
KTU
NOTES

MODULE 5
HAZARD IDENTIFICATION AND ANALYSIS

Syllabus : Hazard and risk, Types of hazards -Classification of Fire, Types of Fire extinguishers, fire explosion and toxic gas release, Structure of hazard identification and risk assessment. Identification of hazards: Inventory analysis, Fire and explosion hazard rating of process plants The Dow Fire and Explosion Hazard Index, Preliminary hazard analysis, Hazard and Operability study (HAZOP)) methodology, criticality analysis, corrective action and follow-up. Control of Chemical Hazards, Hazardous properties of chemicals, Material Safety Data Sheets (MSDS).

HAZARD AND RISK

Hazard is a source or a situation with potential to cause harm in terms of human injury or ill-health, damage to property or environment or both. Hazards are identified in the performance of various activities, storage and handling of materials, and operation and maintenance of plants and equipment's.
Hazard control is that function which is oriented towards recognizing, evaluating and working towards eliminating hazards and destructive effects found at the work-place.

RISK:
A hazard is something that has the potential to cause harm while risk is the likelihood of harm taking place, based on exposure to that hazard. A hazard is something that can cause harm, e.g. electricity, chemicals, working up a ladder, noise, a keyboard, a bully at work, stress, etc. A risk is the chance, high or low, that any hazard will actually cause somebody harm.

TYPES OF HAZARDS
Hazards may be classified as under:
• Mechanical Hazards.
• Electrical Hazards.
• Chemical Hazards.

1. Mechanical Hazards:
These are responsible for the majority of the accidents in work situations, therefore every workplace and equipment should be properly examined for identifying mechanical hazards and for taking mitigating measures.

Common sources of mechanical hazards are:
(a) Unguarded or inadequately guarded moving parts or pits etc.
(b) Machine tools, hand tools, handling materials, lifting and other appliances.
(c) Improper ventilation, unsafe dress or apparel etc.
(d) Improper use of tools.

2. Electrical Hazards:
These may be due to contact of body with wire, cable or rail or from stroke of lightening. The immediate effect of this is shock which may be relatively mild or severe so as to cause death (electrocution) depending upon the strength of the current and/or the path it takes passing the earth through the body. Another result is burning and the burns may be severe and deep, especially with higher voltage.

Causes of the electric hazards may be of the following types:
(a) Electric shocks may be caused by an exposed live conductor or a faulty piece of equipment.
(b) A mobile crane boom, a man carrying aluminium ladder, or vertical metal bars etc. can come in contact with overhead power lines, electric crane rails, open- faced substation switchboards etc.
(c) Other causes may be unskilled electricians, improper, instructions, defective wiring which may cause short circuit, poor installations, misuse or overloading.
(d) Ageing and attack by foreign materials causes insulation failures which causes elec-trical fires or cases of electrocution.

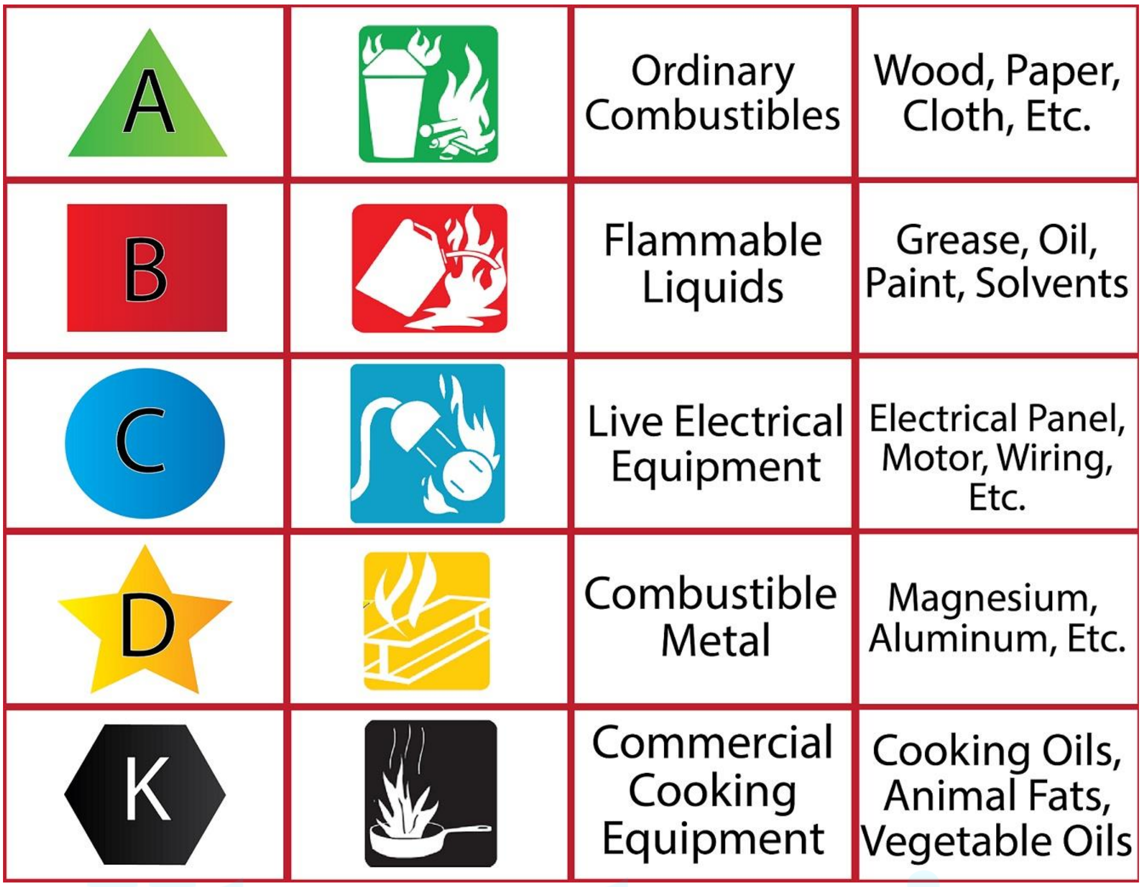
3. Chemical Hazards:
The usage of chemicals with the resultant hazardous gases, vapours and fumes is one of the most dangerous industries.

The effects of noxious gases are:
(a) Simple asphyxiants, e.g., nitrogen gas, methane gas, carbon dioxide. AMPLE COPY
(b) Chemical osphysciants, e.g., carbon monoxide, hydrogen- sulphide, hydro-cyanic acid.
(c) Irritant gases, e.g., nitrogen dioxide or peroxide, flourine, hydrogen flouride, sulphur dioxide, ammonia.
(d) Organic metallic gases, e.g., assenic hydride.
(e) Inorganic metallic gases.

CLASSES OF FIRE

While fire can seem like one big threatening force, it's important to know that there are actually several classes of fires. A fire's class can determine how quickly it burns, how dangerous it is, and the best way to suppress or put it out. The 5 different classes of fires each have their own best approach to put them out safely and effectively.
The 5 main classes of fires are categorized by what caused the fire or what the fire uses as fuel, and are as follows:

Class A: solid materials such as wood or paper, fabric, and some plastics
Class B: liquids or gas such as alcohol, ether, gasoline, or grease
Class C: electrical failure from appliances, electronic equipment, and wiring
Class D: metallic substances such as sodium, titanium, zirconium, or magnesium
Class K: grease or oil fires specifically from cooking



A		Ordinary Combustibles	Wood, Paper, Cloth, Etc.
B		Flammable Liquids	Grease, Oil, Paint, Solvents
C		Live Electrical Equipment	Electrical Panel, Motor, Wiring, Etc.
D		Combustible Metal	Magnesium, Aluminum, Etc.
K		Commercial Cooking Equipment	Cooking Oils, Animal Fats, Vegetable Oils

Class A Fire

Class A fires are the most common type of fire. They are produced from common combustible materials including wood, paper, fabric, rubber, and plastic. Class A fires have relatively low ignition temperatures, and once the fuel or oxygen has been depleted, the fire will burn out. A garbage fire is one example of Class A fires. Generally speaking, if the fire leaves ash behind, it's likely a Class A Fire.
Water and foam agents are most often used when fighting Class A fires.

Class B Fire

Class B fires occur when flammable liquids or gases such as alcohol, kerosene, paint, gasoline, methane, oil-based coolants, or propane ignite. Class B fires are most common in industrial settings, but they may also occur in residential or commercial settings. Class B fires have a low flashpoint, which means they burn easily at any temperature if exposed to a fire source. Class B fires also spread rapidly and produce a thick black smoke as they burn.
Water is not effective when dealing with Class B fires. Instead, Carbon Dioxide (CO_2) or dry chemical agents are often used to fight these fires.

Class C Fire

Class C fires are those fires that have live electrical currents or electrical equipment as a source of fuel. Such fuel sources could include electric tools, appliances, motors, and transformers. Class C fires are most common in industrial settings that deal with energy or electrically-powered equipment, like wind turbines. However, Class C fires can also occur in commercial or residential settings due to issues like faulty wiring.

Electrical fires cannot be fought with water-in fact, it can make it worse. Instead, a non-conductive chemical agent, including clean agents, should be used to put out the flames.

Class D Fires

Class D fires describe those fires that occur with a ombustible metal fuel source. Common combustible metals include aluminum, lithium, magnesium, potassium, titanium, and zirconium. These types of combustible metals are most often used in laboratories and in manufacturing, so the biggest danger for Class D fires occurs in these industries.
Water can cause some combustible metals to explode, so it should not be used to fight Class D fires. Instead, dry powder agents can be used to absorb heat and smother the flames by blocking off the fire's oxygen supply.

Class K Fire

Finally, Class K fires are cooking fires that occur as a result of the combustion of a cooking liquid like grease, oil, vegetable fat, or animal fat. Class K fires are technically a type of liquid fire, but they are separated out as their own class because of their unique setting. Class K fires are most common in the food service and restaurant industry, but can occur in any kitchen. Like other liquid fires, water should not be sprayed onto Class K fires. Instead, wet chemical agents are the best method to use.

TYPES OF FIRE EXTINGUISHERS

Different types of fire extinguishers exist in order to address the 5 different classes of fires. Each fire class describes the fuel or material a fire is burning or what caused it to start - therefore, using the right extinguisher is essential to put out the fire safely.

Water

Water is the primary liquid used in these extinguishers, although sometimes other additives are also included. A drawback for pure water fire extinguishers is that it is not suitable for use in freezing conditions since the water inside will freeze and render the extinguisher unusable. Certain types of water fire extinguishers contain antifreeze which will allow the extinguisher to be used in freezing conditions. Water type fire extinguishers which are designed also sometimes contain wetting agents fire. These extinguishers are intended primarily for use on Class to help increase its effectiveness against A fires.

Water mist extinguishers are a type of water fire extinguisher that uses distilled water and discharges it as a fine spray instead of a solid stream. Water mist extinguishers are used where contaminants in unregulated water sources can cause excessive damage to personnel or equipment. Typical applications include operating rooms, museums, and book collections.

Film-forming foam type

AFFF (aqueous film-forming foam) and FFFP (film-forming fluoroprotein) fire extinguishers are rated for use on both Class A and Class B fires. As the name implies, they discharge a foam material rather than a liquid or powder. They are not suitable for use in freezing temperatures. An advantage of this type of extinguisher when used on Class B flammable liquid fires of appreciable depth is the ability of the agent to float on and secure the liquid surface, which helps to prevent reignition.

Carbon Dioxide type

The principal advantage of Carbon Dioxide (CO_2) fire extinguishers is that the agent does not leave a residue after use. This can be a significant factor where protection is needed for delicate and costly electronic equipment. Other typical applications are food preparation areas, laboratories, and printing or duplicating areas. Carbon dioxide extinguishers are listed for use on Class B and Class C fires. Because the agent is discharged in the form of a gas/snow cloud, it has a relatively short range of 3 ft to 8 ft (1 m to 2.4 m). This type of fire extinguisher is not recommended for outdoor use where windy conditions prevail or for indoor use in locations that are subject to strong air currents, because the agent can rapidly dissipate and prevent extinguishment. The concentration needed for fire extinguishment reduces the amount of oxygen in the vicinity of the fire and should be used with caution when discharged in confined spaces.

Halogenated agent types

i. Halon

The bromochlorodifluoromethane (Halon 1211) fire extinguisher has an agent that is similar to carbon dioxide in that it is suitable for cold weather installation and leaves no residue. It is important to note that the production of Halon has been phased out because of the environmental damage it causes to the earth's ozone. Some larger models of Halon 1211 fire extinguishers are listed for use on Class A as well as Class B and Class C fires. Compared to carbon dioxide on a weight-of-agent basis, bromochlorodifluoromethane (Halon 1211) is at least twice as effective. When discharged, the agent is in the the agent is in the combined form of a gas/mist with about twice the range of carbon dioxide. To some extent, windy conditions or strong air currents could make extinguishment difficult by causing the rapid dispersal of the agent.

ii. Halon Alternative Clean Agents

There are several clean agents that are similar to halon agents in that they are nonconductive, noncorrosive, and evaporate after use, leaving no residue. Larger models of these fire extinguishers are listed for Class A as well as Class B and Class C fires, which makes them quite suitable for use on fires in electronic equipment. When discharged, these agents are in the combined form of a gas/mist or a liquid, which rapidly evaporates after discharge with about twice the range of carbon dioxide. To some extent, windy conditions or strong air currents could make extinguishing difficult by causing a rapid dispersal of agent. Clean agent type extinguishers don't have adetrimental effect on the earth's ozone so these are more widely available than Halon type extinguishers.

Dry chemical types

i. Ordinary Dry Chemical

The fire extinguishing agent used in these devices is a powder composed of very small particulates. Types of agents available include sodium bicarbonate base and potassium bicarbonate base. Dry chemical type extinguishers have special treatments that ensure proper flow capabilities by providing resistance to packing and moisture absorption (caking).

ii. Multipurpose Dry Chemical

Fire extinguishers of this type contain an ammonium phosphate base agent. Multipurpose agents are used in exactly the same manner as ordinary dry chemical agents on Class B fires. For use on Class A fires, the multipurpose agent has the additional characteristic of softening and sticking when in contact with hot surfaces. In this way, it adheres to burning materials and forms a coating that smothers and isolates the fuel from air. The agent itself has little cooling effect, and, because of its surface coating characteristic, it cannot penetrate below the burning surface. For this reason, extinguishment of deep-seated fires might not be accomplished unless the agent is discharged below the surface or the material is broken apart and spread out.

Wet chemical

The extinguishing agent can be comprised of, but is not limited to, solutions of water and potassium acetate, potassium carbonate, potassium citrate, or a combination of these chemicals (which are conductors of electricity). The liquid agent typically has a pH of 9.0 or less. On Class A fires, the agent works as a coolant. On Class K fires (cooking oil fires),forms a foam blanket to prevent reignition. The water content of the agent aids in cooling and reducing the temperature of the hot oils and fats below their auto ignition point. The agent, when discharged as a fine spray directly at cooking appliances, reduces the possibility of splashing hot grease and does not present a shock hazard to the operator. Wet chemical extinguishers also offer improved visibility during firefighting as well as minimizing cleanup afterward.

Dry powder types

These fire extinguishers and agents are intended for use on Class D fires and specific metals, following special techniques and manufacturer's recommendations for use. The extinguishing agent can be applied from a fire extinguisher or by scoop and shovel. Using a scoop or shovel is often referred to as a hand propelled fire extinguisher.

STRUCTURE OF HAZARD IDENTIFICATION AND RISK ASSESSMENT

One of the "root causes" of workplace injuries, illnesses, and incidents is the failure to identify or recognize hazards that are present, or that could have been anticipated. A critical element any effective safety and health program is a proactive, ongoing process to identify and assess such hazards.

To identify and assess hazards, employers and workers:

- Collect and review information about the hazards present
- Collect or likely to be present in the workplace.
- Conduct initial and periodic workplace inspections of the workplace to identify new or recurring hazards.
- Investigate injuries, illnesses, incidents, and close calls/near misses to determine the underlying hazards, their causes, and safety and health program shortcomings.
- Group similar incidents and identify trends in injuries, illnesses, and hazards reported.
- Consider hazards associated with emergency or non routine situations.
- Determine the severity and likelihood of incidents that could result for each hazard identified, and use this information to prioritize corrective actions.

HAZARD IDENTIFICATION

Action item 1: Collect existing information about workplace hazards

Information on workplace hazards may already be available to employers and workers, from both internal and external sources.

How to accomplish it

Collect, organize, and review information with workers to determine what types of hazards may be present and which workers may be exposed or potentially exposed. Information available in the workplace may include:

- Equipment and machinery operating manuals.
- Safety Data Sheets (SDS) provided by chemical manufacturers.
- Self-inspection reports and inspection reports from insurance carriers, government agencies, and consultants.
- Records of previous injuries and illnesses.
- Workers' compensation records and reports.
- Patterns of frequently-occurring injuries and illnesses.
- Exposure monitoring results, industrial hygiene assessments, and medical records (appropriately redacted to ensure patient/worker privacy).
- Existing safety and health programs (lockout/tagout, confined spaces, process safety management, personal protective equipment, etc.).
- Input from workers, including surveys or minutes from safety and health committee meetings.
- Results of job hazard analyses, also known as job safety analyses.

Information about hazards may be available from outside sources, such as:

- National Safety Council, and Department of Labour & Employment websites, publications, and alerts.
- Trade associations.
- Labor unions, state and local occupational safety and health committees/coalitions and worker advocacy groups.
- Safety and health consultants.

Action item 2: Inspect the workplace for safety hazards

Hazards can be introduced over time as workstations and processes change, equipment or tools become worn, maintenance is neglected, or housekeeping practices decline. Setting aside time to regularly inspect the workplace for hazards can help identify shortcomings so that they can be addressed before an incident occurs.

How to accomplish it

- Conduct regular inspections of all operations, equipment, work areas and facilities. Have workers participate on the inspection team and talk to them about hazards that they see or report.

- Be sure to document inspections so we can later verify that hazardous conditions are corrected. Take photos or videos of problem areas to facilitate later discussion and brainstorming about how to control them, and for use as learning aides.
- Include all areas and activities in these inspections, such as storage and warehousing, facility and equipment maintanence, purchasing and office functions, and the activities of on-site contractors, sub contractors and temporary employees.
- Regularly inspect both plant vehicles (e.g., forklifts, powered industrial trucks) and transport vehicles (e.g., cars, trucks).
- Use checklists that highlight things to look for. Typical hazards fall into several major categories, such as those listed below; each workplace will have its own list:

    - General housekeeping
    - Slip,trip,fall hazards
    - Electrical hazards
    - Fire protection
    - Work organization and process flow (including staffing and scheduling)
    - Work practices
    - Workplace violence
    - Equipment operation
    - Equipment maintenance
    - Ergonomic problems
    - Lack of emergency procedures

- Before changing operations, workstations, or workflow; making major organizational changes; or introducing new equipment, materials, or processes, seek the input of workers and evaluate the planned changes for potential hazards and related risks.

Note: Many hazards can be identified using common knowledge and available tools. For example, we can easily identify and correct hazards associated with broken stair rails and frayed electrical cords. Workers can be a very useful internal resource, especially if they are trained in how to identify and assess

Action item 3: Identify health hazards

Identifying workers' exposure to health hazards is typically more complex than identifying physical safety hazards. For example, gases and vapors may be invisible, often have no odor, and may an immediately noticeable harmful health effect. Health hazards include chemical hazards (solvents, adhesives, paints, toxic dusts, etc.), physical hazards (noise, radiation, heat, etc.), biological hazards (infectious diseases), and ergonomic risk factors (heavy lifting, repetitive motions, vibration). Reviewing workers' medical records (appropriately redacted to ensure patient/worker privacy) can be useful in identifying health hazards associated with workplace exposures.

How to accomplish it

- Identify chemical hazards -review SDS and product labels to identify chemicals in the workplace that have low exposure limits, are highly volatile, or are used in large quantities or in unventilated spaces. Identify activities that may result in skin exposure to chemicals.
- Identify physical hazards -identify any exposures to excessive noise (areas where we must raise our voice to beheard by others), elevated heat (indoor and outdoor), or sources of radiation (radioactive materials, X-rays, or radiofrequency radiation).
- Identify biological hazards -determine whether workers may be exposed to sources of infectious diseases, molds, toxic or poisonous plants, or animal materials (fur or scat) capable of causing allergic reactions or occupational asthma.
- Identify ergonomic risk factors -examine work activities that require heavy lifting, work above shoulder height, repetitive motions, or tasks with significant vibration.
- Conduct quantitative exposure assessments –when possible, using air sampling or direct reading instruments.
- Review medical records -to identify musculoskeletal injuries, skin irritation or dermatitis, hearing loss, or lung disease that may be related to workplace exposures

Action item 4: Conduct incident investigations

Workplace incidents -including injuries, illnesses, close calls/near misses, and reports of other concerns- provide a clear indication of where hazards exist. By thoroughly investigating incidents and reports, we can identify hazards that are likely to cause future harm. The purpose of an investigation must always be to identify the root causes (and there is often more than one) of the incident or concern, in order to prevent future occurrences.

How to accomplish it

- Develop a clear plan and procedure for conducting incident investigations, so that an investigation can begin immediately when an incident occurs. The plan should cover items such as:
  - Who will be involved
  - Lines of communication
  - Materials, equipment, and supplies needed
  - Reporting forms and templates
- Train investigative teams on incident investigation techniques, emphasizing objectivity and open- mindedness throughout the investigation process.
- Conduct investigations with a trained team that includes representatives of both management and workers.
- Investigate close calls/near misses.
- Identify and analyze root causes to address underlying program shortcomings that allowed the incidents to happen.
- Communicate the results of the investigation to managers, supervisors, and workers to prevent recurrence.

Effective incident investigations do not stop at identifying a single factor that triggered an incident. They ask the questions "Why?" and "What led to the failure?" For example, if a piece of equipment fails, a good investigation asks: "Why did it fail?" "Was it maintained properly?" "Was it beyond its service life?® and "How could this failure have been prevented?" Similarly, a good incident investigation does not stop when it concludes that a worker made an error. It asks such questions as: "Was the worker provided with appropriate tools and time to do the work?" "Was the worker adequately trained?" and "Was the worker properly supervised?"

Action item 5: Identify hazards associated with emergency and nonroutine situations

Emergencies present hazards that need to be recognized and understood. Nonroutine or infrequent tasks, including maintenance and startup/shutdown activities, also present potential hazards. Plans and procedures need to be developedfor responding appropriately and safely to hazards associated with foreseeable emergency scenarios and nonroutine situations.

How to accomplish it

- Identify foreseeable emergency scenarios and nonroutine tasks, taking into account the types of material and equipment in use and the location within the facility. Scenarios such as the following may be foreseeable:
  - Fires and explosions
  - Chemical releases
  - Hazardous material spills
  - Startups after planned or unplanned equipment shutdowns
  - Nonroutine tasks, such as infrequently performed maintenance activities
  - Structural collapse
  - Disease outbreaks
  - Medical emergencies
  - Weather emergencies & natural disasters
  - Workplace violence

Action item 6: Characterize the nature of identified hazards, identify interim control measures, and prioritize the hazards for control

The next step is to assess and understand the hazards identified and the types of incidents that could result from worker exposure to those hazards. This information can be used to develop interim controls and to prioritize hazards for permanent control.

How to accomplish it

- Evaluate each hazard by considering the severity of potential outcomes, the likelihood that an event or exposure will occur, and the number of workers who might be exposed.

- Use interim control measures to protect workers until more permanent solutions can be implemented.
- Prioritize the hazards so that those presenting the greatest risk are addressed first. Note, however, that employers have an ongoing obligation to control all serious recognized hazards and to protect workers.

Note: "Risk" is the product of hazard and exposure. Thus, risk can be reduced by controlling or eliminating the hazard or by reducing workers' exposure to hazards. An assessment of risk helps employers understand hazards in the context of their own workplace and prioritize hazards for permanent control.

RISK ASSESSMENT TOOLS

Risk assessment tools, sometimes called "risk assessment techniques," are procedures or frameworks that can be used in the process of assessing and managing risks. There are many ways to assess risk, making risk assessment tools flexible and

There are four commonly used risk assessment tools in different businesses. All of them are used often and are easily applicable to different situations. These tools are:

1. Risk matrix

2. Failure Mode and Effects Analysis (FMEA)

3. Decision Tree

4. Bowtie Model

1. Risk Matrix

A risk matrix is a visual representation of risks laid out in a diagram or a table, hence its alternate name as a risk diagram. Here, risks are divided and sorted based on their probability of happening and their effects or impact. A risk matrix is often used to help prioritize which risk to address first, what safety measures and risk mitigation plans to take, and how a certain task should be done. Risk matrices can come in any size and number of columns and rows, depending on the project and risks being discussed.

			Potential Consequences				
			L6	L5	L4	L3	L2
			Minor injuries or discomfort. No medical treatment or measureable physical effects.	Injuries or illness requiring medical treatment. Temporary impairment.	Injuries or illness requiring hospital admission.	Injury or illness resulting in permanent impairment.	Fatality
			Not Significant	Minor	Moderate	Major	Severe
Likelihood	Expected to occur regularly under normal circumstances	Almost Certain	Medium	High	Very High	Very High	Very High
	Expected to occur at some time	Likely	Medium	High	High	Very High	Very High
	May occur at some time	Possible	Low	Medium	High	High	Very High
	Not likely to occur in normal circumstances	Unlikely	Low	Low	Medium	Medium	High
	Could happen, but probably never will	Rare	Low	Low	Low	Low	Medium

2. FMEA

The Failure Mode and Effects Analysis (FMEA) risk assessment tool was first discovered in the 1940s by the US military to identify all possible issues or failures in a design, process, product, and service. This tool is often used during a product or service's design or proposal stage to actively study possible risks and discover their effects. FMEA has two parts to it:

- Failure Modes: the failures, problems, and issues that occur
- Effects Analysis: the analysis of the failures' effects

3. Decision Tree

The decision tree risk assessment tool works by providing project managers a template to calculate and visualize the values of different results and the likelihood of achieving them. In some cases, a decision tree is also often used to help calculate the value of a project, product, or service.

To use this tool, one starts with one element, product, or service they want to evaluate, and then creates different branches from it with different goals. When carried out, the final product looks like a flowchart similar to a tree with different branches, hence the name.

4. Bowtie Model

The Bowtie Model risk assessment tool aims to show the causal links between different sources of risks and their consequences. The left side of the diagram shows what causes the risk, the right shows their potential outcomes, and then both sides meet in the middle with a single risk called "Event." The left and right sides of the Event are larger and wider as many sources may lead to different consequences, but still be centered around one risk. When drawn out, the model starts to look like a bowtie.

Uses of Risk Assessment Tools

Risk assessment tools are an essential part of performing risk assessments and risk management tasks. Not only do they make risk assessments easier, but they also help put different risks into perspective and help create contingency plans better.

Some things risk assessments tools can help with are:

- Creating and spreading awareness on different hazards and risks
- Identifying who are most at risk of encountering or suffering from certain risks
- Determining what control measures and programs are required for which risks and what need to change in existing rules
- Preventing and mitigating injuries, fatalities, and illnesses
- Meeting legal requirements on certain industry-specific tasks where applicable

Assessing the Consequences

In assessing the consequences of a hazard, the first question should be asked "If a worker is exposed to this hazard, how bad would the most probable severe injury be?". For this consideration we are presuming that a hazard and injury is inevitable and we are only concerned with its severity.

It is common to group the injury severity and consequence into the following four categories:

- Fatality - leads to death
- Major or serious injury - serious damage to health which may be irreversible, requiring medical attention and ongoing treatment
- Minor injury reversible health damage which may require medical attention but limited ongoing treatment). This is less likely to involve significant time off work.
- Negligible injuries - first aid only with little or no lost time.

To illustrate how this can be used in the workplace we will use the example of a metal shearing task. A hazard involved could include a piece of metal flying out of the equipment while in use. In this example the probable most severe injury would be "Major or Serious Injury" with the possibility of bruising, breakage, finger amputation.

Assessing the Likelihood

In assessing the likelihood, the question should be asked "If the hazard occurs, how likely is it that the worker will be injured?". This should not be confused with how likely the hazard is to occur. It is common to group the likelihood of a hazard causing worker injury into the following four categories:

- Very likely - exposed to hazard continuously.
- Likely - exposed to hazard occasionally.
- Unlikely - could happen but only rarely.
- Highly unlikely - could happen, but probably never will.

In the metal shearing example, the question should not be "How likely is the machine expected to fail?" but instead "When the machine fails and causes metal to fly out, how likely is the worker expected to be injured?". If in our example we observe a safe distance between the machine and worker and proper PPE being worn, we could rate it as "Unlikely" given our observations.

THE DOW FIRE AND EXPLOSION HAZARD

It is a method for ranking the relative fire and explosion risk associated with a process.The index is developed by the Dow Chemical Company and published by the American Institute of Chemical Engineering, Dow (1994) (www.aiche.org), evaluating the potential risk from a process and assessing the potential loss. A numerical "Fire and explosion index" (F&EI) is calculated, based on the nature of the process and the properties of the process materials. The larger value of the F&EI, the more hazardous the process.

Objectives of dow fire and explosion index

Quantify: The expected damage potential due to fire & explosion incidents in realistic terms

Identify: Equipment that is likely to contribute to the creation or escalation of an incident

Communicate: The fire & explosion potential, to design teams and also the plant personnel.

- It is tailored for the storage, handling, and processing of explosive and flammable material in the chemical industry. Process
- It uses a systematic approach based on the rating form.
- Suitable to be used at an early stage of a project and for auditing the existing plant.
- The final rating number (ie F&EI) provides a relative ranking of hazards.
- It is also used for estimating damage radius (using Dow correlation) and estimate the financial loss in the event of an accident (using consequence analysis form).

Assessment of hazards:

F & EI Range	Degree of hazard
1-60	Light
61-96	Moderate
97-127	Intermediate
128-158	Heavy
>159	Severe

To assess the potential hazard of a new plant, the index can be calculated after the Piping and Instrumentation and equipment layout diagrams have been prepared. In earlier versions of the guide, the index was then used to determine what preventative and protection measures were needed. In the current version, the preventative and protection measures that have been incorporated in the plant design to reduce the hazard-are taken into account when assessing the potential loss: the form of loss control credit factors.

Calculation of the Dow F & EI

The procedure for calculating the index and the potential loss is set out. The first step is to identify the units that would have the greatest impact on the magnitude of any fire or explosion. The index is calculated for each of these units.

The basis of the F & EI is a Material Factor (MF). The MF is then multiplied by a Unit Hazard Factor, F3 to determine the F & El for the process unit. The Unit Hazard factor is the product of two factors which take account of the hazards inherent in the operation of the particular process unit the general and special process hazards.

<u>Material factor</u>

The material factor is a measure of the intrinsic rate of energy release from the burning explosion or other chemical reaction of the material. Values for the MF for over 300 of the most commonly used substances are given in the guide. The guide also includes a procedure for calculating the MF for substances not listed from knowledge of the flash point, (for dusts, dust explosion tests) and a reactivity value, Nr. The reactivity value is a qualitative description of the reactivity of the substance, and ranges from 0 for stable substances, to 4 for substances that are capable of unconfined detonation.

In calculating the F&EI for unit the value for the material with the highest MF, which is present in significant quantities is used.

General Process Hazards

The general process hazards are factors that play a primary role in determining the magnitude of the loss following an

- Exothermic chemical reactions: the penalty varies from 0.3 for a mild exotherm, such as hydrogenation, to 1.25 for a particularly sensitive exotherm, such as nitration.
- Endothermic processes: penalty of 0.2 is applied to reactors only. It is increased to 0.4 if the reactor is heated by the combustion of a fuel.
- Materials handling and transfer: this penalty takes account of the hazard involved in the handling, transfer and warehousing of the material.
- Enclosed or indoor process units: account for the additional hazard where ventilation is restricted.
- Access of emergency equipment. areas not having adequate access are penalised. Minimum requirement is access from two sides.
- Draining and spill control: penalises design conditions that would cause large spills of flammable material adjacent to process equipment such as inadequate design of drainage.

Special process hazards

The special process hazards are factors that are known from experience to contribute to the probability of an incident involving loss.

- Toxic materials: the presence of toxic substances after an incident will make the task of the emergency personnel more difficult. The factor applied ranges from 0 for non- toxic materials, to 0.8 for substances that can cause death after short exposure.
- Sub-atmospheric pressure: allows for the hazard of air leakage into equipment. It is only applied for pressure less than 500 mmHg (9.5 bar).
- Operation in or near flammable range: cover for the possibility of air mixing with material in equipment or storage tanks, under conditions where the mixture will be within the explosive range.
- Dust explosion: covers for the possibility of a dust explosion. The degree of risk is largely determined by the particle size. The penalty factor varies from 0.25 for particles above 175 μm, to 2.0 for particles below 75 μm.
- Relief pressure: this penalty accounts for the effect of pressure on the rate of leakage, should be a leak occur. Equipment design and operation becomes more critical as the

operating pressure is increased. The factor to apply depends on the relief device setting and the physical nature of the process material.

- Low temperature: this factor allows for the possibility of brittle fracture occurring in carbon steel, or other metals, at low temperature.
- Quantity of flammable material: the potential loss will be greater the quantity of hazardous material in the process or in storage. The factor to apply depends on the physical state and hazardous nature of the process material, and the quantity of material.
- Corrosion and erosion: despite good design and materials selection, some corrosion problems may arise, both internally and externally. The factor to be applied depends on the anticipated corrosion rate.
- Leakage-joints and packing: this factor accounts for the possibility of leakage from gaskets. Pump and other shaft seals and packed glands. The factor varies from 0.1 where there is the possibility of minor leaks, to 1.5 for process that have slight glasses, bellows or other expansion joints.
- Use of fired heaters: the presence of boilers or furnaces, heated by the combustion of fuels, increases the probability of ignition should a leak of flammable material occur from a process unit. The risk involved will depend on the sitting of the fired equipment and the flash point of the process material.
- Hot oil heat exchange system: most special heat exchange fluids are flammable and are often used above their flash points; so their use in a unit increases the risk of fire or explosion. The factor to apply depends on the quantity and whether the fluid is above or below its flash point.
- Rotating equipment: this factor accounts for the hazard arising from the use of large pieces of rotating equipment: compressors, centrifuges, and some mixers.

Basic preventative and protective measure

The basic safety and fire protective measures that should be included in all chemical process design are listed below. This list is bases on that given in the Dow Guide, with some minor amendments.

a) Adequate, and secure, water supplies for fire fighting.

b) Correct structural design of vessels, piping, steel work.

c) Pressure-relief devices.

d) Corrosion-resistant materials and adequate corrosion allowances.

e) Segregation of reactive materials.

f) Earthing of electrical equipment.

g) Safe location of auxiliary electrical equipments, transformers, switches gear.

h) Provision of backup utility supplies and services

i) Compliance with national codes and standards.

j) Fail-safe instrumentation.

k) Provision for access of emergency vehicles and the evacuation of personnel.

1) Adequate drainage for spills and fire-fighting water.

m) Insulation of hot surfaces.

n) No glass equipment used for flammable or hazardous materials, unless no suitable alternative is available.

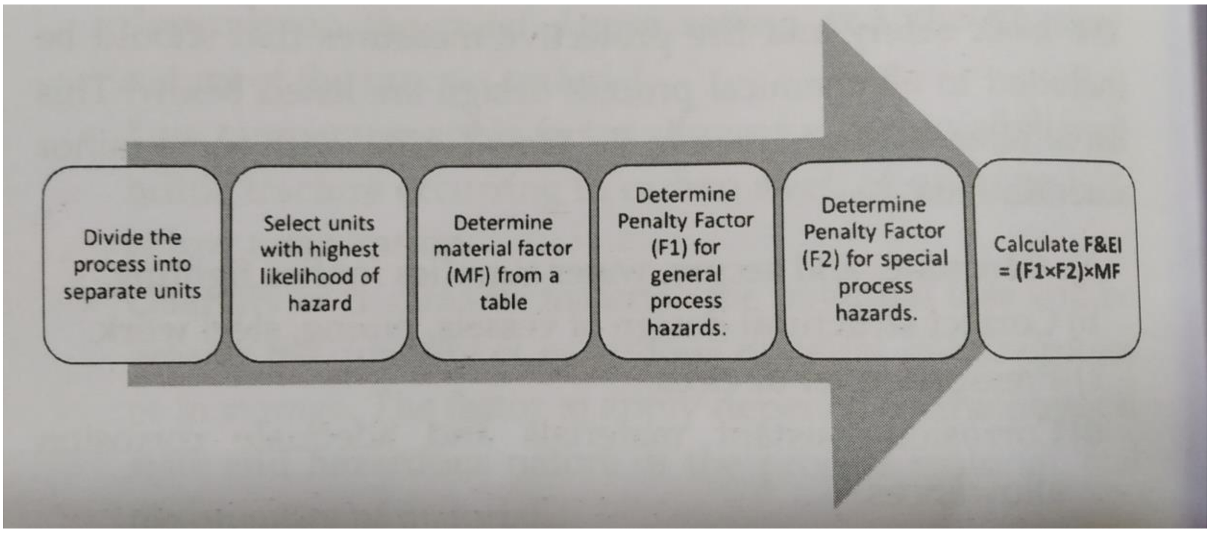
o) Adequate separation of hazardous equipment.

P) Protection of pipe racks and cable trays from fire.

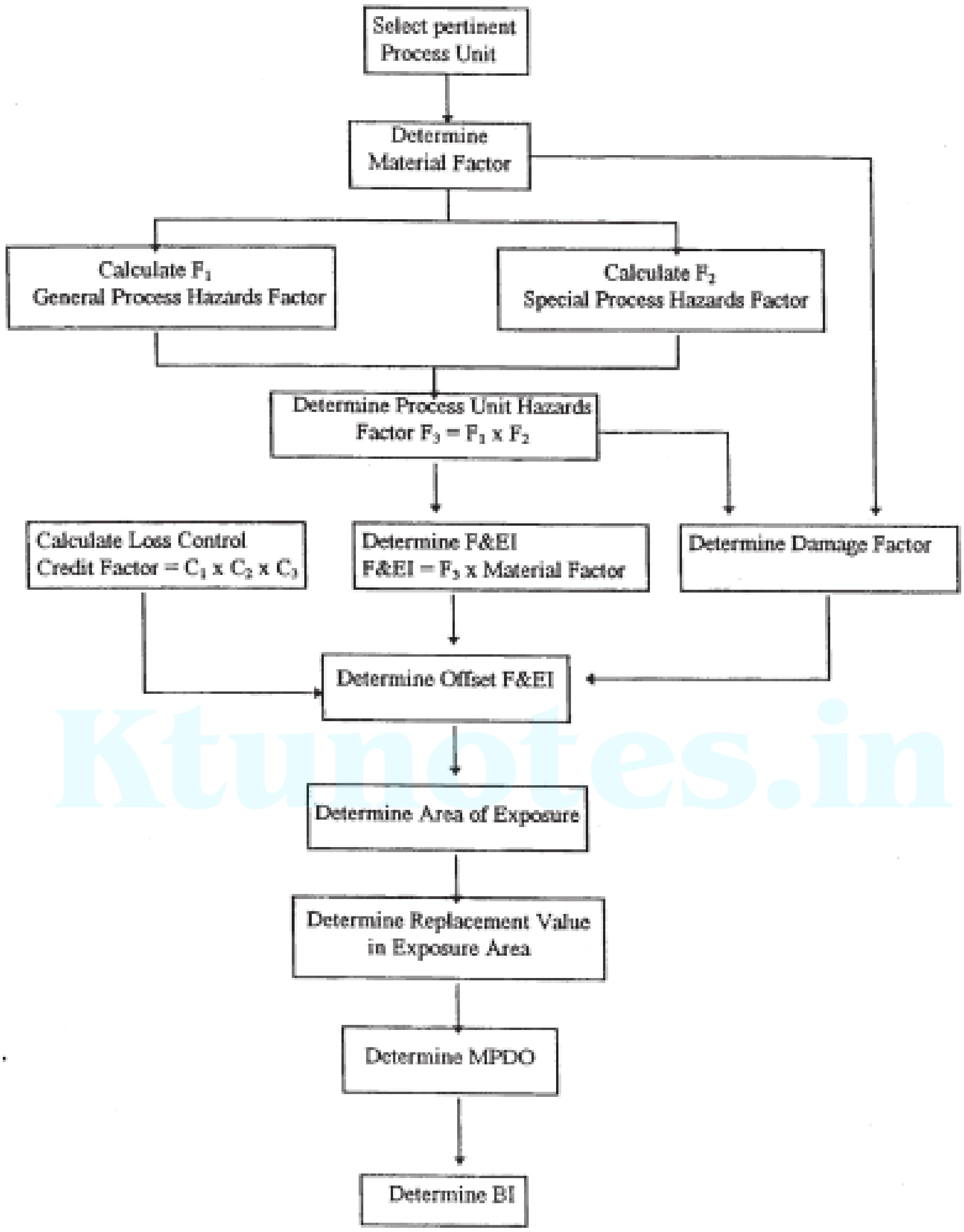
q) Provision of block valves on lines to main processing areas.

r) Safe design and location of control rooms.

Simplified procedure for calculating Dow F&EI



Modified procedure for calculating Dow F&EI



PRELIMINARY HAZARD ANALYSIS

The Preliminary Hazard Analysis (PHA) is usually the first attempt in the system safety process to identify and categorize hazards or potential hazards associated with the operation of a proposed system, process, or procedure. The PHA may be mary Haz preceded with the preparation of a Preliminary Hazard List (PHL). It provides rationale for hazard control and indicates the need for more detailed analyses, such as the Subsystem Hazard Analysis (SSHA) and the System Hazard Analysis (SHA). The PHA is usually developed using the system safety techniques known as Failure Modes and Effects Analysis (FMEA) and/or the Energy Trace and Barrier Analysis (ETBA). PHA development can be somewhat simplified through the use of a Preliminary Hazard Matrix identifying a Generic Hazard Group. The PHA Report can be generated based upon the evaluation and analysis of system hazard risk.

Preliminary hazard analysis (PHA) is a semi-quantitative analysis performed with the intention of identifying all potential hazards and accidental events that can cause an industrial accident.This type of analysis ranks the identified accidental events according to their severity and proposes hazard controls and follow-up actions.

There are several formats of preliminary hazard analysis that can be used under different names, such as Rapid Risk Ranking and Hazard Identification (HAZID). PHA should be carried out in the early stages of a project and continue throughout the system or product's life cycle to identify those accidental events that should be subject to a more-detailed risk analysis.

As a broad, initial study, the preliminary hazard analysis focuses on identifying immediate hazards, assessing the severity of potential accidents that could occur because of these hazards, and identifying safeguards for reducing the risks associated with the hazards. By identifying weaknesses early in the life of a system, PHA aims to save time and money that here. LE COP might be required for ajor redesign if the hazards were discovered at a later date.

Characteristics of PHA

- It relies on brainstorming and expert judgment to assess the significance of hazards and assign a ranking to each situation.
- It is typically performed by one or two people who are knowledgeable about the type of activity in question.
- It is applicable to any activity or system
- It can be used as a high-level analysis early in the life of a process.
- It is used to generates qualitative descriptions of the hazards related to a process. Provides a qualitative ranking of the hazardous situations; this ranking can be used to prioritize recommendations for reducing or eliminating hazards in subsequent phases of the life cycle.
- Quality of the evaluation depends on the quality and availability of documentation, the training of the review team leader with respect to the various analysis techniques employed, and the experience of the review teams.

Advantages and Disadvantages of PHA

Advantages

- Helps ensure that the system is safe
- Modifications are less expensive and easier to implement in the earlier stages of design
- Decreases design time by reducing the number of surprises

Disadvantages

- Hazards must be foreseen by the analysts
- The effects of interactions between hazards are not easily recognized

Procedure for Preliminary Hazard Analysis

The procedure for conducting a preliminary hazard analysis consists of the following steps. Each step is further explained on the following pages.

1. Define the activity or system of interest: Specify and clearly define the boundaries of the activity or system for which preliminary hazard information is needed.

2. Define the accident categories of interest and the accident severity categories. Specify the problems of interest that the risk assessment will address (e.g., health and safety concerns, environmental issues). Specify the accident severity categories that will be used to prioritize resources for risk reduction efforts.

3.Conduct review. Identify the major hazards and associated accidents that could result in undesirable consequences. Also, identify design criteria or alternatives that could eliminate or reduce the hazards.

4. Use the results in decision making. Evaluate the risk assessment recommendations and the benefits they are intended to achieve (e.g., improved safety and environmental performance, cost savings).

<u>Determine implementation criteria and plans.</u>

1. Define the activity or system of interest

Intended functions. Because all risk assessments are concerned with ways in which a system can fail to perform an intended function, clearly defining these intended functions is an important first step in any risk assessment. This step does not have to be formally documented for most preliminary risk assessments,

Boundaries. Few activities or systems operate in isolation. Most interact with or are connected to other activities or systems. By clearly defining the boundaries of an activity or system, especially boundaries with support systems such as electric power and compressed air, the analysis can avoid (1) overlooking key elements of an activity or system at interfaces and (2) penalizing an activity or system by associating other equipment with the subject of the study. Example:

Functions of interest

- Safe handling and use of fuel oil for an LNG cargo ship

- Safe handling and use of LNG cargo for an LNG cargo ship

Boundaries

- Include only shipboard systems or operations

2. Define the accident categories of interest and the accident severity categories

Accident categories: The following paragraphs describe three of the most common types of accidents of interest in a PHA:

Safety problems: The risk assessment team may look for ways in which improper performance of a marine activity or failures in a hardware system can result in personnel injury. These injuries may be caused by many mechanisms, including the following:

- Person overboard
- Exposure to high temperatures (e.g., through steam leaks)
- Fire & explosions

Environmental issues. The risk assessment team may look for ways in which the conduct of a particular activity or the failure of a system can damage the environment. These environmental issues may be caused by many mechanisms, including the following:

- Discharge of material into the water, either intentional or unintentional
- Equipment failures (e.g., seal failures) that result in a material spill
- Disruption of the ecosystem through over utilization of a marine area

Economic impacts. The risk assessment team may look for ways in which the improper conduct of a particular activity or the failure of a system can have undesirable economic impacts

These economic risks may be categorized in many ways, including the following:

- Business risks such as contractual penalties, lost revenue,etc.
- Environmental restoration costs
- Replacement costs for damaged equipment

Some risk assessments may focus only on events above a certain threshold of concern in one or more of these categories.

Accident severity categories

During a PHA, a team assesses the severity of the various accidents that can occur with each of the hazards. Establishing severity categories with definitive boundaries allows the team to assess each accident against a consistent measure of severity. It thus provides the framework for prioritizing SIPLE COPY recommendations for risk reduction alternatives.

3. Conduct review

Performing a PHA identifies major hazards and accident situations that could result in losses. However, the PHA should also identify design criteria or alternatives that could eliminate or reduce those hazards. Obviously, some experience is required in making such judgments. The team performing the PHA should consider the following factors:

- Hazardous vessel equipment and materials, such as fuels, highly reactive chemicals, toxic substances, explosives, high pressure systems, and other energy storage systems
- Safety-related interfaces between equipment and materials, such as material interactions, fire or explosion initiation and propagation, and control or shutdown systems
- Environmental factors that may influence the vessel or facility equipment and materials, such as vibration,flooding, extreme temperatures, electrostatic discharge, and humidity
- Operating, testing, maintenance, and emergency procedures, such as human error potential, crew functions to be accomplished, equipment layout and accessibility, and personnel safety protection
- Vessel support, such as storage, equipment testing, training, and utilities
- Safety-related equipment, such as mitigating systems, redundancy, fire suppression, and personal protective equipment.

4. Use the results in decision making

Judge acceptability. Decide whether the estimated performance for the activity or system meets an established goal or requirement.

Identify improvement opportunities. Identify the elements of the activity or system that are most likely to contribute to future problems. These are the items with the largest percentage contributions to the identified risks.

Make recommendations for improvements. Develop specific suggestions for improving future activity or system performance, including any of the following:

- Equipment modifications
- Procedural changes
- Administrative policy changes, such as planned maintenance tasks or personnel training

Justify allocation of resources for improvements. Estimate how implementation of expensive or recommendations for improvement will affect future controversial performance. Compare the economic benefits of these improvements to the total life-cycle costs of implementing each

Recommend additional risk assessments. As suggested by the name, preliminary hazard analysis is conducted in an early phase of a project. Additional risk assessments will likely be needed to investigate certain issues in more detail. The insights gained from the PHA will help determine what, if any, additional risk assessments should be conducted.

HAZARD & OPERABILITY STUDY (HAZOP)

A HAZOP is a systematic assessment tool used to identify and address potential hazards in industrial processes before an incident occurs that could affect the Safety of people or assets while hindering Productivity. HAZOP studies are typically performed while new facilities are being designed and constructed, when new processes are added or when processes change. Most regulatory agencies also require periodic HAZOP studies on existing processes.

The HAZOP assessment is typically performed by a small team that breaks each step of a process down for individual review to identify potential deviations from the original process design. Like all PHAs, HAZOPs go beyond the review of how a process is supposed to operate in order to identify unintended outcomes and explore their potential ripple effects on health and safety.

The HAZOP Study Process

A Hazard and Operability Study systematically investigates each element in a process. The goal is to find potential situations that would cause that element to pose a hazard or limit the operability of the process as a whole. There are four basic steps to the process:

1. Forming a HAZOP team
2. Identifying the elements of the system
3. Considering possible variations in operating parameters
4. Identifying any hazards or failure points

Once the four steps have been completed, the resulting information can lead to improvements in the such as adding caution signs or traffic signs. The best way to apply the results of a HAZOP study will depend on the nature of the system.

1. Form a HAZOP Team : To perform a HAZOP, a team of workers is formed, including people with a variety of expertise such as operations, maintenance, instrumentation, engineering/process design, and other specialists as needed. These should not be "newbies, but people with experience, knowledge, and an understanding of their part of the system. The key requirements are a understanding of the system, and a willingness to consider all reasonable variations at each point in the system.

2. Identify Each Element and its Parameters : The HAZOP team will then create a plan for the complete work process, identifying the individual steps or elements. This typically involves using the piping and instrument diagrams (P&ID), or a plant model, as a guide for examining every section and component of a process. For each element, the team will identify the planned operating parameters of the system at that point: flow rate, pressure, temperature, vibration, and so on.

3. Consider the Effects of Variation

For each parameter, the team considers the effects of deviation from normal. For example, "What would happen if the pressure at this valve was too high? What if the pressure was unexpectedly low? Would the rate of change in pressure (delta- p) pose its own problems here?" Don't forget to consider the ways that each element interacts with others over time; for example, "What would happen if the valve was opened too early, or too late?"

4. Identify Hazards and Failure Points

Where the result of a variation would be a danger to workers or to the production process, we've found a potential problem. Document this concern, and estimate the impact of a failure at that point. Then, determine the likelihood of that failure; is there a real cause for the harmful variation? Evaluate the existing safeguards and protection systems, and evaluate their ability to handle the deviations that we've considered.

Results of a HAZOP Study

Because HAZOP is a mental exercise, it can be implemented as part of the planning of a new work process, even before a facility is built. Existing facilities and processes can also be assessed with HAZOP.
Where a HAZOP study is performed in the planning stage of a new process, completing the study means that all potential causes of failure will be identified. The HAZOP team will write an assessment weighing the potential deviations, their consequences, their causes, and the protection requirements. From this point, changes to the plan can be made to prevent problems from arising, or to mitigate their effects.

In existing facilities, a HAZOP may be ongoing, working to improve the process without a any specific end date. Instead of a single, large assessment, the study's results will be released a as a stream of action items, as each problem is identified and a solution is created.

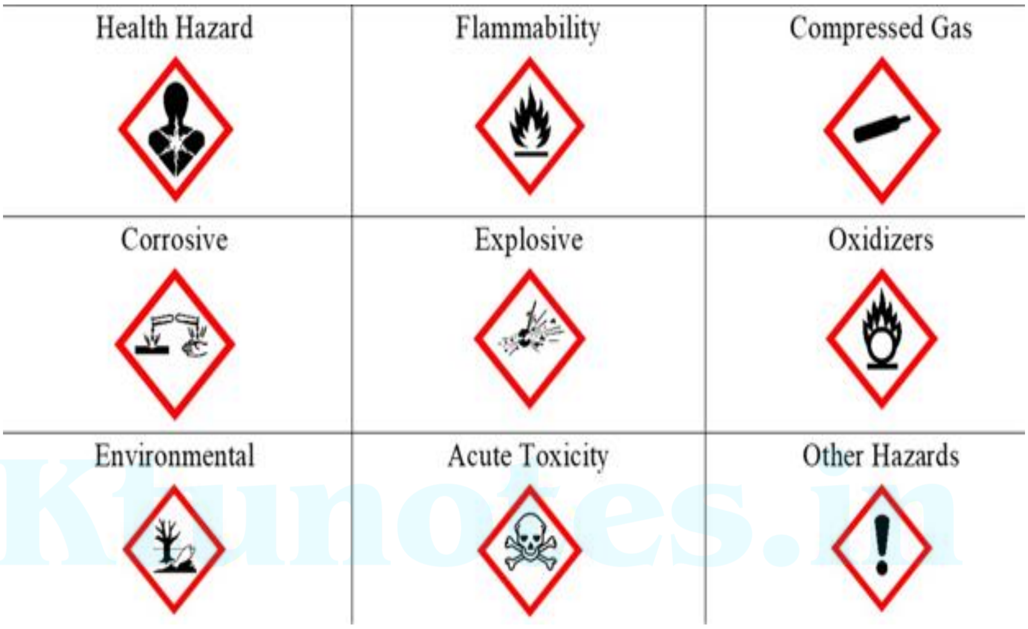
In both cases, when a hazardous condition is identified, recommendations may be made for process or system modifications, or further study by a specialist may be required. A HAZOP study might recommend these typical actions:

- A review of existing protection system designs by a specialist
- Adding or modifying alarms that warn of deviations
- Adding or modifying relief systems
- Adding or modifying ventilation systems
- Increasing sampling and testing frequency

CONTROL OF CHEMICAL HAZARDS

A chemical hazard is any substance, regardless of its form- that can potentially cause physical and health hazards to people, or can result in harm to the environment. It can also be defined as the actual risk associated with specific chemicals, such as skin burns, long-term negative impact to health, lasting environmental damage, fires, or even explosions.

Types of Chemical Hazards



Health hazard :This symbol shows a person with damage Health hazard - and pertains to chemicals that can cause serious and long-term negative impacts on health. Carcinogens are also substances that are known to be cancer-causing chemicals. They are categorized as either natural or manmade, but it is crucial to note that even a small amount of this type of chemical can severely damage human health.

Flammable - The symbol for this is a flame and it pertains to chemicals or highly flammable gases that may catch fire or ignite once exposed to air or other ignition sources or elements.

Irritant/hazardous/hazardous to the ozone layer - This is symbolized by a big exclamation point and refers to chemicals that usually cause redness, rashes, or inflammation of the affected area. Although the presence of symptoms is normally short-term, there are still instances where they create long- lasting effects on others. It is also known to either cause harm to individuals or pose a threat to public health by harming the ozone layer.

Gas under pressure - The symbol for this is a gas cylinder and it pertains to gases that are stored under pressure and may explode if heated or refrigerated gases that may cause burns or injury.

Corrosion - This pictogram shows corrosion of material and skin. It refers to chemicals that can cause severe skin burns and damage to the tissue once contacted with.

Explosives - This is symbolized by an exploding bomb and pertains to chemicals that may explode or can cause a mass explosion.

Oxidizers - This pictogram shows a flame over a circle and symbolizes chemicals or substances that, under certain conditions or exposure to other chemicals or elements, can cause severe physical hazards such as fires or explosions.

Hazardous to environment – the symbol for this is a dead tree and fish. It refers to chemicals that can cause lasting damage to the environment.

Toxic - This pictogram shows a skull and crossbones, and symbolizes chemicals that even at a very low exposure-can cause irreversible changes or mutations to a person's DNA, damage to health, or even fatality.

Controlling Chemical Hazards

Once the hazards involved in the handling and use of chemicals are identified, the next stage is to put control measures in place. This includes,

Elimination : options which get rid of the hazard altogether
Substitution- Replacing a hazardous chemical with a less hazardous one wherever possible.
Engineering Controls- Fume Hoods, local exhaust ventilation, etc.
Administrative control- Standard Operating Procedures (SOP), caution signages, etc. •
Personal protective equipment- Lab coats, safety glasses,hand gloves, etc.

1. Elimination

The risk control measure that has the greatest level of effectiveness is elimination. Before any other control measures are considered, elimination must be applied first. Elimination is the method of totally removing a hazard or hazardous practice from the workplace. Some examples of eliminating the use of a hazardous chemical in the workplace include:

- Eliminating the use of chemical adhesives by using fasteners such as screws or nails.
- Eliminating the use of flammable forklift gas by using electric power forklifts instead of LPG powered forklifts.

2. Substitution

If we can't successfully eliminate the use of a hazardous chemical in our business, we must then try to substitute it. Substitution is when we replace the use of a hazardous chemical with another chemical that is less hazardous and presents a lower level of risk.

Sometimes, substitution can be hard to achieve because the dangerous properties of hazardous chemicals are often what makes them very effective in manufacturing and chemical processes.

3. Isolation

If it's not possible to substitute the use of a hazardous chemical with another chemical that is less hazardous, we must then isolate the hazardous chemical from people and other incompatible substances.

This can be done in a number of ways, for example: If one part of a manufacturing process involves the use of a hazardous chemical, we could build a ventilated enclosure over this part of the manufacturing process. This enclosure would stop the airborne contaminants from this area moving into other areas of the manufacturing facility where people are present. The airborne contaminants that are generated inside this enclosure should be vented to the outside atmosphere in a safe location where people don't congregate.

If large quantities of hazardous chemicals are stored in the workplace, we could isolate these hazardous chemicals from people by storing them outdoors in a compliant chemical storage container. Isolating hazardous chemicals from people by storing them outdoors reduces the risk of harm to people in the event of a workplace fire or chemical spill.

4. Engineering Controls

If isolation cannot be achieved, you can implement a range engineering controls to reduce the risk associated with hazardous chemicals. of

Engineering controls are physical in nature. They are devices or processes that eliminate exposure to hazardous chemicals.
Engineering controls can be used to:

- Minimise the generation of hazardous chemicals
- Suppress or contain chemicals .
- Limit the area of contamination in the event of spills

Engineering controls can include devices such as mechanical ventilation systems, compliant chemical storage containers or the automation of processes involving the use of hazardous chemicals.

5. Administrative Controls

If there is still a chemical risk once higher order controls are implemented, then you must work to reduce this by developing administrative controls.

Administrative controls aren't as effective as other controls, because they don't control the hazard at its source. Administrative controls rely on human behaviour and supervision, therefore, they aren't as consistent or reliable as other controls.

Administrative controls are generally written policies and procedures that outline the best work practices to minimise exposure to hazardous chemicals.

These policies can include things such as:

- Reducing the number of people exposed to hazardous chemicals
- Reducing the duration and frequency of exposure to hazardous chemicals
- Reducing the quantity of hazardous chemicals kept on site through inventory reduction methods such as just in time supply.

6. Personal Protective Equipment

Personal protective equipment (PPE) should not be relied on to control risk.

Instead, PPE should only be used as a last resort when other more effective control measures have been used and the risk has not been eliminated. PPE can also be used as interim protection until higher level controls are fully implemented. PPE is also a useful way to supplement higher level controls when carrying out high-risk work such as spray-painting and abrasive blasting.
Some examples of PPE can include:

- Chemical resistant glasses
- Face shields
- Protective clothing
- Chemical resistant gloves
- Shoe covers
- Respiratory equipment

HAZARDOUS PROPERTIES OF CHEMICALS : Chemical substances that have the ability to create a physical or health hazard are considered hazardous, Due to their may be but are n properties chemical hazardous substances may be, but are not limited to being toxic, explosive, flammable, self-reactive, oxidizing, or corrosive. Exposure to these substances by different routes including inhalation, dermal absorption, or ingestion can lead to adverse health effects, enhancing the need to know about the hazards associated to these substances beforehand.

Toxic :

A toxic substance is a substance that can be poisonous or cause health effects. Chemicals can be toxic because they can harm us when they enter or contact the body. Exposure to a toxic substance such as gasoline can affect your health. Since drinking gasoline can cause burns, vomiting, diarrhea and, in very large amounts, drowsiness or death, it is toxic. Some chemicals are hazardous because of their physical properties: they can explode, burn or react easily with other chemicals

Since gasoline can burn and its vapours can explode, gasoline is also hazardous. A chemical can be toxic, or hazardous, or both.

Explosive

Explosive, any substance or device that can be made to produce a volume of rapidly expanding gas in an extremely brief period. Basically, chemical explosives are of two types: (1) detonating, or high, explosives and (2) deflagrating, or low, explosives. Detonating explosives, such as TNT and dynamite, are characterized by extremely rapid decomposition and development of high pressure, whereas deflagrating explosives, such as black and smokeless powders, involve merely fast burning and produce relatively low pressures.

Flammable

Flammability is the ability of a chemical to burn or ignite, causing fire or combustion. The degree of difficulty required to cause the combustion of a chemical is quantified through fire testing.

Self-reactive

Self-reactive chemicals are thermally unstable liquid or solid chemicals that can undergo exothermic decomposition without interacting with oxygen.

Oxidizing

Oxidizing chemicals are materials that spontaneously evolve oxygen at room temperature or with slight heating or promote combustion. This class of chemicals includes:

- Peroxides
- Chlorates

- Perchlorates
- Nitrates
- Permanganates

Strong oxidizers are capable of forming explosive mixtures when mixed with combustible, organic or easily oxidized materials.

Corrosive

Corrosive chemicals are defined as chemicals that can cause damage to body tissues. These chemicals can be dangerous if they come into contact with user's skin, tissues, eyes, and body parts. Corrosive materials can irritate eyes, burn skin, irritate and burn the inner lining of the nose and throat if inhaled, and have other negative effects if users are not careful when handling these chemicals.

Common corrosive chemicals include acids and bases. Hydrochloric acid, sulfuric acid, and hydrofluoric acid are examples of common corrosive acids, while ammonium hydroxide, potassium hydroxide, and sodium hydroxide are examples of bases.

MATERIAL SAFETY DATA SHEETS (MSDS)

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.

The purpose of a safety data sheet is to act as a quick reference for safely storing, handling, and transporting the chemical product.

The specific contents of the document vary depending on the nature of the substance and the manufacturer. It will, however, typically include the following information:

- Product Information: product (name), manufacturer and suppliers names, addresses, and emergency phone numbers
- Hazardous Ingredients
- Physical Data

- Fire or Explosion Hazard Data Reactivity Data: information on the chemical instability of a product and the substances it may react with
- Toxicological Properties: health effects
- Preventive Measures
- First Aid Measures Preparation Information: who is responsible for preparation and date of preparation of MSDS

Employers and employees need the information contained on MSDSs to protect themselves from hazardous chemical exposures and to work safely with chemical products. The result will be a reduction in chemical source illness and injuries in the workplace. Since the HCS became effective, the use and distribution of MSDSs have proven to be an effective and efficient way to ensure that employers and employees can obtain necessary information on the hazards associated with exposure to chemicals in the workplace.