

# ENGINEERING WORKSHOP TECHNOLOGY

Edited by
H. A. AJIMOTOKAN
R. M. MAHAMOOD

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# CHAPTER TWO

# INDUSTRIAL SAFETY

**J.O. Aweda, R.M. Mahamood and K.O. Abdulrahman**

*Objectives*

The objectives of this chapter are to:

i. Define the concept of industrial safety and specify its various objectives,
ii. Specify typical safety rules and general precautionary measures,
iii. Define the term accidents and specify with examples the causes of accidents,
iv. Discuss the types of accidents,
v. Define the term fire and specify its fighting operations,
vi. Explain the five classes of fire and their suitable fire extinguishers, and
vii. Discuss with examples the basic types of safety equipment used in the workshop.

## 2. Introduction

Establishing policy on safety and work rules are critical processes in the industry. Without adequate safety policies and procedures, the industry may run at a colossal loss, as it is vulnerable to legal battles, downtime, etc. The employers must train and orientate the employees, on the safety rules and available procedures, which would help to protect both the employees and the employers. With proper safety policy in workplaces, the employee could work without getting injured, incurring health bill on the employer and reduction of downtime, which could affect the organisation negatively. As important as it is to educate and train workers, unless the information provided is written into policies and rules, the industry is left vulnerable to misunderstandings, loopholes and legal battles. The policies may be formed based on the understanding that has been developed through working together over a period of time, but it becomes much simpler to enforce when they have been written in black and white. Such well-written policies and rules would protect the industry and its workers. Expectations of any industry as regards safety enforcement must be clear and made available. When industrial accident occurs, it could result to damage of equipment, plant and the environment. Such accident will not only cause serious losses to the industry or employers in terms of finance or temporary stoppage of operation (downtime), but also

in terms of serious pain and suffering to the injured person(s) and with the possibility of losing employees. This may lead to the employee's permanent disability and consequent disengagement from work. Human actions are in no small way directly or indirectly responsible for most industrial accidents. Accidents mostly occur due to human errors, human negligence or irresponsible attitude of not adhering to correct procedures of carrying out assignments or due to unsafe working conditions.

## *2.1 What Industrial Safety is*

Definitions of industrial safety mostly revolve around policies and procedures that are put in place to safeguard workers and equipment during service. Industrial safety can be defined as the policies and protections that have been made available to safeguard the factory and its workers from hazards that could cause injury to personnel, damaged to equipment or both. Occupational safety and health administration (OSHA) has put standard industrial safety policies in place, which is the minimum standard any industry should adhere to. Industrial safety can also be regarded as the ability to manage the risks inherent in operations or related to the environment. Industrial safety is a commitment in identifying risks in relation to production operations, assess them in terms of quality and quantity and manage them. Risk may be considered to be less serious in a less sensitive environment, but similar risk may be considered to be critical in similar operations conducted in a very sensitive environment.

### *2.1.1 Objectives of Industrial Safety*

The objectives of industrial safety are to

i. Educate all workers on safety principles,
ii. Prevent accident in a plant by eliminating hazard or reducing it to the minimum,
iii. Prevent loss of life, permanent disability, and loss of income of worker by eliminating the causes of accident,
iv. Eliminate accident that causes work stoppage and production loss,
v. Reduce all costs of accident, lower worker's compensation and insurance rate,
vi. Improve production means to a higher standard, and
vii. Increase workers' morale and better human relations in the industry.

Industries or production work places are majorly exposed to three major types of risk:

i. Risk related to the products they use and produce,
ii. Risks related to processes and equipment used for their operations, and
iii. Transportation risks related to their products.

It therefore means that risk in any organisation is related to the type of operations or processes taking place in such organisation, and such risk is related to the products the organisation uses, processes and equipment used by the organisation and transportation risk as related to the organisation's operations.

## *2.2 Accidents*

An accident is a mishap that causes injury to worker, damage to tool or machine and equipment. This injury could result in temporary or permanent disability of the worker.

### *2.2.1 Causes of Accidents*

The causes of accidents can be categorised into mechanical, environmental and human causes. The mechanical causes could occur due to continued use of obsolete, poorly maintained or unsafe equipment, use of improperly guarded or unguarded equipment, improper or lack of use of safety devices, improper plant layout and material handling system, among others. The environmental causes could occur due to abnormal temperature and humidity - causing workers' fatigue that increases the chances of accident occurrence, poor ventilation, faulty or poor lightening, presence of dust, fumes and smoke, and poor housekeeping, congestion and bad plant layout, among others. The human causes could occur due to failure of using personal protective equipment (PPE), use of machine or equipment without technical know-how, authority and safety devices, long duration of work or shift duty, working on a machine or equipment in an unacceptable condition, moving equipment operated at unsafe speed, improper or poor transportation of items/ raw materials and improper use of tool, machine or equipment, among others.

### *2.2.2 Types of Accidents*

There are five basic types of accidents. These include:

i. Near miss accident - an accident without injury to worker or damage of equipment,
ii. Trivial accident - an accident with less injury to worker or damage to equipment,
iii. Minor accident - an accident with injury or damage more than the trivial accident,
iv. Serious accident - an accident with severe injury to worker or damage to equipment, and
v. Fatal accident - an accident with very severe injury to worker or damage to equipment. This may cause permanent disability or death.

## *2.3 Safety and Health*

The safety and health condition of workers should be taken seriously by any industrial setup and as such, clear policy statements and goals as they relate to safety and health of workers should be established. This is important because the health of workers has a direct relationship with the productivity of the industry and health claims. Downtimes could occur as a result of illness or injuries to worker.

### *2.3.1 Safety and Health Policy Statement*

Every industrial setup must realise that no job is more important than workers' health and safety. Serious planning should be made to provide a safe process of completing a job that pose a potential safety and health threat. Every process or procedure must be safe, and the management and other personnel responsible, must not tolerate shortcuts to safety practice. When anyone observes unsafe procedures that may pose potential threat to health and safety, the act should be promptly reported for necessary actions. Any work that cannot be done safely should not be done at all, because every worker is entitled to a safe and healthy working environment. See Appendix I for a sample of a company's safety and health policy statements.

### *2.3.2 Safety and Health Goals*

Some of the safety and health goals that should be established by any production environment must include the following:

i. Provision of a safe environment for workers to work,
ii. Provision of personal protective equipment,
iii. Routine and workplace inspection,
iv. Training and re-training of workers on safety,
v. Development and implementation of safe working procedures/ rules,
vi. Safety rules must be enforced and sanctions or penalty given to offenders, and
vii. Creation of awareness on safety rules and obedience to safety rules.

## *2.4 Personal Protective Equipment*

The fundamental approach to accident prevention is by ensuring that the machine and the environment are safe to work. However, the need to safeguard employees at all time by ensuring that personal protective equipment (PPE)/ devices are used always cannot be downplayed. In cases where employees improperly wear or refuse to wear PPE because of discomfort, they tamper with them to render them ineffective. This may result in not providing optimum protection that the equipment meant to offer. For example, many machines are equipped with emergency stop, if the worker tamper with

such setting, the machine would not be able to stop when it is unacceptably operated. The PPE is classified based on the areas of application. These include:

i. Head protection equipment, which are used by employees liable to be hit by falling/ flying objects or exposed to head injuries. Equipment such as the hard hat is worn to protect the head (see Figure 2.1);
ii. Face and eye protection equipment, which are worn during activities involving flying particles, fillings, flashes and high radiation. It is advisable to wear personal protective device such as the eye or welding goggles to protect the face (See Figure 2.2);
iii. Ear protection equipment, which is worn to reduce the intensity of noise getting into the ears. This is important because, exposure to long-term noise could result in hearing impairment or complete hearing loss. The common types of ear protectors that are available are the earplug - a piece of wax, rubber, or cotton wool placed in the ear as protection against noise, water, or cold air (see Figure 2.3 (a)), helmet (see Figure 2.3 (b)), earmuff (see Figure 2.3 (c)), and doughnut or cushion (see Figure 2.3 (d));



**Figure 2.1**: The hard hats

*Source: (Priya Fire, 2009)*



(a) Welding shield (a) Operational eye shields (c) Welding goggles

**Figure 2.2**: Eye protective devices, showing the welding shield in (a), eye shields in (b), and welding goggles in (c)

*Source: (Priya Fire, 2009)*



(a) Earplugs (b) Helmet

(c) Earmuffs (d) Doughnut ear cushion

**Figure 2.3:** Ear protective devices, showing the earplugs in (a), helmet with earmuffs in (b), earmuffs in (c), and doughnut ear cushion in (d)

*Source: (Priya Fire, 2009)*

iv. Hand protection equipment, which provides the capability of protection against wetting, hot, molten or corrosive materials, against sharp object from piercing the hand, and other related risks to the fingers. Equipment such as the gloves is worn to protect the hand (see Figure 2.4);



(a) Cotton gloves (b) Rubber gloves

**Figure 2.4:** Hand protective equipment, showing the cotton gloves in (a), and rubber gloves in (b)

*Source: (Priya Fire, 2009)*

v. Foot and leg protection equipment, which provides the capability of protection against wetting, against heavy objects fallen on the toes, splashing of hot, molten metal or corrosive materials, against sharp object from piercing the feet, and other related risks to the feet or toes. The types of safety boot/ shoe also depend on the type of activity being undertaken. Figure 2.5 shows the most common foot and leg protective boots used in the industry;



**Figure 2.5**: Various types of safety boots

vi. Body protection equipment, which are clothes or straps worn to protect the human body from industrial hazards. The body protection wears provide the capability of protection against wetting or splashing of cold, hot, molten metal or corrosive materials and fire. The type of body protection worn by an individual depends on the type of activity to be undertaken. Figure 2.6 shows pictorial illustrations of body protective wears; and

vii. Respiratory protective equipment, used where the atmospheric air is contaminated and may be hazardous to workers health. The selection of respiratory protective equipment often depends on factors such as the type of contaminant, its physical, chemical and toxicological properties, frequency of exposure to the contaminant, and duration of wearing the protective equipment per. The different respiratory equipment available includes the gas mask, chemical cartridge respirator, mechanical filter respirator, etc. (see Figure 2.7).



Fire proximity suit



Paint coverall



Acid coverall

(a) Coveralls



PVC apron



Leather apron



Cotton apron

(b) Aprons



Raincoat



Lab coat



Boiler suit

(c) Coats and boiler suits



Fire blanket



Cold storage suit



Half body belt



Full body harness

(d) Fire blanket, cold suit, and safety belts

**Figure 2.6:** The body protective gadgets, showing the coveralls in (a), aprons in (b), coats and boiler suit in (c) and fire blanket, cold suit, safety belts in (d)

*Source: (Priya Fire, 2009)*




**Figure 2.7:** Different types of respiratory protective devices

*Source: (Priya Fire, 2009)*

## *2.5 Safety Rules*

In ensuring a high level of industrial safety, production environment should establish a set of basic safety rules. Some of the basic safety rules, which should prevent hazards in a working environment, are as follows:

i. All guards must be kept in place,
ii. Never do anything unsafe to get the job done. If a job is unsafe, it should be reported to the supervisor or safety department,
iii. All safety warning signs must be placed at strategic locations and must be obeyed at all times,
iv. Restrict unwanted people from being in the work area,
v. Personal protective equipment must be worn as prescribed by the management,
vi. Appropriate tools should always be used for specific jobs it was designed to do,
vii. All injuries must be reported and documented as soon as possible no matter how slight. This is for record purpose and to prevent future occurrence,
viii. Working under the influence of alcohol or illegal drugs must be prohibited,

ix. Always stand to the side when operating circuit breakers; never stand directly in front of the device being operated,
x. Electrical equipment must be inspected for defective parts, faulty insulation, loose connections and improper grounding and appropriate remedial action should be taken before working on or near these equipment,
xi. Report any equipment /machine malfunctions or defects to the supervisor and appropriate repair must be carried out before continued use of such equipment,
xii. Horseplay, alcohol or drugs must not be allowed in the work premises,
xiii. Running or fighting are not allowed in the work premises,
xiv. Do not operate any equipment unless you have been trained and authorized to do so,
xv. Tools must be returned to safe drawers or tool boxes after use,
xvi. Walkways should be free of obstacles that will prevent smooth movement, and
xvii. Clean workstations after every operation.

### *2.5.1 Safety Rules and Regulations*

Safety rules outline the main activities to do or not to do for completing a job safely and effectively. Some of the important things to bear in mind regarding safety rules are:

i. No single list of safety rules is adequate for all types of industries,
ii. List of accident experiences and safety rules should be developed based on standard industry practices. An industrial setup should not rely solely on generic list or other industrial setup,
iii. All rules need to be clearly and well communicated to the management and staff alike,
iv. All rules must be strictly enforced at all time, and
v. Manufacturer's recommendations must be followed when operating any equipment.

### *2.5.2 Emergency Regulation*

This involves the rules everyone must observe in emergency situations. All personnel are therefore advised to familiarise themselves with the emergency procedures (e.g. plant emergency shot down), location of the emergency equipment and how to use it, means of escape, and not to linger around incident site.

## *2.6 Fire and Safety*

Fire is an exothermic chemical reaction involving heat and light in a process where fuel organised substances (heat and oxygen) are present. Figure 2.8 illustrates the triangle of fire. The essentials for combustion includes:

i. Fuel - the biggest potential danger, which could arise from leakage and exploration of hydrocarbon (vapour or liquid);
ii. Air - atmospheric air, which contains about 21% of oxygen enough for combustion to take place; and
iii. Heat - the means of ignition, which may be in form of spark, naked flame, electricity, etc.

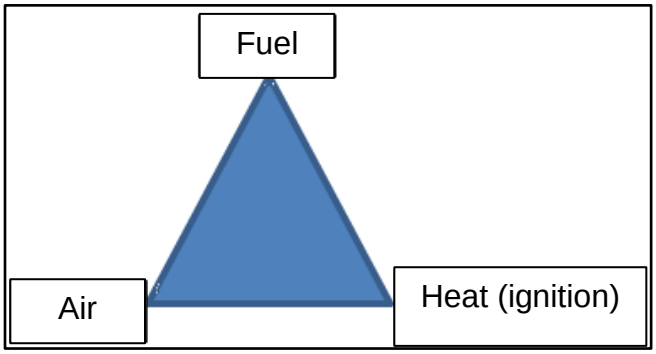



**Figure 2.8**: The triangle of fire with essentials of combustion

### *2.6.1 Fire-Fighting Operations*

Fire fighting is a way of putting out fire after its outbreak. This is carried out using the fire-fighting equipment and fire extinguishers depending on the class of fire that is involved. Figure 2.9 illustrates the fire-fighting extinguishing equipment.




(a) Fire extinguishing cylinders (b) Metal fire bucket

**Figure 2.9:** Pictorial illustrations of fire-fighting extinguishing equipment, showing fire extinguishing cylinders in (a) and metal fire bucket in (b)

*Source: (Priya Fire, 2009)*

### *2.6.2 Classes of Fire*

There are five classes of fire. These include:

i. Class A fire - a type of fire that involves ordinary combustible materials (excluding gases and liquids), e.g. cloth, paper, rubber, plastics, wood, etc.,
ii. Class B fire - a type of fire that involves inflammable liquid/ liquid or liquefied fuel e.g. kerosene, petrol, propane, wax, paint etc., excluding cooking oil and grease,
iii. Class C fire - a type of fire that involves energised electrical equipment such as motors, transformers, and appliances. If the circuit of the Class C fire is de-energised, it becomes any of the other classes of fire,
iv. Class D fire - a type of fire that involves the combustible metal like magnesium, titanium, aluminium, etc., and
v. Class K fire - a type of fire that involves the grease, cooking oil or animal fat.

### *2.6.3 Types of Fire Extinguisher and Suitability*

The types of fire extinguishers are water and foam, carbon dioxide, dry chemical, wet chemical, halogenated, dry powder, and water-mist fire extinguishers.

#### *2.6.3.1 Water and Foam Fire Extinguishers*

Water and foam fire extinguishers extinguish fire by eliminating the heat component of a fire triangle, while the foam agents separate the oxygen from the other components. Water and foam extinguishers are suitable only for extinguishing Class A fire. Class B or C fire should not be extinguished with water and foam extinguisher because the discharge stream of the extinguisher could spread the flammable liquid of a Class B fire or create a shock hazard in a Class C fire.

#### *2.6.3.2 Carbon Dioxide Fire Extinguishers*

Carbon Dioxide fire extinguisher extinguishes fire by eliminating oxygen in a fire triangle and the heat with a very cold discharge stream. Carbon dioxide extinguishers can be suitable for extinguishing Classes B and C fire and are typically not effective on a Class A fire.

#### *2.6.3.3 Dry Chemical Fire Extinguishers*

Dry chemical fire extinguisher extinguishes fire usually by disrupting the chemical reaction of a fire triangle. Generally, the most commonly used type of extinguisher is the multipurpose dry chemical, which is efficiently suitable for extinguishing Classes A, B, and C fire. It works by creating a barrier between the oxygen and fuel components on a

Class A fire. Ordinary dry chemical extinguishers are also suitable for extinguishing Classes B and C fire.

#### *2.6.3.4 Wet Chemical Fire Extinguishers*

Wet chemical fire extinguisher extinguishes fire by eliminating the heat of the fire triangle and preventing re-ignition, using an agent that creates a barrier between the oxygen and fuel elements. Wet chemical extinguishers are suitable for extinguishing modern, high efficiency deep fat fryers fire - a Class K fire, in commercial cooking operations. Also, some can be used to extinguish Class A fire.

#### *2.6.3.5 Halogenated Fire Extinguishers*

Halogenated or clean agent extinguishers include the halogen agents as well as the newer and less ozone depleting halocarbon agents. They extinguish fire by disrupting the chemical reaction of a fire triangle. Typically, the clean agent extinguisher is suitable for extinguishing Classes B and C fire. Some clean agent extinguishers can also be suitable on Class A fire.

#### *2.6.3.6 Dry Powder Fire Extinguishers*

Dry powder fire extinguisher is similar to dry chemical except that they extinguish fire by separating the fuel from the oxygen component or by eliminating the heat component of a fire triangle. Yet, dry powder extinguishers are suitable only to extinguish Class D fire because they are inefficient on any other class of fire.

#### *2.6.3.7 Water-Mist Fire Extinguishers*

Water mist fire extinguisher is a recent advancement, which extinguishes fire by eliminating the heat component of a fire triangle. Water mist extinguishers are alternatives to the clean agent extinguishers where contamination is a concern. They are generally suitable for extinguishing Class A fire, though they are, as well efficient for extinguishing Class C fire.

### *2.7 Training of Employee about Safety and Responsibilities*

In ensuring that the employees and equipment are safe at all times, employees are expected to go through training and re-training programmes covering safe work practices, safety policies and procedures. Depending on employee's job or career path, employees should undergo different aspects of training which may either be in form of on-the-job training, classroom training, a combination of both, or other type of job training schedule. Some of the training programmes that are taken, depending on the type of environment, may include:

i. Induction training - welcoming of new employees and introduction to the safety rules and procedures,
ii. Company safety policy and procedures training,
iii. Accident reporting and investigation training,
iv. Housekeeping training,
v. Work permit system training,
vi. Use of PPE training,
vii. Fire prevention and fire extinguishing training, and
viii. Hazardous materials/ hygiene and decontamination training, among others.

Trainings are normally modified to best meet the need of company and safety of the employees. Employees are expected to follow established policies and procedures. Unsafe acts and working conditions are to be reported to appropriate authority for necessary accident prevention action(s). It is also the responsibility of all employees to work in a professional and safe manner. An employee should cooperate with employer and other workers and observe safety rules at all times. An employee is advised to be careful and considerate in the handling of machines and materials. All employees must be trained on the proper use of fire extinguishers in their work areas. They should also be trained on how to operate the building‘s fire alarm system, and be familiar with evacuation routes. The training of all employees will include the locations and types of materials and processes that pose potential fire hazards. Training should include regular scheduled fire drills. Training program must emphasise the importance of electrical safety, correct storage of combustible and flammable materials, proper use of electrical appliances and equipment, disconnecting heat producing equipment and appliances at the end of each working day, and safe and proper handling of compressed gases and flammable liquids, among others.

### *2.8 Accident Investigation/ Reporting*

Management of industries should establish procedures that will ensure that all accidents are reported and investigated to identify both the obvious and underlying causes. Well-investigated accident would give a number of lessons and corrective actions that will lead to some measures aimed to eliminate or reduce the probability of reoccurrence. Injuries and illnesses are to be reported to management as soon as they occur. It is advisable that when injuries occur, they are investigated as soon as possible (most times within 24 hours of occurrence). A formal accident investigation form should be made available, filled and submitted to safety department or management within a short time. It is important that every incident is reported no matter how mild it may be. This is important in keeping proper records and planning to reduce similar occurrence in the

future. It is advisable that the report is prepared at the end of investigation. The report should contain the following information:

i. Date of accident,
ii. Date the investigation began,
iii. Description of accident and all other relevant details,
iv. Obvious and underlying factors that caused or contributed to the accident,
v. Immediate action(s) taken, and
vi. Measures or recommendation to prevent future reoccurrence, among others.

### *2.9 Importance of Employee's Orientation Programme*

All new employees must attend safety orientation programme prior to starting work within their assigned area. The programme should be conducted under the instruction of the safety director and coordinated with Human Resources. Upon completion of the safety orientation programme, each new employee should be requested to acknowledge that they have received, understood and will abide by the company safety programme. Participants must sign a statement verifying that they have completed the safety programme and such statement should be filed in the employee's personnel file. The topics normally covered in the safety orientation programme may include the company history, responsibilities, tools and equipment use, hazard communication, emergency action, safety education/ training, use of PPE, material handling, and accident reporting/ investigation requirements, among others. At this programme, new employees are given opportunity to ask questions pertaining to their job duties and other relevant issues relating to their employment.

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