regular cleaning of the perforated line is necessary
- Stainer must be installed before the pump & check for its proper functioning to remove dirt particles from boiler feed water as this prevents the blockage of a feed line.
- Water must be treated before feeding it to the boiler to prevent the accumulation of dirt in a Boiler shell.
- Regular inspection and maintenance of boiler including its accessories and valves to check for possible failures and cracks are necessary.
- Make sure that the boiler vents are not restricted by any kind of obstruction such as cloth etc.

- Always check for the leakages of steam, water, air and flue gases from any suspicious place.
- Follow boiler manual for safe and efficient working of your boiler.
- The panel should be cleaned regularly and should be kept in a cool and an isolated place away from your boiler.
- Check if all the hot parts of the boiler are insulated, do not touch the parts with bare hands where the insulation is not provided.
- Maintenance of both FD Fan and ID Fan is important and regularly check for greasing in all the movable parts for the ease of operation.
- Regular cleaning of movable mechanical parts is necessary.
- Do not increase the frequency of a drive above 50 Hz for the safe operation of motors.
- **Pressure switch**, **Mobrey switch** and **Pressure Gauge** should be checked for their proper safety in pressure vessels:
- **Timely Maintenance**: For a pressure vessel to function properly, it requires regular maintenance. You should have a proper maintenance program of the entire pressure system, which checks the age of the vessel. One thing you should keep your eye on is the signs of problems. If a safety valve is discharging rapidly, then it is either a sign of a faulty safety valve or over-pressurizing system. Besides this, you should also check for any signs of wear or corrosion.
- **Proper Knowledge and Training**: The person operating or handling pressure vessels should have a proper skill set, as well as knowledge about the equipment. Necessary training must be given to those who are responsible for repairing, maintaining, installing, or checking the pressure of the equipment. You cannot afford to let a person of little knowledge about the equipment handle it, for obvious reasons.
- **Understanding Operating Conditions**: This is one of the most important factors to be considered. You should have a proper understanding about the gases or liquids contained in pressure vessels, along with its nature – toxic or flammable. Once you know the content of the pressure vessel, you need to know the operating conditions, which include temperatures and pressures. Having the correct information about system's operating limits it extremely important.
- **Installing Protective Devices**: When it comes to taking precautions of pressure vessels, you need to ensure that suitable protective devices are installed, and adjusted

to the correct settings. These protective devices can be safety valves or any device which shuts down the operation, when the temperature or pressure exceeds the maximum value. You can also opt for warning devices, which send out signals by lighting or sound, so that it grabs your attention. It is also necessary to keep these protective devices in good working condition, only then you can expect their proper functioning. One thing should always be followed – the protective devices should only be operated or altered by an authorized person.

**Safety in furnace:**

1. Burns due to contact with hot surfaces.
2. Burns due to contact with hot product, fuel or electricity.
3. Splashing or bubbling of molten metal.
4. Contact of cooling water with the molten metal or slag (e.g. induction furnace) and explosion due to sudden steam generation.
5. Fire or explosion due to leakage of fuel.
6. Carbon monoxide from fuel gas or products of combustion.
7. Explosion due to hydrogen.
8. Good insulation over hot metal surfaces.
9. Protective clothing for head, face, hands and feet.
10. Respirators, safety eye glass (plain or tinted) for protection against dust, fumes, toxic gases and glare.
11. Exhaust hoods and fans to draw dusts, fumes, gases etc.
12. Good ventilation to vent off hazardous waste generated from scrap charged alloys and fluxes.
13. Hot work permit before allowing any workers to enter any hot chamber. Insurances of cooling, fresh air ventilation and lighting necessary.
14. Interlocking to cut off fuel supply in case of flame failure.
15. Precautions while lighting fuel or burner to prevent flash back, fire or explosion.
16. Training and awareness programmes for workers.
17. Provisions of drinking water and shielding to avoid heat disorders.
18. Flameproof electric fitting with solvent drying ovens. PPE against eye and skin irritation or respiratory disorders.
19. Precautions against free silica, asbestos etc., while cleaning and maintaining furnaces. Area monitoring and medical surveillance of such hazardous exposures.

20. Engineering measures like guarding and fencing of dangerous machine parts, floors, stairs and platforms, lifting machine, tackles, transport vehicles and safe work practices.
21. Good ventilation, lighting and housekeeping.
22. Efficient exhaust ventilation for removal of dusts, fumes, gases etc.
23. CO detectors should be used to ensure safety. Self-breathing or air line respirators should be worn while doing this manually. Fixed CO detectors with alarm are desirable at crucial points.
24. Cold drinking water and salt provided to workers working in very hot environment.
25. Rotation of workers after short duration work in hot process.
26. Ergonomic design of man-machine-environment relationship.
27. Pre-employment medical examination to select suitable persons for hard or hot work, crane work etc. TB disqualifies from work with refractory materials and heart diseases, obesity and chronic gastro-enteritis disqualify from work in hot environment.
28. Periodical medical examination of workers exposed to heat stress, dust and high noise.
29. First-aid center, Ambulance with necessary medical facilities.
30. Safety organisation including safety committees, accident investigation and discussion, safety programmes and workers training is essential.
31. Proper supervision.

**Safety in Heat Treatment**

- Confined-space entry procedures
- Lockout and tag-out of all electrical equipment on the furnace
- Be sure you have a “buddy” to recover you if there is a problem when you are in the furnace process chamber.
- Do not go into the furnace without a safety harness attached to both you and your outside partner.
- Be sure that the furnace process chamber has a continuous supply of fresh moving air (air blower, air line, etc.).
- Be sure that both regular and frequent checks are made on firefighting equipment, hoses, extinguishers, etc.
- Conduct quarterly fire-fighting exercises with key personnel.

- Conduct evacuation procedures and assure that all key personnel understand the movements of the people that they are responsible for and to count accurately each individual in that team.
- Make sure that each and every person employed in both the heat-treatment shop as well as the office understands the nature of a fire and how to deal with it without panic.
- Be sure that all of the appropriate safety clothing is issued, functional and, most importantly, worn!
- This applies to the heat-treatment shop and also to the metallurgical laboratory where fume hoods are used for the extraction of toxic and hazardous fumes from the mixing of acid etchants.
- Clean up spills, (oil, water, grease, etc.) as they happen. Do not wait until someone slips or falls.
- Make sure that all of the appropriate exits are clear of equipment blockages and that the exit door actually works.
- Make sure that the appropriate danger and warning signs are in place and visible to everyone.
- Make sure that each shop individual is wearing his/her safety glasses.
- If you are conducting the nitriding process using anhydrous ammonia, know how to neutralize an ammonia leak. Remember that ammonia will also burn very vigorously.
- If you are using any salt-bath equipment (nitrate salts to high-speed salts), appropriate safety clothing is important. Remember that if the molten salt (nitrate or other type) hits your bare skin, it will keep on burning the skin until it goes cold.
- During heat-treating operations, the metal is subjected to heating or cooling to acquire specific properties from that metal.
- Heat-treating operations require a quench as an integral part of this process. Quenching is a process that quickly cools the metal. Liquid quenches normally involve the use of mineral oils, water-based solutions or molten salt. Less severe quenches use circulated gases or forced air, or involve cooling in still air.
- Quenching operations pose various health and safety hazards to workers. These hazards include exposure to chemicals, working in high temperatures, and the risk of fire or explosion.

- Consider the properties of the quenchants plus the design, construction, location, control, monitoring and maintenance of the furnace itself to minimize these risks.
- Quenching operations are often followed by a degreasing with chlorinated solvents or water-soluble compounds.
- Only operate heat-treating equipment when properly trained.
- Refer to Metalworking Machines - General for basic safety tips and Metalworking Fluids for more information.

**Safety in forging:**

- Pass up striking the anvil by the hammer as this create a lot of unnecessary noise. Also, near is danger of pieces flying off the face of the hammer.
- While cutting stock by a chisel (cold/hot) is certain to place or hold the stock in such place that must the severed piece fly across the room; it will not strike one more workman.
- Heated Iron might simply cause fire, then; care must be taken while laying it a side.
- Utilize the bolt tongs while handling round or octagon shapes.
- For all time turn on the exhaust now previous to starting the fire.
- Care for your eyes by wearing goggles, while clipping.
- Forever turn off the blast previous to lighting a forge fire.

**Safety Precautions for Working with Metal Sheet Rolling Machines**

- Safety devices like trip device, hold to run control and emergency stops, etc. should be installed on the machine for effectively dealing with accidental situations.
- The operator working on the machine should have adequate knowledge about the machine. He should know about the various aspects of the machine's safety and controls.
- Metal Sheet Rolling Machines have many moving parts that need regular maintenance for functioning properly. Regular maintenance and repair not only enhances the performance of the machine, but also prevents accidents.
- It is also advised that the operator does not wear gloves while working on this machine, as the work equipment he is holding may slip into the machine and inflict serious injuries.

- While operating this machine, a worker should hold the work piece at a safe distance from where the metal sheet can be inserted between the rollers.
- Also, the area around the Metal Sheet Rolling Machine should be well lit and kept clear of any material that may lead to accidents.

**Safety Precautions for hammering**

- Wear eye protection when hammering.
- Hearing protection is essential.
- Change your posture and working height now and then.
- Take breaks every forty-five minutes or so and do something different now and then.
- Do not use your wrist much when hammering; use your elbow sparingly, your shoulder most. Listen to your body! Snap the hammer forwards a bit at the bottom of the swing-let go and stop pushing then and the hammer will snap itself back up, lifting itself so you have to do less work.
- Keep your forging area separate from the work areas of others, to reduce the damage to their hearing. As well as damaging your ears, noise can distract you or your coworkers, which can lead to injury if they're doing something requiring concentration. It's also just irritating; to quote the American Association of Otolaryngology, "some people react to loud noise with anxiety and irritability, an increase in pulse rate and blood pressure, or an increase in stomach acid." (55).
- Wear safety glasses during hot forging and when hammering in general. Protective clothing (long sleeves, leather shoes, a face shield if sparks are flying around) is also recommended for hot forging.
- Tie your hair back if it's long.
- "Other protective measures with hot forging should include ice for treatment of minor burns, salted water for heat stress, and a cool room for work breaks".

**Safety on heat treatment:**

- Wear a CSA-certified face shield, CSA-certified safety glasses, appropriate gloves and heat-resistant protective clothing when working with hot metal. Quench oils may be very hot (above 100°C) and oil temperature increases during quenching. Splashes or skin contact cause burns. Avoid skin contact with oils by using gloves and protective clothing.

- Check that all safety devices, such as automatic shut-off valves, air switches, and exhaust fans are working properly before lighting the furnace.
- Make sure the volume of the cooling medium is sufficient for the job. As the metal cools, the medium absorbs the heat. If there is not enough medium, it will become too hot to cool the metal at the desired rate.
- Make sure that quenching areas have enough ventilation to keep oil mists at recommended levels.
- Follow the manufacturer's instructions when lighting the furnace.
- Stand to one side when lighting a gas or oil-fired furnace.
- Make sure that water does not contaminate the quenching oil. Any moisture which comes in contact with the oil can cause an explosion.
- Use the proper tongs for the job and make sure the tongs are dry before removing any work from a liquid carburizing pot.
- Ensure that a suitable bacterial inhibitor or fungicide has been added to the quenching liquid.
- Cover quench tanks when not in use.
- Clean up oil spills and leaks immediately using a nonflammable absorbent.
- Keep work areas, jigs, baskets and tools free from oil contamination where possible.
- Wash hands thoroughly after work, at breaks (particularly meal times), before starting other tasks, or before using the toilet.
- Get first aid for all injuries, including cuts and abrasions.
- Report to your supervisor and get medical attention when suffering from, or if you suspect, skin trouble.

**Safety Considerations for Metal Casting:**

- Being a pro-active employer, we engage with our work force to encourage grass roots initiatives that improve our safety culture.
- We provide ongoing training to all team members, in addition to ensuring that at all times they are supplied with adequate and appropriate resources, information and supervision.
- We value our workforce, as we cannot make castings without them. As such, we provide them with a platform where we can effectively consult and communicate. This ensures that we can be ahead of the game should any issues arise, from the comfort of PPE to welfare arrangements.

- Health and safety audits – whether it is an adhoc workplace inspection, a scheduled inspection or an external audit, we constantly strive to keep our manufacturing floors as safe as we can. On any feedback we receive, we proactively work towards improving upon any recommendations or ideas received.
- The provision of Specialist PPE (Personal Protective Equipment) and where necessary, ongoing tests and reviews of its suitability.
- Regular maintenance and servicing of all of our machinery and tools, in addition to our statutory testing and inspection regimes as undertaken by competent external contractors.

**Safety in Moulding:**

- Always wear eye protection to protect against lead spatters.
- Wear gloves and a long sleeve shirt to protect your hands and arms from burns and lead spatters.
- Never let water or moisture come in contact with molten lead. ...
- Use care when handling hot tools and castings.
- Work in a well-ventilated area.

**Safety in electroplating:**

- Always be scared of electroplating. You can be electrocuted or poisoned, dying in agony or permanently disabled and mentally damaged if you survive. Make sure that you receive instruction from at least two separate people in electroplating methods (best is four people-then you may better judge what level of safety you should use - well, we would hope so anyway).
- Follow all electrical safety precautions. Proper grounding, rubber mats, insulated gloves, proper fusing are all appropriate things to consider.
- Use all safety Precautions. Neoprene gloves, apron, splash goggles, fume hood, proper chemical storage (think of what happens in an earthquake or a fire for instance and plan for it) are all essential for working with plating solutions. Never store acids next to cyanides. Always label and date solutions properly. Consider a locking, properly ventilated chemical cabinet for cyanide solutions.
- Use that Fume Hood. Be sure that the ventilation system is appropriate for hazardous fumes. A ventilation hood which is directly over or next to the bath is legally

required in most places. Make sure that the electroplating solution fumes are not carried past your face on their way out. Use a system with a sliding or hanging window on the fume hood so that you are properly protect and air is being drawn in lower than your face height. Make sure that the fume hood does not vent outside the building near any air intake back into the building. Make sure that your ventilation system and air makeup (if you vent air new air has to come from somewhere) does not draw the hazardous fumes back into your space. An open window is not considered sufficient ventilation.

- It's a chemistry lab, set it up like one. When you are working with chemicals consider how chemists work with them. Remember your high school or college lab? Everything clean and wiped down, things put away, lots of safety procedures to follow. When you are acting like a chemist then you need protection like a chemist – don't forget that.
- Always add acid to water. If you get mixed up you can splash acid on yourself (See "Rules for a reason")
- Don't overheat your solutions! While it can ruin the solution for your purposes it may also cause fumes to be generated that are extremely toxic and hazardous.
- Don't mix acid and cyanide solutions. Doing this might kill you. It can generate hydrogen cyanide gas. Make sure all pickle residues are removed from hollow objects before electro-plating.
- Don't wear rings. U.S. Government specifications suggest that no jewelry be worn when one is handling electrical circuits. There have been several incidents where the jewelry contributed to an electrocution incident.

**Safety on Blasting:**

Blasting is a specialized job involved a lot of hazards which often lead to accidents. There are many forms of risk associated with blasting work. Before beginning the work, employers should identify the hazards and assign a knowledgeable person who know the functioning of shot blasting machine trained to recognize hazards and with the authority to quick take corrective actions to remove them.

- Provide training to shot blasters and support personnel on blasting health and safety hazards how to use control, personal hygiene practices and safe work practices.

- Shot blasting operation can create a high level of dust and noise. Shot blasting material and the surface being blasted may contain toxic materials that are harmful to workers. So respirator masks/helmet and safety glasses should be used to protect against nuisance type dust. Also, must cover the worker's head, neck and shoulder to protect the worker from rebounding abrasive.
- Review the blast area and security plan because the blast area is the area having the potential for flying material air overpressure can cause injury to a person. Review the communicating system used between blaster and blast area security personnel.
- Ensure that Machine is in good condition, fuel system of the machine is free from leakage. Blaster should be experienced.
- Use blast room or blast cabinet for smaller operations. Use restricted areas for non-enclosed blasting operations. Use exhaust ventilation system.
- Acknowledge the shot is properly loaded and secured. Steel grit shot have less potential to cause lung damage. So always use less toxic shots blasting material. Always use blasting material that can be delivered with water to reduce dust.
- Do not use compressed air to clean as this will create dust in the air. To prevent the spread of any hazardous material we should avoid blasting in windy conditions.

**Safety on painting:**

Painting a house is often perceived as a fun activity that not only revitalizes the environment of your home, it also increases its longevity by protecting it from wear and tear. However, before you head out to have a colourful day with family and friends, it's important to note that painting a house can be dangerous. The materials used in paints that protect your home from the atmosphere can also be hazardous to health.

For those who are eager to paint a house, here are some necessary precautions that one must take to keep it safe for themselves and others.

**#1 Keeping Safe from Lead Poisoning**

The U.S. Department of Housing and Development (HUD) developed a user-friendly guide for all home owners to follow. An online copy of this guide is available for free at the LEAD PAINT SAFETY FIELD GUIDE

**#2 Using Safety Equipment**

Painting is just one part of the process and equipment is available to make your paint job as safe and easy as possible. Some of the items include:

- Cloth or leather gloves for skin protection during sanding and scraping.

- Eye goggles, glasses or masks to protect your face from chemicals.
- Anti-dust masks to keep your lungs healthy.
- Ear protection if you're painting equipment is noisy.

**#3 Choosing the Right Paint**

When it comes to painting, it's important to know what paint to apply and where. Many brands readily available for homeowners can create dangerous fumes caused by volatile organic compounds (VOC). Overexposure to VOCs can cause nausea, headaches and irritation. To reduce exposure, use only paints with low-VOC or no-VOC (in some cases 0-VOC) printed on the label indoors. There are basically three types of paints:

- Latex paint is water based. It has fewer VOCs than most others and is best for indoors
- Natural paints have ingredients such as citrus, oil, chalk and casein and can emit some VOCs.
- Oil-based paints are highly durable and are best for outdoors. They emit the most VOCs, since they have a petrochemical base.

**#4 General Precautions**

Further ensure your safety and the safety of your loved ones by taking the following precautions:

- Pregnant women are advised to stay away from wet paint till it is fully dried and outgassed.
- Don't mix painting with food, drink, or smoking.
- Keep children and pets away from painted areas and equipment.
- Use ladders safely.
- Keep painted areas and paints away from heat sources.
- Make sure there is ample ventilation available before, during, and after.
- Give painted areas 24 hours minimum and 3 days max to dry, keeping home dwellers from sleeping or working there until its safe.

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## SCHOOL OF MECHANICAL ENGINEERING

## DEPARTMENT OF MECHANICAL ENGINEERING

## COURSE MATERIAL

**Program : M.E - CAD** **Course: Industrial Safety Engineering**
**Course code: SPRA7011** **Semester: III**

## UNIT 3 - SAFETY, HEALTH, WELFARE AND LAW - SPRA7011

Features of Factory Act – explosive Act – boiler Act – ESI Act – workman's compensation Act – industrial hygiene – occupational safety – diseases prevention – ergonomics - Occupational diseases, stress, fatigue - Health, safety and the physical environment - History of legislations related to Safety-pressure vessel act-Indian boiler act - The environmental protection act - Electricity act - Explosive act.

# UNIT 3 - SAFETY, HEALTH, WELFARE AND LAW - SPRA7011

## FEATURES OF FACTORY ACT

For protecting the health of workers, the Act lays down that every factory shall be kept clean and all necessary precautions shall be taken in this regard. The factories should have proper drainage system, adequate lighting, ventilation, temperature etc. Adequate arrangements for drinking water should be made.

The main objective of the Act is not only to ensure adequate safety measures but also to promote health and welfare of the workers employed in factories as well as to prevent haphazard growth of factories.

The Factories act was incorporated in 1948. The main objective of the Factories Act is to regulate the conditions of work in manufacturing establishments coming within a factory. This act contains detailed provisions regarding safety, health and welfare of the employees of a factory.

## COVERAGE OF THE ACT

The coverage of the Act is confined to the: -

- Factories using power and employing 10 or more workers on any working day of the preceding twelve months;
- Factories not using power and employing 20 or more workers on any working day of the preceding twelve months;
- Factories specially notified under Section 85 of the Factories Act by the State Govt/Union Territories.

## EXPLOSIVE ACT

An Act to regulate the manufacture, possession, use, sale, to transport, import and export of Explosives. Whereas, it is expedient to regulate the manufacture, possession, use, sale, transport and. importation of explosives.

## BOILER ACT

An Act to consolidate and amend the law relating to steam-boilers. Whereas it is expedient to consolidate and amend the law relating to steam-boilers; it is hereby enacted as follows:- LEGISLATIVE HISTORY ▼ Repealing Act, 1927 (12 of 1927) Indian Boilers (Amendment) Act, 1929 (9 of 1929).

**INDIAN BOILER ACT**

Indian Boiler act, 1923 provides for the safety of life and property of persons from the danger of explosion of boilers. The provision for constituting Central Boilers Board having the authority to make regulations consistent with the Act was made in the Indian Boilers (Amendment) Act, 1937.

**BOILER**

Boiler means a pressure vessel in which steam is generated for use external to itself by application of heat which is wholly or partly under pressure when steam is shut off but does not include a pressure vessel.

**ESI ACT**

Employees' State Insurance Scheme of India is an integrated social security scheme tailored to provide social protection to workers and their dependents, in the organized sector, in contingencies, such as, sickness, maternity and death or disablement due to an employment injury or occupational hazard.

The Employee State Insurance act was promulgated by the Parliament of India in the year 1948.Tobegin with the ESIC scheme was initially launched on 2 February 1952 at just two industrial centers in the country namely Kanpur and Delhi with a total coverage of about 1.20 lac workers. There after the scheme was implemented in a phased manner across the country with the active involvement of the state government.

Employees covered under the scheme are entitled to medical facilities for self and dependents. They are also entitled to cash benefits in the event of specified contingencies resulting in loss of wages or earning capacity. The insured women are entitled to maternity benefit for confinement. Where death of an insured employee occurs due to employment injury or occupational disease, the dependents are entitled to family pension.

**Various benefits that the insured employees and their dependents are entitled to, the duration of benefits and contributory conditions therefor are as under,**

1. Medical benefit
2. Sickness benefit
3. Extended sickness benefit
4. Enhanced sickness benefit
5. Maternity benefit
6. Disablement benefit
7. Dependents benefits
8. Other benefits

**Workman’s Compensation Act**

The Workmen's Compensation Act, 1923 provides for payment of compensation to workmen (or their dependents) in case of personal injury caused by accident or certain occupational diseases arising out of and in the course of employment and resulting in disablement or death. The Act was last amended in 1976.

**Objectives of Workers' Compensation**

A fundamental objective is to provide broad coverage of employees for job-related accidents and disease. Workers' compensation laws should cover most occupations or job-related accidents and disease. A second objective is to provide substantial protection against the loss of income.

**How compensation is calculated?**

Add up the recruiting, salary, and payroll tax, benefit and incentive expenses to determine the total compensation expenses. To find the monthly compensation expense, calculate the quarterly or annual expenses and divide by 3 or 12, respectively.

**Employer’s liability for compensation**

If personal injury is caused to a workman by accident arising out of and in the course of his employment, his employer shall be liable to pay compensation in accordance with the provisions of this Chapter: Provided that the employer shall not be so liable —

(a) In respect of any injury which does not result in the total or partial disablement of the workman for a period exceeding 1[three] days;

(b) In respect of any 2[injury, not resulting in death 3[or permanent total disablement] caused by] an accident which is directly attributable to—

i. The workman having been at the time thereof under the influence of drink or drugs, or
ii. The wilful disobedience of the workman to an order expressly given, or to a rule expressly framed, for the purpose of securing the safety of workmen, or
iii. The wilful removal or disregard by the workman of any safety guard or other device which he knew to have been provided for the purpose of securing the safety of workman.

**Industrial Hygiene**

Industrial hygiene is the science of protecting and enhancing the health and safety of people at work and in their communities. Health and safety hazards cover a wide range of chemical, physical, biological and ergonomic stressors.

The industrial hygienists use various environmental monitoring and analytical methods to establish how workers are exposed. In turn, they employ techniques such as engineering and work practice controls to control any potential health hazards. Anticipation involves identifying potential hazards in the workplace before they are introduced. The uncertainty of health hazards ranges from reasonable expectations to mere speculations. However, it implies that the industrial hygienist must understand the nature of changes in the processes, products, environments, and workforces of the workplaces and how they can affect workers' well-being. Recognition of engineering, work practice, and administrative controls are the primary means of reducing the workers` exposure to occupational hazards. Timely recognition of hazards minimizes the workers' exposure to the hazards by removing or reducing the hazard's source or isolating the workers from the hazards. Evaluation of a worksite is a significant step that helps the industrial hygienists establish jobs and worksites that are a potential source of problems. During the evaluation, the industrial hygienist measures and identifies the problem tasks, exposures, and tasks. The most effective worksites assessment includes all the jobs, work activities, and operations. The industrial hygienists inspect research and evaluations of how given physical or chemical hazards affect the workers' health. If the workplace contains a health hazard, the industrial hygienist recommends appropriate corrective actions. Control measures include removing toxic chemicals and replacing harmful toxic materials with less hazardous ones. It also involves confining work operations or enclosing work processes and installing general and local ventilation systems. Controls change how the task is performed. Some of the basic work practice controls include: following the laid procedures to reduce exposures while at the workplace, inspecting and maintaining processes regularly, and implementing reasonable workplace procedures.

**OCCUPATIONAL SAFETY**

Occupational safety is your legal right to work in conditions that are free of known dangers. The requirements of the Occupational Safety and Health Act of 1970 helps employers prevent the number of workplace injuries, illnesses and deaths.

**Examples of responsibilities of workers include:**

i. Using personal protection and safety equipment as required by the employer.
ii. Following safe work procedures.
iii. Knowing and complying with all regulations.
iv. Reporting any injury or illness immediately.
v. Reporting unsafe acts and unsafe conditions.

## ERGONOMICS

Ergonomics is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. Ergonomics can roughly be defined as the study of people in their working environment. More specifically, an ergonomist (pronounced like economist) designs or modifies the work to fit the worker, not the other way around. The goal is to eliminate discomfort and risk of injury due to work.

There are three primary types of ergonomics:

i. Physical
ii. Cognitive
iii. Organizational

Physical ergonomics is concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity.

Cognitive ergonomics is the field of study that focuses on how well the use of a product matches the cognitive capabilities of users. It draws on knowledge of human perception, mental processing, and memory.

Organizational ergonomics refers to the optimization of social technical systems, including their organizational structures, policies and processes.

### Advantages

The best ergonomic solutions will often improve productivity. By designing a job to allow for good posture, less exertion, fewer motions and better heights and reaches, the workstation becomes more efficient.

### Occupational Stress

Occupational stress is psychological stress related to one's job. Occupational stress often stems from pressures that do not align with a person's knowledge, skills, or expectations. Job stress can increase when workloads are excessive or too low.

**Some of the factors that commonly cause work-related stress include:**

- Long hours.
- Heavy workload.
- Changes within the organization.
- Tight deadlines.
- Changes to duties.

- Job insecurity.
- Lack of autonomy.

**SAFETY-PRESSURE VESSEL ACT**

**In this Act:**

(a) “Board” means the Boiler and Pressure Vessel Safety Board established pursuant to section 44;

(b) “Boiler” means a vessel in which steam is or may be generated or hot water produced under pressure, and includes any high pressure boiler or low pressure boiler and any pipe, fitting, prime mover, machinery or other equipment attached to the vessel or used in connection with the vessel;

(c) “Chief inspector” means the chief inspector appointed pursuant to and includes an acting chief inspector;

(d) “Compressed gas” means liquefied petroleum gas, oxygen, acetylene, ammonia, chlorine or any other gas, whether in a liquid, vapour or dissolved state, that is explosive, flammable or toxic or contained under pressure exceeding 103 kilopascals;

(e) “Compressed gas plant” means a plant used for producing, manufacturing, transferring, storing, distributing or otherwise handling compressed gas, and includes all pressure vessels, pipes, fittings, machinery and other equipment used in connection with the plant;

(f) “Department” means the department over which the minister presides;

(g) “Expansible fluid” means:

(i) Any vapour or gas; or

(ii) Any liquid that will change to a vapour or gas at atmospheric conditions;

(h) “Fitting” means a valve, gauge, regulating or controlling device, flange, pipe fitting, nozzle or thing that is attached to or forms part of a boiler, pressure vessel or pressure piping system or any combination of them;

(i) “Guarded plant” means a plant that is equipped with fail-safe controls and audio and visual alarm systems and that is licensed as a guarded plant pursuant;

**BOILER AND PRESSURE VESSEL**

(j) “High pressure boiler” means:

(i) A steam boiler designed to carry a working pressure of more than 103 kilopascals but does not include a boiler of that type that is equipped with a safety valve set to relieve at a pressure of not more than 103 kilopascals;

(ii) A hot water or fluid heating boiler that is operated at a pressure in excess of 100 kilopascals or produces a temperature that exceeds 121°C at or near the outlet;

(k) "Inspector" means an inspector appointed pursuant to section 4, and includes the chief inspector and a special inspector;

(l) "Low pressure boiler" means:

(i) A steam boiler designed to carry a working pressure of 103 kilopascals or less; or

(ii) A hot water or fluid heating boiler that is operated at a pressure of 1 100 kilopascals or less or produces a temperature that is 121°C or less at or near the outlet;

(m) "Minister" means the member of the Executive Council to whom for the time being the administration of this Act is assigned;

(n) "Operate":

(i) In relation to operation in the capacity of owner, means to place into operation, or permit to be operated, a boiler, pressure vessel, plant or pressure piping system;

(ii) In relation to operation in the capacity of operator, means:

(A) To supervise the operation of a boiler or plant;

(B) To directly operate a boiler or plant or assist in the direct operation of a boiler or plant; or

(C) To be in immediate charge of a boiler or plant;

(o) "Owner" means an owner of a boiler, pressure vessel, plant or pressure piping system, and includes a lessee or sub lessee of a boiler, pressure vessel, plant or pressure piping system;

(p) "Plant" means:

(i) An installation of two or more high pressure boilers, low pressure boilers or a combination of high pressure and low pressure boilers;

(ii) A refrigeration plant; or

(iii) A compressed gas plant; and includes any pressure piping system that is attached to or used in connection with a component of a plant;

(q) “Prescribed” means prescribed in the regulations;

(r) “Pressure piping system” means pipes, tubes, conduits, gaskets, bolts and other fittings making up a system, the sole purpose of which is the conveyance of an expansible fluid under pressure and the control of the flow of an expansible fluid under pressure between two or more points;

(s) “Pressure vessel” means a vessel or similar apparatus, other than a boiler, that is or may be used for containing, storing, distributing, transferring, distilling, evaporating, processing or otherwise handling gases, fluids or solids and that is normally operated under pressure, and includes any pipe or fitting that is attached to the vessel or used in connection with the vessel;

(t) “Quality management system” means a quality management system

(u) “Refrigeration plant” means an installation of pressure vessels, pipes and fittings, machinery and other equipment by which refrigerants are vaporized, compressed and liquefied in their refrigerating cycle.

The Environment (Protection) Act, 1986 authorizes the central government to protect and improve environmental quality, control and reduce pollution from all sources, and prohibit or restrict the setting and /or operation of any industrial facility on environmental grounds.

**ELECTRICITY ACT**

The Electricity Act, 2003 is an Act of the Parliament of India enacted to transform the power sector in India.

The act covers major issues involving generation, distribution, transmission and trading in power. While some of the sections have already been enacted and are yielding benefits, there are a few other sections that are yet to be fully enforced till date.

An act to consolidate the laws relating to generation, transmission, distribution, trading and use of electricity for taking measures conducive to development of electricity industry, promoting competition therein, protecting interest of consumers and supply of electricity to all areas, rationalization of electricity.

**EXPLOSIVE ACT**

An Act respecting the manufacture, testing, acquisition, possession, sale, storage, transportation, importation and exportation of explosives and the use of fireworks.

**In this Act,**

**Authorized** explosive means any explosive that is declared to be an authorized explosive in accordance with the regulations;

**Convention** means the Convention on the Marking of Plastic Explosives for the Purpose of Detection, concluded in Montreal on March 1, 1991, as amended from time to time; (Convention) Department means the Department of Natural Resources;

**Detection** agent means any of the substances set out in the Table to Part 2 of the Technical Annex to the Convention;

**Explosive** means anything that is made, manufactured or used to produce an explosion or a detonation or pyrotechnic effect, and includes anything prescribed to be an explosive by the regulations, but does not include gases, organic peroxides or anything prescribed not to be an explosive by the regulations;

**Factory** means any building, structure, premises or land in or on which the manufacture or any part of the process of manufacture of an explosive is carried on, the site on which the building, structure or premises are situated, and all other buildings, structures or premises within such a site;

**Illicit manufacture** means any activity that is prohibited.

**Illicit trafficking** means any importation into the place, exportation from the place or transportation in transit through that place of an explosive if

(a) The importation or exportation is not authorized by the country of origin or the country of destination, or

(b) The transportation in transit of the explosive through any country is not authorized by that country;

**Inspector** means the Chief Inspector of Explosives, an inspector of explosives and a deputy inspector of explosives appointed under section 13, and any other person who is directed by the Minister to inspect an explosive, a restricted component, a vehicle, a licensed factory or a magazine, or to hold an inquiry in connection with any accident caused by an explosive;

**Licensed factory** means a factory in respect of which a license issued under section 7 is in force;

**Licensed magazine** means a magazine in respect of which a license issued under section 7 is in force;

**Magazine** means any building, storehouse, structure or place in which any explosive is kept or stored, but does not include

(a) a place where an explosive is kept or stored exclusively for use at or in a mine or quarry in a province in which provision is made by the law of that province for efficient inspection and control of explosives stored and used at or in mines and quarries,

(b) a vehicle in which an authorized explosive is being conveyed in accordance with this Act,

(c) The structure or place in which is kept for private use, and not for sale, an authorized explosive to an amount not exceeding that authorized by regulation,

(d) Any store or warehouse in which are stored for sale authorized explosives to an amount not exceeding that authorized by regulation, or

(e) Any place at which the blending or assembling of the in explosive component parts of an authorized explosive is allowed under section 8;

**Military device** has the meaning assigned to that expression by the regulations;

**Minister** means the Minister of Natural Resources or such other Minister as the Governor in Council may designate;

**Operator** includes the owner, manager or person in charge;

**Plastic explosive** means an explosive that

(a) Is formulated with one or more high explosives that in their pure form have a vapour pressure less than 10-4 Pa at a temperature of 25oC,

(b) Is formulated with a binder material, and

(c) Is, when mixed, malleable or flexible at normal room temperature;

**Restricted component** means any prescribed component of an explosive the acquisition, possession or sale of which is restricted by a regulation

**Transit** means the portion of international trans boundary transportation through the territory of a country that is neither the country of origin nor the country of destination;

**Unmarked plastic explosive** means a plastic explosive that

(a) Does not contain a detection agent, or

(b) At the time of manufacture, does not contain the required minimum concentration level of a detection agent as set out in the Table to Part 2 of the Technical Annex to the Convention;

**Vehicle** means any truck, automobile or other conveyance for use on land but does not include any vehicle running only on rails.

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## SCHOOL OF MECHANICAL ENGINEERING

## DEPARTMENT OF MECHANICAL ENGINEERING

## COURSE MATERIAL

**Program : M.E - CAD** **Course: Industrial Safety Engineering**
**Course code: SPRA7011** **Semester: III**

## UNIT 4 - SAFETY PERFORMANCE MONITORING - SPRA7011

Permanent total disabilities, permanent partial disabilities, temporary total disabilities -Calculation of accident indices, frequency rate, severity rate, frequency severity-incidence, incident rate, accident rate, safety "t" score, safety activity rate – problems.

**Total Permanent Disability:**

Total permanent disability (TPD) is a condition in which an individual is no longer able to work due to injuries. Total permanent disability, also called permanent total disability, applies to cases in which the individual may never be able to work again.

- Total permanent disability (TPD) is a condition in which an individual is no longer able to work due to injuries.
- Insurance companies classify disability as temporary or permanent and pay out benefits accordingly.
- Student loans may be discharged under certain conditions if an individual faces total permanent disability.
- A person will likely not qualify for permanent total disability benefits if there are additional, curative treatment options available, or a doctor thinks they may improve over time

**Understanding Total Permanent Disability**

Total permanent disability may involve an individual's loss of the use of limbs, with the injuries preventing the policyholder from being able to work in the same capacity as they had before the injury. If the policyholder retires or leaves the workforce for any reason other than the injury, coverage may be stopped. If this happens, you may withdraw funds from a Roth IRA without penalty if your account is at least five years old.

Insurance companies classify disability according to the amount of work that an individual can perform. Temporary disabilities prevent an individual from working full-time (called temporary partial disability) or at all for a period (called temporary total disability). Permanent disabilities prevent an individual from being able to work full-time for the rest of their life, referred to as permanent partial disability, while total permanent disability means that the individual will never work again.

Individuals may insure themselves against total permanent disability through a disability policy. The amount of the benefit is typically a fixed percentage of the policyholder's average wage, or in some cases, the average wage of individuals in a geographical region. There is no limit on the number of weeks that an individual can receive benefits if they become permanently disabled.

In some cases, the law may allow an individual on total permanent disability to engage in business activities if the benefit provided from a disability policy plus the wages earned from additional work does not pass a certain threshold. Students with loans may have their loans discharged under certain conditions if they face total permanent disability, provided that the injury is expected to last a minimum period or result in death.

Sallie Mae is one of the few lenders that will forgive a student's balance under these circumstances, even if their parents hold the loan(s).

**Qualifying for Total Permanent Disability**

A person will not likely qualify for permanent total disability benefits until the associated medical condition is fixed and stable. What this means is as long as there are additional, curative treatment options available, or a doctor thinks you may improve over time, an insurance company will not call a person “permanently and totally disabled.” Being in this situation doesn't necessarily mean someone won't eventually receive TPD benefits, but it does mean that a person will have to wait until their medical treatment is complete.

Understanding the difference between these two types of disability benefits can help you know your options after suffering a workplace injury or illness.

Both total and partial disability benefits are designed to protect your wages when you are injured or fall ill due to work-related circumstances. However, one is far more common than the other.

Workers can qualify for payments to replace the wages they would earn had they not been injured, developed a work-related illness that limits their ability to do their jobs, or been otherwise disabled.

However, there is virtually no federal standard in this regard. While programs exist throughout the nation, there is variability in how workers are compensated for their injuries depending on their jurisdiction. With the exception of Texas, every state requires that employers carry disability insurance on their workers. However, the types of disability benefits can vary by state.

**Types of Disability Benefits**

**Disability benefits take one of four structures:**

Looking at the Impairment Itself: “About nineteen states use this approach to compensate for an unscheduled permanent partial disability,” explains the Social Security Administration. “In approximately fourteen of those states, the worker with an unscheduled permanent partial disability receives a benefit based entirely on the degree of impairment. Any future earnings losses of the worker are not considered.”

**Loss of Earning Capacity:** This method requires a forecast of what the disabled worker would have earned had he or she not been injured. Around thirteen states use this method.
Wage-loss: Benefits are based on the actual wages the person lost by being unable to work. Roughly ten states use this approach, most commonly in cases of temporary disability.
Bifurcated Approach: This method looks at the worker's condition after his or her injury has stabilized. It prevails in nine jurisdictions.

**There are differences relating to how disability is defined:**

- Permanent total disability means that you are completely disabled because of your injury or work-related illness and can no longer work in the capacity for which you were trained.
- Permanent partial disability is more common. This type of disability makes up over 50% of workers' compensation claims. Permanent partial disability means that the worker is still able to function in his or her chosen work, but not at full capacity. Common examples of permanent partial disability include back injuries, carpal tunnel syndrome, amputation, hearing loss, and vision damage.

**We will discuss temporary total and temporary partial disability.**

- Temporary Total Disability: In this case, the worker needs to be completely incapacitated for seven consecutive days or longer.
- Temporary Partial Disability: This type of disability benefit is payable until a worker recovers his or her full work capacity after a work-related illness or injury.

However, in both temporary total and temporary partial disability, the impact of the illness or injury is temporary. South Dakota also acknowledges permanent total and permanent partial disabilities, meaning that the prognosis of your condition is not expected to change, so you are compensated up to the remainder of your life. The state also allows that you would be paid disability benefits at the temporary total rate while undergoing vocational rehabilitation.

**Temporary Total Disability**

The workers' compensation system is designed to provide injured workers with the financial support they need in the event that they suffer an injury that prevents them from working. Although every state has a workers' compensation system, the procedures, rules, and requirements of each system varies between jurisdictions. In order to receive benefits from the workers' compensation system, the worker must forgo his or her legal right to sue

the employer in the courts. The workers' compensation system is not free of judicial scrutiny, however, with courts having the power to review workers' compensation board decisions. In order to seek judicial review, a worker must typically exhaust any appellate remedies made available to him or her through the workers' compensation system.

One of the most highly litigated aspects of a workers' compensation case is the determination of the nature and extent of an employee's injuries. After an employee files a workers' compensation case, independent and appointed medical professionals will examine the worker to determine the extensiveness of the injuries and whether they are temporary or permanent in nature. Doctors also evaluate whether the injury is either partial or total.

**Understanding Temporary Total Disability**

For a temporary total disability, the injured worker experiences an injury that prevents him or her from working during the recovery period. During this period, the workers' compensation insurance company provides the worker with temporary total disability benefits. In some jurisdictions, temporary total disability benefits are also referred to as wage loss or time loss benefits. The worker's treating physician will evaluate the extent of the injury to determine the amount of time that the worker will need to recover from his or her injury.

Many workers' compensation insurance companies will fight a doctor's determination that the employee has suffered a temporary total disability and will contend that the worker can return to work. In this instance, an insurance company can request a Qualified Medical Evaluator (QME) to examine the worker. This physician acts as a neutral third party and provides his or her opinion regarding the nature and extent of the injury. If the worker is represented by an attorney, an Agreed Medical Examiner (AME) will conduct the examination.

**Ending Temporary Total Disability Benefits**

Once a medical professional determines that the employee's total temporary injury has healed, the employee can return to work and will no longer receive disability benefits. However, as treatment progresses, the doctor may determine that the nature and extent of the worker's injuries are more permanent in nature and that the employee will be unable to return to gainful employment in the same capacity. At this point, the doctor will declare the individual's status as maximal medical improvement, or MMI, and the temporary disability benefits will stop. The worker will then receive permanent total disability benefits.

In any case, a worker will be terminated from total temporary disability benefits after two years from the date that he or she started collecting them. There are some states that provide exceptions to this limitation for severe injuries, including burns, eye injuries, hepatitis, HIV, amputations, and some types of lung disease.

**Severity rate**

Severity rate is a safety metric which companies and projects use to measure how critical or serious the injuries and illnesses sustained in a period of time were by using the number of lost days (on average) per accident as a proxy for severity.

Calculating and understanding the severity rate of injuries in your workplace supplements the other standard safety KPIs which track the frequency of incidents and accidents by giving companies and managers a better idea as to how bad the accidents on their jobs are, which areas of the business experience more serious injuries, and what could be done in terms of accident response and other processes to reduce the severity of incidents.

**Formula**

**Severity rate = (lost workdays x 200,000) / 2,000,000 hours worked = lost day per accident.**

**The strengths and weaknesses of severity rate**

As you may have already realized from the above severity rate calculation and formula, there are some obvious and unfortunate weakness in the severity rate.

The main weakness is that the final severity rate number derived from the calculation is an average. This means that the result can be skewed dramatically by one serious incident.

While the seriousness of this incident might warrant a much higher severity rate overall, it could also exaggerate one issue or mishap in an unfair way. In the same way, a much lower severity rate in one year could also hide certain issues by not including one of those big incidents which results in several days lost.

Even though there are some mathematical weakness in the severity rate, there are some strengths of the measure which make it important and powerful.

As previously mentioned, common KPI's like lost time injury frequency rate and the total recordable incident rate do a great job of quantifying how often incidents and accidents occur, but they don't do great job with clarifying how severe these incidents were.

**The severity rate really helps here, alongside DART safety and a few other metrics.**

Another reason that severity rate is important is because the most disruptive incidents are those which are most severe. The accidents which cause days or weeks off

work cause a lot of disruption in that replacement people need to be sorted, medical bills need to pay, and production and productivity is affected.

High severity rates are worrying to workers, damaging to productivity and a major red flag for agencies and authorities charged with keeping people safe at work - and who look at and benchmark these measurements across entire industries.

There is a reason that most safety teams and companies have several safety metrics which they monitor to get a comprehensive view of their safety performance - and the severity rate is a key part of this arsenal.

**FREQUENCY, SEVERITY, AND INCIDENCE RATES:**

**Disabling Injury** (Lost Time Injury) – An injury causing disablement extending beyond the day of shift on which the accident occurred.

**Non-disabling Injury** – An injury which requires medical treatment only, without causing any disablement whether of temporary or permanent nature.

**Reportable Disabling Injury** (Reportable Lost Time Injury) – An injury causing death or disablement to an extent as prescribed by the relevant statute.

**Days of Disablement** (Lost Time) – In the case of disablement of a temporary nature, the number of days on which the injured person was partially disabled as defined in Partial Disablement. In the case of death or disablement of a permanent nature whether it be partial or total disablement as defined in 2.7 and 2.8 man-days lost means the charges in days of earning capacity lost due to such permanent disability or death as specified in Appendix B.

In other cases, the day on which the injury occurred or the day the injured person returned to work are not to be included as man-days lost; but all intervening calendar days (including Sundays or, days off, or days of plant shut down) are to be included.

If after resumption of work, the person injured is again disabled for any period arising out of the injury which caused his earlier disablement, the period of such subsequent disablement is also to be included in the man-days lost.

**Partial Disablement** – This is of two types: disablement of a temporary nature which reduces the earning capacity of an employed person in any employment in which he was engaged at the time of the accident resulting in the disablement; and disablement of a permanent nature, which reduces his earning capacity in every employment which he was capable of undertaking at the time.

**Total Disablement** – Disablement, whether of a temporary or permanent nature, which incapacitates a workman for all work which he was capable of performing at the time of the

accident resulting in such disablement, provided that permanent total disablement shall be deemed to result from every type of injury specified in Part A of Appendix A or from any combination of injuries specified in Part B of Appendix A where the aggregate percentage of the loss of earning capacity, as specified in that part against those injuries, amounts to one hundred percent.

**Man-Hours Worked** – The total number of employee-hours worked by all employees working in the industrial premises. It includes managerial, supervisory, professional, technical, clerical and other workers including contractors' labour.

**Man-hours worked shall be calculated** from the pay roll or time clock recorded including overtime. When this is not feasible, the same shall be estimated by multiplying the total man-days worked for the period covered by the number of hours worked per day. The total number of man-days for a period is the sum of the number of men at work on each day of the period. If the daily hours vary from department to department separate estimates shall be made for each department and the result added together. When actual man-hours are not used, the basis on which the estimates are made shall be indicated.

## COMPUTATION OF FREQUENCY, SEVERITY AND INCIDENCE RATES

**Frequency Rate** - The frequency rate shall be calculated both for lost time injury and reportable lost time injury as follows:

$$F_A = \frac{\text{Number of lost time injury} \times 1\,000\,000}{\text{Man-hours worked}}$$

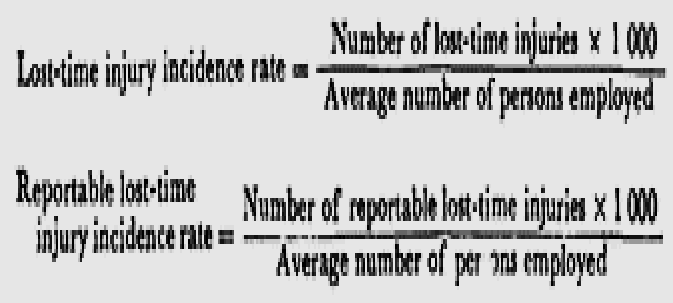
$$F_B = \frac{\text{Number of reportable lost time injury} \times 1\,000\,000}{\text{Man-hours worked}}$$

**Severity Rate** – The severity rate shall be calculated from man days lost both of lost time injury and reportable lost time injury as follows:

$$S_A = \frac{\text{Man-days lost due to lost time injury} \times 1\,000\,000}{\text{Man-hours worked}}$$

$$S_B = \frac{\text{Man-days lost due to reportable lost time injury} \times 1\,000\,000}{\text{Man-hours worked}}$$

Incidence Rates – Ratio of the number of injuries to the number of persons during the period under review. It is expressed as the number of injuries per 1 000 persons employed.




**Accident Incident Rate:**

The Occupational Safety and Health Administration (OSHA) is a regulatory agency of the federal government that ensures, as much as possible, that American workers operate in a safe working environment. The organization requires certain businesses to report their statistics concerning accidents, injuries and other incidents that occur while on the job. Accidents and incidents are logged on an OSHA 300 form that is usually tracked on a spreadsheet.

**Determine your industry** every business is part of a particular industry or sector. Before you can determine whether or not you need to report incidents to OSHA, you need to understand what industry you're part of.

- Industries are usually defined by broad categories like "Construction," "IT Services," "Food Service," etc.
- Pick a keyword or two that best describes your business. You'll need that for the next step.

**Calculating Employee Accidents and Injuries**

Understand the formula for calculating accidents. The formula for calculating incidents is the number of recorded accidents in that year multiplied by 200,000 (to standardize the accident rate for 100 employees) and then divided by the number of employee's labour hours worked. So, the formula, again, is accident rate= (number of accidents*200,000)/number of hours worked.

The 200,000 in this formula represents how many hours would be worked by 100 employees, each putting in 40 hours per week over 50 weeks in a year; OSHA requires the accident rate to be expressed as incidents per 100 employees with maximum straight-time hours.

Pull the number of accidents and recordable incidents from the OSHA 300 log.

The OSHA 300 log is what you use to record workplace injuries. In that log is a table where you record incidents. Simply count the number of lines that you have filled out in that table to determine the number of recordable incidents.

Remember, the rate is calculated on an annual basis for OSHA compliance. So, you will be reviewing data from the previous year to get the rate.

**Total the number of hours worked by all employees during the year in question.**

You will need to pull some payroll data for this step. For example, if you have 20 employees and they each worked 2,000 hours during the year, then the total number of hours worked is 20 x 2,000 or 40,000.

The total number of hours will include overtime hours, but does not include vacation, paid sick leave or holiday pay.

Prepare the monthly average incident rate.

Many businesses like to track the incident rate as a monthly figure to assist them in meeting annual and quarterly goals.

Adjust your calculation for each month to reflect the hours worked by all employees for only that month.

Add the incidents and hours worked from each month and then calculate the incident rate on the totals.

For instance, if you had 1 January incident over 10,000 hours worked, then your January average incident rate would be (1*200,000)/10,000, or 20.

For another example, if you had eight accidents over 400,000 hours worked by employees in a year, you would calculate the accident rate as (8*200,000)/400,000, or 4.

**What is the T Score Formula?**

A t score is one form of a standardized test statistic (the other you'll come across in elementary statistics is the z-score). The **t score formula** enables you to take an individual score and transform it into a standardized form>one which helps you to compare scores.

You'll want to use the t score formula when you don't know the population standard deviation and you have a small.

The t score formula is $t = \frac{\bar{x} - \mu_0}{s/\sqrt{n}}$ Where $\bar{x}$ = sample mean$\mu_0$ = population means = sample standard deviation = sample size

If you have only one item in your sample, the square root in the denominator becomes √1.

$$t = \frac{\bar{x} - \mu_0}{s}$$

This means the formula becomes:

In simple terms, the larger the t score, the larger the difference is between the groups you are testing. It's influenced by many factors including:

- How many items are in your sample?
- The means of your sample.
- The mean of the population from which your sample is drawn.

  The standard deviation of your sample.

**What is the T Score Formula used for?**

You traditionally look up a t score in a t-table. The number of items in your sample, minus one, is your degrees of freedom. For example, if you have 20 items in your sample, then df = 19. You use the degrees of freedom along with the confidence level you are willing to accept, to decide whether to support or reject the null hypothesis.

The t score formula can also be used to solve probability questions. You won't have an alpha level, but you can use the result from the formula, along with a calculator like the TI-83, to find probabilities.

The following example shows how to calculate a t-score formula for a single sample. Paired samples and independent samples use different formulas.

- If you have paired samples, follow the instructions in the *paired samples t-test*.
- For independent samples, see: *independent samples t-test*.

Example of the T Score Formula

**Example question**: A law school claims its graduates earn an average of $300 per hour. A sample of 15 graduates is selected and found to have a mean salary of $280 with a sample standard deviation of $50. Assuming the school's claim is true, what is the probability that the mean salary of graduates will be no more than $280?

**Step 1:** Plug the information into the formula and solve: $\bar{x}$ = sample mean = 280$\mu_0$ =population mean = 300s = sample standard deviation = 50n = sample size = 15

t = (280 – 300)/ (50/√15) = -20 / 12.909945 = -1.549.

**Step 2:** Subtract 1 from the sample size to get the degrees of freedom15 – 1 = 14. The degrees of freedom let you know which form of the t distribution to use (there are many, but you can solve these problems without knowing that fact!).

**Step 3:** Use a calculator to find the probability using your degrees of freedom (8). You have several options, including the TI-83 (see How to find a t distribution on a TI 83) and this online calculator. Here is the result from that calculator. Note that I selected the radio button under the left tail, as we are looking for a result that's no more than $280: The probability is 0.0718, or 7.18%.

**T Scores in Psychometrics**

A t score in psychometric (psychological) testing is a specialized term that is **not the same thing as a t score that you get from a t-test.** T scores in t-tests can be positive or negative. **T scores in psychometric testing are always positive**, with a mean of 50. A difference of 10 (positive or negative) from the mean is a difference of one standard deviation. For example, a score of 70 is two standard deviations above the mean, while a score of 0 is one standard deviations below the mean.

A t score is like a z score — it represents **the number of standard deviations from the mean**. While the z-score returns values from between -5 and 5 (most scores fall between -3 and 3) standard deviations from the mean, the t score has a greater value and returns results from between 0 to 100 (most scores will fall between 20 and 80). Many people prefer t scores because the lack of negative numbers means they are easier to work with and there is a larger range, so decimals are almost eliminated. This table shows z-scores and their equivalent t scores.

**INCIDENT RATES:**

Incident rates are an indication of how many incidents have occurred, or how severe they were. They are measurements only of past performance or lagging indicators. Incident rates are also only one of many items that can be used for measuring performance. There are many items that should be used to measure performance, most of which are positive in nature; incident rates tend to be viewed as an indication of something that is wrong with a safety system, rather than what is positive or right about the system. Despite this, for many companies, incident rates remain the primary indicator of safety performance measurement. This is primarily because incident rates are fairly easy to figure out, and can be easily compared between one company and another, and are used throughout industry.

The most difficult part about incident rates is that the five major types of rates are easily confused with one another. The most common rate used is the Recordable Incident Rate. This is commonly called either the "total case incident rate" or just the "incident rate". The "Lost Time Case Rate" (LTC) is the second most commonly used. The "Lost Workday Rate" and "Severity Rate" are primarily used only in larger companies that have a larger number of Lost Time Cases. The newest incident rate type is called the **DART or "Days Away/Restricted or Transfer Rate"**.

**LOST TIME CASE** – Any occupational injury or illness which results in an employee being unable to work a full assigned work shift. (A fatality is not considered a LTC.) Lost time cases result when there are no reasonable circumstances under which the injured employee could return to meaningful work. It is assumed that if an employee could work, even if it is not their normally assigned duties, alternate tasks that accommodate the restrictive nature of an injury would be assigned to the employee. In this situation, the days are recorded as RESTRICTED WORK DAYS, rather than Lost Work Days. (Note that working from home, on a computer or at other assigned tasks, is not considered restricted work activity unless the employee would normally perform this function from home as part of their assigned work. Situations like this would be considered lost work days. The incident, if employees can report to their normal workplace, and they can be assigned and complete productive tasks to benefit the company, can be considered restricted work days, rather than lost work days.

**LOST WORKDAY RATE** – a mathematical calculation that describes the number of lost work days per 100 full-time employees in any given time frame. LOST TIME CASE RATE – a mathematical calculation that describes the number of lost time cases per 100 full-time employees in any given time frame. OCCUPATIONAL INJURY – Any injury (including a fatality) which results from a work-related incident or exposure involving a single incident
. Examples are:

- Thermal and chemical burns
- Cuts, abrasions and punctures
- Fractures or crushing injuries
- Respiratory irritations
- Instantaneous hearing loss
- Amputations

• Sprains or strains
• Broken bones

**OCCUPATION ILLNESS** – Any abnormal condition or disorder (other than an injury) that resulted from a work-related exposure to a biological, chemical or physical agent. These include both acute and chronic illnesses or diseases that may be caused by inhalation, absorption, ingestion or direct contact.

**RECORDABLE INCIDENTS** – Recordable incidents include all work related deaths, illnesses, and injuries which result in a loss of consciousness, restriction of work or motion, permanent transfer to another job within the company, or that require some type of medical treatment or first-aid. Companies with 10 or more employees need to report their incident rates, types of incidents and lost/restricted work days to OSHA every year. Recordable incidents are incidents that resulted from an exposure or event in the workplace and that required some type of medical treatment or first-aid

**SEVERITY RATE** – a mathematical calculation that describes the number of lost days experienced as compared to the number of incidents experienced. TOTAL INCIDENT RATE – a mathematical calculation that describes the number of recordable incident that a company experiences per 100 full-time employees in any given time frame. WORK **RELATED** – Work relationship is established with the injury or illness results from an event or exposure in the work environment. The work environment is normally considered the company premises, or another location where the employee is present as a condition of employment (i.e. a construction site, or customer location). Driving to or from work is not normally considered work-related, unless the company requires the employee to drive or be transported to a specific location for a specific business purpose. The following flowchart is a simplified version to assist companies in determining work relationship.

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## UNIT 5 - SAFETY MANAGEMENT - SPRA7011

Methods of promoting safe practice – Safety organization- OSHA – Safety controls. visible and latent hazards - human factors and safety - safety audit - Case study roll of management and roll of Govt. in industrial safety - safety analysis Industrial fatigue- role of industrial psychology- risk analysis - safety training - accident and near miss investigations-promotional measures to avoid accidents - human reliability - safety management characteristics-industrial safety policies and implementation

**METHODS OF PROMOTING SAFE PRACTICE:**

The chemical, petrochemical, and refining industries utilize some of the most dangerous materials in very capital-intensive processes with great risk to personnel and assets. The accidental release of toxic, reactive, or flammable liquids and gases in processes involving highly hazardous chemicals can be catastrophic due to the human, financial, and business costs of an incident.

These industries and their HSE executives are committed to executing best practices to maintain a safety-minded culture and prevent highly critical assets from failing.

Here are some ways to help keep OHS awareness at the forefront in your workplace, particularly for young workers:

- Encourage other employees to support young workers by keeping an eye out for them.
- Make yourself available during young worker orientation or induction sessions.
- Demonstrate your commitment to health and safety with your own consistent, safe work practices, and emphasize that unsafe work practices are unacceptable.
- Make health and safety a part of all workplace communications.
- Personally encourage young workers to report health and safety issues that they may encounter, and to share ideas and suggestions.
- Respond to all health and safety concerns and act promptly.
- Promote and attend safety training sessions, and participate in any emergency response training.
- Use and wear protective equipment and safety gear as required and ensure adequate maintenance.

**SAFETY ORGANIZATION:**

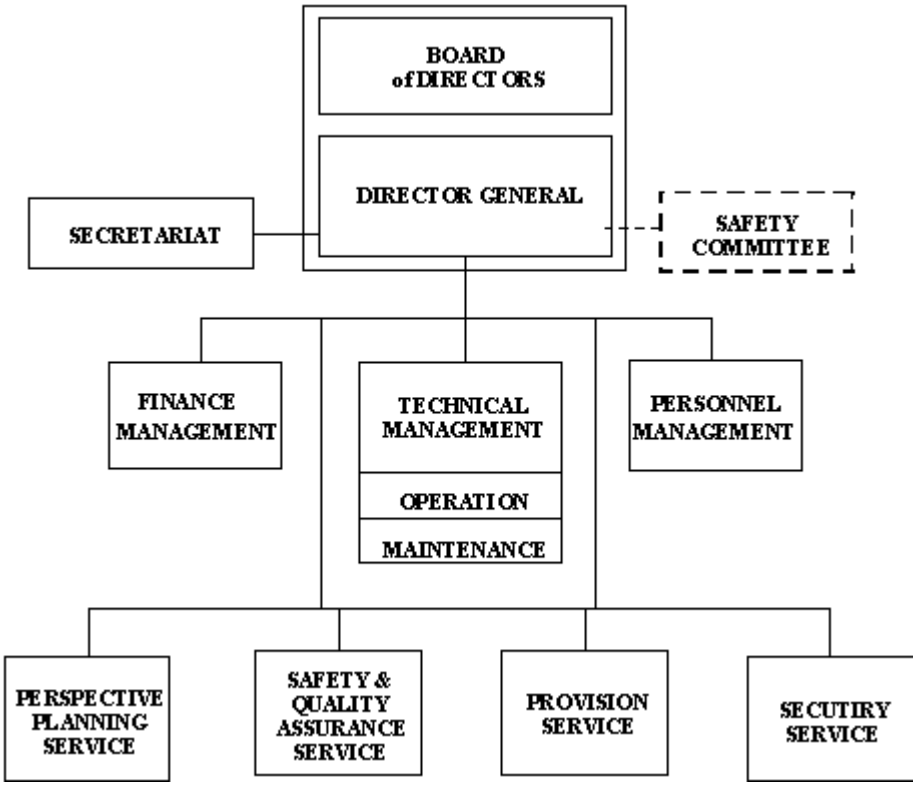


**Fig. 5.1**

**Directors of Services**

- Ensure Heads of Department/managers have sufficient resources to achieve their health and safety duties.
- Ensure Departments meet their required health and safety objectives.
- To review Department reports on health and safety progress and compliance.
- Active member of the Health and Safety Committee, including the review and development of health and safety policies.
- To ensure that health and safety policies are implemented within their division.
- To resolve issues of non-compliance where necessary within their division.

**Heads of Department/Managers of Services**

- Support Departmental Health and Safety Officers (DHSO) by making available time or resources as necessary.
- To implement the health and safety policies that are relevant to the activities within their department, in conjunction with the DHSO.
- Develop Departmental health and safety objectives with the DHSO.
- To provide relevant information and training to staff, ensuring attendance as required.

- To ensure appropriate emergency procedures are in place for departmental activities, facilities and are practiced as necessary.
- To ensure that hazard identification and management is effective and documentation is maintained.
- To raise hazard management issues with the DVC/AVC/Director where the issue cannot be managed at the departmental level or is likely to have implications for the wider.
- To provide reports to the Director on health and safety progress and meeting of objectives.
- To participate in health and safety audits.
- Ensure accident/incident reporting and investigation is thorough.
- Meet regularly (at least quarterly) with the DHSO

**Supervisors**

- Duties include providing a safe place of work or others authorized to be in that place of work.
- To be aware of the hazards and controls involved in the area of work.
- To ensure controls are adhered to.
- To report any hear hits, incidents or injuries to any person authorized to be in the place of work through the reporting system.
- To follow health and safety policies and procedures.

**Departmental Health & Safety Officers (DHSO)**

- To complete hazard identification and maintain hazards register including reviews of the register and hazard auditing.
- To maintain the accident register for the department and provide copies of accident forms to management.
- To report on hazard management issues that require further controls to the HOD/Manager
- To complete accident investigations and associated documentation.
- Co-operate with initiatives from the Health and Safety Team.
- Liase with Departmental Emergency Wardens to ensure emergency procedures are in place and practiced as necessary.
- Act as a resource for information on health and safety matters.
- Ensure that effective health and safety training, information and supervision is

available to those who require it.

- To complete the staff induction for new staff with respect to the health and safety requirements.
- Liase with other departments and organizations as necessary.

**Health & Safety Representatives**

- Health and Safety Representatives are nominated or elected by employees.
- H&S Reps are an additional contact point for staff to raise health and safety issues.
- H&S Reps provide support to DHSOs in the provision of health and safety information
- Facilitate increased involvement by employees and their representatives on health and safety matters.

**SAFETY EDUCATION AND TRAINING:**

Employers must have an overall safety program including relative site specific safety information where applicable. The safety training program should cover topics such as:

- accident prevention and safety promotion
- safety compliance
- accident and emergency response
- personal protective equipment
- safety practices
- equipment and machinery
- chemical and hazardous materials safety
- workplace hazards
- employee involvement

An effective training program can reduce the number of injuries and deaths, property damage, legal liability, illnesses, workers' compensation claims, and missed time from work. An effective safety training program can also help a trainer keep the required safety training courses organized and up-to-date. Safety training classes help establish a safety culture in which employees themselves help promote proper safety procedures while on the job. It is important that new employees be properly trained and embrace the importance of workplace safety as it is easy for seasoned workers to negatively influence the new hires. That negative influence however, can be purged with the establishment of new, hands-on, innovative effective safety training which will ultimately lead to an effective safety culture.

**Training guidelines follow a model that consists of:**

- A. Determining if Training is Needed
- B. Identifying Training Needs
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**Determining if training is needed**

You first have to determine if a situation can be solved using training. Training, or retraining as the case may be, could be required by an OSHA standard. Training is an effective solution to problems such as employee lack of understanding, unfamiliarity with equipment, incorrect execution of a task, lack of attention, or lack of motivation. Sometimes, however, the situation cannot be mitigated through the use of training and other methods, such as the establishment of engineering controls, may be needed to ensure worker safety.

**Identifying training needs**

A job safety analysis and/or a job hazard analysis should be conducted with every employee so that it is understood what is needed to do the job safely and what hazards are associated with the job. A safety trainer may observe the worker in his/her environment to adequately assess the worker's training needs. Certain employees may need extra training due to the hazards associated with their particular job. These employees should be trained not only on how to perform their job safely but also on how to operate within a hazardous environment.

**Identifying Goals and Objectives**

It is important for the Trainer to identify necessary training material. It is equally important that the trainer identify training material that is not needed to avoid unnecessary training and frustration from their trainees.

At the beginning of every safety training session the trainer should clearly iterate the objectives of the class. The objectives should be delivered using action oriented words like: the employee... "will be able to demonstrate" or "will know when to"... which will help the audience understand what he/she should know by the end of the class or what to

information to assimilate during the class. Clearly established objectives also help focus the evaluation process on those skill sets and knowledge requirements necessary to perform the job safely.

**Developing Learning Activities**

Training should be hands-on and simulate the job as closely as possible. Trainers can use instructional aids such as charts, manuals, PowerPoint presentations, and films. Trainers can also include role-playing, live demonstrations, and round-table group discussions to stimulate employee participation. Games like "what's wrong with this picture" (it is usually good to use pictures of situations found at their specific location)" or "safety jeopardy" can be useful ways to make the training fun yet educational.

**Conducting the Training**

Trainers should provide employees with an overview of the material to be learned and relate the training to the employees' experiences. Employers should also reinforce what the employees have learned by summarizing the program's objectives and key points of training. At the beginning of the training program, the trainer should show the employees why the material is important and relevant to their jobs. Employees are more likely to pay attention and apply what they've learned if they know the benefits of the training.

**Evaluating Program Effectiveness**

Evaluation will help employers or supervisors determine the amount of learning achieved and whether an employee’s performance has improved on the job. Among the methods of evaluating training are

(1) Student opinion. Questionnaires or informal discussions with employees can help employers determine the relevance and appropriateness of the training program

(2) Supervisors’ observations. Supervisors are in good positions to observe an employee’s performance both before and after the training and note improvements or changes

(3) Workplace improvements. The ultimate success of a training program may be changes throughout the workplace that result in reduced injury or accident rates

(4) Formal assessments. Practical and written exams also assist in evaluating understanding of training material. For example, for a lift-truck operator, a written and a practical exam would identify areas of training that may need to be revisited. Furthermore administering a pre-test and post-test will establish a knowledge base line or reference point to measure training effectiveness.

**Improving the Program**

As evaluations are reviewed, it may be evident the training was not adequate and that

the employees did not reach the expected level of knowledge and skill. As the program is evaluated, the trainer should ask:

(1) If a job analysis was conducted, was it accurate?

(2) Was any critical feature of the job overlooked?

(3) Were the important gaps in knowledge and skill included?

(4) Was material already known by the employees intentionally omitted?

(5) Were the instructional objectives presented clearly and concretely?

(6) Did the objectives state the level of acceptable performance that was expected of employees? (7) Did the learning activity simulate the actual job?

(8) Was the learning activity appropriate for the kinds of knowledge and skills required on the job?

(9) When the training was presented, was the organization of the material and its meaning made clear?

(10) Were the employees motivated to learn?

(11) Were the employees allowed to participate actively in the training process?

(12) Was the employer's evaluation of the program thorough?

**SAFETY CONTROL:**

**Types of industrial safety systems**

There are three main types of industrial safety systems:

- Process Safety System or Process Shutdown System, (PSS).
- Safety Shutdown System (SSS): This includes Emergency Shutdown-(ESD)
- Emergency Depressurization-(EDP) Systems.

**ESD:**

**These systems may also be redefined in terms of ESD/EDP levels as:**

- ESD level 1: In charge of general plant area shutdown, can activate ESD level 2 if necessary. This level can only be activated from main control room in the process industrial plants.
- ESD level 2: This level shuts down and isolates individual ESD zones and activates if necessary EDP.
- ESD level 3: provides "liquid inventory containment".

**SSS**

The safety shutdown system (SSS) shall shut down the facilities to a safe state in case of an emergency situation, thus protecting personnel, the environment and the asset.

The safety shutdown system shall manage all inputs and outputs relative to emergency shutdown (ESD) functions (environment and personnel protection). This system might also be fed by signals from the main fire and gas system.

**FGS**

The main objectives of the fire and gas system are to protect personnel, environment, and plant (Including equipment and structures). The FGS shall achieve these objectives by:

- Detecting at an early stage, the presence of flammable gas,
- Detecting at an early stage, the liquid spill (LPG and LNG),
- Detecting incipient fire and the presence of fire,
- Providing automatic and/or facilities for manual activation of the fire protection system as required,
- Initiating environmental changes to keep liquids below their flash point
- Initiating signals, both audible and visible as required, to warn of the detected hazards,
- Initiating automatic shutdown of equipment and ventilation if 2 out of 2 or 2 out of 3 detectors are triggered,
- Initiating the exhausting system.

**EDP:**

Due to closing ESD valves in a process, there may be some trapped flammable fluids, and these must be released in order to avoid any undesired consequences (such as pressure increase in vessels and piping). For this, emergency depressurization (EDP) systems are used in conjunction with the ESD systems to release (to a safe location and in a safe manner) such trapped fluids.

**PSV:**

Pressure safety valves or PSVs are mechanical devices and are usually used as a final safety solution when all previous systems fail to prevent any further pressure accumulation and protect vessels from rupture due to overpressure

**FIRST AID FACILITIES AND TRAINING:**

**First aid facilities:**

Depending on the information you collect, you'll need to provide some or all of the following:

- **first aid kits** – these should be clearly identifiable and well stocked, and the

contents, number and location of kits should be determined having regard to the above factors in your workplace

- **first aid rooms** – these must be easily accessible, well lit, ventilated and temperature controlled, contain a sink or wash basin and a supply of hot and cold running water, as well as a means of boiling water, and should not be used for any other purposes
- **first aid policies and procedures** – which have been developed in consultation with staff

**Trained first aiders:**

The number of first aiders and training needs will vary between workplaces. As a general rule, persons designated as first aid officers will need to have undertaken training leading to a Senior First Aid certificate (Level 2 certificate).

**FIRE PREVENTION AND PROTECTION:**

**Fire Protection:** Fire is a chemical reaction that requires three elements to be present for the reaction to take place and continue. The three elements are:

Heat, or an ignition source:  Fuel and  Oxygen

These three elements typically are referred to as the "fire triangle." Fire is the result of the reaction between the fuel and oxygen in the air. Scientists developed the concept of a fire triangle to aid in understanding of the cause of fires and how they can be prevented and extinguished. Heat, fuel and oxygen must combine in a precise way for a fire to start and continue to burn. If one element of the fire triangle is not present or removed, fire will not start or, if already burning, will extinguish.

Ignition sources can include any material, equipment or operation that emits a spark or flame— including obvious items, such as torches, as well as less obvious items, such as static electricity and grinding operations. Equipment or components that radiate heat, such as kettles, catalytic converters and mufflers, also can be ignition sources.

Fuel sources include combustible materials, such as wood, paper, trash and clothing; flammable liquids, such as gasoline or solvents; and flammable gases, such as propane or natural gas.

Oxygen in the fire triangle comes from the air in the atmosphere. Air contains approximately 79 percent nitrogen and 21 percent oxygen. OSHA describes a hazardous atmosphere as one which is oxygen- deficient because it has less than 19.5 percent

oxygen, or oxygen enriched because it has greater than 23.5 percent oxygen. Either instance is regarded by OSHA as an atmosphere immediately dangerous to life and health (IDLH) for reasons unrelated to the presence of fire. Depending on the type of fuel involved, fires can occur with much lower volume of oxygen present than needed to support human respiration.

Every roofing project has all three of the fire triangle elements present in abundance. The key to preventing fires is to keep heat and ignition sources away from materials, equipment and structures that could act as fuel to complete the fire triangle.

**Fire Prevention**

Fire prevention requires segregating the three elements of the fire triangle. In practice, a method to achieve that goal is to post—and enforce—no smoking signs around flammable liquids and gases and have fire watches on all work involving torch-applied materials of a minimum of two hours after the last torch is turned off.

**Flammable and Combustible Liquids**

Proper storage and handling of flammable and combustible liquids will help prevent fires from occurring; only approved, closed containers for storage of flammable or combustible liquids may be used under OSHA rules. Such containers include safety cans or containers approved by the U.S. Department of Transportation. A safety can is a container that has a self-closing lid, internal-pressure relief and flame arrestor with a capacity of not more than 5 gallons. Inexpensive, plastic cans without those features previously mentioned, such as those typically bought at hardware stores or gas stations, are not approved for use in roofing operations. However, manufacturers do sell plastic containers that meet the OSHA requirements for safety cans.

Flammable liquids that are extremely viscous, or difficult to pour, like single ply adhesive, can be left in their original shipping containers. Similarly, OSHA allows the use of original containers of flammable liquids that are in quantities of one gallon or less.

Static electricity may be generated when transferring liquids, gases or solids through pipes or hoses. It is important to dissipate this electric charge when handling flammable and combustible materials. When transferring flammable or combustible liquids from one container to another, the two containers must be “bonded” together. The bonding process involves attaching a wire with alligator clips on each end to both containers. The clips must penetrate the container coating and touch metal. You may need to score the paint with the alligator clips. To dissipate static, the container receiving the liquid must be in contact with the ground and not insulated from contact with the ground. For example, plastic or

composite pickup truck bed liners prevent the flow of static electricity to ground because the liner does not conduct electricity. The receptacle container must have a clear path to ground, by direct contact or use of a grounding strap or wire, to effectively eliminate static. Service or fueling areas at job sites must have a 20BC-rated fire extinguisher within 75 feet of each pump.

Safety cabinets allow for greater quantities of flammable and combustible liquids to be stored safely inside buildings. Up to 60 gallons of a flammable liquid or as much as 120 gallons of a combustible liquid may be stored indoors in a safety cabinet. Each cabinet must be labeled "Flammable— Keep Fire Away." Up to three cabinets may be stored in one room. Without a safety cabinet, only 25 gallons of either flammable or combustible liquids are allowed to be stored inside a building.

**ACCIDENT RECORDS AND REPORTS:**

Work-related accidents for the purposes of report, an accident is a separate, identifiable, unintended incident that causes physical injury. This specifically includes acts of nonconsensual violence to people at work.

**Not all accidents need to be reported, a report is required only when:**

- the accident is work-related; and
- it results in an injury of a type which is reportable (as listed under 'Types of reportable injuries')

**When deciding if the accident that led to the death or injury is work-related, the key issues to consider are whether the accident was related to:**

- the way the work was organised, carried out or supervised;
- any machinery, plant, substances or equipment used for work; and
- the condition of the site or premises where the accident happened. If none of these factors are relevant to the incident, it is likely that a report will not be required.

**Types of reportable injury**

**Deaths**

All deaths to workers and non-workers must be reported if they arise from a work related accident, including an act of physical violence to a worker. Suicides are not reportable, as the death does not result from a work-related accident.

**Specified injuries to workers**

- a fracture, other than to fingers, thumbs and toes;
- amputation of an arm, hand, finger, thumb, leg, foot or toe;
- permanent loss of sight or reduction of sight;
- crush injuries leading to internal organ damage;
- serious burns (covering more than 10% of the body, or damaging the eyes, respiratory system or other vital organs);
- scalping's (separation of skin from the head) which require hospital treatment;
- unconsciousness caused by head injury or asphyxia;
- Any other injury arising from working in an enclosed space, which leads to hypothermia, heat-induced illness or requires resuscitation or admittance to hospital for more than 24 hours.

**Over-seven-day injuries to workers**

This is where an employee, or self-employed person, is away from work or unable to perform their normal work duties for more than seven consecutive days (not counting the day of the accident).

**LESSONS FROM THE RECORDS TO PREVENT ACCIDENTS:**

**Failure to record work related accident, ill health, incident or near miss:**

If a work related accident, ill health, incident or near miss is serious or has long term consequences then there is a danger the event will be repeated. In addition there may be criminal prosecutions as if an accident is not recorded it cannot be reported. Also, if events are not recorded any civil proceedings when staff may decide to sue NERC for compensation will be more difficult for NERC to defend. Remedy

**Encourage accident/incident near miss reporting and follow this procedure.**

Failure to notify HSE of a reportable accident: HSE can prosecute NERC or an individual for failing to notify them of a reportable accident within the required time period.

Remedy – encourage managers to inform site administrative staff of all serious work related accidents, ill health, incidents and near misses so that they can notify HSE without delay if it is reportable.

Failure to carry out an investigation of a serious accident, incident or near miss as soon as possible after they occur: this will also make it more difficult for NERC to collect

evidence and establish true causes. This may make it impossible to refute a claim for compensation but will also mean that lessons cannot be learnt and the event may recur with more serious consequences.

Remedy – the weekly check of the accident reports should show up any serious accidents, incidents or near misses which have not already been notified.