MODULE 5

Hazard identification and analysis

- 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)

INTRODUCTION

- Hazard is a term associated with a substance that is likelihood to cause an injury in a given environment or situation.
- Safety in simple terms means freedom from the occurrence of risk or injury or loss. Industrial safety refers to the protection of workers from the danger of industrial accidents.

DEFINITION

Industrial hazard may be defined as any condition produced by industries that may cause injury or death to personnel or loss of product or property.

- Hazard: Any situation that has potential/capability to cause Injury/harm to the worker, damage to the property, Loss/contamination to the environment.
- Risk: Any situation that has probability to cause Injury/harm to the human, damage to the property, Loss/ contamination to the environment.

- Accidents: These are unplanned, unwanted and improper occurrence involving injury/harm to the employee, damage to the property, Loss/contamination to the environment.

HAZARDOUS WASTE RULES

- Hazardous wastes to be collected, treated, stored and disposed off only on authorised places.
- Authorisation for above to be issued by SPCB.
- Hazardous waste to be packed and transported in sufficiently safe conditions.
- State government or a person authorised shall undertake a continuing programme to identify the sites and publish periodically an inventory of disposal sites within the state for disposal of hazardous wastes.

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TYPES OF HAZARDS

1. Biological hazards
2. Chemical hazards
3. Mechanical hazards
4. Physical hazards
5. Electrical hazards
6. Fire and dust hazards

1. BIOLOGICAL HAZARDS

- A biological hazard is one originating from an organism that is foreign to the organism being affected.
- Many biological hazards are associated with food, including certain viruses, parasites, fungi, bacteria, and plant and seafood toxins.

2. CHEMICAL HAZARDS

- A chemical can be considered a hazard by virtue of its intrinsic properties it can cause harm or danger to humans, property, or the environment.
- Some chemicals occur naturally in certain geological formations, such as radon gas or arsenic.
- Many other chemicals used in industrial and laboratory settings can cause respiratory, digestive, or nervous systems problems if they are inhaled, ingested or absorbed through the skin.

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3. MECHANICAL HAZARDS

A mechanical hazard is any hazard involving a machine or process. Motor vehicles, aircrafts and air bags pose mechanical hazards. Compressed gases or liquids can also be considered a mechanical hazard.

4. PHYSICAL HAZARDS

- A physical hazard is a naturally occurring process that has the potential to create loss or damage.
- Physical hazards often have both human and natural elements.
- Flood problems can be affected by climate fluctuations and storm frequency, both natural elements, and by land drainage and building in a flood plain, human elements.

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5. ELECTRICAL HAZARDS

Electrical injuries consist of four main types:

- Electrocution (fatal),
- Electric shock,
- Burns and
- Falls caused as a result of contact with electrical energy.

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CONTD....

A worker will receive a shock when he/she:

i. Touches two wires at different voltages at the same time.

ii. Touches phase and neutral wire at a time

iii. Touches the phase standing on the ground

iv. Touches the phase having wet cloth, high humidity and perspiration.

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6. FIRE AND DUST HAZARDS

Source of dust hazards in pharmaceutical industries

- Grinding or milling of drugs, excipients, or herbal products.
- During weighing dusts may float on air.
- During powder mixing dusts may be generated.
- During coating operation dusts are generated.
- During capsule filling and tablet punching operation dusts may be generated.

Methods of controlling dust

- Filtration
- Inertial separator
- Electrostatic separator

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Assignment 2

1. Classification of Fire
2. Types of Fire extinguishers
3. Hazards in fire,explosion and toxic gas release

TYPES OF FIRE HAZARDS

Class of Fire	Description
Class A Fires	Fires in ordinary combustible materials, such as wood, cloth, paper, rubber, and many plastics.
Class B Fires	Fires in flammable liquids, combustible liquids, petroleum greases, tars, oils, oil-based paints, solvents, lacquers, alcohols, and flammable gases.
Class C Fires	Fires that involve energized electrical equipment.
Class D Fires	Fires in combustible metals, such as magnesium, titanium, zirconium, sodium, lithium, and potassium.
Class K Fires	Fires in cooking appliances that involve combustible cooking media (vegetable or animal oils and fats).

What is Fire Extinguisher ?

- A **Fire extinguisher** is a device which can be used to control a fire. Fire extinguishers can help remove the fire, and may stop it from burning.

Things to remember before installation of fire extinguishers.

- Brass Valve Chrome Plated Heavy duty
- BIS Approved
- CE Certified.
- Maintenance should be done as per IS 2190:2010
- Must Check the color band according to need.
- Extinguisher/ Equipments must be according to guidelines given by concerned disaster authority.

Water Based Fire Extinguisher

- 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 can also sometimes contain wetting agents which are designed to help increase its effectiveness against fire.
- These extinguishers are intended primarily for use on Class 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.

Carbon Dioxide type Fire Extinguisher

- 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.
- 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.

A B C Type Dry Powder

- ABC or Multi-Purpose extinguishers comprise of a special fluidized and siliconized mono ammonium phosphate dry chemical
- It is use for Class A fires and breaks the chain reaction of Class B fires
- Easy and More Economical to Maintain and Service
- Used in- Homes, Offices, Buildings, Warehouses, Cinema halls.
- Color Band- Blue
- Capacity-1-9kg

Dry Powder

- Dry Chemical powder extinguishers utilize a specially siliconized Sodium Bicarbonate.
- It insulates class B , C fires by forming a cloud and cutting off the oxygen supply.
- Used in- Homes / Offices,Buildings,Warehouses,Pump Room, Refinery
- Color band- Blue
- Capacity- 4kg-9kg

Foam Based Extinguisher

- Foam has the ability to form an aqueous film which quickly over water-insoluble hydrocarbon fuel surfaces causing rapid fire extinguishment and vapour suppression for class B fires.
- Also it provides excellent penetrating and wetting qualities when used on class A fires.
- Foam extinguishers are ideal for fires involving volatile liquids and freely burning materials such as lubricant, oil fires, paper, cloth, wood, etc.
- Only for fighting class A and B fire.
- Easy and Maintenance and Service.
- Do not use on electrical fires.

- Used in-Paints, Lubricants, Chemical Industry, Oil Fire/Refinery, Kitchen/Restaurant, Boiler Room.
- Color Band- Yellow

Clean Agent Fire Extinguisher

- CLEAN AGENT replaces Halon 1211 as the agent-of-choice for applications where the agent must be clean, electrically nonconductive, environment-friendly, extremely low in toxicity and exceptionally effective.
- Suitable for Class A, B and C fires.
- Low Global Warming Potential.
- Low Ozone Depletion Potential.
- Short Atmospheric Lifetime

- Useful for- Computer Rooms / Laboratories, Essential Communication Area, Server-data Room / Tele-communications, Aerospace- Warehouse, Hospitals - Medical Equipment's, Sensitive Expensive Equipment.
- Color Band- Green

Other Fire Extinguisher

- Sand Bucket
- Water Bucket

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 of any effective safety and health program is a proactive, ongoing process to identify and assess such hazards

Structure of hazard identification and risk assessment

To identify and assess hazards, employers and workers:

- Collect and review information about the hazards present 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 nonroutine 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
- Action item 2: Inspect the workplace for safety hazards
- Action item 3: Identify health hazards
- Action item 4: Conduct incident investigations
- Action item 5: Identify hazards associated with emergency and nonroutine situations
- Action item 6: Characterize the nature of identified hazards, identify interim control measures, and prioritize the hazards for control

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.

Action item 1: Collect existing information about workplace hazards

- 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, such as OSHA 300 and 301 logs and reports of incident investigations.
  - Workers' compensation records and reports.
  - Patterns of frequently-occurring injuries and illnesses.

Action item 1: Collect existing information about workplace hazards

- 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:

- OSHA, National Institute for Occupational Safety and Health (NIOSH), and Centers for Disease Control and Prevention (CDC) websites, publications, and alerts.
- Trade associations.
- Labor unions, state and local occupational safety and health committees/coalitions ("COSH groups"), 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.

Action item 2: Inspect the workplace for safety hazards

How to accomplish it

- Be sure to document inspections so you can later verify that hazardous conditions are corrected.
  - Take photos or video of problem areas to facilitate later discussion and brainstorming about how to control them, and for use as learning aids.
- Include all areas and activities in these inspections
  - storage and warehousing, facility and equipment maintenance, purchasing and office functions, and the activities of on-site contractors, subcontractors, and temporary employees.
- Regularly inspect both plant vehicles (e.g., forklifts, powered industrial trucks) and transportation vehicles (e.g., cars, trucks).
- Use checklists that highlight things to look for.

- Typical hazards fall into several major categories and each workplace will have its own list
  - General housekeeping
  - Slip, trip, and fall hazards
  - Electrical hazards
  - Equipment operation
  - Equipment maintenance
  - Fire protection
  - Work organization and process flow (including staffing and scheduling)
  - Work practices
  - Workplace violence
  - 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.

- **Action item 3: Identify health hazards**
  - Identifying workers' exposure to health hazards is more complex than identifying physical safety hazards.
  - Eg: gases and vapors may be invisible, often have no odor, and may not have an immediately noticeable harmful health effect.
  - Health hazards include chemical hazards, physical hazards, biological hazards and ergonomic risk factors.
  - Reviewing workers' medical records can be useful in identifying health hazards associated with workplace exposures.

Action item 3: Identify health hazards

How to accomplish it

- Identify chemical hazards –review SDS and product labels to identify chemicals in your 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 you must raise your voice to be heard 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.

Action item 3: Identify health hazards

How to accomplish it

- 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 cases of 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, you will 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

Action item 4: Conduct incident investigations

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- 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.

Action item 4: Conduct incident investigations

- 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.

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 developed for responding appropriately and safely to hazards associated with foreseeable emergency scenarios and nonroutine situations.

Action item 5: Identify hazards associated with emergency 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
  - Weather emergencies and natural disasters
  - Medical emergencies
  - 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.
- Employers have an ongoing obligation to control all serious recognized hazards and to protect workers.

DOW Fire & Explosion Index

- It is a method for ranking the relative fire and explosion risk associated with a process.
- The index is developed by Dow Chemical Company
- Analysts calculate various hazard and explosion indexes using material characteristics and process data.
- Originated due to poor loss (accident) record in 1966
- One of the first “chemical plant” hazard analysis systems
- Unique Features
  - Maximum Probable Property Damage
  - Maximum Probable Days Outage
- Continues to be upgraded in use and application
- Fill out like a “Tax Form”

DOW Fire & Explosion Index

- Uses material factors that relate to reactivity and flammability
- Identifies equipment that can present a flammable or explosive hazard
- Suggests approaches to control a hazard
- Useful in determining plant layout and separation between vessels
- Requires engineering judgement
- Is not a perfect tool
- Is a useful tool

Primary Purpose of DOW Fire & Explosion Index

- It serves as a guide for the selection of fire and explosion protection methods.
- It is a guide for insurance agencies to set insurance rates.
- It ranks individual process units where special safety attention can be focused.

Who Usually Performs the FEI?

- Generally a senior process engineer, who is acquainted with the details of the project, is assigned the task.
- Different groups tackle the assignment and results are compared for consensus building.

Limitation

- No scientific basis for many of the features can be found in Dow records
- Does not correlate well with known plant disasters
- While explosion damage is fairly advanced fire damage alone is more difficult to predict.

Objectives of DOW Fire & Explosion Index

Quantify

- the expected damage of potential fire & explosion incidents in realistic terms

Identify

- equipment that would likely contribute to the creation or escalation of an incident

Communicate

- the fire & explosion potential to design teams and plant personnel

Objectives of DOW Fire & Explosion Index

- It is tailored for storage, handling and processing of explosive and flammable material in chemical process industry.
- It uses systematic approach based on rating form.
- Suitable to be used at an early stage of a project and for auditing existing plant.
- Final rating number (F&EI) provided a relative ranking of hazard.
- It is also used for estimating damage radius (using Dow correlation) and estimate dollar losses in the event of accident (using consequences analysis form).

Parameter of DOW Fire & Explosion Index

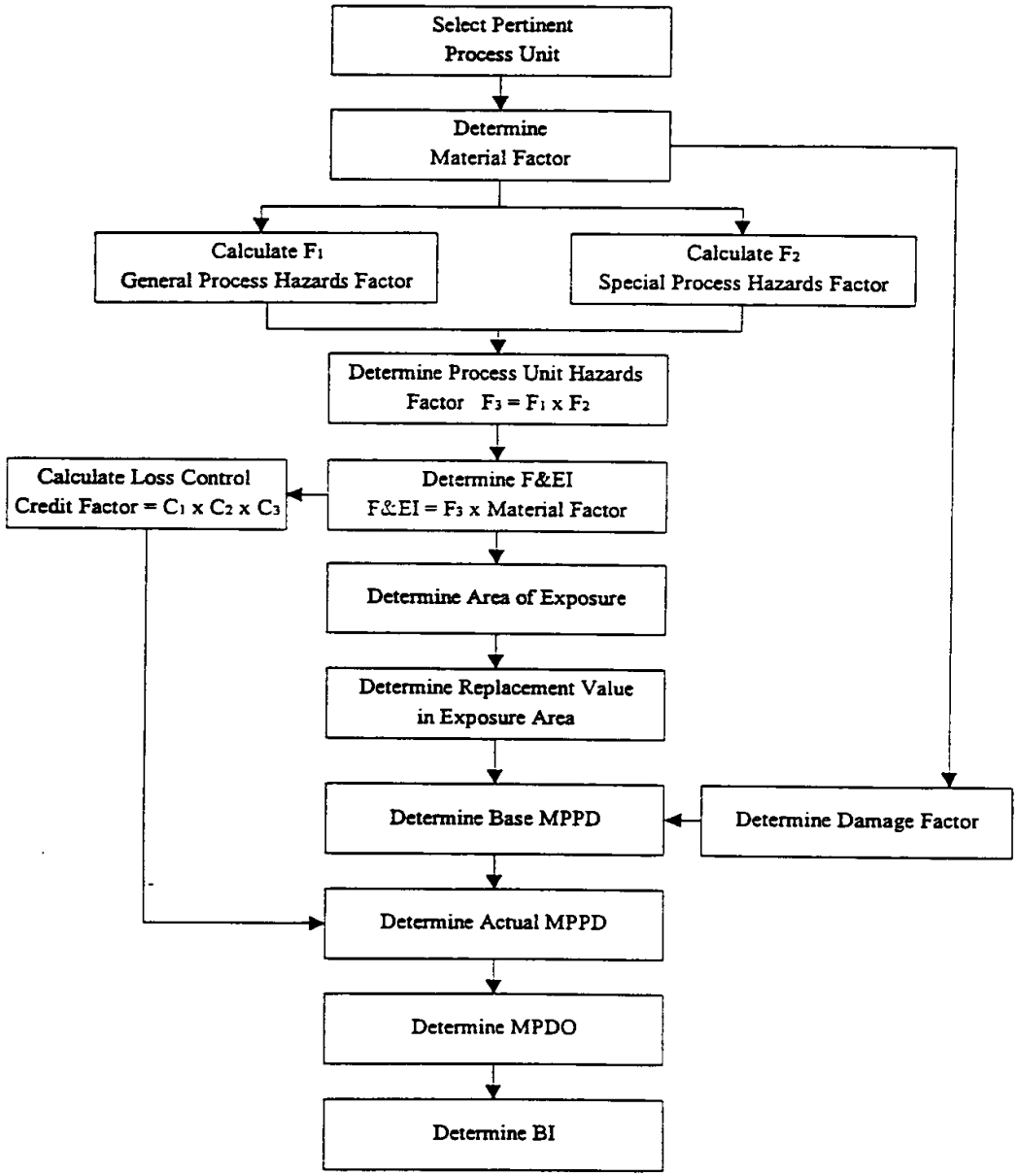
- Material Factor(MF)
  - Measure of Reactivity and Flammability
- General Process Hazards(F1)
  - Play a primary role in determining the magnitude of a loss incident
- Special Process Hazards(F2)
  - Contribute to the probability of a loss incident
- Fire & Explosion Index(F&FI)
  - A measure of the relative hazard and relates to an exposure radius

Parameter of DOW Fire & Explosion Index

- Loss control credits(LCCF)
  - Are features that have proved beneficial in preventing serious incidents and reducing the magnitude of a particular incident
  - Process Control
  - Material Isolation
  - Fire Protection
- Actual Maximum Probable Property Damage(MPPD)
  - Represents the property damage that could result from an incident of reasonable magnitude with adequate functioning of protective equipment
- Maximum Probable Days Outage(MPDO)
  - Time required to rebuild the plant to its original capacity
- Business Interruption(BI)
  - The lost profit to the company due to an incident

FIGURE 1

PROCEDURE FOR CALCULATING FIRE & EXPLOSION INDEX AND OTHER RISK ANALYSIS INFORMATION



Items Required to Develop an F & EI

1. Accurate Plot Plan for an existing plant
2. Preliminary Plot Plan for a new plant
3. Process Flow Sheet
4. F & EI Hazard classification guide
5. F & EI form

DOW Fire & Explosion Index

IDENTIFY PERTINENT PROCESS UNIT

(An item of equipment that could impact the process from a safety & loss prevention standpoint)

* Chemical Energy Potential (Material Factor)
* Quantity of hazardous materials in the process unit
* Capital density
* Process pressure and temperature
* Past history of problems

Not all unit operation need to be analyzed.

Knowledge of the process is essential

DOW Fire & Explosion Index

MATERIAL FACTOR

* Measure of the flammability (N_F) and reactivity (N_R) of a material

* Material factor adjusted for process conditions
  - Flash Point
  - Boiling Point

DOW Fire & Explosion Index

TABLE 1

MATERIAL FACTOR DETERMINATION GUIDE

Liquids & Gases Flammability or Combustibility[1]	NFPA 325M or 49	Reactivity or Instability $N_R = 0$	$N_R = 1$	$N_R = 2$	$N_R = 3$	$N_R = 4$
Non-combustible[2]	$N_F = 0$	1	14	24	29	40
F.P. > 200 °F (> 93.3 °C)	$N_F = 1$	4	14	24	29	40
F.P. > 100 °F (> 37.8 °C) ≤ 200 °F (≤ 93.3 °C)	$N_F = 2$	10	14	24	29	40
F.P. ≥ 73 °F (≥ 22.8 °C) < 100 °F (< 37.8 °C) or F.P. < 73 °F (< 22.8 °C) & BP. ≥ 100 °F (≥ 37.8 °C)	$N_F = 3$	16	16	24	29	40
F.P. < 73 °F (< 22.8 °C) & B.P. < 100 °F (< 37.8 °C)	$N_F = 4$	21	21	24	29	40
Combustible Dust or Mist[3]						
St-1 (K_{St} ≤ 200 bar m/sec)		16	16	24	29	40
St-2 (K_{St} = 201-300 bar m/sec)		21	21	24	29	40
St-3 (K_{St} > 300 bar m/sec)		24	24	24	29	40
Combustible Solids						
Dense > 40 mm thick[4]	$N_F = 1$	4	14	24	29	40
Open < 40 mm thick[5]	$N_F = 2$	10	14	24	29	40
Foam, fiber, powder, etc.[6]	$N_F = 3$	16	16	24	29	40

F.P. = Flash Point, closed cup B.P. = Boiling Point at Standard Temperatures and Pressure (STP)

DOW Fire & Explosion Index

MATERIAL FACTOR TEMPERATURE ADJUSTMENT

	Flammability Ranking	St	Instability Ranking
a. Enter Flammability (St for dusts) and Instability rankings.			
b. If process unit temperature is less than 140 °F (60 °C), go to "e."			
c. If process unit temperature is above the material flash point and is greater than 140 °F (60 °C), enter "1" under flammability ranking.			
d. If process unit temperature is above the exotherm start or autoignition temperatures and the process unit is not a reactor, enter "1" under instability ranking (see below).			
e. Add each column, but enter 4 if the total is 5.			
f. Using "e." and Table 1, determine Material Factor (MF) and enter on F&EI Form and Manufacturing Unit Risk Analysis Summary.			

Note: A material temperature up to 140 °F (60 °C) can be reached in ambient storage due to solar heat and stratification of temperature layers.

Flash point and autoignition data are generally available and understood, but "Exotherm Start" requires explanation. Exotherm Start is the temperature at which a heat-generating chemical reaction is first detected in Accelerating Rate Calorimetry (ARC) or similar calorimeter. Exotherm Start can be estimated from data secured by Differential Thermal Analysis (DTA) or Differential Scanning Calorimetry (DSC) either by:

a. subtracting 70 °C (126 °F) from the first exotherm start temperature or
b. subtracting 100 °C (180 °F) from the first exotherm peak temperature.

The use of "a." is preferred. Of course, if the "real" exotherm start temperature is known from operating experience (with a reactor in a plant, for example), the "real" temperature should be used. Consultation with a reactive chemicals testing person can be of great help in interpreting test data.

FIRE & EXPLOSION INDEX

AREA / COUNTRY	DIVISION	LOCATION	DATE
SITE	MANUFACTURING UNIT	PROCESS UNIT	
PREPARED BY:	APPROVED BY: (Superintendent)	BUILDING	
REVIEWED BY: (Management)	REVIEWED BY: (Technology Center)	REVIEWED BY: (Safety & Loss Prevention)	
MATERIALS IN PROCESS UNIT			
STATE OF OPERATION ___ DESIGN ___ START UP ___ NORMAL OPERATION ___ SHUTDOWN	BASIC MATERIAL(S) FOR MATERIAL FACTOR		
MATERIAL FACTOR (See Table 1 or Appendices A or B) Note requirements when unit temperature over 140 °F (60 °C)			

1. General Process Hazards	Penalty Factor Range	Penalty Factor Used(1)
Base Factor	1.00	1.00
A. Exothermic Chemical Reactions	0.30 to 1.25	
B. Endothermic Processes	0.20 to 0.40	
C. Material Handling and Transfer	0.25 to 1.05	
D. Enclosed or Indoor Process Units	0.25 to 0.90	
E. Access	0.20 to 0.35	
F. Drainage and Spill Control _____ gal or cu.m.	0.25 to 0.50	
General Process Hazards Factor (F_1)		
2. Special Process Hazards		
Base Factor	1.00	1.00
A. Toxic Material(s)	0.20 to 0.80	
B. Sub-Atmospheric Pressure (< 500 mm Hg)	0.50	
C. Operation In or Near Flammable Range ___ Inerted ___ Not Inerted		
1. Tank Farms Storage Flammable Liquids	0.50	
2. Process Upset or Purge Failure	0.30	
3. Always in Flammable Range	0.80	
D. Dust Explosion (See Table 3)	0.25 to 2.00	
E. Pressure (See Figure 2) Operating Pressure _____ psig or kPa gauge Relief Setting _____ psig or kPa gauge		
F. Low Temperature	0.20 to 0.30	
G. Quantity of Flammable/Unstable Material: Quantity _____ lb or kg H_C = _____ BTU/lb or kcal/kg		
1. Liquids or Gases in Process (See Figure 3)		
2. Liquids or Gases in Storage (See Figure 4)		
3. Combustible Solids in Storage, Dust in Process (See Figure 5)		
H. Corrosion and Erosion	0.10 to 0.75	
I. Leakage – Joints and Packing	0.10 to 1.50	
J. Use of Fired Equipment (See Figure 6)		
K. Hot Oil Heat Exchange System (See Table 5)	0.15 to 1.15	
L. Rotating Equipment	0.50	
Special Process Hazards Factor (F_2)		
Process Unit Hazards Factor (F_1 x F_2) = F_3		
Fire and Explosion Index (F_3 x MF = F&EI)		

(1) For no penalty use 0.00.

DOW Fire & Explosion Index

CONTRIBUTING HAZARD FACTORS

Evaluate the process unit to eliminate over estimating penalties

* General Process Hazards (F_1)

* Special Process Hazards (F_2)

DOW Fire & Explosion Index

GENERAL PROCESS HAZARDS
F_1

Penalties for:

Exothermic/Endothermic

Material Handling & Transfer

Enclosed processes

Access

Drainage and spill control

F & EI workbook has various penalties

DOW Fire & Explosion Index

SPECIAL PROCESS HAZARDS
F_2

Penalties for:

Toxic materials (0.2 x N_H)

Sub-atmospheric pressure (P<500mHg, 0.5)

Dust explosions

Operating in flammable range

Low temperature operation

Corrosion & Erosion

Leakage

Rotating equipment

F & EI workbook has various penalties

DOW Fire & Explosion Index

F & EI IS USED TO DETERMINE

- An area having a potential for impact from a flammable or over pressure event

DOW Fire & Explosion Index

F & EI	Degree of Hazard
1 - 60	Light
61 - 96	Moderate
97 - 127	Intermediate
128* - 158	Heavy
159+	Severe

* Trigger for more detailed PHA

WHAT CAN I DO TO LOWER THE RISK?

* Reduce the Hazards (most impact)

* Add Loss Control Features (Least impact)

* Increase spacing (plant layout)

❖It is more effective to reduce the hazards early in the project than to add loss control features late in the project

❖The system makes us quantify the risk and suggests ways to reduce the risk

Risk assessment tools

- Risk assessment tools/risk assessment techniques are procedures or frameworks that can be used in the process of assessing and managing risks.
- Commonly Used Risk Assessment Tools

1. Risk matrix
2. Failure Mode and Effects Analysis (FMEA)
3. Decision Tree
4. Bowtie Model

Risk matrix(risk diagram)

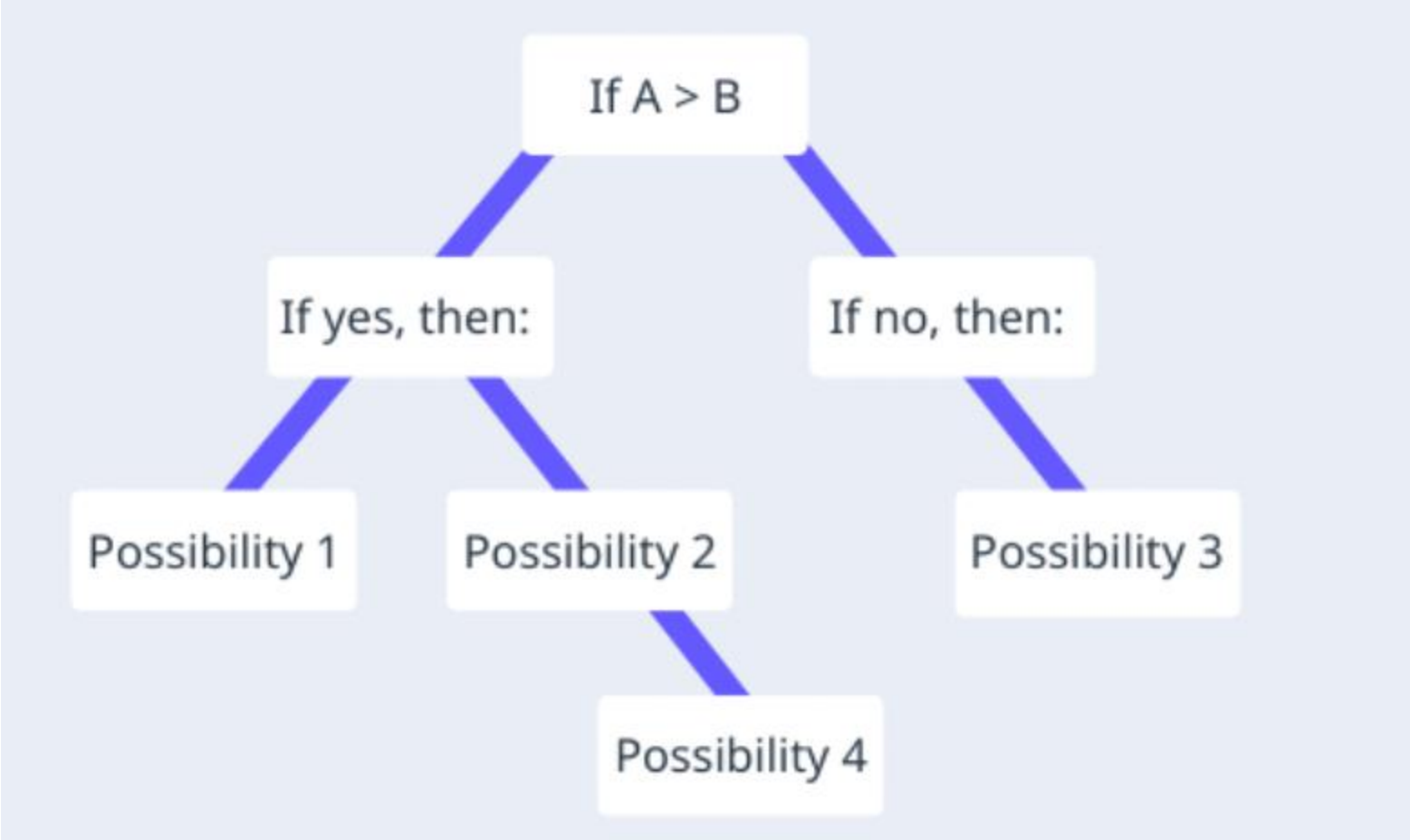
- A visual representation of risks laid out in a diagram or a table
- Risks are divided and sorted based on their probability of happening and their effects or impact.
- A risk matrix is used to help prioritize which risk to address first, what safety measures and risk mitigation plans to take, and how 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.

Likelihood		**Very Likely**	**Likely**	**Unlikely**	**Highly Unlikely**
Consequences	Fatality	High	High	High	Medium
	Major Injuries	High	High	Medium	Medium
	Minor Injuries	High	Medium	Medium	Low
	Negligible Injuries	Medium	Medium	Low	Low

FMEA(Failure Mode and Effects Analysis)

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

Decision Tree

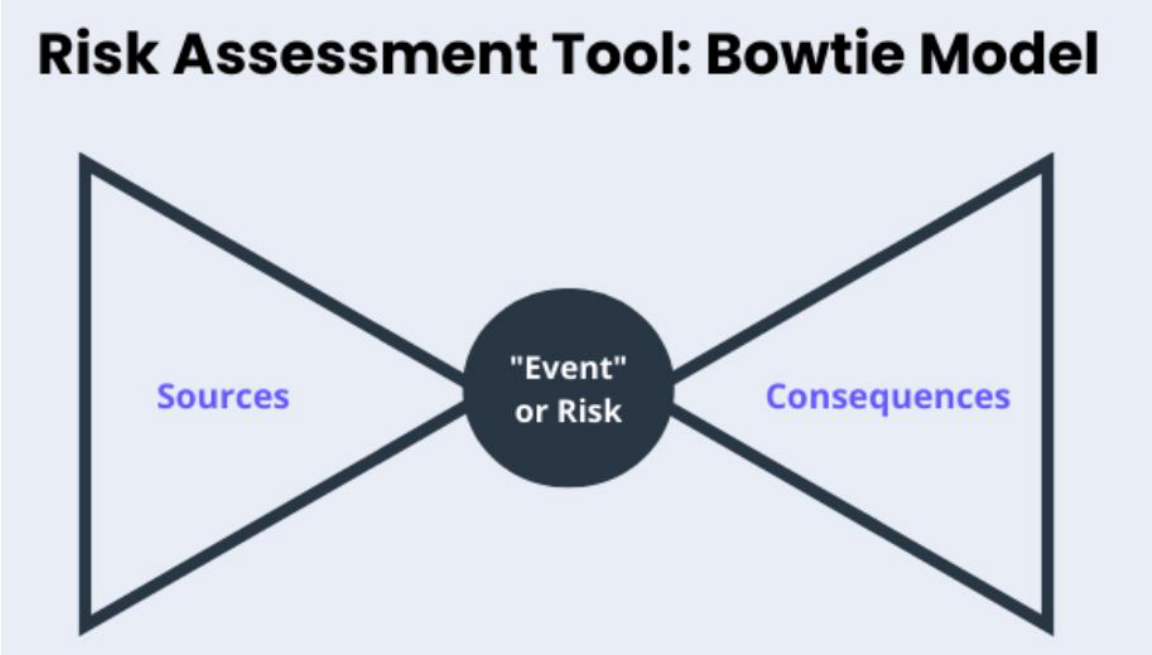


Decision Tree

- 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.
- 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.

Bowtie Model

- 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.



Assessing the Consequences

- Injury severity and consequence can be divided into 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.

Assessing the likelihood

- **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.

Uses of Risk assessment tools

- 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 changed in existing rules
- Preventing and mitigating injuries, fatalities, and illnesses
- Meeting legal requirements on certain industry-specific tasks where applicable
- assessing the consequences

Preliminary Hazard Analysis

- Preliminary hazard analysis (PHA) is 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; it is used in the early stages of system design.
- It is a semi-quantitative analysis that is performed to identify all potential hazards and accidental events that may lead to an accident, rank the identified accidental events according to their severity and identify required hazard controls and follow-up actions.
- Preliminary hazard analysis that can be used under different names, such as Rapid Risk Ranking and Hazard Identification (HAZID).

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 generate 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

Steps To Carry Out Preliminary Hazard Analysis (PHA)

1. **PHA prerequisites:**

- This involves, establishing a PHA team, description of the system to be analysed, and collection of risk information from previous system.

2. **Hazard identification:**

- This is where all hazards and possible accidental events must be identified.
- All part of the system should be considered at this stage.
- All findings should be recorded.
- No hazards are too insignificant to be recorded.

3. **Consequence and frequency estimation:**

- To determine the risk level, we have to estimate the frequency and the severity of each accidental event.
- At this stage, the consequence and frequency of every hazard is considered.

4. **Risk ranking and follow-up actions:**

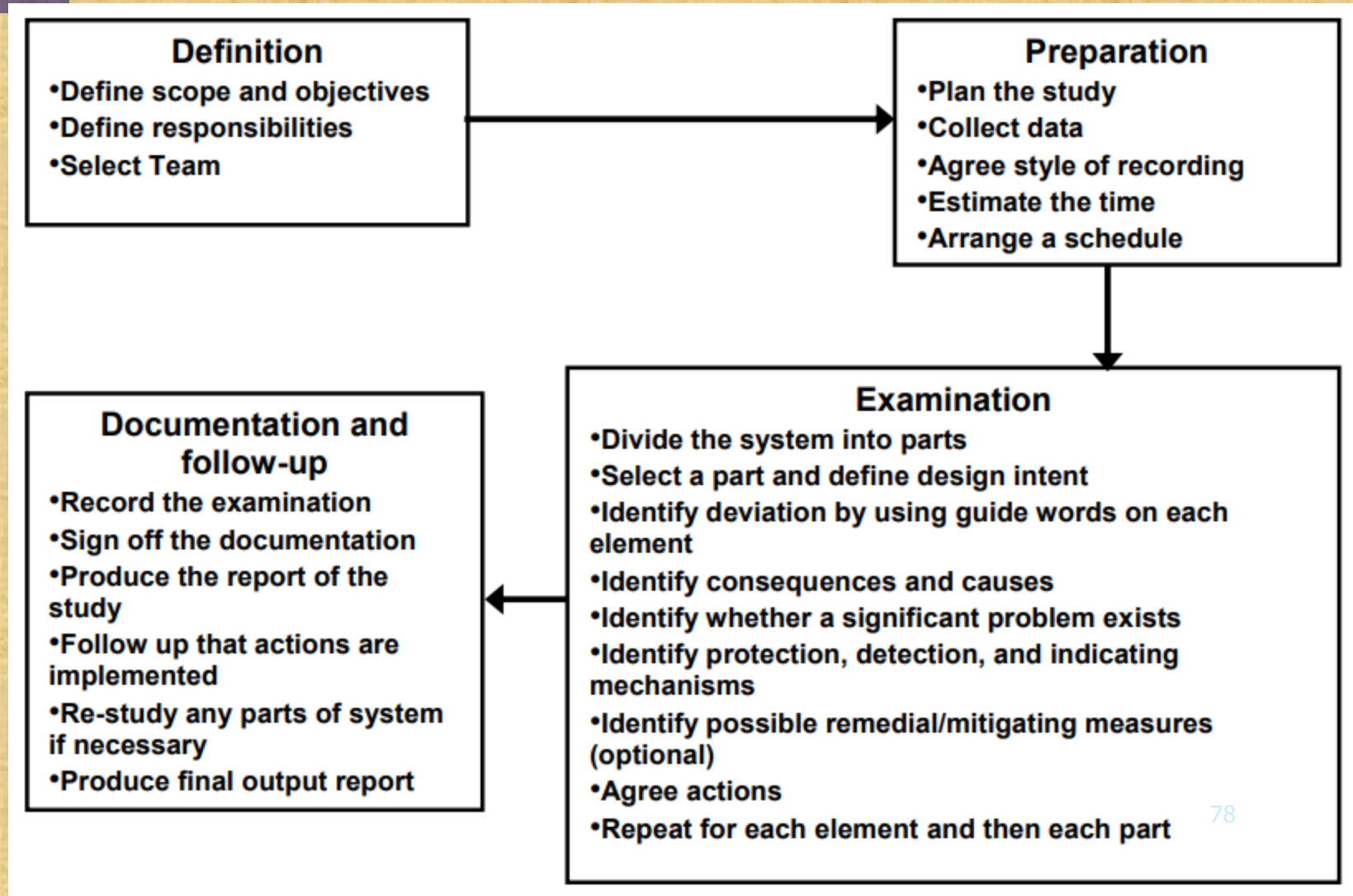
- Risk is established as a combination of a given event/consequence and a severity of the same event/consequence.
- This will enable a ranking of the events/consequences in a risk matrix.
- This ranking level will determine the follow up actions necessary for the risk.

Hazard & Operability Analysis (HAZOP)

- Hazard and Operability Analysis (HAZOP) is a structured and systematic technique for system examination and risk management.
- HAZOP is often used as a technique for identifying potential hazards in a system and identifying operability problems likely to lead to nonconforming products.
- HAZOP is based on a theory that assumes risk events are caused by deviations from design or operating intentions.
- Identification of such deviations is facilitated by using sets of "guide words" as a systematic list of deviation perspectives.
- This approach is a unique feature of the HAZOP methodology that helps to stimulate the imagination of team members when exploring potential deviations.

HAZOP Methodology

- The HAZOP analysis process is executed in four phases as illustrated below:



Definition Phase

- The Definition Phase begins with preliminary identification of risk assessment team members.
- HAZOP is intended to be a cross-functional team effort, and relies on specialists (SMEs) from various disciplines with appropriate skills and experience who display intuition and good judgment.
- SMEs should be carefully chosen to include those with a broad and current knowledge of system deviations.
- HAZOP should always be carried out in a climate of positive thinking and frank discussion.
- During this phase, the risk assessment team must identify the assessment scope carefully in order to focus effort.
- This includes defining study boundaries and key interfaces as well as key assumptions that the assessment will be performed under

Preparation Phase

- The Preparation Phase includes the following activities: Identifying and locating supporting data and information
  - Identification of the audience and users of the study outputs
  - Project management preparations (ex: scheduling meetings, transcribing proceedings, etc.)
  - Consensus on template format for recording study outputs
  - Consensus on HAZOP guide words to be used during the study

- Risk assessment teams are responsible for identifying the guide words that will best suit the scope and problem statement for their analysis.
- Common HAZOP guide words include:

▪ No or not	▪ Other than
▪ More	▪ Early
▪ Less	▪ Late
▪ As well as	▪ Before
▪ Part of	▪ After
▪ Reverse (of intent)	▪ Others can be crafted as needed…

Tip: ***The HAZOP guide word concept can be used to stimulate brainstorming of potential risks within other risk assessment tools as well***

Examination Phase

- The Examination Phase begins with identification of all elements (parts or steps) of the system or process to be examined.
- Eg:
  - Physical systems may be broken down into smaller parts as necessary
  - Processes may be broken down into discrete steps or phases
  - Similar parts or steps may be grouped together to facilitate assessment

- The HAZOP guide words are then applied to each of the elements.
- In this fashion a thorough search for deviations is carried out in a systematic manner.
- Not all combinations of guide words and elements are expected to yield sensible or credible deviation possibilities.
- All reasonable use and misuse conditions which are expected by the user should be identified and subsequently challenged to determine if they are “credible” and whether they should be assessed any further.
- There is no need to explicitly document the instances when combinations of elements and guide words do not yield any credible deviations

Documentation & Follow-up Phase

- The documentation of HAZOP analyses is facilitated by utilizing a template recording form as detailed in IEC Standard 61882.
- Risk assessment teams may modify the template as necessary based on factors such as:
  - Regulatory requirements
  - Need for more explicit risk rating or prioritization (ex: rating deviation probabilities, severities, and/or detection)
  - Company documentation policies
  - Needs for traceability or audit readiness
  - Other factors

Risk Review

- On a long-term basis, operational feedback should confirm that the assessment and control steps are adequately addressing the risk question.
- It is also important to note that new risks may arise from risk control practices.
- Risks that were not originally identified or may have been filtered out during the initial risk assessment can due to the implementation of risk control measures.

Risk Communication

- HAZOP is a powerful communication tool.
- The output of the tool should always be presented at a level of detail appropriate for the various stakeholders.
- This is important not just for presenting results, but also for obtaining early buy-in on the approach.

Chemical hazards

Types of Chemical Hazards

- Irritant chemicals
- Sensitizers
- Toxic Chemicals
- Asphyxiates
- Anesthetic and Narcotic
- Systematic poisons

Chemical hazards

- Respiratory fibro gens
- Carcinogens

Chemical Hazards

Irritant chemical:

- Primary irritant causing inflammation is one of the body's defense mechanisms.
- It is the reaction of tissue to harm which in sufficient to kill the tissue and is typified by construction of the small vessels in the affected area, dilution of the blood vessels, increased permeability of vessel walls, and migration of the white blood cell and defensive cells to the invading harmful chemicals
- eg: sulphur dioxide may make a blistering effect on upper respiratory tract

Chemical Hazards

Sensitizers(allergens)

- They cause an allergic reaction in people who face repeated exposure over time to certain chemicals.
- Reactions to chemicals deemed as sensitizers vary from person to person and can be either acute or chronic.
- Chemical exposure can manifest as swelling of the airway or develop into dangerous illnesses such as lung disease.
- Some diseases such as asthma and contact dermatitis become common among people due to over-exposure to chemicals.
- Eg: Chlorine and alkalis.

- **Asphyxiants**
- Chemical asphyxiants deprive the body of oxygen; interrupting the transfer and use of oxygen by the bloodstream.
- Asphyxiant Chemical Examples: Carbon monoxide and cyanide.

Chemical Hazards

Anesthetic and Narcotic:

- Hydrocarbons and certain derivatives such as the various chlorinated solvents or other, exert a depressant action on the central nervous system i.e. Aliphatic alcohols, petroleum etc.

Chemical hazards

Systematic poisons:

- Systematic poisons attack organs other than the initial site of contact.
- The critical organs are the kidneys, liver, bone marrow etc.
- Many halogenated hydrocarbons are effects the Visceral organs in Hematopoietic(i.e. blood-forming system) Nervous system.

Chemical hazards

Respiratory fibro gens:

- The hazard of particulate matter is influenced by the toxic and size and morphology of the particles.
- The critical size of dust (and aerosol) particles is 0.5 to 7 gm, since these can become deposited in the respiratory bronchioles and alveoli. i.e. Free crystalline silica.

Chemical hazards

Carcinogens

- Carcinogens are cancer-causing chemical substances, and a small amount of such a chemical is enough to severely harm human health.
- The hazards of such chemical substances will only appear many years after exposure.
- There are over 200 known human carcinogens.
- The diseases may be a genetic or influenced by life style or exposure to certain chemicals, termed carcinogens i.e. Coal tar, pitch dust, Asbestos etc.

GHS Pictograms and Hazard Classes		
 • Oxidizers	 • Flammables • Self Reactives • Pyrophorics • Self-Heating • Emits Flammable Gas • Organic Peroxides	 • Explosives • Self Reactives • Organic Peroxides
 • Acute toxicity (severe)	 • Corrosives	 • Gases Under Pressure
 • Carcinogen • Respiratory Sensitizer • Reproductive Toxicity • Target Organ Toxicity • Mutagenicity • Aspiration Toxicity	 • Environmental Toxicity	 • Irritant • Dermal Sensitizer • Acute toxicity (harmful) • Narcotic Effects • Respiratory Tract Irritation

Identification of Hazardous Waste Common Symbols

Oxidizer

Explosive

Flammable

Poison or toxic

Environmental Hazard

Corrosive

Controlling Chemical Hazards

- Controlling exposures to chemical hazards and toxic substances is the fundamental method of protecting workers.
- A hierarchy of controls is used as a means of determining how to implement feasible and effective controls.
- Engineering and work practice controls must be the primary means used to reduce employee exposure to toxic chemicals, as far as feasible, and that respiratory protection is required to be used when engineering or work practice controls are infeasible or while they are being implemented.
- Where possible, elimination or substitution is the most desirable followed by engineering controls.
- Administrative or work practice controls may be appropriate in some cases where engineering controls cannot be implemented or when different procedures are needed after implementation of the new engineering controls.
- Personal protection equipment is the least desirable but may still be effective.

Type of Control	Examples
Elimination/Substitution	▪ Substitute with safer alternatives
Engineering Controls (implement physical change to the workplace, which eliminates/reduces the hazard on the job/task)	▪ Change process to minimize contact with hazardous chemicals. ▪ Isolate or enclose the process. ▪ Use of wet methods to reduce generation of dusts or other particulates. ▪ General dilution ventilation. ▪ Use fume hoods.
Administrative and Work Practice Controls (establish efficient processes or procedures)	▪ Rotate job assignments. ▪ Adjust work schedules so that workers are not overexposed to a hazardous chemical.
Personal Protective Equipment (use protection to reduce exposure to risk factors)	▪ Use chemical protective clothing. ▪ Wear respiratory protection. [See the Respiratory Protection Safety and Health Topics page] ▪ Use gloves. ▪ Wear eye protection.

Hazardous Properties of Chemicals

Chemical hazards

- Toxic Chemicals: Chemicals having following values of acute toxicity and which, owing to their physical and chemical property, are capable of producing major accidents hazards.

Sometimes they can explode and cause burns, vomiting, drowsiness, etc

Chemical hazards

- Flammable: these are the substances which may get ignited by source of ignition i.e. alcohol, acids etc.
- Explosive: These substances may get explode due source of ignition, temperature increase i.e. ammonium nitrite.

Chemical hazards

- Corrosive: These are the chemicals which corrode the substance while contact i.e. Acids.
- Oxidizing: These are the chemicals which may create depression of oxygen in the atmosphere.
- Reactive: These are the substances which react with other substances i.e. Aluminium borohydride (Al(BH4)3) if mix with water H_2o it will get explode.

Chemical hazards

- Radioactive: These are the substances which may generates radiation in the atmosphere i.e. potassium-40, carbon-14

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What is MSDS

- **M**aterial **S**afety **D**ata **S**heet is Horoscope of the Chemical.
- MSDS Reveals the properties of chemical, its nature, different hazards, preventive measures in storage & handling, First Aid measures.
- It has 16 (Ten) sections

Identification of the substance or mixture and of the supplier

- Identification of Chemical/Mixture
- Other means of identification.
- Supplier's details (including name, address, phone number, etc.)
- Emergency Phone No.

Hazards identification

- Hazard Classification

- Hazard symbol including precautionary statements. (Hazard symbols may be provided as a graphical reproduction of the symbols in black and white or the name of the symbol, e.g., flame, skull and crossbones.)

- Any other hazard (dust, explosion etc.)

Hazard Class :

		
▪ Oxidizers	▪ Flammables ▪ Self Reactives ▪ Pyrophorics ▪ Self-Heating ▪ Emits Flammable Gas ▪ Organic Peroxides	▪ Explosives ▪ Self Reactives ▪ Organic Peroxides
		
▪ Acute toxicity (severe)	▪ Corrosives	▪ Gases Under Pressure

Hazard Class :

		
• Carcinogen • Respiratory Sensitizer • Reproductive Toxicity • Target Organ Toxicity • Mutagenicity • Aspiration Toxicity	• Environmental Toxicity	• Irritant • Dermal Sensitizer • Acute toxicity (harmful) • Narcotic Effects • Respiratory Tract • Irritation

Composition/information on ingredients

Substance

- Chemical identity.
- Common name, synonyms, etc.
- CAS number, EC number, etc.
- Impurities and stabilizing additives which are themselves classified and which contribute to the classification of the substance.

Composition/information on ingredients..contd...

Mixture

The chemical identity and concentration or concentration ranges of all ingredients which are hazardous within the meaning of the GHS and are present above their cutoff levels.

CAS Registry Number-

- is a unique numeric identifier
- designates only one substance
- has no chemical significance
- is a link to a means of information about a specific chemical substance

A CAS Registry Number is a numeric identifier that can contain up to 9 digits, divided by hyphens into 3 parts:

the right digit is a check digit used to verify the validity and uniqueness of the entire number

First aid measures

✓Description of different routes of exposure, i.e., **inhalation, skin and eye contact, and ingestion.**

✓Most important symptoms/effects, acute and delayed.

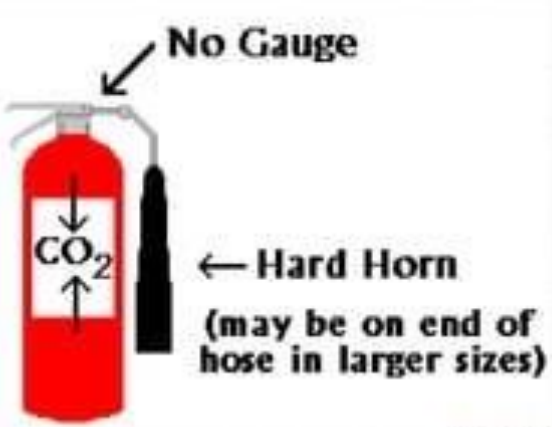
✓Indication of immediate medical attention and special treatment needed

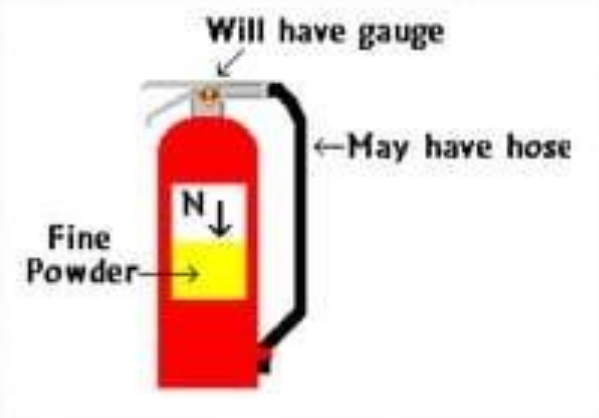
Firefighting measures

- Suitable (and unsuitable) extinguishing media.

- Specific hazards arising from the chemical (e.g., nature of any hazardous combustion products).

- Special Protective equipment and precautions for firefighters





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Accidental release measures

- Personal precautions, protective equipment and emergency procedures.
- Environmental precautions.
- Methods and materials for containment and cleaning up

Handling and storage

- Precautions for safe handling.

- Condition for safe storage including any incompatibilities

Exposure controls/personal protection.

✓Control parameters, e.g., occupational exposure limit values or biological limit values.

TLV –TWA **TLV-STEL**

✓Appropriate engineering controls.

✓Individual Protection measures : Personal Protective Equipment

Eye protection
Skin Protection
Respiratory Protection

Definition of Key Words

- **Threshold Limit Value-Time-Weighted Average, TLV-TWA** -- Time-weighted average concentration for an 8-hour workday and a 40-hour work week in which a worker may be repeated exposed without adverse health effects.

- **Threshold Limit Value-Short-Term Exposure Limit, TLV-STEL** -- This is the maximum concentration which workers can be exposed for **15 minutes continuously** without adverse health affects. Only four of these 15-minutes exposures are permitted per day and must have 60 minutes between exposures. The **TLV-TWA** still must not be exceeded.

- **Threshold Limit Value-Ceiling** -- This is a defined boundary unlike TLVs which are guidelines. It is the concentration which should **never be exceeded** at any time during the working exposure.

- **Permissible Exposure Limit, PEL** -- This is one of the most important OSHA limits used. It is defined as the **allowable limit** for air contaminant in which workers may be exposed **day after day without adverse health effects**.

Physical and Chemical Properties

- ✓ Appearance
- ✓ Molecular Weight :
- ✓ Flashpoint: oC
- ✓ Auto ignition Temperature: oC
- ✓ Boiling Point: oC @ 760 mm Hg
- ✓ Melting Point: oC
- ✓ Vapor Pressure: mm Hg @ 230C
- ✓ Vapor Density(Air=1):
- ✓ % Solubility in Water: @ 20ºC
- ✓ Odor/Odor threshold:

Physical and Chemical Properties contd..

- ✓ Lower Flammability Limit: %
- ✓ Upper Flammability Limit: %
- ✓ Specific Gravity: @ 200C
- ✓ % Volatile:
- ✓ Evaporation Rate (Water=1):
- ✓ Viscosity: cP @ 250C
- ✓ Octanol/Water Partition Coefficient: log Kow:
- ✓ pH:

Definitions

- **Flash point** -- the lowest temperature at which a flammable liquid gives off enough vapor to form an ignitable mixture with air. In other words, the lowest temperature at which a liquid can ignite if a spark is present. Liquids with very low flash points are dangerous fire hazards (e.g., ethyl ether -49 C).

- **Auto ignition temperature** -- the temperature at which the liquid will set itself on fire without a flame or spark.

- **Lower Explosive Limit** -- the minimum concentration of a flammable gas or vapor (% by vol. in air) in which an explosion can occur if a flame or spark is present.

- **Upper Explosive Limit** -- the maximum concentration of a flammable gas or vapor (% by vol. in air) in which an explosion can occur if a flame or spark is present.

- **Hazardous Products of Combustion** -- In most fires, the greatest danger to human life is not the heat of the flames, but the toxic smoke that can fill the area. All the anticipated products of combustion are listed here. Fires of the laboratory are far more dangerous than common fires because the toxic fumes are often far more dangerous.

Stability and Reactivity

- ✓Chemical stability.
- ✓Hazardous Reactions/Decomposition Products
- ✓Possibility of hazardous reactions.
- ✓Conditions to avoid (e.g., static discharge, shock or vibration).
- ✓Incompatible materials

Toxicological information

Concise but complete and comprehensible description of the various toxicological (health) effects and the available data used to identify those effects, including:

✓ information on the likely routes of exposure (inhalation, ingestion, skin and eye contact);

✓Symptoms related to the physical, chemical and toxicological characteristics;

✓Target Organ Effects

✓Acute and also chronic effects from short- and long-term exposure;

Acute Toxicity Values
Oral LD50 (Rat) :100 mg/kg
Dermal LD50 (Rabbit) : mg/kg
Inhalation LC50 (Rat): ppm/4 hr., ppm vapor/1 hr

Definition :

Routes of entry -- A hazardous materials may enter the body through the skin or the eye, by inhalation, or ingestion.
Acute health effects -- The adverse health effects from short-term exposure.
Chronic health effects -- The detrimental health conditions which may result from long-term exposure.
Symptoms of exposure -- A description of how a victim of exposure might look or act like.
Medical conditions aggravated by exposure -- These terms are not easily recognized by non-medical personnel.
Target organs -- Some materials harm a particular organ of the body, (heart, liver, brain, etc).

Definition :

Lethal Concentration 50, LC-50 -- This concentration of a hazardous material in air is expected to **kill 50% of a group of test animals** when given as a single respiratory exposure in a specific time period.

Lethal Concentration Low, LC-LO -- This value indicates the **lowest concentration** of a substance in air that **caused death in humans or laboratory animals**. The value may represent periods of exposure that are less than 24 hours(acute) or greater than 24 hours (sub-acute and chronic).

Lethal Dose 50, LD-50 -- The single dose, other than inhalation, that **causes death in 50% of an animal population** from exposure to a hazardous substance.

Lethal Dose Low, LD-LO --The **lowest dose**, other than inhalation, that **caused death in humans or animals**.

Acute Oral Toxicity

	Category 1	Category 2	Category 3	Category 4	Category 5
LD_{50}	£ 5 mg/kg	> 5 < 50 mg/kg	³ 50 < 300 mg/kg	³ 300 < 2000 mg/kg	³ 2000 < 5000 mg/kg
Pictogram					No symbol
Signal word	Danger	Danger	Danger	Warning	Warning
Hazard statement	Fatal if swallowed	Fatal if swallowed	Toxic if swallowed	Harmful if swallowed	May be harmful if swallowed

Ecological information

Ecotoxicity (aquatic and terrestrial, where available).

Persistence and degradability.

Bioaccumulative potential.

Mobility in soil.

Disposal considerations

Description of waste residue and information on their safe handling and disposal including the disposal of any contaminated packaging.

Transport information

- ✓UN Number.
- ✓UN Proper shipping name.
- ✓Transport Hazard class(es).
- ✓Packing group, if applicable.
- ✓Marine pollutant (Yes/No).
- ✓Special precautions which a user needs to be aware of or needs to comply with in connection with transport or conveyance either within or outside their premises.

Transport information contd...

U.S. Department of Transportation (DOT)
Proper Shipping Name:
Hazard Class:
UN/NA Number:
Packing Group:
Labels Required:

International Maritime Organization (IMDG)
Proper Shipping Name:
Hazard Class:
UN/NA Number:
Packing Group:
Labels Required:

Transport Pictograms :

		
Flammable Liquid Flammable Gas Flammable Aerosol	Flammable solid Self-Reactive Substances	Pyrophorics (Spontaneously Combustible) Self-Heating Substances
		
Substances, which in contact with water, emit flammable gases (Dangerous When Wet)	Oxidizing Gases Oxidizing Liquids Oxidizing Solids	Explosive Divisions 1.1, 1.2, 1.3
		
Explosive Division 1.4	Explosive Division 1.5	Explosive Division 1.6

Transport Pictograms :

		
Compressed Gases	Acute Toxicity (Poison): Oral, Dermal, Inhalation	Corrosive
		
Marine Pollutant	Organic Peroxides	

Regulatory information

✓Safety, Health & Environment information specific for the product in question.

Other Information

National Fire Protection Association (NFPA) Ratings: This information is intended solely for the use of individuals trained in the NFPA system.

Health:
Flammability:
Reactivity:
Special Hazard

Revision Indicator: