ROHINI COLLEGE OF ENGINEERING AND TECHNOLOGY

Kanyakumari Main Road, Near Anjugramam, Palkulam, Tamil Nadu 629401

Department of Mechanical Engineering

VALUE ADDED COURSE ON INDUSTRIAL SAFETY

SYLLABUS

UNIT 1- INTRODUCTION
UNIT 2- HAZARDS
UNIT 3- HAZARD ANALYSIS
UNIT 4- SAFETY APPRAISAL
UNIT 5- HEALTH HAZARDS AND LEGAL ASPECTS

1.1 INTRODUCTION

Safety is very important aspect for any industry as an accident-free work environment boosts the morale of the team members working in any hazardous situations. Recognizing these facts industries involving various hazards and risks industries prepare their own safety policy, safety manual and have a separate department/section for safety so as to create proper aware-ness and provide the know-how-about the safety. Adherence to the useful information, rules, and mandatory requirements governing the safety and guidelines will help prevent occupa-tional injuries and accidents which constitute an unavoidable and needless waste of human and material resources. Industrial safety refers to the management of all operations and events within an industry in order to protect its employees and assets by minimizing hazards, risks, accidents, and near misses.

Industrial safety is overseen by federal, state, and local laws and regulations. The Occupational Safety and Health Association (OSHA) is the primary regulatory body in the United States dedicated to ensuring industrial safety.

Industrial safety covers a number of issues and topics affecting safety of personnel and the integrity of equipment in a particular industry.

The following topics are generally discussed:

- General Safety – General aspects of safety which are common to all industries
- Occupational Safety and Health – Particularly associated with the occupation
- Process and Production Safety
- Material Safety
- Workplace Safety – Safety issues directly related to the workplace setting
- Fire Safety
- Electrical Safety – Arising from the equipment used
- Building and Structural Safety – Including installations as per existing building code
- Environmental Safety – Concerns the direct and indirect environmental impact of the industry

Definition:

The importance of industrial safety was realized because of the fact that every year millions occupational/ industrial accidents occur which result in loss of production time equivalent to millions of man hours, machine hours etc.

Of this about one-fifth production time is lost by those actually injured due to temporary and permanent disablement and the remaining production time is lost by fellow operators/ people in helping the injured, in taking care of the damage caused by accident etc. the loss to the industrial unit would appear much more alarming when death cases due to accidents are considered.

It is therefore essential to identify/examine the causes of industrial accidents and take steps to control them. Many disciplines are concerned with this safety approach. Industrial engineering is one field which deals with design of efficient work place, equipment and industrial layout design. Other disciplines which can contribute to safe working environment are psychology, sociology and Medicare science.

The following steps may be taken to effectively and efficiently eliminate an unsafe working environment:

(1) Elimination if possible, of the causes of accidents.

(2) If it is not possible to eliminate the cause of accidents, make arrangements to shield the hazardous place by guards, enclosures or similar arrangements.

Need for Safety:

In view of above discussion, need and concern for safety is therefore need of the hour. There are some direct costs/ effects of an accident but there are certain indirect costs involved in it also e.g. machine down time, damage to machine, ideal time of nearby equipment and horror created among workers, loss of time etc. in aid cost compensation, legal implications and allied costs etc. So, safety measures would not only eliminate/ avoid above cost but would mean performing their moral responsibility towards workmen/operators also.

An accident is by virtue of unsafe factor he results of an unsafe condition it may be the combined effect of two. An unsafe act results in the form of operator/people doing thing without proper authority, misuse of safety devices, ignoring warnings and precautions etc.

An unsafe condition may be present in various forms e.g. faulty or defective electrical fittings, inadequate maintenance of gang way. Use of defective tools etc. So, to prevent the occurrence of accidents, unsafe acts have to be avoided/ eliminated or checked.

Unsafe acts:

For rectification of the causes because of unsafe acts attention must be paid to following factors:

(1) Personnel adjustment:

If a foreman/supervisor identifies that a worker is unfit either physically or mentally or a job/ task, he should be quickly taken off the work in consultation with the personnel department.

(2) Method/technique used:

Some techniques requiring change should be replaced by safe methods.

(3) Operator training:

Job method may be safe or unsafe but the operator must be trained to perform the job.

(4) Publicity and education about accident prevention:

The workers/ people are led by the skill, energy and leadership of foreman/supervisor. So, it is the duty of these people to educate the workmen about prevention of accidents. The aim is to teach them to become safety conscious so that they are able to recognize an unsafe act or situation and act in such a manner that accident is avoided.

The unsafe conditions:

To avoid accidents due to unsafe conditions, various provisions have been discussed in the "Factories Act" these may be concerned with moving parts of prime movers, electrical generators and transmission machinery: fire protection devices, control of dangerous fumes, lifting of excessive weights and safe guards over lighting machines, chains and ropes etc.

Thus, safety in industry helps:

(i) Increasing the production rate.

(ii) Reducing the cost of production.

(iii) Reducing damage to machinery and equipment.

(iv) Preventing unwanted suffering and pain to employees of the organization.

(v) Preventing premature/untimely death of talented workers who may be an asset to the enterprise and society.

Safety Programmes:

A safety programme intends to identify when where and why accidents occur. On the same lines a safety programme aims at reducing accidents and associated losses. A safety programme is initiated with the assumption that it is possible to prevent most work connected accidents.

A safety programme is a continuous process and tries to be decrease the influence of personal and environmental factors which cause accidents. Normally a safety programme consists of providing safety equipment's and special training to workmen or employees.

Indian standards Institute has done commendable job in this context and lays down as follows:

(i) Safety precautions to be taken during manifesting operations.

(ii) Standards for proper lighting, ventilation and proper layout of the industrial unit.

(iii) Standards and specifications of safe industrial operations and practices etc.

(iv) Requirements for effective maintenance of tools and equipment's.

(v) Guidance on safe cutting and welding processes.

(vi) Guidance on use of powered industrial trucks, belt conveyors and fire protection equipment's.

(vii) Safety requirements for personal protective equipment's.

(viii) Classification of hazardous chemicals and provision of accident provision tags.

(ix) Markings for handling and labeling of dangerous items/ goods.

(x) Standards for safety:

(a) In industrial building

(b) Safety procedures to be followed in electrical work

(c) in use of electrical appliances in hazardous area and explosive atmosphere.

(xi) Specifications for protective clothing, safety helmets face shields and safety equipment for eyes ears lags hands and feet etc.

1.2 INDUSTRIAL SAFETY PRINCIPLES

Safety is no longer just the following of Occupational Safety & Hazard Analysis OSHA regulations. It is the coordination of all departments to produce the greatest profit for the company at the most minimal risk.

The importance of safety

Main reasons

- 1.Economic
- 2. Legal
- 3. Moral

  – worker compensation

- medical bills
- abatement costs
- equipment damage
- OSHA fines
- loss of productivity

- Legal
  - OSHA regulations and fines
  - Worker compensation laws
  - Third party lawsuits
- Moral Issues
  - Safety is just the right thing to do for your employees

The best thing to do is to recognize and control hazards before they ever impact your business

1.3 ACCIDENTS

So, the content is we will see some of the major industrial accidents, what has already happened? Then safety and health issues, stakeholders, accident causation model and knowledge base, most of the information related to the figure to the past accidents to the models are taken from publicly available internet sources and some taken from standard literature.

Industrial Accidents are caused by chemical, mechanical, civil, electrical, or other process failures, negligence or incompetence, in an industrial plant which may spill over to the areas outside the plant causing damage to life and property. These may originate in:

- Manufacturing and formulation installations including during commissioning and process operations; maintenance and disposal.
- Material handling and storage in manufacturing facilities, and isolated storages; warehouses and go-downs including tank farms in ports and docks and fuel depots.
- Transportation (road, rail, air, water, and pipelines).

Probable causes of accidents

- Process deviations i.e. pressure, temperature & flow.
- Parameters with regard to the state of the substance i.e., solid, liquid or gas, proximity to other toxic substances.
- Runaway reaction.
- Hardware failure, resulting in large-scale spills of toxic substances.
- Boiling Liquid Expanding Vapor Explosion (BLEVE) on the chemicals during transportation.

Major Consequences

- Loss of life / injuries
- Impact on livestock
- Damage to Flora/fauna
- Environmental Impact (air, soil, water)
- Financial losses to industry.

Case studies

You all know that union carbide India limited Bhopal the case of 3rd December 1984 3rd December 1984, what happened, what was the event? Event was leakage of water into MIC tank caused increase in temperature and pressure of MIC and release of 40,000 kg of MIC. And, what is the loss immediate loss is 2500 people died immediately 8000 more due to diseases and pep 500 000 injuries and in fact, even today the effect is there.

So, can safety engineering help you to understand why such accident has taken place? And when you design the, or design a new system of similar nature. So, what are the things you have to do ok? So, if we go further you see that, what actually happened in union carbide case? Here you see that this is MIC storage tank Methyl isocyanate 40 tons in E 6 1 0, then 15 tons in E 6 1 9 and 6 1 11 this 1 11 this 1 9 E 6 1 9 was empty 40 tons 15 tons in here 40 tons here and this one empty, water let into this what let into this and causing runway heat heating heat producing reaction. Then, you see that there are so, many protection measures refrigeration system. Fuel system to cool liquid MIC was shut down.

The design was that that a this it may happen under such situation that Freon system that will that will be used and to cool liquid MIC was shut down. In June 1984 to save money and Freon shipped to other plants. Another one you see water curtain not high enough to reach the gas, flare tower designed to burn off gas, but a connecting pipe had been removed for maintenance. So, few think maintenance. Here it is basically mar that is of cost or the benefits with business of a things. Here what happen the there is a water cut in which basically use, but what happened it was not that high the design problem.

Then, when vent gas scrubber leaking gas could have been detoxified by the scrubber was turned off this is a show people problem. So; that means, when we talk about such accident and it as these are these are high risk plans. And in all high-risk plans, what happen? The design will be such that there will be different layer of protection. So, layer of protection like this and this.

So, as a safety engineering, if you if you look into this then you will find out that there will be there will be normal control system normal control, which require for the day to day operation, then there will be emergency safety system, emergency safety system that if something gone wrong then how the system will behave. So, that that things can be system can be restricting to the normal.

Then, there will be one side upside counter measures even after that also the when accident has taken place then the consequence to be reduced. And there will be a physical contentment for hazard and basically that separating the hazard from the people of the target ok. Here, it was there, but having those things does not mean that it is a full safety engineering. It is the design point of view those things must be there. What else require? Well seek like the emergency control system counter measures all those things are basically, if I say that under high risk operation these all risk control measures, that risk control measures must be operational also.

They must work. Now, if I see here re refrigerating system is working, but it is not it is dedicated for this, but it has been bypassed to some other plant. So, what happened? It is it is not the design problem it is the problem with the maintaining the system protection system given to you.

Similarly, here see flare tower this is also it was there the control system emergency control system was there, but what happened? Because of poor maintenance that connecting pipe that is that was not working. This was a design problem because the height that gas can reach that was not understood so; that means, the height is not sufficient enough.

And here you see vent gas scrubber that this is also another good ex so, that the gas whatever will come out that if can be de detoxified at the release point, what will happen it will not affect the environment as a whole and the people at society will not be affected. So, that not be affected that much will be affected, but it was it was basically turned off.

So, that means one thing is that you must have a proper design you understand that what are the hazards that can take place? And the hazards ultimately lead to accident. So, you have though identified the hazards and then hazard lead to accident hazard lead to accident and accordingly that there will be layer of protections layer of protections. So, all those things during design you have to understand and definitely these are there.

But, even under very good design system also this will happen if the maintenance, monitoring, control, all those things are not done properly. So, all those things will come together under safety engineering one is design, then you if you go by the system life cycle, when design, bill, operation maintenance, disposal all those things will be there at every time we will find out that there will be number of hazards. And, for every hazard there is protection measure and those protection systems must work and that is that is what also to be one is you design into the system you see that they are working. So, all those things are coming under safety engineering.

So, very quickly now we will see some of the other issues, but from the report there will like la reports available in it now a few of them just like I have written here, that storing MIC in large tanks and filling beyond recommended level beyond design level design recommendation you are filling up.

So, this is this is not permitted, but it is done. Failure of safety system as I told you that normal control then, emergency safety system onset offset counter measures like why this detoxified that main scrubber was there. Because, if the gas is detoxified at the release point, then an effect of con impact of gas will be reduced that is upside counter measures, but that was not working because of because these are all coming because of the maintenance control for all these things this is a poor maintenance.

To save money safety system, have been switched off. I do not have any answer to this lack of skilled labor competency. And an inadequate emergency action plan. So, there are many more, but these are the few which are basically which are that should be talked about. So, that means one hand here what happened the design problem? One hand the on the other hand what happened the maintenance and operation problem? And all those things come um joining together ultimately leads to such disastrous accidents.

1. Bhopal Gas tragedy – December 2-3,1984 Union carbide India limited, Madhya Pradesh, India.

- Worst industrial disaster in history
- 2,000 people died on immediate aftermath (within three days)
- Another 13,000 died in next fifteen years
- 10-15 persons dying every month
- 520,000 diagnosed chemicals in blood causing different health complications
- 120,000 people still suffering from
  - Cancer
  - Tuberculosis
  - Partial or complete blindness,
  - Post-traumatic stress disorders,
  - Menstrual irregularities
- Rise in spontaneous abortion and stillbirth

Another one Chernobyl nuclear power

Actually, this is in 26th April 1986. During test of safety feature called emergency core cooling you require to have the domain knowledge to understand all those things. So, for ma to me basically this is what I am giving you the different example and with some information, but this is a nuclear power plant here. So, your knowledge about emergency core cooling and although how the nuclear power plant once that also require? But for here we are basically setting the tone that why this subject is so, much important?

So, emergency core cooling catastrophic power increase leading to explosions in it is in it is core in turn release radioactive particles and you know that 31 died immediately and this much died due to cancer between 1986 to this 4 2004.

Operators error lack of knowledge, I told you that la knowledge domain knowledge is very important lack of knowledge about nuclear reactor physics and engineering. This nuclear reactor physics and engineering it is part of that particular subject domain. It is not the part of a pa part of a everybody industrial safety engineering we will not be it is learning that what is nuclear reactor physics? Whether, what we will be learning here that, that how do you make it is your that the safety engineering is in proper place? So, someone wish a knowledgeable in nuclear reactor case he will be in the team so, that that the safety engineering is in proper prospective.

Violation of SOP lack of "safety culture" so, in previous example we have seen that there are design problem, there are maintenance problem, there are competency problem, here what we are finding out again we are finding out competency problem and SOP violation another one is a safety culture. It is a used thing, but we are now we will not be talking about safety culture in industrial safety engineering. In 1974 rupture of temporary bypass pile leading to release of 40 tons of cyclohexane 28 people died and 38 got serious injuries.

Poor design of high-pressure pipe system by inexperienced engineering this cannot be tolerated. You when you are designing such high-risk plant and you know that the people at work and the society has large may be exposed to such thing. So, you cannot design poorly. So, if you design poorly that you will carry for over the entire lifecycle of the system unless, otherwise it is rejected and relegent, but when you are designing such a high technology system. So, relegent you it is will not serve the purpose.

Simultaneous sati shutting down of critical systems, it is I can say this basically problem with the red operation shape operating procedure that what is should not be done we are dividing presence of water in reactors; So, more of your design and operation problem here.

World accidents

The **Flixborough disaster** was an explosion at a chemical close to the village of Flixborough, England on 1 June 1974. It killed 28 people and seriously injured 36 out of a total of only 72 people on site at the time; from the devastation on site it was clear that had the explosion happened in normal office hours the casualty figures could have been much higher. A contemporary campaigner on process safety wrote "the shock waves rattled the confidence of every chemical engineer in the country". The disaster involved (and may well have been caused by) a hasty modification. Mechanical engineering issues with the modification were overlooked by the managers (chemical engineers) who approved it, and the severity of the potential consequences of its failure was not appreciated. Flixborough led to a widespread public outcry over process plant safety. Together with the passage of the Health and Safety at Work Act in the same year it led to (and is often quoted in justification of) a more systematic approach to process

safety in UK process industries, and – in conjunction with the Seveso disaster and the consequent EU 'Seveso directives' – to explicit UK government regulation of plant processing or storing large inventories of hazardous materials, currently (2014) by the Control of Major Accident Hazards Regulations. Two months prior to the explosion, the number 5 reactor was discovered to be leaking. When lagging was stripped from it, a crack extending about 6 feet (1.8 m) was visible in the mild steel shell of the reactor. It was decided to install a temporary pipe to bypass the leaking reactor to allow continued operation of the plant while repairs were made. In the absence of 28-inch nominal bore pipe (DN 700 mm), 20-inch nominal bore pipe (DN 500 mm) was used to fabricate the bypass pipe for linking reactor 4 outlet to reactor 6 inlet. The new configuration was tested for leak-tightness at working pressure by pressurization with nitrogen. For two months after fitting the bypass was operated continuously at temperature and pressure and gave no trouble. At the end of May (by which time the bypass had been lagged) the reactors had to be depressurized and allowed to cool in order to deal with leaks elsewhere. The leaks having been dealt with, early on 1 June attempts began to bring the plant back up to pressure and temperature.

Mexico City, 19.11.1984

The **San Juanico disaster** was an industrial disaster caused by a massive series of explosions at a liquid petroleum gas (LPG) tank farm in San Juanico, Mexico on 19 November 1984.The explosions consumed 11,000 m^3 of LPG, representing one third of Mexico City's entire liquid petroleum gas supply. The explosions destroyed the facility and devastated the local town of San Juan, with 500–600 people killed, and 5000–7000 others suffering severe burns. The San Juanico disaster was one of the deadliest industrial disasters in world history. The disaster was initiated by a gas leak on the site, likely caused by a pipe rupture during transfer operations, which caused a plume of LPG to concentrate at ground level for 10 minutes. The plume eventually grew large enough to drift on the wind towards the west end of the site, where the facility's waste-gas flare pit was located. At 5:40 a.m., the cloud reached the flare and ignited, resulting in a vapor cloud explosion that severely damaged the tank farm and resulted in a massive conflagration fed by the LPG leaking from newly damaged tanks. Just four minutes later, at 5:44 a.m., the first tank underwent a BLEVE (Boiling Liquid/Expanding Vapor Explosion). Over the next hour, 12 separate BLEVE explosions were recorded. The fire and smaller explosions continued until 10 a.m. the next morning. It is believed that the escalation was caused by an ineffective gas detection system. The town of San Juan Ixhuatepec surrounded the facility and consisted of 40,000 residents, with an additional 61,000 more living in the hills. The explosions demolished houses and propelled twisted metal fragments (some measuring 30 tons) over distances ranging from a few meters to up to 1200

m. Much of the town was destroyed by the explosions and ensuing fire, with the current statistics indicating 500 to 600 deaths, and 5,000–7,000 severe injuries. Radiant heat generated by the inferno incinerated most corpses to ashes, with only 2% of the recovered remains left in recognizable condition.

Incident: An *unplanned, undesired* event that hinders completion of a task and may cause injury, illness, or property damage or some combination of all three in varying degrees from minor to catastrophic.

Accident: Definition is often similar to incident, but supports the mindset that it *could not have been prevented.* An accident is the opposite of the fundamental intentions of a safety program, which is to find hazards, fix hazard, and prevent incidents.

1.4 INDUSTRIAL VENTILATION

Industrial ventilation generally involves the use of supply and exhaust ventilation to control emissions, exposures, and chemical hazards in the workplace. Traditionally, nonindustrial ventilation systems commonly known as heating, ventilating, and air-conditioning (HVAC) systems were built to control temperature, humidity, and odors.

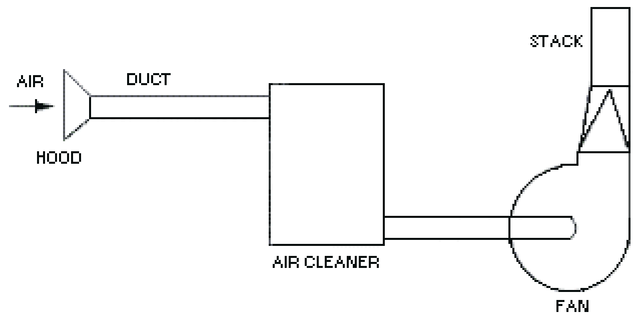
A. Ventilation may be deficient in:

- confined spaces;
- facilities failing to provide adequate maintenance of ventilation equipment;
- facilities operated to maximize energy conservation;
- windowless areas; and areas with high occupant densities.

Any ventilation deficiency must be verified by measurement.

B. There are five basic types of ventilation systems:

1. dilution and removal by general exhaust;
2. local exhaust
3. makeup air (or replacement);
4. HVAC (primarily for comfort); and
5. Recirculation systems.



C. Ventilation systems generally involve a combination of these types of systems.

For example, a large local exhaust system may also serve as a dilution system, and the HVAC system may serve as a makeup air system.

Health Effects

Inadequate or improper ventilation is the cause of about half of all indoor air quality (IAQ) problems in nonindustrial workplaces (see Section III, Chapter 2, Indoor Air Quality). This section of the manual address's ventilation in commercial buildings and industrial facilities.

A. Indoor Air Contaminants

Indoor Air Contaminants include but are not limited to particulates, pollen, microbial agents, and organic toxins. These can be transported by the ventilation system or originate in the following parts of the ventilation system:

- wet filters;

- wet insulation;
- wet under coil pans;
- cooling towers; and
- evaporative humidifiers.

People exposed to these agents may develop signs and symptoms related to "humidifier fever," "humidifier lung," or "air conditioner lung." In some cases, indoor air quality contaminants cause clinically identifiable conditions such as occupational asthma, reversible airway disease, and hypersensitivity pneumonitis.

B. Volatile Organic and Reactive Chemicals

Volatile Organic and Reactive Chemicals (for example, formaldehyde) often contribute to indoor air contamination. The facility's ventilation system may transport reactive chemicals from a source area to other parts of the building. Tobacco smoke contains a number of organic and reactive chemicals and is often carried this way. In some instances, the contaminant source may be the outside air. Outside air for ventilation or makeup air for exhaust systems may bring contaminants into the workplace (e.g., vehicle exhaust, fugitive emissions from a neighboring smelter).

1.5 BASIC RULES AND REQUIREMENTS WHICH GOVERN THE CHEMICAL INDUSTRIES

The government has certain human safety and environmental regulations in place, which chemical manufacturing units in India need to adhere. The Bhopal gas tragedy in 1984 was one of the worst accidents in the history of the chemical industry in India. This disaster was an eye- opener after which human safety regulations for factories in India were tightened considerably.

The first human safety regulation in the country was the Explosives Act 1884. This act regulates the manufacture, use, and transport of explosives. Similarly, the Indian Factories Act of 1948 deals with worker health and welfare. Specification standards for storage vessels and transportation of compressed gases are dealt under the Static & Mobile Pressure Vessels Rules of 1981.

Regulations on Environment and Human Safety

S.No.	**Acts**	**Objectives**
1.	Indian Factories Act,1948	To deal with worker welfare, health and to introduce safety culture
2.	Explosives Act,1884	To regulate the manufacture, use and transport, import of explosives
3.	Static and Mobile Pressure Vessels Rules ,1981	To specify standards for storage vessel and license requirement for storage and transportation of gas.
4.	Environment Protection Act ,1986	To protect the environment by preventing major incidents
5.	Air Act, 1987	To prevent and control air pollution and abatement of air pollution
6.	Hazardous Waste Management and Handling Rules ,1989	To provide guidelines for management and transport of hazardous waste
7.	Public Liability Insurance Act,1991	To insist operators to carry insurance to cover any incident that has an impact on the residents in the vicinity.

Checks and Balances on Chemicals - The Indian chemical industry is very diverse and covers basic chemicals and their intermediates, petrochemicals, fertilizers, paints, pesticides, bulk drugs and pharmaceuticals. It also contributes significantly toward the industrial and economic growth of the nation. One of the significant fallouts of the European Reach regulation is the reactionary approach by several countries of setting up equivalent or similar regulations to counterbalance the cross-frontier trade position. The major concerns regarding chemicals are their presence in the food chain; indiscriminate use of chemicals in consumer products, such as toys and cosmetics; worker safety; hazardous waste handling, its storage and disposal; and minimization of volatile organic compounds. Increasing consumer awareness and proactive initiatives by voluntary organizations have stepped up pressure for governments to formulate policies that can ensure adequate checks and balances on the chemical industry and safeguard the general population from potential chemical hazards.

Existing Laws in India

About 15 acts and 19 rules govern chemicals in India. These can be classified into the following groups:

Import and export

Manufacturing of chemicals

Transportation of chemicals

Consumers' interest in using chemicals

Protection of human health and environment

Regulations have been framed for each of these groups. However, the Environment (Protection) Act of 1986 serves as an umbrella to link regulations without interfering with the autonomy of other rules. Various ministries and regulatory agencies at the national and state level are responsible for implementing the laws.

India has woken up to the need for regulatory policies to protect human health and the environment from the hazards posed by chemicals. The Ministry of Environment and Forest (MoEF) has for the first time created electronic waste management rules, which will take effect May 1. These rules recognize producers' accountability for recycling and reducing e-waste.

The Indian government is also proposing to adopt the Globally Harmonized System (GHS) of classification and labeling of chemicals.

The highlights of the policy have been discussed with the various stakeholders and the MoEF is set to finalize the framework of this regulation that could be implemented early next year. With India set to implement the new GHS rules in phases, the industry is expecting radical revision of laws on handling and storage of hazardous chemicals.

1.6 SITE SELECTION AND PLANT LAYOUT

1. Layout planning should be in sequential process flow order so that piping required is minimum.
2. The blocks representing flammable gases should be located in such a way that the gases are not carried by wind to ignition source.
3. Main process unit should be centrally located.
4. Storage tanks should be grouped according to product classification.
5. Provide at least 60 m distance between tanks and equipment's. Distance between two floating roof tanks should be a minimum distance of 30 m. Such spacing provides room for good drainage.
6. Plant utilities such as heaters, compressed air supply, cooling towers etc., should be located adjacent to main process unit.
7. Fire stack should be on the upwind side from process units.
8. Effluent treatment units should be on the downwind side and at lower elevation than process units. It helps to have gravity flow.
9. Furnaces, heaters should be located upwind of process units, while cooling towers, dusty operations should be located in downwind direction.
10. High hazard places should be clearly marked

Location is one of the first decisions in the design of a new chemical plant. It impacts profitability and scope for future expansion. If the project is a new facility, a suitable site must be found and an optimal layout of the site and process units must be planned. If the project adds to an existing site, the impact of the new addition on the existing plant must be considered. The plant also needs to accommodate for the nearby infrastructure, the services that it requires, and its environmental impacts.

Location Decision Factors

Initially, economists viewed the plant location decision as a cost-minimization problem. The optimal location was one where the transportation costs of raw material to the plant and product to the market was minimized. Between the early 1900s and post-World War II period, most industries were sensitive to the cost of transportation. As transportation costs became less of an obstacle, the approach to the problem developed with considerations of trade-offs between transportation and factors such as wages, energy, local regulations, etc. If lower wages could balance the higher transportation costs of building the plant in a low-wage area, the low-wage location may be more desirable.

Although location is a long-term investment, a firm does not decide on a location with the sole objective of maximizing its profits or minimizing its costs. Managers may choose a “safer” location that is more likely to produce higher profits rather than a riskier location that yields the maximum investment return. Personal factors of the people involved are also influences. For example, new businesses tend to locate where the founders live.

In the current age, a plant's site is chosen based on several factors.

1. Raw material supply: The source and price of raw materials is one of the most important factors that determine the location of a plant. Facilities that produce chemicals in bulk are usually located close to the source of raw material if the costs of shipping the product is less than the costs of shipping the feed. For example, ethylene production is growing in the Middle East since cheap ethane from natural gas is readily available. Oil refineries tend to be located near areas with high population and crude oil supplies since it is expensive to transport the oil.

2. Location with respect to market: If the plant produces high-volume and low-cost products, such as cement and fertilizer, it may be better to situate the plant closer to the primary market since transportation cost is a large fraction of the sales price. If the product is low-volume and high-cost,

like pharmaceuticals, then the benefits of being closer to the primary market may not be there.

3. Transport facilities: Facilities should be close to at least two major forms of transportation, whether that be road, rail, waterway, and/or seaport. For example, paper manufacturing plants in the US use various types of pulp that are delivered by truck or by train from various places in North and South America, so paper facilities need to be close to rail and major roads. Transportation by road is common for local distribution from central warehouses, while transportation by rail is more widespread for long distance transport of bulk chemicals. Pipeline is used to ship industrial gases and bulk fuels. Air freight can be efficient for shipment of personnel and essential units and supplies and for small volume products that have high value, such as pharmaceuticals. Of course, products that are delivered by air must meet aviation regulations.

4. Availability of labor: Skilled workers are usually brought to the plant from outside the area. There should be a local pool of unskilled labor that can be trained to operate the plant, and of skilled craft workers to maintain the process units. Local labor laws, trade union customs, restrictive practices for recruitment and training should also be taken into consideration. A 10% increase in unionization of a state's labor force is projected to reduce the number of expanding facilities by 30 to 45%.

5. Availability of utilities: Processes that require a substantial amount of cooling water is usually located near water sources, such as rivers or wells. Cooling water may be directly taken from the water source, or may be stored in cooling towers. Those that need large quantities of power, such as electrochemical ones, are typically close to cheap power sources.

6. Availability of suitable land: The ideal land is flat, well-drained, with suitable load-bearing characteristics. Further considerations have to be made if the land is reclaimed land near the ocean in earthquake zones. Property tax is also a factor when choosing a site since property taxes vary area to area. Under a third of plants that relocate move to regions with lower property taxes, which is the proportion that would be expected if companies move to a new location regardless of property tax. High property taxes are not as significant as other factors such as labor supply and land costs.

7. Environmental impact: Depending on the location, it may be more difficult and costly to dispose of wastes. During the project design phase, experts are typically consulted to learn more about an area's local regulations. More details about environmental regulations are found below.

8. Local community considerations: State and local planners are typically motivated by the desire

to create jobs and improve the tax base. Introduction of facilities to an area is usually viewed as the most direct way to stimulate the area's economy. However, recent studies have found that communities with high-growth are already characterized by the fast growth of businesses that are already there. It is rare for a plant to completely close in one area and relocate to another, and if plants do relocate, the majority is over short distances and often within the same community. Therefore, local policymakers favor the expansion of existing plants. The opening of a new plant at a location should impost no additional risk to the local residents. For example, they should be downwind of the residential areas. Local communities also need to be able to accommodate the plant personnel. For example, traffic, housing, and facilities must be able to accommodate the influx of workers. Additional factors are property taxes and water consumption.

9. Climate: The climate of the area may affect processes and costs. For example, plants in cold areas need more insulation and special heating. Facilities in earthquake areas need to be seismically sound. Plants in areas with high ambient humidity will usually use air cooling instead of water cooling. More detailed information about the effects of weather can be found in the Site condition and design page.

10. Political and strategic considerations: Government sometimes gives capital grants, tax concessions, and other incentives to encourage plants to be built in specific areas. Physical assistance such as roads, water, and other public infrastructure are more popular than financial assistance. Companies can also globalize and take advantage of areas with preferential tariff agreements. The tax policy of an area is inversely related to growth. High personal income sometimes hinder employment growth. Personal income does not affect the cash flow of the company, but it reduces the after-tax income of its managers, and thus high personal income tax can be classified as a personal region. High state corporate taxes have also and detrimental effects on growth, but that is not always the case. Corporate tax is more important to firms with high capital expenditures.

Site Selection Process

The decision for the location of a facility is part of a larger corporate planning process. Usually, a corporate planning office or a division of the company initiates the site selection process by forecasting future capacity requirements. If capacity shortages are in the forecasts, the managers may choose to outsource, increase price to reduce the demand, expand existing sites, or open a new facility. If the managers decide on a new facility, the site selection team enters the project.

The structure of the site selection team depends on the firm's organization. In companies with centralized staff, the site selection team generally consists of representatives from relevant areas, such as engineering, real estate, and transportation. In companies with strong divisions, the locational decisions may be done at the divisional level, with the corporate office supervising the process.

The site selection team determines what characteristics are important for the new location by considering how the new facility will fit in the company's overall strategy, if the company wants to target new markets, if the corporation wants to divide or integrate its functions, or how the company wants to be seen by the public. Next, potential locations are listed and studied against the desired characteristics.

Locational decisions are typically made sequentially. The first step is at the state or regional level. Then, the team studies specific communities and sites. Different locational factors are important to different stages. When selecting a general region, the site selection team focuses on factors with interregional variations such as labor, tax policies, climate, and market locations. At the more focused stage, details like inexpensive land, access to major roads, and good schools are important. Consultants are often hired to do site analyses.

Once site options are narrowed down, the company discusses potential problems and incentives with local public officials. Construction costs are estimated, and a feasibility analysis is done to show that the project has a high rate of return.

Site Layout

The process units and buildings need to be arranged in such a way that allows for the most economical flow of materials and people. Dangerous processes need to be a safe distance from other buildings, and the layout should be planned to allow for future expansion.

Process units are usually laid out first in an arrangement that allows for smooth flow of materials between the process steps. The distance between equipment is usually at least 30 m. Next, the location of the principal ancillary buildings is sited as to minimize the time that it takes the workers to travel between buildings. Administrative offices and laboratories are located away from hazardous processes. Control rooms are next to the processing equipment. Utility buildings are located as to minimize piping between the process units. Storage is placed between the loading and unloading facilities and next to the process units that they serve. Tanks containing hazardous material are placed at least 70 m from the plant. An example of a typical site plan is shown below

Site Layout Factors

The main factors that are considered when planning the layout of the plant are listed below.1

1. Economic considerations (construction and operating costs): Construction costs can be minimized by arranging process units and buildings that minimize pipes between equipment, the amount of structural steel work, etc. However, this layout may conflict with the layout that gives the optimal operation and maintenance.

2. Process requirements: Examples of process considerations that must be taken into account is the elevation of the base of columns to give enough net positive suction head to a pump.

3. Operation convenience: Process units that are attended to frequently should be placed with convenient access. Valves, heads, and sample heads should be placed where operators can easily access. If the plant anticipates replacement of equipment, space must be allowed for removal and installation.

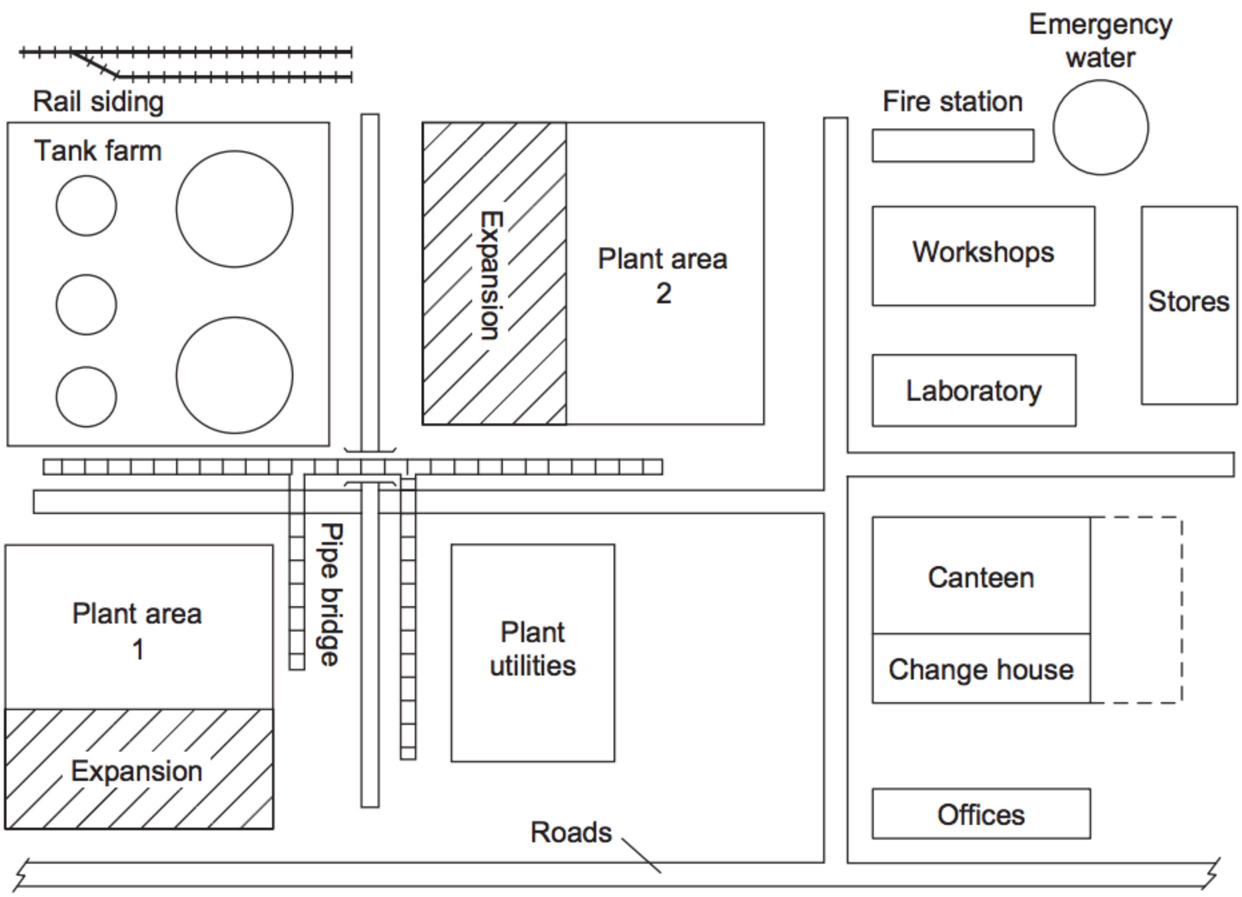
4. Maintenance convenience: Equipment that requires maintenance should be in a location with easy access, and should have sufficient space for the maintenance tasks. For example, shell-and-tube exchangers need space so that tube bundles can be removed for cleaning and repair.

5. Future expansion: The layout should be planned to conveniently allow for future expansion of processes. Pipe racks should have space for future piping, and pipes should be oversized to allow for more flow in the future.

6. Modular Construction: Modular construction is where sections of the plant are constructed outside of the plant, and then transported to the site by road or sea. Advantages include improved quality control, reduced construction costs, less requirements for skilled labor on site. Tradeoffs are more flanged connections and possible problems with onsite assembly.

7. Safety: Escape routes for workers need to be in place at each level in process buildings. Blast walls must isolate equipment that pose hazards to confine potential explosions.

First, a conceptual flowsheet for the process is developed. The types of equipment and their connections with each other is described in a process flow diagram (PFD). Before the PFD is translated into detailed piping and instrumentation diagrams (P&ID) the layout of the process units must be planned.3,5 Scale drawings are made to show the relationships between storage space and process equipment based on the flow of materials and people, and on future expansion. Three-dimensional visualization are the layouts are then carried out with cardboard cutouts of the equipment outlines or rectangular and cylindrical blocks. When a layout of the major process units has been decided, drawings of the plan and elevation are made, and design of the structural steelwork and foundations are done. Computer-aided design has also become increasingly popular.1,



1.8 EMERGENCY RESPONSE SYSTEM

Large chemical process plants usually have an emergency response team with required equipment's and materials. This trained team has to play a key role in major emergencies or disasters. The team coordinator determines the measures that need to be taken during emergencies and he co-ordinates the activities of various departments and services

The objective of emergency plan is

1. Control the hazard
2. Safeguard the lives

3. Minimize damage to process plant
4. Minimize damage to environment.
5. Start rescue operations and offer medical treatment.
6. Identify the affected personnel, offer them financial assistance, inform their relatives.

   Emergency plans can be divided into

   1. On-site emergency plan
   2. Off-site emergency plan

On-site emergency plan

It deals with emergencies which have been envisaged. It considers circumstances, size, complexity of the unit, nature of process, materials handled, type of personnel working and location of the unit.

Off-site emergency plan

It deals with major emergencies and disasters. It also considers minor emergencies which can turn into major ones.

Dangerous goods, abbreviated DG, are substances that when transported are a risk to health, safety, property or the environment. Certain dangerous goods that pose risks even when not being transported are known as hazardous materials (abbreviated as HAZMAT or hazmat).

Hazardous materials are often subject to chemical regulations. Hazmat teams are personnel specially trained to handle dangerous goods, which include materials that are radioactive, flammable, explosive, corrosive, oxidizing, asphyxiating, biohazardous, toxic, pathogenic, or allergenic. Also included are physical conditions such as compressed gases and liquids or hot materials, including all goods containing such materials or chemicals, or may have other characteristics that render them hazardous in specific circumstances.

In the United States, dangerous goods are often indicated by diamond-shaped signage on the item (see NFPA 704), its container, or the building where it is stored. The color of each diamond indicates its hazard, e.g., flammable is indicated with red, because fire and heat are generally of red color, and explosive is indicated with orange, because mixing red (flammable) with yellow (oxidizing agent) creates orange. A nonflammable and nontoxic gas is indicated with green, because all compressed air vessels are this color in France after World War II, and France was where the diamond system of hazmat identification originated.

1.9 EMERGENCY PLANNING AND PREPAREDNESS

Emergency situations are highly unpredictable and can range from natural disasters to man-made catastrophes.

Often people take the time to prepare for a crisis situation, but not natural disasters.

If there is an earthquake, hurricane or tornado in your area and your home comes crumbling down around you, whatever food and water (affiliate link) supplies you have stored are going to destroyed.

The structural integrity of your home will be compromised, and it won't be safe to stay there or even safe enough to try to salvage anything that might be left.

At this point, you and your family have no choice but to evacuate.

This is why every prepper needs to have an evacuation plan that the entire family knows and can execute in a moment's notice.

This is why packing at least one, if not two, emergency evacuation bugs out bags well ahead of time and placing them in several easy to access locations – such as right by your front door and in your vehicle – is so important.

Hopefully these articles will give you a few points to bear in mind when formulating your plan.

Make Sure Your Emergency Preparedness Plan Is Very Detailed

Ensure that all family members from infants to adults have a laminated card with a list of all their family members and their contact information.

For infants and young children, it is a good idea to secure this laminated card to their clothing using safety pins or some other method so if they are separated from you, someone else can find the information and know who to contact.

Include emergency phone numbers such as the hospital, doctor's office and police stations.

You might even include the poison control center just in case someone is accidentally poisoned while trying to evacuate.

Best of all, if anyone is alone and injured, first responders will know how to reach the next of kin.

Including information about allergies or medications on this card is a good idea so the first responders have that information before they begin treatment.

If there is panic and everyone is scrambling for their lives, as would happen in a tsunami or other type of natural disaster, you may lose sight of a family member or two because of how chaotic the situation is.

By taking the time before hand to make sure every member of your family has this information easily accessible, there is a much higher chance of finding them sooner.

TEXT / REFERENCE BOOKS

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2.1 INTRODUCTION

The meaning of the word hazard can be confusing. Often dictionaries do not give specific definitions or combine it with the term "risk". For example, one dictionary defines hazard as "a danger or risk" which helps explain why many people use the terms interchangeably.

There are many definitions for hazard but the most common definition when talking about workplace health and safety is:

A hazard is any source of potential damage, harm or adverse health effects on something or someone.

The CSA Z1002 Standard "Occupational health and safety - Hazard identification and elimination and risk assessment and control" uses the following terms:

Harm - physical injury or damage to health.

Hazard - a potential source of harm to a worker.

Basically, a hazard is the potential for harm or an adverse effect (for example, to people as health effects, to organizations as property or equipment losses, or to the environment). Sometimes the resulting harm is referred to as the hazard instead of the actual source of the hazard. For example, the disease tuberculosis (TB) might be called a "hazard" by some but, in general, the TB-causing bacteria (Mycobacterium tuberculosis) would be considered the "hazard" or "hazardous biological agent".

Workplace hazards also include practices or conditions that release uncontrolled energy like:

an object that could fall from a height (potential or gravitational energy),

a run-away chemical reaction (chemical energy),

the release of compressed gas or steam (pressure; high temperature),

entanglement of hair or clothing in rotating equipment (kinetic energy), or

contact with electrodes of a battery or capacitor (electrical energy).

Risk is the chance or probability that a person will be harmed or experience an adverse health effect if exposed to a hazard. It may also apply to situations with property or equipment loss, or harmful effects on the environment.

The CSA Z1002 Standard "Occupational health and safety - Hazard identification and elimination and risk assessment and control" uses the following terms:

Risk – the combination of the likelihood of the occurrence of a harm and the severity of that harm.

Likelihood – the chance of something happening.

Note: In risk assessment terminology, the word “likelihood” is used to refer to the chance of something happening, whether defined, measured, or determined objectively or subjectively, qualitatively or quantitatively, and described using general terms or mathematically (e.g., a probability or a frequency over a given time period).

For example: the risk of developing cancer from smoking cigarettes could be expressed as:

"cigarette smokers are 12 times (for example) more likely to die of lung cancer than non-smokers", or

"the number per 100,000 smokers who will develop lung cancer" (actual number depends on factors such as their age and how many years they have been smoking). These risks are expressed as a probability or likelihood of developing a disease or getting injured, whereas hazard refers to the agent responsible (i.e. smoking).

Factors that influence the degree or likelihood of risk are:

the nature of the exposure: how much a person is exposed to a hazardous thing or condition (e.g., several times a day or once a year),

how the person is exposed (e.g., breathing in a vapor, skin contact), and

the severity of the effect. For example, one substance may cause skin cancer, while another may cause skin irritation. Cancer is a much more serious effect than irritation.

Risk assessment is the process where you:

Identify hazards and risk factors that have the potential to cause harm (hazard identification).

Analyze and evaluate the risk associated with that hazard (risk analysis, and risk evaluation).

Determine appropriate ways to eliminate the hazard, or control the risk when the hazard cannot be eliminated (risk control).

The OSH Answers document on Risk Assessment has details on how to conduct an assessment and establish priorities.

A general definition of adverse health effect is "any change in body function or the structures of cells that can lead to disease or health problems".

Adverse health effects include:

bodily injury,

disease,

change in the way the body functions, grows, or develops,

effects on a developing fetus (teratogenic effects, fetotoxic effects),

effects on children, grandchildren, etc. (inheritable genetic effects)

decrease in life span,

change in mental condition resulting from stress, traumatic experiences, exposure to solvents, and so on, and

effects on the ability to accommodate additional stress.

Will exposure to hazards in the workplace always cause injury, illness or other adverse health effects?

Not necessarily. To answer this question, you need to know:

what hazards are present,

how a person is exposed (route of exposure, as well as how often and how much exposure occurred),

what kind of effect could result from the specific exposure a person experienced?

the risk (or likelihood) that exposure to a hazardous thing or condition would cause an injury, or disease or some incidence causing damage, and how severe would the damage, injury or harm (adverse health effect) be from the exposure.

The effects can be acute, meaning that the injury or harm can occur or be felt as soon as a person comes in contact with the hazardous agent (e.g., a splash of acid in a person's eyes). Some responses may be chronic (delayed). For example, exposure to poison ivy may cause red swelling on the skin two to six hours after contact with the plant. On the other hand, longer delays are possible: mesothelioma, a kind of cancer in the lining of the lung cavity, can develop 20 years or more after exposure to asbestos.

Once the hazard is removed or eliminated, the effects may be reversible or irreversible (permanent). For example, a hazard may cause an injury that can heal completely (reversible) or result in an untreatable disease (irreversible).

A common way to classify hazards is by category:

biological - bacteria, viruses, insects, plants, birds, animals, and humans, etc.,

chemical - depends on the physical, chemical and toxic properties of the chemical,

ergonomic - repetitive movements, improper set up of workstation, etc.,

physical - radiation, magnetic fields, pressure extremes (high pressure or vacuum), noise, etc.,

psychosocial - stress, violence, etc.,

safety - slipping/tripping hazards, inappropriate machine guarding, equipment malfunctions or breakdowns.

2.2 CHEMICAL HAZARDS

Chemicals can be broken down into hazard classes and exhibit both physical and health hazards. It is important to keep in mind, that chemicals can exhibit more than one hazard or combinations of several hazards. Several factors can influence how a chemical will behave and the hazards the chemical presents, including the severity of the response:

Concentration of the chemical.

Physical state of the chemical (solid, liquid, gas).

Physical processes involved in using the chemical (cutting, grinding, heating, cooling, etc.).

Chemical processes involved in using the chemical (mixing with other chemicals, purification, distillation, etc.).

Other processes (improper storage, addition of moisture, storage in sunlight, refrigeration, etc.).

2.3 HAZARDS CLASSIFICATION

- Physical Hazard
- Chemical Hazard
- Biological Hazard
- Psychosocial Hazard

Chemical Hazards classification

Chemical hazards are substances that are dangerous to people, wildlife and the environment at any stage from production to use to disposal.

1. Explosives

OSHA laboratory standard defines an explosive as a chemical that causes a sudden release of pressure, gas and heat when subjected to sudden shock, pressure or high temperature. In Department of transportation, this is rated as a hazard class

1. Nitro cellulose, DNT etc.,

2. Flammable and combustible materials

OSHA laboratory standard defines a flammable as an any material which has a flash point below 100 F or 37.8 C

e.g. Acetone, Benzene

Flash point is the minimum temperature at which a liquid gives enough vapor to ignite in the presence of an ignition source.

3.Combustible OSHA laboratory standard defines a Combustible as an any material which has a flash point above 100 F or 37.8 C

Example diesel, kerosene etc.,

4. Poison

Are substances which cause harm to any organism when sufficient quantities are absorbed, inhaled or digested.

e.g. ammonia, bleaching powder.

5. Radiation hazard

The danger to health arising from exposure to ionizing radiation, either due to external irradiation or internal irradiation.

somatic effects- harmful to the person Genetic
effects- harmful to the offspring
E.g. Radium, plutonium

Routes of Entry Inhalation

Inhalation of chemicals occurs by absorption of chemicals via the respiratory tract once chemicals have entered into the tract, the chemicals will then be absorbed by the blood stream for distribution to body parts. Chemicals can be inhaled in the form of vapors, fumes, mists, aerosols and fine dust.

Absorption

Some chemicals are absorbed through eyes or skin

Ingestion

Chemical exposure occurs by absorption of chemicals through the digestive tract.

2.4 OBJECTIVE OF MSDS/CSDS

CSDS assists the user in

- understanding recommended safety measures and its rationale
- understanding the effect of noncompliance to recommended safety measures
- identifying the effect of over exposure
- formulation of strategies for safe utilization of chemicals

Chemical Safety Data Sheet / Material Safety Data Sheet (MSDS)

- CSDS is a form with data regarding the properties of a particular substance
- Also known as material safety data sheet (MSDS)
- Must be supplied by the supplier of materials
- Can also be obtained from many sources including over the internet Example for MSDS is given below

Product Data Sheet – Arexons Motorsil D

Product Description

A high temperature silicone RTV Sealant cures in the presence of moisture to form a reliable seal in flanges.

Properties

Acetic elastomer component type. Cures at room temperature. Good resistance to temperature, water, moisture. Excellent oil resistance. Good dielectric properties. Excellent tear resistance. High degree of vibration absorption. Good resistance to mechanical stress. Temperature range: -70 ° C to +300 °C. Does not harm catalytic converters.

The product, after curing, resists water, fuels, mineral oils and synthetic fluids for radiators.

Technical Characteristics (before curing):

Appearance : Paste
Colour : Red
Odour: Typical
Density; 1.120g/ml
Viscosity: 250000 cPs
Volatile %: 3% approx

Technical Characteristics (after curing):

Shore Hardness A : 50
Elongation 200%
Tensile Strength : 4.5 mpa
Modulus of Elasticity : 1.8 MPa
Skin Formation Time: 10 minutes approx..
Curing Time: 4.5mm/ 24 hours
Temperature Resistance : from -70 deg C to + 300 deg C

How to use:

Apply on clean, degreased surfaces. Assemble after 20 minutes. Curing can be accelerated with heat.

Storage Life

In unopened and stored at room temperature environment and protected from direct sunlight: 2 years

Country of Origin: Italy

More information: Project Sales Corp, 28 Founta Plaza, Suryabagh, Visakhapatnam 530020, AP, India
http://www.facebook.com/pages/Aexons-Motorsil/105082426215183?ref=sgm
http://www.projectsalescorp.com

2.5 VARIOUS EXPLOSIONS

An explosive (or explosive material) is a reactive substance that contains a great amount of potential energy that can produce an explosion if released suddenly, usually accompanied by the production of light, heat, sound, and pressure. An explosive charge is a measured quantity of explosive material, which may either be composed solely of one ingredient or be a mixture containing at least two substances.

The potential energy stored in an explosive material may, for example, be chemical energy, such as nitroglycerin or grain dust pressurized gas, such as a gas cylinder or aerosol can nuclear energy, such as in the fissile isotope's uranium-235 and plutonium-239

Explosive materials may be categorized by the speed at which they expand. Materials that detonate (the front of the chemical reaction moves faster through the material than the speed of sound) are said to be "high explosives" and materials that deflagrate are said to be "low explosives". Explosives may also be categorized by their sensitivity. Sensitive materials that can be initiated by a relatively small amount of heat or pressure are primary explosives and materials that are relatively insensitive are secondary or tertiary explosives.

A wide variety of chemicals can explode; a smaller number are manufactured specifically for the purpose of being used as explosives. The remainder are too dangerous, sensitive, toxic, expensive, unstable, or prone to decomposition or degradation over short time spans.

In contrast, some materials are merely combustible or flammable if they burn without exploding.

The distinction, however, is not razor-sharp. Certain materials—dusts, powders, gases, or volatile organic liquids—may be simply combustible or flammable under ordinary conditions, but become explosive in specific situations or forms, such as dispersed airborne clouds, or confinement or sudden release

2.5.1 Vapor Cloud Explosions (VCE)

Major incidents worldwide have involved large vapor cloud explosions, including the Buncefield explosion in 2005. It is important to learn from historical incidents to understand the risk profile of installations.

Following the Buncefield explosion, a large body of published research has improved scientific understanding of the release event, the flammable cloud formation and the explosion. This report describes work done by HSE with US safety regulators to consolidate previous research and to incorporate recently published analysis into a single, systematic review of historical incidents.

Important new conclusions have been reached that a high proportion of large vapor cloud explosions occur at nil or very low wind speeds. In these conditions, the dispersion from large and medium scale releases will be gravity-driven and the vapor cloud will continue to grow as long as it remains undetected. Large vapor clouds will almost always ignite, the probability of a severe explosion event is very high, especially for gasoline.

These findings have important implications for safety practitioners considering installations where such releases of flammable substances can occur. They reinforce the importance of the main risk control measures of overfill prevention and maintaining plant integrity; but they also suggest that the value of mitigation measures such as vapor detectors and vapor barriers should be reviewed.

Mal-operation of a valve at the foot of a tank of gasoline led to a fountain of gasoline driven by the head of liquid in the tank. There was no wind and over a period of 75-90 minutes a vapor cloud spread in all directions to cover the whole site – approximately 700 x 700 m (2300 x 2300 ft). A boundary wall (height 2.5m – 8 ft) prevented spillage of vapor from the site into the neighborhood. The leak was detected immediately and the tank was fitted with a remote shutoff valve that could have been used to stop the loss of containment but this valve had not been operational for several years.

The large site was sparsely occupied: tanks, loading gantries, pump houses offices etc. were separated by large open areas of semi-arid scrub land. A severe VCE occurred that caused overpressure in excess of 2000 mbar (29 psi) and drag damage across almost all of site. Severe explosion effects were confined an area within a few tens of meters from the site but minor damage (e.g. windows breaking) extended to a range of 2 km (6500 ft). Six people were killed on the IOC site and five others in buildings immediately adjacent to the site.

Thanks to the efforts of a number of investigators the incident has provided one of the most complete records of the progress of a severe explosion in a very extended, low-lying vapor cloud. Hundreds of smallish trees scattered across the site provided very detailed evidence of the direction of explosion propagation.

2.5.2 Unconfined Vapor Cloud Explosion (UCVE)

When a flammable vapor is released, its mixture with air will form a flammable vapor cloud. If ignited, the flame speed may accelerate to high velocities and produce significant blast overpressure.

The explosion of unconfined vapor clouds produced by the dispersion of flammable liquid or vapor spills is becoming a serious problem, mainly because of the increased size of the spills in recent years. This paper surveys accidental explosions that have occurred over the past 40 years and also evaluates recent research efforts which pertain to the dispersion and explosion of large vapor clouds. The major problem appears to be the lack of a fundamental understanding of a transient flame-buoyancy interaction during combustion of the cloud, since both accidental and deliberate explosions have exhibited over-all flame propagation rates almost an order of magnitude above the values one would expect without the consideration of buoyancy effects. Other problems which are discussed include, 1) the initial dispersion of the cloud, 2) the prediction of blast effects, and 3) the question of direct initiation of detonation.

Unconfined vapor cloud explosions (also known as vapor cloud explosions) in open air often result when accidental releases of vapors or gases to the atmosphere are ignited. Astonishingly high pressure can result from an unconfined vapor cloud explosion; 70 kPa (10 psi) or so may occur at the outer edge of the exploding cloud, with still higher pressures near the center of the blast. Numerous severe explosions of this nature have occurred in past years (Lenoir and Davenport, “A Survey of Vapor Cloud Explosions: Second Update,” Process Safety Prog., vol. 12, no. 1, January 1993, pp. 12–33).

In a survey of property damage losses in 100 large losses in the hydrocarbon-chemical industries, M & M Protection Consultants of Marsh & McLennan found that a vapor cloud was the initiating mechanism in 43 percent of the cases. Releases of liquefied dense gases have caused many of the reported UVCEs. Such heavy gases tend to hug the ground with limited dispersion in ambient air; this condition results in accumulation of these gases where they can cause maximum casualties to people and damage to property, if ignited. Notwithstanding, releases of mammoth amounts of compressed natural gas from ruptured pipelines have caused vapor cloud explosions. As an example, in 1969 a 356-mm (14-in) pipeline carrying natural gas at more than 5378 kPa gauge (780 psig) ruptured; about 8 to 10 min later the escaping gas exploded violently (National Transportation Safety Board, Pipeline Accident Report Mobil Oil Corporation, High-Pressure Natural Gas Pipeline Accident, Houston, Texas, September 9, 1969, NTBS-Par-71-1, Washington, D.C., 1971).

Elevated emergency unflared releases with vents of sufficient height normally do not cause damaging overpressure at the ground, if accidentally ignited (Bodurtha, “Vent Heights for Emergency Releases of Heavy Gases,” Plant/Operations Prog., vol. 7, no. 2, April 1988, pp. 122–126). Numerous tests on dispersion of heavy gases and on causes of UVCEs have been performed in recent years. Dispersion tests and computer models based on them may not be representative of all conditions at a plant, however, because of equipment plus heat sources that cause better spreading of a plume than is modeled in tests.

Moreover, vapors flashed from release of a liquefied gas will be cold; such vapors flowing over warmer ground may promote atmospheric instability with accompanying turbulence and, thereby, cause more mixing with ambient air than in some tests. In addition, some tests have been so-called meteorological area sources, while the dispersion equations are generally meteorological point sources. (Only concentrations relatively close to the location of discharge of the vapors will be affected by this difference in sources.) Also, the momentary concentration of a combustible gas or flammable vapor is the important duration of a concentration for UVCEs; not all dispersion models specify their averaging time of concentrations. Thus, predictions of concentrations must be treated as estimates.

2.5.3 Boiling Liquid Expansion Vapor Explosions (BLEVE)

Boiler & water heater tank explosion cause & prevention:

BLEVES This article discusses and defines BLEVE or boiling liquid expansion vapor explosions.

We discuss the cause and prevention of explosions of heating boilers and hot water storage tanks, and the role of pressure / temperature relief valves on that equipment.

We explain how scale in a boiler or water heater can lead to failure or even an explosion, and we describe other conditions or mistakes that can cause a BLEVE explosion.

Definition of BLEVE - Boiling Liquid Expanding Vapor Explosion:

A BLEVE is a sudden, explosive release of energy that occurs when a closed container (like a water heater tank) containing heated, pressurized and superheated liquid (water) suddenly ruptures.

The state change from water to steam releases an explosive amount energy to the surroundings. A BLEVE results from the sudden loss of containment of a liquid heated above its normal boiling point. The loss of containment is usually the result of a catastrophic failure of the container or vessel holding the superheated liquid. There are two contributors to the BLEVE blast wave:

(1) the compressed vapor in the container head space and

(2) the vapor flashing from the superheated liquid. The magnitude of the blast also depends on the degree of superheat, that is, the temperature increment above the normal boiling point.

As the degree of superheat increases, the fraction of liquid that flashes increase, thus increasing the severity of the blast. - Ogle 2012

Explanation of BLEVEs: The actual amount of energy released in a BLEVE depends on several variables of which two critical data are the pressure and temperature of water inside the container - in our case a water heater or boiler.

BLEVE energy also varies depending on the liquid that is being superheated. The energy release from a liquid propane tank BLEVE will be different from a water heater tank BLEVE.

Water in an open container will boil at 212°F (100°C or 373.2 K). But when we enclose and heat water in a water heater tank, cylinder, calorifier or similar appliance such as a heating boiler, increased pressure causes the water to become superheated

. If a closed container of superheated water ruptures, the superheated water changes state: it flashes suddenly from water to steam. This state change of water from liquid to vapor (steam) releases a tremendous amount of energy.

Definition of superheated water & latent energy: Water is considered superheated when its temperature is above 212°F (100°C).

Superheated water contains latent energy that will be released if the pressure is suddenly released. It is this latent energy from superheated water that causes a Boiling Liquid Expansion Vapor Explosion or BLEVE).

Energy Release from a BLEVE

Just how much energy is released during a BLEVE explains why these explosions are so serious - so catastrophic when they occur.

gle (2012) points out that a number of investigators have described varying methods to calculate the explosive energy of a BLEVE, complicated further by a varying set of starting assumptions of temperature, pressure, head space of vapor, volume of flashed vapor, and more parameters that would give a plumber or homeowner a headache.

We offer some examples of possible energy released by a water heater BLEVE.

Watts gives this example of the amount of energy released in a water heater BLEVE explosion: where water supply pressure to the water heater is 90psi, the boiling point is not reached until 331.2°F.

At only 50 psi, water flashes into steam and boils at 297°F.

This energy, if released by a water heater rupture, equals more than one pound of dynamite." - Watts (2011). Watts and other experts and companies also point out that

2.6 FIRE HAZARDS

An object, building etc. that could easily catch fire or cause a fire and thereby endanger life

electrical hazards

housekeeping hazards

friction hazards

process or operation-related hazards

storage hazards

smoking hazards

include all types of live flames, causes of sparks, hot objects, and chemicals that are potential for ignition, or that can aggravate a fire to become large and uncontrolled.

Fire hazards are workplace hazards that involve the presence of flame or the risk of an uncontrolled fire.

Fire hazards include:

Live flames

Sparks

Hot objects

Flammable chemicals

Chemicals that can aggravate a fire

Another category of fire hazard are situations and events that impede fire protection and prevention methods. This can include impediments to firefighting, compromised built-in fire safety systems, and situations that restrict the escape of people from an affected building or area in the event of a fire.

OSHA requires workers to train all employees to recognize fire hazards, use fire extinguishing equipment and systems in a safe and effective manner, and how to evacuate safely in the event that a fire cannot be controlled.

Every workplace that has potential fire hazards must be equipped with a sufficient number of conveniently located and easily accessible fire exits.

The following fire hazards are found in various workplaces:

Open flames used in various applications (such as welding)

Electric wires, higher loads, loose connections, and old electrical equipment

All cooking and heat generating appliances

Smoking and the use of personal lighters or matches

Improper or unauthorized stowage of flammable and hazardous materials and chemicals

Insufficient capacity and numbers of emergency exits and stairs

Hindrance to sight or reach firefighting equipment, markings, and alarm systems

Insufficient numbers and types of fire extinguishers

Absence of fire detection and alarm system

Violation of building and fire codes

2.7 POTENTIAL HAZARD

The likelihood that a specific chemical or toxic material will cause an ill effect at a given dose.

e.g. experiments with acids

Risk

Risk is the correlation between likelihood and consequence.

An org chart for the acceptability of risk when certain levels of risk have been met, e.g:

- Risk Level Risk Authority
- Low risk = Supervisor
- Medium risk = Superintendent
- Significant risk = Manager
- High risk = Unacceptable without mitigation.

Workplace hazard identification and an assessment of those hazards should be performed before every job.

Scientific research involves exposure to various hazards. When deciding to allow your child to participate in research projects conducted in University of Florida laboratories, greenhouses and animal facilities, you need to be aware of the potential hazards he or she may encounter. The following information provides the most common potential hazards, but is not intended to be an exhaustive list of all potential hazards.

Your child's research project may involve one or more of the following potential hazards. A table is attached with examples.

Chemicals – can be unstable, making them reactive and prone to explosion. Potential injuries include skin and eye burns, respiratory problems, allergic reactions, skin, eye, and mucous membrane irritation, and illnesses.

Pathogens – found in human, animal and plant tissue can cause infections and acute or chronic illnesses.

Recombinant materials/technology – can interact with the human body and its cells and produce potentially hazardous results.

Mechanical/electrical equipment and instrumentation – can cause electrocution, burns, cuts, scrapes and injuries from pinch points. High noise levels can cause hearing loss.

Radiation/irradiation – can cause skin and eye damage, cellular damage and long-term health problems.

Animals – can bite, scratch, and transmit zoonotic diseases, such as rabies, toxoplasmosis, pox virus, cat bite fever, rat bite fever, and various parasitic infections or release allergens.

Gas cylinders/compressed gasses – gas cylinders with compressed gasses can explode, causing injury from high speed projectiles. Released gasses can cause eye and skin irritations, respiratory problems, light-headedness, asphyxiation and fainting.

2.8 JOB SAFETY ANALYSIS

A Job Safety Analysis (JSA) is one of the risk assessment tools used to identify and control workplace hazards.

JSAs are usually developed when directed to by a supervisor, when indicated by the use of a first-tier risk assessment and whenever a hazard associated with a task has a likelihood rating of 'possible' or greater.

A JSA is a documented risk assessment developed when company policy directs people to do so. Generally, high consequence, high likelihood tasks are addressed by way of a JSA.
High consequence, high likelihood tasks include, but are not limited to, those with:
A history of, or potential for, injury, harm or damage such as those involving:

1. Fire, chemicals or a toxic or oxygen deficient atmosphere.
2. Tasks carried out in new environments.
3. Rarely performed tasks.
4. Tasks that may impact on the integrity or output of a processing system.

The JSA or JHA should be created by the work group performing the task. Sometimes it is expedient to review a JSA that has been prepared when the same task has been performed before but the work group must take special care to review all of the steps thoroughly to ensure that they are controlling all of the hazards for this job this time. The JSA is usually completed on a form. The most common form is a table with three columns (although each company has a variation with many having five or six columns). The headings of the three columns are (1) Job Step (2) Hazard (3) Controls. A Hazard is any factor that can cause damage to personnel, property or the environment (some companies include loss of production or downtime in the definition as well). A Control is any process for controlling a hazard. The work group firstly breaks down the entire job into its component steps. Then, for each step, hazards are identified. Finally, for each hazard identified, controls are recorded in the 3rd column.

When the task is complete it is often of benefit to have a close-out or "tailgate" meeting, to discuss any lessons learned so that they may be incorporated into the JSA the next time the task is undertaken.

Four basic stages in conducting a JSA are:

- selecting the job to be analyzed
- breaking the job down into a sequence of steps
- identifying potential hazards
- determining preventive measures to overcome these hazards

  Example of JSA form is given below

Types of JSA

1. Physical Job safety analysis

   JSA which deals with mechanical failure, falling, skidding etc., are classified thus
2. Chemical Job safety analysis

   JSA which deals with chemicals like flammables, combustibles, explosives etc., are classified thus

2.9 High pressure and high temperature operations

Install and operate the equipment within suitable barricade, if required, using appropriate safety accessories and operating in full compliance with local safety codes and rules.

Establish training procedures to ensure that any person handling the equipment knows how to use it properly.

Maintain the equipment in good condition and establish procedures for periodic testing to be sure that the vessel remains structurally sound.

Reactions involving highly reactive compounds such acetylene, butadiene, dioxane, ethylene oxide, oxygen and all strong oxidizing agents, must be handled cautiously. Close attention must also be given to any reactions that might release sudden surges of heat and pressure, and to any by-products or end-products suspected to have explosive or detonating properties. It is always advisable to run preliminary experiments using small volumes of reactants when starting work with new or unfamiliar materials. The amounts can be increased later after it has been shown that the reaction proceeds smoothly with no indication of erratic or explosive behavior.

The maximum pressure and temperature at which any reactor or pressure vessel can be used will depend upon the design of the vessel and the materials used in its construction. Since all materials lose strength at elevated temperatures, any pressure rating must be stated in terms of the temperature at which it applies. Catalog listings for Parr reactors and pressure vessels show the maximum allowable working pressure at 350 °C for vessels made of Type 316 stainless steel (except certain high pressure/high temperature units which are rated at 500 °C). Pressures are shown in pounds per square inch gage pressure (psig) and in bars. The table of Pressure Rating Factors shown below provides a set of multipliers which can be used to convert pressure ratings for T316SS vessels from 350 °C to higher or lower temperatures. It can also be used to determine the pressure rating for a vessel of the same design made of a material other than T316 stainless steel.

2.10 MATERIALS OF CONSTRUCTION

Type 316 Stainless Steel is an excellent material for use with most organic systems. A few organic acids and organic halides can, under certain conditions, hydrolyze to acetic, formic and other organic acids that are routinely handled in T316SS. T316SS is not normally the material of choice for inorganic acid systems. At ambient temperatures it does offer useful resistance to dilute sulfuric, sulfurous, phosphoric and nitric acids which readily attack T316SS in higher concentrations and temperatures. Halogen acids attack all forms of stainless steel rapidly, even at low temperatures and in dilute solutions. T316SS offers excellent resistance to surface corrosion by caustics, but this is misleading. Caustics can cause stress corrosion cracking in stainless pressure vessels. This phenomenon begins to appear at temperatures just above 100 °C and has been the most common cause of corrosion failure in stainless laboratory vessels. T316SS does offer good resistance to ammonia and to most ammonia Nominal Chemical Composition compounds.

Zirconium offers excellent resistance to hydrochloric and sulfuric acids but, as with Hastelloy B-2, oxidizing ions such as ferric, cupric and fluorides must be avoided. Zirconium also offers good resistance to phosphoric and nitric acids, and to alkaline solutions as well.

Lethal dose and lethal concentration

LD stands for "Lethal Dose". LD50 is the amount of a material, given all at once, which causes the death of 50% (one half) of a group of test animals. The LD50 is one way to measure the short-term poisoning potential (acute toxicity) of a material.

Toxicologists can use many kinds of animals but most often testing is done with rats and mice. It is usually expressed as the amount of chemical administered (e.g., milligrams) per 100 grams (for smaller animals) or per kilogram (for bigger test subjects) of the body weight of the test animal. The LD50 can be found for any route of entry or administration but dermal (applied to the skin) and oral (given by mouth) administration methods are the most common.

Chemicals can have a wide range of effects on our health. Depending on how the chemical will be used, many kinds of toxicity tests may be required.

Since different chemicals cause different toxic effects, comparing the toxicity of one with another is hard. We could measure the amount of a chemical that causes kidney damage, for example, but not all chemicals will damage the kidney. We could say that nerve damage is observed when 10 grams of chemical A is administered, and kidney damage is observed when 10 grams of chemical B is administered. However, this information does not tell us if A or B is more toxic because we do not know which damage is more critical or harmful.

Therefore, to compare the toxic potency or intensity of different chemicals, researchers must measure the same effect. One way is to carry out lethality testing (the LD50 tests) by measuring how much of a chemical is required to cause death. This type of test is also referred to as a "quantal" test because it is measuring an effect that "occurs" or "does not occur".

LC stands for "Lethal Concentration". LC values usually refer to the concentration of a chemical in air but in environmental studies it can also mean the concentration of a chemical in water.

According to the OECD (Organization for Economic Cooperation and Development) Guidelines for the Testing of Chemicals, a traditional experiment involves groups of animals exposed to a concentration (or series of concentrations) for a set period of time (usually 4 hours). The animals are clinically observed for up to 14 days.

The concentrations of the chemical in air that kills 50% of the test animals during the observation period is the LC50 value. Other durations of exposure (versus the traditional 4 hours) may apply depending on specific laws.

Acute toxicity is the ability of a chemical to cause ill effects relatively soon after one oral administration or a 4-hour exposure to a chemical in air. "Relatively soon" is usually defined as a period of minutes, hours (up to 24) or days (up to about 2 weeks) but rarely longer.

In nearly all cases, LD50 tests are performed using a pure form of the chemical. Mixtures are rarely studied.

The chemical may be given to the animals by mouth (oral); by applying on the skin (dermal); by injection at sites such as the blood veins (i.v.- intravenous), muscles (i.m. - intramuscular) or into the abdominal cavity (i.p. - intraperitoneal).

The LD50 value obtained at the end of the experiment is identified as the LD50 (oral), LD50 (skin), LD50 (i.v.), etc., as appropriate. Researchers can do the test with any animal species but they use rats or mice most often. Other species include dogs, hamsters, cats, guinea-pigs, rabbits, and monkeys. In each case, the LD50 value is expressed as the weight of chemical administered per kilogram body weight of the animal and it states the test animal used and route of exposure or administration; e.g., LD50 (oral, rat) - 5 mg/kg, LD50 (skin, rabbit) - 5 g/kg. So, the example "LD50 (oral, rat) 5 mg/kg" means that 5 milligrams of that chemical for every 1-kilogram body weight of the rat, when administered in one dose by mouth, causes the death of 50% of the test group.

If the lethal effects from breathing a compound are to be tested, the chemical (usually a gas or vapor) is first mixed in a known concentration in a special air chamber where the test animals will be placed. This concentration is usually quoted as parts per million (ppm) or milligrams per cubic meter (mg/m^3). In these experiments, the concentration that kills 50% of the animals is called an LC50 (Lethal Concentration 50) rather than an LD50. When an LC50value is reported, it should also state the kind of test animal studied and the duration of the exposure, e.g., LC50 (rat) - 1000 ppm/ 4 hr. or LC50 (mouse) - $5mg/m^3$/ 2hr.

Inhalation and skin absorption are the most common routes by which workplace chemicals enter the body. Thus, the most relevant from the occupational exposure viewpoint are the inhalation and skin application tests. Despite this fact, the most frequently performed lethality study is the oral LD50. This difference occurs because giving chemicals to animals by mouth is much easier and less expensive than other techniques. However, the results of oral studies are important for drugs, food poisonings, and accidental domestic poisonings. Oral occupational poisonings might occur by contamination of food or cigarettes from unwashed hands, and by accidental swallowing.

2.11 SAFE HANDLING AND OPERATION OF MATERIALS AND MACHINERY

1. Only those materials and machines which meet the essential requirements on safety & health be put into service.

2. All parts of a machine which cause danger of a person being trapped or cut must be equipped with guards or protective devices.

3. The operations for adjustment, cleaning, greasing and repairing must be performed with the machine turned off and the power source disconnected.

4. Loose clothing, loose hair or jewellery etc., must be avoided while operating a machine.

5. Every machine must be equipped with emergency stoppage mechanisms that make it possible to stop the machine safely under emergency.

6. Every person who uses a machine has to receive proper training and information on the risk that the work involves.

7. The danger zones of the machines must be marked with warnings and signs.

8. Proper illumination should be provided.

9. Operators should read and adhere to manufacturers operating manual and instructions.

10. Proper housekeeping/maintenance.

TEXT / REFERENCE BOOKS

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3.1 INTRODUCTION

A hazard is defined as a "Condition, event, or circumstance that could lead to or contribute to an unplanned or undesirable event." A hazard is a situation that poses a level of threat to life, health, property, or environment. Most hazards are dormant or potential, with only a theoretical risk of harm; however, once a hazard becomes "active", it can create an emergency. A hazardous situation that has come to pass is called an incident.

A hazard analysis is used as the first step in a process used to assess risk. The result of a hazard analysis is the identification of different type of hazards. A hazard is a potential condition and exists or not (probability is 1 or 0). It may in single existence or in combination with other hazards (sometimes called events)

Risk is the chance or probability that a person will be harmed or experience an adverse health effect if exposed to a hazard. It may also apply to situations with property or equipment loss.

3.2 Types of hazard analysis

A hazard analysis is used as the first step in a process used to assess risk. The result of a hazard analysis is the identification of different type of hazards. A hazard is a potential condition and exists or not (probability is 1 or 0). It may in single existence or in combination with other hazards (sometimes called events) and conditions become an actual Functional Failure or Accident (Mishap). The way this exactly happens in one particular sequence is called a scenario. This scenario has a probability (between 1 and 0) of occurrence. Often a system has many potential

failure scenarios. It also is assigned a classification, based on the worst-case severity of the end condition. Risk is the combination of probability and severity. Preliminary risk levels can be provided in the hazard analysis. The validation, more precise prediction (verification) and acceptance of risk is determined in the Risk assessment (analysis). The main goal of both is to provide the best selection of means of controlling or eliminating the risk. The term is used in several engineering specialties, including avionics, chemical process safety, safety engineering, reliability engineering and food safety

3.2.1 Process Hazard Analysis (PHA)

PHA is a thorough, orderly, and systematic approach for identifying, evaluating, and controlling the hazards of processes involving highly hazardous chemicals. The process hazard analysis methodology selected must be appropriate to the complexity of the process and must identify, evaluate, and control the hazards involved in the process.

First, the facility must determine and document the priority order for conducting process hazard analyses based on a rationale that includes such considerations as the extent of the process hazards, the number of potentially affected employees, the age of the process, and the operating history of the process. The process hazard analyses should be conducted as soon as possible.

Whichever method(s) are used, the process hazard analysis shall address the following:

- The hazards of the process
- The identification of any previous incident that had a likely potential for catastrophic consequences

• Engineering and administrative controls applicable to the hazards and their interrelationships, such as appropriate application of detection methodologies to

provide early warning of releases.

• Consequences of failure of engineering and administrative controls

• Human factors

A qualitative evaluation of a range of the possible safety and health effects of failure of controls. The process hazard analysis shall be performed by a team with expertise in engineering and process operations, and the team shall include at least one employee who has experience and knowledge specific to the process being evaluated. Also, one member of the team must be knowledgeable in the specific process hazard analysis methodology being used.

3.3 HAZARD IDENTIFICATION

Hazard identification is the process in which the hazards of a workplace are identified within a system, procedure or equipment. Hazard identification is a part of risk assessment in which the hazards are identified for further investigation. Once the hazards are identified then proper measures can be taken to eliminate them by using engineering controls. For example, if a fan is installed without a fan cage, then installing a fan cage will be an engineering control to eliminate the associated hazards of using the fan without a cage. The administrative controls can also be incorporated. For example, in this case, the administrative control will be to repeatedly check if the fan cage is still intact.

This is the process of examining each work area and work task for the purpose of identifying all the hazards which are “inherent in the job”. Work areas include but are not limited to machine workshops, laboratories, office areas, agricultural and horticultural environments, stores and transport, maintenance and grounds, reprographics, and lecture theatres and teaching spaces. Tasks can include (but may not be limited to) using screen-based equipment, audio and visual equipment, industrial equipment, hazardous substances and/or teaching/dealing with people, driving a vehicle, dealing with emergency situations, construction. This process is about finding what could cause harm in work task or area.

Identify Hazards

WHS legislation in New South Wales requires that PCBUs, in consultation with workers identify all potentially hazardous things or situations that may cause harm. In general, hazards are likely to be found in the following; - Physical work environment, - Equipment, materials or substances used, - Work tasks and how they are performed, - Work design and management

In order to identify hazards, the following are recommended:

(i) Past incidents/accidents are examined to see what happened and whether the incident/accident could occur again.

(ii) Employees be consulted to find out what they consider are safety issues, I.e. ask workers about hazards near misses they have encountered as part of their work. Sometimes a survey or questionnaire can assist workers to provide information about workplace hazards.

(iii) Work areas or work sites be inspected or examined to find out what is happening now. Identified hazards should be documented to allow further action. The work environment, tool and equipment as well as tasks and procedures should be examined for risks to WHS.

(iv) Information about equipment (e.g. plant, operating instructions) and Material Safety Data Sheets be reviewed to determine relevant safety precautions.

(v) Welcome creative thinking about what could go wrong takes place, i.e. what hazardous event could take place here?

3.4HAZOP

A **hazard and operability study** (HAZOP) is a structured and systematic examination of a planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment, or prevent efficient operation; it is carried out by a suitably experienced multi-disciplinary team (HAZOP team) during a set of meetings.

As a risk assessment tool, HAZOP is often described as:

- A brainstorming technique
- A qualitative risk assessment tool
- An inductive risk assessment tool, meaning that it is a "bottom-up" risk identification approach, where success relies on the ability of subject matter experts (SMEs) to predict deviations based on past experiences and general subject matter expertise

A HAZOP study is a team effort. The team should be as small as possible consistent with their having relevant skills and experience.

A minimum team size of 4-5 is recommended. The Hazard and Operability Analysis (HAZOP) was originally developed to identify both hazards

and operability problems at chemical process plants, particularly for processes using technologies with which the plant was not familiar. The technique has been found to be useful for existing processes as well.

A HAZOP requires an interdisciplinary team and an experienced team leader. The purpose of a HAZOP is to review a process or operation systematically to identify whether process deviations could lead to undesirable consequences. AIChE states that the technique can be used for continuous or batch processes and can be adapted to evaluate written procedures. It can be used at any stage in the life of a process.

HAZOPs usually require a series of meetings in which, using process drawings, the team systematically evaluates the impact of deviations. The team leader uses a fixed set of guide words and applies them to process parameters at each point in the process. Guide words include "No," "More," "Less," "Part of," "As well as," "Reverse, “and "Other than." Process parameters considered include flow, pressure, temperature, level, composition, pH, frequency, and voltage.

As the team applies the guide words to each process step, they record the deviation, with its causes, consequences, safeguards, and actions needed, or the need for more information to evaluate the deviation. HAZOPs require more resources than simpler techniques.

AIChE states that a simple process or a review with a narrow scope may be done by as few as three or four people, if they have the technical skills and experience. A large or complex process usually requires a team of five to seven people. AIChE/CCPS estimates that for a small or simple system a HAZOP analysis will take 8 to 12 hours to prepare, 1 to 3 days to evaluate the process, and 2 to 6 days to document the results. For larger or more complex processes, a HAZOP will take 2 to 4 days to prepare, 1 to 3 weeks to evaluate, and 2 to 6 weeks to document.

3.4.1 HAZOP Procedure

- Familiarization with background documentation
- Planning of the workshop meeting in a pre-meeting with the customer in order to identify
- HAZOP strategy, division of the subsystems/nodes (e.g. line, pump, vessel, compressor),
- choose relevant Piping and Instrument Diagrams (P&ID), and identifying guide words
- Accomplishment of the HAZOP review
- Documentation of observations into information and actions point, document findings on the
- P&IDs.
- Draft report for client review.
- Final HAZOP report.

The success or failure of the HAZOP depends on several factors:

- The completeness and accuracy of drawings and other data used as a basis for the study

- The technical skills and insights of the team
- The ability of the team to use the approach as an aid to their imagination in visualizing deviations, causes, and consequences

The ability of the team to concentrate on the more serious hazards which are identified

3.5 MATERIAL SAFETY DATA SHEET (MSDS)

A Material Safety Data Sheet (MSDS) is a document that gives detailed information about the nature of a chemical, such as physical and chemical properties, health, safety, fire, and environmental hazards of a chemical product. In addition to giving information about the nature of a chemical, an MSDS also tells how to work safely with a chemical and what to do if there is an accidental spill.

A Material Safety Data Sheet (MSDS) is a document that contains information on the potential hazards (health, fire, reactivity and environmental) and how to work safely with the chemical product. It is an essential starting point for the development of a complete health and safety program. It also contains information on the use, storage, handling and emergency procedures all related to the hazards of the material. The MSDS contains much more information about the material than the label. MSDSs are prepared by the supplier or manufacturer of the material. It is intended to tell what the hazards of the product are, how to use the product safely, what to expect if the recommendations are not followed, what to do if accidents occur, how to recognize symptoms of overexposure, and what to do if such incidents occur.

MSDSs must contain the same basic kinds of information, such as

Chemical Identity: Name of the product.

Manufacturer's Information: Name, address, phone number and emergency phone number of the manufacturer.

Hazardous Ingredients/Identity Information: List of hazardous chemicals. Depending on the state, the list may contain all chemicals even if they are not hazardous, or only those chemicals which have OSHA standards. Since chemicals are often known by different names, all common (trade) names should be listed. The OSHA Permissible Exposure Limit (PEL) for each hazardous ingredient must be listed

Physical/Chemical Characteristics: Boiling point, vapor pressure and density, melting point, evaporation rate, etc.

Fire and Explosion Hazard Data: Flash point, flammability limits, ways to extinguish, special firefighting procedures, unusual fire and explosion hazards.

Reactivity Data: How certain materials react with others when mixed or stored together. Health Hazard Data: Health effects (acute= immediate; chronic= long- term), ways the hazard can enter the body (lungs, skin or mouth), symptoms of exposure, emergency and first aid procedures.

Precautions of Safe Handling and Use: What to do in case materials spill or leak, how to dispose of waste safely, how to handle and store materials in a safe manner.

Control Measures: Ventilation (local, general, etc.), type of respirator/filter to use, protective gloves, clothing and equipment, etc.

Safety Data Sheets (SDSs)

The Safety Data Sheets (previously known as the Material Safety Data Sheet or "MSDS") is an important source of information for the worker at the worksite. It is one of the three basic elements of the WHMIS right-to-know-system.

The SDS includes the following: relevant technical information on the substance, a list of its hazardous ingredients (if it's a mixture), chemical hazard data, control measures-such as proper engineering controls and personal protective equipment, instructions on accident prevention while using the substance, specific handling, storage and disposal procedures, and emergency procedures to follow in the event of an accident.

The information provided is expected to be comprehensive and must include what can reasonably be expected to be known about the material and the hazards it may present.

Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.

If inhaled: Move person to fresh air, if person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth if possible. Call a poison control center or doctor for further treatment advice.

Notes to doctor/physician: No specific antidote, treat symptomatically.

Section 5: **Fire Fighting Measures:**

National Fire Protection Rating (NFPA)

Health:	Flammability:	Reactivity:
1	0	0

Legend: **4 = Severe | 3 = Serious | 2 = Moderate | 1 = Slight | 0 = Minimal**

Flashpoint: >200°F / >100°C

Extinguishing Media: Use foam, dry chemical, or water spray.

Fire and explosion hazard: Can burn in fire, releasing irritating and toxic gases due to thermal decomposition or combustion.

Fire fighting instructions and equipment: Evacuate area and fight fire upwind from a safe distance to avoid hazardous vapours and decomposition products. Dike and collect water used to fight fire to prevent environmental damage due to run off. Foam or dry chemical fire extinguishing systems are preferred to prevent environmental damage from excessive water runoff. Minimise use of water to prevent environmental contamination

Section 6: **Accidental Release Measures:**

In case of spills or leaks: Clean up spills immediately, observing precautions in Section 8 of this document. Isolate hazard area. Keep unnecessary and unprotected personnel from entering.

Small spill: Absorb small spills on sand, vermiculite or other inert absorbent. Place contaminated material in appropriate container for disposal.

Large spill: Dike large spills using absorbent or impervious material such as clay or sand. Recover and contain as much free liquid as possible for reuse. Allow absorbed material to solidify, and scrape up for disposal. After removal, clean contaminated area thoroughly with water. Pick up wash liquid with additional absorbent and place in a disposable container.

Section 7: **Handling and Storage:**

Handling: Use only in a well-ventilated area. Minimize dust generation and accumulation.

Handling:

Section 8: **Exposure Controls, Personal Protection:**

Exposure limits: OSHA PEL: Not listed, ACIGH TLV: Not listed

Engineering controls: Proper ventilation is required when handling or using this product. Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower.

Personal EYE PROTECTION - Safety goggles or glasses with side shields.

3.6 SAFETY AUDITS

Safety audits are conducted in order to assess the degree of compliance with the applicable safety regulatory requirements and with the procedural provisions of a Safety Management System if one is in place. They are intended to provide assurance of the safety management functions, including staffing, compliance with applicable regulations, levels of competency and training.

An audit may include one or more components of the total system, such as safety policy, change management, SMS as a whole, operating procedures, emergency procedures, etc. The aim is to disclose the strengths and weaknesses, to identify areas of non-tolerable risk and devise rectification measures. The outcome of the audit will be a report, followed by an action plan prepared by the audited organization and approved by the regulator/supervisory authority. The Implementation of the agreed safety improvement measures shall be monitored by the supervisory authority.

Safety audits are used to ensure that:

- Organization's SMS has a sound structure and adequate staffing levels;
- Approved procedures and instructions are complied with;
- The required level of personnel competency and training to operate equipment and facilities, and to maintain their levels of performance, is achieved;

  • Equipment performance is adequate for the safety levels of the service provided;

  • Effective arrangements exist for promoting safety, monitoring safety performance and

  • processing safety issues;

  • Adequate arrangements exist to handle foreseeable emergencies.

  Safety audits are carried out by a single individual or a team of people who are competent (adequately qualified, experienced and trained) and have a satisfactory degree of independence from the audited organization or unit. The frequency of the audits depends on the regulatory/management policy. For example, some State authorities may conduct annual safety audits; others may consider that a full safety audit is only necessary at a few years' interval.

Ad- hoc safety audits may be conducted to verify the compliance of a particular system component or activity, or may be initiated following an incident. Safety audits are one of the principal methods for fulfilling the safety performance monitoring requirements. Often audits are integrated, i.e. they include not only safety but also other business processes and performance areas, such as quality, capacity, cost efficiency etc.

All audits should be pre-planned and supporting documentation (usually in the form of checklists) of the audit content prepared. Among the first steps in planning an audit will be to verify the feasibility of the proposed schedule and to identify the information that will be needed before commencement of the audit. It will also be necessary to specify the criteria against which the audit will be conducted and to develop a detailed audit plan together with checklists to be used during the audit.

The conduct of the actual audit is essentially a process of inspection or fact-finding. Information from almost any source may be reviewed as part of the audit.

The techniques for gathering the information include:

- Review of documentation
- Interviews with staff
- Observations by the audit team

3.7 EVENT TREE ANALYSIS (ETA)

Event tree analysis (ETA) is a forward, bottom up, logical modeling technique for both success and failure that explores responses through a single initiating event and lays a path for assessing probabilities of the outcomes and overall system analysis.

This analysis technique is used to analyze the effects of functioning or failed systems given that an event has occurred. ETA is a powerful tool that will identify all consequences of a system that have a probability of occurring after an initiating event that can be applied to a wide range of systems including: nuclear power plants, spacecraft, and chemical plants. This Technique may be applied to a system early in the design process to identify potential issues that may arise rather than correcting the issues after they occur. With this forward logic process use of ETA as a tool in risk assessment can help to prevent negative outcomes from occurring by providing a risk assessor with the probability of occurrence.

ETA uses a type of modeling technique called event tree, which branches events from one single performing a probabilistic risk assessment starts with a set of initiating events that change the state or configuration of the system.

An initiating event is an event that starts a reaction, such as the way a spark (initiating event) can start a fire that could lead to other events (intermediate events) such as a tree burning down, and then finally an outcome, for example, the burnt tree no longer provides apples for food. Each initiating event leads to another event and continuing through this path, where each intermediate events probability of occurrence may be calculated by using fault tree analysis, until an end state is reached (the outcome of a tree no longer providing apples for food).

Intermediate events are commonly split into a binary (success/failure or yes/no) but may be split into more than two as long as the events are mutually exclusive, meaning that they cannot occur at the same time.

If a spark is the initiating event there is a probability that the spark will start a fire or will not start a fire (binary yes or no) as well as the probability that the fire spreads to a tree or does not spread to a tree. End states are classified into groups that can be successes or severity of consequences.

An example of a success would be that no fire started and the tree still provided apples for food while the severity of consequence would be that a fire did start and we lose apples as a source of food.

Loss end states can be any state at the end of the pathway that is a negative outcome of the initiating event. The loss end state is highly dependent upon the system, for example if you were measuring a quality process in a factory a loss or end state would be that the product has to be reworked or thrown in the trash. Some common loss end states

• Loss of Life or Injury/ Illness to personnel

• Damage to or loss of equipment or property (including software)

• Unexpected or collateral damage as a result of tests

• Failure of mission

• Loss of system availability

• Damage to the environment.

The event tree diagram models all possible pathways from the initiating event. The initiating event starts at the left side as a horizontal line that branch vertically. The vertical branch is representative of the success/failure of the initiating event. At the end of the vertical branch a horizontal line is drawn on each the top and the bottom representing the success or failure of the first event where a description (usually success or failure) is written with a tag that represents the path such as 1s where s is a success and 1 is the event number similarly with 1f where 1 is the event number and f denotes a failure (see attached diagram). This process continues until the end state is reached. When the event tree diagram has reached the end state for all pathways the outcome probability equation is written.

3.7.1 Steps to perform an event tree analysis

1.Define the system: Define what needs to be involved or where to draw the boundaries.

2.Identify the accident scenarios: Perform a system assessment to find hazards or accident scenarios within the system design.

3.Identify the initiating events: Use a hazard analysis to define initiating events.

4.Identify intermediate events: Identify counter measures associated with the specific scenario.

5.Build the event tree diagram

6.Obtain event failure probabilities: If the failure probability cannot be obtained use fault tree analysis to calculate it.

7.Identify the outcome risk: Calculate the overall probability of the event paths and determine the risk.

8.Evaluate the outcome risk: Evaluate the risk of each path and determine its acceptability.

9.Recommend corrective action: If the outcome risk of a path is not acceptable develop design changes that change the risk.

10.Document the ETA: Document the entire process on the event tree diagrams and update for new information as needed

Advantages

- Enables the assessment of multiple, co-existing faults and failures
- Functions simultaneously in cases of failure and success
- No need to anticipate end events
- Work can be computerized
- Can be performed on various levels of details
- Visual cause and effect relationship
- Relatively easy to learn and execute
- Models complex systems into an understandable manner
- Follows fault paths across system boundaries
- Combines hardware, software, environment, and human interaction
- Permits probability assessment
- Commercial software is available

Limitations

- Addresses only one initiating event at a time.
- The initiating challenge must be identified by the analysis
- Pathways must be identified by the analyst
- Level of loss for each pathway may not be distinguishable without further analysis
- Success or failure probabilities are difficult to find.
- Can overlook subtle system differences

- Partial successes/failures are not distinguishable
- Requires an analyst with practical training and experience

Though ETA can be relatively simple, software can be used for more complex systems to build the diagram and perform calculations more quickly with reduction of human errors in the process. There are many types of software available to assist in conducting an ETA. The software available is generally not available from your local store but easily found with an online search. In nuclear industry, Risk Spectrum PSA software is widely used which has both event tree analysis and fault tree analysis.

3.8 FAULT TREE ANALYSIS (FTA)

Fault tree analysis (FTA) is a top down, deductive failure analysis in which an undesired state of a system is analyzed using boolean logic to combine a series of lower-level events. This analysis method is mainly used in the field of safety engineering and Reliability engineering to determine the probability of a safety accident or a particular system level (functional) failure.

FTA can be used to:

- Understand the logic leading to the top event / undesired state.
- Show compliance with the (input) system safety / reliability requirements.
- Prioritize the contributors leading to the top event - Creating the Critical
- Equipment/Parts/Events lists for different importance measures.

3.8.1 Steps involved in FTA

1. Define the undesired event to study

Definition of the undesired event can be very hard to catch, although some of the events are very easy and obvious to observe. An engineer with a wide knowledge of the design of the system or a system analyst with an engineering background is the best person who can help define and number the undesired events. Undesired events are used then to make the FTA, one event for one FTA; no two events will be used to make one FTA.

2. Obtain an understanding of the system

Once the undesired event is selected, all causes with probabilities of affecting the undesired event of 0 or more are studied and analyzed. Getting exact numbers for the probabilities leading to the event is usually impossible for the reason that it may be very costly and time consuming to do so. Computer software is used to study probabilities; this may lead to less costly system analysis.

System analysts can help with understanding the overall system. System designers have full knowledge of the system and this knowledge is very important for not missing any cause affecting the undesired event. For the selected event all causes are then numbered and sequenced in the order of occurrence and then are used for the next step which is drawing or constructing the fault tree.

3. Construct the fault tree

After selecting the undesired event and having analyzed the system so that we know all the causing effects (and if possible, their probabilities) we can now construct the fault tree. Fault tree is based on AND and OR gates which define the major characteristics of the fault tree.

4.Evaluate the fault tree

After the fault tree has been assembled for a specific undesired event, it is evaluated and analyzed for any possible improvement or in other words study the risk management and find ways for system improvement. This step is as an introduction for the final step which will be to control the hazards identified. In short, in this step we identify all possible hazards affecting in a direct or indirect way the system.

5. Control the hazards identified

This step is very specific and differs largely from one system to another, but the main point will always be that after identifying the hazards all possible methods are pursued to decrease the probability of occurrence.

3.9 FAILURE MODES AND EFFECTS ANALYSIS (FMEA)

Failure Modes and Effects Analysis (**FMEA**) is a systematic, proactive method for evaluating a process to identify where and how it might fail and to assess the relative impact of different failures, in order to identify the parts of the process that are most in need of change.

FMEA is an analytical methodology used to ensure that potential problems have been considered and addressed throughout the product and process development cycle.

FMEA helps to:

- Discover the potential failures, their potential cause mechanisms and the risks designed into a product or process
- Develop actions that reduce the risk of failure
- Follow-up and evaluate the results of actions on the risks that were discovered

FMEAs are conducted by a core team of three or four people with supporting Subject Matter Experts (SME). This group creates the Cross Functional Team (CFT). Ideally, the CFT should be selected from disciplines that have a slightly different view of the product or process under investigation. The synergy created by the CFT is what makes FMEA so powerful.

TEXT / REFERENCE BOOKS

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3. Jain.R.K and Sunil Rao, Industrial Safety, Health and Environmental Management Systems, 1st Edition, Khanna Delhi 2006.

4. Shrikant Dawande., Chemical Hazards and Safety, 2nd Edition, Khanna Publishers, 2012.

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4.1 SAFETY AUDIT

Audit is a systematic and, wherever possible, independent examination to determine whether activities and related results conform to planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve the organization's policy and objectives.

The health and safety management audit our members adopted is a structured process of collecting independent information on the efficiency, effectiveness and reliability of the total H&S management system and drawing up plans for corrective action.

Auditing examines each stage in the H&S management system by measuring compliance with the controls the organization has developed, with the ultimate aim of assessing their effectiveness and their validity for the future.

PROCESS SAFETY AUDITS

It is a self-evaluation audit which aims at:

gather all relevant documentation covering process safety management requirements at a specific facility

determine the program's implementation and effectiveness by following up on their application to one or more selected processes.

PRODUCT SAFETY AUDIT

Safety Audit is important in the product design and development stages. It is to ensure that the company had adequately protected the user of a product from hazards that it did not know existed. This type of audit is to

-Identify and classify hazards associated with the product i.e. catastrophic, critical, occasional, remote, or improbable

-Develop a hazard risk index and priority setting

-Get employee to present design alternatives and to review for feasibility

(Accident Prevention Manual for Business and Industry, NSC)

Safety Management Audit Rating Tool (SMART)

Safety Management Audit Rating Tool (SMART) is developed by the Society of Accredited Safety Auditors for assessing the occupational safety and health management system of contractors in construction work.

The design of SMART is based on British Standard BS8800:1996 Guide to Occupational health and safety management systems and standards set by local legislation. SMART provides an easy step by step assessment of the site health and safety management functions and its compliance with local legislation. Its aim is to unveil deficiency and weakness of the system for the management which in turn would help the management to further improve on site health and safety management.

SAMART can be used as an in-house management tool for self-assessment and it can be used by an external auditor for an independent audit. A scoring system is introduced to help in setting baseline for further improvement and for comparison among sites of the company.

1. The Safety & Health Audit Recognition Programme (SHARP)

The Safety & Health Audit Recognition Programme (SHARP) is developed and administered by the Society of Accredited Safety Auditors Ltd. (SASA) and The Hong Kong Registered Safety Auditors Association (HKRSAA) (collectively referred to as the Programme Administrator or PA) to enhance the professional standard and performance of safety and health audits conducted in accordance with the Factories and Industrial Undertakings (Safety Management) Regulations. The objective is to procure excellent and quality audits that are well above legal requirements and trade expectation so as to achieve advancement in the occupational safety and health performance in Hong Kong.

Auditors enrolled in this programme (SHARP Auditors) undertake that they will abide by the criteria of safety audit practice issued by the PA from time to time. Audit reports prepared by SHARP Auditors will bear a label and a seal of the SHARP Auditor issued under this programme on the cover page confirming that the audit was conducted and the report was prepared in accordance with the criteria set under SHARP. Audits that are conducted in accordance with SHARP may gain respected recognition and popularity amongst factory proprietors and contractors as they signify quality audits and quality reports.

4.2 EFFECTIVE STEPS TO IMPLEMENT SAFETY PROCEDURES

A safe and healthy workplace is one of the keys to the success of any industry. By establishing good health and safety practices in the workplace, an industry is likely to have more motivated and productive employees.

4.2.1 The following goals have to be established by any industry

(1) Provide workers with a safe work environment.

(2) Conduct routine/regular workplace inspections.

(3) Provide Personal Protective Equipment.

(4) Develop and implement safe work procedures and rules.

(5) Provide on-going safety training

(6) Enforce safety rules and appropriate discipline.

(7) Provide on-going property conservation practices.

4.2.2 Employee orientation program

All new employees must attend the Safety Orientation Session prior to starting work within their assigned area. This session will be conducted under the direction of the Safety Director and in coordination with Human Resources. Upon completion of the Safety Orientation Session, each new employee will be required to acknowledge that they have received, understand, and will abide by the industry's Safety Program. All participants must sign a statement verifying that they have completed the session. This report will be filed in the employee's personnel file.

The following topics are covered in the Safety Orientation Session:

1. Company History
2. Safety Program/Policy & Work rules
3. Responsibilities
4. Safety Education/Training

5. Safety Audit/Inspections

6. Accident Reporting/Investigation Requirements

7. First Aid & Blood borne Pathogens

8. Personal Protective Equipment

9. Tool & Equipment Use

10. Material Handling

11. Machine Guarding

12. Hazard Communication

13. Emergency Action

4.2.3 Safety Rules

All safety rules must be obeyed. Failure to do so will result in strict disciplinary action.

1. All injuries must be reported as soon as possible.

2. No horseplay, alcohol, or drugs allowed on premises. No alcohol usage allowed during lunch break.

3. PPE must be worn as prescribed by management.

4. All tools/equipment must be maintained in good condition.

5. Only appropriate tools shall be used for specific jobs.

6. All guards must be kept in place.

7. No spliced electrical cords/wiring allowed.

4.2.4 Safety committee

General functions of the Safety Committee can include:

(1) Identifying workplace hazards

(2) Enforcement of Safety Rules

(3) Measuring safety performance

(4) Reducing frequency/severity of injuries

(5) Creating safety policies

(6) Developing and monitoring safety programs Specific tasks of the Safety Committee can include:

(1) Conducting self-inspections of the workplace

(2) Review employee reports of hazards

(3) Assist in safety training

(4) Creating safety incentive programs

(5) Publish/distribute safety newsletter

(6) Inspect PPE

(7) Post safety posters/slogans on bulletin board

(8) Identify Light Duty Jobs

4.2.5 Emergency action plan

The Emergency Action Plan (EAP) is in place to ensure employee safety from fire and other emergency. At the time of an emergency, all employees should know

what type of evacuation is necessary and what their role is in carrying out the plan? In some emergencies total and immediate evacuation will be necessary. In other emergencies only partial evacuation may be necessary.

When a fire is detected it is necessary that the fire alarm pull station be activated as soon as possible. The fire alarm will notify the emergency response team who will perform assigned duties. The activation of the alarm will also notify the local fire department.

In the event of bomb threat, toxic chemical release, hazardous weather, or other emergencies - notification will be made over the public address system. In the event of fire, bomb threat, or toxic chemical release; employees are to proceed to the nearest available and safe exit and leave the building as soon as possible. Floor plans (maps) and exits have to be posted in each department.

4.3 SAFETY EDUCATION AND PERIODIC TRAINING

4.3.1 Safety Education

It deals primarily in the development of mind, broadening one's knowledge in the field of safety by understanding the concept or principle of any hazardous material on the job activity. The cause for the hazard or the hazardous property of the material one handles can be ascertained easily through education and then it could be explained even to the uneducated employees through any kind of communication technique. This develops the consciousness, awareness and a state of mental alertness among the workers to identify and prevent the hazardous situations.

4.3.2 Safety Training

Safety training is an extension of safety education which lies effectively in the use of safety work practices and techniques. The general benefits from the safety training are

1. Training activities indirectly demonstrate company's interest in employees which leads to good human relations at work.

2. Understanding the importance of safety and hence following safe work procedures in the operation of machines, equipment’s and handling materials

3. Training saves the time spent by the supervisor to instruct and correct

4. Knowing the techniques of firefighting, first aid, lifting, stacking etc. helps a lot in the accident prevention and in emergencies.

Level - Training Needs

Helper - Need for safety at work, hazards connected with his work, ways to safeguard

Operator - Need for Safety, safety requirements of his job, his responsibilities

Supervisor - Hazards in the operations supervised and the technical skills to identify and prevent them, a broad knowledge of company's policy, techniques of supervision, human relations and communication skills.

Manager - Responsibility for safety, company’s policy and direction, techniques to identify and control hazards, safety engineering and management, human relations and communication.

Training programmes on specific areas like fire extinguishing, first aid, noise, industrial hygiene, major hazards control during emergencies, uses of personal protective equipment’s must be covered. Training can be given by

1. On-Job training
2. Lecture Method
3. Group Discussions
4. Case Studies
5. Learning by doing
6. Demonstration and visit.

4.4 PERSONAL PROTECTIVE EQUIPMENTS(PPE’S)

Personal protective equipment’s commonly referred to as "PPE "includes all clothing and work accessories designed to protect employees from injury or infection. It refers to the protective clothing, helmets, hard hats, hearing protectors, respirators, goggles or other garments or equipment’s meant to protect the wearers' body from injury by heat, chemicals, infection, electrical hazards, airborne particulate matter etc. The purpose of personal protective equipment is to reduce employee exposure to hazards when engineering and administrative controls are not effective to reduce these risks’ does not eliminate the hazard but reduce the employees’ risk of exposure to accident causing situations protects only the

user and does not eliminate the hazard from the workplace are a second line of defense for employee protection. The first line of defense is to eliminate accident causing situations in the workplace.

4.4.1 classification

Personal protective equipment's can be broadly classified into

1. Non - respiratory protective equipment's
2. Respiratory protective equipment's

Non- respiratory protective devices include Head protectors, eye protectors, hand and arm protectors, foot and leg protectors, body protectors and skin protectors. Respiratory protective equipment's include different kinds of breathing apparatus like filter respirators, airline respirators, self- contained breathing apparatus etc.

When selecting a PPE to reduce a risk to health and safety, the employer should ensure that the PPE is

Suitable for the nature of work and any hazard associated,

A suitable size and fit and reasonably comfortable for the person to wear

Maintained, repaired or replaced

Used or worn by the worker, so far as is reasonably practicable Duties of employees on using PPE

- PPE must be worn and used in accordance with the instructions provided to them
- PPE must be examined before use
- Any defected must be immediately reported to the supervisor
- Employees must take care of the PPE provided to them

4.4.2 Head Protection

An Injury to the head can pose serious threat to the brain. Therefore, head protection is considered important. Head injuries are usually caused by the falling objects, bumping against a fixed object, contacting exposed electrical conductors etc.

Safety Helmets

A safety helmet must be worn where a person may be struck on the head by a falling body, flying objects, overhead spills of hot and corrosive chemicals, electric shock etc. A wide range of accessories can be fitted with the helmets for variable working conditions.

The hard shell of the safety helmet is designed to protect the head against impact.

Helmets are made out of materials such as fiber-glass reinforced plastic, HDPE, aluminum alloy etc.

To provide best protection, a safety helmet must fit properly. Care and Maintenance of helmets are essential. Helmets must be checked regularly for cracks or other damages. Helmets must be cleaned at least once in a month in warm water or recommended cleanser and air dried. The helmet must be protected from direct exposure to extreme conditions of heat and cold, chemicals etc.

Hard Hats

Safety hats protect the head from impact, penetration and electrical shock. A hard hat is a type of helmet predominantly used in workplace environments such as construction sites, to protect the head from injury. Hard hats are classified into three categories

Class A - General Service, limited voltage protection Class B - Utility Service, high voltage protection Class C - Special Service, no voltage protection

4.4.3 Ear Protection

High noise levels are predominant in most industrial settings, carry a very serious impact on the employees. Hearing loss has an impact on the person's quality of life. Hearing loss can also affect the safety of the working environment when a worker can't hear a warning or alarm signal. People working in highly noisy areas must wear ear protection aids.

Ear Plugs

An ear plug is a device that is meant to be inserted in the ear canal to protect the wearer from loud noise, intrusion of water, foreign bodies, dust or excessive wind. Most earplugs are made of foam that is inserted into the ear canal. Ear plugs are rated with Noise Reduction Ratings which provide a guide to the noise protection provided by the device. Ear plugs may be better in hot, humid or confined work areas and better for employees who wear other personal protective equipment’s.

The ear plugs may be disposable or reusable in nature. Disposable ear plugs are meant for one-time usage and made of formable material. Reusable ear plugs are premolded and made of silicone, plastic or rubber.

Ear Muffs

Ear muffs are the objects designed to cover a person's ear for protection or for warmth. Ear muffs have cups and cushions that fit securely around the ears, covering them completely, and are held in place by a head band. Thermal ear muffs work in cold environment to keep a person's ear warm. Acoustic ear muffs protect the wearer from extreme noises.

4.4.4 Eye and Face Protection

Eyes are vulnerable to mechanical, chemical and thermal hazards. The employer shall ensure that each affected employee uses appropriate eye or face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation.

OSHA suggests that eye protection be routinely considered for use by carpenters, electricians, machinists, mechanics, millwrights, plumbers and pipefitters, Sheetmetal workers and tinsmiths, assemblers, sanders, grinding machine operators, sawyers, welders, laborers, chemical process operators and handlers, and timber cutting and logging workers.

Employers of workers in other job categories should decide whether there is a need for eye and face PPE through a hazard assessment.

Examples of potential eye or face injuries include:

1. Dust, dirt, metal or wood chips entering the eye from activities such as chipping, grinding, sawing, hammering, the use of power tools or even strong wind forces.

2. Chemical splashes from corrosive substances, hot liquids, solvents or other hazardous solutions.

3. Objects swinging into the eye or face, such as tree limbs, chains, tools or ropes.

4. Radiant energy from welding, harmful rays from the use of lasers or other radiant light (as well as heat, glare, sparks, splash and flying particles).

Eye protection choices include the following

Safety Glasses

Safety glasses are the most commonly used form of eye protection. They are basically designed to provide protection from flying particles that may strike the eyes from the front. Ordinary prescription glasses do not provide adequate protection. It must confirm to the standards. All safety glasses should have side shields.

Goggles

Goggles are intended for use when protection is needed against chemicals or particles. Impact protection goggles which contain perforations on the sides of goggle are not to be used for chemical splash protection, therefore are not recommended.

Splash goggles which contain shielded vents at the top of the goggle are appropriate for chemical splash protection, and also provide limited eye impact protection. Goggles only protect the eyes, offering no protection for the face and neck.

Face Shields

Full face shields provide the face and throat and partial protection from flying particles and liquid splash. For maximum protection against chemical splash, a full-face shield should be used in combination with chemical splash goggles. Face shields are appropriate as secondary protection when implosion (e.g. vacuum applications) or explosion hazards are present. Face shields which are contoured to protect the sides of the neck as well as frontal protection are preferred.

4.4.5 Arm and Hand Protection

Arms and hands are vulnerable to cuts, burns, bruises, electrical shock, chemical spills, and amputation.

Gloves

Gloves provide protection for the hands and arms from chemicals, temperature extremes, and abrasion.

Their proper selection is vital to their ability to protect. This is especially true when dealing with potential exposure to chemicals. It is imperative to remember that both the thickness and the type of material the glove is manufactured from affect the ability to serve as a barrier against a chemical.

Another factor in the selection of gloves is the wearer's need for dexterity. It is often advisable to reduce the size and thickness of the glove to increase the dexterity. Caution is also required when using gloves around moving equipment. Gloves should not be used by anyone whose hands are exposed to moving parts in which their hands could get caught.

The following is a general list of the types of gloves

- Disposable latex gloves
- Chemical resistant gloves
- Leather gloves
- Non asbestos heat-resistant gloves
- metal-mesh gloves for operations cutters
- Cotton gloves.

4.4.6 Foot Protection

The toes, ankles and feet are exposed to a wide range of on the job injuries. Safety shoes and boots provide impact and compression protection for workers who handle heavy materials or work in areas where materials could roll or fall onto their feet. Foot protection is usually in the form of

steel-toed work boots, with a steel shank to protect the bottom of the foot from puncture wounds. In wet environments, steel-toed boots that are waterproof and slip-resistant may be necessary. The hazards that workers are exposed to will determine what type of foot protection is most appropriate for the job.

4.4.7 Respiratory Protection

Respiratory hazards include airborne contaminants such as dusts, mists, fumes and gases or oxygen deficient atmospheres. A respirator is a protective face piece, hood or helmet that is designed to protect the wearer against various harmful airborne agents.

Respirators should not be

the first choice for respiratory protection in workplaces. They should only be used

- when following the "hierarchy of control" is not possible (elimination, substitution, engineering or administrative controls)
- while engineering controls are being installed or repaired
- when emergencies or other temporary situations arise (e.g., maintenance operations)

The two main types are air-purifying respirators (APRs) and supplied-air respirators (SARs).

Air-purifying respirators can remove contaminants in the air that you breathe by filtering out particulates (e.g., dusts, metal fumes, mists, etc.). Other APRs purify air by adsorbing gases or vapors on a sorbent (adsorbing material) in a cartridge or cannister. They are tight-fitting and are available in several forms

- mouth bit respirator (fits in the mouth and comes with a nose clip to hold nostrils closed -
  - o for escape purposes only)
- quarter-mask (covering the nose and mouth),
- half-face mask (covering the face from the nose to below the chin), or
- full facepiece (covering the face from above the eyes to below the chin).

Respirators with a full-face piece also protect the eyes from exposure to irritating chemicals.

Supplied-air respirators (SARs) supply clean air from a compressed air tank or through an airline. This air is not from the work room area. The air supplied in tanks or from compressors must meet certain standards for purity and moisture content

Supplied-air respirators may have either tight-fitting or loose-fitting respiratory inlets. Respirators with tight-fitting respiratory inlets have half or full facepieces. Types with loose-

fitting respiratory inlets can be hoods or helmets that cover the head and neck, or loose-fitting

facepieces with rubber or fabric side shields. These are supplied with air through airlines.

Examples of these classes of respirators include:

Air-purifying respirators (APRs)

- particulate respirators (previously called dust, fume, and mist respirators or masks),
- chemical cartridge respirators that can have a combination of chemical cartridges, along with a dust prefilter: this combination provides protection against different kinds of contaminants in the air
- gas masks (contain more adsorbent than cartridge-type respirators and can provide a higher level of protection than chemical cartridge respirators)
- powered air-purifying respirators (PAPRs).
- Supplied-air respirators (SARs)
- self-contained breathing apparatus (SCBA),
- airline supplied-air respirators,
- protective suits that totally encapsulate the wearer's body and incorporate a life- support system.

There are some combinations of airline respirators and SCBAs that allow workers to work for extended periods in oxygen-deficient areas or where there are airborne toxic contaminants. The auxiliary or backup SCBA source allows the worker to escape with an emergency source of air if the airline source fails.

There are also combination air-purifying and atmosphere supplying respirators. These will offer worker protection if the supplied-air system fails, if the appropriate air-purifier units are selected. These cannot be used in oxygen-deficient areas or where the air concentration of a contaminant exceeds the IDLH level (i.e., immediately dangerous to life or health). Since filters capture particles, caution must be exercised to always check that these filters are not clogged as it makes it harder for air to pass through and increase the likelihood of contaminated air entering the mask. Cartridges can also become "full" or saturated. It will stop working and "breakthrough" will occur - this term means that the gases or vapors will leak through the cartridge. Both cartridges and filters must be replaced on a regular basis by using the manufacturer's recommendations (usually determined by using warning properties or end-of- service indicators).

There are 9 classes of particulate filters, depending on the particulate material. They are also classified based on levels of oil resistance and filter efficiency. Oil can break down certain types of filters which means it is important to know the materials you are working with at all times and always select the right cartridge for your respirator.

The main categories are:

- N series (Not resistant to oil) - May be used in any atmosphere where there is no oil particulate.

- R series (Resistant to oil) - May be used in any atmosphere where there is no oil particulate, or up to one shift where there is oil particulate present. "One shift" means eight hours of continuous or intermittent use.

- P series (Oil-Proof) - May be used in any atmosphere, including those with oil particulates, for more than one shift. If the filter is used in atmospheres with oil particulates, contact the manufacturer to find out the service life of the filter.

4.5 FIRE FIGHTING EQUIPMENTS

Fire is a chemical reaction in which oxygen is combined with a gaseous or vaporous fuel. Note that, even if the fuel is a solid (e.g. wood) or a liquid (e.g. petrol) it is the vapors given off when the fuel is heated that burn. This rapid oxidation produces heat and light (flames). Fire can usually take place only when these three elements are present: • Oxygen • Fuel • Heat (energy) These 3 elements make up what is commonly called the 'Fire Triangle.

Essentially, fires are extinguished by taking away one or more of the elements in the fire tetrahedron. This can be achieved by

- Removal or separation of un burnt fuel (eg turn off the gas)

- Removal or dilution of the oxygen supply (eg smothering the fire with a fire blanket or an inert

gas)

- Removal of the heat of the oxidation reaction (eg spraying the fuel with water)
- Inhibiting the chain reaction by modifying the combustion chemistry

A fire extinguisher, or extinguisher, is an active fire protection device used to extinguish or control small fires, often in emergency situations. It is not intended for use on an out-of-control fire, such as one which has reached the ceiling, endangers the user (i.e., no escape route, smoke, explosion hazard, etc.), or otherwise requires the expertise of a fire department.

Typically, a fire extinguisher consists of a hand-held cylindrical pressure vessel containing an agent which can be discharged to extinguish a fire.

Different classes of fire extinguishers

Class A: Extinguishers are for ordinary combustible materials such as paper, wood, cardboard and most plastics

Class B: Fires involve flammable or combustible liquids such as gasoline, kerosene and oil.

Class C: Fires involve electrical equipment such as appliances, wiring, circuit breakers and outlets

Class D: Fires that involve combustible metals such as magnesium, potassium and sodium

The selection of a suitable extinguisher is primarily influenced by the following factors

- The size and rate of fire spread
- The Class of fire (i.e. type of materials involved)
- The training and capabilities of the person using the extinguisher

4.5.1 Use of fire extinguisher

There are a number of different types of portable fire extinguishers, each can be identified by the color coding and labelling. Check that the extinguisher you intend to use is suitable for the type of fire encountered eg a water extinguisher must never be used on any fire involving electrical equipment.

There are four (4) basic steps for using modern portable fire extinguishers. The acronym PASS is used to describe these four basic steps

1. Pull (Pin)

Pull pin at the top of the extinguisher, breaking the seal. When in place, the pin keeps the handle from being pressed and accidentally operating the extinguisher. Immediately test the extinguisher. (Aiming away from the operator) This is to ensure the extinguisher works and also shows the operator how far the stream travels

2. Aim

Approach the fire standing at a safe distance. Aim the nozzle or outlet towards the base of the fire.

3. Squeeze

Squeeze the handles together to discharge the extinguishing agent inside. To stop discharge, release the handles.

4. Sweep

Sweep the nozzle from side to side as you approach the fire, directing the extinguishing agent at the base of the flames. After an A Class fire is extinguished, probe for smoldering hot spots that could reignite the fuel.

4.5.2 Water Extinguisher

Water extinguishers are extinguishers that contain water and compressed gas. The water is ejected through the nozzle by a CO_2 gas cartridge or by stored pressure typically nitrogen gas.

These are used on Class A fires (wood, paper, fabric). They are typically 9 to 10 liters capacity and can project a jet of water about 6 meters. For the best effect the water stream should be directed at the burning material.

4.5.3 Foam extinguisher

The contents are ejected about 4 to 5 meters by a gas cartridge or by stored pressure and they are about 9 liters in capacity. These are used on Class B fires (liquids such as petrol, paints, oils etc.). For the best effect the foam should be applied to fall as lightly as possible onto the burning material. This can be achieved by applying the foam to a rear wall in the case of an enclosed area, or if in an open space aiming the foam to strike the ground just short of the fire so that it flows gently over the burning fuel.

4.5.4 Dry Chemical Powder extinguisher

The contents are ejected by a gas cartridge or by stored pressure. They are used on Class B fires, that is on flammable liquid fires to assist foam in the combined- agent suppression. They are safe to use on live electrical equipment, but are generally not preferred for this role because of the clean-up afterwards. They range in size from 1kg to 11kg, though 9 kg is the most common. The 'standard' powder is sodium bicarbonate, but a number of high-performance powders are also in use. Dry chemical powder is most effectively applied to flammable liquid fires in a low sweeping motion so as to apply a cloud of powder over the fire area. There is a possibility of re-ignition once the powder has dispersed from concealed flames or hot spots. When applied to 'running fuel fires' the powder should be directed first at the lowest parts of the fire and gradually worked upwards extinguishes are rated as either 'ABE' or 'BE'. This will be indicated on the label.

4.4.5 Carbon dioxide extinguisher

They are used as a first attack on electrical fires. The portable units vary in size from 2.5 kg to 7 kg. CO_2 is a colorless, odorless gas, which does not support combustion. It is not poisonous but is suffocating in large quantities. The gas is discharged through a wide 'horn' discharge nozzle and the gas stream projects for 1 to 2 meters. This discharge is accompanied by a large roar and the gas is intensely cold, and can cause frostbite. It is applied in a low sweeping motion at the base of the fire, and the possibility exists for re-ignition after the gas disperses. However, it leaves no mess or residue and is therefore preferred for electrical fires.

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5.1 OCCUPATIONAL HEALTH HAZARDS

Occupational health hazards are hazards of exposure to pollution, noise and vibrations in the working environment. Occupational illness normally develops over a period of time because of workplace conditions. Such conditions might include exposure to disease-causing bacteria and viruses, or to chemicals or dust.

Under the Occupational Health and Safety Act, occupational illness is defined as a condition that results from exposure in a workplace to a physical, chemical or biological agent to the extent that the normal physiological mechanisms are affected and the health of the worker is impaired. Occupational Health is the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations by preventing departures from health, controlling risks and the adaptation of work to people, and people to their jobs.

5.2 OSHA

The Occupational Safety and Health Administration (OSHA) is an agency of the United States Department of Labor. OSHA officially formed on April 28, 1971, the date that the OSH Act became effective. OSHA has a number of training, compliance assistance, and health and safety recognition programs throughout its history.

Responsibilities under OSHA Law

Employers have the responsibility to provide a safe workplace.

By law, employers must provide their workers with a workplace that does not have serious hazards and must follow all OSHA safety and health standards. Employers must find and correct safety and health problems. OSHA further requires that employers must first try to eliminate or reduce hazards by making feasible changes in working conditions rather than relying on personal protective equipment such as masks, gloves, or earplugs. Switching to safer chemicals, enclosing processes to trap harmful fumes, or using ventilation systems to clean the air are examples of effective ways to eliminate or reduce risks.

Employers must also

- Inform workers about chemical hazards through training, labels, alarms, color- coded systems, chemical information sheets and other methods.
- Provide safety training to workers in a language and vocabulary they can understand.
- Keep accurate records of work-related injuries and illnesses.
- Perform tests in the workplace, such as air sampling, required by some OSHA standards.
- Provide required personal protective equipment at no cost to workers. (Employers must pay for most types of required personal protective equipment.)
- Provide hearing exams or other medical tests when required by OSHA standards.
- Post OSHA citations and annually post injury and illness summary data where workers can see them.
- Prominently display the official OSHA Job Safety and Health - It's the Law poster that describes rights and responsibilities under the OSH Act.
- Not retaliate or discriminate against workers for using their rights under the law, including their right to report a work-related injury or illness.

Workers have the right to

- Working conditions that do not pose a risk of serious harm.
- File a confidential complaint with OSHA to have their workplace inspected.
- Receive information and training about hazards, methods to prevent harm, and the OSHA standards that apply to their workplace. The training must be done in a language and vocabulary workers can understand.
- Receive copies of records of work-related injuries and illnesses that occur in their workplace.
- Receive copies of the results from tests and monitoring done to find and measure hazards in their workplace.
- Receive copies of their workplace medical records.

- Participate in an OSHA inspection and speak in private with the inspector.
- File a complaint with OSHA if they have been retaliated or discriminated against by their employer as the result of requesting an inspection or using any of their other rights under the OSH Act.
- File a complaint if punished or retaliated against for acting as a "whistleblower" under the 21 additional federal laws for which OSHA has jurisdiction.

5.3 SAFE WORKING ENVIRONMENT

1. Entry and exit

Workers must be able to safely enter and leave the workplace. This may include making sure that any workers with special needs or disabilities can safely enter and exit.

2. Housekeeping

Keeping the workplace clean and tidy can minimize injuries resulting from slips and trips. This includes providing sufficient space for storage.

3. Work areas

There should be sufficient clear space between furniture, fixtures and fittings so that the workers can move about freely without strain or injury, and can also evacuate quickly in case of an emergency.

4. Floors and other surfaces

Floor surfaces should be suitable for the work area. The type of floor surfaces or coverings (e.g. carpet) in use will depend on the type of work carried out as well as materials used during the work process.

Floors should be inspected regularly and maintained to eliminate slip and trip hazards.

Common examples of hazards include trailing cables, uneven edges or broken surfaces, gratings or covers, loose mats or carpet tiles.

5. Workstations

Workstations should be designed so that the workers can carry out their work in a comfortable, upright position. It is best to provide adjustable workstations to make the work height suitable for the person and the task. Seating should provide good body and foot support (especially for the lower back) and allow adequate space for leg clearance and freedom of movement.

6. Lighting

Sufficient lighting (natural or artificial) to allow safe movement around the workplace and for the workers to perform their work without having to strain their eyes. Emergency lighting for the safe evacuation of people in the event of an emergency.

7. Air quality

Workplace should be adequately ventilated with fresh, clean air. Workplaces may have natural ventilation, mechanical ventilation (fans or extraction units) or air- conditioning. Natural ventilation should consist of permanent openings, including windows and doors, and may be assisted by mechanical ventilation.

Air-conditioning and other ventilation systems should be regularly serviced and maintained in accordance with the manufacturer's instructions.

Work processes that release harmful substances should have specific controls to extract these at the source e.g. local exhaust ventilation.

8. Heat and cold

Workers must be able to carry out work in extreme heat or cold without a risk to their health and safety, so far as is reasonably practicable. Comfortable temperature for the workers with the use of air-conditioning, fans, electric heating and open windows, and by controlling airflow and the source of drafts.

9. Welfare facilities

Workers with access to adequate welfare facilities, including

- clean drinking water
- clean toilets

- Hand washing facilities.
- hygienic dining facilities
- accessible and secure personal storage
- Showering facilities.

10. Remote or isolated work

Isolated work means work that is isolated from the assistance of other people - including rescue, medical assistance and emergency services - because of the location, time or nature of the work being done.

Identify and manage the risks associated with any remote or isolated work. Risk means anything that may cause harm to workers or other people at your workplace.

This will involve

- identifying any problems (known as hazard identification) - exposure to violence and poor
- access to emergency assistance are the main hazards that increase the risk of remote or isolated work
- making an assessment of the risks (determining how serious the problems are)
- Finding ways to control the risks (deciding what needs to be done about the problem).

11. Emergency plans

Prepare an emergency plan for the workplace that includes:

- emergency procedures
- testing of the emergency procedures
- Information, training and instructions to relevant workers in relation to carrying out the emergency procedures.

5.4 FACTORIES ACT

The object of the Factories Act is to regulate the conditions of work in manufacturing establishments coming within the definition of the term "factory" as used in the Act.

The first Act, in India, relating to the subject was passed in 1881.

According to the Factories Act, 1948, a 'factory' means "any premises including the precincts thereof –

(i) whereon ten or more workers are working, or were working on any day of the preceding twelve months, and in any part of which a manufacturing process is being carried on with the aid of power, or is ordinarily so carried on, or

(ii) whereon twenty or more workers are working, or were working on any day of the preceding twelve months, and in any part of which a manufacturing process is being carried on without the aid of power, or is ordinarily so carried on; but this does not include a mine subject to the operation of the Mines Act, 1952 , or a mobile unit belonging to the armed forces of the union, a railway running shed or a hotel, restaurant or eating place."

The Act is administered by the Ministry of Labor and Employment through its Directorate General Factory Advice Service & Labor Institutes (DGFASLI) and by the State Governments through their factory inspectorates. DGFASLI was set up with the objective of advising the Central and State Governments on administration of the Factories Act and coordinating the factory inspection services in the States. It serves as a technical arm to assist the Ministry in formulating national policies on occupational safety and health in factories and docks. It also advises factories on various problems concerning safety, health, efficiency and well- being of the persons at work places.

5.4.1 The important provisions of the Act are as follows: -

- No adult worker shall be required or allowed to work in a factory: - (i) for more than forty-eight hours in any week; and/ or (ii) for more than nine hours in any day.

- Where a worker works in a factory for more than nine hours in any day or for more than forty-eight hours in any week, he shall, in respect of overtime work, be entitled to wages at the rate of twice his ordinary rate of wages.

- The 'ordinary rate of wages' means the basic wages plus such allowances, including the cash equivalent of the advantage accruing through the concessional sale to workers of food grains and other articles, as the worker is for the time being entitled to, but does not include a bonus and wages for overtime work.

- Where a worker is deprived of any of the weekly holidays, he shall be allowed, within the month in which the holidays were due to him or within the two months immediately following that month, compensatory holidays of equal number to the holidays so lost.

- The periods of work of adult workers in a factory each day shall be so fixed that no period shall exceed five hours and that no worker shall work for more than five hours before he has had an interval for rest of at least half an hour.

- Every worker who has worked for a period of 240 days or more in a factory during a calendar year shall be allowed during the subsequent calendar year, leave with wages for a number of days calculated at the rate of - (i) if an adult, one day for every twenty days of work performed by him during the previous calendar year

(ii) if a child, one day for every fifteen days of work formed by him during the previous calendar year. In the case of a female worker, maternity leave for any number of days not exceeding twelve weeks.

5.4.2 In order to safeguard the health of the workers: -

- Every factory shall be kept clean and free from effluvia arising from any drain, privy or other nuisance and in particular accumulations of dirt.

- Effective arrangements shall be made in every factory for the treatment of wastes and effluents due to the manufacturing process carried on therein, so as to render them innocuous and for their disposal.

- Effective and suitable provision shall be made in every factory for securing and maintaining in every workroom adequate ventilation by the circulation of fresh air; and such a temperature that will secure to workers reasonable conditions of comfort and prevent injury to health.

- No room in any factory shall be overcrowded to an extent injurious to the health of the workers employed therein.

- Every part of a factory, where workers are working or passing, shall be provided with sufficient and suitable lighting, natural or artificial, or both.

- In every factory effective arrangement shall be made to provide, at suitable points conveniently situated for all workers employed therein, a sufficient supply of wholesome drinking water.

5.4.3 In order to ensure safety of the workers: -

- Every dangerous part of any machinery shall be securely fenced and constantly maintained to keep it in position.

- No young person shall be required or allowed to work at any dangerous machine

unless he has been fully instructed as to the dangers arising from it and the precautions to be observed as well as has received sufficient training in work at the machine.

- No woman or child shall be employed in any part of a factory for pressing cotton in which a cotton-opener is at work (subject to the given conditions).

- In every factory every hoist and lift shall be - (i) of good mechanical construction, sound material and adequate strength; (ii) properly maintained, and thoroughly examined by a competent person at least once in every period of six months.

- No person shall be required or allowed to enter any chamber, tank, vat, pit, pipe, flue or other confined space in any factory in which any gas, fume, vapor or dust is likely to be present to such an extent as to involve risk to the workers, unless it is provided with a manhole of adequate size or other effective means of egress.

5.4.4 Certain facilities to be provided to the workers: -

- Every factory shall provide and maintain readily accessible first-aid boxes or cupboards equipped with the prescribed contents, and the number of such boxes or cupboards shall not be less than one for every one hundred and fifty workers ordinarily employed at any one time in the factory.

- In any factory wherein more than two hundred and fifty workers are ordinarily employed, a canteen or canteens shall be provided and maintained by the occupier for the use of the workers.

- In every factory wherein more than one hundred and fifty workers are ordinarily employed, adequate and suitable shelters, rest rooms and lunch room, with provision for drinking water, where workers can eat meals brought by them, shall be provided and maintained for the use of the workers.

- In every factory wherein more than thirty women workers are ordinarily employed, there shall be a suitable room or rooms for the use of children under the age of six years of such women. Such rooms shall provide adequate accommodation, lighting and ventilation with clean and sanitary condition.

The Factories Act empowers the State Government to appoint Inspectors, Chief Inspectors of Factories, Additional Chief Inspectors, Joint Chief Inspectors and Deputy Chief Inspectors. Every District

Magistrate is an Inspector for his district. No person can act as an Inspector if. he is or becomes directly or indirectly interested in a factory or in any process or business carried on therein or in any patent or machinery connected therewith

5.4.5 Powers of Inspectors.

(a) enter, with such assistants, being persons in the service of the Government or any local or other public authority, as he thinks fit, and place which is used, or which he has reason to believe is used, as a factory;

(b) Make examination of the premises, plant and machinery;

(c) Require the production of any prescribed register and any other document relating to the factory, and take on the spot or otherwise statements of any person which he may consider necessary for carrying out the purposes of the Act; and.

(d) Exercise such other powers as may be prescribed for carrying out the purposes of this Act. No person shall be compelled under this section to answer any question or give any evidence tending to incriminate himself.

Under Section 91, an Inspector may take a sample of any substance, used or Intended to be used in a factory, for the purpose of finding out whether the substance is injurious and if the factory is violating any of the provisions of the Act.

5.4.6 Duties of Inspector.

It is the duty of factory inspectors to enforce the provisions of the Factories Act and other industrial laws. For this purpose, they inspect factories periodically. If any rule is violated, they take steps like prosecuting the guilty persons etc.

1. Cleanliness. Every factory shall be kept clean and free from dirt, and the outflow of drains etc. The floors must be cleaned. Drainage shall be provided. Inside walls, partitions and ceilings must be repainted at least once in five years. When washable water paint is used, they must be painted once every three years and washed at least every period of six months.

2. Disposal of wastes and effluents. The waste materials produced from the manufacturing process must be effectively disposed off

3. Ventilation 'and Temperature. There must be provision for adequate ventilation by the circulation of fresh air: The temperature must be kept at a comfortable level. Hot parts of machines must be separated and insulated.

4. Dust and Fume. If the manufacturing process used gives off injurious or offensive dust and fume steps must be taken so that they are not inhaled or accumulated. The exhaust fumes of internal combustion engines must be conducted outside the factory.

5. Artificial humidification. The water used for this purpose must be pure. It must be taken from some source of drinking water supply. The State Government can frame rules. regarding the process of humidification

6. Over Crowding. There must be no overcrowding in a factory. In factories existing before the commencement of the Act there must be at least 350 c.ft. (~r 55 cubic metres) of space per worker. For factories built afterwards, there must be at least 500 c.ft. (or 75 cubic metres) of space.

In calculating the space, an account is to be taken of space above 14 ft. (or 5 meters) from the floor.

7. Lighting. Factories must be well lighted. Effective measures must be adopted to prevent glare or formation of shadows which might cause eyestrain.

8. Drinking water. Arrangements must be made to provide a sufficient supply of wholesome drinking water. All supply' points of such water must be marked "drinking water". No such points shall be within 20 ft. (or 7.5 meters) of any latrine, washing place etc. Factories employing more than 250 workers must cool the water during the hot weather.

9. Latrines and Urinals. Every factory must provide' sufficient number of latrines and urinals. There must be separate provision for male and female workers. Latrine and urinals must be kept in a clean and sanitary condition. In factories. employing more than 250 workers, they shall be of prescribed sanitary types.

5.5 EMPLOYEE STATE INSURANCE ACT

The Employee State Insurance Act, [ESI] 1948, is a piece of social welfare legislation enacted primarily with the object of providing certain benefits to employees in case of sickness, maternity and employment injury and also to make provision for certain others matters incidental thereto. This act becomes a wider spectrum than factory act. In the sense that while the factory act concerns with the health, safety, welfare, leave etc of the workers employed in the factory premises only. But the benefits of this act extend to employees whether working inside the factory or establishment or elsewhere or they are directly employed by the principal employee or through an intermediate agency, if the employment is incidental or in connection with the factory or establishment.

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

The ESI Act is a social welfare legislation enacted with the object of providing certain benefits to employees in case of sickness, maternity and employment injury. Under the Act, employees will receive medical relief, cash benefits, maternity benefits, pension to dependents of deceased workers and compensation for fatal or other injuries and diseases.

5.5.1 Employers' / Employees' Contribution

Like most of the social security schemes, the world over, ESI scheme is a self- financing health insurance scheme. Contributions are raised from covered employees and their employers as a fixed percentage of wages. Presently covered employees contribute 1.75% of the wages, whereas as the employers contribute 4.75% of the wages, payable to the insured persons.

Employees earning less than and up to Rs. 50 per day are exempted from payment of contribution. The contribution is deposited by the employer in cash or by cheque at the designated branches of some nationalized banks. The responsibility for payment of all contributions is that of the employer with a right to deduct the employees share of contribution from employees‟ wages relating to the period in respect of which the contribution is payable.

There are two contribution periods each of six months duration and two corresponding benefit periods. Cash benefits under the scheme are generally linked with contribution paid.

Contribution period - 1st April to 30th September, its corresponding Cash Benefit period is 1st January to 30th June of the following year. Contribution period - 1st October to 31st March, its corresponding Cash Benefit period is 1st July to 31st December of the following year.

Benefits under the Scheme 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 thereof are as under:

Medical benefits

- From day one of entering insurable employment for self and dependents such as spouse, parents and children own or adopted.

- For self and spouse on superannuation subject to having completed five years in insurable employment on superannuation or in case of having suffered permanent physical disablement during the course of insurable employment.

Sickness benefits

- Sickness benefit is payable to an insured person in cash, in the event of sickness resulting in absence from work and duly certified by an authorized insurable medical officer/ practitioner. The benefit becomes admissible only after an insured has paid contribution for at least 78 days in a contribution period of 6 months.

- Sickness benefit is payable for a maximum of 91 days in two consecutive contribution period.

Extended sickness benefit

- Extended sickness benefit is payable to insured persons for the period of certified sickness in case of specified 34 long-term diseases that need prolonged treatment and absence from work on

- medical advice.

- For entitlement to this benefit an insured person should have been in insurable

- employment for at least 2 years. He/ she should also have paid contribution for a minimum of 156 days in the preceding 4 contribution periods or say 2 years.

- ESI is payable for a maximum period of 2 years on the basis of proper medical certification and authentication by the designated authority.

- Amount payable in cash as extended sickness benefit is payable within 7 days following the submission of complete claim papers at the local office concerned. Enhanced sickness benefit

- This cash benefit is payable to insured persons in the productive age group for undergoing sterilization operation, viz., vasectomy/ tubectomy.

- The contribution is the same as for the normal sickness benefit. o Enhanced sickness benefit is payable for 14 days for tubectomy and for seven days in case of vasectomy.

Maternity benefit

- Maternity benefit is payable to insured women in case of confinement or miscarriage or sickness related thereto. o for claiming this an insured woman should have paid for at least 70 days in 2 consecutive contribution periods i.e. 1 year.

- The benefit is normally payable for 12 weeks, which can be further extended up to 16 weeks on medical grounds.

- The rate of payment of the benefit is equal to wage or double the standard sickness benefit rate.

- The benefit is payable within 14 days of duly authenticated claim papers

Disablement benefit

- Disablement benefit is payable to insured employees suffering from physical disablement due to employment injury or occupation disease.

Dependents benefit

- Dependents benefit [family pension] is payable to dependents of a deceased insured person where death occurs due to employment or occupational disease.

- A widow can receive this benefit on a monthly basis for life or till remarriage. A son or daughter can receive this benefit till 18 years of age.

- Other dependents like parents including a widowed mother can also receive the benefit under certain condition.

- The rate of payment is about 70% of the wages shareable among dependents in a fixed ratio.

- The first installment is payable within a maximum of 3 months following the death of an insured person and thereafter, on a regular monthly basis.

Other benefits like funeral expenses, vocational rehabilitation, free supply of physical aids and appliances, preventive health care and medical bonus.

Records to Be Maintained for Inspection by ESI authorities

1. Attendance Register / Muster Roll

2. Salary / Wage Register / Payroll

3. EC (Employee's & Employer's Contribution) Statement

4. Employees" Register

5. Accident Book

6. Return of Contribution

7. Return of Declaration Forms 8. Receipted Copies of Challans

9. Books of Account viz. Cash/Bank, Expense Register, Sales/Purchase Register, Petty Cash

Book, Ledger, Supporting Bills and Vouchers, Delivery Challans

10. Form of annual information on company

5.5.2 Employees Insurance Court

Any dispute arising under the ESI Act will be decided by the Employees Insurance

Court and not by a Civil Court. It is constituted by the State Government for such local areas as may be specified and consists of such number of judges, as the Government may think fit. It shall adjudicate on the following disputes and claims.

Disputes as to:

i.Whether an employee is covered by the Act or whether he is liable to pay the contribution, or

ii. The rate of wages or average daily wages of an employee, or

iii. The rate of contribution payable by the employer in respect of any employee, or

iv. The person who is or was the principle employer in respect of any employee, or

v. The right to any benefit and the amount and duration thereof, or

vi. Any direction issued by the Corporation on a review of any payment of dependents benefit, or

vii. Any other matter in respect of any contribution or benefit or other due payable or recoverable under the Act.

5.6 WORKMEN COMPENSATION ACT

The Workmen's Compensation Act, aims to provide workmen and/or their dependents some relief in case of accidents arising out of and in the course of employment and causing either death or disablement of workmen. It provides for payment by certain classes of employers to their workmen compensation for injury by accident.

5.6.1 Employees Entitled to Compensation:

Every employee (including those employed through a contractor but excluding casual employees), who is engaged for the purposes of employer's business and who suffers an injury in any accident arising out of and in the course of his employment, shall be entitled for compensation under the Act.

Employers Liability for Compensation (Accidents)

The employer of any establishment covered under this Act, is required to compensate an employee:

a. Who has suffered an accident arising out of and in the course of his employment, resulting into

(i) death,

(ii) permanent total disablement,

(iii) permanent partial disablement, or

(iv) temporary

disablement whether total or partial, or

b. Who has contracted an occupational disease.

Employer Shall Not Be Liable:

a. In respect of any injury which does not result in the total or partial disablement of the workmen for a period exceeding three days;

b. In respect of any injury not resulting in death, caused by an accident which is directly attributable to

i. the workmen having been at the time thereof under the influence or drugs, or

ii. the willful 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 willful removal or disregard by the workmen of any safeguard or other device which he knew to have been provided for the purpose of securing the safety

of workmen. The burden of proving intentional disobedience on the part of the employee shall lie upon the employer.

iv. when the employee has contacted a disease, which is not directly attributable to a specific injury caused by the accident or to the occupation; or

v. when the employee has filed a suit for damages against the employer or any other person, in a Civil Court.

5.6.2 Definition of Disablement

Disablement is the loss of the earning capacity resulting from injury caused to a workman by an accident.

Disablements can be classified as

(a) Total, and

(b) Partial.

It can further be classified into (i)Permanent, and

(ii) Temporary, Disablement, whether permanent or temporary is said to be total when it incapacitates a worker for all work, he was capable of doing at the time of the accident resulting in such disablement.

Total disablement is considered to be permanent if a workman, as a result of an accident, suffers from the injury specified in Part I of Schedule I or suffers from such combination of injuries specified in Part II of Schedule I as would be the loss of earning capacity when totaled to one hundred per cent or more.

Disablement is said to be permanent partial when it reduces for all times, the earning capacity of a workman in every employment, which he was capable of undertaking at the time of the accident. Every injury specified in Part II of Schedule I is deemed to result in permanent partial disablement.

Temporary disablement reduces the earning capacity of a workman in the employment in which he was engaged at the time of the accident.

5.6.3 General principles of the Act

There must be a causal connection between the injury and the accident and the work done in the course of employment;

The onus is upon the applicant to show that it was the work and the resulting strain which contributed to or aggravated the injury;

It is not necessary that the workman must be actually working at the time of his death or that death must occur while he was working or had just ceased to work; and Where the evidence is balanced, if the evidence shows a greater probability which satisfies a reasonable man that the work contributed to the causing of the personal injury it would be enough for the workman to succeed. But where the accident involved a risk common to all humanity and did not involve any peculiar or exceptional danger resulting from the nature of the employment or where the accident was the result of an added peril to which the workman by his own conduct exposed himself, which peril was not involved in the normal performance of the duties of his employment, then the employer will not be liable.

TEXT / REFERENCE BOOKS

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