Preface

Human life is the most precious thing in this world. One of the Tenets of International Labour organization (ILO) is "Decent Work for workers at large". ILO defines decent work as safe work. Human safety is of utmost importance in all situation. Business and industry are run by mankind. At least till now, machine can't run the business. Rather we need human to run machine. Loss of human life is the greatest loss for the organization. It is not only a loss of one skilled manpower but also loss of reputation and brand image of the company. Union Carbide is the glaring example. Before the Bhopal Gas tragedy, it has business in many countries across the globe. But after the gas disaster, company had been wiped out from the globe. Accident follows the "Karya-Karan" theory of Buddhism. It means there is a cause for every action. Every accident has a cause and mostly it is rooted in human negligence or carelessness. Of course there are accidents due to natural calamities, but we have no control over natural calamities. We can only have the preparedness and post disaster action plan. But we can't avoid natural disaster. With proper information, training and awareness we can definitely avoid accidents and loss of human life.

In our country we have Acts and Regulations for Industrial safety. But Acts and Regulation alone can't prevent accidents and loss of life. We need to have robust safety management system in the organization. It should come from the top management. If top management is concerned about value of human life, accident can definitely be avoided. It has been seen from the record of various industries that there is zero accident, years after years, where Top management is serious about safety. Reverse is also true. Wherever there has been serious accident, it is observed that the Top management has lackadaisical approach towards safety.

Safety and Quality are inseparable. Quality cannot be achieved without a safe working environment. For example, a worker doing welding at a height without safety gears will never be able to do quality welding. A car painting without water curtain and air suction facility which reduces hazards from volatile organic chemicals (VOC), cannot result in good finish. The organization where safety is compromised does not get good quality workers and quality of their product or services are not up to the mark. The organization where safety is a part of work culture, the workers work with a fearless mind and their productivity and quality are always better. Safety is discipline which everyone has to follow. Accident does not differentiate rich or poor, manager or worker, boss or subordinate. Rule for safety is for everyone. There are organizations where all the entrants have to undergo mandatory safety training and use required personal protective equipment irrespective of their status. The famous Quality Guru Eiji Toyoda has rightly said "Safe work is the door to all work. Let us pass through this door every day"

Bureau of Indian Standards has brought out several standards on safety. Two technical committees are mainly involved in formulating safety related standards namely CHD 7 & 8. International Organization for Standardization has brought out a very important standard ISO 45001 on Occupational Health and Safety management system, which is immensely popular and many organizations throughout the world have benefited through it to improve its safety performance. In each product or guideline standards, safety is the integral part and there can't be quality in product if there is no safety.

This Handbook contains basic concepts and issues related to Safety and Indian standards related to safety with an ultimate aim to prevent & reduce accidents in work place.

Acknowledgement

While writing this book substantial assistance has been taken from the open and free source available in the internet. Various photographs and some charts have been copied from the internet sources also.

My sincere thanks to Shri L M Deshmukh, author of "Industrial Safety Management Hazard Identification and Risk Control" from which I learnt many insights of safety hazards & Risks which has been reflected in this handbook. Some assistances have also been derived from European Commission's training material on "Introduction to Toxicology", an Article on "Fire Safety" by IIT Roorkee and "Industrial Toxicology" Lifoia Clement. ILO reports, OSHA standards, ISO standards and Indian standards are extensively used in writing this Hand Book.

I extend my sincere gratitude to my Ex Senior colleague and my Guru in OHSMS & EMS Dr D K. Chaudhuri Ex DDGE who has vast experience, both theoretical as well as practical knowledge. Teachings and knowledge provided by him have been extensively used.

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CHAPTER I

ACCIDENTS -WHAT, WHY AND HOW?

CHAPTER I

ACCIDENTS -WHAT, WHY AND HOW?

Just How Unsafe is Indian Workplaces?

The latest broad accident statistics appeared under this title by Mr. N. Vidyasagar in the 'Business Times' supplement of the Times of India dated September 19, 2003.

- Around 125 workers die every day.
- 50,000 are injured every day.
- India accounts for 32% of global mishaps and 37% of occupational injuries.

This is a grave situation which should alarm us as progressive thinker's and push us to investigate, in-depth, the causative factors responsible for the present day situation.

What is ACCIDENT ?

As per **IS/ISO 45001 :2018 (Clause 3.35) ,** occurrence arising out of, or in the course of, work that could or does result in *injury and ill health is called* ***Incident. An incident*** *where injury and ill health occurs is sometimes referred to as an* ***"accident.***

An incident where no injury and ill health occurs, but has the potential to do so, may be referred

to as a **"near-miss", "near-hit" or "close call".**

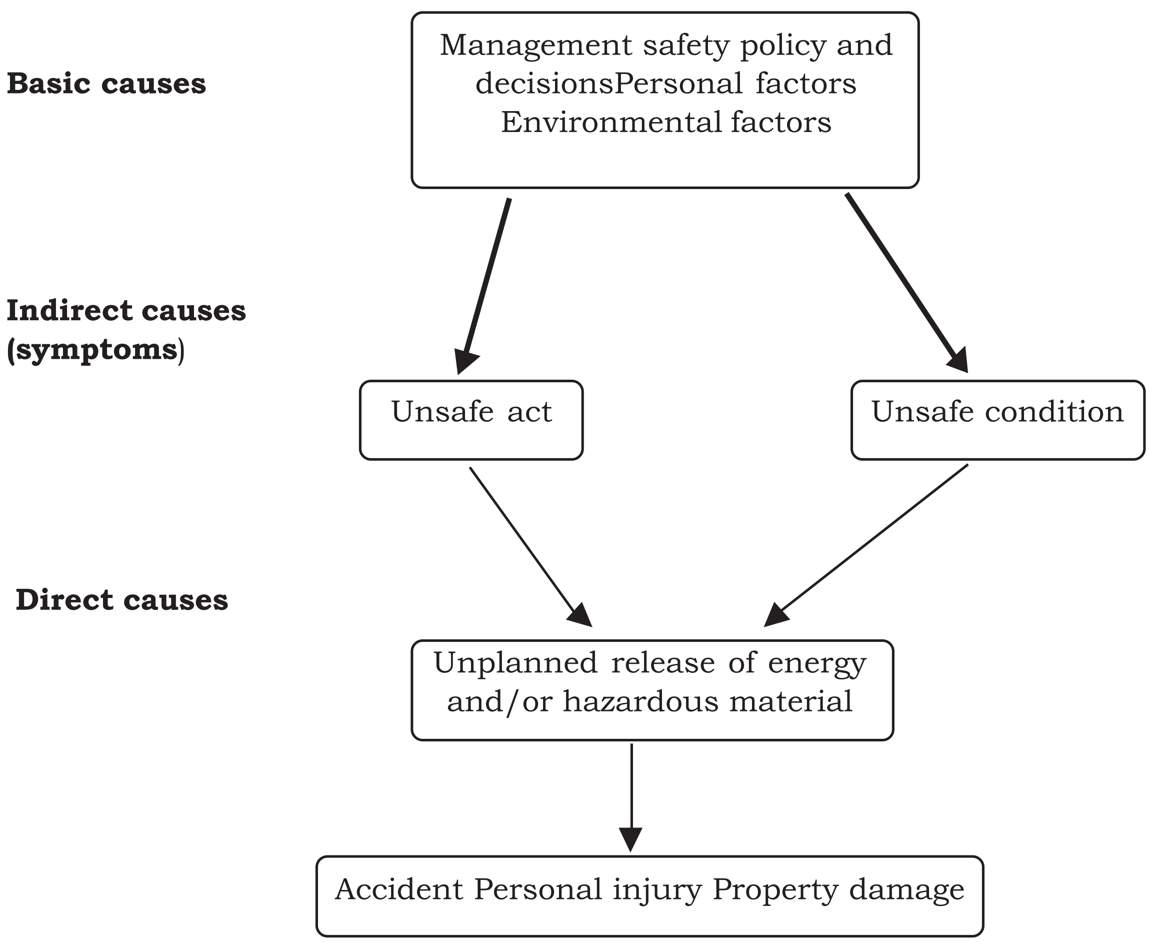
Why Do Accidents Occur?

In order to prevent the accident or near miss, we must know what are the factors which leads to accident or near miss so that appropriate and effective corrective action can be taken(**Clause 3.6 & clause 10.2 of IS/ISO 45001:2018)**

Accidents occur due to the following factors:

- Lack of risk awareness
- Lack of knowledge on the activity being undertaken
- Lack of safety aspects in design
- Lack of commitment to safety
- Lack of control
- Lack of education, training and motivation
- Lack of team-work and safety culture
- Lack of discipline
- Lack of social responsibility in general and personal responsibility and accountability to safety.

- Failure to learn from past experiences of similar incidents.
- Failure to inspect safety gadgets and devices and maintain them in order regularly and adequately.
- Failure to employ competent and well-trained people.
- Lack of continual efforts in training employees.
- No efforts to prevent hazards by employing safer designs or by adopting control methods.
- Failure to identify critical components and comply with the preventive maintenance requirements of the installation.
- Failure to sponsor candidates who are qualified, deserving and are interested in making safety profession as their career to professional courses in safety.
- Lack of instituting safety in the organisation. Out of all the various management functions, safety function remains the most neglected function apparently, considered non-profitable.
- Safety profession is, at the most, given a subordinate position in the management hierarchy. It generally falls to the middle management level which is not aware of even the basic principles of safety.



A detailed analysis of an accident will normally reveal three cause levels: Basic, Indirect and Direct. An important principle in safety, by Heinrich, states: "The causes of the accidents are visible before the accident"

ACCIDENT

Generally caused due to:

- Lack of knowledge, skill and/or motivation
- Incorrect attitudes, human/mechanical failures unsafe acts
- Unsafe conditions

Possibly, resulting in:

- Near-miss (no injury)
- Injury (major or minor)
- Death/permanent disability
- Catastrophic
- Production delay
- Property damage

However, the basic cause remains lack of Management commitment

PREVENTION

We must investigate the accidents:

- To identify these causes in-depth
- Eliminate them; and
- Prevent recurrence

Programme integrated safety management system could then be built in to:

- Formulate corporate safety policy and objectives.
- Assign responsibility to ensure safety.
- Establish targets and fix accountability.
- Provide management with leadership/control.

So that we will achieve

* Productivity
* Profitability
* Growth
* Corporate image
* Liability protection

CHAPTER II

HEINRICH'S LAW FOR ACCIDENTS

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HEINRICH'S LAW FOR ACCIDENTS

In the 1930s, a man named H. W. Heinrich had a theory about workplace safety. So, he reviewed 75,000 injury records from his insurance company's archives, as well as documents by manufacturing sites. The result is a theory called Heinrich's Law or the safety pyramid.

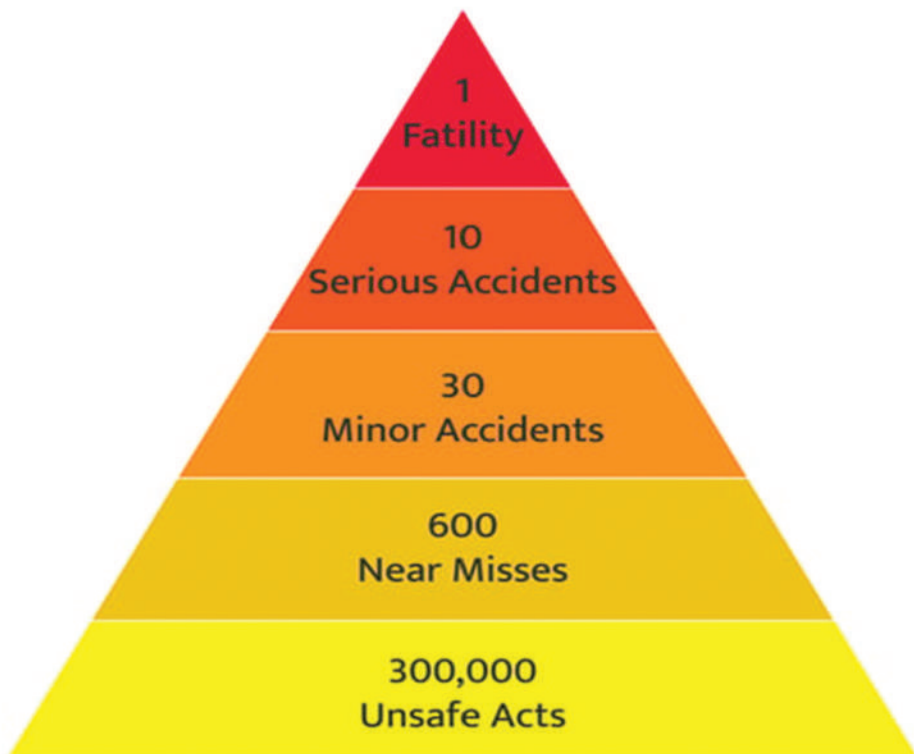
The safety pyramid, sometimes called the safety triangle, is a pictorial representation of a concept called Heinrich's Law, developed by H. W. Heinrich. Heinrich, an employee of the Traveler's Insurance Company in the 1930s, published a series of groundbreaking theories on health and safety at work.

The most famous of these is Heinrich's Law, which states, "in a workplace, for every accident that causes a major injury, there are 29 accidents that cause minor injuries and 300 accidents that cause no injuries."

Heinrich's Law indicates a relationship between major injuries, minor injuries, and near-misses. Heinrich's most-cited figure states that 88% of all injuries and incidents are caused by a human decision to perform an unsafe act.

Heinrich concluded that by lowering the number of minor injuries, businesses could reduce the total number of major injuries and incidents. And while Heinrich's most often cited figure would suggest an emphasis on man-made failures, Heinrich actually suggested that workplaces focus on hazards, not just worker behaviour.

Heinrich's Triangle or Accident Triangle



The Heinrich Triangle underlines that the system gives numerous warnings before it punishes to fatality. If we ignore these unsafe acts, it will result into the fatality.

CHAPTER III

BASIC CONCEPTS OF SAFETY HAZARDS & RISKS

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Safety Hazards & Risks

Introduction

Occupational hazards include all those work activities and processes involving the worker, raw materials, and processing activities such as operating machineries and handling chemicals. Workers whether they are farmers, students, secretaries, teachers, industrial workers or soldiers are exposed to some sort of hazards that may result from the nature of their day-to-day occupation. The identification of occupational health safety and hygiene hazards has often come from observations of adverse health effect among workers. Unquestionably it is in the workplace that the impact of industrial exposures is best understood.

What is Hazard :

As per the definition given in **Clause 3.19 of IS/ISO 45001:2018** , Hazard is source with a potential to cause *injury and ill health(* ***Clause 3.18 of IS/ISO 45001 Injury and ill health- adverse effect on the physical, mental or cognitive condition of a person****)*

Hazards can include sources with the potential to cause harm or hazardous situations, orcircumstances with the potential for exposure leading to injury and ill health.

Examples: Slippery floors, height of work surface/ platform, fire/explosion, moving vehicles, flying particles/objects, toxic/acidic/alkaline chemicals, electricity (bare conductors), pressure, radiation, noise, vibration, rotating/moving parts of machines etc.

What is Risk :

As per the definition given in **Clause 3.20 of IS/ISO 45001 :2018 ,**Risk is effect of uncertainty An effect is a deviation from the expected — positive or negative.

Uncertainty is the state, even partial, of deficiency of information related to, understanding or knowledge of, an event, its consequence, or likelihood.

Risk is often characterized by reference to potential "events" **(as defined in ISO Guide 73:2009, 3.5.1.3)** and "consequences" **(as defined in ISO Guide 73:2009, 3.6.1.3),** or a combination of these.

Risk is often expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated "likelihood" (**as defined in ISO Guide 73:2009, 3.6.1.1**) of occurrence.

Risk expresses the likelihood that the harm from a particular hazard will be realized. The extent of risk covers the population that might be affected by a risk i.e., the number of people who might be exposed and the consequences for them.

- A hazard is a source of danger, such as sharp point

A risk is exposure to danger, such as handling the sharp point, which could result in a puncture

What is Hazard Identification, Risk Assessment and Risk Control (IS 18347:2023 & Clause 6.1.2 of IS/ISO 45001:2018)

To prevent accident, the most important step to be taken is hazard identification. It means we have to find out what are the occupational health and safety (OH&S) hazards associated with the work or process. Next important step is to assess the Risks associated with those hazards. It is important to know that whether that risk is significant or non significant ? . What is the probability of occurrence of such hazards and how severe are the consequences.. . [**Clause 4.2 of IS 18347:2018]**

- Hazard identification is the process used to identify all possible situations in the workplace where people may be exposed to injury, illness or disease. ***"Find it"***
- Risk assessment is the process used to determine the likelihood that people may be exposed to injury, illness or disease in the workplace arising from any situation identified during the hazard identification process. ***"Assess it"***
- Risk control is the process used to identify all practicable measures for eliminating or reducing the likelihood of injury, illness or disease in the workplace, to implement the measures and to continually review the measures in order to ensure their effectiveness. ***"Fix it"***

Why Hazard Identification, Risk Assessment and Risk Control are important? (Clause 4.2.2 of IS 18347:2018)

The organizations are legally bound to carry out OH &S risk assessments. For many years OH&S risk assessments have been carried out on an informal basis. It is now recognized that risk assessment is a key foundation for pro-active OH&S management and that systematic procedures are necessary to ensure their success

- Employer has business objectives as well as moral and legal obligations to provide and maintain a safe and healthy workplace.
- To effectively manage business (including health and safety in the workplace) and discharge moral and legal obligations, it is imperative that:
- Any potentially hazardous situations (which may cause injury, illness or disease) in the workplace are identified on an ongoing basis before they occur
- The likelihood of each of the hazardous situations occurring are assessed
- If there is any likelihood of occurrence, appropriate measures to prevent their occurrence are identified and effectively implemented and
- The measures are continually reviewed to ensure their effectiveness.

The terms "hazard identification", "risk assessment" and "risk control" are commonly used to summarize the systematic approach for undertaking the above activities for managing workplace health and safety.

- **Basic steps: [Clause 5.2 of IS 18347:2023]**

  a) Identify hazards;

  b) Estimate the risk (the likelihood and severity of harm) from each hazardous event; and

  c) Decide if the risk is tolerable (for this purpose a tolerable risk criteria should be evolved which should take into consideration the legal requirements and other norms in that activity).

- **Necessity**

  a) Employers are legally obliged to carry out OH&S risk assessments. Their main purpose is to determine whether planned or existing control are adequate. The intention is that risks should be controlled before harm could occur.

Sources of Hazards in a Workplace

Hazards in a workplace can arise from a number of sources including:

- Poor workplace design
- Hazardous task being performed in the workplace
- Poorly designed plant being introduced into the workplace
- Incorrect installation, commissioning, use, inspection, maintenance, service, repair or alteration of plant in the workplace
- People being exposed to hazardous substances, processes or environment

Logical Approach to Dealing with a Hazard:

a) Identification of the hazard

b) Elimination of the hazard where possible

c) Segregation of hazards from those at risk

d) Reduction of risk if elimination or segregation is not possible

e) Provision of information for those who may create hazards or be at risk from them

f) Monitoring and review of the hazard and risk of exposure

- ***Control of OH&S Risks*** : Four possible alternatives

  a) Termination (elimination of risk)

  b) Treatment (improvement/modification)

  c) Tolerance (acceptance)

  d) Transfer (Insurance)

- ***Preventing and Controlling of Risks*** :

  a) Preventive methods – Elimination of hazardous substances, substitution with less hazardous substances

  b) Control methods

- Clean – Immediate removal of solid/liquid contaminants
- Contain – Hazardous substances during process
- Dispose – Safe disposal of hazardous substances
- Enclose – Enclosure for the hazardous process
- Exclude – Isolating the operator from hazardous process
- Minimize – Generation of hazardous wastes
- Suppress – Air-borne contaminants during process
- Ventilate – To remove the air-borne contaminants
- Store – Minimum inventory
- Reduce – Number of employees exposed, period of exposure
- Prohibit – Eating, drinking, smoking in contaminated areas

"The essence of Risk Management is to avoid high risk, manage medium risk and live with low risk"

Tools to assist the identification of hazards [Clause 5.3, 6 & 7 of IS 18347:2023]:

- Consultation – People who may have experience in aspects of the job that they like least and may lead to hazardous activities.
- Inspection – A physical inspection of the work environment.
- Illness and injury records – Records of past incidents involving injury and illness highlight sources of potential harm.
- Information/specialist advice – The identification of some hazards will require specialist advice, research and information.
- Task analysis – By breaking a task down into its individual element's hazards associated with the task can be identified.
- Formal hazard analysis systems for example HAZOP/HAZAN.

Some methods available for Hazard Analysis or Risk Assessment are given in the following Table:

Method	**Principle**	**Quantification**
Safety Review ("What if?")	Review of components of the process by an experienced multidisciplinary team.	No
Check – lists	Comparison of materials and equipment with data and codes established by experience.	No
Matrices (Relationship Chart)	Detection of potential hazardous interactions.	No
Hazard operability study (HAZOP)	Detection of causes and effects of deviations by use of guide words.	No
Action Error Analysis	Detection of critical human operating errors.	No
Fault Tree Analysis (FTA)	Deductive description of event leading from failures of components to a hazardous situation.	Possible

Method	Principle	Quantification
Failure Modes and Effects Analysis (FMEA)	Detection of critical faults in the functioning of individual components.	Possible
Failure Modes, Effects and Consequences Analysis (FMECA)	Detection of critical faults in the functioning of multiple components.	Possible
Event Tree Analysis (ETA)	Inductive determination of pathways of disturbance having led to a hazardous situation.	Difficult
Causes Consequence Diagram	Inductive determination of pathways of disturbance having led to a hazardous situation.	Difficult
Dow Fire and Explosion Index	Determination of probable damage resulting from an accident in a process plant	Relative ranking
Mond Fire, Explosion and Toxicity Index	Determination of probable damage resulting from an accident in a process plant	Relative ranking
Effects Models	Determination of physical damage from emissions,heat radiation, explosions.	Yes
Vulnerability Models	Determination of effects on human and the environment of emissions, heat, explosions.	Yes

The above methods are elaborately described in **IS 15656 :2006** which has been given in the later pater part of this chapter.

The hazard identification process is designed to identify all the possible situations where people may possibly be exposed to injury, illness and diseases arising from all sources.

Prior to the introduction of any plant, substances, processes or work practices in the workplace, it is essential for the hazard identification process to be carried out to identify whether there is any potential for injury, illness or disease associated with such introduction. This will assist to take the necessary actions for what may otherwise be extremely costly further down the track if no action is taken at this early stage.

Carrying out hazard identification for all existing plant, substances, processes and work practices in the workplace may require some effort. In a large workplace it is a good idea to split it into several discrete areas for the hazard identification process, and to tackle one area at a time. Priority should be given to areas with hazardous plant, substances, processes or environment.

In order to minimize the time involved, it is better to perform hazard identification on all sources of hazards in a particular area of the workplace instead of doing hazard source (e.g. plant, hazardous substances etc.) at a time.

The relevant health and safety personnel need to be consulted during the hazard identification process.

Employees working in the area have day to day experience of any hazards and should be involved in the hazard identification process. Advice should also be sought from people who are associated with the activities and processes in the area because they may provide valuable input.

- People undertaking hazard identification should have the necessary training to look for :
  - ❖ Mechanical hazards including
    - "drawing in" points
    - Shearing points
    - Impact and crushing areas
    - Cutting areas
    - Entanglement areas
    - Stabbing points
    - Abrasion areas
    - Flying particles
    - Any protrusions which could cause injury
  - ❖ Non-mechanical hazards including
    - Ergonomic hazards including manual handling
    - Electrical shocks and burns
    - Chemical burns, toxicity, flammability
    - Noise
    - Vibration
    - Radiation
    - Mist, dust, fumes
    - Suffocation
    - Engulfment
    - Biological hazards, viral
    - Slipping, tripping and falling hazards
    - Falling objects
    - High pressure fluids
    - High temperature objects
    - Working in very hot or cold conditions

Checklists should be developed to assist people who are involved in the hazard identification process in the systematic identification of hazards.

Hazards in the workplace can change from day to day. In order to effectively manage workplace health and safety it is essential to introduce proper systems and procedures to ensure hazard identification is carried out on a regular basis

- **Risk Assessment** :

Once the hazards have been identified, they should be listed for a risk assessment to be carried out in consultation with the relevant health and safety representatives and employees.

The purpose of risk assessment is to determine whether there is any likelihood of injury, illness or disease associated with each of the potentially hazardous situations identified in the hazard identification process by considering :

- Whether any person (workers and visitors) would be exposed to the identified situations under all possible scenarios (e.g. during installations, commissioning, erection, operation, inspection, maintenance, repair, service and cleaning of the plant)
- What existing measures are in place to protect the health and safety of people who may be exposed and
- How adequate the existing measures are for protecting the health and safety of people who may be exposed
- If the likelihood that anyone will be exposed to a situation under all possible scenarios is nil, then there is no risk and no additional risk control measures are required.
- The adequacy of existing control measures should be considered if there is the potential that someone may be exposed to a particular situation
- Existing control measures should not be regarded as adequate simply because an incident hasn't occurred. This particularly applies where the existing control measures are only administrative controls (e.g. training, safety procedures, safety signs, supervision) or personal protective equipment (e.g. safety gloves, safety glasses). These types of control rely heavily on human behaviours in doing the right thing and any deviation in behaviours (e.g. employees not following the safety procedures because some person or situation is distracting them) could cause injury, illness or disease.

- ***Risk Control* [Clause 8 of IS 18347:2023]:**

OHS legislation requires that new control measures to be introduced to eliminate the risk, or if that is not practicable, to reduce the risk so far as is practicable, if the current measures are found to be inadequate and there is a likelihood that injury, illness or disease will result from a particular situation.

- ❖ Practicable means having regard to
    - The severity of the hazard or risk in question
    - The state of knowledge about that hazard or risk and any ways of removing or mitigating that hazard or risk
    - The availability and suitability of ways to remove or mitigate that hazard or risk and
    - The cost of removing or mitigating that hazard or risk

The risk control process should be carried out in consultation with the relevant health and safety representatives and employees. In identifying new risk control measures, the most effective form of control measures is to eliminate the risk (e.g. by eliminating the process). If that is not practicable, it is needed to identify effective measures to reduce the risk. The OHS legislation specifies not to depend solely on the use of administrative controls or personal protective equipment to reduce the risk unless it has been established that the following measures are not practicable measures:

- Substituting the plant or substance with another one that is less hazardous
- Using engineering controls (e.g. modifying the design of the workplace or plant, or environmental conditions)
- Isolating people from the source of exposure
- Changing the objects used in the task involving manual handling
- Using mechanical aids for manual handling tasks

Before any decision is taken as to which type of risk control measures ought to be used, consideration should be given to the severity of injury, illness or disease that could occur.

If the severity is high (i.e., fatality, serious injury etc.), a higher hierarchy order of control (i.e. elimination, substitution, engineering controls, isolation) should be used. Sometimes they may have to be used in combination with administrative controls and in some cases personal protective equipment.

It is not always practicable to immediately implement the higher hierarchy of control and there may still be a need to keep the process/activity going. In such situations interim control measures (in the form of administrative controls in combination with personal protective equipment) may be used until the higher hierarchy of control can be implemented.

(**Note** : **If there is an immediate risk to health or safety, it must be made sure that the process/activity in question is ceased until measures are taken to remove the immediate risk**)

Once a decision is taken on the suitable risk control measures, a plan should be developed in consultation with the relevant health and safety representatives and employees for the implementation of those measures. The implementation plan should identify:

- The actions required
- Implementation timetable
- Who are responsible for the implementation of the actions (they should be adequately briefed on the expectations)

Progress towards the implementation plan should be monitored with enough lead time to take any corrective actions necessary to complete the plan on time. If a need is discovered for corrective action, it is to be documented in the implementation plan in the same way it is done for overall plan.

Once the new risk control measures are in place, they are required to be maintained. If there are new hazards requiring attention, then the hazard identification, risk assessment and risk control processes are to be repeated.

Record Keeping:

Maintenance of appropriate records assist to:

- Know what has been done and what more needs to be done and
- Demonstrate compliance with the obligations under the OHS legislation

Documented information should be kept which provide information on:

- When and where hazard identification was carried out
- A summary of identified hazards
- Whether there is any risk associated with each hazard identified
- The risk assessment method used
- What new measures have been identified to control any risk
- What measures are regarded as not practicable and the reasons for such
- What are the practicable risk control measures for implementation
- Timeline and responsible person for the implementation of the practicable risk control measures
- Who was involved in the hazard identification, risk assessment and risk control processes
- Who was consulted in the hazard identification, risk assessment and risk control processes

(A simple recording form may be used)

Risk can occur in a number of different ways, not all of them obvious to those exposed. Risk can thus be further broken down as follows:

- **Unknown risks** – risks of which the consequences are either not known or not fully understood, a good example being the risks perceived to be associated with nuclear power and with genetic engineering techniques.
- **Concealed or unconscious risks** – risk which are not readily detected by the senses; situation in which people may be lulled into a false sense of security. Ionizing radiation is an example of a hazard which is not detected by the senses.
- **Conscious risks** – risks of which people are aware; they can be detected by the senses giving the exposed person some warning and perhaps the ability to take mitigating action. Examples are the risk of getting burned in the event of a fire or of falling of a rock-face when climbing.
- **Predictable risks** – risks of which both the probability and the consequence can be estimated with some degree of confidence. This can allow some form of judgment to be made by those exposed and those responsible for their protection.
- **Temporary risks** – risks which are present only for a short period of time and may be acceptable only for that reason; an industrial example is the risk involved in some maintenance operations, a more mundane example is crossing a busy road.
- **Calculated risks** – predictable risks which are taken knowingly because there is a large perceived gain, because of special circumstances such as rescue or maintenance or because the risk is part of the attraction, as in dangerous sports.

Another way of classifying risk is to look at the *probability/consequence relationship*. Thus, risks can range from *high probability/low consequence* to *high consequence/low probability*. The latter tend to be more difficult to assess and comprehend.

Accepted and Imposed Risk – Three categories of risk are normally considered while examining industrial activities:

- **Occupational risk to the workforce** – self explanatory and can easily be assigned a higher risk value than the other categories.
- **Individual Risk to the General Public** – A risk, usually of an immediate consequence, to individual members of general public from an untoward event. Such a risk is both person and location-specific and can be defined as:
    - Risk = (frequency of event) x (casualty probability) x (fractional exposure)
    - Casualty probability is the probability of an untoward event causing a fatality and fractional exposure is the fraction of time for which a person is likely to be present at the location in question.
    - Where there are several untoward events or potentially hazardous locations, overall risk is the summation of individual events and location risks.
- **Risk to Society/Society Risk**
    - Societal risk reflects the likelihood of accidents involving multiple casualties and/or long-term detriment including, for example, contamination of environment. Burning examples are Chernobyl accidents and Bhopal incident.

There are several methods for hazard identification & risk controls, only one method is being detailed below;

METHOD I

Hazard Identification

It may include:

- Job hazard analysis
- Planned workplace inspection
- Accident investigations
- Review of new projects during design stages
- Workplace & personal exposure monitoring

Task Inventory

- Duration and frequency
- Location
- Who performs the task
- Others affected by task

- Written procedures
- Training received
- Equipment & tools used
- Substance used
- Existing controls
- Monitoring & effects data
- Regulatory requirements

Hazard Checklist

- Hazard associated with manual lifting and handling of materials, tools etc.
- Falls from heights at and above ground
- Fires and explosion
- Substances that may be inhaled
- Substances that may be ingested (Toxicology)
- Substances that could cause harm by coming into contact with skin
- Falls of materials, equipment or tools
- Inadequate headroom
- Hazards associated with the assembly, commissioning, operation, maintenance, repair or dismantling of machinery or equipment
- Vehicle hazards to personnel, vehicles and property
- Harmful energies such as noise, vibration, electricity, radiation, pressure, temperature
- Inadequate lighting to perform tasks
- Inadequate guards on machinery or handrails on stairs.

Risk Assessment

- **Key Questions:**
  - Is there a source of harm?
  - Who or what could be harmed?
  - How could harm occur?
- Determination of Risk
  - Objective is to assess:
    - Potential severity of harm
    - Likelihood that harm will occur
  - Qualitative methods appropriate for comparative assessment
  - More complex numerical methods can be applied where consequences could be catastrophic
  - Simple 3X3 qualitative risk assessment matrix is useful
  - Larger matrices e.g. 4X4, 4X5 may also be used.
  - Numerical values may be assigned to categories to arrive at a score
  - Numerical scoring does not imply greater accuracy.

[Risk Level = Severity X Probability]

Simple 3X3 Qualitative Risk Assessment Matrix

Severity	Probability
• Catastrophic – serious ▪ Death ▪ Disabling injury ▪ Occupational cancer ▪ Life shortening illness • Moderate ▪ Medical treatment • Minor ▪ First aid or nuisance, irritation, temporary discomfort	• Likely ▪ Frequent or probable • Unlikely ▪ Infrequent or occasionally • Highly unlikely ▪ Remote or improbable.

RISK ASSESSMENT MATRIX

Severity/ Probability	**Likely**	**Unlikely**	**Highly Unlikely**
Catastrophic-serious	Intolerable	Significant	Moderate
Moderate	Significant	Moderate	Tolerable
Minor	Moderate	Tolerable	Insignificant

Risk Assessment

- Risk Control Plan – While planning of the risk control following are to be considered:
  - Hazard elimination
  - Engineering controls
  - Workplace/equipment layout
  - Procedural controls
  - Training
  - Planned maintenance
  - Personal protective equipment (PPE)
  - Monitoring

Risk Level	**Priority and Action**
Intolerable	Stop or prohibit activity immediately until risk has been reduced.
Significant	• Do not start activity until risk has been reduced. If activity is in progress, take urgent action.
Moderate	• Implement risk reduction measures within a defined period
	• Costs may be considered and limitedMore detailed risk assessment of serious consequences to determine more precisely the probability of occurrence.
Tolerable	• No additional controls are required
	• Monitoring may be required to verify ongoing effectiveness of controlsInvestigate more cost effective controls
Insignificant	No action is required.

Risk Assessment

- Review Control Plan – While reviewing the control plan following must be considered:
- Do the new controls result in tolerable levels of risk?
- Are new hazards created?
- Do the controls result in new hazards?
- Do operators think the control plan is practical?
- Is the control plan the most cost-effective solution?

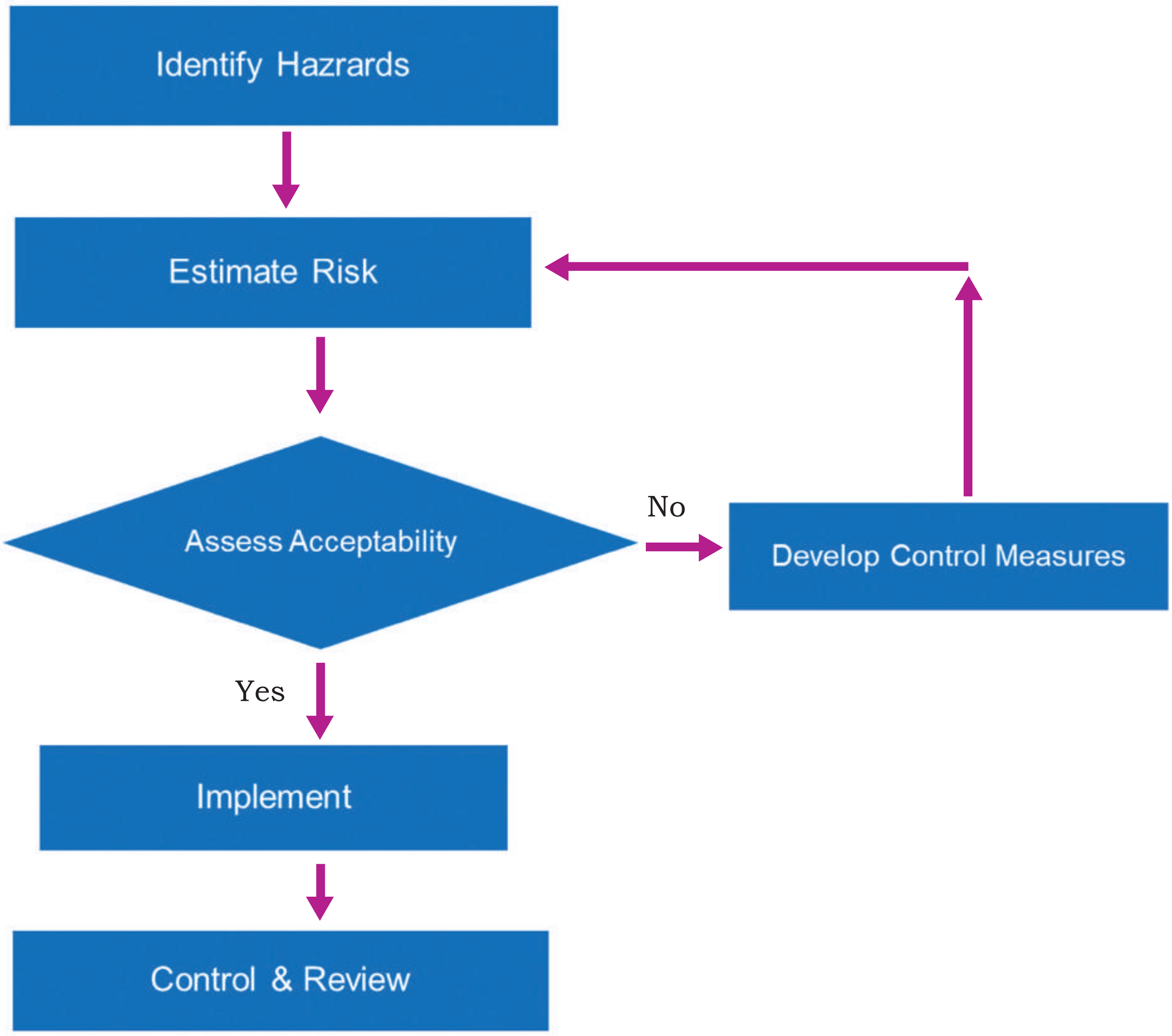
Hazard Identification, Risk Assessment and Risk Control

PRINCIPLE [Clause 5 of IS 18347:2023]

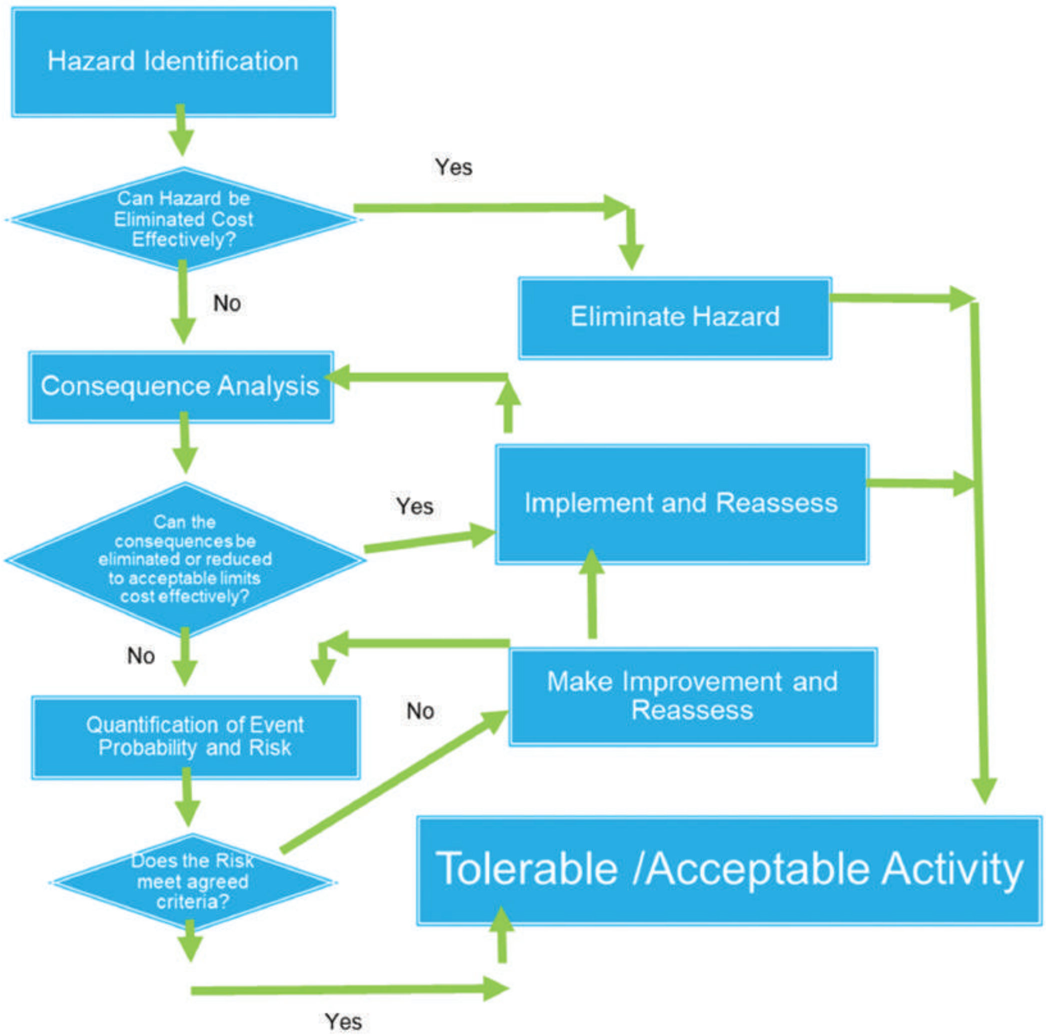
Fig. Process of Risk Assessment

Hazard Identification, Risk Assessment and Risk Control

RISK ASSESSMENT PROCESS [Clause 5 of IS 18347:2023]



PROCEDURE FOR THE APPLICATION OF RISK ASSESSMENT



Searching for Hazards – an example

Diesel engines and its auxiliaries

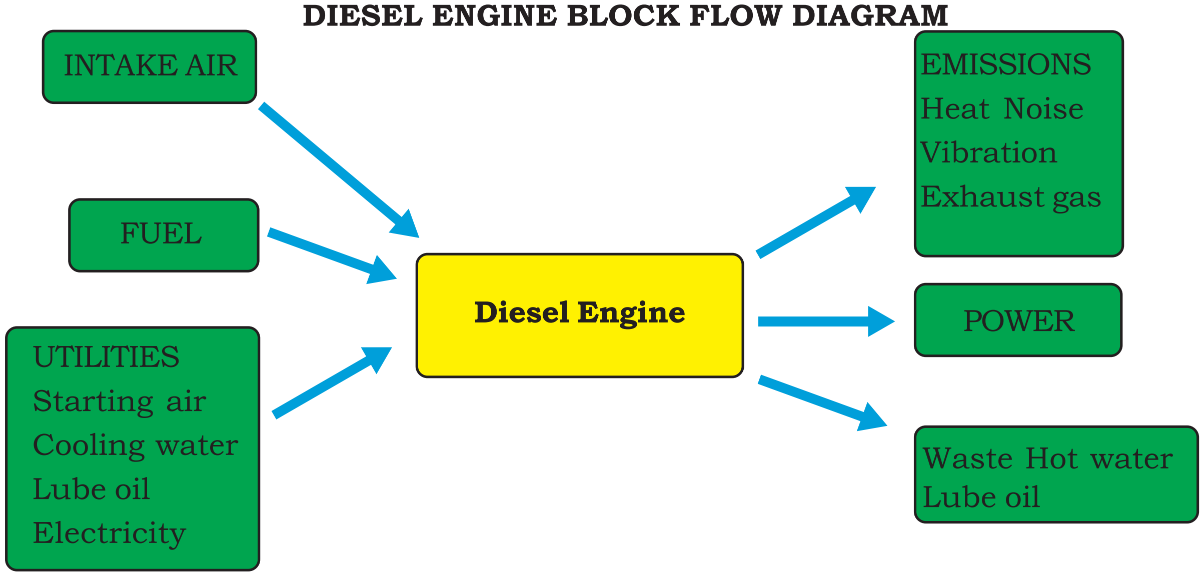
- Construct a block flow diagram showing all the streams that cross into and out of the diesel engine
- Examine each of the stream to find if any hazards are present.
- Hazards can generally be divided into dangers from the materials used, emissions and energy sources
- Hazards can either be to safety to health or environment
- Wastes and other hazards to the environment are ultimately hazards to health
- Once all hazards are found, the decision to be taken as to what design actions are needed, either to eliminate the hazard or to reduce the risk that could be caused.
- Consequences that could arise from the hazard are also to be considered.
- If there is an explosion, what other damage could occur and could it have an impact on safety?

- A fire could cause the starting air pressure vessel to explode and the venting down of the vessel will need to be part of the fire protection control system.

The design action needed will depend on the level of hazard and need to be verified by examination of the design data like noise emissions, exhaust gas temperature (285ºC), cooling water (inlet 60ºC, Outlet 90ºC), starting air (working pressure, 30 bar max. 8 bar min.), Fuel (Flashpoint 75ºC), Lube oil (Flashpoint 200ºC).

Review of the design data as above may confirm that action must be taken on noise and hot surface temperatures. Fire risk from fuel and lube oil is considered to be very low. However, they will feed a fire should a fire occur and if fuel were to spray on to a hot un-insulated exhaust pipe, it will ignite.

DIESEL ENGINE BLOCK FLOW DIAGRAM



Diesel engine hazards

Hazard	Item	Notes
Material	Diesel fuel Lube oil Cooling water	Skin contact can cause dermatitis Spillage can cause injury due to slips and falls Check safety instruction from water additives manufacturers
Emissions	Exhaust gas Noise Vibration Heat radiation Lube oil vapour	Air pollution, NOX, H2S Hearing damage Well-being Dehydration Air pollution
Energy	Starting air Electricity Moving parts Diesel fuel Lube oil Hot surfaces	Explosion Shock Physical injury Fire Fire Burns
Waste	Diesel fuel Lube oil Cooling water	Sludge disposal Lube oil disposal Contaminated water disposal

Classifications of occupational health, safety and hygiene hazards [Clause 7.1.2 of IS 18347:2023]

The various hazards which give rise to occupational diseases or adversely affect health through work may be classified as: -

a. Physical Hazards
b. Mechanical Hazards
c. Chemical Hazards
d. Biological Hazards
e. Ergonomic Hazards
f. Psychosocial Hazards

a. Physical Hazards

Physical hazard has possible cumulative or immediate effects on the health of employees. Therefore, employers and inspectors should be alert to protect the workers from adverse physical hazards.

Physical hazard include:

i) Extremes of temperature
ii) Ionizing radiation
iii) Non ionizing radiation
iv) Excessive noise
v) Occupational Health Safety and Hygiene

i) Extremes of Temperature

The work environment is either comfortable or extremely cold or hot and uncomfortable. The common physical hazard in most industries is heat. Extreme hot temperature prevails on those who are working in foundries, or in those industries where they use open fire for energy. Examples of these includes soap factories in large industries and in the informal sectors who use extreme heat to mould iron or process other materials.

Effect of hot temperature in work place include:

1. Heat Stress

Heat stress is a common problem because people in general function only in a very narrow temperature range as seen from core temperature measured deep inside the body. Fluctuation in core temperature about 2 degrees Celsius below or 3 degrees Celsius above the normal core temperature of 37.6 degree Celsius impairs performance markedly and a health hazard exists. When this happens the body attempt to counteract by:

- Increasing the heart rate
- The capillaries in the skin dilate to bring more blood to the surface so that the rate of cooling is increased.
- Sweating to cool the body

2. Heat stroke

Heat stroke is caused when the body temperature rises rapidly in a worker who is exposed to a work environment in which the body is unable to cool itself sufficiently. Predisposing factors for heat stroke is excessive physical exertion in extreme heat condition. The method of control is therefore, to reduce the temperature of the surrounding or to increase the ability of the body to cool itself.

3. Heat Cramp

Heat cramp may result from exposure to high temperature for a relatively long time particularly if accompanied by heavy exertion or sweating with excessive loss of salt and moisture from the body.

4. Heat Exhaustion

This also results from physical exertion in hot environment. Signs of the problem include:

- Mildly elevated temperature
- Weak pulse
- Dizziness
- Profuse sweating
- Cool, moist skin, heat rash

ii) Ionizing Radiation

Radiation is a form of energy. Any electromagnetic or particulate radiation capable of producing ions is referred to as ionizing radiation. Radioactive materials emit energy that can damage living tissues. Different kinds of radioactivity presents different kinds of radiation safety problems. The types of ionizing radiation with which we will be concerned are:

Electromagnetic

- X-ray
- Gamma ray Particles
- Neutron, electron, protons
- Alpha radiation
- Beta-rays

Radioactive materials can be hazardous in two ways:

1. Those materials that could be hazardous even when they are located some distance away from the body (external)
2. Others that are hazardous only when they get inside the body through breathing, eating or through broken skin (internal)

iii) Non-Ionizing Radiation

This is a form of It is electromagnetic radiation with varying effects on the exposed body depending largely on the particular wavelength of the radiation involved. It includes:-

- Radio transmitters
- TV
- Power line
- Powerful radio aerials
- Microwaves
- Lasers, etc

iv) Excessive Noise

Noise is defined as unwanted sound. Sound is any pressure variation or a stimulus that produces a sensory response in the brain. The compression and expansion of air created when an object vibrates.

Industrial Noise

Although the problem of noise was recognized centuries ago, for example Ramazini in 1700 described how workers who hammer copper have their ears injured due to exposure to the sound. The extent of the problem, which was caused by such noise, was not felt until the industrial revolution in England. The increasing mechanization in industries, farms, transport and others are likely to be more intense and sustained than any noise levels experienced outside the work place. Industrial noise problems are extremely complex. There is no " standard " program that is applicable to all situations. However, industries are responsible to consider and evaluate their noise problems and to take steps toward the establishment of effective hearing conservation procedures. The effectiveness of hearing conservation program depends on the cooperation of employees, supervisors, employers, and others concerned. The management responsibility is to take measurements, initiating noise control measures, undertaking the audiometer testing of employees, providing hearing protective equipment with sound policies, and informing employees of the benefits to be derived from a hearing conservation program.

Effects of Noise exposure

Noise is a health hazard in many in many occupational settings. Effects of noise on humans can be classified in various ways. For example, the effect can be treated in the context of health or medical problems owing to their underlying biological basis. Noise induced hearing loss involves damage to the structure of the hearing organ.

General Class of Noise Exposure

There are three general classes into which occupational noise exposure may be grouped.

1. *Continuous noise:* Normally defined as broadband noise of approximately constant level and spectrum to which an employee is exposed for a period of eight hours per day or 40 hours a week.
2. *Intermittent Noise:* This may be defined as exposure to a given broadband sound pressure level several times during a normal working day
3. *Impact type Noise:* is a sharp burst of sound. A sophisticated instrumentation is necessary to determine the peak levels for this type of noise.

The effects of noise on humans can be classified into two types:

- Auditory effects
- Non auditory effects

Auditory effects

Auditory effects consist of permanent or temporary hearing loss. The ear is especially adapted and most responsive to the pressure changes caused by airborne sound or noise. The outer and middle ear structures are rarely damaged by exposure to intense sound energy except explosive sounds or blasts that can rupture the ear drum and possibly dislodge the ossicular chain. More commonly, excessive exposure produces hearing loss that involves injury to the hair cells in the organ of corti within the cochlea of the inner ear.

Non-auditory effects

This consists of fatigue, interference with communication by speech, decreased efficiency and annoyance.

b. Mechanical Hazards

The mechanical hazards in industries are contributed from machinery, protruding and moving parts. About 10% of accidents in industry are said to be due to mechanical causes. Examples of vibrating and rotating tools are those used in drilling holes to burry dynamite in road construction and grinding metals. These activities can cause vibration disorders such as " dead hand "which is usually temporary and seldom leads to permanent damage. In industries repetitive movements of the hands and forearms are common, the tendon sheaths and Musculo-cutaneous junctions become inflamed. Workers who use hand tools such as picks, hammers, shovels, or who habitually kneel at their work may suffer from " beat" condition of the hand, knee or elbow. Beat hand is subcutaneous cellulites, which occurs among miners and stoker caused by infection of tissues devitalized by constant bruising.

c. Chemical Hazards

There is hardly any industry, which does not make use of chemicals. The chemical hazards are on increase with the introduction of newer and complex chemicals. Chemical hazards form the most important group and comprise over 12000 toxic materials. Such materials may endanger life, affect health adversely, or cause severe discomfort due to their acute effect.

Moreover, they may produce long-term disease such as cancer and pneumoconiosis by their chronic effects. Naturally occurring materials such as lead and mercury have been recognized as source of occupational disease for hundreds of years. With rapid industrial development other minerals like asbestos, radioactive ores, and oil, which are also sources of occupational disease, have been taken from the earth. Growing range of manmade materials such as plastics, synthetic fibres, solvents, fertilizers, and pharmaceutical products all of which may be hazardous to those who make or use them. Plastics of all kinds are now widely used in Ethiopian urban centres and rural communities or villages and their effects are being felt in some areas already. The physical state of a chemical compound is important in determining its toxicity to man and the environment.

The effects of chemical agents are as follows:

1. Asphyxiation
2. Systemic intoxication
3. Pneumoconiosis
4. Carcinogens
5. Irritation

Among all chemical agents in work place the most notorious and most in contact with the skin or respiratory system that deserve attention is **Solvent.** In most occupational settings or industries, a potential threat to the health, productivity and efficiency of workers is their exposure to organic solvents. Exposure to solvents occurs throughout life. Example, organic solvent vapor inhaled by a mother could reach the foetus.

Classification of Solvents

The term solvent means materials used to dissolve another material and it includes aqueous or non-aqueous system. Aqueous system includes those based in water.

Example:

- Aqueous solution of acids
- Aqueous solution of alkalis
- Aqueous solution of detergents

Aqueous system has low vapor pressure thus the potential hazard by inhalation and subsequent systemic toxicity is not great.

Examples of non-aqueous systems

- Aliphatic hydrocarbons.
- Aromatic hydrocarbons.
- Halogenated hydrocarbons.
- Cyclic hydrocarbons

The solvent we are concerned in occupational health and safety will include any organic liquid commonly used to dissolve other organic material.

These are:

- Naphtha
- Mineral spirits
- Alcohol

Effects of Solvents

The severity of a hazard in the use of solvents and other chemicals depends on the following factors:

1. How the chemical is used.
2. Type of job operation, which determines how the workers are exposed.
3. Work pattern.
4. Duration of exposure.
5. Operating temperature.
6. Exposed body surface.
7. Ventilation rates.
8. Pattern of airflow.
9. Concentrations of vapours in workroom air.
10. House keeping

1 Health Effect

The effect of solvents varies considerably with the number and type of halogen atoms (fluorine and chlorine) present in the molecules. Carbon tetrachloride, which is a highly toxic solvent act acutely on the kidney, the liver, gastro intestinal tract (GIT). Chronic exposure to carbon tetrachloride also, damages and cause liver cancer. This solvent should never be used for open cleaning processes where there is skin contact or where the concentration in the breathing zone may exceed recommended level.

2. Fire and explosion

Using non-flammable solvents can minimize the potential for this or solvents with flash point greater than 60 degrees Celsius or 140-degree Fahrenheit. However, the non-flammable halogenated hydrocarbons decompose when subjected to high temperature and give off toxic and corrosive decomposition products. If flammable solvents with Flash point less than this are used precaution must be taken to:

- Eliminate source of ignition such as flames, sparks, high temperature smoking etc.
- Properly insulate electrical equipment when pollutants are released outdoors.

Solvent hydrocarbons are important compounds in the formation of photochemical smog. In the presence of sunlight, they react with oxygen and ozone to produce Aldehyde, acids, nitrates, and other irritant and noxious compounds. The great portion of Hydrocarbons contributing to air pollution originates from automobiles and industries.

Health and safety procedures

Occupational health professionals should be concerned with health and safety in recognizing that the use of solvent can be a major threat. It is also important that control measures and safety precaution be exercised.

1. Surveys should be made for evidence of disease
   - Dermatitis
   - Unusual behaviour
   - Coughing
   - Complaints of irritation
   - Headache - etc.

2. You should note conditions and practices that contribute to excessive exposure.

3. Design safety and control methods.

Dangerous chemical substances

Many dangerous substances are used in industry, commerce, agriculture, research activities, hospitals and teaching establishments. The classification of dangerous substances is based largely on the characteristic properties of such substances and their effects on man.

Legislation this subject also requires the provision of a specific pictorial symbol on any container or package. The following terms are used in the classification of dangerous substances in the classification, packing and labelling of dangerous substances regulations 1984.

A. Corrosion
B. Oxidizing
C. Harmful Occupational Health Safety and Hygiene
D. Very toxic and toxic
E. Irritant
F. Highly flammable
G. Explosive

A. Corrosive

Hazard: living tissue as well as equipment are destroyed on contact with this chemical.

Caution: Do not breathe vapours and avoid contact with skin eyes, and clothing

B. Oxidizing

Hazard: ignite combustible material or worsen existing fire and thus make firefighting more difficult.

Caution: Keep away from combustible material. No open cigarette fire allowed in that area.

C. Harmful

Hazard: Inhalation and insertion of or skin penetration by these substances is harmful to heath.

Caution: Avoid contact with the human body, including inhalation of vapours and in cases of malaise consult doctor.

D. Very toxic and toxic

Hazard: The substances are very hazardous to health whether breathed, swallowed or in contact with the skin and may even lead to death.

Caution: Avoid contact with human body, and immediately consult a doctor in case of malaise.

E. Irritant

Hazard: May have an irritant effect on skin, eyes and respiratory organs

Caution: Do not breathe vapours and avoid contact with skin and eye

F. Highly Flammable

Flammable gases: Gases at 20 ^{0}C and SP 101.3 KPa which are

(a) Ignitable when in a mixture of 13% or less by volume with air.

(b) Have a flammable range with air of at least 12 percentage points regardless of the lower flammable limits

Extremely flammable liquids: Chemicals having boiling point (BP) < 35^{o} C and flash point (FP)<23^{o} C.

- Very high flammable liquids: Chemicals having FP <23 ^{o}C and Initial BP > 35^{o}C.
- Highly flammable liquids: Chemicals having FP <60^{0}C but >23 ^{0}C.
- Flammable liquids: Chemicals with FP >60 ^{0}C but < 90 ^{0}C.

Caution: keep away source of ignition.

G. Explosive

It is defined as a Solid or Liquid or a Mixture of Substances or an Article,

- which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings,
- which is designed to produce an effect by heat, light, sound, gas or smoke or a combination of these as the result of non-detonative self-sustaining exothermic chemical reaction

Hazard: Substances which may explode under certain condition

Caution: Avoid shock, friction, sparks and heat.

H. Hazardous waste

For identification of hazardous two methods are adopted

Criteria Approach -This is based on the hazardous properties of the waste. The following properties are considered to qualify as hazardous waste:

* CORROSIVITY
* IGNITABILITY / FLAMMABILITY
* REACTIVITY
* TOXICITY

The other approach is listing approach based on Schedule I ,II, & III as per Hazardous waste rule 2000. There are two methods in this approach namely:

a) Process based- For example, refinery process, bleaching process etc.

b) Non process based (Constitution based) – the chemical composition of the based.

There are two ways to deal with this hazard:

PREVENTIVE OPTIONS - By avoiding use/generation of these waste

CONTROL / DISPOSAL OPTIONS – Controlling or disposing the hazardous waste by

- Stabilization / Solidification
- Neutralization
- Physicochemical (Oxidation / Reduction / precipitation
- Incineration
- Secured Landfill

d. Biological Hazards

Knowing the biohazards and their classification based on severity of exposure problem is very important. It has to be understood that:

1. Any involvement with biohazards material may end up with infection.

2. When dealing with biological agents of which its etiology is not known, it must be assured that it is a bio-hazard.

Exposure to biological hazards in workplace results in a significant amount of occupationally associated diseases. Biological hazards include viruses, bacteria, fungus, parasites, or any living organism that can cause disease to human beings.

Biological hazards can be transmitted to a person through:

a. Inhalation
b. Injection
c. Ingestion
d. Contact with the skin

The contract of biohazard depends on:

a. The combination of the number of organisms in the environment.
b. The virulence of these organisms
c. The resistance of the individual
d. Concomitant physical/chemical stresses in the environment.

Classification of Biohazard Agents

Knowing the biohazard and their groupings is important for us to decide on what to do to safeguard the workers from the hazards.

There are two points that are important to remember. These are:

1. Any accident involving biohazard material can result in infection.
2. When working with biological agents or materials for which Epidemiology and etiology is not known or not completely understood, it must be assumed that the materials present a biological hazard.

Occupational Exposure to Biohazards

Most obvious work place in which employees are subjected to hazards as a result that the work requires handling and manipulation of biological agents include: surgery, autopsy, contaminated discharges, and blood, pipettes, laboratory specimens etc.

1. Laboratory Research

Health personnel such as Laboratory technicians and scientists working on biological specimens are at risk with biological hazards in the laboratory. Specimen such as blood, pus, stool and other tissue samples may expose the workers to hazards such as HIV, Hepatitis, etc.

2. Hospitals

Many potential biological agents exist in hospital environment. These are bacterial infection and viral agents. Those working in laundry, housekeeping, laboratory, central supply, nursing station and dietary are highly exposed to biohazard from the patient they handle, from the specimen they collect and from the cloth, needle and pans they handle and from their general day to day activities.

2.1 Laundry

Workers in laundry are exposed to discharges from patients by virtue that they are constantly in contact with linen (bed sheet), nightdresses and washable articles that are sent to the laundry for cleaning every day. Control of infection or exposure is possible only if workers and hospital administration adhere to the following:

- All linen should be placed in plastic or other bags at the bed side rather than carried carelessly across the corridor or through the halls to where collection bags or the laundry is collected.
- Laundry bags should be color coded in order to alert laundry workers that, what is contained in the bags is potentially hazardous.
- When the soiled laundry item reached the laundry the contents of the bags should be emptied directly into the washing basin, machine or trough.
- Employees responsible for sorting and folding linens can also be sources of infection as a result of poor personal hygiene.

Thorough hand washing and the use of rubber gloves are essential and basic infection control methods.

2.2 Housekeeping

Housekeepers in hospitals are the single highest group exposed to infectious biological agents.

The areas and condition of contamination are:

- Contact with discarded contaminated disposable materials during all general cleaning activities.
- Widespread use of disposable materials, especially those used in intravenous administration and blood collection.
- Contaminated hypodermic needles and intravenous catheters
- Dry sweeping of the floor does not remove many microbes. It rather pushes dust and other materials from one area to the other. When mops and brooms are improperly treated dust is dispersed back into the air.

2.3 Central Supply

The most serious problem in this department is the cleansing of surgical instruments. Grossly contaminated materials should be sterilized in an autoclave before any handling or rinsing. Scrubbing action is much more efficient than soaking, but it is during scrubbing that exposure to biohazard is the greatest. Direct injection of microorganisms is possible if the skin is punctured with dirty instruments or if the skin has a lesion that comes into contact with contaminated instruments.

Health care staff

The possibility of exposure to infection of health care professionals that have direct contact with patients is always present. The health care worker can spread infection from:

- Patient to patient
- Patient to other staff
- Patient to his/her own family
- Patient to visitors especially if consulting with family members of the patient

To avoid such contamination health care workers should:

- Dispose of contaminated equipment properly so that no health hazard is exposed to infect others.
- Hands should be thoroughly washed with soap and water after visiting each patient to minimize the chance of spreading harmful infection or organisms from patient to patient
- Isolation gowns, masks and caps must be worn whenever necessary and removed before entering clean areas such as rest areas and lunchrooms.

Dietary

Staffs involved in food preparation are exposed to infection from infectious agents such as salmonella, botulism, amoeba and staphylococcus, which can result from contact with raw fish, meat, and some vegetables contaminated by sewage or human waste or dirty water. Staphylococcus infection or food poisoning is produced by an enterotoxin that develops as the organism grows in the food product.

Primary prevention against infection or contamination of the food include:

- Proper handling of food products (raw or cooked)
- Use clean hands and garments in the food processing areas
- No skin lesion of the food handlers
- Refrigeration of the food products at a safe temperature level in order to prevent growth of bacteria.
- Adequate cooking of foods.

The problem of biological hazard in health care delivery system is increasing because of:

1. Inadequate sanitation, disinfect ion and sterilization methods.
2. Increase in drug as well as chemical resistant strains of microbes.
3. Increase of high-risk patients (HIV/AIDS and TB).

3. Agriculture

Occupational exposures to biohazard also occur in agriculture. There are four types of relationships in terms of disease transmission between humans and animals.

These are:

- Disease of vertebrate animals transmissible to human and other animals (Zoonosis)
- Disease of humans transmissible to other animals (Anthropozoonosis)
- Disease of vertebrate animals chiefly transmissible to humans (Zooanthroponosis)
- Disease transmissible to human from the environment (animals being the source of environmental contamination)

Zoonosis

It consists of viral, bacterial, rickettsial, fungal, protozoal, and helminthic disease.

Among the most important throughout the world are:

Anthrax, brucellosis, tetanus, encephalitis, leptospirosis, rabies, and salmonellosis. The infection could enter the body through inhalation, ingestion, or through the skin or mucus membrane.

Health hazards associated with tannery

1. Hook worm and Ascaris infection
2. Salmonellosis
3. Malaria and onchocerciasis
4. Schistosoma and anthrax
5. Hydrated cysts
6. Tetanus and infections of gangrene.

There are about 48 types of disease divided into three categories.

Diseases with definite risk - Anthrax Salmonellosis Cowpox

Disease with quantifiable risk - Rabies Plague Taeneasis, Tetanus TB Trichniasis

Doubtful risk - Tularemia Giardiasis

Health hazard Associated with Poultry Farming

Salmonellosis and scabies are the major health problem

Biohazard Control Program

1. Employee health

- Pre placement examination for new employee.
- Periodic physical examination as part of a surveillance program.
- Vaccination

2. Laboratory safety and health

- Employee training
- Avoid if possible, entering into a biohazard area.
- Avoid eating, drinking, smoking and gum chewing in biohazard areas
- Wearing personal protective equipment is always advisable.

3. Biological safety cabinet

- To protect workers from exposure to aerosols especially when there is contact with biohazards in laundry activities.

4. Animal care and handling

Periodic examination, disposal of manure, cleanliness, collection of medical history and treatment.

e. Ergonomic Hazards

[IS/ISO 26800:2011 IS/ISO 27500: 2016 IS 17009 :2018]

Ergonomics is a specialised stream of study. Bureau of Indian standards has set up a separate Technical committee namely PGD 15 to formulate Standards on Ergonomics. BIS has formulated about 59 standards on various aspects of Ergonomics till now.

The term ergonomics began to be used by a group of physical, biological, and psychological scientists and engineers to describe interdisciplinary activities that were designed to solve problems created by wartime technology. The term is derived from the Greek roots ERGON, which is related to work and strength, the NOMOS, indicating law or rule. It also means Human engineering or" Fitting the job to the worker." The study of human characteristics for the appropriate design of scientific principles, method and data drawn from a variety of disciplines to the development of engineering systems in which people play a significant role are:

i. Human capabilities,
ii. Human limitations,
iii. Human motivations, and
iv. Human desires

Ergonomics is the application of human biological science in conjunction with the engineering science in order to achieve optimum mutual adjustment of man and his work. It includes considerations of the total physiological demands of the job upon the worker even beyond productivity, health and safety. In general Ergonomics deals with the interaction between humans and such additional environmental elements such as heat, light, sound, atmospheric contaminants and all tools and equipment pertaining to the work place. Ergonomics or the proper designing of work systems based on man factors has the following advantages:

1. There will be more efficient operations
2. There will be fewer accidents
3. There will be reduced training time
4. There will be fewer costs of operations
5. There will be more effective use of workers or personnel.

The goal of "ERGONOMICS" or human factors ranges from making work safe to humans, and increasing human efficiency and wellbeing. To ensure a continuous high level performance work system must be tailored to human capacities and limitations measured by anthropometry and biomechanics.

Principles of biomechanics

Ergonomics is a broad science encompassing the wide variety of working conditions that can affect worker comfort and health." It depends on the body dimension, weight, reach envelop, strength and movement envelop. It Treats Human Body as series of Levers and fulcrums.

It deals with the functioning of the structural element of the body and the effect of external and internal forces on various parts of the body. Taking an example of "lifting" an object from the ground biomechanics seek relevant information:

1. What is the task to be performed (task variable)
2. Would the person be able to do the task (human variable)
3. What is the type of work environment (environmental variable)

Task variable

1. Location of object to be lifted
2. Size of object to be lifted
3. Height from which and to which the object is to be lifted

4. Frequency of lift
5. Weight of object
6. Working position

Human Variable

1. Sex of worker
2. Age of worker
3. Training of worker
4. Physical fitness of worker
5. Body dimension of worker

Environmental variable

1. Extremes of temperature (hot/cold)
2. Humidity
3. Air contaminants

Work physiology

People perform widely different tasks in daily work situation. These tasks must be matched with human capabilities to avoid "over loading" which may cause the employee to breakdown, suffer reduced performance capability or even permanent damage.

Matching people with their work

It is important to match human capabilities with the related requirements of a given job. If the job demands are equal to the worker's capabilities or if they exceed them, the person will be under much strain and may not be able to perform the task.

Work classification

The work demands are classified from light work to extremely heavy in terms of energy expenditures per minute and the relative heart rate in beats per minute. For example the energy requirement for light work is 2.5 Kcal/minute

and the heart rate is 90 beats per minute while if it was extremely heavy work energy requirement is 15 Kcal. Min. and heart beat is 160/minute.

Workstation design[IS 16595(Pt-5) :2018 & IS 10224 :1982]

Workstation means the immediate area where the person working is performing his/her duties. The goal of designing a workstation is to promote ease and efficiency of the person working. Productivity will suffer if the operator is uncomfortable and suffering or if the workstation is awkwardly designed.

Work place design

Workplace is the establishment or deportment where the person or worker is performing his/her duties. The most basic requirement for a work place is that it must accommodate the person working in it. Specifically, this means that:

1. The work space for the hands should be between hip and chest height in front of the body
2. Lower location are preferred for heavy manual work, and

3. Higher locations are preferred for tasks that require close visual observations.

Another key ergonomic concept is that workplace should be designed relating the physical characteristics and capabilities of the worker to the design of equipment and to the layout of the work place.

When this is accomplished:

- There is an increase in efficiency
- There is a decrease in human error
- Consequent reduction in accident frequency.

Design is accomplished after learning what the worker's job description will be, kind of equipment to be used for that process, the biological characteristic of the person (worker).

Workspace dimension

Workspace dimension can be grouped in three basic categories:

Minimal, maximal, and adjustable dimensions.

- Minimal workspace provides clearance for ingress and egress in walkways and doors.
- Maximal workspace dimensions permit smaller workers to see the equipment.

  This is ensured by selecting workspace dimension over which a small person can reach or by establishing control forces that are small enough so that even a weak person can operate the equipment.
- Adjustable dimensions permit the operator to modify the work environment and equipment so that it conforms to those individuals on particular set of anthropometric characteristics.

- **What can cause injuries**?

  - Repeated use over time of vibrating tools and equipment, such as a jackhammer.
  - Tools and tasks which require twisting hand or joint movements, such as the work many mechanics perform;
  - Applying force in an awkward position;
  - Applying excessive pressure on parts of the hand, back, wrists or joints;
  - Working with the arms outstretched or over the head;
  - Working with a bent back;
  - Lifting or pushing heavy loads

Ergonomic concerns

Following are the main ergonomic concerns :

A) Ergonomic groups

- Manual material handling (37%)

- Repetitive strain injuries (30%)
- Posture (14%)
- Improper lighting (14%)
- VDU (3%)
- Other (2%)

B) Types of injury

- Sprains and strains (50%)
- Broken skin or bone (30%)
- Inflammation of joints (3%)
- Chemical burns (2%)
- Other (15%)

Note: Maximum number of injuries are caused due to ergonomic concerns at workplace

C) Heavy physical work

- Whenever possible, use mechanical power in place of heavy work. Machines can be used by workers to perform the most arduous tasks, not to replace workers.
- Heavy work should be varied with lighter work throughout the day.
- Rest periods must be included in the job.
- Consider ergonomic factors, such as the weight and shape of the load and how often a worker must lift the load, when designing heavy physical job tasks.
- Other ergonomic recommendations include: reducing the weight of the load; making the load easier to handle; using storage techniques to make handling easier, minimizing the distance a load must be carried; minimizing the number of lifts; and minimizing twisting of the body.

D) Job Design

- Well designed jobs consider the worker's mental and physical characteristics as well as health and safety conditions.
- Job design determines whether the work is varied or repetitive, whether it allows the worker to be comfortable or forces him or her into awkward positions, and whether it involves interesting/stimulating tasks or boring/ monotonous ones.

There are a number of ergonomic factors that should be considered when designing or redesigning jobs, such as the type of tasks, how they need to be accomplished, and the type of equipment that is needed to complete the tasks. A well designed job should allow a worker to vary the body position; it should include a variety of interesting tasks; give the worker some decision-making authority; provide a sense of accomplishment; include training for new job tasks; provide adequate work/rest schedules; and allow an adjustment period for new job tasks.

Psychosocial hazards

The term "stress" means the strain imposed on the worker by psychosocial influences associated with urbanization and works, which cause stress, which may affect health, wellbeing, and productivity. Within the work environment itself, emotional stress may arise from a variety of psychosocial factors, which the worker finds unsatisfactory, frustrating, or demoralizing. For example:

- A peasant who migrates from the rural areas to a city will face entirely different environment if he starts to work in an industry. In his rural life he used to work at his own speed but in the factory, he may have to work continuously at speeds imposed by the needs of production.
- Workers may be working in shifts that will expose them to unusual hours. They may upset their family's life as a result of their work conditions.
- Workers may be working with a person who is paid more but who is incapable of working.
- Financial incentives are too low etc.

These and other stresses will have adverse psychosocial problems on workers. Reduction of occupational stresses depends not only on helping individuals to cope with their problems but also on:

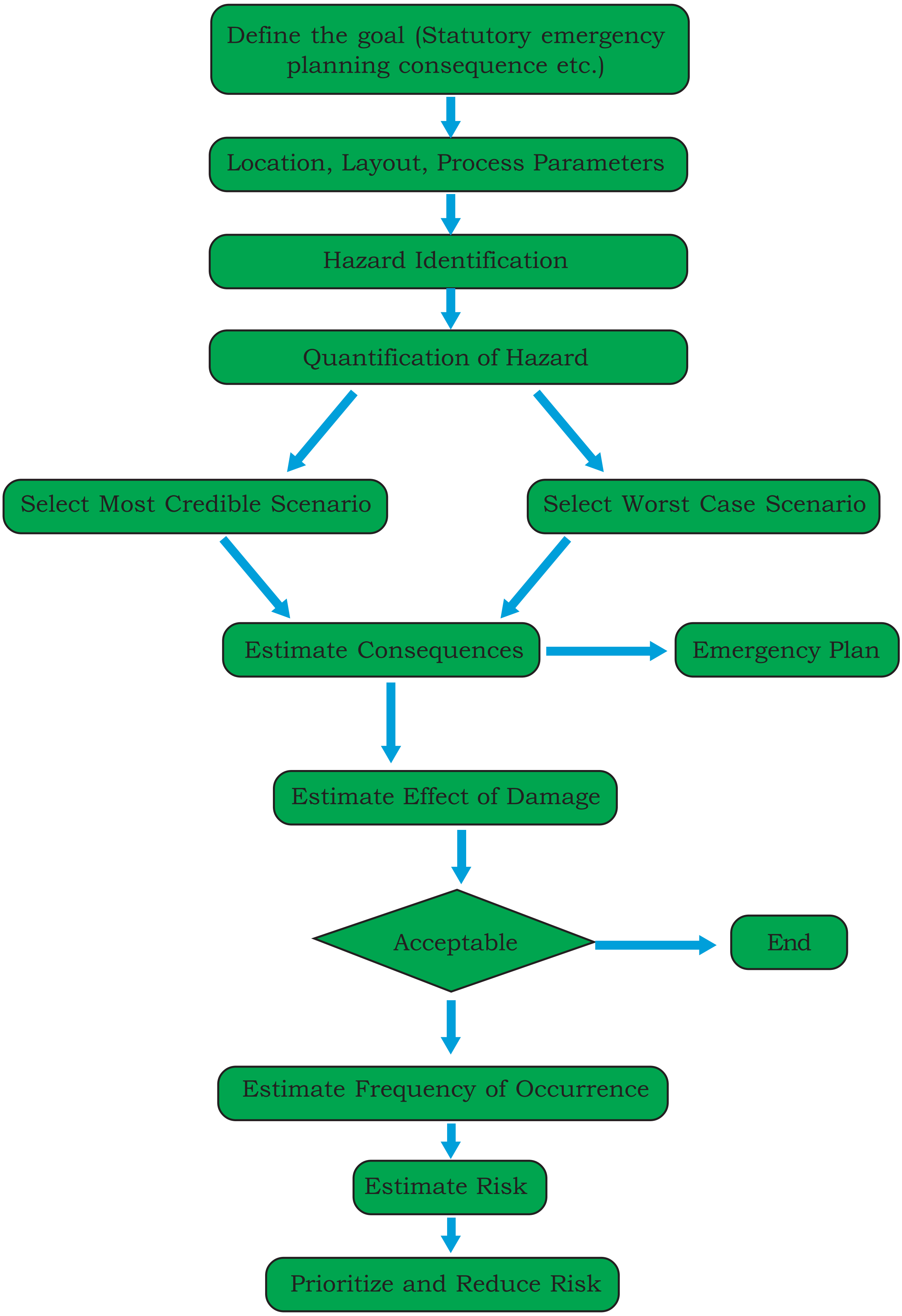
- Improved vocational guidance,
- Arrangement of working hours,
- Job design, and work methods;
- Good management.

Indian standards on Hazard and Risk for Chemical process plant (IS 15656 : 2006)

Bureau of Indian Standards has brought out beautiful standards on Hazard identification and Risk analysis. IS IS 15656 deals with chemical industries. In addition to the basic definitions like Accident, Hazard, Risk, Explosion, worst case scenario, Mitigation system etc, it has dealt with details of how to identify the hazards and do the risk analysis.

Risk Analysis Methodology[Clause 3 of IS 15656:2006]

Pl see fig below



F1a. l Flow CHART FOR RISK ANALYSIS

• STAGES OF PROCESS PLANT AND RISK ANALYSIS [Clause 4 of is 15656:2006]

The life span of a process industry comprises a number of stages from conceptual to decommissioning. Each stage of a plant may have hazards, some general and some stage- specific. Hazard identification and risk analysis techniques that may be applied at different stages of a plant are given in Table 1.

Table 1 Plant Stages *vis-a-vis* Hazard Identification and Hazard Analysis Techniques

Sl No	Project Stages	Hazard Identification/ Hazard l\Analysis Techniques
1	Pre Design	a) Hazard indices b) Preliminary hazard analysis c) What-if analysis d) Check lists
2	Design/ Modification	a) Process design checks and use of checklist b) HAZOP studies c) Failure mode and effects analysis d) What if analysis e) Event tree analysis
3	Construction	a) Checklists b) What if analysis
4	Commissioning	a) Checklists b) Plant safety audits c) What if analysis
5	Operation and maintenance	a) Plant safety audit b) Checklists c) What if analysis
6	Decommissioning/shut down	a) Check lists b) What if analysis

• HAZARD IDENTIFICATION AND HAZARD ANALYSIS[Clause 5 of IS 15656:2006]

A hazard is generally realized as a loss of containment of a hazardous material. The routes for such loss of containment can include release from pipe fittings containing liquid or gas, releases from vents/relief and releases from vessel rupture. Adhering to good engineering practices alone may not be adequate for controlling plant hazards thus, a variety of techniques of hazard identification and probability of their occurrence have been developed for analysis of processes, systems and operations.

The objective of hazard identification is to identify and evaluate the hazards and the unintended events, which could cause an accident. The first task usually is to identify the hazards that are inherent to the process and/or plant and then focus on the evaluation of the events, which could be associated with hazards. In hazard identification and quantification of probability of occurrence it is assumed that the plant will perform as designed in the absence of unintended events (component and material failures, human errors, external event, process unknown), which may affect the plant/process behaviour.

2.1 Hazard Identification

Formal hazard identification studies generate a list of failure cases. The list can usually be derived reliably by considering: (a) form in which chemicals are stored or processed, (b) nature of hazard it poses, and (c) quantity of the material contained. The hazard identification methods may be categorized as comparative methods and fundamental methods. These techniques are also described in Annex -2 of IS 15656: 2006

2.1.1 Comparative Methods

These techniques are based on hazard identification by comparing with standards. The various methods are checklist, safety audit, hazard indices and preliminary hazard analysis.

2.1.1.1 Checklist Purpose Applicability

Purpose	For quick identification of hazards
Applicability	In all phases - design construction, commissioning, operation and shutdown
Data required	Checklist is prepared from prior experience/standard procedure/ manual/ knowledge of system or plant
Result	Essentially qualitative in nature and leads to "yes-or-no" decision with respect to compliance with the standard

2.1.1.2 Safety audit

Purpose	For ensuring that procedures match design intent
Applicability	In all phases of the plant and periodicity of review depending on the level of hazard
Data Required	Applicable codes and guides, plant flow sheet, P & I diagrams, start-up shutdown procedure, emergency control, injury report, testing and inspection report, material properties
Result	Qualitative in nature - the inspection teams report deviation from design and planned procedures and recommends additional safety features

2.1.1.3 Hazard Indices

Purpose	For identifying relative hazards
Applicability	In design and operation phase used as an early screening technique for fire/ explosion potential
Data Required	Plot plan of a plant, process flow condition, Fire and Explosion Index Form, Risk Analysis Form, Worksheets
Result	Relative quantitative ranking of plant process units based on degree of risk

2.1.1.4 Preliminary hazard analysis

Purpose	For early identification of hazards
Applicability	In preliminary design phase to provide guidance for final design.
Data required	Plant design criteria, hazardous materials involved and major plant equipment
Result	List of hazards (related to available design details) with recommendation to designers to aid hazard reduction.

2.1.2 Fundamental Methods

These techniques are a structured way of stimulating a group of people to apply foresight along with their knowledge to the task of identifying the hazards mainly by raising a series of questions. These methods have the advantage that they can be used whether or not the Codes of practice are available for a particular process. Three main techniques are available in this family of methods that is What-if Analysis, Failure Modes and Effects Analysis(FMEA) and Hazard and Operability Study (HAZOP).

2.1.2.1 What-if Analysis

Purpose	Identifying possible event sequences related to hazards
Applicability	During plant changes, development stage or at pre start-up stage.
Data required	Detailed documentation of the plant, the process and the operating procedure
Result	Tabular listing of accident scenarios, their consequences and possible risk reduction methods

2.1.2.2 Failure modes and effects analysis

Purpose	Identifying equipment failure mode and their effects
Applicability	In design, construction and operation phases, useful for plant modification
Data required	Knowledge of equipment/system/plant functions
Result	Qualitative in natural and includes worst- case estimate of consequence resulting from failure of the equipment

2.1.2.3 Hazard and operability study

Purpose	Identifying hazard and operability problem
Applicability	Optimal when applied to a new/modified plant where the design is nearly firm
Data required	Detailed process description, detailed P&I drawing and operating procedure for batch process
Result	Identification of hazards and operating problems, recommends change in design, procedure and further study

2.2 Hazard Analysis

The principle techniques are fault tree analysis (FTA) and event tree analysis (ETA). These techniques are also described **in Annex -3 of IS 15656: 2006**

2.2.1 Fault Tree Analysis

Purpose	Identifying how basic events lead to an accident event
Applicability	In design and operation phases of the plant to uncover the failure modes
Data required	Knowledge of plant/system function, plant/system failure modes and effects on plant/system
Result	Listing of set of equipment or operator failures that can result in specific accidents.

2.2.2 Event Tree Analysis

Purpose	Identifying the event sequences from initiating event to accident scenarios
Applicability	In design/operating plants to assess adequacy of existing safety features
Data required	Knowledge of initiating events and safety system/emergency procedures
Result	Provides the event sequence that result in an accident following the occurrence of an initiating event

3 CONSEQUENCE ANALYSIS METHODOLOGIES [Clause 6 of IS 15656:2006]

All processes have a risk potential and in order to manage risks effectively, they must be estimated. Since risk is a combination of frequency and consequence, consequence (or impact) analysis is a necessary step in risk analysis. This section provides an overview of consequence and effect models commonly used in risk analysis.

An accident begins with an incident, which usually results in loss of containment of material. The material may possess hazardous properties such as flammability, explosivity, toxicity, etc. Typical incidents might include the rupture of a pipeline, a hole in a tank or pipe, runaway reaction, external fire impinging on the vessel and heating it.

Once the incident is defined source models are selected to describe how materials are discharged from the containment. Source models provide a description of the rate of discharge, the total quantity discharged, the duration of discharge, and the state of discharge, that is liquid, vapour or two-phase flow. Evaporation models are subsequently used to calculate the rate at which the material becomes air-borne.

Next a dispersion model is used to describe how the material is transported downwind and dispersed to specified concentration levels. For flammable releases, fire and explosion models convert the source model information on the release into energy hazard such as thermal radiation flux and explosion overpressures. Finally effect models convert these incident specific results into effects on people and structures. Environmental impacts could also be considered but these are beyond the scope of the present Code.

In this Code a brief -introduction to the methods of consequence analysis is provided. Annex F shows the steps to be followed in consequence analysis. These models are also described in **Annex-4 of IS 15656 :2006**

3.1 Source Model

Source models are used to quantitatively define the loss of containment scenario by estimating the discharge rate, total quantity released, release duration, extent of flash and evaporation from a liquid pool and aerosol formation and conversion of source term outputs to concentration fields.

3.1.1. Discharge rate model

Purpose	Evaluation of discharge of material
Applicability	First stage in developing the consequence estimates
Data required	a) Physical condition of storage. b) Phase at discharge. c) Path of the discharge (hole size).
Result	a) Discharge rate of the gas/liquid/ two-phase flow. b) Duration of release. c) Phase change during release

3.1.2 Flash and Evaporation Models

Purpose	Estimation of the total vapour
Applicability	During spillage of liquid on surface because of loss of containment
Data required	a) Heat capacity, latent heat, boiling point of liquid. b) Leak rate, pool area, wind velocity,temperature. c) Vapour pressure, mass transfer coefficient. d) Viscosity, density, a turbulent friction coefficient
Result	a) Amount of vapour from a liquid discharge. b) Time dependent mass rate of boiling. c) Radius or radial spread velocity of the pool.

3.1.3 Dispersion Models

Accurate prediction of the atmospheric dispersion of vapours is central to consequence analysis. Typically, the dispersion calculations provide an estimate of the geographical area affected and the average vapour concentrations expected. The simplest calculations require an estimate of the released rate of the gas, the atmospheric conditions, surface roughness, temperature, pressure and release diameter. Two types of dispersion models are usually considered:

a) Positively buoyant or neutrally buoyant, and
b) Negatively buoyant or dense gas.

The dispersion of gases that are lighter than or equal to the density of dispersing medium are considered as positively buoyant and the gases with higher density at the point of dispersion is considered as negatively buoyant or dense gas. The dispersion is further categorized into puff model that is, instantaneous release or plume model that is continuous release or time varying continuous release. A large number of parameters affect the dispersion of gases. These include atmospheric stability, wind speed, local terrain effects, height of the release above the ground, release geometry, that is, point, line or area source, momentum of the material released and the buoyancy of the material released.

Annex C of IS 15656:2006 gives the meteorological conditions defining the Pasquill-Gifford Stability Classes denoted by letters A to F, which correlate to wind-speed and cloud cover. The stability is commonly defined in terms of atmospheric vertical temperature gradient. For local application, the wind speed and cloud cover should be taken from meteorological records. ·For practical purpose two stability conditions given below can be used to find the dispersion pattern.

Normal: 'D' at wind velocity of S mis (Windy day time condition), and *Extreme calm:* 'F' at wind velocity of 2 *mis* (Still night-time condition).

Annex D gives the terrain characteristics that affect the mixing of the released gas and air as they flow over the ground; thus the dispersion over a lake would be different Annex D gives the terrain characteristics that affect the mixing of the released gas and air as they flow over the ground; thus the dispersion over a lake would be different 0.000 I m over sea. For most practical purposes flat rural terrain (Few ·trees, long grass, fairly level grass plains) with surface roughness value of 0.1 is used.

As the release height increases, the ground level concentration decreases since the resulting plume has more distance to mix with fresh air prior to contacting the ground.

3.1.3.1 Positively buoyant or neutral dispersion model

Purpose	Prediction of average concentration -time profile
Applicability	Used in prediction of atmospheric dispersion of lighter gases than air.
Data required	Discharge rate, release duration, stability class, wind speed, location, averaging time, roughness factor.
Result	Downwind concentration, area affected, duration of exposure.

3.1.3.2 Negatively buoyant or dense gas model

Purpose	Prediction of average concentration -time profile.
Applicability	Used in prediction of atmospheric dispersion denser than air
Data required	Discharge. rate, release duration, density of air, density of fluid, location.
Result	Downwind concentration, area affected, duration of exposure

3.2 Fires and Explosions Models

These models are used only when the material released is flammable and the yapour cloud concentration is within the flammable range. The various types of fire and explosion models are:

a) Pool fires,
b) Jet fires,
c) Flash fires,

d) Vapour cloud explosions,

e) Boiling liquid expanding vapour explosions (BLEVE), and

f) Physical explosions.

3.2.1 Pool Fire Model

Purpose	Calculation of thermal radiation.
Applicability	Fire resulting from burning of pools of flammable liquid spilled.
Data required	Quantity, pool diameter, heat of combustion and vaporizatio11, density of air, temperature, view factor, etc.
Result	Thermal radiation flux at a distance.

3.2.2 Jet Fire Model

Purpose	Calculation of thermal radiation.
Applicability	Fire resulting from combustion of material as it is being released from pressurized process unit
Data required	Flow rate, hole diameter, heat of combustion and vaporization, density of fluid, temperature, view factor, etc
Result	Thermal radiation flux at a distance.

3.2.3 Flash Fire Model

Purpose	Calculation of thermal radiation.
Applicability	Fire resulting from non-explosive combustion of a vapour cloud
Data required	Material released, dispersion coefficients, flame emissivity, view factor, atmospheric attenuation.
Result	Thermal radiation flux at a distance.

3.2.4 Vapour Cloud Explosion Model

Purpose	Calculation of over pressure
Applicability	Explosion of a flammable cloud formed due to release/flashes to vapour.
Data required	Mass of flammable material in vapour Results cloud, heat of combustion of material, etc.
Result	Over pressure at a distance.

3.2.5 Boiling liquid Expanding Vapour Explosion (BLEVE) Model

Purpose	Calculation of thermal radiation
Applicability	Release of a large mass of pressurized superheated liquid to the atmosphere
Data required	Mass involved in fire ball, radiative fraction of heat of combustion, heat of combustion for unit mass, atmospheric transmissivity.
Result	Thermal radiation flux from the surface of fireball

3.2.6 Physical Explosion Model

Purpose	Calculation of missile damage
Applicability	Vessel rupture resulting in release of stored energy producing a shock wave.
Data required	Pressure, volume, heat capacity, mass of container, ratio of heat capacities, temperature.
Result	Overpressure at a distance, ·fragment size and velocity

3.3 Effect Model

Applicability	Method of assessing property damage and human injury/fatality due to: a) thermal radiation. b) overpressure. c) toxic exposure
Data required	In the Probit function *Pr* = *a* + *b* In *V* the causative factor *V* in the Probit Equation varies as follows; a) Fire: *Pr*= *a*+ *b* In (t I413), *t* is duration of exposure and/ is thermal intensity b) Explosion: *Pr*= *a*+ *b* In (J's), where *Ps* is the peak over pressure c) Toxicity: *Pr*= *a*+ *b* In (C'tc), where C = concentration in ppm by volume, tc = exposure time, in minutes and *n* = constant. The constants *a* and *b* in the probit equation are calculated from the experimental data and are available in Methods for determination of possible damage to people and objects resulting from release of hazardous materials [*see* Foreword (f) of IS 15656]
Result	The percent of fatality or the percent of damage to equipment

4 RISK CALCULATION [Clause 7 of is 15656:2006]

4.1 Risk can be defined as a measure of economic loss, human injury or environmental damage both in terms of likelihood and magnitude of loss, injury or damage. In this document only the property damage, that is, economic loss and human loss have been considered. **Risk** is expressed as the product of frequency of an event and the magnitude of the consequences that result each time the event occurs. The mathematical expression for risk is:

R =FC

where,

R = risk (loss or injury per year);

F = frequency (event per year); and

C = consequence (loss or injury per event).

4.2 In many cases the hazard cannot be completely eliminated though the probability of occurrence can be reduced with addition of safety measures and at a financial cost.

4.3 The basic approach for estimating frequency has been discussed in **2.2.**

4.4 The consequence in terms of deaths/year or in terms of monetary Joss p.er year can be estimated-by the methods of consequence analysis described in 3**.**

4.5 Risk Criteria

Risk criteria are the acceptable levels of risk that can be tolerated under a particular situation. -in many countries the acceptable risk criteria has been defined for industrial installations and are shown in Annex E. These criteria are yet to be defined in the Indian context, but values employed in other countries can be used for comparison.

5. GUIDELINES FOR APPLICATION OF RISK ANALYSIS TECHNIQUES

This Code essentially outlines the various approaches and techniques that may be used during the risk analysis of a process plant. This concluding section enumerates some of the critical features-of the methodology of risk analysis so as to aid the prospective users apply the Code most effectively:

a) While undertaking a risk analysis, ·careful consideration of the various possible approaches/ techniques is necessary, since each have their individual strengths and limitations.

b) The method of risk analysis requires realistic accident scenario assumptions as well as comprehensive plant operational information and, in particular, reliable data pertaining to component/ system failure frequencies, human error rates, etc. In the event of any uncertainties relating to the relevant information and data, the use of experience and judgment would be critical to obtaining risk estimates that provide reliable support to subsequent decision-making.

c) All assumptions applied during a risk analysis exercise need be documented with clarity, so as to enable better comparison and communication.

d) In specific instances, the risk analysis method may require consideration of the external events as probable causative factors in large-scale hazardous chemical releases.

e) Wherever feasible the risk analysis for a process plant should incorporate possible environmental consequences as well as possible human health effects that are immediate and/or delayed.

f) Risk analysis need be undertaken newly in the event of any major changes introduced in the plant configuration. It must also be updated periodically whenever improved plant operational information and equipment/human failure data becomes available. Further, it is advisable to improve risk calculations using newer analytical methods as and when they are developed.

With the techniques used for the analysis large number of results based on numbers of accident scenarios used, the various weather classes chosen, the assumptions in calculating each cases would be available. But finally, it is very important to summarize all the results in one format providing clearly what factor appear to be important in overall analysis. A format has to be chosen for presenting the results of the analysis and acceptability is to be established either in terms of ‘risk criteria’ or ‘distance under consideration which face the consequence’ *or* ‘% damage up to a distance under consideration’.

One typical format for reporting the analysis is given in **Annex B of IS 15656 :2006.**

Annexures of IS 15656:2006 are very useful and it serves as practical guidelines for Hazard identification and Risk analysis.

Note : Though this version of IS 15656 considers property loss as safety issue , however as per present definition of safety as per ISO 45001 :2018 , property loss is not considered as safety issue.

CHAPTER IV

SAFETY PROCEDURES & ARRANGEMENTS

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SAFETY PROCEDURES & ARRANGEMENTS

1 Operations [Clause 8 of IS/ISO 45001:2018 Annex-c of IS 14489:2018]

1.1 Management should ensure that each installation in an enterprise has written operating procedures and instructions in order to establish the necessary conditions to satisfy the design intent of the installation and maintain its integrity. These should take into account the relevant standards, codes and guidance in order to ensure that equipment, plant and premises provide a safe place of work under both normal and abnormal operating conditions.

1.2 Before new products, processes or equipment are handed over from one department to another (for example, from research to production), management should ensure that there are written, agreed operating procedures and safety instructions in order that knowledge and experience gained in research, development, pilot plant and production are passed on. This handover should be formalised by an appropriately signed handover/clearance report.

1.3 Appropriate procedures should exist to ensure effective protection against accidents involving hazardous substances during abnormal conditions such as when critical instruments, alarms and emergency equipment are not available, and during periods of stress at the installation (for example, when there are unusual production demands or an economic decline that affects the installation).

1.4 Appropriate arrangements should be introduced at a hazardous installation for the prevention of fires, and should a fire occur, for the protection of personnel, buildings and equipment and fire fighting. These arrangements should make provision for the necessary equipment, procedures, training, testing and personnel.

1.5 Appropriate procedures should exist for the safe shutdown and decommissioning of a hazardous installation to ensure that hazards are controlled during the shutdown process and while the installation in out of operation.

During transition phases of operation of a hazardous installation which involve shutdowns and start-ups, for example, during maintenance of equipment, special efforts should be made to avoid potential causes of risk such as communication problems and split responsibility, since such phases may involve people who are not fully aware of the details of an installation's operation, policies and procedures.

1.6 Appropriate arrangements should be in place for maintaining the security of a hazardous installation to minimise the possibility of sabotage or vandalism. The management of the hazardous installation should specify those areas of the installation to which access should be restricted or controlled and implement measures to maintain control and prevent unauthorised access.

1.7 Management should endeavour to choose the safest practicable means of transport and routing of hazardous substances being taken from or delivered to an installation in order to minimise the number of people potentially affected in the event of an accident.

1.8 A high standard of housekeeping and operational efficiency should be maintained at hazardous installation since there is clear correlation between these functions and good safety performance.

2 Maintenance[Clause 8 of IS/ISO 45001:2018 Annex-c of IS 14489:2018]

2.1 Management, particularly of hazardous installations, should establish programmes for the regular maintenance, inspection and testing of equipment to ensure that it is at all times fit for the purpose for which it was designed.

1. Maintenance programmes should be adhered to strictly and reviewed periodically to ensure they continue to be appropriate in relation to safety requirements.

2. Maintenance standards should be developed to help guarantee the safety of each operation.

3. Maintenance jobs should be performed according to established maintenance procedures.

4. Records should be kept of all safety-related maintenance work carried out and equipment reviews and reliability assurance procedures should be established.

5. Records should be kept of any faults found during maintenance of equipment, which might materially affect safety, and prompt action taken to rectify the faults.

2.2 The local management at each hazardous installation should regularly inspect and maintain emergency alarms, protective and emergency devices and all devices critical to the orderly shutdown of operation in conjunction with the relevant public authorities, where appropriate.

3 Modifications [Clause 8 of IS/ISO 45001:2018 Annex-c of IS 14489:2018]

3.1 The management of a hazardous installation should establish formal procedures to ensure that no repair work or modifications to plant, equipment, processes, facilities or procedure to ensure compromise safety.

1. Modification procedures should apply to both permanent and temporary changes, and should be based on up-to-date process documentation and, where appropriate, a physical inspection of the installation.

2. All modification proposals should be registered and assessed so that the necessary hazard studies are carried out, the appropriate design considerations are made and the changes proposed are properly engineered and recorded.

3. Major modifications should be subject to the same notification and reporting requirements as new installations

3.2 Proposals for significant modifications require a review by competent technicians who are independent of those directly responsible for the proposal.

1. The level of management approval necessary for a modification should be based on the associated level of risk.

2. Supervisors having the authority to make a modification for example, to a manufacturing procedure or operating instruction, should be fully aware of the hazards involved and should consult competent specialist(s) before initiating such a change.

3.3 In the case of any changes made to a process which could affect safety for example, use of different process materials, alterations of conditions, increase in batch size, or use of larger/different equipment, the original hazard analysis should be reviewed and the process documentation file or plant dossier maintained accordingly. Techniques should be developed to assess how a series of minor changes, taken together, can affect safety at an installation and what could be done to mitigate any increased potential for accidents.

3.4 After repair, modification, and/or overhaul of plant and equipment, the necessary test runs and safety checks should be carried out in the presence of the supervisor responsible for the operation of the installation, who should be required to formally approve the restarting of operations.

3.5 Procedures should also exist to ensure that changes in management, other personnel and organisation do not compromise safety. Such changes should trigger review procedures to ensure safety has not been adversely affected.

4 Storage of Hazardous Substances [Clause 8 of is/iso45001:2018 Annex-c of IS 14489:2018] : Special Considerations

All the Guiding Principles in this section apply to storage facilities for hazardous substances. Storage presents special risks or concerns which warrant additional guidance. These apply to both on-site (at the installation) and off-site (contract) storage, including bulk storage (for example, in tank farms) and non-bulk storage (for example, of packaged goods). The warehouse keeper, for purposes of this text, is the person responsible for the storage facility, whether on-site or off-site.

4.1 The management of an enterprise seeking to store hazardous substances off-site including products, raw materials and intermediates should satisfy itself as to the suitability of the facility for storage of such substances and of the competence of the warehouse-keeper to undertake the storage required in a safe manner. This could involve the enterprise monitoring the storage facility and training employees of the off-site facility.

4.2 The warehouse-keeper should ensure that all relevant legislative requirements and applicable codes of practice for the safe storage of hazardous substances are strictly applied wherever necessary.

4.3 The owner/supplier of the hazardous substances being stored should provide the warehouse- keeper the information necessary to prevent accidents and to respond appropriately should an accident occur.

1. In this regard, the owner/supplier should provide a material safety data sheet (MSDS) or product data sheet so that the warehouse-keeper can ensure that physical, chemical and (eco) toxicological and other properties relevant in the case of an accident are understood by all relevant employees working in the storage facility.

2. Particular attention should be given to proper labelling of hazardous substances, indicating any hazardous properties on labels and the appropriate precautions to be taken.

3. In addition, the owner/supplier of the hazardous substances should provide information concerning reaction and/or decomposition products formed in the event of a fire.

4.4 The owner/supplier of hazardous substances should consider reducing the amount of hazardous substances requiring storage, off-site and/or on-site, if this would reduce the adverse consequences of an accident involving the hazardous substances.

4.5 A storage facility should be designed taking into account the nature of the hazardous substances to be stored in the facility.

1. The design of the facility should allow for the separation of incompatible substances and subdivision of inventories by the use of separate buildings, fire walls, etc. and should enable access for inspection of hazardous substances, reduce the likelihood of domino effects should an accident occur and permit fire-lighting.

2. In designing such facilities, particular attention should be given to incorporating automated systems for handling hazardous substances, which reduce the risk of an accident involving such substances.

3. In order to prevent explosions and fires, consideration should be given to whether the conditions of storage (including, for example, temperature and pressure) create special risks. Consideration should also be given to avoiding potential sources of ignition such as smoking. Welding, and shrink-wrapping equipment. All power equipment should be specially protected, as necessary.

4.6 Storage facilities should incorporate safety features to prevent accidents and to reduce the adverse effects in the event of an accident. For example, security measures should be in place and fire protection equipment should be available. Adequate catchment facilities should be provided for the activation of spill mitigation procedures to protect the environment in the event of an accident.

4.7 Storage plans should be drawn up by the warehouse-keeper showing the nature of the hazardous substances in each part of the storage facility. The storage plan can be made available to the relevant local public authorities for example, fire services. Information concerning hazardous substances held in a storage facility should be maintained up-to-date.

4.8 Procedures should be established at storage facilities to prevent the risk of degradation of hazardous substances or packages as well as labels or other markings. Good housekeeping practices should be initiated to prevent accidents.

Hazards in working in a confined space [Clause 8 of is/iso45001:2018, Annex-c of IS 14489:2018 Clause 3.3 of IS 17893:2023]

1 Introduction

NIOSH defines a confined space as one which, by design, has limited openings for entry and exit or unfavourable natural ventilation which contains or produces dangerous air contamination not intended for continuous occupancy. Confined spaces include but are not limited to storage tanks, compartments of ships, process vessels, pits, silos, vats, wells, sewers, digesters, degreasers, reaction vessels, boilers, ventilation and exhaust ducts, tunnels, underground utility vaults, and pipelines. Confined spaces can be found in many industrial settings, from steel mills to paper mills, from shipyards to farms, and from public utilities to the construction industry. The hazards associated with confined spaces can cause serious injury and death to workers.

Two major factors lead to fatal injuries in confined spaces.

1. Failure to recognise and control the hazards associated with confined spaces, [and]
2. Inadequate or incorrect emergency response.

Confined spaces may be classified into two categories.

1. Open-topped enclosures with depths which restrict the natural movement of air (e.g., degreasers, pits, selected types of tanks, and excavations), [and]
2. Enclosures with limited openings for entry and exit (e.g., sewers, tanks, and silos).
3. The hazards found in any confined space are determined by the material being stored or used, the process-taking place inside the space and by the effects of the external environment. Worker entry into confined spaces may occur during construction activities or during necessary frequent functions such as cleaning, inspection, repair or maintenance.

2 Confined-Space Hazards - Atmospheric Hazards[Clause 3.3 of IS 17893:2023]

2.1 Oxygen Deficiency

2.2 Oxygen Displacement: Inert Gases and Simple Asphyxiants

2.3 Flammable Atmospheres

2.4 Toxic Atmospheres

2.5 Solvents

2.6 Physical Hazards

3 Prevention

The worker who is required to enter and work in a confined space may be exposed to a number of hazards. Therefore it is essential to develop and implement a comprehensive, written confined- pace-entry programme, for which the following elements are recommended:

1. Identification of all confined spaces at the facility and/or operation.
2. Posting a warning sign at the entrance of all confined spaces.
3. Evaluation of hazards associated with each type of confined space.
4. Job safety analysis for each task to be performed in the confined space.
5. Confined space entry procedures.
6. Initial plan for entry.
7. Assigned standby person(s).
8. Communications between workers inside and standby.

4 Rescue Procedures

Specified work procedures within the confined space include:

1. Evaluation to determine if entry is necessary can the work be performed from the outside of the confined space.
2. Issuance of a confined-space-entry permit this is an authorisation and approval in writing that specifies the location and type of work to be done, and certifies that the space has been.

   Confined-Space Hazards evaluated and tested by a qualified person and that all necessary protective measures have been taken to ensure the safety of the worker.

3. Testing and monitoring the air quality in the confined space to ensure the:

   a. Oxygen level is at least 19.5% by volume
   b. Flammable range is less than 10% of the LFL (lower flammable limit)
   c. Absence of all toxic air contaminants.

4.1 Confined-Space Preparation

1. Isolation/lockout/tag-out
2. Purging and ventilation
3. Cleaning processes
4. Requirements for special equipment and tools.

4.2 Safety Equipment and Protective Clothing for Confined-Space Entry

1. Head, hand, foot and body protection
2. Hearing and respiratory protection
3. Safety belts, lifelines, harness
4. Mechanical-lift device-tripod.

4.3 Training of Workers and Supervisors

Workers and supervisors must be trained in the selection and use of

1. Safe entry procedures
2. Respiratory protection
3. Lifelines and retrieval systems
4. Protecting clothing
5. Training of employees in confined-space rescue procedures
6. Conducting safety meetings to discuss confined-space safety
7. Availability and use of proper ventilation equipment
8. Monitoring the air quality while the workers are in the space.

CHAPTER V

OCCUPATIONAL HEALTH AND INDUSTRIAL HYGIENE

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"There are harmless ways of using harmful substances"

1 Worksite Analyses (Clause 6.1.2 of IS/ISO 45001:2018 , Annex-c of IS 14489:2018& IS 17893:2023)

A worksite analysis is an essential first step that helps an industrial hygienist determine what jobs and workstations are the sources of potential problems. During worksite analysis, industrial hygienists measure and identify exposures to substances, problem tasks and risks. The most effective worksite analyses include all jobs, operations and work activities. Industrial hygienists inspect, research, or analyse how particular chemicals or physical hazards place worksite affect worker health. If a hazardous situation is discovered, they recommend appropriate corrective action

2 Recognising and Controlling Hazards

Industrial hygienists recognise that engineering, work practice and administrative controls are the primary means of reducing employee exposure to occupational hazards. Engineering controls minimise employee exposure by either reducing or removing the hazard at the source of isolating the worker from the hazard. They include eliminating toxic chemicals or substituting non-toxic chemicals, enclosing work processes or confining work operations, and the installation of general and local ventilation systems.

Work practice controls alter the manner in which a task is performed. Some fundamental and easily implemented work practice controls include:

1. Changing existing work practices to follow proper procedures that minimise exposures when operating production and control equipment;
2. Inspecting and maintaining process and control equipment on a regular basis;
3. Implementing good housekeeping procedures;
4. Providing good supervision; and
5. Mandating that eating, drinking, smoking, chewing tobacco or gum and applying cosmetics in regulated areas be prohibited.

Administrative controls include controlling employees' exposure by scheduling production and tasks, or both, in ways that minimise exposure levels. For example, the employer might schedule operations with the highest exposure potential during periods when the least number of employees are present.

When effective work practices or engineering controls are not feasible or while such controls are being instituted, personal protective equipment must be used. Examples of personal protective equipment are gloves, safety goggles, helmets, safety shoes, protective clothing and respirators. To be effective, personal protective equipment must be individually selected, properly fitted and periodically refitted; conscientiously and properly worn; regularly maintained; and replaced when necessary.

3 Examples of Job Hazards

To be effective in recognising and evaluating on-the-job hazards and recommending controls, industrial hygienists must be familiar with the hazards' characteristics. Potential hazards can include air contaminants, and chemical, biological, physical and ergonomic hazards.

3.1 Air Contaminants(Annex-A of IS 14489:2018)

These are commonly classified as either particulate or gas and vapour contaminants. The most common particulate contaminants include dusts, fumes, mists, aerosols and fibres.

3.2 Chemical Hazards(Annex-A of IS 14489:2018)

Harmful chemical compounds in the form of solids, liquids, gases, mists, dusts, fumes and vapours exert toxic effects on inhalation (breathing), absorption (through direct contact with the skin, of ingestion (eating or drinking). Airborne chemical hazards exist gases, fumes or solids.

The degree of risk from exposure to any given substance depends on the nature and potency of the toxic effects and the magnitude and duration of exposure.

Information on the risk to workers from chemical hazards can be obtained from the Material Safety Data Sheet (MSDS). The MSDS is a summary of the important health, safety and toxicological information on the chemical or the mixture's ingredients.

Other provisions of the Hazard Communication Standard require that all containers of hazardous substances in the workplace have appropriate warning and identification labels.

3.3 Biological Hazards(Annex-A of IS 14489:2018)

These include bacteria, viruses, fungi, and other living organisms that can cause acute and chronic infections by entering the body either directly or through breaks in the skin. Occupations that deal with plants or animals or their products or with food and food processing may expose workers to biological hazards. Laboratory and medical personnel can also be exposed.

Any occupations that can involve contact with bodily fluids pose a risk to workers from biological hazards.

3.4 Physical Hazards

These include excessive levels of ionising and non-ionising electromagnetic radiation, noise, vibration, illumination and temperature. In occupations where there is exposure to it time, hence the shorter the distance, and shielding are important tools in ensuring worker safety.

Danger from radiation increases with the amount of time one in exposed to it, hence, the shorter the time of exposure the smaller the radiation danger.

Distance is a valuable tool in controlling exposure to both ionising and non-ionising radiation. Radiation levels from some sources can be estimated by comparing the squares of the data between the worker and the source. For example, at a reference point of 10 feet from a sere, the radiation is 1/100 of the intensity at I foot from the source.

Shielding protects against radiation. The greater the protective mass between a radioactive source and the worker, the lower the radiation exposure. Shielding workers from non- radiation can also be an effective control method. In some instances, however, limiting exposure to or increasing distance from certain forms of non-ionising radiation, such as lasers, it is not effective. For example, exposure to laser radiation, which is faster than the blink of an eye can be hazardous and requires workers to be miles from the laser source before being adequately protected.

Noise, another significant physical hazard, can be controlled by various measures. Noise can be reduced by installing equipment and systems that have been engineered, designed and built ta operate quietly; enclosing or shielding noisy equipment; making certain that equipment is in god repair and properly maintained with all worn or unbalanced parts replaced, mounting noisy equipment on special mounts to reduce vibration; and by installing silencers, mufflers or baffles

Substituting quiet work methods for noisy ones is another significant way to reduce nose-for example, welding parts rather than riveting them. Treating floors, ceilings and walls with acoustical material can reduce reflected or reverberant noise. In addition, erecting sound barriers at adjacent workstations around noisy operations will reduce worker exposure to noise generated.

It is also possible to reduce noise exposure by increasing the distance between the source and the receiver, by isolating workers in acoustical booths, limiting workers' exposure time to noise and by providing hearing protection. Industrial legislation requires that workers in noisy surroundings be periodically tested as a precaution against hearing loss.

Another physical hazard, radiant heat exposure in factories such as steel mills, can be controlled by installing reflective shields and by providing protective clothing.

3.5 Ergonomic Hazards

The science of ergonomics studies and evaluates a full range of tasks including, but not limited to, Sting, holding, pushing, walking and reaching. Many ergonomic problems result from technological changes such as increased assembly line speeds, adding specialised tasks and increased repetition. Some problems arise from poorly designed job tasks. Any of these conditions can cause ergonomic hazards such as excessive vibration and noise, eyestrain, repetitive motion, and heavy lifting problems. Improperly designed tools or work areas can also be ergonomic hazards. Repetitive motions or repeated shocks over prolonged periods of time as in jobs involving sorting, assembling and data entry can often cause irritation and inflammation of the tendon sheath in hands and arms, a condition known as carpal tunnel syndrome.

Ergonomic hazards are primarily avoided by the effective design of a job or jobsite and by better-designed tools or equipment that meet workers' needs in terms of physical environment and job tasks. Through thorough worksite analysis, employers can set up procedures to correct or control ergonomic hazards by using the appropriate engineering controls (e.g., designing or redesigning workstations, lighting, tools and equipment); teaching correct work practices (e.g., proper lifting methods); employing proper administrative controls (e.g., shifting workers among several different tasks, reducing production demand and increasing rest breaks); and, if necessary, providing and mandating personal protective equipment. Evaluating working conditions from an ergonomic standpoint involves looking at the total physiological and psychological demands of the job on the worker. Overall, the benefits of a well-designed, ergonomic work environment can include increased efficiency, fewer accidents, lower operating costs, and more effective use of personnel.

3.6 Electrical Hazards

Accidents while using portable electrical tools are caused due to the following reasons:

1. When bare live conductors are exposed and come in contact with damaged enclosure.
2. Insulation failures causing leakage of current make the metal works live if the equipment is not earthed properly.
3. If the earth wire is detached from the plug terminal because of loose or ineffective cord grip and comes in contact with the live terminal, the metal work of the apparatus can become live.

   "Okay! Turn on the electricity!"

4. Metal work becoming live as a result of wrong electrical connections.
5. Damaged flexible cables used with the apparatus.
6. Badly made joints in flexible cables which lose their insulation or pull apart when strained.
7. Servicing tools without disconnecting them from the power supply.
8. Unauthorised repairs carried out by the operator or his associates.
9. Electrical leakage in damp or wet location increases the electrical shock hazard. Perspiration on the workman will lower his body resistance and hence permit a higher current through the body increasing the resulting injury. Usually, the operator is unable to release his grip on the electrical tool and gets a shock increasing the severity of the injury.

3.7 Mechanical Hazards

1. Particles flying from grinding wheels or drills can fall in operator's eyes. This can sometimes blind the person.
2. While working at heights with portable electrical tools, the chances of the tool falling and injuring people standing below or the operators themselves falling from a height are high.

3. The equipment connecting the electrical cable with the power supply, if left on the floor, may cause up passers-to trip, causing nasty injuries.

3.8 Fire Hazards

1. The heat and sparks generated from the tools can at times ignite combustible material nearby.

2. Work with portable tools should not be carried out in areas where hazardous gases are likely to be present. This is because the sparks and heat generated by the tools could cause an explosion and fire.

3. Overloading and short circuits in the electrical supply system of the portable electrical tools can give rise to heat and sparks resulting in fire when combustible materials are present in the vicinity.

INDUSTRIAL EPIDEMOLOGY [Clause 6.1.2 ,6.1.3 & 8 of IS/ISO 45001:2018 Annex -A &C of IS 14489 :2018]

Industrial epidemiology involves the application of epidemiologic methods to populations of workers. Occupational epidemiologic studies may involve looking at workers exposed to a variety of chemical, biological or physical (e.g., noise, heat, radiation) agents to determine if the exposures result in the risk of adverse health outcomes. Alternatively, epidemiologic studies may involve the evaluation of workers with a common adverse health outcome to determine if an agent or set of agents may explain their disease. It is a study of distribution & determinants of health related states & events in working population & application of this study to control health problems & Relationship between occupational factors & disease trends. It helps in establishment of dose response relationship and also contribute in estimating safe levels of exposure.

Occupational Health and Occupational Health Services

- Occupational health implies the adaptation of work to man and of each man to his job
- It is a multidisciplinary approach comprising medicine, physiology, engineering, toxicology, chemistry, psychology and the ergonomics(man-machine interactions)

It's objective:

- Control of work related health hazards
- Prevention of health impairment
- Promotion of personal health of the employees

Elements of Occupational Health Services

- General preventive health measures- General preventive health measures like yoga classes, meditation classes, regular health check are essential to control work related health hazards.

- Assessment and control of work environment- Regular assessment of hazards and risks at the work place and its control is important tool to reduce and eliminate work related hazards.

- Medical treatment – In case a worker is diagnosed any occupational disease, it is the responsibility of the organization to provide proper treatment.
- Preventive medical examinations – Many of the progressive organization has adopted this as a tool to upkeep the good health of workers.

- **Examples of Occupational Health Hazards**
  - Diseases due to Physical Agents :
    - Heat – Heat stroke, Burns
    - Cold – Frostbite
    - Light – Miners Nystagmus, Cataract
    - Pressure – Caisson disease, Air Embolism
    - Noise – NIHL, Hypertension
    - Radiation – Leukemia, Aplastic Anaemia
    - Mechanical – Injuries, Accidents
    - Electricity – Electric shock, Burns
  - Diseases due to Chemical Agents :
    - Gases – CO, CO_2 , HCN, H_2S, CS_2
    - Dusts – Pneumoconiosis
    - Metals – Lead, Mercury, Chromium, Manganese
    - Acids, Alkalis
    - Solvents – Benzene, Trichloroethylene
  - Diseases due to Biological Agents :
    - Brucelosis
    - Leptospirosis
    - Actinomycosis
  - Occupational Cancers :
    - Cancer of Skin, Lungs, Bladder
  - Occupational Dermatitis :
    - Dermatitis, Eczema
  - Psychological Diseases :
    - Neurosis, Peptic Ulcers, Hypertension

Medical Surveillance :

It is the systematic collection of & evaluation of employee health data to identify specific instances of illness or health trends suggesting an adverse effect of work exposure coupled with actions to reduce hazardous workplace exposures

- A safety net to catch illness early

- Activate interventions to prevent illness from progressing further
- A backup to exposure assessments
- Exposure assessment should precede Medical Surveillance

Health Surveillance or Medical Surveillance can help to evaluate the effectiveness of risks controls. However, it is not a risk control, nor is it an alternative to the implementation and proper maintenance of higher order risk controls. Organization should identify those situations where employee health surveillance should occur and has implemented system to conduct this surveillance.

- Health surveillance may include the following :
- Biological testing e.g., determination of the presence of substance or their metabolites in blood, urine or expired air
- Specific medical tests, such as Lung Function Test (LFT)
- General medical examination
- Audiometer test
- Optometry

Components of Medical Surveillance :

The following are the components of effective medical surveillance

- Exposure assessment- Determining type & extent of exposure
- Selection of medical test – Type of medical tests to be carried out
- Determination of frequency of testing – what will be the frequency of such medical tests
- Natural history of the disease – What is the natural history of the disease & its present correlation
- Level of exposure to hazardous agents – Level of exposure need to measured and monitored specially the duration of exposure and the concentration or quantity of exposure.
- Anticipated susceptibility of exposed person- Whether the exposed person is from immunocompromised group ?
- Triggering medical monitoring – Determination of triggering signals for each occupational disease which will indicate start of medical monitoring.
- Training – Training of worker on occupational diseases , its cause and its prevention.
- Identification of employees to be tested - Identification of workers who are more prone to occupational diseases
- Interpretation of individual test results – to ascertain the extent of illness.
- Interpretation of aggregate test results – to ascertain whether the occupation disease has taken shape of epidemic.
- Action based on test results – Necessary treatment and other actions needed to control the hazards, removal of the affected person from the hazardous job.

- Notification – Notifying to the concern persons, the affected person, the management and statutory authority.
- Record keeping – Maintenance of medical records of all the workers.
- Quality control

Purpose of Medical Surveillance : The following are the purpose of medical surveillance:

- Screening of individual workers
- Establishing work relationship of previously diagnosed condition
- Surveillance of group of workers to identify high risk individuals
- To detect impairment which may cause decreased functional capacity
- Health promotion programme

Methods of Medical Surveillance : Popular methods of medical surveillance are given below:

- Pre-placement/Pre-employment medical examination
- Periodic medical examination
- Fitness medical examination
- Medical examination on retirement
- Executive & above 40 years Medical Check-up

Pre-placement Medical Examination : The purpose of pre placement Medical examinations are:

- To determine the physical & emotional capacity of the individual to perform the job
- To provide base-line health data for epidemiological & legal purposes
- To counsel the person for correction of diseases/habits which may harm later
- Assessment of pre-existing toxicity/impairment due to past exposure, if any

Periodic Medical Examination : Why? For:

- Evaluation of general health status
- Earliest detection and prevention of work related disorders
- Early detection, control and prevention of any health disorder which may affect the ability to perform the job
- To detect deviation in health status from base line data
- Detection of infectious/communicable diseases which may affect others

Medical Examination on Retirement : Purpose of the medical examination after retirement is:

- To detect cumulative toxicity effects
- To predict late effects on health

- Good gesture towards retiring employees
- Employees satisfaction

Follow-up Action on Surveillance : The following are the suggestive follow up actions:

- Verification of test results
- Notification of test results to employee and employer
- Additional diagnostic tests
- Treatment as required
- Removal from exposure ,if any
- Exposure evaluation and control
- Expansion of number of employees
- Reduction of number of employees
- Change in screening tests
- Change in frequency of tests

Medical Records : What, why, retention period ?

- Results of medical examination
- Purpose of medical tests conducted
- Interpretation of test conducted
- Action plan in response to results
- Duration
- Sufficient time to cover adverse effects

Other Records : Following other records are to be maintained:

- To document the medical screening procedures
- No./Names of exposed employees
- Inventory of potential exposure
- Details of environmental monitoring
- Action taken by the employer

Statutory Records : Following records are mandatory records as per statutory provisions:

- Work injury record
- Health Register in Form 7 for persons in dangerous operations under Section 87 of the Factories Act
- Special certificate of fitness in Form 23 for persons in occupations prescribed under Schedule III,IV,XIII,&IX of Rule 144 of the State Factories Rule under Section 87

Confidentiality to be maintained :

- Ensure full professional confidentiality
- Data not to be released without employer consent

- Identity of the employee may not be relevant to the evaluation of work environment and need not be disclosed
- Do not allow access to medical records to non-medical personnel

Quality Assurance : The following quality assurance activities are to be established and implemented:

- Procedures for screening tests including questionnaires
- Procedure/references for interpretation of test results
- Calibration of equipment etc.
- Supervision of by qualified experts
- Adherence to expert standards(e.g.WHO/OSHA)
- Participation in proficiency testing programmes

The "permit-to-work" system (IS 17893:2023)

The permit-to-work is essentially a document which sets out the work to be done, the hazards involved and the precautions to be taken. It predetermines a safety drill and is a clear record that all foreseeable hazards have been considered and that appropriate precautions are defined and put in correct sequence. It does not in itself make the job safe.

1 Application of 'Permit-to-Work' System

The classifications of systems and their requirements are as follows.

1.1 Hazardous Operation Permit

1. Work in confined-space. (Covered under the Factories Act, 1948, Section 36.). Refer to Section 13 in 'Confined-Space Hazards'.
2. Breaking or opening equipment or pipelines containing hazardous chemicals (liquids and/or gases). (Covered under the Maharashtra Factories Rules, 1963, Rule 73-C.).
3. Hot-work in areas or on equipment where flammables are stored or processed.
4. Work on high voltage electrical equipment.
5. Loading and unloading of hazardous substances.
6. Excavation: underground cables, pipeline-work, vessels, etc.
7. Operations involving disposal of hazardous substances.
8. Operations for testing of systems, equipment, pipeline, pressure plants, etc.

1.2 Hazardous Location Permit

1. Work on fragile roof or ceiling (eg. A C. Sheet) where workers are liable to fall. (Covered under the Maharashtra Factories Rules, 1963, Rule 73-F.)
2. Work at dangerous heights, on scaffolding/walls/tall chimneys.
3. Work on or below or in the vicinity of guarded or unguarded electrically operated and/or mechanically moving machinery or equipment.

4. Work on equipment that requires complete isolation.
5. Work involving propping and centring of RCC slab.

1.3 Hazardous Work Area Permit

1. Explosive building work.
2. Acid area work.
3. Flammable area work.
4. Noxious fumes area work.

1.4 Special Hazard Permit

1. Use of toxic materials matches or lighter, flammables.
2. Use of repaired/modified electrical and other tools/equipment/application.

1.5 Equipment Operating Permit

1. Operating vehicle, fork-lift etc.
2. Sprinkler valve closing

2 Basic Elements of the 'Permit-to-Work' System

The following should be considered, specified in precise detail and recorded on the permit.

2.1 Preparation

1. The job to be done.
2. The possible dangers involved. A checklist used.
3. The necessary isolations, disconnection and tests. A checklist used.
4. The safety precautions which must be taken. A checklist used. 5. The time limits between which the permit is valid.

When the above steps are complete, ensuring that the particulars are correct, the permit is signed by the authorised initiator and handed over to the **job-undertaker.**

2.2 Transfer and Acceptance of Responsibility

1. The job-undertaker assures the initiator that the permit has been properly completed and that he understands the work to be done and precautions to be taken.
2. The job-undertaker signs the permit.
3. He checks that the necessary safety equipment is available and ensures that the specified precautions are carried out.
4. He consults and obtains renewal or continuation of the permit if the job is delayed beyond the specified limit.

2.3 Completion of the Job

1. The job-undertaker signs to the effect that the job is complete, that all his men have withdrawn and normal safeguards effectively restored.

2. When more than one trade is involved in the work, the supervisor of each group signs.
3. The machinery or plant is handed back to the production initiator who signs accepting responsibility.
4. The permit is withdrawn from the display and normal working is resumed.

Indian Standard on Work permit system – Code of practice (IS 17893:2023)

Bureau of Indian Standards has brought out this immensely useful standard on safety point of view. This standard gives detailed guideline on general procedure for work permit. This standard prescribes work permit for the following work areas:

a) Cold work permit;
b) Hot work permit;
c) Confined space/vessel entry permit;
d) Excavation permit;
e) Electrical work permit;
f) Work at height permit; and
g) Radiography

As prescribed in this standard, In general, Work permit procedure is applicable to all restricted areas in the plant or unit. However, work permit may not be applicable for the following areas/activities:

a) Routine welding/cutting and similar maintenance/fabrication jobs carried out inside or adjacent to any plant unit workshops and central workshops or the area demarcated/allotted by the approval of the facility in-charge;

b) Routine sampling for the purpose of laboratory analysis;

c) Canteen for cooking, preparing tea/food, etc.;

d) Torches, furnaces, sparking equipment, etc. located in designated locations of laboratory;

e) Collection of garbage from specified safe locations in the plant area;

f) All cold jobs in office buildings including control room buildings. However, jobs requiring electrical isolation, work at height and excavation, etc in these areas will require work permit

g) Visual inspection by maintenance or inspection personnel of rotary or static equipment in the plant.

h) Replacement of tube light rods inside buildings. Verbal permission from shift in-charge/area in-charge is to be obtained before starting the job. Replacement of bulbs on poles inside plant areas and on a road requires permit

i) Gardening related manual jobs like grass cutting with hand cutter, branch trimming cutting, etc. around office buildings, control room buildings, plant areas, non-plant areas. However, for jobs requiring electrical connection like lawn movers, mechanized hacksaw machine, and work at height like climbing on tree and excavation more than 30 cm deep will require respective work permit.

j) Any other routine activities authorized by the facility in-charge by a separate notification.

Clause 2 of this standards stipulates the general requirement related to work permit detailing the work to be taken up, its processes, responsibility, working conditions, the condition when the work permit can be withdrawn etc.

Clause 3 describes different types of works with examples like cold work, hot work, electrical work, excavation, confined space, work at height and radiography.

Clause 4 deals with details & procedure for work permit format. It requires the following:

a)Job Particular b) Nature of job c) Checklist d) Isolaton / blindings e) *Isolation / "DO NOT OPERATE"TAG f) Depressurization/ Draining g) Washing/ Steaming/ Purging h) Electrical Isolation and Restoration i) Mechanically Blocked to Avoid Rotation j) Use of Non-sparking Tools Required k) Portable Fire Extinguisher Provided l) Running Water Hose Provided m) Return Earthing Cable Should be Provided and Welding Cable should be Insulated n) Ladder o) Scaffolding Certified for Use p) Radioactive Source Isolation q) Escape Route should be Checked and*

Cleared r) Ventilation should be Ensured s) Proper Illumination Should be Available (24 V Flame Proof, Hand Lamp) t) Stand by Person/Fireman

Clause 5 prescribes personal protective equipment to be used **for carrying out the work**

Clause 6 talks about the gas test to be carried out (if vessel/tank used for chemicals, toxic in nature)

Clause 7 talks about approvals . The permit will be finally approved by issuer and the job executor. Plant HOD shall authorize hot work and vessel entry permits and excavation permits. Job executor shall mention the name of contractor if contractor is performing the job**.**

Clause 8 deals with interplant clearances where two or more plants are involved**.**

Clause 9 deals with revalidation and renewals of the work permit.

Clause 10 talks about closure and cancellation of the work permit. The permit can be extended for a total of

seven calendar days maximum. For work extending beyond seven days, a new work permit has to be issued after closing the present work permit. Also if there is a break in the work for more than one calendar day, a new permit has to be issued. After completion of the job, agency undertaking the job must ensure that all tools, tackles, men and material have been removed from the place of work and the area has been made clean. Guards, gratings, railings if have been removed shall be fixed properly.

All signing authorities for approval must sign the permit for closure of the permit.

Cancellation of Work permit

Permit shall be cancelled under the following conditions:

a) Declaration of plant/site emergency situation (fire, etc);
b) Any accident at the permit work area; and
c) Permit conditions are violated

Clause 11 Stipulates requirements for auditing the work permit system.

Clause 12 talks about the **Responsibility matrix** and **clause 13** stipulates **Records** to be maintained for work permit system at least for 30 days after closure of the work permit.

Annexures to this standards gives details of the formats to be and necessary conditions to be fulfilled for different categories of work permits,

CHAPTER VI

INDUSTRIAL TOXICOLOGY

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INDUSTRIAL TOXICOLOGY

"All substances are Poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy."

Introduction [Clause 6.1.2, 6.1.2 & 8 of IS/ISO 45001 :2018 and IS 15656 : 2004]

Among all safety hazards , toxic substances are most deadly hazards. Bhopal gas tragedy is the glaring example . To understand or to estimate the severity of the Chemical Hazards, it is pertinent to have some idea about basic concept of Industrial Toxicology.

Definition of industrial toxicology

Industry is a commercial activity that provides goods and services such as agriculture, transportation, hospitality, and many others. Industry is classified into three different categories known us primary, secondary and tertiary. Primary industries are those that extract or produce raw materials from which useful items can be made, example mining activities. Secondary industries are those that change raw materials into usable products through processing and manufacturing. Bakeries that make flour into bread and factories that change metals and plastics into vehicles. Tertiary industries are those that provide essential services and support to allow other levels of industry to function. Often simply called service industries, this level includes transportation, finance, utilities, education, retail, housing, medical, and other services. The word "toxicity" describes the degree to which a substance is poisonous or can cause injury. The toxicity depends on a variety of factors: dose, duration and route of exposure shape and chemical & physical properties of the chemical itself, and biological susceptibility individual human. Toxic is a term relates to poisonous or deadly effects on the body by inhalation (breathing), ingestion (eating), or absorption, or by direct contact with a chemical. In addition, A toxicant is any chemical that can injure or kill humans, animals, or plants; a poison. The term "toxicant" is used when talking about toxic substances that are produced by or are a by-product of human-made activities.

For example, dioxin (2, 3-7, 8-tetrachlorodibenzo*p*-dioxin {TCDD}), produced as a byproduct of certain chlorinated chemicals, and it is a toxicant. On the other hand, arsenic, a toxic metal, may occur as a natural contaminant of ground water may contaminate groundwater as a by-product of industrial activities.

If the second case is true, such toxic substances are referring to as toxicant rather than toxins. Furthermore, the term “toxin” usually is used when talking about toxic substances produced naturally. A toxin is any poisonous substance of microbial (bacteria or other tiny plans or animals), vegetable, or synthetic chemical origin that reacts with specific cellular components to kill cells, alter growth or development, or kill the organism . During those commercial activities above, the releasing of the toxins or poisons come into contact, and affects the environment and human health if less measure were considered. Therefore, industrial toxicology is the study of harmful effects caused by physical phenomena, such as radiation of various kinds and noise. In addition, it is also “the study of the detection, occurrence, properties, effects, and regulation of toxic substances,” within the industries or factories (Ernest H, 1932).

Brief history of Toxicology

Toxicology is rank as one of oldest practical science where some used for judiciary execution, suicide and even political assassinations. The Egyptian papyrus, Ebers, dating from about 1500 BC, must rank as the earliest surviving pharmacopeia, and the surviving medical works of Hippocrates, Aristotle, and Theophrastus published during the period 400 to 250 BC all include some mention of poisons. The early Greek poet Nicander treats, in two poetic works, animal toxins (Therica) and antidotes to plant and animal toxins(Alexipharmica). The earliest surviving attempt to classify plants according to their toxic and therapeutic effects is that of Dioscorides, a Greek employed by the Roman emperor Nero about AD 50. There appear to have been few advances in either medicine or toxicology between the time of Galen (AD 131–200) and Paracelsus (1493–1541). It was the latter who, despite frequent confusion between fact and mysticism, laid the groundwork for the later development of modern toxicology by recognizing the importance of the dose-response relationship. His famous statement, “All substances are poisons; there is none that is not a poison. The right dose differentiates a poison and a remedy” succinctly summarizes that concept. His belief in the value of experimentation was also a break with earlier tradition. There were some important developments during the eighteenth century. Probably the best known is the publication of Ramazini’s Diseases of Workers in 1700, which led to his recognition as the father of occupational medicine. The correlation between the occupation of chimney sweeps and scrotal cancer by Percival Pott in 1775 is almost as well known, although it was foreshadowed by Hill’s correlation of nasal cancer and snuff use in 1761. Orfila, a Spaniard working at the University of Paris in the early nineteenth century, is generally regarded as the father of modern toxicology. He clearly identified toxicology as a separate science and, in 1815, published the first book devoted exclusively to toxicology. An English translation in 1817 was entitled “A General System of Toxicology or, A Treatise on Poisons, Found in the Mineral, Vegetable and Animal Kingdoms, Considered in Their Relations with Physiology, Pathology and Medical Jurisprudence”. Workers of the late nineteenth century who produced treatises on toxicology include Christian, Kobert, and Lewin. The recognition of the site of action of curare by Claude Bernard (1813–1878) began the modern study of the mechanisms of toxic action. Since then, advances have been numerous too numerous to list in detail. They have increased our knowledge of the chemistry of poisons, the treatment of poisoning, the analysis of toxicants and toxicity, modes of toxic action and detoxication processes, as well as specific molecular events in the poisoning process. With the publication of her controversial book, *The Silent Spring*, in 1962, Rachel Carson became an important influence in initiating the modern era of environmental toxicology. Her book emphasized stopping the widespread, indiscriminate use of pesticides and other chemicals and advocated use patterns based on sound ecology. Although sometimes inaccurate and with arguments often based on frankly anecdotal evidence, her book is often credited as the catalyst leading to the establishment of the US Environmental Protection Agency and she is regarded, by many, as the mother of the environmental movement. It is clear, however, that since the 1960s toxicology has entered a phase of rapid development and has changed from a science that was largely descriptive to one in which the importance of mechanisms of toxic action is generally recognized. Since the 1970s, with increased emphasis on the use of the techniques of molecular biology, the pace of change has increased even further, and significant advances have been made in many areas, including chemical carcinogenesis and xenobiotic metabolism, among many others (John W & Son, 2004).

Source of toxic compound

The source of toxic compound however, are natural products, many are synthetic organic chemical of use to society, while others are by-products of industrial processes and waste disposal. For an example, silver was the precious metal at the foundation of the Roman Empire's Economy (REE) and since silver is often embedded in lead ore, lead was an abundant byproduct available throughout the empire. As such, Romans used lead in everything from plumbing pipes to wine to women's makeup. In a sense, it was the high fructose corn syrup of its day: it was found in a plethora of common items and caused negative health effects. Lead poisoning is well documented in the Roman era and forever linked with that society's fascination with silver. Surely, centuries later, humanity has learned its lesson (David L, 2011).

On the other hand, leather industry has significant economic influence. However, it enhanced the tannery waste produced during leather processing processes. This source generates chemical oxygen demand, dissolved solids, chlorides, sulfates and heavy metal pollution. When these chemicals discharged into aquatic systems, it would be end up in highly polluted sediments and salinization or rivers which cause harm for people if they use the river (Sumita D, 2015). Source of toxic compound is however, categorize in two forms:

1. Exposure Class

Exposure classes include toxicants in food, air, water, and soil as well as toxicants characteristic of domestic and occupational Settings. This simply refers to either workers or ordinary people expose to pollution via those above toxicants.

2. User Class

Use classes include drugs of abuse, therapeutic drugs, agricultural chemicals, food additives and contaminants, metals, solvents, combustion products, cosmetics, and toxins. Some of these, such as combustion products, are the products of use processes rather than being use classes (Ernest H, 1932).

2.1 Characteristic of toxicology

Adverse effects or toxic substances in biological systems can be caused by chemicals that undergo biotransformation and dosage as well as the arrangement suited to induce a toxic state. The response to toxic materials, among others, depend on the physical and chemical properties, exposure situations, the vulnerability of biological systems, so if you want to classify the toxicity of a substance you must know the type of effects that would arise and the dosages as well as information on exposure and the targets.

Comparison of a lethal dose of pollutants and differences in the driveway of exposure is very helpful with regard to its absorptions. A pollutant can be administered in the same dose but the inclusion of different ways. For example, pollutants first intravenously, while other materials are going through the mouth, it can be estimated that the pollutants that entered through the mouth would give immediate reaction. Conversely, if the dose is given in different mode, its absorption will estimate differently. For example, a material entered the skin with a higher dose while on the other side, it entered through the mouth with the lower doses, it could be expected that the skin is more resistant for the toxins (pollutant) to enter the skin because it required high dosage (https://yazhid28bashar.blogspot.co.id/).

2.2 The Movement of Toxicants in Environment

Chemicals released into the environment rarely remain in the form, or at the location, of release. For example, agricultural chemicals used as sprays may drift from the point of application as air contaminants or enter runoff water as water contaminants. Many of these chemicals are susceptible to fungal or bacterial degradation and are rapidly detoxified, frequently being broken down to products that can enter the carbon, nitrogen, and oxygen cycles. Other agricultural chemicals, particularly halogenated organic compounds, are recalcitrant to a greater or lesser degree to metabolism by microorganisms and persist in soil and water as contaminants; they may enter biologic food chains and move to higher trophic levels or persist in processed crops as food contaminants. This same scenario is applicable to any toxicant released into the environment for a specific use or as a result of industrial processes, combustion, and so on. Chemicals released into the environment are also susceptible to chemical degradation, a process often stimulated by ultraviolet light. Although most transport between inanimate phases of the environment results in wider dissemination, at the same time dilution of the toxicant in question and transfer among living creatures may result in increased concentration or bioaccumulation. Lipid soluble toxicants are readily taken up by organisms following exposure in air, water, or soil. Unless rapidly metabolized, they persist in the tissues long enough to be transferred to the next trophic level. At each level the lipophilic toxicant tends to be retained while the bulk of the food is ingested, utilized, and excreted, thus increasing the toxicant concentration. At some point in the chain, the toxicant can become deleterious, particularly if the organism at that level is more susceptible than those at the level preceding it. Thus the eggshell thinning in certain raptorial birds was almost certainly due to the uptake of DDT (dichlorodiphenyltrichloroethane) and DDE (dichlorodiphenyldichloroethyenel) and their particular susceptibility to this type of toxicity. It is clear that such transport can occur through both aquatic and terrestrial food chains, although in the former, higher members of the chains, such as fish, can accumulate large amounts of toxicants directly from the medium. This accumulation occurs because of the large area of gill filaments, their intimate contact with the water and the high flow rate of water over them. Given these characteristics and a toxicant with a high partition coefficient between lipid membranes and water, considerable uptake is inevitable (Ernest, H 1932).

2.3 How can chemicals enter the body?

Exposure normally occurs through inhalation, skin or eye contact, and ingestion. These are known as the routes of exposure;

1. **Inhalation.** A very important type of workplace exposure occurs when you breathe a substance into the lungs. The lungs consist of branching airways (called bronchi) with clusters of tiny air sacs (called alveoli) at the ends of the airways. The alveoli absorb oxygen and other chemicals into the bloodstream. The surface area of a person's alveoli is roughly equal to that of half of a tennis court. Some chemicals are irritants and cause eye, nose, and throat irritation. They may also cause discomfort, coughing, or chest pain when they are inhaled and come into contact with the bronchi (chemical bronchitis). Other chemicals may be inhaled without causing such warning symptoms, but they still can be dangerous. Although body filters many of the normal pollutants from the air breathe, it cannot eliminate every type of contaminant. Small particles are difficult for the body to eliminate and can get deep into the lungs where they can cause respiratory problems. Workers in dusty occupations are more susceptible to respiratory diseases than workers in non-dusty occupations. Chemicals, in their various forms, can be inhaled and damage various target organs as well as the lungs. It is important to notice warning signals, such as smelling chemical odours. It is also important to notice if one stops smelling a chemical odour that one used to smell – he may be accustomed or used to the smell and not know that he is being exposed to the chemical.

2. **Skin Contact.** The skin is a protective barrier that helps keep foreign chemicals out of the body. However, some chemicals can easily pass through the skin and enter the bloodstream. If the skin is cut or cracked, chemicals can penetrate through the skin more easily. Also, corrosive substances, like strong acids and alkalis, can chemically burn the skin. Diseases can develop when chemicals and other materials used at work come into contact with your skin." Skin in a major route of entry for hazardous substances in the workplace. Chemicals can be absorbed through health skin into the bloodstream and transported to target organs where they can have damaging results.

   Exposure to chemicals, physical hazards and biological hazards in the workplace can result in occupational diseases and allergic reactions

3. **Eye Contact.** Some chemicals may burn or irritate the eye. The eyes are easily harmed by chemicals, so any eye contact with chemicals (particularly liquids) should be taken as a serious incident.

4. **Ingestion (swallowing). "**Hazardous agents can also get into the body by ingestion." Hazardous agents can enter the body by being ingested (swallowed). Some ingested hazardous agents are neutralized in the stomach, while others are absorbed into the bloodstream and transported to target organs. Eliminating hazardous agents is the best method of preventing their ingestion. Other

important methods of prevention are personal hygiene and ensuring workers have access to washing facilities, food storage and eating areas that are away from their work areas. Vomiting and diarrhea are ways the body tries to remove certain toxic substances from the digestive system.

2.4 How can toxic substance harm the body?

When a toxic substance causes damage at the point where it first contacts the body, that damage is called a local effect. The most common points at which substances first contact the body are the skin, eyes, nose ,throat, and lungs. Many toxic substances can also enter the body and travel in the bloodstream to internal organs. Effects that are produced this way are called systemic. The internal organs most commonly affected are the liver, kidneys, heart, nervous system (including the brain), and reproductive system.

A toxic chemical may cause local effects, systemic effects, or both. For example, if ammonia gas is inhaled, it quickly irritates the lining of the respiratory tract (nose, throat, and lungs). Almost no ammonia passes from the lungs into the blood. Since damage is caused only at the point of initial contact, ammonia is said to exert a local effect. An epoxy resin is an example of a substance with local effects on the skin. On the other hand, if liquid phenol contacts the skin, it irritates the skin at the point of contact (a local effect) and can also be absorbed through the skin, and may damage the liver and kidneys (systemic effects). Sometimes, as with phenols, the local effects caused by a chemical provide a warning that exposure is occurring. You are then warned that the chemical may be entering your body and producing systemic effects which you can't yet see or feel. Some chemicals, however, do not provide much warning, so they are particularly hazardous. For example, some toxic solvents can pass through the skin and cause serious internal damage without producing any observable effect on the skin (Arnold S, 2008).

Some of the Chemical or Physical Properties of toxic agents are given below:

- Acids and Bases – Corrosive (Inhalation, Dermal)
- Hydrocarbon – Blood brain barrier, CNS depressant (Ingestion, Dermal, Inhalation)
- Inorganic Elements – cumulative Poisons e.g. Pb, Hg

2.5 Classification of toxic agent

Toxic substances are classified into the following:

a. Heavy Metals

Metals differ from other toxic substances in that they are neither created, nor destroyed by humans. Their use by humans plays an important role in determining their potential for health effects. Their effect on health could occur through at least two mechanisms: first, by increasing the presence of heavy metals in air, water, soil, and food, and second, by changing the structure of the chemicals. For example, chromium III can be converted to or from chromium VI, the more toxic form of the metal.

b. Solvents and Vapours

Nearly everyone is exposed to solvents. Occupational exposures can range from the use of "white-out" by administrative personnel, to the use of chemicals by technicians in a nail salon. When a solvent evaporates, the vapours may also pose a threat to the exposed population.

c. Radiation and Radioactive Materials

Radiation is the release and propagation of energy in space or through a material medium in the form of waves, the transfer of heat or light by waves of energy, or the stream of particles from a nuclear reactor.

d. Dioxin/Furans

Dioxin (or TCDD) was originally discovered as a contaminant in the herbicide Agent Orange. Dioxin is also a by-product of chlorine processing in paper producing industries.

e. Pesticides

The EPA defines pesticide as any substance or mixture of substances intended to prevent, destroy, repel, or mitigate any pest. Pesticides may also be described as any physical, chemical, or biological agent that will kill an undesirable plant or animal pest.

f. Plant Toxins

Different portions of a plant may contain different concentrations of chemicals. Some chemicals made by plants can be lethal. For example, taxon, used in chemotherapy to kill cancer cells, is produced by a species of the yew plant.

g. Animal Toxins

These toxins can result from venomous or poisonous animal releases. Venomous animals are usually defined as those that are capable of producing a poison in a highly developed gland or group of cells, and can deliver that toxin through biting or stinging. Poisonous animals are generally regarded as those whose tissues, either in part or in their whole, are toxic.

h. Subcategories of Toxic Substance Classifications

All of these substances may also be further classified according to their:

- Effect on target organs (liver, kidney, hematopoietic system),
- Use (pesticide, solvent, food additive),
- Source of the agent (animal and plant toxins),
- Effects (cancer mutation, liver injury),
- Physical state (gas, dust, liquid),
- Labelling requirements (explosive, flammable, oxidizer),
- Chemistry (aromatic amine, halogenated hydrocarbon), or
- Poisoning potential (extremely toxic, very toxic, slightly toxic)

i. General Classifications of Interest to Communities

a. Air pollutants
b. Occupation-related
c. Acute and chronic poisons

All chemicals (or any chemical) may be poisonous at a given dose and through a particular route. For example, breathing too much pure oxygen, drinking excessive amounts of water or eating too much salt can cause poisoning or death (http://www.atsdr.cdc.gov).

2.6 The exposure limits of toxin

Exposure limits are established by health and safety authorities to control exposure to hazardous substances. In California the most important exposure limits are the Permissible Exposure Limits (PELs). These are set forth in California regulations. By law, California employers who use regulated substances must control exposures to be below the PELs for these substances. An employer can be cited and fined if employees are exposed over the PEL. Exposure limits usually represent the maximum amount (concentration) of a chemical which can be present in the air without presenting a health hazard. However, exposure limits may not always be completely protective, for the following reasons:

1. Although exposure limits are usually based on the best available information, this information, particularly for chronic (long-term) health effects, may be incomplete. Often, we learn about chronic health effects only after workers have been exposed to a chemical for many years, and then as new information is learned, the exposure limits are changed.

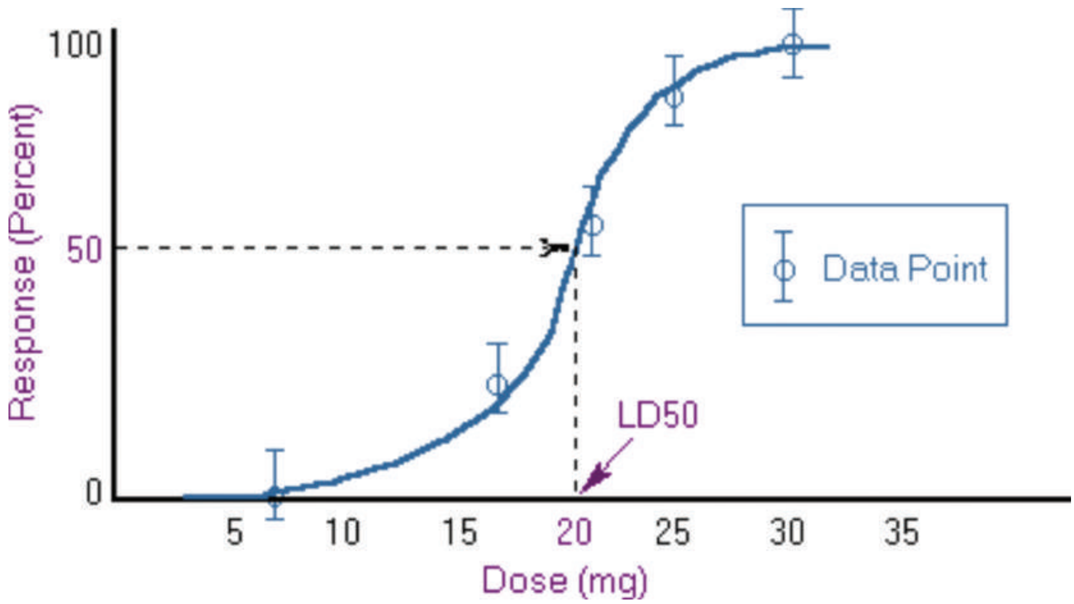
2. Exposure limits are set to protect most workers. However, there may be some workers who will be affected by a chemical at levels below these limits. For instance, employees performing heavy physical exertion breathe in more air and more airborne chemicals, and so may absorb an excessive amount.

3. Exposure limits do not take into account chemical interactions. When two or more chemicals in the workplace have the same health effects, industrial hygienists use a mathematical formula to adjust the exposure limits for those substances in that workplace. This formula applies to chemicals that have additive effects.

4. Limiting the chemical concentration in air may not prevent excessive exposure through skin contact or ingestion. Chemicals that may produce health effects as a result of absorption through the skin have an “S” designation next to their numerical value in the Cal/OSHA PEL table. Workers exposed to these chemicals must be provided with protective clothing to wear when overexposure through the skin is possible. In California, Permissible Exposure Limits (PELs) are set by the Occupational Safety and Health Standards Board, and enforced by the

Division of Occupational Safety and Health (known as DOSH or Cal/OSHA). PELs have been set for about 850 chemicals. They are periodically, revised when new information on toxicity becomes available. California PELs can be the same as federal OSHA PELs, or may be more protective (Victoria L.B, 2008).

Dose estimates



Dose Estimates of Toxic Effects

Dose-response curves are used to derive dose estimates of chemical substances. A common dose estimate for acute toxicity is the **LD50** (*Lethal Dose 50%*). This is a statistically derived dose at which 50% of the individuals will be expected to die. The figure illustrates how an LD50 of 20 mg is derived. Other dose estimates also may be used. LD0 represents the dose at which no individuals are expected to die. This is just below the threshold for lethality. LD10 refers to the dose at which 10% of the individuals will die. For inhalation toxicity, air concentrations are used for exposure values. Thus, the LC50 is utilized which stands for Lethal Concentration 50%, the calculated concentration of a gas lethal to 50% of a group. Occasionally LC0 and LC10 are also used.

Chemicals having the following values of acute toxicity and which owing to their physical and chemical properties are capable of producing major accident hazards:

Toxicity	Oral LD50 (mg/KG)	Dermal LD50 (mg/kg)	Inhalation LC50 (mg/l)
Extremely toxic	<5	<40	<0.5
Highly toxic	>5-50	>40-200	>0.5-2.0
Toxic	>50-200	>200-1000	>2-10

2.7 How to measure and monitor toxicant substance

Bureau of Indian Standards, has adopted an ISO standards on DETERMINATION OF TOXICITY OF A GAS OR GAS MIXTURE IS 16529 : 2022 ISO 10298 : 2018. Test method and calculation of LD50 value of toxic gases

There are several ways to measure and monitor the toxicant substance.

These are as follows;

1. Air sampling

When toxic chemicals are present in the workplace, your exposure can be estimated by measuring the concentration of a given chemical in the air and the duration of exposure. This measurement is called air or environmental monitoring or sampling and is usually done by industrial hygienists, using various types of instruments. Laboratory analysis may be required. The air is collected from your breathing zone (the air around your nose and mouth) so that the concentrations measured will accurately reflect the concentration you are inhaling. The exposure levels calculated from this monitoring can then be compared to exposure limits for that chemical.

2. Biological monitoring

Environmental monitoring is the most accurate way to determine your exposure to most chemicals. However, for chemicals that are absorbed by routes other than inhalation, such as through the skin and by ingestion, air monitoring may underestimate the amount of chemical you absorb. The levels of the chemical (or its breakdown products) in the body can sometimes be measured in the blood, urine, or exhaled air. Such testing is called biological monitoring, and the results provide an estimate of the actual dose absorbed into the body. For several substances, biological monitoring is required by law when air monitoring results are above a certain level. The American Conference of Governmental Industrial Hygienists (ACGIH) has recommended test methods, and the acceptable range of test results, for biological monitoring for some chemicals. There are approximately 50 of these Biological Exposure Indices (BEIs); they are published together with TLVs. For most workplace chemicals, however, biologic monitoring is neither practical nor informative.

3. Practical clues to exposure

a. Odour

If you smell a chemical, you are inhaling it. However, some chemicals can be smelled at levels well below those that are harmful, so that detecting an odour does not mean that you are inhaling harmful amounts. On the other hand, some chemicals cannot be smelled even at levels that are harmful. The odour threshold is the lowest level of a chemical that can be smelled by most people. If a chemical's odour threshold is lower than the amount that is hazardous, the chemical is said to have good warning properties. One example is ammonia. Most people can smell it at 5 ppm, below the PEL of 25 ppm. It is important to remember that for most chemicals, the odour thresholds vary widely from person to person. In addition, some chemicals, like hydrogen sulfide, cause you to rapidly lose your ability to smell them; this is called olfactory fatigue. With these cautions in mind, knowing a chemical's odour threshold may serve as a rough guide to your exposure level. Don't depend on odour to warn you. Remember that your sense of smell may be better or worse than average, that some very hazardous chemicals have no odour (carbon monoxide), some chemicals of low toxicity have very strong odours (for example, mercaptans added to natural gas), and other chemicals produce olfactory fatigue.

b. Taste

If you inhale or ingest a chemical, it may leave a taste in your mouth. Of course, you should not taste toxic or unknown chemicals on purpose to identify them.

c. Particles in Nose or Mucous

If you cough up mucous (sputum or phlegm) with particles in it, or blow your nose and see particles or discoloration, then you have inhaled some chemical in particle form. unfortunately, most particles which are inhaled into the lungs are too small to see.

d. Settled Dust or Mist.

If chemical dust or mist is in the air, it will eventually settle on work surfaces or on your skin, hair, and clothing. It is likely that you inhaled some of this chemical while it was in the air.

e. Immediate Symptoms.

If you or your co-workers experience symptoms known to be caused by a chemical during or shortly after its use, you may have been overexposed. Symptoms might include irritation and tearing of the eyes, a burning sensation of skin, nose, or throat, and cough, dizziness, or headache.

4. Exposure health effect test

Sometimes Medical surveillance is a program of medical examinations and tests designed to detect early warning signs of disease. A medical surveillance program may discover small changes in health before severe damage occurs. Testing for health effects is called medical monitoring. The type of testing needed in a surveillance program depends upon the particular chemical involved. Unfortunately, medical monitoring tests that accurately measure early health effects are available only for a small number of chemicals. A complete occupational surveillance program should consist of industrial hygiene monitoring, medical monitoring, and biological monitoring when appropriate. Tests for health effects when you are already sick are not part of medical surveillance, and must be selected by your physician on a case-by-case basis. When there is employee exposure to certain chemicals, such as asbestos, arsenic, cadmium, formaldehyde, hexavalent chromium, and lead, employers are required by Cal/OSHA regulations to establish medical surveillance programs. You have the right under Cal/OSHA regulations (CCR, Title 8, Section 3204) to see and copy your own medical records and records of exposure to toxic substances. Your employer must keep these records for at least 30 years after the end of your employment (Arnold S, 2008).

2.8 How to reduce exposure

The surest way to prevent toxic chemicals from causing harm is to minimize or prevent exposure. Below are some methods of controlling exposure;

a. Training

Everyone who works with toxic substances should know the names, toxicity, and other hazards of the substances they use. Employers are required by law to provide this information, along with training in how to use toxic substances safely. A worker may obtain information about a chemical's composition, physical characteristics, and toxicity from the Material Safety

Data Sheet (MSDS). Under California law manufacturers are required to supply an MSDS for products that contain toxic substances. Employers obtain the MSDS when they purchase the product and must make the MSDS available to employees. Unfortunately, the precise chemical composition may be proprietary (trade secret) information, and the toxicity information on an MSDS may be incomplete and unreliable. HESIS can help you interpret the information on an MSDS.

b. Engineer Controls

Limiting exposure at the source is the preferred way to protect workers. The types of engineering controls, in order of effectiveness, are listed below;

i. Substitution

It is using a less hazardous substance. But before choosing a substitute, thoroughly consider its physical and health hazards. For example, mineral spirits (Stoddard solvent) is less of a health hazard than perchloroethylene for dry cleaning, but is more of a fire hazard. Also consider environmental aspects such as air pollution and waste disposal.

ii. Process or equipment enclosure

It is the isolation of the source of exposure, often through automation. This completely eliminates the routine exposure of workers. For example, handling of radioactive materials is often done by mechanical arms or robots.

iii. Local exhaust ventilation

It is a hood or intake close to the source of exposure to capture or draw contaminated air from its source before it spreads into the room and into your breathing zone. All ventilation systems require careful engineering design and regular maintenance.

iv. General or dilution ventilation

It is continual replacement and circulation of fresh air sufficient to keep concentrations of toxic substances diluted below hazardous levels. However, concentrations will be highest near the source, and overexposure may occur in this area. If the dilution air is not well mixed with the room air, pockets of high concentrations may exist.

c. Work practice

Work practices are behaviours performed by workers in order to reduce exposures. Controlling dust dispersion by spraying water (or dust suppressant products), closing containers of volatile chemicals when not in use, and labelling containers of hazardous substances, are common and effective chemical control work practices.

d. Personal protective equipment

The following devices should be used only when engineering controls are not possible or are not sufficient to reduce exposure.

i. Respiratory protective equipment

It consists of devices that cover the mouth and nose to prevent substances in the air from being inhaled. A respirator is effective only when used as part of a comprehensive program established by the employer, which includes measurement of concentrations of hazardous substances, selection of the proper respirator, training the worker in its proper use, fitting of the respirator to the worker, maintenance, and replacement of parts when necessary. A health care professional must first determine whether the individual worker can wear a respirator safely.

ii. Protective clothing

It includes gloves, aprons, goggles, boots, face shields, and any other materials worn as protection. It should be made of material designed to resist penetration by the particular chemical being used. Such material may be called impervious to that chemical. However, most materials do not remain impervious for very long. The manufacturer of the protective clothing usually can provide some information regarding the substances that are effectively blocked and how often replacement is necessary (Kim B, 2008).

CHAPTER VII

BEHAVIOURAL SAFETY

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BEHAVIOURAL SAFETY

[Clause 6.1.2, 6.1.2 & 8 of IS/ISO 45001 :2018 and IS 17893 :2023 Annex-c of IS 14489:2018]

What Is Behavioural Safety?

Behavioural safety refers to health and safety approaches that focus on potentially 'unsafe' human behaviour that may result in accidents. It is often described as tackling habitual (repeated behaviour). It may be that an individual engages in the behaviour unconsciously without awareness of potential dangers. A concept that has been around since the 1930s with the advent of Heinrich's triangle, behavioural safety aims to build safe habits in individuals by challenging potentially unsafe behaviour. Behavioural safety puts the attention on individuals rather than the employers, implying that workplace health and safety guidelines are effective only to a point. Because behavioural safety methods aim to modify behaviour, it is also sometimes referred to as behavioural modification.

What does behavioural safety focus on?

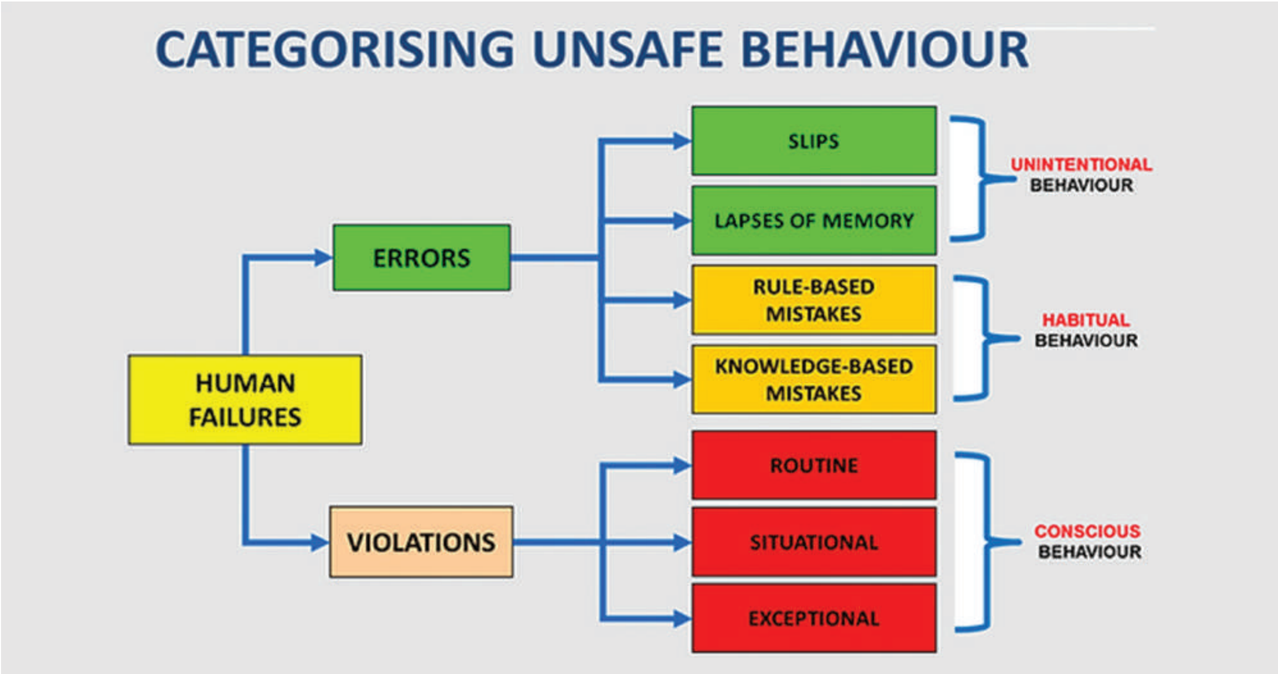
1. At-risk behaviours that could lead to an injury
2. Safe behaviours that could contribute to injury prevention
3. Influencing a culture change through attitudes and perceptions
4. Driving leading indicators rather than lagging indicators

Why is behavioural safety important?

It's reported that up to 90% of workplace accidents/ incidents are down to unsafe behaviours, or human error. If we focus our attention on the unsafe acts, then we can drive change before it's too late. Using this methodology, we can address the unsafe acts, monitor and measure them, and take appropriate action where needed. The data gathered associated to unsafe acts and near misses, combined with the organisational culture of stopping jobs and interrupting people, is something that will drive change within your organisation.

Categories of unsafe behaviour

When we look at the categories of one safe behaviour, we see this as human failures, broken into **errors** and **violations**.



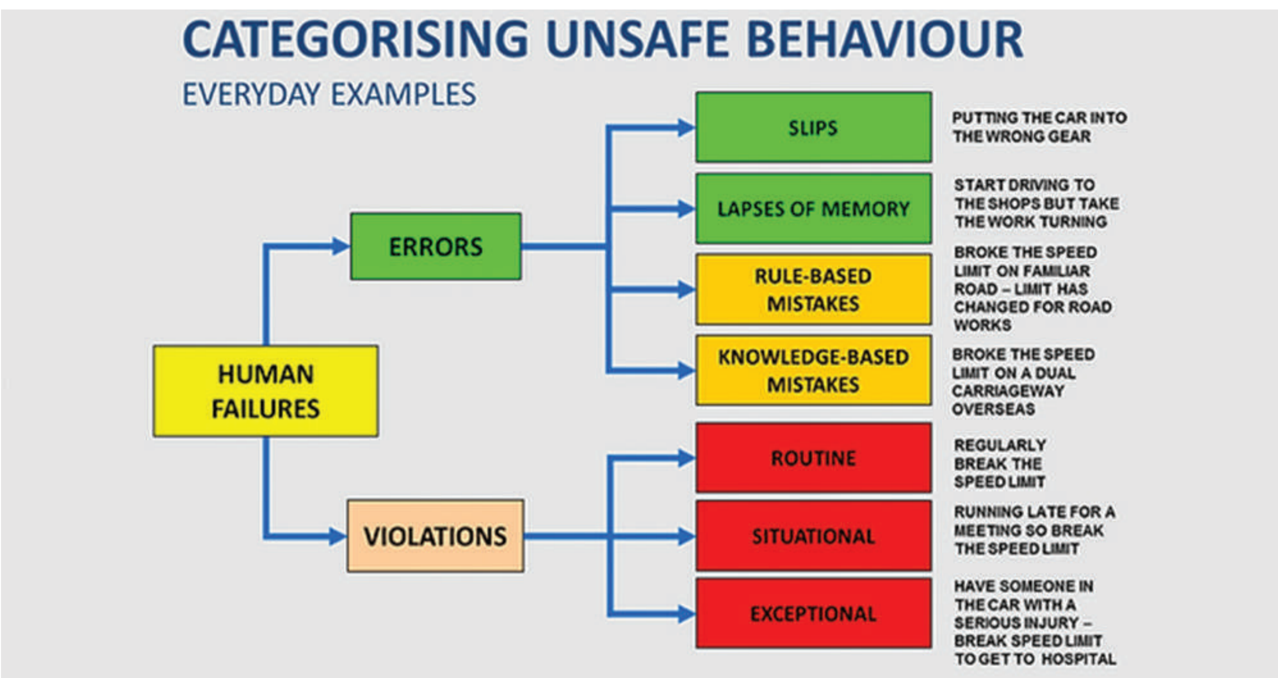
Within errors, we can then break this into four additional categories,

1. Slips in judgment
2. Lapses of memory
3. Rule-based mistakes
4. Knowledge-based mistakes

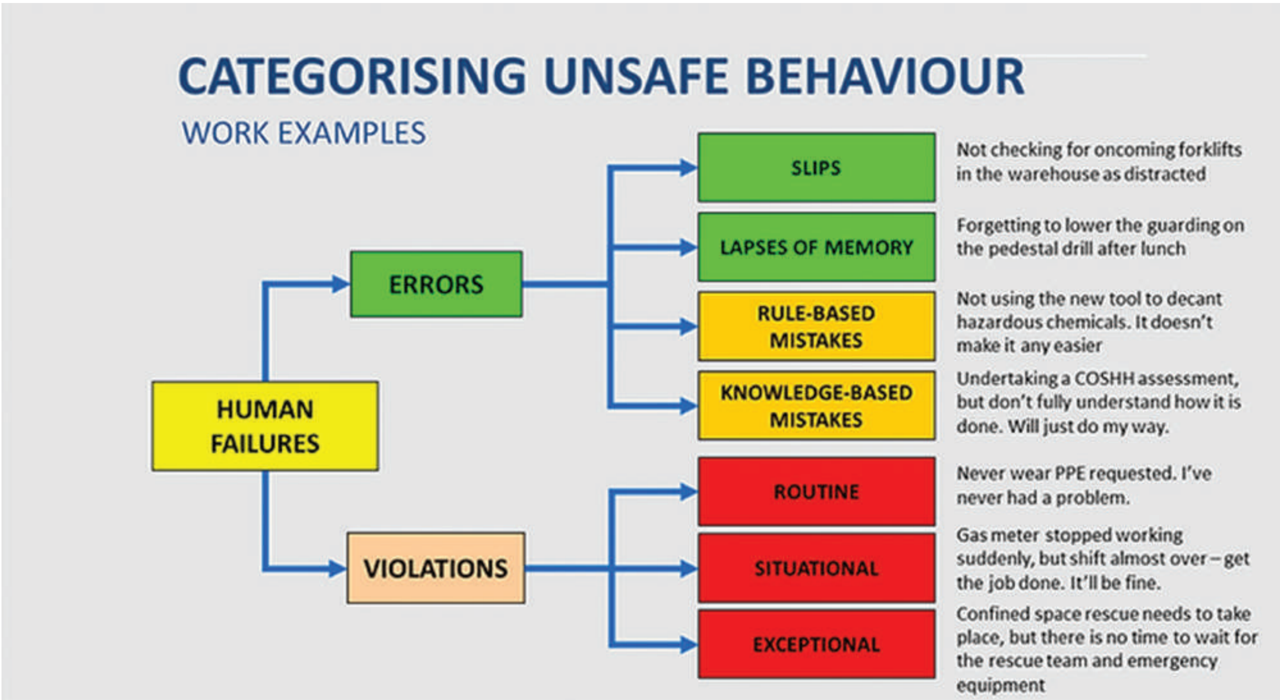
Within violations, the three additional areas could be:

1. Routine violations
2. Situational violations
3. Exceptional violations

Below are everyday examples of unsafe behaviours:



Below are worksite examples of unsafe behaviours:



Unintentional Errors

We all make unintentional errors from time to time. It's important when you see another person doing this, that you bring it to their attention right away. This may prevent them from harming themselves or others in the future.

Habitual Errors

Habitual errors are simply something that becomes a habit, because you have always done it that way. To break out of this, make sure you understand the importance of doing it correctly, and get some training on how to do things if required. Often it is the individual that holds our **imperfect** systems together - The fact that things are working, and people have not been hurt, is down to your employees efforts and luck.

Human Error

Human error is not a cause of failure - it is the effect or the symptom of a deeper-rooted issue. Human error is not the conclusion of an investigation into an incident or a near miss, its often the starting point. Think about the influencing factors that cause the human to undertake that error.

We're all fallible, so it's important to ask yourself:

- What was he thinking when he did that?
- Why didn't she see us?
- She should have known about this... why didn't she?
- That was a strange decision for him to make... where's his decision making coming from?

Violations to behavioural safety

Violations are conscious decisions made by individuals - whether this is down to laziness, carelessness or lack of consequences - they need to be stopped.

The methods of how they should be reported need to be understood by the whole organisation:

1. Do not walk past
2. Do not ignore
3. Involve others within the organisation

Decisions around how to deal with employees making intentional errors may need to be dealt with by the human resources department, or possibly top management.

It is estimated that human behaviour contributes to around 80% of accidents in the workplace, so employers should consider how behavioural safety can help to create safer workplaces.

According to the Health and Safety Executive (HSE), 561,000 non-fatal workplace accidents occurred in 2022/23. Of these accidents, slips, trips and falls were the most common. Accidents like these can occur through workplace hazards or human error, or a combination of both.

In this guide we discuss what behavioural safety is and how it can be implemented to improve safety performance.

How does behavioural safety affect workplace health and safety?

Behavioural safety views employees as having direct control over hazardous behaviour they engage in, such as taking shortcuts or carrying too many items. Employees might engage in this behaviour even when it is warned against in an organisation's written health and safety policies. Reasons for this include:

- Time pressure. Employees may feel the need to cut corners or take shortcuts to save time, believing that it helps them meet deadlines or be more productive.
- Lack of awareness. Employees may be unaware of the risks associated with their actions or may not fully understand the potential consequences. In some cases, they may genuinely believe that the unsafe behaviour poses no harm because they lack an understanding about the hazards involved.
- Sometimes employees misunderstand procedures or guidelines. They might misinterpret instructions or be unclear about the correct way to perform a task safely.
- Workplace culture. Workplace culture and long-standing practices can influence behaviour. Phrases like, "we've always done it this way" reflect a resistance to change and a cultural acceptance of unsafe practices.
- Supervisor influence. The behaviour of supervisors can play a significant role. If supervisors turn a blind eye to unsafe practices or prioritise speed and productivity over safety, employees may follow suit to avoid consequences or meet performance expectations.

- Ergonomic factors. Inappropriately designed machinery, controls or workstations can lead to unsafe behaviour. Employees may be forced to work in ways that strain their bodies or increase the risk of accidents.
- If employees have not experienced accidents or incidents in the past while engaging in unsafe behaviour, they may become complacent and believe that the actions are safe.
- Perceived efficiency. Employees might perceive unsafe behaviour as more efficient, thinking it allows them to get tasks done more quickly.

Health and safety policies have played a major role in reducing the number of workplace injuries, accidents and deaths As a direct result of these policies , non-fatal injuries have been considerably reduced.

Behavioural safety strategies complement health and safety policies by focusing on the human element and encouraging a proactive approach to safety, ultimately reducing workplace risks and accidents.

How to implement behavioural safety

In the workplace, health and safety is viewed as the responsibility of the management. These behaviours can be hard to unlearn because unconscious behaviour results from months or years of unchallenged actions.

It is important to remember that there is no one correct way to implement behavioural safety. The term applies to a collection of frameworks, and what framework is used depends on the organisation and its circumstances. While there is no one-size-fits-all approach, a basic behavioural safety framework may look something like this:

Define safe and unsafe behaviour

Define what counts as 'safe' and 'unsafe' behaviours in your specific workplace by working with employees and safety experts. Develop clear and concise safety guidelines and procedures that employees can easily understand and follow.

Observation

Train designated observers or safety champions to regularly observe and document employee behaviour. Use a checklist or digital tool to record observations of both safe and unsafe behaviours. Encourage employees to report unsafe behaviours without fear of reprisals. Discuss these behaviours and the potential risks with employees.

Leadership and commitment

Ensure that top management is committed to promoting a safety culture. Clearly communicate the importance of behavioural safety to all employees. Encourage employees to self-report unsafe behaviour without fear of reprisal.

Feedback and communication

Provide constructive feedback to employees when unsafe behaviours are observed. Engage in open and non-punitive communication with employees about their **actions. Emphasize the potential risks associated with unsafe behaviours, explain** what can be done to mitigate the unsafe behaviour and the importance of corrective actions.

Involve employees

Involve employees in the decision-making process related to safety measures. Encourage them to actively participate in safety committees, discussions, initiatives, and they could be part of conducting risk assessments. Foster a sense of ownership and responsibility among employees for their own safety and the safety of their colleagues.

Training and education

Offer relevant training and education to employees on safety procedures and best practices. This could be in the form of eLearning behavioural safety training or attending health and safety seminars.

Ensure employees understand why certain behaviours are unsafe and the consequences they may entail. Provide resources, such as safety manuals and instructional materials to support training.

Corrective actions

Implement corrective actions and interventions to address unsafe behaviours. Collaborate with employees to identify and implement practical solutions to mitigate risks associated with unsafe behaviours. Encourage employees to suggest improvements and share their insights on safety issues.

Monitoring and follow-up

Monitor employee behaviours to track improvements after training and assess the effectiveness of interventions. Regularly review safety data and reports to identify trends and areas that require additional attention.

Conduct follow-up observations to ensure sustained behaviour change.

Recognition and reward

Recognise and reward employees who consistently demonstrate safe behaviours. Establish a system of positive reinforcement to motivate employees to prioritise safety. Use both tangible rewards and verbal recognition to acknowledge safe practices.

Continuous improvement

Regularly review and refine your behavioural safety program based on feedback, data, and changing circumstances. Adapt the program to address emerging safety concerns or evolving workplace conditions.

Behavioural safety is an ongoing process and success depends on the commitment of all levels of the organisation. Creating a culture of safety and making safety a core value will help ensure sustained effectiveness.

What are the pitfalls with behavioural safety?

A central belief of behavioural safety is that workplace injuries are a result of unsafe acts by employees.

Critics of behavioural safety would argue that the main cause of injuries is failings in the management of health and safety. This is because before an accident can occur, there must be a hazard. If a hazard results in an accident or injury, the blame falls on management for not identifying it and then removing or mitigating the risk.

For example, an employee may slip on an unclean warehouse floor. The employer may say it is the fault of the employee for not looking where they were walking or for wearing the wrong footwear, but the employee could say that it's the employer's fault for the floor not being clean. In reality, all these factors have contributed to the accident.

Behavioural safety also overlooks the Hawthorn effect – when those who know they are being observed change their behaviour to match what the observer expects/wants to see. Employees who know they are being observed for 'unsafe' behaviour may avoid doing so, but once they are no longer being watched, they may revert to less safe behaviours.

While the Hawthorn effect and a possible over-emphasis on human actions rather than the removal and management of hazards must be taken into account, behavioural safety can play an important role in improving workplace health and safety.

How can behavioural safety improve workplace health and safety?

Behavioural safety leadership is the key to changing people's behaviour to improve safety. Effective safety leadership can impact people's behaviour by 86% and decrease incidents by 35%.

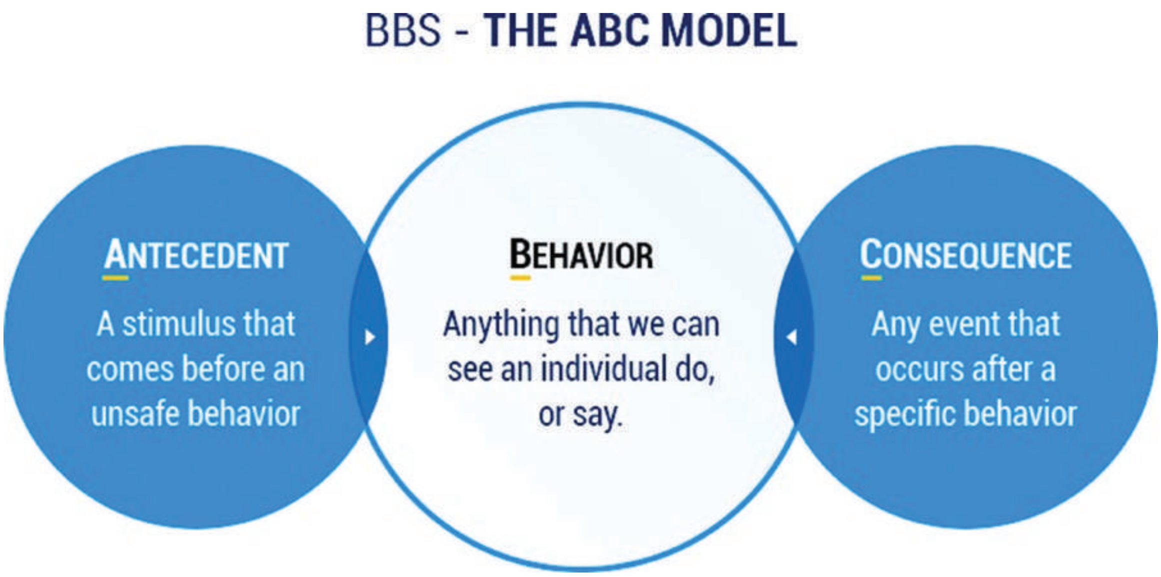
A study into behaviour-based intervention for occupational safety has shown that implementing behaviour-based safety training, increasing the quality and frequency of feedback, and promoting open communication between employers and employees reduces accidents and incidents.

The key is to build a culture of trust in which employees know they are part of a team and feel empowered to take ownership of their own safety.

Behaviour based safety approach – the ABC model

What is the ABC model in behaviour based safety?

The ABC model or the Antecedent-Behaviour-Consequence model is the well-established and scientific approach to analyse why people act in a certain way and find ways to implement behavioural changes. According to this cognitive behaviour therapy, The A stands for antecedent, which is the prevailing condition that works as a catalyst for the preceding action. Antecedents reveal what set off the behaviour. The B stands for Behaviour, which is defined as the visible action that a person performs which is observable and measurable. The C stands for consequence; it is the action that takes place after the outcome of the behaviour is triggered. It could either be positive or negative depending on the result of the behaviour. Rectifying antecedents may be a safe bet for controlling risky behaviour. However, it is the consequence of a behaviour that can effectively reinforce behavioural changes.



Improvement Process:

Here is a 7-step process that can help in improving Behaviour Based Safety in your organization:

1. Identify critical problem behaviours.
   Discover behavioural patterns that elicit danger
2. Identify root causes.
   Identify lead indicators that cause negative behaviour
3. Generate potential actions.
   Find possible solutions to contain the behaviour.
4. Evaluate possible actions.
   Shortlist the most productive solutions
5. Develop an action plan.
   Create a strategy to implement the behavioural change
6. Implement an action plan
   Execute the strategy to easily adapt to prevalent conditions.

7. Conduct follow up.

Measure and evaluate if the implemented change has created a difference.

How to implement a behaviour based safety program?

To implement a strong behaviour based safety program, your organization should inculcate a safety culture that promotes.

Open Communication:

Create a feedback-rich environment where employees can freely voice their concerns and where the management conducts consistent awareness programs.

Reporting Culture:

Promoting a culture where are all dangerous activities/behaviours are duly reported to take timely actions.

Management commitment:

Ensure company-wide transparency in following safety procedures from owners, safety officers, and other high-ranking officials.

Timely Reaction:

Be quick to act on unsafe behavioural reports, align teams to rapidly spread precautionary measures before it escalates into an incident.

Behaviour based safety checklist

A behaviour-based checklist is generally used for directly observing on-field behavioural patterns. The checklist serves as a powerful tool to identify unsafe acts, identify root causes and list down corrective measures. Commonly used behaviour based checklist usually includes:

- Identification of the site and personnel involved in work procedures.
- Progressive evaluation of each process for unsafe practices
- Hazard list for identifying and projecting unsafe conditions or acts.
- PPE observation along with details of site safety, lockout tagout implementation and more.
- Details of observation including precautions to be taken and corrective actions needed.

Benefits of a behaviour based safety program:

Improved Safety practices that stem from a behavioural shift from unsafe to safe practices

- With awareness comes better situational preparedness again a known hazard.
- React impulsively in a safe manner when an emergency arises.
- Get continuous feedback on the effectiveness of an implied change
- Engage employee participation by rewarding positive behaviour
- Provides a benchmark to measure improvement.

Elements of a world-class BBS program

Create a checklist from target behaviour:

Utilize data from safety audits, safety meetings to find site vulnerabilities and identify critical safe behaviours that can be implemented in the observational checklist.

Employ a measurement system:

Ensure that there is a mechanism that weighs the frequency of safe and unsafe behaviours during an observation

Carry out observations

Conduct regular observation with trained HSE professionals who can blend into the work environment without acting as a deterrent to work procedures.

Deliver Consistent Feedback

Make sure that dangerous behaviour that is observed is conveyed to the employee as fast as possible - creating an immediate feedback loop where the employee voices his concerns and overall corrective action is determined by the management.

Utilize data to take corrective action:

With valuable observation results at hand, find trends that need immediate corrective measures, ensure that all staff is informed of any newly discovered anomaly or prevalent condition.

Evaluate change:

Set improvement goals by monitoring the effectiveness of each behavioural modification, implemented as a countermeasure to obtain positive results.

Mistakes in implementing BBS

The effectiveness of a properly implemented BBSO system is undeniable in curbing unsafe acts, yet negative safety trends such as negative reporting quotas and wrongful implementation of the BBS program can prove disastrous to your organization. Here are a few common challenges and mistakes to avoid while implementing a BBS program:

Pushing the buck onto employees:

While the unsafe risk taker may be the blip in your safety program. Creating an environment where the blame game leads to unwarranted frictions can prove a dangerous mindset for your organization. A BBS system requires active employee participation through positive reinforcement and motivation to effectively sustain and bear results.

Failure to apply positive reinforcement:

It is natural for people to elicit a certain behaviour, be it safe or unsafe acts, if it provides some form of benefit. In the workplace, taking a risk may save time, effort and in some cases ease into our comfort zone. With no leading indicators to affect change, the behavioural pattern will continue to manifest. Behavioural change should stem from positive reinforcement and safety culture that imbibes open communication and facts. Employees need to know the specifics of the hazards they are likely to face due to their behaviour and the management also must provide an alternative solution to contain the hazard.

Failure to engage participation:

Resentment at being constantly admonished for unsafe practices may sway employees away from participating or even reporting unsafe acts due to fear of being reprimanded and terminated. To imbue a culture of active participation, companies need to make their staff feel like valued contributors to your safety culture and take to rewarding safe acts rather than punishing bad behaviour. Unsafe behaviour must be delicately conveyed using a corrective action process.

CHAPTER VIII

FIRE SAFETY

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FIRE SAFETY

INTRODUCTION [Clause 6.1.2 ,6.1.3 & 8 of IS/ISO 45001 :2018 , IS 5656 :2006 & IS/ISO 19706 : 2011]

Fire safety is the set of practices intended to reduce the destruction caused by fire. Fire safety measures include those that are intended to prevent ignition of an uncontrolled fire, and those that are used to limit the development and effects of a fire after it starts. Fire safety measures include those that are planned during the construction of a building or implemented in structures that are already standing, and those that are taught to occupants of the building. Threats to fire safety are commonly referred to as fire hazards. A fire hazard may include a situation that increases the likelihood of a fire or may impede escape in the event a fire occurs. Fire safety is often a component of building safety.

Fire Safety is a vast subject in itself. Two technical committees of Bureau of Indian Standards namely CED 22-Fire Fighting Sectional Committee which is responsible for formulating standards on Fire fighting equipment and materials and CED 36-Fire Safety Sectional Committee which formulates standards on guidelines and design requirements of buildings on fire safety . Around 200 standards has been published on these subjects. To understand the Fire as safety hazard, its risk and its mitigation it is necessary to have basic idea of the fire , its causes, types of fire, its prevention and protection and fire extinguishers.

The staff/employees should have a working knowledge of basic fire science and chemistry. A fire, or combustion, is a chemical reaction. An understanding of the chemical reaction is the basis for preventing fires, as well as extinguishing fires once they initiate. A working knowledge of basic fire science and chemistry is essential for developing and implementing a successful fire safety program.

DEFINITION OF FIRE

A fire is a chemical reaction. There are many variables that can affect a fire. Effective fire safety management programs control the variables that can affect a fire. Therefore, it is imperative to understand the variables. A fire is self-sustained oxidation of a fuel that emits heat and light. A fire requires three variables to initiate: a fuel, oxygen, and heat. The fire triangle is a well-known representation of the three variables needed to initiate a fire. In order to initiate a fire, fuel, oxygen, and heat are required.

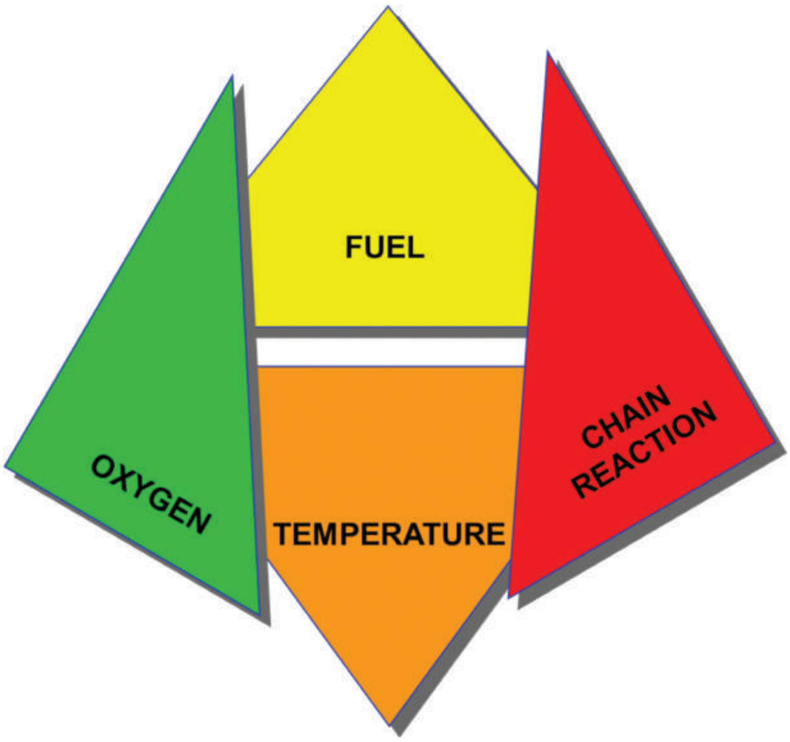
FIRE TETRAHEDRON

Fire prevention is the concept of preventing the variables of the fire triangle from coming into contact with each other to initiate a fire. Once a fire begins, it requires four variables to sustain the combustion reaction. The four variables required to sustain a fire are fuel, oxygen, heat, and chemical chain reactions. These four variables represent the fire tetrahedron.

Chemical chain reactions are a product of the combustion process. The chemical reactions ultimately produce combustion byproducts such as carbon monoxide, carbon dioxide, carbon, and other molecules , depending on the specific fuel. It is these byproducts of combustion found in the smoke that usually affect the safety and health of occupants and fire fighters.

Once a fire begins and is self-sustaining, the goal is to control and extinguish the fire. Fire extinguishment is done by eliminating one of the variables of the fire tetrahedron. By removing the fuel, oxygen, or heat, or inhibiting the chemical chain reactions, a fire can be extinguished. The concept of fire protection assumes fires will occur, and focuses on controlling fires by eliminating or otherwise controlling the variables of the fire tetrahedron. The concept of fire prevention differs from fire protection because fire prevention attempts to control the variables of the fire triangle before a fire occurs.

THE FIRE TETRAHEDRON



To further understand the fire triangle, it is necessary to analyze what influence each side of the fire triangle has in the combustion process. For the safety manager, this analysis is the key for understanding the concept of fire prevention. Fire prevention attempts to prevent fuels, oxygen, and heat from combining to start a fire. Fire prevention strategies include controlling fuels, controlling oxygen sources, and con- trolling heat sources. A discussion of fuels, oxygen, and heat sources follows.

FUEL:

A fuel is a combustible solid, liquid, or gas. Like in any chemical reaction, a source of energy is needed to sustain the heat required. The most common solid fuels are wood, paper, cloth, coal, and so forth. Flammable and combustible liquids include gasoline, fuel oil, paint, kerosene, and other similar materials. Propane, acetylene, and natural gas are some examples of gases that are flammable. Solid and liquid fuels share a common characteristic; they must be converted into a gas in order to support combustion. Gaseous fuels can undergo direct oxidation because the molecules are already in the gas state. Some liquid fuels can undergo direct oxidation because they produce vapors at ambient temperatures and pressures. Other liquid fuels and solid fuels, however, undergo sequential oxidation. This means that a fuel must be heated first to produce sufficient concentrations of gas to support combustion. From a fire safety standpoint, the safety manager should be aware of the different types of fuels located in the workplace.

The ease of ignition of a solid fuel is dependent on several factors. The most important factor is the surface to mass ratio of the fuel. The surface to mass ratio refers to how much of a fuel' s surface area is exposed to the environment in relation to its overall mass. The safety manager should be concerned with two things regarding the surface to mass ratio of a fuel. First, the more surface area that is exposed, the easier it is for a fire to initiate and the more rapidly it can burn. Second, the more mass that a solid fuel has, the more difficult it will be to initiate and sustain combustion. Consider cotton as a fuel in a textile mill. Cotton dusts and lint will burn easier and faster than a tightly bound bale of cotton. Liquid fuels are affected by several factors. The safety manager should be familiar with the terms flash point, fire point, boiling point, and specific gravity. Chapter 4 explores these factors in detail. However, one

of the most critical indicators of a liquid's flammability should be mentioned—flash point. The flash point refers to the temperature at which adequate vapors are produced to form an ignitable mixture in air. Therefore, a liquid heated to a temperature at or above its flash point will ignite in the presence of an ignition source such as a spark, cigarette, hot surface, or open flame.

OXYGEN:

The atmosphere contains approximately 21% oxygen by volume. During combustion, the oxygen necessary for oxidation is sufficiently provided from the surrounding air. When the oxygen content of the atmosphere falls below 15%, a free-burning fire will begin to smolder. When the oxygen content of the atmosphere falls below 8%, a smoldering fire will stop burning (Bryan, 1982). Oxygen can also be provided by other sources that release oxygen molecules during a chemical reaction. The safety manager should be aware of these oxidizers in the workplace and segregate them from any fuels.

HEAT:

The safety manager should be concerned with sources of heat commonly found in the workplace. This is a concern because sources of heat provide the energy necessary to initiate combustion. By preventing heat sources from contacting the ignitable fuel-air mixtures, fires can be effectively prevented from occurring. Some common sources of heat for ignition in the workplace are:

- Open flames such as from cutting and welding torches
- Cigarettes
- Sparks such as from electrical equipment, brazing, or grinding
- Hot surfaces such as electrical motors, wires, and process pipes
- Radiated heat from boilers or portable heaters
- Lightning

- Static discharges such as during the transfer of flammable liquids
- Arcing from wires and electrical equipment
- Compression such as hydraulic oil under pressure on a machine
- Exothermic chemical reactions
- Spontaneous ignition from slow oxidation or fermentation combined with proper insulation of a fuel

Heat is transferred by three methods: conduction, convection, or radiation. Conduction occurs when two bodies are touching one another and heat is transferred from molecule to molecule. Convection is the transfer of heat through a circulating medium rather than by direct contact. The medium can be either a gas or a liquid. Radiation is the transfer of electromagnetic waves through any medium. For the safety manager, recognizing how heat can be transferred in the workplace is helpful for preventing fires.

As mentioned, four fire extinguishing principles exist. They are highlighted below:

1. ***Control the fuel—*** Controlling the fuel is accomplished by two methods. First, the fuel can be physically removed or separated from the fire. For instance, a fire involving stacks of wood pallets could be controlled by removing any exposed stacks of pallets to a safe location. Another example is closing a valve feeding a gas or flammable liquid fire. Second, the fuel can be chemically affected by diluting the fuel.

2. ***Control the oxygen—*** Controlling the oxygen requires that the oxygen be inhibited, displaced, or the concentration of oxygen be reduced below 15% by volume. Smoldering fires should be diluted to an oxygen concentration below 8% by volume. The oxygen supply to a fire can be inhibited by smothering the fire. Smothering a fire places a barrier between the flame and the atmosphere. This can be accomplished with a blanket or applying a layer of foam to form a vapor barrier. Displacing and reducing the oxygen concentration involves applying an inert gas to the fire, such as carbon dioxide. The carbon dioxide displaces the oxygen thus lowering the concentration to a level that cannot sustain the fire. Applying an inert gas to a fire requires that the fire be located in a confined space. Personnel must be aware that displacing the oxygen or diluting the oxygen concentration affects their ability to breathe. Fire extinguishment using this method requires that personnel be absent from the confined area or protected by self -contained breathing apparatus.

3. ***Control the heat—*** Controlling the heat requires that the heat be absorbed. Combustion is an exothermic chemical reaction. If the heat emitted by the reaction can be absorbed faster than the reaction can produce the heat, then the reaction cannot be sustained. Water is the most common extinguishing agent. Water is also the most efficient extinguishing agent because it has the capability to absorb immense amounts of heat.

4. ***Inhibit the chemical chain reactions—*** Inhibiting the chemical chain reactions requires that a chemical agent be introduced into the fire. Certain chemical agents can interfere with the sequence of reactions by absorbing free radicals

from one sequence that are needed to complete the next sequence. Dry chemical extinguishing agents commonly used in portable fire extinguishers have this ability.

CLASSES OF FIRE

Fires are classified based upon the type of fuel that is consumed. Fires are classified into categories so personnel can quickly choose appropriate extinguishing agents for the expected fire and associated hazards. Fires are classified into five general classes. Each class is based on the type of fuel and the agents used in extinguishment. The five classes of fire are described next:

- **Class A—** Class A fires involve ordinary combustibles such as wood, paper, cloth, rubber, and some plastics. Water is usually the best extinguishing agent because it can penetrate fuels and absorb heat. Dry chemicals used to interrupt the chemical chain reactions are also effective on Class A fires.
- **Class B—** Class B fires involve flammable and combustible liquids and gases such as gasoline, alcohols, and propane. Extinguishing agents that smother the fire or reduce the oxygen concentration available to the burning zone are most effective. Common extinguishing agents include foam, carbon dioxide, and dry chemicals.
- **Class C—** Class C fires involve energized electrical equipment. Non-conductive extinguishing agents are necessary to extinguish Class C fires. Dry chemicals and inert gases are the most effective agents. If it can be done safely, personnel should isolate the power to electrical equipment before attempting to extinguish a fire. Once electrical equipment is de-energized, it is considered a Class A fire.
- **Class D—** Class D fires involve combustible metals such as magnesium, sodium, titanium, powdered aluminium, potassium, and zirconium. Class D fires require special extinguishing agents that are usually produced for the specific metal.
- **Class K—** Class K fires most often occur where cooking media (fats, oils, and greases) are used, and most of the time are found in commercial cooking operations. Class K fire extinguishers are required in any location that cooks oils, grease, or animal fat. Any location that fries must have a Class K fire extinguisher. Every commercial kitchen should have a Class K extinguisher located in it to supplement the suppression system.

THREE STAGES OF FIRE

Fires evolve through several stages as the fuel and oxygen available are consumed. Each stage has its own characteristics and hazards that should be understood by safety managers and fire-fighting personnel.

INCIPIENT STAGE:

The incipient stage is the first or beginning stage of a fire. In this stage, combustion has begun. This stage is identified by an ample supply of fuel and oxygen. The products of combustion that are released during this stage normally include water vapor, carbon dioxide, and carbon monoxide. Temperatures at the seat of the fire may have reached 1000°F, but room temperatures are still close to normal.

FREE-BURNING STAGE:

The free-burning stage follows the incipient stage. At this point, the self-sustained chemical reaction is intensifying. Greater amounts of heat are emitted and the fuel and oxygen supply is rapidly consumed. Room temperatures can rise to over 1300°F. In an enclosed compartment, the free-burning stage can become dangerous. Because of the heat intensity, the contents within a compartment are heated. At some point, if the compartment is not well ventilated, compartment contents will reach their ignition temperature. A flashover occurs when the contents within a compartment simultaneously reach their ignition temperature and become involved in flames. It is not uncommon for room temperatures to exceed 2000°F following a flashover. Human survival, even for properly protected fire fighters, is difficult if not impossible for a few seconds within a compartment following a flashover.

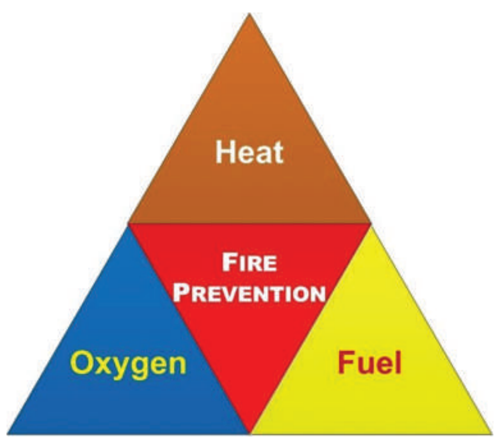
SMOLDERING STAGE:

The smoldering stage follows the free-burning stage. As a free-burning fire continues to burn, the chemical reaction will eventually consume the available oxygen within the compartment and ultimately convert it into carbon monoxide and carbon dioxide. This causes the oxygen concentration within the compartment to decrease. When the oxygen concentration decreases to 15% by volume, the chemical reaction will not have sufficient oxygen to support free-burning combustion. Visibly, the flames subsist and the fuel begins to glow. A smoldering fire is identified by a sufficient amount of fuels and lower oxygen concentrations. Smoldering fires, especially when insulated within a compartment, can continue the combustion process for hours. Room temperatures can range from 1000–1500°F. The byproducts of combustion also fill the compartment and human survival is impossible. During the smoldering stage, an extreme hazard, called a backdraft, can develop. A backdraft occurs when oxygen is introduced into a smoldering compartment fire. The immediate availability of sufficient oxygen in the presence of sufficient fuel, heat, and chemical chain reactions causes flaming combustion again. In some cases, the backdraft is so violent that an explosion will occur. Human survival, even of properly protected fire fighters, is usually not possible.

FIRE PREVENTION & PROTECTION:

FIRE PREVENTION

Fire prevention requires segregating the three elements of the fire triangle. A fire needs three elements - heat, oxygen and fuel. Without heat, oxygen and fuel a fire will not start or spread. A key strategy to prevent fire is to remove one or more of heat, oxygen or fuel.



HEAT

Heat can be generated by work processes and is an essential part of some processes such as cooking. This heat must be controlled and kept away from fuel unless carefully controlled. Heat generated as a by-product of a process must be dealt with properly.

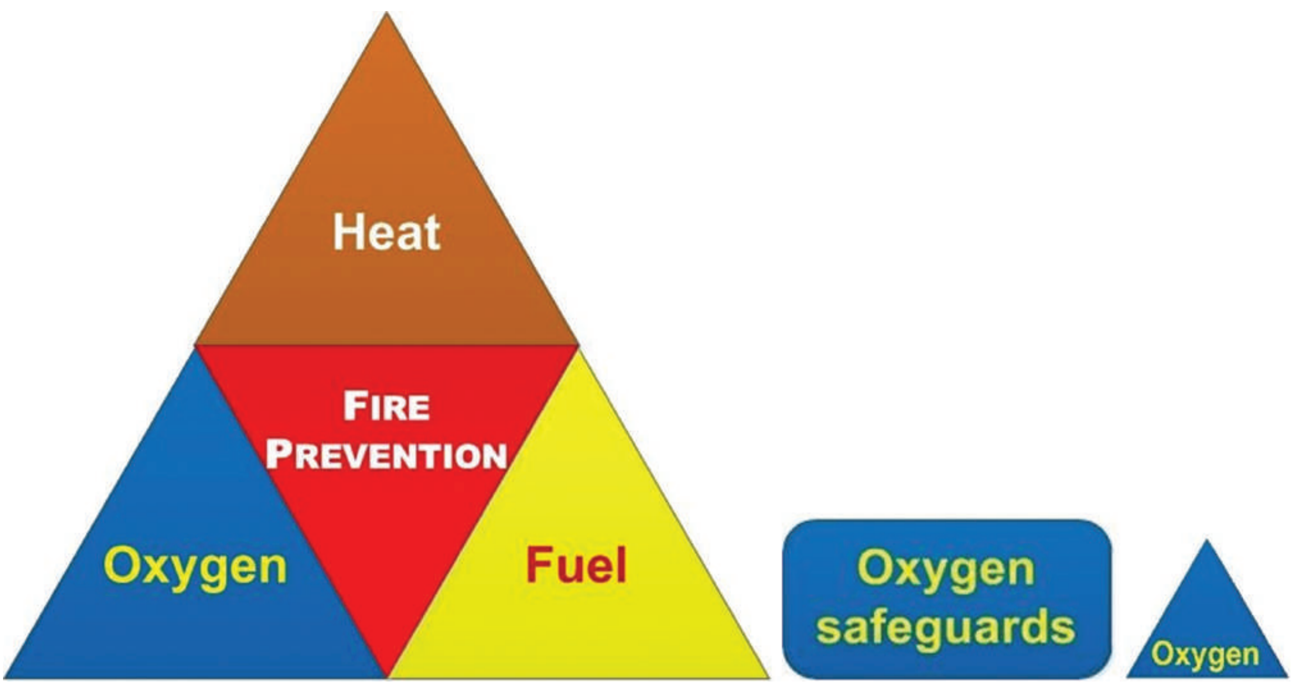
Heat Safeguards

- Ensure employees are aware of their responsibility to report dangers
- Control sources of ignition
- Have chimneys inspected and cleaned regularly
- Treat independent building uses, such as an office over a shop as separate purpose groups and therefore compartmentalize from each other
- Ensure cooking food is always attended
- Use the Electricity Supply Board's Safety webpage
- Have regard to relevant Authority Safety Alerts, e.g. Mobile Phone "Expert XP-Ex-1", Filling LPG Cylinders
- Use the Code of Practice For Avoiding Danger From Underground Services

OXYGEN

Oxygen gas is used

- in welding, flame cutting and other similar processes
- for helping people with breathing difficulties
- in hyperbaric chambers as a medical treatment
- in decompression chambers
- for food preservation and packaging
- in steelworks and chemical plants



The air we breathe contains about 21% oxygen. Pure oxygen at high pressure, such as from a cylinder, can react violently with common materials such as oil and grease. Other materials may catch fire spontaneously. Nearly all materials including textiles, rubber and even metals will burn vigorously in oxygen.

With even a small increase in the oxygen level in the air to 24%, it becomes easier to start a fire, which will then burn hotter and more fiercely than in normal air. It may be almost impossible to put the fire out. A leaking valve or hose in a poorly ventilated room or confined space can quickly increase the oxygen concentration to a dangerous level.

The main causes of fires and explosions when using oxygen are

- oxygen enrichment from leaking equipment
- use of materials not compatible with oxygen
- use of oxygen in equipment not designed for oxygen service
- incorrect or careless operation of oxygen equipment

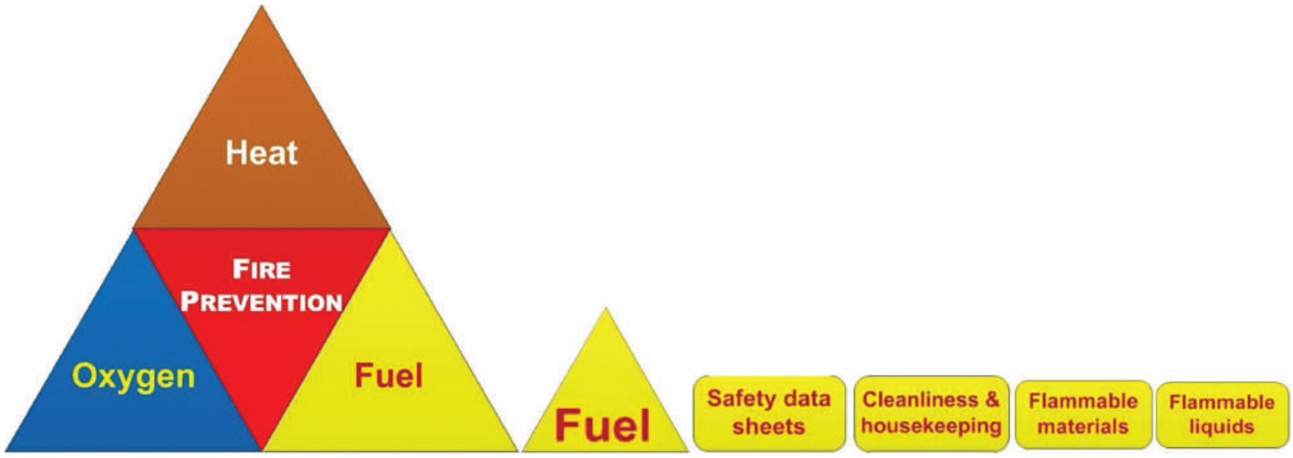
Oxygen Safeguards

- Ensure employees are aware of their responsibility to report dangers
- See safeguards in the Code of Practice for Working in Confined Spaces
- Oxygen should never be used to “sweeten” the air in a confined space
- **Where oxygen is used,**
  - follow safety advice from the supplier
  - follow the safeguards on the safety data sheet
  - keep the safety data sheet readily available
- Be aware of the dangers of oxygen if in doubt, ask
- Prevent oxygen enrichment by ensuring that equipment is leak-tight and in good working order
- Check that ventilation is adequate
- Always use oxygen cylinders and equipment carefully and correctly
- Always open oxygen cylinder valves slowly
- Do not smoke where oxygen is being used
- Never use replacement parts which have not been specifically approved for oxygen service
- Never use oxygen equipment above the pressures certified by the manufacturer
- Never use oil or grease to lubricate oxygen equipment
- Never use oxygen in equipment which is not designed for oxygen service
- Operators of locations storing large amounts of oxidising substances

FUEL

Workplaces in which large amounts of flammable materials are displayed, stored or used can present a greater hazard than those where the amount kept is small.

In relation to fire, fuel consists of flammable material. Flammable material is material that burns readily in a normal atmosphere. Flammable materials include flammable liquids (e.g. petrol), flammable gasses (e.g. propane and butane) and flammable solids (e.g. charcoal, paper). It is important to identify all flammable materials that are in your workplace so that proper controls can be put in place.



Great care is required in the storage, handling and use of flammable materials. Safety Data sheets may provide detailed advice.

Fuel Safeguards

- Identify all flammable materials so that proper controls can be put in place
- Identify use of substances with flammable vapours (e.g. some adhesives)
- Reduce quantities of flammable materials to the smallest amount necessary for running the business and keep away from escape routes
- Replace highly flammable materials with less flammable ones
- Store remaining stocks of highly flammable materials properly outside, in a separate building, or separated from the main workplace by fire-resisting construction
- Provide clearly marked separate storage for flammable chemicals, gas cylinders, and waste materials
- Train employees on safe storage, handling and use of flammable materials
- Keep stocks of office stationery and supplies and flammable cleaners' materials in separate cupboards or stores. They should be fire-resisting with a fire door if they open onto a corridor or stairway escape route.
- This is highly specialised work and a detailed risk assessment must be conducted
- Detailed work instructions must be put in place
- Advice should be sought from the gas supplier as needed
- Workers must be properly trained and supervised
- The quantity of flammable liquids in workrooms should be kept to a minimum, normally no more than a half-day's or half a shifts supply
- Flammable liquids, including empty or part-used containers, should be stored safely. Small quantities (Tens of Litres) of flammable liquids can be

stored in the workroom if in closed containers in a fire-resisting (e.g. metal), bin or cabinet fitted with means to contain any leaks

- Flammable liquids should not be decanted within the store. Decanting should take place in a well-ventilated area set aside for this purpose, with appropriate facilities to contain and clear up any spillage
- Container lids should always be replaced after use, and no container should ever be opened in such a way that it cannot be safely resealed
- Flammable liquids should be stored and handled in well ventilated conditions. Where necessary, additional properly designed exhaust ventilation should be provided to reduce the level of vapour concentration in the air
- Storage containers should be kept covered and proprietary safety containers with self-closing lids should be used for dispensing and applying small quantities of flammable liquids
- There should be no potential ignition sources in areas where flammable liquids are used or stored and flammable concentrations of vapour may be present at any time. Any electrical equipment used in these areas, including fire alarm and emergency lighting systems, needs to be suitable for use in flammable atmospheres
- Avoid accumulations of combustible rubbish and waste and remove at least daily and store away from the building
- Never store flammable or combustible rubbish, even temporarily, in escape routes, or where it can contact potential sources of heat
- Position skips so that a fire will not put any structure at risk
- Clean cooking surfaces on a regular basis to prevent grease build-up
- Rags and cloths which have been used to mop up or apply flammable liquids should be disposed of in metal containers with well-fitting lids and removed from the workplace at the end of each shift or working day
- Handle material in accordance with the advice on the safety data sheet
- Keep safety data sheets readily available
- Keep safety data sheets safely available in the event of a fire so that the information is available for emergency services

FIRE PROTECTION

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

- Heat, or an ignition source
- Fuel
- Oxygen

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

Ignition sources can include any material, equipment or operation that emits a spark or flame —including obvious items, such as torches, as well as less obvious items, such as static electricity and grinding operations. Equipment or components that radiate heat, such as kettles, catalytic converters and mufflers, also can be ignition sources. Fuel sources include combustible materials, such as wood, paper, trash and clothing; flammable liquids, such as gasoline or solvents; and flammable gases, such as propane or natural gas. Oxygen in the fire triangle comes from the air in the atmosphere. Air contains approximately 79 percent nitrogen and 21 percent oxygen. OSHA describes a hazardous atmosphere as one which is oxygen-deficient because it has less than 19.5 percent oxygen, or oxygen enriched because it has greater than 23.5 percent oxygen. Either instance is regarded by OSHA as an atmosphere immediately dangerous to life and health (IDLH) for reasons unrelated to the presence of fire. Depending on the type of fuel involved, fires can occur with much lower volume of oxygen present than needed to support human respiration. Every roofing project has all three of the fire triangle elements present in abundance. The key to preventing fires is to keep heat and ignition sources away from materials, equipment and structures that could act as fuel to complete the fire triangle.

Fire Classifications Fires are classified as A, B, C, D or K based on the type of substance that is the fuel for the fire, as follows:

Class A—fires involving ordinary combustibles, such as paper, trash, some plastics, wood and cloth. A rule of thumb is if it leaves an ash behind, it is a Class A fire.

Class B—fires involving flammable gases or liquids, such as propane, oil and gasoline

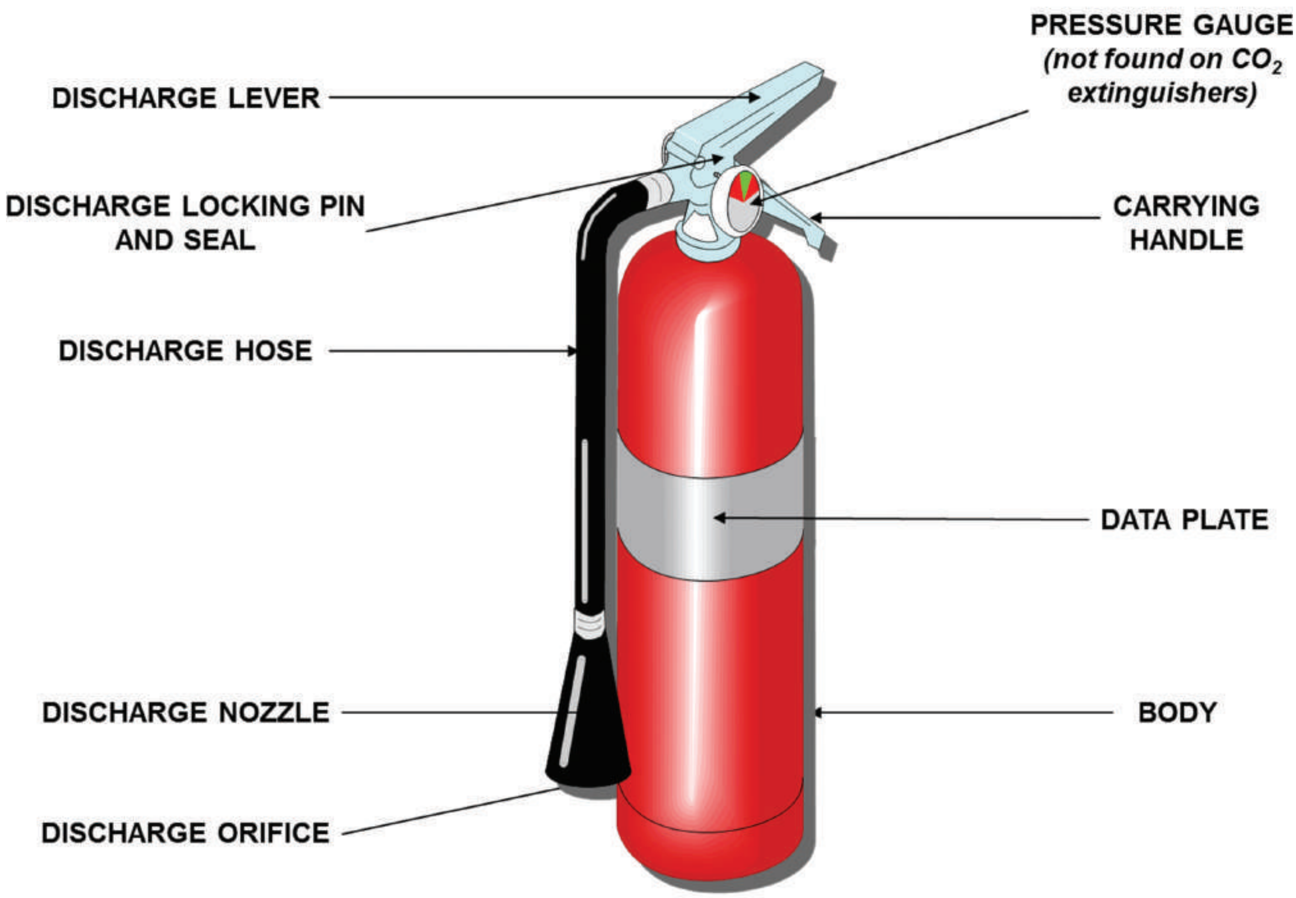
Class C—fires involving energized electrical components

Class D—fires involving metal. A rule of thumb is if the name of the metal ends with the letters "um," it is a Class D fire. Examples of this are aluminum, magnesium, beryllium and sodium. Class D fires rarely occur in the roofing industry.

Class K—fires involving vegetable or animal cooking oils or fats; common in commercial cooking operations using deep fat fryers.

There are different types of fire extinguishers designed to put out the different classes of fire. Selecting the appropriate fire extinguisher is an important consideration for a roofing contractor. The wrong extinguisher actually may make a fire emergency worse. For example, failing to use a Crated extinguisher on energized electrical components may endanger workers by causing the extinguishing material to be electrified by the energized components that are on fire. C-rated fire extinguishers put out the fire by using a chemical that does not conduct electricity.

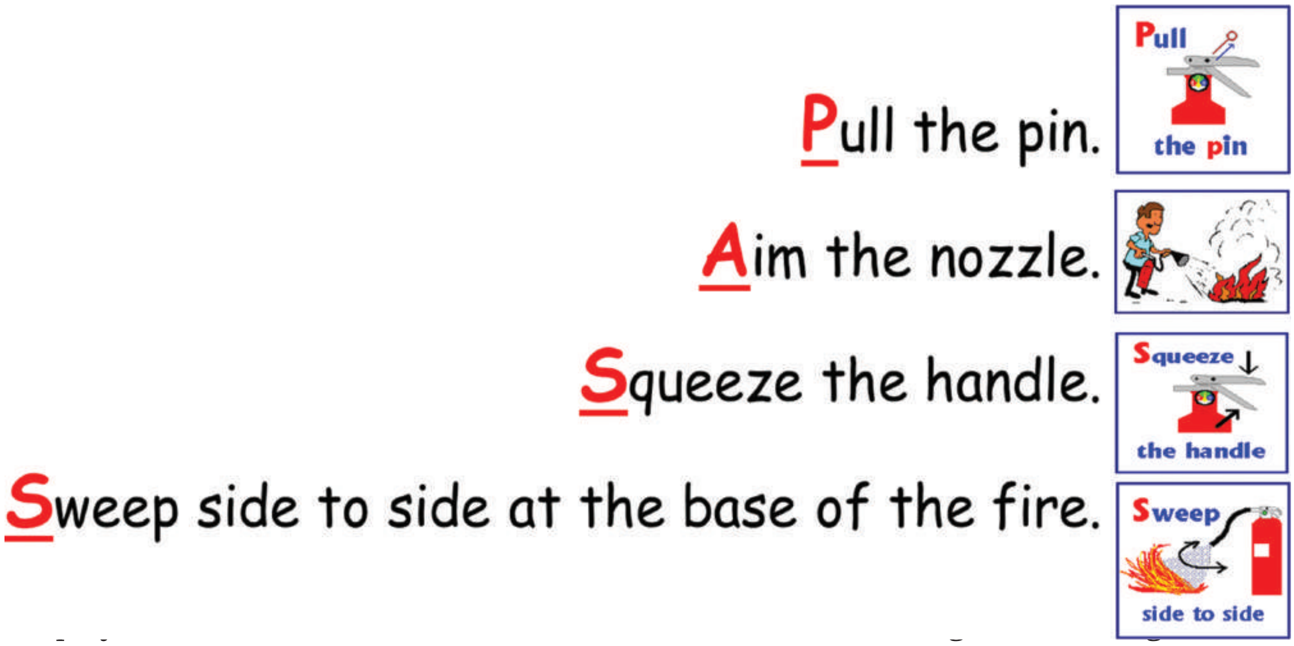
Fire Extinguisher Anatomy



used and the limitations of each extinguisher.

Fire Extinguisher Type	*Class of Fire it Extinguishes*	*Extinguisher Limitations/ Comments*
Dry Chemical (multipurpose)	*A, B, C*	*Generally good for use in roofing industry*
Foam—alcohol-resistant and aqueous film-forming foam (AFFF) types	*B*	*Expensive; effective on Class B only; limited shelf life; generally not needed in roofing industry*
Water	*A*	*Good only for Class A fires*
Metal X	*D B, C;*	*Expensive; must be kept dry; ineffective on A, typically not needed in roofing industry*
Carbon Dioxide	*B, C*	*If used in confined areas, will create oxygen deficiency; not effective in windy conditions; can cause frostbite during discharge; typically not used in roofing industry*
Halon	*B, C*	*Expensive; not effective in windy conditions; toxic gases may be released in extremely hot fires because of decomposition; generally not used in roofing industry*
Potassium Acetate	*K*	*Expensive, wet chemical extinguisher for commercial cooking operations using oils and fats*

Reme



extinguisher, they should evacuate the site and let the fire department handle the situation.

Indian Standards on Fire Fighting

Bureau of Indian standards has published nearly 200 No of standards. List is enclosed in Annex- A. Most of the standards pertains to Product standard related to Fire Extinguishers, Fire Hoses, Nozzels, Fire sprinkles, firefighting chemicals Landing valves & Fire fighting assesaries. BIS has also published several standards on guidelines, code of practices also which are good practices to be used for dealing with fire hazards. National Building code has exhaustive details on Fire safety in different types of Buildings. Similarly National Electrical code has described several requirements of Electrical fire safety.

EMERGENCY EVACUATION

Emergency evacuation is the urgent immediate egress or escape of people away from an area that contains an imminent threat, an ongoing threat or a hazard to lives or property.

Examples range from the small-scale evacuation of a building due to a storm or fire to the large-scale evacuation of a city because of a flood, bombardment or approaching weather system, especially a Tropical Cyclone. In situations involving hazardous materials or possible contamination, evacuees may be decontaminated prior to being transported out of the contaminated area.

Evacuation Sequence-

The sequence of an evacuation can be divided into the following phases:

1. detection
2. decision
3. alarm

4. reaction
5. movement to an area of refuge or an assembly station
6. transportation

The time for the first four phases is usually called pre-movement time. The most common equipment in buildings to facilitate emergency evacuations are fire alarms, exit signs, and emergency lights. Some structures need special emergency exits or fire escapes to ensure the availability of alternative escape paths.

CHAPTER IX

INDIAN STANDARDS ON CHEMICAL SAFETY AND OCCUPATIONAL HAELTH AND SAFETY

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Bureau of Indian Standards has set up two Technical committees to formulate Indian Standards on Chemical safety namely CHD 7 and for Occupational Health and safety the technical committee is CHD 8.

CHD 7 has formulated 79 Indian standards , mostly code of safety for various hazardous chemicals like hexane, Malathion, Phosphorous trichloride etc..

Code of safety Standards

Each of these code of safety standards, details about general information like chemical formula, chemical name, molecular weight . It also describes Physical properties like Freezing point, boiling point, specific gravity, solubility etc. Under chemical properties, affinity to other chemicals, Important common reaction, stability at higher temperature and flammability characteristics have been provided.

Flash point , ignition temperature, explosive limits, spontaneous heating or combustion properties and shock sensitivity are provided under Fire and Explosive properties. Corrosion properties has also been informed for the chemical .

There are detailed information chemical about its health effects and toxic information. Threshold limit values, routes of entry, antidote and health effects have been provided.

The storage , handling and transport guidelines have been provided for the chemical. The precautions to be taken during storage , handling and transportation have been provided. In case fire what types of fire fighting equipment are to be used are also detailed.

In case of spillage and leakage , the procedure to be adopted are given in a vivid manner. . Waste disposal and methods fire prevention have been stipulated in the standard.

The hazard information labelling has been detailed in the standard. Personal protective equipment required by the personnel while handling these chemicals are also prescribed. The health monitoring and first aid required in case of emergency has been detailed.

Other standards under CHD 7

Another important standard on chemical safety is IS 1446 :2024 Classification of Dangerous goods. This standard covers classification on the basis of UN numbers and type of hazards involved. This standard facilitates national and international transport.

This committee has brought out a standard on Glossary of terms relating to chemical, radiation hazards and hazardous chemical. Definition of all terms related to these have been provided in this standard.

Standard on Work Permit system (IS 17893) has been discussed in detail in Chapter 4

This committee has published yet another important standard i.e. **IS 17889 :2022 – Guideline Standard on Material Safety Data sheet**. This standard prescribes requirements for the format for Material Safety data sheet (MSDS). The possible contents that should be given under each of the 16 sections of the formats are outlined. Guidelines for compilation and completion of an MSDS have also been provided.

Section Headings

S No	Section	Headings
I	1	Chemical product and company identification
Ii	2	Hazard Identification
Iii	3	Composition /information on ingredients
Iv	4	First aid measures
V	5	Fire fighting measures
Vi	6	Accidental release measure
vii	7	Handling and storage
viii	8	Exposure controls and personal protection
ix	9	Physical and chemical properties
x	10	Stability and reactivity
xi	11	Toxicological information.
xii	12	Ecological information
xiii	13	Disposal consideration
xiv	14	Transport Information
xv	15	Regulatory information
xvi	16	Other information.

Standards Published by CHD 8

Most of the standard published by this technical committee are related to product standard which are used for personal safety like Respiratory protective safety devices , breathing apparatus, Industrial safety equipment for protection of foot and leg, safety harnesses etc

One of the important standard formulated by this committee is **IS 15793 : 2007 on Managing Health and Safety Legal compliance** . This standard specifies requirements for good practices that an organization needs to implement to demonstrate compliance with the legal requirements related to environment health and safety. This is a management system standard though it does not have high level structure as this was formulated before HLS was mandated. It has clauses typical of management system standards like General requirements, Legal requirements, Roles and responsibility, communication, resource management, document control, operational controls, monitoring and measurement, Internal audit,a non-conformity , correction, corrective action and preventive action and finally management review. It is given an illustrative list of relevant Indian legislation related to Occupational Health and safety and the Environment as Annex-B. A typical format for legal register has also been given as Annex-C.

A code of safe practice on Industrial Plant Lay out (**IS 8091:2018**) has also been published. This standard provide safe practices for lay out and building structure inside as well as outside facilities in an industrial plant. It has detailed about the Design for safety, Building equipment and processes, site planning, plant lay out, ventilation, heating and air conditioning, storage, receiving and despatch, railway siding, roads & footpath and parking area.

One standard has also been formulated on Specification for accident prevention tags. It prescribes different colour code for various types of accident prevention tag along with the warnings to be printed on it.

A very important standard on **Safety colours and safety signs (IS 9457 :20005)** has been formulated. This standard prescribes the safety identification colours and design principles for safety signs to be used in workplaces and in public areas for the purpose of accident prevention, fire protection, health hazard information and emergency evacuation. This standard is applicable to workplaces, all locations and all sectors where safety-related questions may be posed.

However, it is not applicable to the signalling used for guiding rail, road, river, maritime and air traffic and generally speaking, to those sectors subject to regulations which may differ.

Table 1 General Meaning of Geometric Shapes, Safety Colours and Contrast Colours

(*Clause* 5.2)

List No. (1)	Geometric Shape (2)	Meaning (3)	Safety Colour (4)	Contrast Colour (5)	Graphical Symbol Colour (6)	Example of Use (7)
i)	 Circle with Diagonal Bar	Prohibition	Red	White	Black	a) No Smoking b) No Unauthorised Vehicles c) Do not Drink
ii)	 Circle	Mandatory Action	Blue	White	White	a) Wear Eye Protection b) Wear Personal Protective Equipment c) Switch off Before Beginning Work
iii)	 Equilateral Triangle	Warning	Yellow	Black	Black	a) Danger Hot Surface b) Danger Acid c) Danger High Voltage
iv)	 Square  Rectangle	Safe Condition Means of Escape Safety Equipment	Green	White	White	a) First Aid Room b) Fire Exit c) Fire Assembly Point
v)	 Square  Rectangle	Fire Safety	Red	White	White	a) Fire Alarm Call Point b) Fire Fighting Equipment c) Fire Extinguisher
vi)	 Square  Rectangle	Supplementary Information	White or the Colour of the Safety Sign	Black or the Contrast Colour of the Relevant Safety Sign	Symbol Colour of the Relevant Safety Sign	As Appropriate to Reflect Message given by Graphical Symbol

Right from the present location

Left from the existing location


Danger Zone


Prohibited zone

ANNEX A

(*Clause* 10.1.1)

SAFETY SYMBOLS IN COMMON USE

Smoking Prohibited

Caution, Risk of Danger

Fire and Lighting Matchstick Prohibited

Caution, Risk of Fire

Thoroughfare Prohibited for Pedestrians

Caution, Risk of Explosion

Water as Extinguishing Agent Prohibited

Caution, Risk of Corrosion

Water not for Drinking

Caution, Risk of Life

Caution, Risk of Ionizing Radiation

Caution, Risk of Electric Shock

First Aid

General Indication of Direction

Indication of Direction to First Aid

Eye Protector Must be Worn

Respiratory Protector Must be Worn

Head Protector Must be Worn

Hearing Protector Must be Worn

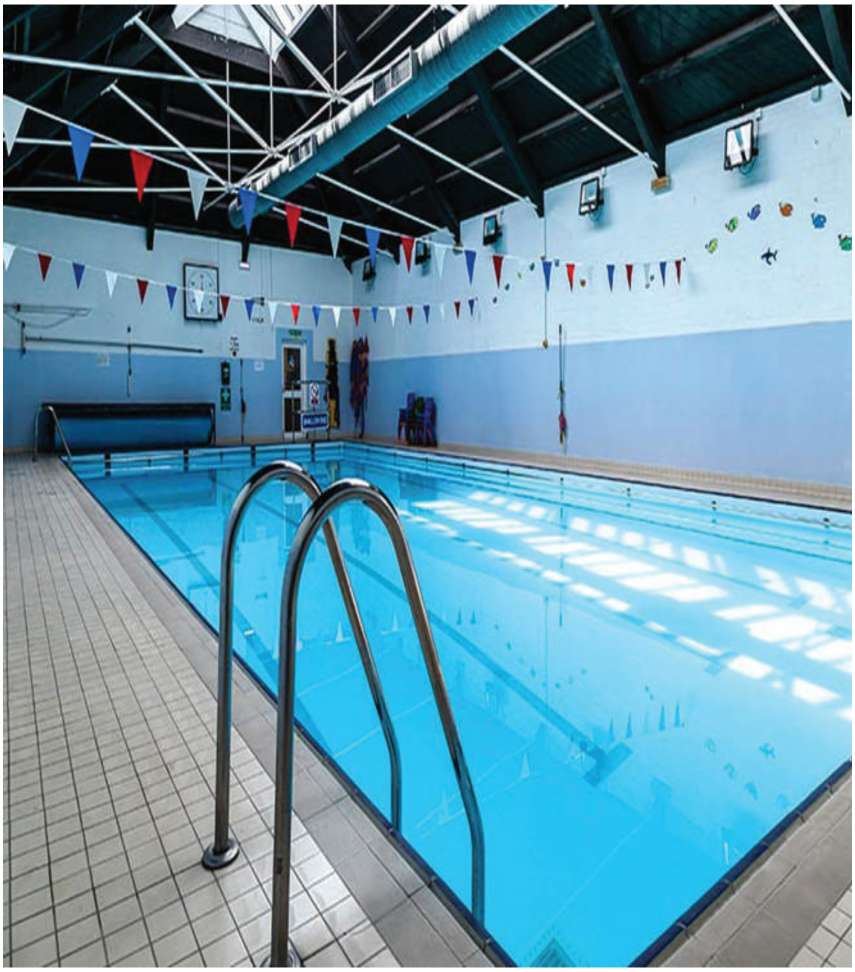
Hand Protector Must be Worn

Foot Protector Must be Worn

CHD 8 has also formulated standard for **Swimming pool for public – Code of safety. IS 16508: 2017.**

This standard prescribes the code of safe practices for aspects of design, operation and maintenance of public swimming pool, keeping in view general and specific safety requirements.

This Code is not intended to contravene the provision of any of the existing Government regulations. It is the responsibility of the user of this Code to establish appropriate safety and health practices and comply with regulatory and statutory requirements.



This Code does not address residential and above ground swimming pools.

This standard prescribes Design, structure, material to be used, dimensional requirement, floor slopes, transition point, pool wall, water depth, walkways & Deck areas, ladders step holders & ramps, diving area starting platforms, Electrical installations-Lighting, ventilation and additionally about shower and bathrooms.

It has also dealt with swimming pool water treatment system, which include filtration and disinfection.

Personnel requirements like pool manager and swimming coach instructor and life guard. Have been provided Specific requirement like rescue equipment, first aid kit and depth markers are provided.

The requirement of water quality like disinfection residuals, operation & maintenance and responsibility of pool users have also been provided. It is indeed a good document for safety of swimming pool users.

CHAPTER X

OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT SYSTEM [IS/ISO 45001 :2018]

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Introduction

In the changed global industrial scenario drive for competitiveness based on improved quality in all functions of an organization, concerns for occupational safety, health and environment have received special significance.

Industrial & personal safety has been a matter of great concern for many years and remained a major issue for all – Govt., employers and common public in general.

Safety got immense importance in every aspects of human life. International agencies (ILO, WHO, UNDP, ISO) have renewed their thrust for suitable global framework to implement cost effective OH&S delivery systems, management methods and programmes to prevent workplace ailments and promote health and welfare of workers.

Standardization has been accepted as an effective tool for tackling the various types of hazards associated with different activities, products & services to protect people from unintentional injury & death. OH&S has become one of the prime considerations in management of industries globally, after human civilization witnessed couple of disasters and some shocking facts and failures in the last few decades. In almost all such disasters, it has been observed that failure of management system was more obvious than other reasons.

Role of legislation

It is now an accepted fact that legislation alone cannot guaranty an accident free environment. There is plethora of legal provision even then fatal accidents are happening on daily basis. The foremost preamble of the constitution of ILO "Labour is not a commodity" is yet to be understood by many.

Preamble to the constitution of WHO, "The enjoyment of highest attainable standard of health is one of the fundamental rights of every human being…. The achievement of any state in the promotion and protection of health is of value to all. Primarily, effective management of worker safety and health protection is a decisive factor in reducing work-related injuries and illnesses. An ideal OH&S management system should provide a structured process to minimize work-related injuries and illnesses, and reduce the direct and indirect costs associated with accidents. Also, it must provide a direction to OH&S activities, with reference to organizational policies, regulatory requirements, recommended guidelines, industry practices and standards, including negotiated labour agreements. Therefore, conforming to a management system may be of significant value for the small and medium-sized organizations that traditionally receive little regulatory guidance.

Health and Safety is one of the most important aspects of an organizations' smooth and effective functioning. Good health and safety performance ensures an accident free industrial environment. With the continuous and untiring efforts of various legislative authorities as well as NGO's the awareness of Occupational Health and Safety (OH&S) has started attaching the same importance to achieve high OH&S performance as they do to the key aspects of their business activities. This demands adoption of a structured approach for the identification of hazard, their evaluation and control of risks.

WHY OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT SYSTEM?

Workers spend over 30% of their waking hours at the workplace. It thus becomes imperative to institute and maintain a programme to protect employees from, and to allow them to recognize work-related health and safety hazards.

Ill health is expensive, to employer, employee and society as a whole, and with costs continuing to increase the Government is steadily transferring costs more and more to the employer.

At elite companies, safety is a core value, on par with quality and production. Safety is an integral part of the world famous Toyota production system, , for example. Its cooperative, participative approach would be impossible if management were indifferent to the well-being of the team members.

Traditional safety programmes emphasize discipline and top down control and

- Focus on injuries, illnesses and other end-of-the-pipeline measures. A narrow view of accident is taken. Near-misses, at-risk behaviours, and other upstream measures are not tracked or understood.
- Tend to be reactive, not preventive
- Consider safety as a separate function than a part of all functions
- Tend to be project oriented than system oriented
- Tend to blame the workers for accidents. Often a view is taken of workers that they do not like work or responsibility and must be closely supervised
- Focus on the attitudes of workers. The underlying assumptions is that, because workers are responsible for accidents, they must have bad attitudes
- Rely heavily on promotional campaigns to get people to feel responsible for safety and to give them the "appropriate" attitudes
- Are based on a top-down model. Management bosses, coaxes and entices. Workers are rewarded with prizes or are disciplined
- Place a strong emphasis on rules and close supervision of workers

But these are no longer valid. A structured approach to safety management has become essential. Evidences are there that workplace health promotion lead to number of potential benefits and substantial gains to the organization.

- Parkinson identifies workplace health promotion as "a combination of educational, organizational and environmental activities designed to support behaviour conducive to the health of the employees and their families."
- Rationale for workplace health improvement is that the workers are also a captive audience for any health promotion intervention.

There are evidences of:

- Improving employee health and fitness.
- Reducing absenteeism
- Decreasing medical and disability costs
- Decreasing staff turnover;
- Improving employee mental alertness;
- Improving morale and job satisfaction;
- Enhanced corporate image;
- Improving productivity

Occupational Health & Safety

Whilst health and safety management covers many areas, there are a number of aspects which are significant, namely:

- The company Statement of Health and Safety Policy;
- Processes for health and safety monitoring and performance measurement;
- Clear identification of the objectives and standards which must be measurable and achievable by the persons concerned;
- The system for improving knowledge, attitudes and motivation and for increasing individual awareness of health and safety isissues, responsibilities and accountabilities**;**
- Procedures for eliminating potential hazards from plant, machinery, substances and working practices through risk assessment, the design and operation of safe systems of work and other forms of hazard control; and
- Measures taken by management to ensure legal compliance.

The way forward for successful health and safety management is to involve everyone in the organization, using a proactive approach to identify hazards and to control those risks that are not tolerable. This ensures that those employees at risk are aware of the risks they face and of the need for the control measures.

In order to achieve positive benefits health and safety management should be an integral feature of the undertaking contributing to the success of the organization. It can be an effective vehicle for efficiency and effectiveness, encouraging employees to suggest improvements in working practices.

In an ideal environment health and safety is an agenda item alongside production, services, etc. at any senior management review of the undertaking, rather than an inconvenient add-on item.

What is Occupational Health & Safety Management System (OH&SMS)?

As per the definition given in IS/ISO 45001:2018

"*Management system* or part of a management system used to achieve the *OH&S policy*."

Note 1 to entry: The intended outcomes of the OH&S management system are to prevent *injury and ill health* to *workers* and to provide safe and healthy *workplaces* .

Note 2 to entry: The terms "occupational health and safety" (OH&S) and "occupational safety and health" (OSH) have the same meaning.

Basically to simplify it "An Occupational Health & Safety Management System (OH&SMS) is a structured process to minimize potentials of work –related fatalities, injuries and illness, to increase productivity by reducing the direct and indirect costs associated with accidents.,

OH &SMS Standard- A historical perspective

BS 8800:1996 is perhaps the first formalized OH&SMS that provided a template for the development of an international standard on OH&SMS. This guideline had three major sections. First section deals with actual management system based on British OH&SMS regulations HS (G) 65. Second section is based on ISO 14001 and third section contains annexes that provide guidance information relevant to each of the primary sections.

ILO Guidelines on OS&HMS ILO – OSH 2001-

The protection of workers against work related sickness, disease and injury forms parts of the historical mandate of the ILO. Disease and injury do not go with the job nor can poverty justify disregard for workers safety and health. ILO's primary goal is to promote opportunities for women and men to obtain decent and productive work in conditions of freedom, equity, security and human dignity. Decent work is safe work and safe work is also a positive factor for productivity and economic growth.

These guidelines are voluntary in nature, have no legal binding and not intended to replace national laws, regulations or accepted standards. Their application does not require certification. The ILO has designed these guidelines as a practical tool for assisting organizations and competent institutions as a means of achieving continual improvement in OSH performance.

The guidelines, ILO-OSH 2001 were prepared on the basis of a broad based approach involving the ILO and its tripartite constituents and its other stakeholders. It addresses, the development of national guidelines on OSH-MS, including tailored systems for small and medium-sized organizations, professional contributions of labour inspection and OHS services, and the recognition of the existence of successful OSH management systems, such as responsible care, private voluntary initiatives, good practice on OHS, and the ISO standards on quality and environmental management.

ISO Initiative on OH&SMS Standard

After the grand success of two of its premium standards namely ISO 9001 & ISO 14001 on Quality and Environmental Management system, there was demand from Industry for Standard on yet another very important subject i.e. Occupational Health & safety management system . This subject was taken up for standardization by ISO but International Organization for Labour(ILO) intervened stating that it is the mandate of ILO to formulate any standard on the subject of labour. ISO dropped the subject for standardization after preparing working draft. Since the subject was in great demand , a conglomeration of 13 certification bodies and NSBs , approached OSHA for taking the subject further to bring out a private standard. Then OSHA brought out an standard

OSHAS 18001 which was adopted for certification by those 13 certification bodies and NSBs. Based on market demand Bureau Of Indian Standards also brought out a standard IS 18001 with some modification from the OSHAS 18001 . Though the structure of both the standards were same , IS 18001 was not an identical standard to OSHA 18001.

Later on ILO came to an understanding with ISO and the subject was again taken up by ISO and ISO 45001 : 2018 was prepared by its Project Committee ISO PC 283.

Bureau of Indian Standard , adopted this ISO standard as IS/ISO 45001 :2018. This standard is extremely popular and thousands of organizations has implemented this standard and received certification.

Occupational Health and Safety Management Systems —Requirements with Guidance for Use – IS/ISO 45001 :2018

Like any other management system standards this standard is also based on High Level Structure (HLS) and the clauses are arranged in Plan -Do-Check- Act or PDCA cycle.

The purpose of an OH&S management system is to provide a framework for managing OH&S risks and opportunities. The aim and intended outcomes of the OH&S management system are to prevent work- related injury and ill health to workers and to provide safe and healthy workplaces; consequently, it is critically important for the organization to eliminate hazards and minimize OH&S risks by taking effective preventive and protective measures.

When these measures are applied by the organization through its OH&S management system, they improve its OH&S performance. An OH&S management system can be more effective and efficient when taking early action to address opportunities for improvement of OH&S performance.

Implementing an OH&S management system conforming to this document enables an organization to manage its OH&S risks and improve its OH&S performance. An OH&S management system can assist an organization to fulfil its legal requirements and other requirements.

Effectiveness of Implementation:

The implementation of an OH&S management system is a strategic and operational decision for an organization. The success of the OH&S management system depends on leadership, commitment and participation from all levels and functions of the organization.

The implementation and maintenance of an OH&S management system, its effectiveness and its ability to achieve its intended outcomes are dependent on a number of key factors, which can include:

a) top management leadership, commitment, responsibilities and accountability;

b) top management developing, leading and promoting a culture in the organization that supports the intended outcomes of the OH&S management system;

c) communication;

d) consultation and participation of workers, and, where they exist, workers' representatives;

e) allocation of the necessary resources to maintain it;

f) OH&S policies, which are compatible with the overall strategic objectives and direction of the organization;

g) effective process(es) for identifying hazards, controlling OH&S risks and taking advantage of OH&S opportunities;

h) continual performance evaluation and monitoring of the OH&S management system to improve OH&S performance;

i) integration of the OH&S management system into the organization's business processes;

j) OH&S objectives that align with the OH&S policy and take into account the organization's hazards, OH&S risks and OH&S opportunities;

k) compliance with its legal requirements and other requirements

Demonstration of successful implementation of this document can be used by an organization to give assurance to workers and other interested parties that an effective OH&S management system is in place. Adoption of this document, however, will not in itself guarantee prevention of work-related injury and ill health to workers, provision of safe and healthy workplaces and improved OH&S performance.

Plan- Do-Check-Act Cycle

The OH&S management system approach applied in this document is founded on the concept of Plan- Do-Check-Act (PDCA).

The PDCA concept is an iterative process used by organizations to achieve continual improvement. It can be applied to a management system and to each of its individual elements, as follows:

a) Plan: determine and assess OH&S risks, OH&S opportunities and other risks and other opportunities, establish OH&S objectives and processes necessary to deliver results in accordance with the organization's OH&S policy;

b) Do: implement the processes as planned;

c) Check: monitor and measure activities and processes with regard to the OH&S policy and OH&S objectives, and report the results;

d) Act: take actions to continually improve the OH&S performance to achieve the intended outcomes.

This document incorporates the PDCA concept into a new framework, as shown in F igure 1.

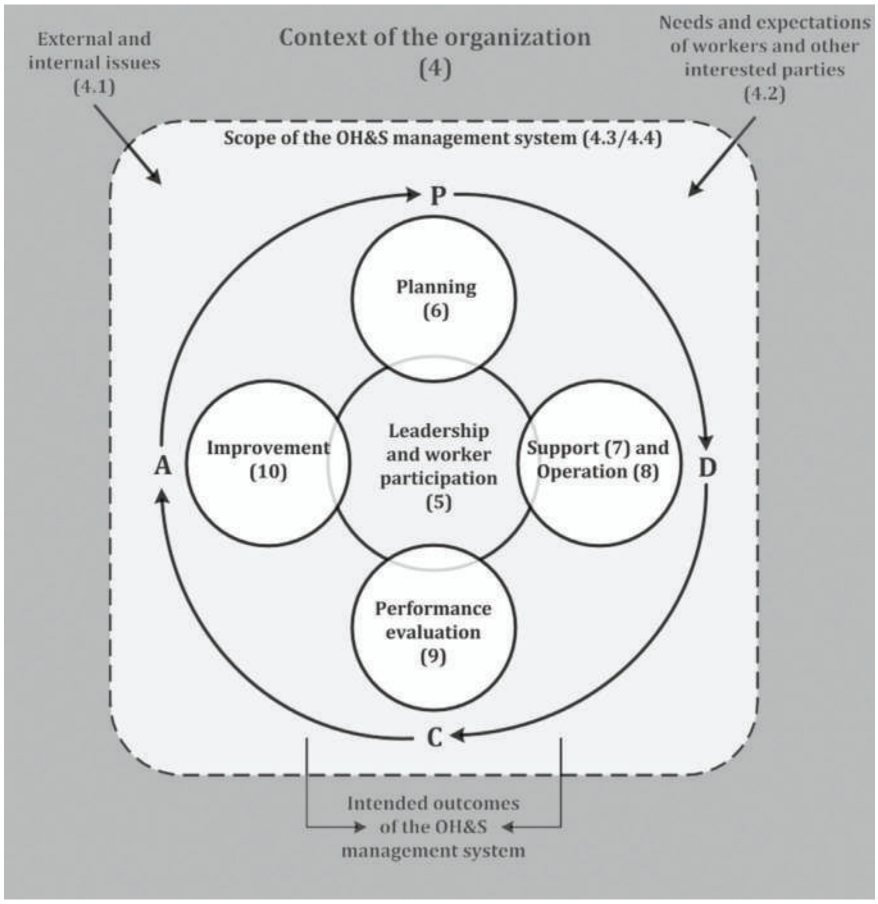

Figure 1 — Relationship between PDCA and the framework in this document

Process Concept of Safety

Definition of process is "**Set of interrelated and interacting activities which transforms inputs into outputs."** As it is said Quality cannot be achieved by fluke, it is a result of meticulous planning and execution. Similarly, safety has to be planned for each and every process. Let us take an example of tea making process to understand the concept. For getting a quality tea, we must determine and take care of parameters which affects the quality like tea leaves, sugar, water, milk, the method of making, etc. Similarly, we have to identify the risk and its associated hazards involved in tea making and how to take care of these hazards while making the tea safely. Let us list out some of the risks & hazards in making tea:

a) Gas leakage if gas stove is used for making tea which can cause uncontrolled fire or blast.

b) Contact of hot surface and getting burned

c) Hot liquid spillage falling onto body parts and getting burned.

Now if we have plan to mitigate those risks and accordingly take action, we can ensure safe tea making process.

Scope :

This standard specifies requirements for an occupational health and safety (OH&S) management system, and gives guidance for its use, to enable organizations to provide safe and healthy workplaces by preventing work-related injury and ill health, as well as by proactively improving its OH&S performance.

Like any other Management system standard, this standard is also a generic standard and can be applicable regardless of type, size or activities of the organization.

Terms & Definition : Terms & definitions related to this standard has been provided in clause 3. A few important definition are given below which will provide clarity in understanding the standard. Most of the other terms are same as given in other management system standards.

Worker :

person performing work or work-related activities that are under the control of the *organization*

Note 1 to entry: Persons perform work or work-related activities under various arrangements, paid or unpaid, such as regularly or temporarily, intermittently or seasonally, casually or on a part-time basis.

Note 2 to entry: Workers include *top management* , managerial and non-managerial persons.

Note 3 to entry: The work or work-related activities performed under the control of the organization may be performed by workers employed by the organization, workers of external providers, contractors, individuals, agency workers, and by other persons to the extent the organization shares control over their work or work- related activities, according to the context of the organization.

Here it may be seen that Top Management and managerial persons are also considered as worker for the purpose of this standard.

Participation

Involvement in decision-making

Note 1 to entry: Participation includes engaging health and safety committees and workers' representatives, where they exist.

Consultation

seeking views before making a decision

Note 1 to entry: Consultation includes engaging health and safety committees and workers' representatives, where they exist.

occupational health and safety policy OH&S policy

policy to prevent work-related *injury and ill health* to *workers* and to provide safe and healthy *workplaces*

Occupational health and safety Management system OH&S management system

management system or part of a management system used to achieve the *OH&S policy*

Note 1 to entry: The intended outcomes of the OH&S management system are to prevent *injury and ill health* to *workers* and to provide safe and healthy *workplaces*

Note 2 to entry: The terms “occupational health and safety” (OH&S) and “occupational safety and health” (OSH) have the same meaning.

injury and ill health

adverse effect on the physical, mental or cognitive condition of a person

Note 1 to entry: These adverse effects include occupational disease, illness and death.

occupational health and safety risk OH&S risk

combination of the likelihood of occurrence of a work-related hazardous event(s) or exposure(s) and the severity of *injury and ill health* that can be caused by the event(s) or exposure(s)

Requirements starts from Clause 4 of the standard. Clause 4 to Clause 10 are requirement clauses.

Clause 4 – Context of the Organization

This clause stipulates requirements for determining external &internal issues which has effect on OH& SMS. It also tells about determination of need & expectation of workers & interested parties related to OH&SMS. Scope of OH&SMS in the organization need to be defined interns of activities, product services under the control of the organization. This Clause also stipulates that the organization shall establish, implement, maintain, and continually improve an OH&S management system, including the processes needed and their interactions, in accordance with IS/ISO 45001:2018.

Clause 5 – Leadership and Worker’s Participation

This clause stipulates commitment from top management or leadership by preventing work-related injury and ill health, as well as the provision of safe and healthy workplaces and activities, by establishing OH&S policy and related objectives, ensuring availability of resources, by effective communication regarding effective OH&SMS. protecting workers from reprisals when reporting incidents, hazards, risks and opportunities; etc.

This clause also provides requirement related to OH&S policy ,its awareness and communication. Organizational roles, responsibilities and authority needs to be assigned and communicated within the organization.

One of the significant requirement of this clause is worker’s consultation and participation. The organization shall consult or seek views while decision making of the non-managerial workers on the following:

- determining the needs and expectations of interested parties (see 4 .2);
- establishing the OH&S policy
- assigning organizational roles, responsibilities and authorities, as applicable
- determining how to fulfil legal requirements and other requirements.
- establishing OH&S objectives and planning to achieve them.
- determining applicable controls for outsourcing, procurement and contractors
- determining what needs to be monitored, measured and evaluated

- planning, establishing, implementing and maintaining an audit programme(s)
- ensuring continual improvement

But organization must involve non managerial worker on the following:

- determining the mechanisms for their consultation and participation;
- identifying hazards and assessing risks and opportunities
- determining actions to eliminate hazards and reduce OH&S risks
- determining competence requirements, training needs, training and evaluating training
- determining what needs to be communicated and how this will be done
- determining control measures and their effective implementation and use
- investigating incidents and nonconformities and determining corrective actions

Planning – Clause 6

This is most important clause as this is the clause where hazards are required to be identified and risk and opportunity are to be analysed. Hazard identification should start from design stage. It should be continued in operation, maintenance and modification, if done. It may be noted that product safety is not under the scope of this standard, but the hazards to workers occurring during manufacture, construction, assembly or testing of products should be considered. Hazard identification is necessary to recognize and understand the hazards in the workplace and to workers, in order to assess, prioritize and eliminate hazards or reduce OH&S risks.

Hazards can be physical, chemical, biological, psychosocial, mechanical, electrical or based on movement and energy.

The organization's hazard identification process(es) should consider:

a) routine and non-routine activities and situations:

   1) routine activities and situations create hazards through day-to-day operations and normal work activities;

   2) non-routine activities and situations are occasional or unplanned;

   3) short-term or long-term activities can create different hazards;

b) human factors:

   1) relate to human capabilities, limitations and other characteristics;

   2) information should be applied to tools, machines, systems, activities and environment for safe, comfortable human use;

   3) should address three aspects: the activity, the worker and the organization, and how these interact with and impact on occupational health and safety;

c) new or changed hazards:

1) can arise when work processes are deteriorated, modified, adapted or evolved as a result of familiarity or changing circumstances;

2) understanding how work is actually performed (e.g. observing and discussing hazards with workers) can identify if OH&S risks are increased or reduced;

d) potential emergency situations:

1) unplanned or unscheduled situations that require an immediate response (e.g. a machine catching fire in the workplace, or a natural disaster in the vicinity of the workplace or at another location where workers are performing work-related activities);

2) include situations such as civil unrest at a location at which workers are performing work- related activities which requires their urgent evacuation;

e) people:

1) those in the vicinity of the workplace who could be affected by the activities of the organization (e.g. passers-by, contractors or immediate neighbours);

2) workers at a location not under the direct control of the organization, such as mobile workers or workers who travel to perform work-related activities at another location (e.g. postal workers, bus drivers, service personnel travelling to and working at a customer's site);

3) home-based workers, or those who work alone;

f) changes in knowledge of, and information about, hazards:

1) sources of knowledge, information and new understanding about hazards can include published literature, research and development, feedback from workers, and review of the organization's own operational experience;

2) these sources can provide new information about the hazards and OH&S risks.

Assessment of OH&S risks and other risks to the OH&S management system

An organization can use different methods to assess OH&S risks as part of its overall strategy for addressing different hazards or activities. The method and complexity of assessment does not depend on the size of the organization, but on the hazards associated with the activities of the organization.

Other risks to the OH&S management system should also be assessed using appropriate methods.

Processes for the assessment of risk to the OH&S management system should consider day-to- day operations and decisions (e.g. peaks in work flow, restructuring) as well as external issues (e.g. economic change). Methodologies can include ongoing consultation of workers affected by day-to-day activities (e.g. changes in work load), monitoring and communication of new legal requirements and other requirements (e.g. regulatory reform, revisions to collective agreements regarding occupational health and safety), and ensuring resources meet existing and changing needs (e.g. training on, or procurement of, new improved equipment or supplies).

OH&S opportunities along with other opportunities are also to be assessed in order to improve the OH&SMS performance.

A.1.1.1 Determination of legal requirements and other requirements

a) Legal requirements can include:

   1) legislation (national, regional or international), including statutes and regulations;
   2) decrees and directives;
   3) orders issued by regulators;
   4) permits, licences or other forms of authorization;
   5) judgments of courts or administrative tribunals;
   6) treaties, conventions, protocols;
   7) collective bargaining agreements.

b) Other requirements can include:

   1) contractual conditions;
   2) employment agreements;
   3) agreements with interested parties;
   4) agreements with health authorities;
   5) non-regulatory standards, consensus standards and guidelines;
   6) voluntary the organization's requirements;
   7) principles, codes of practice, technical specifications, charters;
   8) public commitments of the organization or its parent organization.

Planning action

The organization shall plan:

a) actions to:

   - address these risks and opportunities
   - address legal requirements and other requirements
   - prepare for and respond to emergency situations

b) how to

   - integrate and implement the actions into its OH&S management system processes or other business processes;
   - evaluate the effectiveness of these actions

The organization should consider hierarchy of actions i.e. eliminate, substitute, engineering controls, administrative controls and use of PPE while planning for action to address risks and legal & other requirements.

When planning its actions, the organization shall consider best practices, technological options and financial, operational and business requirements.

OH&S Objective

Objectives are established to maintain and improve OH&S performance. The objectives should be linked to risks and opportunities and performance criteria which the organization has identified as being necessary for the achievement of the intended outcomes of the OH&S management system.

OH&S objectives can be integrated with other business objectives and should be set at relevant functions and levels. Objectives can be strategic, tactical or operational:

a) strategic objectives can be set to improve the overall performance of the OH&S management system (e.g. to eliminate noise exposure);

b) tactical objectives can be set at facility, project or process level (e.g. to reduce noise at source);

c) operational objectives can be set at the activity level (e.g. the enclosure of individual machines to reduce noise).

The measurement of OH&S objectives can be qualitative or quantitative. Qualitative measures can be approximations, such as those obtained from surveys, interviews and observations. The organization is not required to establish OH&S objectives for every risk and opportunity it determines.

Planning to achieve OH&S objectives

Planning must include resources required(financial, personnel, technological etc), timeline , processes, responsibility , method to monitor the progress, and how this process can be integrated in the business process of the organization.

SUPPORT- Clause 7

RESOURCES

The organization needs to determine and provide necessary resources (financial , human, technological etc) for successful implementation and improvement of OH&SMS.

COMPETENCE & AWARENESS

The competence of workers should include the knowledge and skills needed to appropriately identify the hazards and deal with the OH&S risks associated with their work and workplace.

In determining the competence for each role, the organization should take into account things such as:

a) the education, training, qualification and experience necessary to undertake the role and the re- training necessary to maintain competence;

b) the work environment;

c) the preventive and control measures resulting from the risk assessment process(es);

d) the requirements applicable to the OH&S management system;

e) legal requirements and other requirements

f) the OH&S policy &objectives;

g) the potential consequences of compliance and noncompliance, including the impact on the worker's health and safety;

h) the value of participation of workers in the OH&S management system based on their knowledge and skill;

i) the duties and responsibilities associated with the roles;

j) individual capabilities, including experience, language skills, literacy and diversity;

k) the relevant updating of the competence made necessary by context or work changes. Workers can assist the organization in determining the competence needed for roles.

Workers should have the necessary competence to remove themselves from situations of imminent and serious danger. For this purpose, it is important that workers are provided with sufficient training on hazards and risks associated with their work.

In addition to workers (especially temporary workers), contractors, visitors and any other parties should be aware of the OH&S risks to which they are exposed.

Communication

The communication process(es) established by the organization should provide for the gathering, updating and dissemination of information. It should ensure that relevant information is provided, is received and is understandable to all relevant workers and interested parties. The external communication should take in account the legal and other requirements.

Documented information

It is important to keep the complexity of the documented information at the minimum level possible to ensure effectiveness, efficiency and simplicity at the same time.

This should include documented information regarding planning to address legal requirements and other requirements and on evaluations of the effectiveness of these actions.

The documented information should be available and suitable for use, protected and controlled. For the control of documented information, following are addressed:

— distribution, access, retrieval and use;

— storage and preservation, including preservation of legibility;

— control of changes (e.g. version control);

— retention and disposition.

Document of external origin, such as national/international standards, legal documents etc are identified and controlled.

CLAUSE 8 - OPERATION

OPERATION & CONTROL

The organization should control of the processes by eliminating hazards or, if not practicable, by reducing the OH&S risks to levels as low as reasonably acceptable for operational areas and activities.

Examples of operational control of the processes include:

a) the use of procedures and systems of work;

b) ensuring the competence of workers;

c) establishing preventive or predictive maintenance and inspection programmes;

d) specifications for the procurement of goods and services;

e) application of legal requirements and other requirements, or manufacturers' instructions for equipment;

f) engineering and administrative controls;

g) adapting work to workers; for example, by:

  1) defining, or redefining, how the work is organized;

  2) the induction of new workers;

  3) defining, or redefining, processes and working environments;

  4) using ergonomic approaches when designing new, or modifying, workplaces, equipment, etc

Eliminating hazards and reducing OH&S risks

The hierarchy of controls is intended to provide a systematic approach to enhance occupational health and safety, eliminate hazards, and reduce or control OH&S risks. Each control is considered less effective than the one before it. It is usual to combine several controls in order to succeed in reducing the OH&S risks to a level that is as low as reasonably acceptable.

The following examples are given to illustrate measures that can be implemented at each level.

a) Elimination: removing the hazard; stopping using hazardous chemicals; applying ergonomics approaches when planning new workplaces; eliminating monotonous work or work that causes negative stress; removing fork-lift trucks from an area.

b) Substitution: replacing the hazardous with less hazardous;; adapting to technical progress (e.g. replacing solvent-based paint by water-based paint; changing slippery floor material with anti-skid flooring ; lowering voltage requirements for equipment).

c) Engineering controls, reorganization of work, or both: isolating people from hazard; implementing collective protective measures (e.g. isolation, machine guarding, ventilation systems); addressing mechanical handling; reducing noise by acoustic enclosure; protecting against falls from height by using guard rails; reorganizing work to avoid people working alone, unhealthy work hours and workload, or to prevent victimization.

d) Administrative controls including training: conducting periodic safety equipment inspections; conducting training to prevent bullying and harassment; managing health and safety coordination with subcontractors' activities; conducting induction training; administrating forklift driving licences; providing instructions on how to report incidents, nonconformities and victimization without fear of retribution; changing the work patterns (e.g. shifts) of workers; managing a health or medical surveillance programme for workers who have been identified as at risk (e.g. related to hearing, hand-arm vibration, respiratory disorders, skin disorders or exposure); giving appropriate instructions to workers (e.g. entry control processes).

e) Personal protective equipment (PPE): providing adequate PPE, including clothing and instructions for PPE utilization and maintenance (e.g. safety shoes, safety glasses, hearing protection, gloves).

Management of Change

Whenever organization encounters change in any or more of the following situation,

a) new products, services and processes, or changes to existing products, services and processes, including:
    - workplace locations and surroundings;
    - work organization;
    - working conditions;
    - equipment;
    - work force;

b) changes to legal requirements and other requirements;

c) changes in knowledge or information about hazards and OH&S risks;

d) developments in knowledge and technology

The organization shall review the consequences of unintended changes, taking action to mitigate any adverse effects, as necessary.

The objective of a management of change process is to enhance occupational health and safety at work, by minimizing the introduction of new hazards and OH&S risks into the work environment as changes occur (e.g. with technology, equipment, facilities, work practices and procedures, design specifications, raw materials, staffing, standards or regulations). Depending on the nature of an expected change, the organization can use an appropriate methodology(ies) (e.g. design review) for assessing the OH&S risks and the OH&S opportunities of the change. The need to manage change can be an outcome of planning

Procurement.

The procurement process(es) should be used to determine, assess and eliminate hazards, and to reduce OH&S risks associated with, for example, products, hazardous materials or substances, raw materials, equipment, or services before their introduction into the workplace.

The organization's procurement process(es) should address requirements including, for example, supplies, equipment, raw materials, and other goods and related services purchased by the organization to conform to the organization's OH&S management system. The process should also address any needs for consultation non managerial workers and communication with appropriate interested parties.

The organization should verify that equipment, installations and materials are safe for use by workers by ensuring:

a) equipment is delivered according to specification and is tested to ensure it works as intended;

b) installations are commissioned to ensure they function as designed;

c) materials are delivered according to their specifications;

d) any usage requirements, precautions or other protective measures are communicated and made available.

Contractors

The organization shall coordinate its procurement process(es) with its contractors, in order to identify hazards and to assess and control the OH&S risks arising from:

a) the contractors' activities and operations that impact the organization; for example contractor for maintenance

b) the organization's activities and operations that impact the contractors' workers; for example production activity of the organization can impact maintenance work of contractor.

c) the contractors' activities and operations that impact other interested parties in the workplace. For example maintenance works of electrical and mechanical contractors.

The organization shall ensure that the requirements of its OH&S management system are met by contractors and their workers. The organization's procurement process(es) shall define and apply occupational health and safety criteria for the selection of contractors.

Outsourcing

When outsourcing, the organization needs to have control of the outsourced functions and process(es) to achieve the intended outcome(s) of the OH&S management system. In the outsourced functions and process(es), the responsibility for conforming to the requirements of this document is retained by the organization.

The organization should establish the extent of control over outsourced function(s) or process(es) based upon factors such as:

— the ability of the external organization to meet the organization's OH&S management system requirements;

— the technical competence of the organization to define appropriate controls or assess the adequacy of controls;

— the potential effect the outsourced process or function will have on the organization's ability to achieve the intended outcome of its OH&S management system;

— the extent to which the outsourced process or function is shared;

— the capability of the organization to achieve the necessary control through the application of its procurement process;

— opportunities for improvement.

Emergency preparedness and response

Emergency preparedness plans can include natural, technical and man-made events that occur inside and outside normal working hours.

CLAUSE-9 —PERFORMANCE EVALUATION-

Monitoring, measurement, analysis and performance evaluation

General

In order to achieve the intended outcomes of the OH&S management system, the processes should be monitored, measured and analyzed.

a) Examples of what could be monitored and measured can include, but are not limited to:

1) occupational health complaints, health of workers (through surveillance) and work environment;
2) work-related incidents, injuries and ill health, and complaints, including trends;
3) the effectiveness of operational controls and emergency exercises, or the need to modify or introduce new controls;
4) competence.

b) Examples of what could be monitored and measured to evaluate the fulfilment of legal requirements can include, but are not limited to:

1) identified legal requirements (e.g. whether all legal requirements have been determined, and whether the organization's documented information of them is kept up-to-date);
2) collective agreements (when legally binding);
3) the status of identified gaps in compliance.

c) Examples of what could be monitored and measured to evaluate the fulfilment of other requirements can include, but are not limited to:

1) collective agreements (when not legally binding);
2) standards and codes;
3) corporate and other policies, rules and regulations;
4) insurance requirement

d) Criteria are what the organization can use to compare its performance against.

1) Examples are benchmarks against:
   i) other organizations;
   ii) standards and codes;
   iii) the organization's own codes and objectives;
   iv) OH&S statistics.

2) To measure criteria, indicators are typically used; for example:
   i) if the criterion is a comparison of incidents, the organization may choose to look at frequency, type, severity or number of incidents; then the indicator could be the determined rate within each one of these criteria;
   ii) if the criterion is a comparison of completions of corrective actions, then the indicator could be the percentage completed on time.

Monitoring can involve continual checking, supervising, critically observing or determining the status in order to identify change from the performance level required or expected. Monitoring can be applied to the OH&S management system, to processes or to controls. Examples include the use of interviews, reviews of documented information and observations of work being performed.

Measurement generally involves the assignment of numbers to objects or events. It is the basis for quantitative data and is generally associated with the performance evaluation of safety programmes and health surveillance. Examples include the use of calibrated or verified equipment to measure exposure to a hazardous substance or the calculation of the safe distance from a hazard.

Analysis is the process of examining data to reveal relationships, patterns and trends. This can mean the use of statistical operations, including information from other similar organizations, to help draw conclusions from the data. This process is most often associated with measurement activities.

Performance evaluation is an activity undertaken to determine the suitability, adequacy and effectiveness of the subject matter to achieve the established objectives of the OH&S management system.

Evaluation of compliance

The frequency and timing of compliance evaluations can vary depending on the importance of the requirement, variations in operating conditions, changes in legal requirements and other requirements and the organization's past performance. An organization can use a variety of methods to maintain its knowledge and understanding of its compliance status.

Internal audit

The extent of the audit programme should be based on the complexity and level of maturity of the OH&S management system.

An organization can establish objectivity and impartiality of the internal audit by creating a process(es) that separates auditors' roles as internal auditors from their normal assigned duties, or the organization can also use external people for this function.

Management review

The terms used in relation to management review should be understood as follows:

a) "suitability" refers to how the OH&S management system fits the organization, its operation, its culture and business systems

b) adequacy" refers to whether the OH&S management system is implemented appropriately;

c) effectiveness" refers to whether the OH&S management system is achieving the intended outcome

The management review topics listed in 9 .3 a) to g) of ISO 45001 :2018 need not be addressed all at once; the organization should determine when and how the management review topics are addressed.

IMPROVEMENT -CLAUSE 10

General

The organization should consider the results from analysis and evaluation of OH&S performance, evaluation of compliance, internal audits and management review when taking action to improve.

Examples of improvement include corrective action, continual improvement, breakthrough change, innovation and re-organization

Incident, non-conformity and corrective action

On the event of occurrence of any incident or non-conformity, the organization must carry out root cause analysis and take corrective actions. Examples of incidents, nonconformities and corrective actions can include, but are not limited to:

a) incidents: same level fall with or without injury; broken leg; asbestosis; hearing loss; damage to buildings or vehicles where they can lead to OH&S risks;

b) nonconformities: protective equipment not functioning properly; failure to fulfil legal requirements and other requirements; prescribed procedures not being followed;

c) corrective actions (as indicated by the hierarchy of controls; see 8 .1.2 of ISO45001:2018): eliminating hazards; substituting with less hazardous materials; redesigning or modifying equipment or tools; developing procedures; improving the competence of affected workers; changing the frequency of use; using personal protective equipment.

Root cause analysis refers to the practice of exploring all the possible factors associated with an incident or nonconformity by asking what happened, how it happened and why it happened, to provide the input for what can be done to prevent it from happening again.

When determining the root cause of an incident or nonconformity, the organization should use methods appropriate to the nature of the incident or nonconformity being analysed. The focus of root cause analysis is prevention. This analysis can identify multiple contributory failures, including factors related to communication, competence, fatigue, equipment or procedures.

Reviewing the effectiveness of corrective actions refers to the extent to which the implemented corrective actions adequately control the root cause(s). If it does not control the root cause, it is imperative that the corrective action is not suitable. Then some other suitable corrective action may be taken. This cycle is continued till suitable corrective actions is implemented.

Continual improvement

Continual improvement is essential for survival of any system. The technology, situation, circumstances etc keep changing and are evolving. For any system to survive, it must improve to deal with changing circumstances. Continual improvement helps to improve the image of the organization in term of OH&S.

Examples of continual improvement issues include, but are not limited to:

a) new technology;

b) good practices, both internal and external to the organization;

c) suggestions and recommendations from interested parties;

d) new knowledge and understanding of occupational health and safety-related issues; new or improved materials

e) changes in worker capabilities or competence;

f) achieving improved performance with fewer resources (i.e. simplification, streamlining, etc.).

CHAPTER XI

LIST OF INDIAN STANDARDS ON SAFETY

CHAPTER XI

LIST OF INDIAN STANDARDS ON SAFETY

Chemical Hazards Standards CHD 7

SI. No.	IS No.	Title
1.	IS 10870 : 1984 Reviewed In : 2021	Code of Safety for Hexane
2.	IS 10871 : 1984 Reviewed In : 2021 Reaffirmed but not taken up for revision	Code of Safety for Hydrzine and Hydrazine Hydrate
3.	IS 10872 : 2023	Malathion Code of Safety First Revision
4.	IS 10920 : 1984 Reviewed In : 2021 Reaffirmed but not taken up for revision	Code of Safety for Phosphorus Trichloride
5.	IS 11141 : 1984 Reviewed In : 2021 Reaffirmed but not taken up for revision	Code of Safety for Acrylonitrile
6.	IS 12033 : 1986 Reviewed In : 2021 Reaffirmed but not taken up for revision	Code of Safety for Dinitrotoluene Dnt
7.	IS 12034 : 1986 Reviewed In : 2021 Reaffirmed but not taken up for revision	Code of Safety for Methyl Bromide
8.	IS 12035 : 1986 Reviewed In : 2021 Reaffirmed but not taken up for revision	Code of Safety in Microbiological Laboratories
9.	IS 12141 : 1987 Reviewed In : 2021 Reaffirmed but not taken up for revision	Code of Safety for Methyl Ethyl Ketone
10.	IS 12142 : 1987 Reviewed In : 2021 Reaffirmed but not taken up for revision	Code of Safety for 1 1 1 - Trichloro Ethane

Sl. No.	IS No.	Title
11.	IS 12143 : 1987 Reviewed In : 2021 Reaffirmed but not taken up for revision	Code of Safety for Tetrachloroethane
12.	IS 13440 : 1992 Reviewed In : 2023 Reaffirmed but not taken up for revision	Methyl Chloride - Code of Safety
13.	IS 13441 : 1992 Reviewed In : 2018 Reaffirmed but not taken up for revision	Ethyl ether - Code of safety
14.	IS 13442 : 1992 Reviewed In : 2023 Reaffirmed but not taken up for revision	Trichloro Ethylene - Code of Safety
15.	IS 13447 : 1992 Reviewed In : 2023 Reaffirmed but not taken up for revision	P - Nitro Aniline - Code of Safety
16.	IS 13910 : 1993 Reviewed In : 2023	Sulphur Dioxide - Code of Safety
17.	IS 13911 : 1993 Reviewed In : 2023	Sulphur - Code of Safety
18.	IS 13914 : 1993 Reviewed In : 2023 Reaffirmed but not taken up for revision	Perchlorates of Ammonium Potassium and Sodium - Code of Safety
19.	IS 14165 : 1995 Reviewed In : 2018	Handling Carcinogenic Substances - Code of Safety
20.	IS 14200 : 1994 Reviewed In : 2022	Hydrogen Peroxide - Code of Safety
21.	IS 1446 : 2024	Classification of Dangerous Goods Third Revision
22.	IS 14518 : 2023	Acetaldehyde - Code of Safety First Revision
23.	IS 14572 : 2022	Chloroform Code of Safety First Revision
24.	IS 14631 : 1999 Reviewed In : 2021	Styrene - Code of Safety
25.	IS 14814 : 2023	Acetylene - Code of Safety First Revision

SI. No.	IS No.	Title
26.	IS 14983 : 2022	Phosphorous White or Yellow - Code of Safety First Revision
27.	IS 14984 : 2001 Reviewed In : 2023	1 3 - Butadiene - Code of Safety
28.	IS 14985 : 2001 Reviewed In : 2023	Methyl Acrylate and Ethyl Acrylate - Code of Safety
29.	IS 15200 : 2024	Hydrogen Sulphide Code of Safety First Revision
30.	IS 15201 : 2022	Hydrogen- Code of Safety First Revision
31.	IS 15465 : 2015 ISO 10156 : 2010 Reviewed In : 2021	Gases and Gas Mixtures - Determination of Fire Potential and Oxidizing Ability for the Selection of Cylinder Valve Outlets First Revision
32.	IS 15548 : 2005 Reviewed In : 2022	Hydrofluorocarbon HFC - 134a - Code of safety
33.	IS 15656 : 2006 Reviewed In : 2023	Hazard Identification and Risk Analysis - Code of Practice
34.	IS 15738 : 2007 Reviewed In : 2023	Stable Bleaching Powder - Code of Safety
35.	IS 16529 : 2022 ISO 10298: 2018	Determination of Toxicity of a Gas or Gas Mixture First Revision
36.	IS 17752 : 2021	Testing and Evaluation of Chemical Warfare Agent Detectors Code of Practice
37.	IS 17889 : 2022	Material Safety Data Sheets - Guidelines
38.	IS 17893 : 2023	Work Permit System - Code of Practice
39.	IS 18099 : 2022	Sodium Hypochlorite - Code of Safety
40.	IS 4155 : 2023	Glossary of Terms Relating to Chemical and Radiation Hazards and Hazardous Chemicals First Revision
41.	IS 4209 : 2013 Reviewed In : 2023	Chemical laboratories - Code of safety Second Revision
42.	IS 4262 : 2022	Sulphuric acid - Code of Safety Second Revision
43.	IS 4263 : 1967 Reviewed In : 2023	Code of Safety for Chlorine
44.	IS 4264 : 2023	Caustic Soda Code of Safety First Revision
45.	IS 4312 : 1967 Reviewed In : 2021	Code of Safety for Lead and its Compounds
46.	IS 4544 : 2000 Reviewed In : 2022	Ammonia - Code of Safety First Revision

SI. No.	IS No.	Title
47.	IS 4560 : 1968 Reviewed In : 2023	Code of Safety for Nitric Acid
48.	IS 4644 : 1968 Reviewed In : 2023	Code of Safety for Benzene Toluene and Xylene
49.	IS 4906 : 2017 Reviewed In : 2022	Radiochemical Laboratory - Code of Safety First Revision
50.	IS 5184 : 1969 Reviewed In : 2021	Code of Safety for Hydrofluoric Acid
51.	IS 5208 : 1969 Reviewed In : 2023	Code of Safety for Acetic Acid
52.	IS 5302 : 1969 Reviewed In : 2021	Code of Safety for Acetic Anhydride
53.	IS 5311 : 1969 Reviewed In : 2021	Code of Safety for Carbon Tetrachloride
54.	IS 5685 : 1970 Reviewed In : 2021	Code of safety for carbon disulphide Carbon Bisulphide
55.	IS 5931 : 1970 Reviewed In : 2021	Code of safety for handling cryogenic liquids
56.	IS 6156 : 1971 Reviewed In : 2021	Code of Safety for Chlorosulphonic Acid
57.	IS 6164 : 2023	Hydrochloric Acid Code of Safety First Revision
58.	IS 6269 : 1971 Reviewed In : 2021 Reaffirmed but not taken up for revision	Code of Safety for Ethylene Oxide
59.	IS 6270 : 1971 Reviewed In : 2023	Code of Safety for Phenol
60.	IS 6818 : 1973 Reviewed In : 2021	Code of Safety for Phosphoric Acid
61.	IS 6819 : 1973 Reviewed In : 2021	Code of Safety for Calcium Carbide
62.	IS 6953 : 1973 Reviewed In : 2022	Code of Safety for Bromine
63.	IS 6954 : 1973 Reviewed In : 2021	Code of Safety for Caustic Potash
64.	IS 7415 : 1974 Reviewed In : 2023	Code of Safety for Aniline

SI. No.	IS No.	Title
65.	IS 7420 : 1974 Reviewed In : 2021	Code of Safety for Phthalic Anhydride
66.	IS 7444 : 1974 Reviewed In : 2023 Reaffirmed but not taken up for revision	Code of Safety for Methanol
67.	IS 7445 : 2022	Acetone Code of Safety First Revision
68.	IS 7812 : 1975 Reviewed In : 2021 Reaffirmed but not taken up for revision	Code of Safety for Mercury
69.	IS 8185 : 1976 Reviewed In : 2021	Code of Safety for Phosgene
70.	IS 8388 : 1977 Reviewed In : 2023	Code of Safety for Nitrobenzene
71.	IS 9052 : 1978 Reviewed In : 2021 Reaffirmed but not taken up for revision	Code of safety for Aluminium Chloride Anhydrous
72.	IS 9053 : 1978 Reviewed In : 2021 Reaffirmed but not taken up for revision	Code of Safety for m - Dinitrobenzene
73.	IS 9277 : 1979 Reviewed In : 2021	Code of Safety for Monochlorobenzene
74.	IS 9278 : 1979 Reviewed In : 2021	Code of Safety for Zinc Phosphide
75.	IS 9279 : 2023	Clamp Compression Muller 39 s Pattern - Specification First Revision
76.	IS 9744 : 1981 Reviewed In : 2021	Code of Safety for Thionyl Chloride
77.	IS 9785 : 1981 Reviewed In : 2021 Reaffirmed but not taken up for revision	Code of Safety for Aluminium Alkyls
78.	IS 9786 : 1981 Reviewed In : 2023	Code of Safety for Vinyl Chloride VCM
79.	IS 9787 : 1981 Reviewed In : 2021	Code of Safety for Phosphoryl Chloride

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SI. No.	IS No. & Year	TITLE
1.	IS 10245 (Part 1) : 1996 Reviewed In : 2022	Breathing Apparatus Part 1 closed circuit breathing apparatus Compressed Oxygen Cylinder - Specification First Revision
2.	IS 10245 (Part 2) : 2023	Respiratory Protective Devices - Specification Part 2 self-contained open circuit breathing apparatus Second Revision
3.	IS 10245 (Part 3) : 1999 Reviewed In : 2022	Breathing Apparatus Part 3 fresh air hose and compressed air line breathing apparatus - Specification First Revision
4.	IS 10245 (Part 4) : 1982 Reviewed In : 2019	Specification for breathing apparatus Part 4 escape breathing apparatus Short Duration Self - Contained Type
5.	IS 13293 : 1992 Reviewed In : 2019 Reaffirmed but not taken up for revision	Gas Detector Tubes - General Requirements and Methods of Test
6.	IS 13366 : 1992 Reviewed In : 2019	Resuscitators Intended for Use with Humans - Specification
7.	IS 14138 (Part 1) : 2024	Respiratory Protective Devices - Threads for Facepieces - Specification Part 1 standard thread connection First Revision
8.	IS 14138 (Part 2) : 2024	Respiratory Protective Devices - Threads for Facepieces - Specification Part 2 centre thread connection First Revision
9.	IS 14166 : 1994 Reviewed In : 2019	Respiratory Protective Devices Full - Face Masks - Specification
10.	IS 14170 : 2024	Respiratory Protective Devices - Mouthpiece Assemblies - Specification First Revision
11.	IS 14746 : 1999 Reviewed In : 2019	Respiratory Protective Devices - Half Masks and Quarter Masks - Specification
12.	IS 15322 : 2003 Reviewed In : 2019	Particle Filters used in Respiratory Protective Equipment - Specification
13.	IS 15323 : 2003 Reviewed In : 2019	Gas Filters and Combined Filters used in Respiratory Protective Equipment - Specification
14.	IS 15803 : 2008 Reviewed In : 2023	Respiratory Protective Devices - Self Contained Closed Circuit Breathing Apparatus Chemical Oxygen KO2 Type Self Generating Self Rescuers - Specification

SI. No.	IS No. & Year	TITLE
15.	IS 3521 (Part 1) : 2021	Personal fall arrest systems - Specification Part 1 full body harness Fourth Revision
16.	IS 3521 (Part 2) : 2021	Personal fall arrest systems - Specification Part 2 lanyards and energy absorbers
17.	IS 3521 (Part 3) : 2021 ISO 10333-3	Personal fall arrest systems - Specification Part 3 self-retracting lifelines
18.	IS 3521 (Part 4) : 2021 ISO 10333-4	Personal fall arrest systems - Specification Part 4 vertical rails and vertical lifelines incorporating a sliding-type fall arrester
19.	IS 3521 (Part 5) : 2021 ISO 10333-5	Personal fall arrest systems - Specification Part 5 connectors with self-closing and self-locking gates
20.	IS 3521 (Part 7) : 2021ISO	14567 : 1999 Personal fall arrest systems - Specification Part 7 Single point anchor devices
21.	IS 3521 (Part 8) : 20210	Personal fall arrest systems - Specification Part 8 Flexible horizontal lifeline systems
22.	IS 3521 (Part 9) : 20210	Personal fall arrest systems - Specification Part 9 Descending devices
23.	IS 8095 : 1976 Reviewed In : 2023	Specification for accident prevention tags
24.	IS 8521 (Part 1) : 2022 ISO 16321-1	Eye and face protection for occupational use Part 1 General requirements First Revision
25.	IS 8521 (Part 2) : 2022 ISO 16321-3	Eye and face protection for occupational use Part 2 Additional requirements for mesh protectors First Revision
26.	IS 9167 : 1979 Reviewed In : 2021	Specification for ear protectors
27.	IS 9473 : 2002 Reviewed In : 2019	Respiratory protective devices - Filtering half masks to protect against particles - Specification First Revision
28.	IS 9937 : 1981 Reviewed In : 2018 Reaffirmed but not taken up for revision	Specification for portable methanometer Electrical Type

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SI. No.	IS No.	Title
1.	IS 10460 : 1983 Reviewed In : 2020	FUNCTIONAL REQUIREMENTS FOR SMALL FOAM TENDER FOR FIRE BRIGADE USE
2.	IS 10993 : 1984 Reviewed In : 2020	Functional requirements for 2000 kg dry powder tender for fire brigade use
3.	IS 11101 : 1984 Reviewed In : 2017	Specification for extended branch pipe for fire brigade use
4.	IS 11108 : 1984 Reviewed In : 2020	Specification for portable fire extinguishers - Halon 1211 type
5.	IS 11360 : 1985 Reviewed In : 2020	Specification for smoke detectors for use in automatic electrical fire alarm system
6.	IS 11833 : 1986 Reviewed In : 2017	Specification For Dry Powder Fire Extinguisher For Metal Fires
7.	IS 12717 : 1989 Reviewed In : 2020	Fire fighting equipment - High capacity portable pump set 1100 - 1600 L min - Functional requirements
8.	IS 12796 : 1989 Reviewed In : 2020	Fire rake - Specification
9.	IS 12805 : 1989 Reviewed In : 2020	Tool mcleod for fighting forest fires - Specification
10.	IS 12835 (Part 1) : 2021	Design And Installation Of Fixed Foam Fire Extinguishing System - Code Of Practice Part 1 Low Expansion Foam First Revision
11.	IS 12853 : 1989 Reviewed In : 2020	Specification pulaski tool for forest fire
12.	IS 12859 : 1989 Reviewed In : 2020	Fire fighting - Brush hook for forest fires - Specification
13.	IS 12861 : 1989 Reviewed In : 2020	\Fire fighting - Double bit axe for forest fires - Specification
14.	IS 12862 : 1989 Reviewed In : 2020	Fire fighting - Shovel for forest fires - Specification
15.	IS 13039 : 2014 Reviewed In : 2019	External hydrant systems - provision and maintenance - Code of practice First Revision
16.	IS 14851 : 2000 Reviewed In : 2020	Maintenance of fire hose - Code of practice
17.	IS 14933 : 2001 Reviewed In : 2020	High Pressure Fire Fighting Hose -Specification

SI. No.	IS No.	Title
18.	IS 14951 : 2001 Reviewed In : 2020	Fire extinguisher - 135 litres capacity mechanical foam type - Specification
19.	IS 15051 : 2001 Reviewed In : 2017	High pressure fire hose delivery couplings - Specification
20.	IS 15105 : 2021	Design and Installation of Fixed Automatic Sprinkler Fire Extinguishing Systems - Code of Practice
21.	IS 15220 : 2002 Reviewed In : 2017	Halogenated hydrocarbons - Halon 1211 and halon 1401 - Fire extinguishing media - Specification
22.	IS 15221 : 2002 Reviewed In : 2017	Safe handling and transfer procedures of halon1211 and halon 1401 Halogenated Hydrocarbons - Fire extinguishing media - Code of practice
23.	IS 15222 : 2002 Reviewed In : 2017	Carbon dioxide as fire extinguishing media for fire protection - Specification
24.	IS 15301 : 2003 Reviewed In : 2018	Installation and Maintenance of Fire Fighting Pumps - Code of Practice
25.	IS 15325 : 2020	Design and Installation of Fixed Automatic High and Medium Velocity Water Spray System Code of Practice First Revision
26.	IS 15493 : 2021	Gaseous Fire Extinguishing Systems - General Requirements First Revision
27.	IS 15496 : 2004 Reviewed In : 2020	Inspection and maintenance of gaseous fire extinguishing systems - Code of practice
28.	IS 15497 : 2004 Reviewed In : 2020	Gaseous fire extinguishing systems - IG 01 extinguishing systems
29.	IS 15501 : 2004 Reviewed In : 2020	Gaseous fire extinguishing systems - IG 541 extinguishing systems
30.	IS 15505 : 2004 Reviewed In : 2020	Gaseous fire extinguishing systems - HCFC blend a extinguishing systems
31.	IS 15506 : 2004 Reviewed In : 2020	Gaseous fire extinguishing systems - IG 55 extinguishing systems
32.	IS 15517 : 2004 Reviewed In : 2020	Gaseous fire extinguishing systems - HFC 227ea Hepta Fluoro Propane extinguishing systems
33.	IS 15519 : 2020	Water Mist Fire Protection Systems - System Design Installation and Commissioning - Code of Practice First Revision
34.	IS 15525 : 2004 Reviewed In : 2020	Gaseous fire extinguishing systems - IG 100 extinguishing systems

Sl. No.	IS No.	Title
35.	IS 15528 : 2004 Reviewed In : 2020	Gaseous fire extinguishing systems - Carbon dioxide total flooding and local application Sub - Floor And In - Cabinet high and low pressure Refrigerated systems
36.	IS 15682 : 2006 Reviewed In : 2017	Fire fighting vehicles and equipment - Symbols for operator controls and other display
37.	IS 15683 : 2018	Portable Fire Extinguishers Performance and Construction Specification First Revision
38.	IS 15811 : 2008 Reviewed In : 2018	Long - Range water - Cum - Foam monitor with self - Inducting aspirating and non - Aspirating jetand spray fog nozzle for fire fighting - Specification
39.	IS 15821 : 2008 Reviewed In : 2018	Gaseous fire extinguishing systems - Physical properties and system design - CF4I extinguishant
40.	IS 15835 : 2009 Reviewed In : 2020	Gaseous Fire Extinguishing Systems - HCFC-125 Extinguishing Systems
41.	IS 15908 : 2021	Selection installation and maintenance of control and indicating equipments for fire detection and alarm system - Code of Practice First Revision
42.	IS 16018 : 2012 Reviewed In : 2017	Wheeled fire extinguishers - Performance and construction - Specification
43.	IS 16088 : 2012 Reviewed In : 2017	Chlorinated polyvinyl chloride CPVC pipes for automatic sprinkler fire extinguishing system - Specification
44.	IS 16095 : 2013 Reviewed In : 2018	Hazmat vehicle - Specification
45.	IS 16109 : 2013 Reviewed In : 2018	Turntable ladder - Specification
46.	IS 16534 : 2017	Chlorinated Polyvinyl Chloride CPCV Pipe Fittings for Automatic Sprinkler Fire Extinguishing System - Specification
47.	IS 1941 (Part 1) : 1976 Reviewed In : 2017	Functional requirements for electric motor sirens Part 1 ac 4 - Phase 50 hz 415 volts type Second Revision
48.	IS 2097 : 2012 Reviewed In : 2017	Foam making branch pipe and foam inductor - Specification Second Revision
49.	IS 2175 : 1988 Reviewed In : 2020	Specificationfor heat sensitivefiredetectorsfor usein automaticfirealarm system Second Revision
50.	IS 2189 : 2008 Reviewed In : 2018	Selection installation and maintenance of automatic fire detection and alarm system code of practice Fourth Revision

SI. No.	IS No.	Title
51.	IS 2190 : 2010 Reviewed In : 2020	Selection installation and maintenance of first-aid fire extinguishers - Code of practice Fourth Revision
52.	IS 2546 : 1974 Reviewed In : 2020	Specification for galvanized mild steel fire bucket First Revision
53.	IS 2696 : 1974 Reviewed In : 2017 Reaffirmed but not taken up for revision	Functional requirements for 1 125-1 min light fire engine First Revision
54.	IS 2745 : 1983 Reviewed In : 2020	Specification for non - Metal helmet for firemen and civil defence personnel Second Revision
55.	IS 2871 : 2012 Reviewed In : 2017	Branch pipe universal for fire fighting purpose - Specification Second Revision
56.	IS 2925 : 1984 Reviewed In : 2020	Specification for industrial safety helmets Second Revision
57.	IS 2925 : 1984 Reviewed In : 2015	Specification for Industrial Safety Helmets Bi-Lingual
58.	IS 2930 : 1980 Reviewed In : 2017	Functional requirements for hose laying tender for fire brigade use First Revision
59.	IS 3582 : 1984 Reviewed In : 2020	Basket Strainers For Fire Fighting Purposes cylindrical Type First Revision
60.	IS 3744 : 1985 Reviewed In : 2020	Specification hose binding machine
61.	IS 3844 : 1989 Reviewed In : 2020	Code of practice for installation and maintenance of internal fire hydrants and hose reels on premises First Revision
62.	IS 4151 : 2015 Reviewed In : 2020	Protective helmets for motorcycle riders - Specification Fourth Revision
63.	IS 4308 : 2019	Dry Chemical Powders for Fire Fighting BC ABC and D Types Specification Third Revision
64.	IS 4571 : 1977 Reviewed In : 2020	Specification for aluminium extension ladders for fire brigade use First Revision
65.	IS 4643 : 1984 Reviewed In : 2020	Specification for suction wrenches for fire brigade use First Revision
66.	IS 4862 (Part 1) : 1986 Reviewed In : 2020	Specification for portable fire extinguisher for aircraft Part 1 halon 1211 type First Revision
67.	IS 4927 : 1992 Reviewed In : 2017	Unlined flax canvas hose for fire fighting - Specification First Revision

SI. No.	IS No.	Title
68.	IS 4928 : 1986 Reviewed In : 2020	Specification for delivery valve for centrifugal fire pump outlets First Revision
69.	IS 4947 : 2006 Reviewed In : 2022	GAS CARTRIDGES FOR USE IN FIRE EXTINGUISHERS - SPECIFICATION Third Revision
70.	IS 4989 : 2018	Foam concentrate for producing mechanical foam for fire fighting - Specification Fourth Revision
71.	IS 4989 (Part 4) : 2003 Reviewed In : 2018	Multipurpose aqueous film forming foam liquid concentrate for extinguishing hydrocarbon and polar solvent fires - Specification
72.	IS 5131 : 2002 Reviewed In : 2017	Dividing Breeching with Control for Fire Brigade Use -Specification Second Revision
73.	IS 5290 : 1993 Reviewed In : 2018	Landing valves - Specification Third Revision
74.	IS 5486 : 1985 Reviewed In : 2020	Specification for quick release knife First Revision
75.	IS 5505 : 1985 Reviewed In : 2020	Specification for multi - Edged rescue axe Non - Wedging First Revision
76.	IS 5612 (Part 1) : 1977 Reviewed In : 2017	Specification for hose - Clamps and hose - Bandages for fire brigade use Part 1 hose - Clamps First Revision
77.	IS 5612 (Part 2) : 1977 Reviewed In : 2017	Specification for hose - Clamps and hose - Bandages for fire brigade use Part 2 hose - Bandages First Revision
78.	IS 5714 : 1981 Reviewed In : 2017	Specification for hydrant stand - Pipe for fire fighting First Revision
79.	IS 5888 : 1970 Reviewed In : 2020	Code of practice for design and construction of fire service drill - Tower
80.	IS 5896 (Part 1) : 1970 Reviewed In : 2020	Code of practice for selection operation and maintenance of special fire fighting appliances Part 1 combined foam and cop crash tender
81.	IS 5896 (Part 3) : 1975 Reviewed In : 2017	Code of practice for selection operation and maintenance of fire fighting appliances Part 3 Turntable ladders
82.	IS 6026 : 1985 Reviewed In : 2020	Specification for hand - Operated sirens First Revision
83.	IS 6067 : 1983 Reviewed In : 2020	Functional Requirements for Water Tender Type X 39 for Fire Brigade Use First Revision
84.	IS 6070 : 1983 Reviewed In : 2020	Code of practice for selection operation and maintenance of trailer fire pumps portable pumps water tenders and motor fire engines First Revision

SI. No.	IS No.	Title
85.	IS/ISO 6182-7 : 2004 ISO 6182-7 : 2004 Reviewed In : 2018	Fire protection - Automatic sprinkler systems Part 7 requirements and test methods for early suppression fast response Esfr sprinklers
86.	IS/ISO 7240-2 : 2003 ISO 7240-2 : 2003	Fire detection and alarm systems Part 2 control and indicating equipment
87.	IS/ISO 7240-3 : 2010 ISO 7240-3 : 2010	Fire detection and alarm systems Part 3 audible alarm devices
88.	IS/ISO 7240-4 : 2003 ISO 7240-4 : 2003	Fire detection and alarm systems Part 4 power supply equipment
89.	IS/ISO 7240-5 : 2012 ISO 7240-5 : 2012	Fire Detection and Alarm Systems Part 5 Point-Type Heat Detectors
90.	IS/ISO 7240-6 : 2011 ISO 7240-6 : 2011	Fire detection and alarm systems Part 6 carbon monoxide fire detectors using electro - Chemical cells
91.	IS/ISO 7240-7 : 2011 ISO 7240-7 : 2011 Reviewed In : 2018	Fire detection and alarm systems Part 7 point - Type smoke detectors using scattered light transmitted light or ionization
92.	IS/ISO 7240-8 : 2014 ISO 7240-8 : 2014	Fire Detection and Alarm Systems Part 8 Point-Type Fire Detectors Using a Carbon Monoxide Sensor in Combination with a Heat Sensor
93.	IS/ISO 7240-10 : 2012 ISO 7240-10 : 2012	Fire Detection and Alarm Systems Part 10 Point-Type Flame Detectors
94.	IS/ISO 7240-1 : 2011 ISO 7240-11 : 2011 Reviewed In : 2018	Fire detection and alarm systems Part 11 manual call points
95.	IS/ISO 7240-12 : 2014 ISO 7240 -12 : 2014	Fire detection and alarm systems Part 12 line type smoke detectors using a transmitted optical beam
96.	IS/ISO 7240-13 : 2005 ISO 7240-13 : 2005	Fire Detection and Alarm Systems Part 13 Compatibility Assessment of System Components
97.	IS/ISO 7240-15 : 2004 ISO 7240-15 : 2004 Reviewed In : 2018	Fire detection and alarm systems Part 15 point type fire detectors using scattered light transmitted light or ionization sensors in combination with a heat sensor
98.	IS/ISO 7240-16 : 2007 ISO 7240-16 : 2007	Fire detection and alarm systems Part 16 sound system control and indicating equipment
99.	IS/ISO 7240-17 : 2009 ISO 7240-17 : 2009	Fire detection and alarm systems Part 17 short - Circuit isolators
100.	IS/ISO 7240-18 : 2017 ISO 7240-18 : 2017	Fire Detection and Alarm Systems Part 18 Input Output Devices

SI. No.	IS No.	Title
101.	IS/ISO 7240-20 : 2010 ISO 7240-20 : 2010	Fire detection and alarm systems Part 20 aspirating smoke detectors
102.	IS/ISO 7240-21 : 2005 ISO 7240-21 : 2005	Fire Detection and Alarm Systems Part 21 Routing Equipment
103.	IS/ISO 7240-22 : 2017 ISO 7240-22 : 2017	Fire Detection and Alarm Systems Part 22 Smoke-Detection Equipment for Ducts
104.	IS/ISO 7240-23 : 2013 ISO 7240-23 : 2013	Fire Detection and Alarm Systems Part 23 Visual Alarm Devices
105.	IS/ISO 7240-24 : 2016 ISO 7240-24 : 2016	Fire Detection and Alarm Systems Part 24 Fire Alarm Loudspeakers
106.	IS/ISO 7240-25 : 2010 ISO 7240-25 : 2010	Fire Detection and Alarm Systems Part 25 Components Using Radio Transmission Paths
107.	IS/ISO 7240-27 : 2018 ISO 7240-27 : 2018	Fire Detection and Alarm Systems Part 27 Point Type Fire Detectors Using a Smoke Sensor in Combination with a Carbon Monoxide Sensor and Optionally One or More Heat Sensors
108.	IS/ISO 7240-29 : 2017	Fire Detection and Alarm Systems Part 29 Video Fire Detectors
109.	IS 7673 : 2004 Reviewed In : 2018	Fire Fighting Equipment - Glossary of Terms First Revision
110.	IS 7692 : 1993 Reviewed In : 2018	Headforms for testing of helmets - Specification First Revision
111.	IS 8090 : 1976 Reviewed In : 2020	Specification for couplings branch pipe nozzle used in hose reel tubing for fire fighting First Revision
112.	IS 8096 : 1992 Reviewed In : 2017	Fire beaters - Specification First Revision
113.	IS 8423 : 1994 Reviewed In : 2020	Specification for controlled percolating hose for fire fighting First revision
114.	IS 8442 : 2008 Reviewed In : 2018	Stand post type water and foam monitor for fire fighting - Specification First Revision
115.	IS 884 : 1985 Reviewed In : 2020	Specification for first - Aid hose - Reel for fire fighting First Revision
116.	IS 901 : 1988 Reviewed In : 2017	Specification for couplings double male and double female instantaneous pattern for fire fighting Third Revision
117.	IS 902 : 1992 Reviewed In : 2017	Suction hose couplings for fire fighting purposes - Specification Third Revision

Sl. No.	IS No.	Title
118.	IS 903 : 1993 Reviewed In : 2018	Specification for Fire Hose Delivery Couplings Branch Pipe Nozzles And Nozzle Spanner - Specification Fourth Revision
119.	IS 904 : 1983 Reviewed In : 2020	Specification for 2 - Way and 4 - Way suction collecting heads for fire fighting purposes Second Revision
120.	IS 905 : 1980 Reviewed In : 2017	Specification for delivery breechings dividing and collecting instantaneous pattern for fire fighting purposes Second Revision
121.	IS 906 : 1988 Reviewed In : 2020	Specification for revolving branch pipe for fire fighting Third Revision
122.	IS 907 : 1984 Reviewed In : 2020	Specification for suction strainers cylindrical type for fire fighting purposes Second Revision
123.	IS 908 : 1975 Reviewed In : 2020	Specification for fire hydrant stand post type Second Revision
124.	IS 909 : 1992 Reviewed In : 2017	Underground fire hydrant sluice valve type - Specification Third Revision
125.	IS 910 : 1980 Reviewed In : 2017	Specification for combined key for hydrant hydrant cover and lower valve Second Revision
126.	IS 926 : 1985 Reviewed In : 2020	Specification For Fireman 39 s Axe Second Revision
127.	IS 927 : 1981 Reviewed In : 2017	Specification for fire hooks Second Revision
128.	IS 928 : 1984 Reviewed In : 2020	Specification for fire bells Second Revision
129.	IS 937 : 1981 Reviewed In : 2017	Specification for Washers For Water Fittings For Fire Fighting Purposes Second Revision
130.	IS 939 : 1977 Reviewed In : 2017	Specification for Snatch Block for Use with Fibre Rope for Fire Brigade Use First Revision
131.	IS 941 : 1985 Reviewed In : 2020	Specification for blower and exhauster - For fire fighting Second Revision
132.	IS 942 : 1982 Reviewed In : 2020 Reaffirmed but not taken up for revision	Functional requirements for 275 1 min portable pump set for fire fighting Second Revision
133.	IS 943 : 1979 Reviewed In : 2018 Reaffirmed but not taken up for revision	Functional Requirements for 680-1 Min Trailer Pump For Fire Brigade Use Second Revision

SI. No.	IS No.	Title
134.	IS 944 : 1979 Reviewed In : 2017	Functional requirements of 1800-1 min trailer pump for fire brigade use Second Revision
135.	IS 947 : 1985 Reviewed In : 2017 Reaffirmed but not taken up for revision	Specification for washers for water fittings for fire fighting purposes Second Reuision
136.	IS 948 : 1983 Reviewed In : 2020	Functional Requirements for Water Tender Type A 39 for Fire Brigade Use Second Revision
137.	IS 949 : 2012 Reviewed In : 2017	Specification for snatch block for use with fibre rope for fire brigade use First Revision
138.	IS 950 : 2012 Reviewed In : 2017	Functional requirements for water tender type B for fire brigade use Third Revision
139.	IS 951 : 2003 Reviewed In : 2018	Functional requirements for crash fire tender for air fields Fourth Revision
140.	IS 952 : 2012 Reviewed In : 2017	Fog nozzle for fire brigade use - Specification Second Revision
141.	IS 955 : 1980 Reviewed In : 2018	Functional requirements for dry powder tender for fire brigade use First Revision
142.	IS 956 : 2004 Reviewed In : 2020	Functional requirements for rescue tender for air fields Second Revision
143.	IS 9562 : 1980 Reviewed In : 2017	Specification for non - Metal helmet for police force
144.	IS 957 : 1967 Reviewed In : 2020	Specification for control van for fire brigade use
145.	IS 9668 : 1990 Reviewed In : 2020	Provision and maintenance of water supplies for fire fighting - Code of practice First Revision
146.	IS 9695 : 1980 Reviewed In : 2020	Methods for sampling of helmets
147.	IS 9972 : 2002 Reviewed In : 2017	Specification for automatic sprinkler heads for fire protection service First Revision
148.	IS 9973 : 1981 Reviewed In : 2017	Specification for visor for scooter helmets
149.	IS 9995 : 1981 Reviewed In : 2017	Specification for visor for non-metal police and firemen helmets

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SI. No.	IS No.	Title
1.	IS 13214 (Part 1) : 2020 ISO 7250-1 : 2017	Basic Human Body Measurements for Technological Design Part 1 Body Measurement Definitions and Landmarks Second Revision
2.	IS 13214 (Part 3) : 2019 ISO 7250-3 : 2016	Basic human body measurements for technological design Part 3 worldwide and regional design ranges for use in product standards
3.	IS 15257 : 2018 ISO 1503 : 2008	Spatial orientation and direction of movement - Ergonomics requirements First Revision
4.	IS 15836 (Part 1) : 2008 ISO 15534-1 Reviewed In : 2023	Ergonomic design for the safety of machinery Part 1 principles for determining the dimensions required for openings for whole - Body access into machinery
5.	IS 15836 (Part 2) : 2008 ISO 15534-2 Reviewed In : 2021	Ergonomic design for the safety of machinery Part 2 principles for determining the dimensions required for access openings
6.	IS 15836 (Part 3) : 2008 15534-3Reviewed In : 2021	Ergonomic design for the safety of machinery Part 3 anthropometric data
7.	IS 16559 : 2019 ISO 7243 : 2017	Ergonomics of the Thermal Environment Assessment of Heat Stress Using the WBGT Wet Bulb Globe Temperature Index First Revision
8.	IS 16560 : 2017 ISO 7726 : 1998 Reviewed In : 2022	Ergonomics of the Thermal Environment Instruments for Measuring Physical Quantities
9.	IS 16561 (Part 1) : 2017 ISO 11604-1 : 2000 Reviewed In : 2022	Ergonomic design of control centres Part 1 principles for the design of control centres
10.	IS 16561 (Part 2) : 2017 ISO 11064-2 : 2000 Reviewed In : 2022	Ergonomic design of control centres Part 2 Principles for the Arrangement of Control Suites
11.	IS 16561 (Part 4) : 2017 ISO 11064-4 : 2013 Reviewed In : 2022	Ergonomic design of control centres Part 4 layout and dimensions of workstations
12.	IS 16561 (Part 5) : 2018 ISO 11064-5 : 2008 Reviewed In : 2023	Ergonomic design of control centres Part 5 displays and controls
13.	IS 16561 (Part 6) : 2022 ISO 11604-6	ERGONOMIC DESIGN OF CONTROL CENTRES PART 6 ENVIRONMENTAL REQUIREMENTS FOR CONTROL ROOMS

SI. No.	IS No.	Title
14.	IS 16562 (Part 1) : 2017 ISO 15536-1 : 2005 Reviewed In : 2022	Ergonomics - Computer manikins and body templates Part 1 general requirements
15.	IS 16562 (Part 2) : 2018 ISO 15536 (Part 2) : 2007 Reviewed In : 2023	Ergonomics - Computer manikins and body templates Part 2 verification of functions and validation of dimensions for computer manikin systems
16.	IS 16563 (Part 2) : 2017 ISO 9355-2 : 1999 Reviewed In : 2022	Ergonomic requirements for the design of displays and control actuators Part 2 displays
17.	IS 16563 (Part 3) : 2017 ISO 9355-3 : 2006 Reviewed In : 2022	Ergonomic requirements for the design of displays and control actuators Part 3 control actuators
18.	IS 16564 : 2018 ISO 24504 : 2014 Reviewed In : 2023	Ergonomics - Accessible design - Sound pressure levels of spoken announcements for products and public address systems
19.	IS 16565 : 2018 ISO 24503 : 2011	Ergonomics - Accessible design - Tactile dots and bars on consumer products
20.	IS 16566 : 2017 ISO 24502 : 2010 Reviewed In : 2022	Ergonomics-Accessible Design-Specification of Age Related Luminance Contrast for Coloured Light
21.	IS 16567 : 2018 ISO 24501 : 2010 Reviewed In : 2023	Ergonomics - Accessible design - Sound pressure levels of auditory signals for consumer products
22.	IS 16568 : 2017 ISO 24500 : 2010 Reviewed In : 2022	Ergonomics - Accessible design - Auditory signals for consumer products
23.	IS 16569 : 2018 ISO 11429 : 1996 Reviewed In : 2023	Ergonomics - System of auditory and visual danger and information signals
24.	IS 16570 : 2017 ISO 11428 : 1996 Reviewed In : 2022	Ergonomics - Visual danger signals - General requirements design and testing
25.	IS 16572 : 2017 ISO 14738 : 2002 Reviewed In : 2022	Safety of machinery - Anthropometric requirements for the design of workstations at machinery
26.	IS 16573 : 2017 ISO 15535: 2012 Reviewed In : 2022	General requirements for establishing anthropometric databases

SI. No.	IS No.	Title
27.	IS 16574 : 2017 ISO 15537 : 2004	Principles for selecting and using test persons for testing anthropometric aspects of industrial products and designs
28.	IS 16595 (Part 5) : 2018 9241-5 : 1998	Ergonomic Requirements for Office Work With Visual Display Terminals VDTs Part 5 Workstation Layout and Postural Requirements
29.	IS 16595 (Part 11) : 2020 ISO 9241-11 : 1998	Ergonomics of Human-System Interaction Part 11 Usability Definitions and Concepts First Revision
30.	IS 16595 (Part 20) : 2018 ISO 9241-20 : 2008	Ergonomics of Human - System Interaction Part 20 Accessibility Guidelines for Information Communication Technology ICT Equipment and Services
31.	IS 16595 (Part 110) : 2023 ISO 9241-110:2020	Ergonomics of human-system Interaction Part 110 Interaction principles ISO 9241-110
32.	IS 16595 (Part 154) : 2018 ISO 9241-154 : 2013 Reviewed In : 2023	Ergonomics of human - System interaction Part 154 interactive voice response IVR applications
33.	IS 16595 (Part 171) : 2023 ISO 9241-171 : 2008	Ergonomics of human-system interaction Part 171 Guidance on software accessibility ISO 9241-171
34.	IS 16595 (Part 210) : 2023 ISO 9241-210:2019	Ergonomics of human-system interaction Part 210 Human-centred design for interactive systems ISO 9241-210
35.	IS 16595 (Part 300) : 2023 ISO 9241-300:2008	Ergonomics of human-system Interaction Part 300 Introduction to electronic visual display requirements ISO 9241-300
36.	IS 16595 (Part 302) : 2023 ISO 9241-302:2008	Ergonomics of human-system Interaction Part 302 Terminology for electronic visual displays ISO 9241-302
37.	IS 16595 (Part 410) : 2023 ISO 9241-410 : 2008	Ergonomics of human-system interaction part 410 design criteria for physical input devices ISO 9241-410
38.	IS 16595 (Part 411) : 2023 ISO/TS 9241-411 : 2012	Ergonomics of human-system Interaction Part 411 Evaluation method for the design of physical input devices ISO 9241-411
39.	IS 16595 (Part 971) : 2023 ISO 9241-971:2020	Ergonomics of human-system Interaction Part 971 Accessibility of tactilehaptic interactive systems ISO 9241-971
40.	IS 17009 : 2018 ISO 11226 : 2000	Ergonomics - Evaluation of static working postures

SI. No.	IS No.	Title
41.	IS 17030 : 2018 ISO 20685 : 2010	3 - D scanning methodologies for internationally compatible anthropometric databases
42.	IS 17030 (Part 2) : 2019 ISO 20685-2 : 2015	Ergonomics 3 - D scanning methodologies for internationally compatible anthropometric databases Part 2 evaluation protocol of surface shape and repeatability of relative landmark positions
43.	IS 17031 (Part 1) : 2018 ISO 11228-1 : 2003	Ergonomics Manual Handling Part 1 Lifting and Carrying
44.	IS 17031 (Part 2) : 2019 ISO 11228-2 : 2007	Ergonomics Manual Handling Part 2 Pushing and Pulling
45.	IS 17031 (Part 3) : 2018 ISO 11228-3 : 2003	Ergonomics Manual Handling Part 3 Handling of Low Loads at High Frequency
46.	IS 17032 : 2018 ISO/TS 20646 : 2014	Ergonomics Guidelines for the Optimization of Musculoskeletal Workload
47.	IS 17033 : 2018	Ergonomics - Manual handling of people in the healthcare sector
48.	IS 17102 : 2019 ISO 7731 : 2003	Ergonomics - Danger signals for public and work areas - Auditory danger signals
49.	IS 17103 : 2019 ISO 9886 : 2004	Ergonomics - Evaluation of thermal strain by physiological measurements
50.	IS 17104 : 2019 ISO 10551 ; 1995	Ergonomics of the thermal environment - Assessment of the influence of the thermal environment using subjective judgement scales
51.	IS 17105 : 2019 ISO 28802 : 2012	Ergonomics of the physical environment - Assessment of environments by means of an environmental survey involving physical measurements of the environment and subjective responses of people
52.	IS 18232 : 2023 ISO 24508 : 2019	Ergonomics Accessible design Guidelines for designing tactile symbols and characters ISO 24508-2019
53.	IS 18254 : 2023 ISO 28803 : 2012	Ergonomics of the physical environment Application of International Standards to people with special requirements Adoption of ISO 28803 2012
54.	IS 18259 : 2023 ISO 24505 : 2016	Ergonomics Accessible design Method for creating colour combinations taking account of age-related changes in human colour vision ISO 24505

SI. No.	IS No.	Title
55.	IS 18263 (Part 1) : 2023 ISO 10075-1 : 2017	Ergonomic principles related to mental workload Part 1 General issues and concepts terms and definitions
56.	IS 18263 (Part 3) : 2023 ISO 10075-3 : 2004	Ergonomic principles related to mental workload Part 3 Principles and requirements concerning methods for measuring and assessing mental workload
57.	IS/ISO 26800 : 2011 ISO 26800 : 2011 Reviewed In : 2023	Ergonomics General Approach Principles and Concepts
58.	IS/ISO 27500 : 2016 ISO 27500 : 2016 Reviewed In : 2023	The Human - Centered Organization - Rationale and General Principles
59.	IS 4838 : 1990 Reviewed In : 2020	Anthropometric dimensions for school children age group 5 - 17 years Second Revision

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BIBLIOGRAPHY

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BIBLIOGRAPHY

[1] ISO 9000:2015, Quality management systems — Fundamentals and vocabulary

[2] ISO 9001, Quality management systems — Requirements

[3] ISO 14001, Environmental management systems — Requirements with guidance for use

[4] ISO 19011, Guidelines for auditing management systems

[5] ISO 20400, Sustainable procurement — Guidance

[6] ISO 26000, Guidance on social responsibility

[7] ISO 31000, Risk management — Guidelines

[8] ISO 37500, Guidance on outsourcing

[9] ISO 39001, Road traffic safety (RTS) management systems — Requirements with guidance for use

[10] ISO Guide 73:2009, Risk management — Vocabulary

[11] IEC 31010, Risk management — Risk assessment techniques

[12] ILO. Guidelines on occupational safety and health management systems, ILO-OSH 2001. 2nd ed. International Labour Office, Geneva, 2009. Available at: http://www.ilo.org/safework/info/standards-and-instruments/WCMS_107727/lang—en/index.htm

[13] ILO. International Labour Standards (including those on occupational safety and health).International Labour Office, Geneva. Available at: http://www.ilo.org/normlex (click on "instruments", then "Conventions and Recommendations by subject")

[14] OHSAS 18001. Occupational health and safety management systems — Requirements. 2nd ed. OHSAS Project Group, London, July 2007, ISBN 978 0 580 50802 8

[15] OHSAS 18002. Occupational health and safety management systems — Guidelines for the implementation of OHSAS 18001:2007. 2nd ed. OHSAS Project Group, London, Nov 2008, ISBN 978 0 580 61674 7

[16] The standards by CHD 7, CHD 8, CED 22 and PGD 15 that are mentioned in Annex-A, Annex-B, Annex-C and Annex-D respectively.

[17] Industrial Safety Management: Hazard Identification and Risk Control by L.M.Deshmukh

[18] European Commission's training material on "Introduction to Toxicology" and "Industrial Toxicology" Lifoia Clement. ILO reports, OSHA standards, ISO standards