MCN 401

INDUSTRIAL SAFETY ENGINERING

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Definition of industrial safety

- Safety is the state of being "safe", the condition of being protected against physical, social, spiritual, financial, or other types or consequences of failure, damage, error, accidents, harm or any other event which could be considered non-desirable.
- This can take the form of being protected from the event or from exposure to something that causes health or economical losses.

What is industrial safety

Industrial safety is primarily a management activity which is concerned with

- Reducing
- Controlling
- Eliminating hazards from the industries or industrial units.

Significance of Industrial Safety

Industrial causes a great loss to both the Employer & Employee, that's it is having importance

- Cost of compensation
- Cost of medical-aid
- Cost of training a new worker
- Cost of the lost time
- Cost of investigation
- Cost of supervision & inspections
- Cost to the Govt. in terms of factory inspectors, & public health services

Objective

- To prevent accidents in the plant by reducing the hazard to minimum.
- To eliminate accident caused work stoppage and lost production.
- To achieve lower workmen's compensation, insurance rates and reduce all other direct and indirect costs of accidents.
- To prevent loss of life, permanent disability and the loss of income of worker by eliminating causes of accidents.

Objective

- To evaluate employee’s morale by promoting safe work place and good working condition
- To educate all members of the organization in continuous state of safety mindless and to make supervision competent and intensely safety minded

Foures of safety

- **Engineering:** i.e. safety at the design, equipment installation stage.
- **Education:** i.e. education of employees in safe practices.
- **Enlistment:** i.e. it concerns the attitude of the employees and management towards the programmed and its purpose. This necessary arose the interest of employees in accident prevention and safety consciousness.
- **Encouragement:** i.e. to enforce adherence to safe rules and practices.

SAFETY AND PRODUCTIVITY

- Safety, quality, and productivity are inextricably linked
- When organizations put better care into maintaining their safety, quality, and productivity, they are also better able to serve their customers and protect their employees

The Three Pillars:
Safety, Quality, and Productivity

- Too often, businesses will see safety, quality, and productivity as interfering with each other, while they actually operate in concert.
- Organizations must not think of safety as a nuisance, but rather as an incredibly important component to business success

Safety

- Improves quality and productivity
- When operations are unsafe, they aren't well-managed
- Employees will not be motivated nor mindful, and employee churn will be far greater
- Quality and productivity both suffer when employees are under stress, unsatisfied, or unable to complete their mission
- But when businesses are safe, it frees up employees to focus on their quality and their productivity
- The safer the organization is, the less frequently the organization will experience large scale disruption

Quality

- Improves safety and productivity
- Safety is a measure of conscientiousness and proactiveness
- High quality work means better results and better products
- The higher quality the work, the fewer reworks are needed, and the greater overall productivity is
- When quality is high for a business, it can be assumed that standards for the business are generally high, including safety equipment, safety software, and safety processes

Productivity

- Improves safety and quality
- Carelessness is often what begets safety issues
- With the appropriate (and productive) safety processes, safety can be improved, and quality can be improved as well
- The more productive employees are, the less likely they are to cut corners on things like safety processes
- The more productive they are, the more likely they are to put extra attention into the quality of their work

Traditional Barriers to Safety, Quality, and Productivity

- It’s easy to see that safety improves business outcomes
- Dangerous operations lead to lost time, injured employees, and a loss of morale
- Nevertheless, many organizations fear that additional safety processes can take time and money
- While true, it’s time and money well spent; it’s better to spend a small amount for preventative care than a large amount for an emergency

Traditional Barriers to Safety, Quality, and Productivity (Cont….)

- In terms of quality, the primary issue is often expediency
- Companies may feel they have to choose between fast, cheap, or high-quality
- When companies are forced to reduce costs (cheap) and produce quickly (fast) they need to sacrifice quality
- But sacrificing quality actually ends up driving up time and costs; unsatisfied customers demand reworks, which can often be upwards of three times the original budget

Traditional Barriers to Safety, Quality, and Productivity (Cont.…)

- Productivity must never be seen to be at odds with safety or quality
- Organizations may feel that safety and productivity are mutually exclusive, and that it’s difficult to maintain a productive office

Accident

- The ordinary definition of the word “Accident” as derived from lexicons is an unforeseen of an unexpected event.
- The American Safety council has defined accident as “that occurrence in a sequence of events which usually produces unintended injury, death or the property damage.
- Heinrich has defined accident as “an unplanned and uncontrolled event in which the action or reaction on an object, substance, person or radiation result in personal injury”.

WHAT IS AN ACCIDENT ???

"An accident is an unplanned & uncontrolled event which causes or is likely to cause an injury".

- It is some thing which un-expected , un-predictable or intended or not desired.
- An accidents may cause a result of some unsafe activity, act, working condition etc ,…..

WHAT IS AN INDUSTRIAL ACCIDENT ???

- It can be define as “An accident or occupational accident is an event of accident that suddenly occurs when one or no. of employees / workers placed in plant.
- For instance, In an organization a person / labor while working receiving an electric current, a labor cut his finger from machine, blast in chemical industry because of various reasons, fired in textile section etc..
- These are all the example of industrial accidents.

Injury

- An injury or illness is an abnormal condition or disorder. Injuries include cases such as, but not limited to, a cut, fracture, sprain, or amputation. Illnesses include both acute and chronic illnesses, such as, but not limited to, a skin disease, respiratory disorder, or poisoning.

Injury (Cont.…)

- "Injury" means mental or physical harm to an employee caused by accident or disease, and also means damage to or destruction of artificial members, dental appliances, teeth, hearing aids and eyeglasses, but, in the case of hearing aids or eyeglasses, only if such damage or destruction resulted from accident which also caused personal injury entitling the employee to compensation therefore either for disability or treatment.

UnSafe Acts & UnSafe Condition

Why do accidents happen?

- Accidents happen because of one or both of the following:

Unsafe acts

Unsafe conditions

UNSAFE ACTS

Unsafe act is any activity or task that is conducted in a manner which increase the probabilities of an accident.

UNSAFE CONDITIONS

A condition in the work place that is likely to cause property damage or injury.

Unsafe Acts

Unsafe acts are actions by people that directly cause or contribute to an accident. Examples are:

- Horseplay, running
- Influence of drugs or alcohol
- Not following procedures – taking shortcuts
- Operating equipment or tools without authority
- Using damaged and defective equipment
- Not using personal protective equipment
- Operating equipment at improper speeds
- Taking and improper working position
- Servicing equipment in motion

Unsafe Acts

- Removing safety device
- Performing unauthorized procedure
- Dressing improperly
- Welding with no shield
- Portable cord across in a walkway
- Standing on a top rung of step ladder
- Working at height without protection
- Poor house keeping
- Throwing of materials after finished work
- Taking Short cuts
- Improper lifting

Unsafe Conditions

Examples of unsafe conditions are:

- Damaged or Defective tools or equipment
- Poor lighting
- Poor or improper ventilation
- Missing machine guards
- Inadequate machine guards
- Unsafe atmosphere
- Slippery floors
- Lack of proper equipment
- Congestion of working area

Unsafe Conditions

- Poor housekeeping
- Wet floor
- Noise exposure / Excessive noise
- Inadequate warning system
- Heat, dust, fumes, chemicals & vibration
- Unsafe piling, stacking & storing
- Sharp edges
- Inadequate work clothes
- Inadequate / broken personal protective equipments
- Broken ladders for height work
- Breach of permit to work
- Loose electrical wirings

CATEGORY OF ACCIDENTS

There are FOUR category of accidents…..

2) MINOR ACCIDENTS
3) REPORTABLE ACCIDENTS
4) FATAL ACCIDENTS
5) ACCIDENTS DUE TO DANGERIOUS OCCURANCE

1) MINOR ACCIDENTS

- It includes all those accidents that are
- Less harmful in nature to the worker
- Preventing employees from working for the period less than 48 hours from the time of accidents.
- These accidents are not reported to the higher management.
- These accidents are easily control.

REPORTABLE ACCIDETNS

- It includes the category of accidents which is little complicated then of minor accidents.
- Here the injuries caused to the worker prevent him from working for the period of 48 hours or more.
- Here supervisor is responsible to report to the higher management and arrange another worker so that the production could not be affected.

ACCIDENTS DUE TO THE DANGRIOUS OCCURANCES

- These occurs due to
- Bursting of vessel for containing steam under pressure greater then atmospheric pressure.
- Failure of crank or other appliances.
- Explosion of fire causing damage to any room or place where person are employed.
- Explosion of container used for storage of any gas or liquid at a pressure greater than atmospheric pressure.

THEORIES OF ACCIDENT CAUSATION

Theories of Accident Causation

There are several major theories concerning accident causation, each of which has some explanatory and predictive value.

1. The domino theory developed by H. W. Heinrich, a safety engineer and pioneer in the field of industrial accident safety.
2. Human Factors Theory
3. Accident/Incident Theory
4. Epidemiological Theory
5. Systems Theory
6. The energy release theory, developed by Dr. William Haddon, Jr., of the Insurance Institute for Highway Safety.
7. Behavior Theory

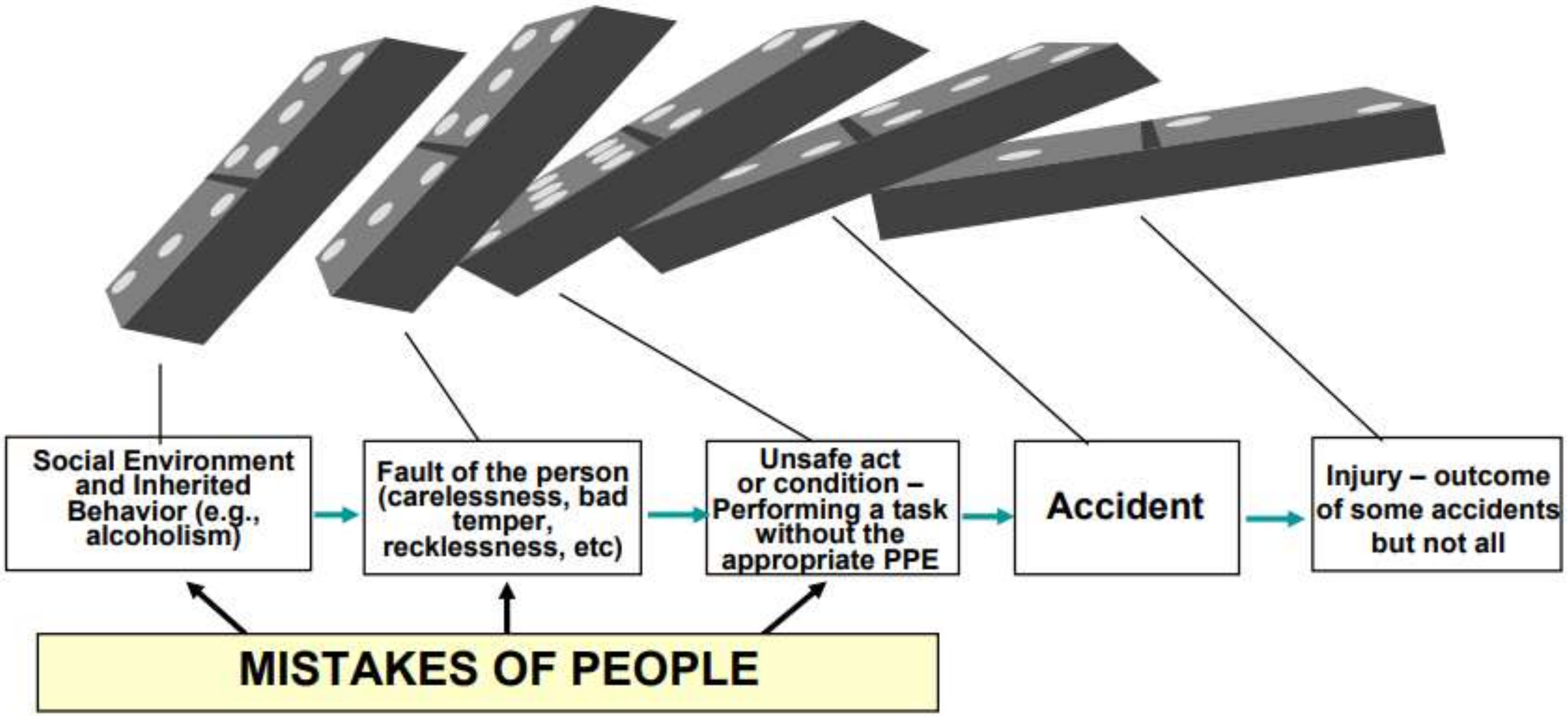
Accident theories guide safety investigations. They describe the scope of an investigation.

Heinrich's Domino Theory

According to Heinrich, an "accident" is one factor in a sequence that may lead to an injury.

- The factors can be visualized as a series of dominoes standing on edge; when one falls, the linkage required for a chain reaction is completed.
- Each of the factors is dependent on the preceding factor.

1932 First Scientific Approach to Accident/Prevention - H.W. Heinrich



Heinrich's Dominos – The Process

1. A personal injury (the final domino) occurs only as a result of an accident.
2. An accident occurs only as a result of a personal or mechanical hazard.
3. Personal and mechanical hazards exist only through the fault of careless persons or poorly designed or improperly maintained equipment.
4. Faults of persons are inherited or acquired as a result of their social environment or acquired by ancestry.
5. The environment is where and how a person was raised and educated.

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Heinrich's Domino Theory – Critical Issues

- The factor preceding the accident (the unsafe act or the mechanical or physical hazard) and it should receive the most attention.
- Heinrich felt that the person responsible at a company for loss control should be interested in all five factors, but be concerned primarily with accidents and the proximate causes of those accidents.
- Heinrich also emphasized that accidents, not injuries or property damage, should be the point of attack.
  - An accident is any unplanned, uncontrolled event that could result in personal injury or property damage. For example, if a person slips and falls, an injury may or may not result, but an accident has taken place.

Heinrich's Domino Theory – Corrective Action Sequence (The three "E"s)

- **Engineering**
  - Control hazards through product design or process change
- **Education**
  - Train workers regarding all facets of safety
  - Impose on management that attention to safety pays off
- **Enforcement**
  - Insure that internal and external rules, regulations, and standard operating procedures are followed by workers as well as management.

HUMAN FACTORS THEORY

Heinrich posed his model in terms of a single domino leading to an accident. The premise here is that human errors cause accidents. These errors are categorized broadly as:

- ***OVERLOAD***
  - The work task is beyond the capability of the worker
    1. Includes physical and psychological factors
    2. Influenced by environmental factors, internal factors, and situational factors
- ***INAPPROPRIATE WORKER RESPONSE***
  - To hazards and safety measures (worker's fault)
  - To incompatible work station (management, environment faults)
- ***INAPPROPRIATE ACTIVITIES***
  - Lack of training and misjudgment of risk

But the structure of this theory is still a cause/effect format.

ACCIDENT/INCIDENT THEORY

Extension of human factors theory. Here the following new elements are introduced:

- ***Ergonomic traps***
  - These are incompatible work stations, tools or expectations (management failure)
- ***Decision to err***
  - Unconscious or conscious (personal failure)
- ***Systems failure***
  - Management failure (policy, training, etc.)

EPIDEMIOLOGICAL THEORY

Epidemiology

– This field studies relationship between environmental factors and disease

– Can be used to study causal factors in a relationship

***Two key components*:**

1 Predisposition characteristics

- tendencies may predispose worker to certain actions

2 Situational characteristics

- peer pressure, poor attitude, risk taking

Together these characteristics can cause or prevent accidents that a person predisposed to a given situation or condition may succumb to.

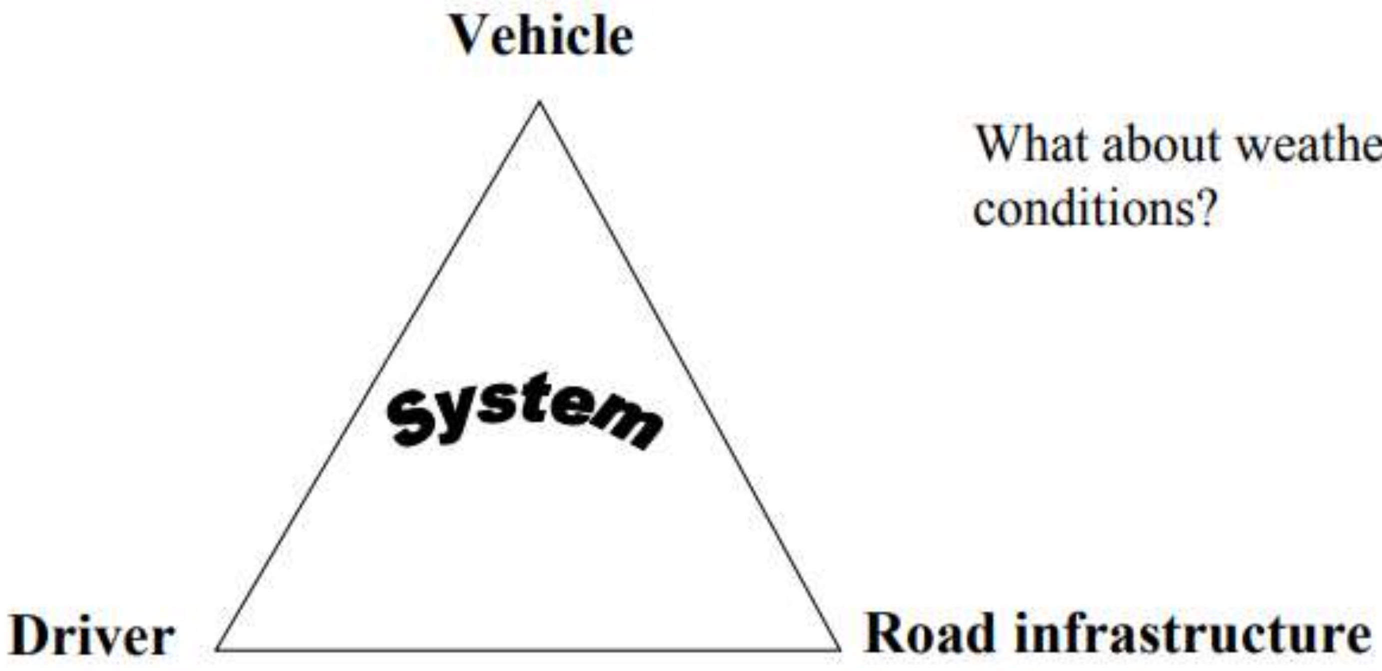
A Systems Theory Model of Accidents

- Accidents arise from interactions among humans, machines, and the environment.
  - Not simply chains of events or linear causality, but more complex types of causal connections.

Under normal circumstances chances of an accident is low. Rather than looking at the environment as being full of hazards and people prone to errors, system safety assumes harmony (steady state) exists between individuals and the work environment.

- Safety is an emergent property that arises when components of system interact with each other within a larger environment.
  - A set of constraints related to behavior of components in system enforces that property.
  - Accidents when interactions violate those constraints (a lack of appropriate constraints on the interactions).
  - Software as a controller embodies or enforces those constraints.

Systems Theory Applied to Transportation Engineering



What about weather conditions?

Road accidents are seen as failures of the whole traffic system (interaction between the three elements) rather than a failure of the driver.

- The driver is a victim – this assumes the demands that the traffic system puts on the driver is too complex for the driver's limited capacity to process information.
- As a result of this assumption the system must be designed to be less complex, which *prevents* errors from occurring.
- "The energy and barriers perspective": The system must also *reduce* the negative consequences of errors, i.e., introduce safety margins that allows the driver to incur an error without being hurt too seriously.

HADDON'S ENERGY RELEASE THEORY

Willam Haddon a medical doctor and the adminstrator of NHTSA at one point in time, in 1966 helped to impose the following regulations for new cars:

1. Seat belts for all occupants
2. Energy-absorbing steering column
3. Penetration-resistant windshield
4. Dual braking systems
5. Padded instrument panel
6. All measures correspond with the energy and barrier concept

- The systems theory approach, in contrast to the energy release theory, treats the driver as a **passive** responder in his environment.

- The evidence is that he is in fact an **active** participant, regulating his/her level of preferred risk

- Risk compensation/ behavioural adaptation: operators within a system may take advantage of safety measures in other ways than to increase safety

- Two basic forms of compensation to road safety measures:
  - Increased speed
  - Reduced attention

” … more efficient brakes on an automobile will not in themselves make driving the automobile any safer. Better brakes will reduce the absolute size of the minimum stopping zone, it is true, but the driver soon learns this new zone and .. he allows only the same relative margin between field and zone as before.”

Reference: Gibson J. J. & Crooks L. E. (1938): A theoretical field analysis of automobile driving. The American Journal of Psychology, 51, 453-471

BEHAVIORAL THEORY

- Often referred to as behavior-based safety (BBS)
- 7 basic principles of BBS
  - Intervention
  - Identification of internal factors
  - Motivation to behave in the desired manner
  - Focus on the positive consequences of appropriate behavior
  - Application of the scientific method
  - Integration of information
  - Planned interventions

COMBINATION THEORY

- Accidents may/may not fall under any one model
- Result from factors in several models.
- One model cannot be applied to all accidents

SAFETY PROFESSIONAL/OFFICER

The role of the safety officer is in most respects advisory. It is essential however, for the safety officer to be influential and to have technical competence and experience to be accepted by line management. The later for their part are not likely persistently to disregard the advice of the safety officer if he possesses these qualifications and is seen to be supported by senior management.

The situation of the safety officer is one where there is a potential conflict between function and status. He may have to give unpopular advice to managers more senior than himself. It is a well understood principle of safety organization, however, that on certain matters function carries with it authority.

The safety officer should have direct access to a senior manager, eg. Works manager, should take advantage of this by regular meetings and should be seen to do so. This greatly strengthens the authority of safety officer.

Although the safety officer's duties are mainly advisory, he may have certain line management functions such as responsibility for the fire fighting and security systems, and his assistants often have responsibilities in respect of the permit- to-work system.

Qualifications of the safety professional

1. He should possess a recognized degree in any branch of engineering or technology or physics or chemistry and have sufficient practical experience of working
2. Possess a degree or diploma in industrial safety recognized by the Central Government.
3. Has adequate knowledge of the language spoken by majority of the workers in the industry which he has appointed.

Duties of safety officer

i. To advice the concerned departments in planning and organizing measures necessary for the effective control of personal injuries
ii. To advice on safety aspects on all departmental work, and to carry out detailed job safety studies of selected work.
iii. To check and evaluate the effectiveness of the action taken or proposed to be taken to prevent personal injuries
iv. To advice purchasing and stores departments in ensuring high quality and availability of personal protective equipment
v. To carry out safety inspections of industry, in order to observe the physical conditions of work and the work practices and procedures followed by workers and to render advice on measures to be adopted for removing the unsafe physical conditions and preventing unsafe actions by workers.
vi. To investigate the cases of occupational diseases contracted and reportable dangerous occurrences

vii. To advice maintenance of such records as are necessary relating to accidents, dangerous occurrences and occupational diseases.
viii. To investigate fatal and other selected accidents
ix. To promote setting up of safety committees and act as advisor and catalyst of such committees
x. To organise in association with the concerned departments, campaigns, competitions, contests and other activities which will develop and maintain the interest of the workers in establishing and maintaining safe conditions of work and procedures
xi. To design and conduct either independently or in collaboration with the training department, suitable training and educational programmes for the prevention of accidents to industrial workers.
xii. Frame departmental safety rules and are working practices in consultation with the various departments or authorities
xiii. Supervise and guide in respect of safety precautions to be taken while handling dangerous operations

SAFETY COMMITTEE

The primary purpose of the Safety Committee is to promote safety awareness and reduce the potential for injury/loss throughout a Manufacturing Company.

The Safety Committee is to be chaired by the Safety Director and include representatives from each department (total number of committee members not to exceed five individuals). Members can be volunteers or appointed. Membership is limited to two terms (1 year each) during any four year period.

Meetings are to be scheduled, when possible, for the same day each month. All meetings are to take place in the conference room. Each meeting should have a set agenda and minutes of each meeting recorded. A copy of the minutes shall be forwarded to the Executive Vice-President within 48 hours of meeting.

Each Safety Committee Meeting shall include a review of the prior month's minutes as well as a review of the prior month's injury/illness log and investigations of losses/claims. Past injuries/claims/losses need to be reviewed for any patterns or trends.

General functions of the Safety Committee can include:

(1) Identifying workplace hazards

(2) Enforcement of Safety Rules

(3) Measuring safety performance

(4) Reducing frequency/severity of injuries

(5) Creating safety policies

(6) Developing and monitoring safety programs

Specific tasks of the Safety Committee can include:

(1) Conducting self-inspections of the workplace

(2) Review employee reports of hazards

(3) Assist in safety training

(4) Creating safety incentive programs

(5) Publish/distribute safety newsletter

(6) Inspect **PPE** (Personal Protective Equipment)

(7) Post safety posters/slogans on bulletin board

(8) Identify Light Duty Jobs

Safety Functions with Objectives and Duties

1. **Management Commitment to Workplace Safety and Health**
    - Establish procedures for review and management's response to minutes.
    - Submit written recommendations for safety/health improvement/changes and response.
    - Evaluate employer's safety/health policies and procedures.
    - Respond in writing to safety committee recommendations.
    - Review corrective action taken by management.

2. Committee Meetings and Employee Involvement

- Establish procedures for employee input, i.e. to receive suggestions, report hazards, and other pertinent safety and health information.
- Include employee input on agenda for safety committee meetings.
- Hold monthly meetings.
- Keep meeting minutes.
- Develop and make available a written agenda for each meeting.
- Take meeting minutes and distribute to management and the safety committee members.
- Include in the meeting minutes all recommendations.

3. Hazard Assessment and Control

- Establish procedures for workplace inspections to identify safety and health hazards.
- Assist the employer in evaluating the accident and illness prevention program.
- Appoint an inspection team of at least one employee representative and one employer representative.
- Conduct workplace inspections at least quarterly.
- Make a written report of hazards discovered during inspections.
- Review corrective measures. Make written recommendation to correct the hazard, and submit it to management for timely response.
- Identify high risk job tasks and develop written safe operating conditions.

4. **Safety/Health Planning**

- Establish procedures to review inspection reports and make appropriate implementation of new safety/health rules and work practices.
- Develop/establish procedures for an annual review of the company safety and health program.

5. **Accountability**

- Evaluate the company safety and health accountability program.
- Make recommendations to implement supervisor and employee account ability for safety and health.

6. Accident/Incident Investigations

- Establish procedures for reviewing reports completed for all safety incidents, including injury accidents, illnesses and deaths.
- Review these reports so that recommendations can be made for appropriate corrective action to prevent recurrence.

7. Safety/Health Training for Committee-Members

- Identify and make accessible applicable OSHA standards and other codes that apply to your particular industry.
- Provide specific training on your type of business activity. Include at a rninimum, hazard identification of the workplace and how to perform effective accident incident investigation.
- Identify the location of safety procedures provided with appropriate equipment and inform employees of their location.
- Recommend training for new employees and refresher training on company, department and work location safety practices, procedures and emergency response.
- Management should maintain (and make available to the safety committee) records on employee safety training.

Workplace safety committee member duties

Chair person

- Prepare agenda for next meeting
- Arrange for meeting place
- Notify members of meeting
- Arrange program
- Set time schedule for meeting
- Arrange all seating for members
- Review previous minutes and material for meeting
- Conduct meeting

Secretary

- Record minutes of meeting
- Distribute minutes to committee member s
- Post minutes for other employees
- Report status of recommendation s
- Assume chairperson 's duties, if required

Members

- Report unsafe conditions and practices
- Attend all safety meetings
- Report all accidents or near misses
- Review injury accidents, illnesses and death investigations
- Contribute ideas and suggestions for improvement of safety
- Work safely
- Influence others to work safely
- Make or assist in inspections

The Importance of Establishing a Safety Committee

- Safety committees help provide an overall perspective of the safety status of the organization. It serves as a visible body that can be approached for safety or health complaints, suggestions, and other types of feedback.
- As the committee solely deals with safety-related issues, it ensures that there are employees focused on and dedicated to coordinating safety-related activities. It also encourages and motivates employees to follow safety standards and signals to them that the organization is taking measures to protect their wellbeing.

SAFETY ORGANIZATIONS

A safety organization consists of a systematic procedure by means of which interest is created and maintained and all safety activities are co-related and directed. The accident prevention is a continuing process and hence continuous systematic efforts are necessary.

The basic objectives of safety organization are:

(i) Creating and maintaining interest.

(ii) Fact finding through periodical inspections and surveys of structures, machine tools, equipment, processes and employee procedures, accident investigation and analysis.

(iii) Selection of remedies and corrective action with regard to unsafe acts and conditions based upon the found facts.

The organization setup depends upon the size and complexities of the industries. In small industry foreman or supervisor may be responsible for achievement of all the objectives of safety.

The Organization set up consists of:

1. Executive safety committee.
2. Operations safety committee.

Executive safety committee: The executive safety committee consists of presidents' representative, the General Manager, the plant superintendent and the sales manager. The chief function of the executive safety committee is to determine the policy and set the standards or plan at which the safety work is to be conducted.

Specific responsibilities and activities of the executive safety committee shall include:

1. Review and action on the report s and recommendations of the operations safety committee.
2. Periodical considerations of trends and progress in the control of accident frequency and severity.
3. Approval for abnormal expenditures for accident prevention.
4. Approval for major changes in safety organization and of activities effecting matters of policy.

Operations safety committee: the function of the operations safety committee is to execute the policies sat up by the executive safety committee regarding all the phases of accident prevention.

Membership shall consist of executive safety committee, the plant safety inspector, sales supervisors and plant superintendents.

Specific responsibilities and activities of the committee include:

1. Study and discuss the principal accident producing conditions and circumstances and to take and recommend practical effective corrective action
2. Review of and action on the reports and recommendations received from the service engineering
3. Review of and action on the reports of the plan safety inspector.
4. Review of and action on accident investigation reports submitted by supervisors.
5. Periodical check of all authorized safety procedure and their proper functioning.
6. Approval of proposed new construction and installation of equipment, changes in procedures and processes etc. from the safety viewpoint.

Steps taken by safety organization to control accidents

In order to control the accident the following steps must be taken by safety organization:

A. Supervisory Safety Performance:

(1) Job safety analysis.

(ii) Proper job placement.

(iii) Development of safe working conditions.

(iv) Enforcement of Safety Rules.

(v) Promotion of employee participation in safety.

B. Mental Condition of Person:

(i) Adequate induction and job training.

(ii) Safety training, safety awareness, safety promotion/publicity.

(iii) Regular safety contacts by supervisor.

(iv) Involvement/participation.

(v) Adequate communication concerning the employee.

C. Physical Conditions of Person:

(i) Pre-employment medical examination.

(ii) Periodical medical checkup.

(iii) Proper job placement.

(iv) Adequate medical facilities.

(v)Recognition of physical limitations of workers who are new on job.

How accident can be prevented by safety programme?

For setting up a safety programme the various means generally used may be:

(a) Safety code-Regarding safe working conditions, design, maintenance, inspection, testing, training etc.

(b) Standardization-Regarding equipment, practices, protective devices.

(c) Inspection- To secure enforcement of (a) above.

(d) Investigation of Accidents-To find out the root cause(s) and remove those.

(e) Research-{a) Technical (b) Medical (c) Psychological (d) Statistical.

(f) Education/training-For all categories of personnel.

(g) Persuasion/Appeal/Counselling of employees-Motivation.

(h) Insurance-To cover risks.

(z) Set up full-fledged safety department-For self-regulation within the organization.

Assignment

- National Safety Council
- Roles

Module II

(Personal protection in work environment- 7 hrs)
Personal protection in the work environment, Types of PPEs, Personal protective equipment respiratory and non-respiratory equipment. Standards related to PPEs. Monitoring Safety Performance: Frequency rate, severity rate, incidence rate, activity rate. Housekeeping: Responsibility of management and employees. Advantages of good housekeeping. 5 s of housekeeping. Work permit system- objectives, hot work and cold work permits. Typical industrial models and methodology. Entry into confined spaces.

Personal protection in the work environment,

- Personal safety in the workplace depends on your own awareness of potential threats and risks as well as your employer's safety policies and procedures.
- Employers may have different priorities to consider besides your personal safety, such as losses from shoplifting, fraud against the company or the need to control costs.
- By giving some thought to managing the risks, you can make yourself safer on the job.
- **Personal protective equipment** (**PPE**) is protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection.
- The hazards addressed by protective equipment include physical, electrical, heat, chemicals, biohazards, and airborne particulate matter.
- Protective equipment may be worn for job-related occupational safety and health purposes, as well as for sports and other recreational activities.
- *Protective clothing* is applied to traditional categories of clothing, and *protective gear* applies to items such as pads, guards, shields, or masks, and others.
- PPE suits can be similar in appearance to a clean room suit.
- The purpose of personal protective equipment is to reduce employee exposure to hazards when engineering controls and administrative controls are not feasible or effective to reduce these risks to acceptable levels.
- PPE is needed when there are hazards present.
- PPE has the serious limitation that it does not eliminate the hazard at the source and may result in employees being exposed to the hazard if the equipment fails.
- Any item of PPE imposes a barrier between the wearer/user and the working environment.
- This can create additional strains on the wearer, impair their ability to carry out their work and create significant levels of discomfort.
- Any of these can discourage wearers from using PPE correctly, therefore placing them at risk of injury, ill-health or, under extreme circumstances, death.
- Good ergonomic design can help to minimise these barriers and can therefore help to ensure safe and healthy working conditions through the correct use of PPE.

Types of PPEs

- Personal Protective Equipment (PPE) means any device or appliance designed to be worn or held by an individual for protection against one or more health and safety hazards.
- It could include safety glasses, gloves, face shields, protective clothing or footwear.

There are two types of PPE these include **simple** and **complex.**

- **Simple personal protective equipment** – this refers to equipment that has a basic design model, it protects against lower risk hazards. It is reasonable to assume with this type of PPE that the user – is aware of the hazards, can see the risk gradually increasing and is able to make an assessment and safely identify the need for PPE to be worn.
- **Complex personal protective equipment** – this refers to equipment that it more of a technical design and provides protection against fatal or serious risk. With this type of PPE the user cannot identity the hazard in sufficient time and is immediately exposed to hazards that have irreversible effects.

- About 0 to 40% of total accidents can be prevented or controlled by the proper use of personal protective equipment.
- The **PPE** provides good defense against hazards of toxic exposure, oxygen deficiency, dusting, chemical splashes, steam, water and liquids, flying particles, hot substances, radiation, sharp edges, welding, cutting, grinding, striking against and stepping over objects, glare, personal falls and injury due to falling bodies, noise, scarp cleaning, material handling, the opening of pipelines or any hazardous work, electric shocks, burn and firefighting.

The need for PPE exists because:

1. Chances of failure of engineering controls, materials, process, equipment, and safety devices cannot be denied and in those circumstances, the **PPE** can act as a barrier between the man and hazard and save from the injury.
2. There are certain operations or accidental situations where engineering controls are less possible and **PPE** becomes necessary. For repair or maintenance or to enter into a toxic or oxygen-deficient atmosphere, or while working at height or doing jobs like welding, cutting grinding, chipping, **PPE** gives good protection.
3. It effectively avoids the contact of dangerous substances, noise, vibration, and radiation.
4. It protects from atmospheric contaminants.
5. It is a legal as well as moral duty to provide suitable PPE.

Respiratory Protective Equipment (RPE)

- Respiratory Protective Equipment (RPE) is a particular type of Personal Protective Equipment (PPE), used to protect the individual wearer against the inhalation of hazardous substances in the workplace air.
- Employers are required to firstly attempt to eliminate the hazard at source.
- RPE should only be used after all other reasonably practicable control measures have been taken.
- PPE is considered a last resort because it only protects individual workers, is prone to failure or misuse, such as wearing the wrong RPE for the job, and employees wearing RPE may get a false sense of security when using RPE.
- Respiratory Protective Equipment (RPE) not worn or selected appropriately is totally ineffective and may give the user a false sense of protection.

RPE is divided into two main types:

I. **Respirator (filtering device)** – uses filters to remove contaminants in the workplace air , there are two main types:
   a. Non-powered respirators – rely on the wearer's breathing to draw air through the filter
      Eg: Disposable filteing half mask, Half mask, full face mask
   b. Powered respirators – use a motor to pass air through the filter to give a supply of clean air to the wearer
      Eg: Half mask , full face mask, helmets, hoods, visors

II. **Breathing apparatus (BA)** – needs a supply of breathing-quality air from an independent source (eg air cylinder or air compressor)

- Both respirators and BA are available in a range of different styles, which can be put into two main groups:

▪ Tight-fitting face pieces (often referred to as masks) - rely on having a good seal with the wearer's face. These are available as both non-powered and powered respirators and BA. Examples are filtering face pieces, half and full-face masks.

▪ Loose-fitting face pieces – rely on enough clean air being provided to the wearer to prevent contaminant leaking in (only available as powered respirators or BA). Examples are hoods helmets, visors, blouses and suits.

- WARNING: Only BA is suitable for use in oxygen deficient atmospheres

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Non Respiratory PPEs

➢ There are many different types of PPE for the body and depending on the job type.

- Eye protection (e.g. goggles)(RPE)
- Head protection (e.g. safety helmets)
- Ear protection (e.g. earplugs)
- Foot protection (e.g. steel toecap boots)
- Hand and arm protection (e.g. gloves)
- Body protection (e.g. high-visibility clothing)
- Fall protection (e.g. safety harnesses).
- Skin protection (e.g. protective clothing)

Eye Protection

- These help protect the mucus membranes of the eyes, as well as help to reduce the risk of foreign objects entering the eyes and damaging them.
- Needed when an employee work presents the potential of causing eye injury from physical, chemical, or radiation agents.

Examples of hazards:

- Machines
- Lasers
- Impacts
- Heat
- Tools
- Flying Particles / Dust
- Electrical work
- Chemical handling

There are three main types of eye protection, these are

- Safety glasses – These are effective for flying objects heading straight towards the face, but they are not effective for vapors and dust that can enter the eyes.
- Goggles – They are effective at protecting the eyes from all angles, as the rim is in contact with the face
- Face shields and visors – These can be worn with prescription glasses underneath, and they help to protect the whole face.

Head protection

- Head protection can protect the head from physical hazards, they can also protect other parts of the upper body, such as the neck, hair, nose and ears.

There are two main types of head protection that are used in the workplace, these are:

- Industrial safety helmets – These protect the head from falling objects such as – tree-felling, building and construction and blasting at a quarry.
- Bump caps – These protect the head from being bumped, they are useful for maintenance personnel working under machinery and plumbers working under pipework. However, the do not offer adequate protection from the risk of a falling object.

- Firefighter helmets are similar to industrial safety helmets, however they cover more of the head and give greater protection against impact, heat and flames.
- Head Protection: Care Considerations
    - Remove and replace hard hats if they have:
    - Perforation, cracking, or warping of the brim or shell;
    - Indication of exposure to heat, chemicals or UV light (loss of surface gloss, chalking orflaking)
    - Always replace a hard hat if it sustains an impact
    - Suspension can be changed if excessive wear is noticed
    - Never drill holes, paint or apply labels to headgear
    - Do not store headgear in the rear window shelf of a car: sunlight and extreme heat can damage them

Types of Head Protection

- Hard Hats are divided into three industrial classes
- **Class A hard hats** provide impact and penetration resistance along with limited voltage protection(up to 2200 volts)
- **Class B hard hats** provide the highest level of protection against electrical hazards, with high-voltage shock and bum protection(up to 20000 volts)
- **Class C hard hats** provide lightweight comfort and impact protection but offer no protection from electrical hazards.
- **Bump hats** for use in areas with low head clearance

Ear protection

- Exposure to noise levels over 85 dB can cause hearing loss
- Hearing protection required at 90 dB
- Implement effective Hearing Conservation

Program There are three main types of ear protection,

these include:

- Ear defenders (ear muffs) – The cups are lined with a sound absorbing material, this helps toreduce the level of noise to the ears
- Ear plugs – These fit into the ear canal and form a seal, they also can have a cord on them, thatyou can put behind the back of the neck, to help prevent them from becoming lost.
- Canal caps – These are similar to ear plugs, however they offer less protection they are suitablefor operations where earplugs would be frequently taken out and put back in.

Foot protection

There are two common types of foot protection, they both offer a variety of protection, these are:

- Safety boots and shoes – They come with slip-resistant soles, penetration-resistant midsoles, protective toe caps.
- Wellington boots – These are suitable for people who work in wet conditions, they are normally made from rubber, they also come with slip-resistant soles, penetration-resistant midsoles, protective toe caps.

- Toe and foot injuries account for 5% of all disabling workplace injuries. Workers not wearing safety shoes have 75% of all occupational foot injuries.
- Situations where employees should wear foot / leg protection include:
    - Heavy objects such as barrels or tools might roll or fall in feet
    - Sharp objects such as nails or spikes that can pierce ordinary shoes
    - Exposure to molten metal that might splash on feet or legs
    - Working on or around hot, wet or slippery surfaces
    - Working when electrical hazards are present

- Safety footwear must meet ANSI minimum compression and impact performance standards in ANSI Z41-1991 (American National Standard for Personal Protection- Protective Footwear)

- Foot and leg protection choices
  - **Leggings** protect the lower legs and feet from heat hazards such as molten metal or welding sparks. Safety snaps allow leggings to be removed quickly.
  - **Metatarsal guards** protect the instep area from impact and compression. Made of aluminum, steel, fiber or plastic, these guards may be strapped to the outside of shoes.
  - **Toe guards** fit over the toes of regular shoes to protect the toes from impact and compression hazards. They may be made of steel, aluminum or plastic.
  - **Combination foot and shin guards** protect the lower legs and feet, and may be used in combination with toe guards when greater protection is needed.
  - **Safety shoes** have impact-resistant toes and heat-resistant soles that protect the feet against hot work surfaces common in roofing, paving and hot metal industries. The metalinsoles in some safety shoes protect against puncture wounds.
- Special Purpose Shoes
  - **Safety shoes** may also be designed to be electrically conductive to prevent the buildup ofstatic electricity in areas with the potential for explosive atmospheres or nonconductive to protect workers from workplace electrical hazards.
  - **Electrically conductive shoes** provide protection against the buildup of static electricity. Workers in explosive and hazardous locations such as explosives manufacturing facilities or grain elevators must wear conductive shoes to reduce the risk of static electricity buildup.
  - **Electrical hazard, safety-toe shoes** are nonconductive and will prevent the wearers' feet from completing an electrical circuit to the ground. These shoes can protect against opencircuits of up to 600 volts in dry conditions.
  - **Foundry Shoes** insulate the feet from extreme heat and keep hot metal from lodging in shoe eyelets, tongues or other shoe parts.

Hand and arm protection

- Hand and finger injuries account for 18% of all disabling injuries and about 25% of all industrialwork place accidents
- Some factors that influence selection of protective gloves:
  - Type of chemicals handled.
  - Nature of contact (total immersion, splash, etc.).
  - Duration of contact. •
  - Area requiring protection (hand only, forearm, arm).
  - Grip requirements (dry, wet, oily).
  - Thermal protection.
  - Size and comfort.
  - Abrasion/resistance requirements.
- Gloves materials fall into 4 groups
  - Leather, canvas or metal mesh
  - Fabric and coated fabric gloves
  - Chemical- and liquid-resistant gloves
  - Insulating rubber gloves

There are four main types of hand and arm protection, these include:

- Gloves – These protect the hands, they can prevent blisters from occurring, people from burning themselves or getting splinters in their hands.
- Gloves with cuffs – These protect both the hand and the wrists
- Gauntlets, sleeves and long gloves – These provide protection for the hands, wrists and parts of the forearms.
- Sleeves and arm protection – These can provide protection for the whole forearms and upper arms.

Skin protection

Types of skin protection

There are three main types of whole-body skin protection

- Separates – these only cover part of the body (e.g. jackets or trousers).
- Aprons – these only cover part of the body.
- Overalls, coveralls, body suits, boiler suits and chemical suits – these cover the whole body, and may be reusable or disposable.

For leg protection (as well as trousers), there is also;

- Knee pads.
- Gaiters – these cover the shins.
- Hard fiber or metal guards, which help to protect against some impact hazards.

For skin protection to be effective;

- Protective clothing must be suitable for the hazard (e.g. chemical resistance and protection against physical hazards can vary widely).
- Manufacturer's instructions must be followed (e.g. do not use chemical resistance for longer than the recommended breakthrough times, and clean as to not damage its effectiveness).
- Worn or contaminated clothing must be stored separately from clean clothing.
- Check for surface damage, which could reduce its effectiveness.
- Do not wear loose clothing near moving machinery, if there is a chance that it could get caught.

High visibility clothing

This is required to protect the body against certain hazards such as moving vehicles, the main types are:

- Jackets
- Tops
- Trousers
- Vests

Fall protection systems

These can be used by individuals when they are working at height, they can wear the harness, there are two main types of fall protection systems, these include:

- Work restraint systems – These prevent the user from reaching zones where the risk of a fall exists, this means they will be protected from falling and hurting themselves
- Work positioning systems – These are similar to work restraint systems and allows the user to have both hands for working. If using this system, you must always have a back up system in place.

Personal Protective Equipment (PPE) Standards

- The existing Occupational Safety and Health Administration (OSHA) personal protective equipment (PPE) standards are found in 29 Code of Federal Regulations (CFR) Part 1910 Subpart I for General Industry, Part 1915 Subpart I for Maritime, Part 1917 Subpart E for Marine Terminals, Part 1918 Subpart J for Longshoring and Part 1926 Subpart E for Construction.
- **29 CFR 1910.133 Eye and Face Protection**: "The employer shall ensure that each affected employee uses appropriate eye or face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation." Eye and face protection must comply with: ANSI/ISEA Z87.1American National Standard for Eye and Face Protection which was last updated in 2015.
- **29 CFR 1910.134 Respiratory protection:** "The employer shall provide arespirator to each employee when such equipment is necessary to protect the health of such employee. The employer shall provide the respirators which are applicable and suitable for the purpose intended. The employer shall be responsible for the establishment and maintenance of a respiratory protection program.
- **29 CFR 1910.135 Head protection:** "The employer shall ensure that each affected employee wears a protective helmet when working in areas where there is a potential for injury to the head from falling objects. The employer shall ensure that a protective helmet designed to reduce electrical shock hazard is worn by each such affected employee when near exposed electrical conductors which could contact the head." Performance criteria for head protection are provided in the American National Standards Institute (ANSI) Z89.1 American National Standard for Industrial Head Protection. This standard is incorporated by reference in 29 CFR 1910.135 and 29 CFR 1910.6. The most recent revision was issued on May 15, 2014.
- **29 CFR 1910.136 Occupational foot protection:** "The employer shall ensure that each affected employee uses protective footwear when working in areas where there is a danger of foot injuries due to falling or rolling objects, or objects piercing the sole, and where such employee's feet are exposed to electrical hazards." Protective footwear must comply with ASTM F-2412-18a: Standard Test Methods for Foot Protection and ASTM F-2413-18 Standard Specification for Performance Requirements for Protective Footwear
- **29 CFR 1910.137 Electrical protective equipment:** details the design requirements for specific types of electrical protective equipment—rubber insulating blankets, rubber insulating matting, rubber insulating covers, rubber insulating line hose, rubber insulating gloves, and rubber insulating sleeves used for the primary insulation of employees from energized circuit parts. It also details the in-service care and use of all electrical protective equipment covered by this standard.
- **29 CFR 1910.138 Hand protection:** "Employers shall select and require employees to use appropriate hand protection when employees' hands are exposed to hazards such as those from skin absorption of harmful substances; severe cuts or lacerations; severe abrasions; punctures; chemical burns; thermal burns; and harmful temperature extremes." Employers should select appropriate hand protection relative to the application, present conditions, duration of use and any identified or potential hazards.
- **29 CFR 1910.140 Personal Fall Protection Systems:** "Employers shall ensure that each personal fall protection system used to comply with this part must meet all applicable requirements of this section. This section establishes performance, care, and use criteria for all personal fall protection systems such as personal fall arrest systems and positioning systems."

29 CFR 1910.132: General requirements says that all PPE has to meet these minimum requirements:

- Provide adequate protection against the particular hazards for which they are designed
- Be of safe design and construction for the work to be performed
- Be reasonably comfortable when worn under the designated conditions

- Fit snugly and not unduly interfere with the movements of the wearer
- Be durable
- Be capable of being disinfected
- Be easily cleanable
- Be distinctly marked to facilitate identification only of the manufacturer
-

Monitoring Safety Performance:

Frequency rate

A Question "How often do injuries occur?" is replied by the frequency rate which is defined as the disabling(lost time) injuries per 10^6 man hours worked

or

Number of lost time injuries per million man hours worked.

6.1 Frequency Rate — The frequency rate shall be calculated both for lost time injury and reportable lost time injury as follows:

$$F_A = \frac{\text{Number of lost time injury} \times 1\,000\,000}{\text{Man-hours worked}}$$

$$F_B = \frac{\text{Number of reportable lost time injury} \times 1\,000\,000}{\text{Man-hours worked}}$$

NOTE 1 — If the injury does not cause loss of time in the period in which it occurs but in a subsequent period, the injury should be included in the frequency rate of the period in which the loss of time begins.

NOTE 2 — If an injury causes intermittent loss of time, it should only be included in the frequency rate once, that is, when the first loss of time occurs.

NOTE 3 — Since frequency rate F_B is based on the lost time injuries reportable to the statutory authorities, it may be used for official purposes only. In all other cases, frequency rate F_A should be used for comparison purposes.

- What does 1000000 mean ?
  - No of workers in a year = 500
  - Daily Hour Worked = 8 hrs
  - No. of days worked in a week = 5 days
  - Total hours worked in a week = 8 * 5 = 40 hrs
  - Total week in a year = 50 week
  - So, In a year = 50 week * 40 hrs/week * 500 workers = 10 00 000
- The frequency rate is the number of disabling injuries per one million man-hours worked
- Man-Hours Worked
  - The total number of employee-hours worked by all employees in the industrial premises,
  - It includes managerial, supervisory, professional, technical, clerical and other workers including contractors labour
  - It shall be calculated from the pay roll or time clock recorded including overtime.

- When this is not feasible, the same shall be estimated by multiplying the total man-days worked for the period covered by the number of hours worked per day
- Total number of man-days is the sum of the number of men at work on each day of the period

- Disabling Injury (Lost Time Injury) - An injury causing disablement extending beyond the day of shift on which the accident occurred.
- Reportable Disabling Injury (Reportable Lost Time Injury) - An injury causing death or disablement to an extent as prescribed by the relevant statute.
- **Example 1.**Using the following data calculate the frequency rate of accident in an industrial plant.

  Number of workers=500

  Number of disabling injuries per year= 5.

  Average number of hours worked by worker per year=2000.

  Sol. Frequency rate=numbers of disabling injuries/number of man-hours worked x 1000,000

  = 5/500×2000 x 1000000=5.

<u>**Severity rate**</u>

A question how serious are the injuries ? Is replied by the severity rate which is defined as the number of days of lost time per 10^6 man hours worked

Or

- **Number of man –days lost per million man hours worked.**
- **The severity rate is the total number of days lost or charged due to accidents per one million man-hours worked**

6.2 Severity Rate — The severity rate shall be calculated from man-days lost both of lost time injury and reportable lost time injury as follows:

$$S_A = \frac{\text{Man-days lost due to lost time injury} \times 1\,000\,000}{\text{Man-hours worked}}$$

$$S_B = \frac{\text{Man-days lost due to reportable lost time injury} \times 1\,000\,000}{\text{Man-hours worked}}$$

Note — Since severity rate S_B is based on the lost time injuries reportable to the statutory authorities, it should be used for official purposes only. In all other cases severity rate S_A should be used for comparison purposes.

- **Here days lost=** actual days lost due to accidents + standard number of days considered to be lost depending on nature of disabling injury.
- Standard number of days lost is correlated to the nature of injury, as for example, standard number of days lost in 35days, the nature of injury being cutting of the tip of a finger, whereas standard number of days lost in 6000 days for a total disability case.

6.2.1 Calculation of man-days lost under **6.2** shall be based on the following:

a) Man-days lost due to temporary total disability;

b) Man-days lost according to schedule of charges for death and permanent disabilities as given in Appendix A. In case of multiple injury, the sum of schedule charges shall not be taken to exceed 6 000 man-days;

c) Days lost due to injury in previous periods, that is, if any accident which occurred in previous period is still causing loss of time in the period under review, such loss of time is also to be included in the period under review;

d) In the case of intermittent loss of time, each period should be included in the severity rate for the period in which the time is lost; and

e) If any injury is treated as a lost time injury in one statistical period and subsequently turns out to be a permanent disability; the man-days charged to the injury shall be subtracted from the schedule charge for the injury when permanent disability becomes known.

Example 2. Using the following date calculate the severity rate of accident in an industrial plant where only one accident occurred during the year, the type of injury being cutting of the tip of a finger.
Number of workers=2000.
Number of days lost in a year due to accidents=100
Average number of hours worked by worker per year=2000.

Sol. Severity rate=days lost in year due to accidents/number of man-hours worked x 1000,000

Number of man-hours worked in this case=2000 X 2000.

Days lost in year due to accidents=100+35=135.

$$\text{Severity Rate} = \frac{135}{2000*2000}*10000000=\frac{135}{4}=33.75$$

Eg : Using the following data calculate the severity rate of accident in an industrial plant where only one accident occurred during the year involving total disability of a worker.
Number of workers=2000.
Number of days lost in a year due to accident=100.
Average number of hours worked by worker per year=2000.

Sol. Severity rate= days lost in year due to accidents/number of man hours worked x 1000000.

Number of hours worked in this case=2000×2000.

Total disability; days lost=100+6000=6100 days.

Severity rate =6100/2000x2000x1000000= 6100/4=1525

Incidence Rate

General incidence rate is the ratio of the number of injuries to the number of employees during the period under review .It is expressed as the number of accidents or injuries per 1000 persons employed

- Or -Number of lost time injuries per thousand persons employed

6.3 Incidence Rates

General incidence rate is the ratio of the number of injuries to the number of persons during the period under review. It is expressed as the number of injuries per 1 000 persons employed.

The incidence rate may be calculated both for lost-time injuries and reportable lost-time injuries as follows:

$$\text{Lost-time injury incidence rate} = \frac{\text{Number of lost-time injuries} \times 1\,000}{\text{Average number of persons employed}}$$

$$\text{Reportable lost-time injury incidence rate} = \frac{\text{Number of reportable lost-time injuries} \times 1\,000}{\text{Average number of persons employed}}$$

NOTE — Since reportable lost-time injury incidence rate is based on the lost time injuries reportable to the statutory authorities, it should be used for official purposes only. In all other cases lost-time injury incidence rate should be used.

Activity rate

- The safety activity rate is the overall safety promotional & awareness activity which including safety training & safety inspection conducted in a year with respect to total employees present & man hours worked in a year.
- This emphasizes the cost of accident prevention activities against the cost of accident occurrences incidents.

$$\text{Safety Activity Rate} = \frac{\text{(safety activity number) } 5*10\text{^}6}{\text{Man hours worked *total number of employees present/year}}$$

Housekeeping

- Refers to the management of duties and chores involved in the running of a household, such as cleaning, cooking, home maintenance, shopping, and bill payment.
- These tasks may be performed by members of the household, or by other persons hired for the purpose.
- This is a more broad role than a cleaner, who is focused only on the cleaning aspect.

- The term is also used to refer to the money allocated for such use.
- By extension, it may also refer to an office or organization, as well as the maintenance of computer storage systems.
- A housekeeper is a person employed to manage a household and the domestic staff.
- Effective housekeeping can help control or eliminate workplace hazards.
- Poor housekeeping practices frequently contribute to incidents. If the sight of paper, debris, clutter and spills is accepted as normal, then other more serious hazards may be taken for granted.
- Housekeeping is not just cleanliness. It includes keeping work areas neat and orderly, maintaining halls and floors free of slip and trip hazards, and removing of waste materials (e.g., paper, cardboard) and other fire hazards from work areas.
- It also requires paying attention to important details such as the layout of the whole workplace, aisle marking, the adequacy of storage facilities, and maintenance.
- Good housekeeping is also a basic part of incident and fire prevention.
- Effective housekeeping is an ongoing operation: it is not a one-time or hit-and-miss cleanup done occasionally.
- Periodic "panic" cleanups are costly and ineffective in reducing incidents
- Although this effort requires a great deal of management and planning, the benefits are many.

Responsibility of management and employees.

- Managers must train employees to recognize potentially hazardous conditions and take corrective actions before they cause injuries like sprains, strains, falls;

  - Wet floors and slippery walkways

  - Messy floors

  - Equipment left out in the way

  - Improper lifting techniques

- Best practices for handling chemicals, proper personal protective equipment selection, material handling, and slip, trip, and fall prevention are discussed.
- Housekeepers are exposed to a variety of hazards while on the job and perform a variety of tasks throughout their work shift.
- Proper training to identify hazards and risks associated with these tasks will help prevent employee injury
- Prepare a safety manual that is read and understood at the time of induction of new employees.
- Paste safety rules on walls at strategic points in the work area.
- Reinforce safety rules in daily briefings.
- Organize continuous safety training. Involve experts like the equipment manufacturers, Engineering to take classes on fire safety etc.
- Have a Preventive maintenance programmed for all equipment.
- Include safety inspection in the supervisor’s checklist.
- Ensure that toxic chemicals are stored in closed cupboards and properly labeled.

- Ensure that all waste disposal containers are leak proof and maintained in sanitary conditions. Waste disposal external to the building must be in designated municipal area and with concern for public health. The recycled items are put in their appropriate containers.
- Make sure that locker rooms have proper washing and shower facilities. Locker rooms must be kept clean and dry at all times. Water closets must be sanitized frequently.
- Ensure that housekeeping employees consume food and beverage in the staff canteens and not in public areas.
- Ensure rest breaks for employees during their shift vigil.
- Keep appropriate signs like "Wet Floor"; "Engineering at Work", labels for detergents and toxic material, safety instructions on equipment, "
- Not to stack anything in the corridors.
- Fire exit staircase should always be clear, not to stack items which will obstruct the movement.
- Ensure hot and cold indicators on the tap faucets.
- In the rooms and corridor's few lights should be connected to UPS.
- Swimming pool pH and chlorine levels to be maintained.
- Pool area no diving signage to be painted.
- Bed corner to be covered.
- Non - smoking zone signage.
- Safety shoes for Engineering and Kitchen and Gum boots for Kitchen Stewarding.
- Smoke detectors indicator light to blink at all the times.

Advantages of good housekeeping.

Effective housekeeping results in:

- reduced handling to ease the flow of materials
- fewer tripping and slipping incidents in clutter-free and spill-free work areas
- decreased fire hazards
- lower worker exposures to hazardous products (e.g. dusts, vapours)
- better control of tools and materials, including inventory and supplies
- more efficient equipment cleanup and maintenance
- better hygienic conditions leading to improved health
- more effective use of space
- reduced property damage by improving preventive maintenance
- less janitorial work
- improved morale
- improved productivity (tools and materials will be easy to find)

- Good housekeeping and cleanliness normally results into

1. a workplace which is cleaner, safer, well organized and more pleasant for work,
2. improved utilization of floor space,
3. smoother and systematic workflow with substantial reduction in non-value added activities,
4. better inventory control of tools and materials,
5. reduced handling to ease the flow of materials,
6. reduction in wastages of materials,
7. more efficient equipment clean-up and maintenance leading to lower break-downs,
8. minimization of errors leading to better products,
9. safe environment for work and lower exposures of employees to hazardous substances (such as dusts, and vapors etc.),
10. more hygienic workplace conditions which lead to improved health of the employees,
11. improved overall look and feel of the work environment, and
12. improved morale of the employees.

- Poor housekeeping can be a cause of incidents, such as:

    - tripping over loose objects on floors, stairs and platforms
    - being hit by falling objects
    - slipping on greasy, wet or dirty surfaces
    - striking against projecting, poorly stacked items or misplaced material
    - cutting, puncturing, or tearing the skin of hands or other parts of the body on projecting nails, wire or steel strapping

- Poor housekeeping and cleanliness, on the contrary, creates workplace hazards which lead to various accident such as

    1. slips, trips and falls,
    2. caught in-between objects,
    3. struck by falling objects,
    4. struck by moving objects,
    5. cut/stabbed by objects, and
    6. struck against objects.
    7. Furthermore, poor housekeeping and cleanliness also create fire hazards which inevitably lead to increased fire risk.

- To avoid these hazards, a workplace must "maintain" order throughout a workday.

<u>Elements of housekeeping and cleanliness at workplace</u>

- **Dust and dirt removal –** Working in a dusty and dirty area is unhygienic as well unhealthy for the employees since there can be respiratory type irritations. Also, if dust and dirt are allowed to accumulate on surfaces, there is a potential for a slip hazard. Hence, regular sweeping the workplace for the removal of dust and dirt is an essential housekeeping and cleanliness practice. Further, compressed air is not to be used for removing dust or dirt off employees or equipment. Compressed air can cause dirt and dust particles to be embedded under the skin or in the eye.
- **Employee facilities** – Adequate employees' facilities such as drinking water, wash rooms, toilet blocks, and rest rooms etc. are to be provided for the employees at the workplace so that employees can use them when there is a need. Cleanliness at the place of these facilities is an important aspect of the facilities.
- **Flooring** – Floors are to be cleaned regularly and immediately if liquids or other materials are spilled. Poor floor conditions are a leading cause of accidents in the workplace. Areas such as entranceways which cannot be cleaned continuously are to have mats or some type of anti-slip flooring. It is also important to replace worn, ripped or damaged flooring that poses a trip hazard.
- **Lighting** – Adequate lighting reduces the potential for accidents. It is to be ensured that inoperative light fixtures are repaired and dirty light fixtures are cleaned regularly so that the light intensity levels are maintained at the workplace.
- **Aisles and stairways** – Aisles and stairways are to be kept clear and not to be used for storage. Warning signs and mirrors can improve sight lines in blind corners and help prevent accidents. It is also important to maintain adequate lighting in stairways. Further stairways need to have railings preferably round railings for adequate grip.
- **Spill control** – The best method to control spills is to prevent them from happening. Regular cleaning and maintenance on machines and equipment is an essential practice. Also, the use of drip pans where spills might occur is a good preventative measure. When

spills do occur, it is important to clean them up immediately. When cleaning a spill, it is required to use the proper cleaning agents or absorbent materials. It is also to be ensured that the waste products are disposed of properly.

- **Waste disposal** – The regular collection of the waste materials contribute to good housekeeping and cleanliness practices. It also makes it possible to separate materials that can be recycled from those going to waste disposal facilities. Allowing material to build up on the floor wastes time and energy since additional time is required for cleaning it up. Placing containers for wastes near the place where the waste is produced encourages orderly waste disposal and makes collection easier. All recyclable wastes after their collection are to be transferred to their designated places so that the waste materials can be dispatched to the point of use or sold.
- **Tools and equipment** – Tools and equipment are required to be inspected prior to their use. Damaged or worn tools are to be taken out of service immediately. Tools are to be cleaned and returned to their storage place after use.
- **Maintenance** – One of the most important elements of good housekeeping and cleanliness practices is the maintenance of the equipment and the buildings housing them. This means keeping buildings, equipment and machinery in safe and efficient working condition. When a workplace looks neglected then there are broken windows, defective plumbing, broken floor surfaces and dirty walls etc. These conditions can cause accidents and affect work practices. It is important to have a replacement program for replacing or fixing broken and damaged items as quickly as possible.
- **Storage** – Proper storage of materials is essential in a good housekeeping and cleanliness practice. All storage areas need to be clearly marked. Flammable, combustible, toxic and other hazardous materials are to be stored in approved containers in designated areas which are appropriate for the different hazards that they pose. The stored materials are not to obstruct aisles, stairs, exits, fire equipment, emergency eyewash fountains, emergency showers, or first aid stations. Also it is important that all containers be labeled properly. If materials are being stored correctly, then the incidents of strain injuries, chemical exposures and fires get reduced drastically.
- **Clutter control** – Cluttered workplaces typically happen because of poor housekeeping practices. This type of workplace can lead to a number of issues which include ergonomic as well as injuries. It is important to develop practices where items like tools, chemicals, cords, and containers are returned to their appropriate storage location when not in use. Clutter is not only unattractive but, in a work area, it is also a serious threat to safety. Danger to the employees increases if the established exit routes and doors are blocked. For this reason, as well as to prevent slips and trips, assorted waste materials need to be disposed of promptly in the appropriate waste containers. Aisles are to be kept clear of obstructions for obvious reasons.
- **Individual workspace** – Individual workspace need to be kept neat, cleared of everything not needed for work. Many workplace injuries occur right in the employee’s workspace. This space is often overlooked when conducting general housekeeping and cleanliness inspections. It is necessary to make a checklist which is to be used by the employees to evaluate their workspace.

5 S of Housekeeping.

- 5S is a system for organizing spaces so work can be performed efficiently, effectively, and safely. This system focuses on putting everything where it belongs and keeping the workplace clean, which makes it easier for people to do their jobs without wasting time or risking injury.

- 5S is a systematic approach to good housekeeping. .

1. Sort

- The first step of 5S, Sort, involves going through all the tools, furniture, materials, equipment, etc. in a work area to determine what needs to be present and what can be removed.
- go through everything; throw away rubbish, archive old stuff you may need, decide what you need in that area on a daily and weekly basis.
- Everything else must be removed. Sentiment can not play a part here – this is a manufacturing environment
- When a group has determined that some items aren't necessary, consider the following options:
    - Give the items to a different department
    - Recycle/throw away/sell the items
    - Put items into storage
-

2. Set in Order – take the items you need in that area on a daily or weekly basis and find the best homes for them; label, mark locations, colour code – make it clear to anyone entering the area what should be where

3. Shine & Clean – as you are setting a location for each item, give it a wipe and check it is is good working order. Any broken item needs to be fixed. If your working area is particularly dirty, more time needs to be set aside so a thorough clean can be completed.

- These first three steps will get you well on your way to visually improving your factory. When our factories look better, our people feel better about working in them – suddenly there is more space to move and those little annoying things are easier to find.
- The Challenge is to Maintain this New Level of Organization
- This is where the “Standardization” and “Sustaining” come into play, which we will delve into below.
- The first part of 5S is the easy part, once you get going – we understand how to sort and tidy, as we do it all this time – at home, in our cars, in our garages, for our tax returns (although some people are better at it than others), The challenge is to maintain the new level of cleanliness and improve on it as time progresses; not to let it naturally let is slip back. This is where the last two “S”’s come into the process.

4. Standardization – the new arrangement and level of cleanliness is our new standard for each area. Take photos and display in the area; talk about the 5S activities in your toolbox talks and daily meetings; share ideas across the factory. This helps to create your new 5S standards and brings consistency across the factory.

5. Sustain – if the first 4 S’s have been done well, sustaining the cleanliness and origination becomes simpler as it is clear where everything goes and each person working in an area knows where to return things at the end of the job or end f the shift. Using simple audits, we can track how we are going to maintaining our 5S baseline on a weekly basis and to also note the areas of improvement we need to make in the week ahead.

Where ever you are in your Lean Manufacturing implementation, using 5S as your housekeeping tool ensures you are keeping on track and involving every person in your factory. If you are a little lost or have fallen behind, then start the process again; get back to Sorting and Setting in order. This is the foundation of your Lean production system and you can make it work.

Work permit system

- The work permit specifies the conditions and procedures for safe execution of the work and allows the work to be carried out under controlled risk conditions.

Aim:
The purpose of the work permit system is to ensure that:

1. Only authorized persons are allowed to work in hazardous area which is clearly notified.
2. The person permitted for work are being aware of the various safety issues involved and knows that necessary safety precautions have been taken.
3. Work permit is legal documents between issuer and executor for commencement of job inside refinery.
4. Client has implemented the work permit system to distribute the equal responsibilities of job being performed.

So don't do anything without proper work permit.

Purpose & Objective :

The purpose of this standard "Work Permit System" is to describe procedures and guidelines on work permit system to carry out jobs of inspection, testing, maintenance, alternation, repair, upkeepment and construction in safest possible manner. The implementation of this system will help in bring down the risks at work sites to acceptable level, thereby reducing possibility of any accident, fire, explosion, property damage and adverse effect on environment.

The objectives of the Work Permit System are to exercise control over the maintenance, repair and construction activities by assigning responsibilities, ensuring clear cut communication between interested functions & safety considerations to the job, its hazards & the precautions required. It ensures that the work is properly defined, authorised, operating personnel are aware what is going on, precautions to be taken are specified and the persons executing the job understand the nature and extent of hazards involved.

Work Permit System is an important element of **safety management system** and implementation of this in true spirit shall help in ensuring a safe working environment, thereby reducing possibility of injury to personnel, protect property, avoid fire, explosion & adverse affect on environment.

A hot work and cold work permits.

- Hot work and cold work permits are work permits that authorize controlled work in nonstandard, potentially hazardous conditions.
- They consist of specific instructions regarding the nature of the job, time and place, and communicate information regarding safety procedures.

Cold work permit (Green color)

- Is required for any job which does not involve or use of any source of ignitions, spark, and fire.
- Cold work permits are green colored permids issued for hazardous maintenance work that does not involve the ignition hazards found in hot work.

- Cold work situations are determined by conducting a risk assessment for the task and the working environment. If no flammable or explosive risks are identified, a cold work permit is sufficient for carrying out the work.

Hot work permit (Red color)

- is required for any job which involves or use of source of ignition, spark, and fire.
- Hot work permits are red-colored permits used to authorize work that will generate heat or sparks, such as:

    - Welding
    - Drilling
    - Grinding
    - Riveting
    - Cutting
    - Use of internal combustion engines

- Hot work involves working with a source of ignition in an environment with a potentially flammable or explosive atmosphere.
- Hot works takes into account the presence of flammable and combustible materials as well as combustible gas in the vicinity of the work.

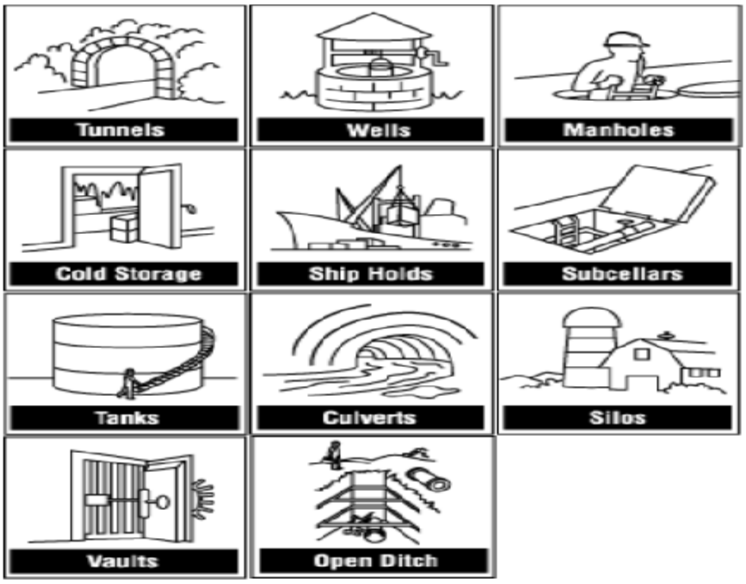
Entry into confined spaces.

- Generally speaking, a confined space is a fully or partially enclosed space that:

    - ✓ is not primarily designed or intended for continuous human occupancy
    - ✓ has limited or restricted entrance or exit, or a configuration that can complicate first aid, rescue, evacuation, or other emergency response activities
    - ✓ Can represent a risk for the for the health and safety of anyone who enters, due to one or more of the following factors:

        - its design, construction, location or atmosphere
        - the materials or substances in it
        - work activities being carried out in it, or the
        - mechanical, process and safety hazards present

- Confined spaces can be below or above ground.
- Confined spaces can be found in almost any workplace.
- A confined space, despite its name, is not necessarily small.
- Examples of confined spaces include silos, vats, hoppers, utility vaults, tanks, water supply towers, sewers, pipes, access shafts, truck or rail tank cars, aircraft wings, boilers, manholes, pump stations, digesters, manure pits and storage bins.
- Ditches, wells, and trenches may also be a confined space when access or egress is limited (but they still have "blue sky" above).
- Barges, shipping containers and fish holds are also considered as possible confined spaces.

- 

What are the hazards in a confined space?

- All hazards found in a regular workspace can also be found in a confined space.
- However, they can be even more hazardous in a confined space than in a regular worksite.

Hazards in confined spaces can include:

- Poor air quality:
    - Insufficient amount of oxygen for the worker to breathe.
    - toxic gases that could make the worker ill or cause the worker to lose consciousness.
    - asphyxiants – simple asphyxiants are gases which can displace oxygen in the air (normally about 21 percent). Low oxygen levels (19.5 percent or less) can cause symptoms such as rapid breathing, rapid heart rate, clumsiness, emotional upset, and fatigue. As less oxygen becomes available, nausea and vomiting, collapse, convulsions, coma and death can occur. Unconsciousness or death could result within minutes following exposure to a simple asphyxiant. Asphyxiants include argon, nitrogen, or carbon monoxide.
- Chemical exposures due to skin contact or ingestion (as well as inhalation of toxic gases).
- Fire hazard - An explosive or flammable atmosphere due to flammable liquids and gases and combustible dusts which, if ignited, would lead to fire or explosion.
- Process-related hazards - such as residual chemicals, or release of contents of a supply line.
- Physical hazards – noise, heat/cold, radiation, vibration, electrical, and inadequate lighting.
- Safety hazards - such as moving parts of equipment, structural hazards, engulfment, entanglement, slips, or falls.
- Vehicular and pedestrian traffic.
- Shifting or collapse of bulk material (engulfment).
- Barrier failure that results in a flood or release of free-flowing solid or liquid.
- Visibility - such as smoke particles in air.
- Biological hazards – viruses, bacteria from fecal matter and sludge, fungi, or moulds.

What should be done when preparing to enter the confined space?

- The important thing to remember is that each time a worker plans to enter any work space, the worker should determine if that work space is considered a confined space.
- Be sure the confined space hazard assessment and control program has been followed.
- Before entering any confined space, a trained and experienced person should identify and evaluate all the existing and potential hazards within the confined space.
- Evaluate activities both inside and outside the confined space.
- **Air quality testing:** The air within the confined space should be tested from outside of the confined space before entry into the confined space. Care should be taken to ensure that air is tested throughout the confined space - side-to-side and top to bottom. Continuous monitoring should be considered in situations where a worker is in a space where atmospheric conditions have the potential to change (e.g., broken or leaking pipes or vessels, work activities create a hazardous environment, isolation of a substance is not possible). A trained worker using detection equipment which has remote probes and sampling lines should do the air quality testing. Always ensure the testing equipment is properly calibrated and maintained. The sampling should show that:
    - The oxygen content is within safe limits - not too little and not too much.
    - A hazardous atmosphere (toxic gases, flammable atmosphere) is not present.
    - Ventilation equipment is operating properly.
    - The results of the tests for these hazards are to be recorded on the Entry Permit along with the equipment or method(s) that were used in performing the tests.
- Air testing is often ongoing, depending on the nature of the potential hazards and the nature of the work.
- Conditions can change while workers are inside the confined space and sometimes a hazardous atmosphere is created by the work activities in the confined space.

How are hazards controlled in confined spaces?

The traditional hazard control methods found in regular worksites can be effective in a confined space. These include engineering controls, administrative controls and personal protective equipment. Engineering controls are designed to remove the hazard while administrative controls and personal protective equipment try to minimize the contact with the hazard.

However, often because of the nature of the confined space and depending on the hazard, special precautions not normally required in a regular worksite may also need to be taken. The engineering control commonly used in confined spaces is mechanical ventilation. The entry permit system is an example of an administrative control used in confined spaces. Personal protective equipment (such as respirators, gloves, hearing protection, etc.) is commonly used in confined spaces as well. However, wearing of PPE sometimes may increase heat and loss of mobility. Those situations should be carefully evaluated. When using PPE, always use as part of a PPE program and be sure to evaluate all possible hazards and risks associated with PPE use.

How is air quality maintained?

Natural ventilation (natural air currents) is usually not reliable and not sufficient to maintain the air quality. Mechanical ventilation (e.g., blowers, fans) is usually necessary to maintain air quality.

- If mechanical ventilation is provided, there should be a warning system in place to immediately notify the worker in the event of a hazard or a failure in the ventilation equipment.

- Care should be taken to make sure the air being provided by the ventilation system to the confined space is 'clean' throughout the entire space.
- Ease of air movement throughout the confined space should be considered because of the danger of pockets of toxic gases still remaining even with the use of mechanical ventilation.
- Do not substitute oxygen for fresh air. Increasing the oxygen content will significantly increase the risk of fire and explosion.
- The use of mechanical ventilation should be noted on the entry permit.
- Ensure air being removed from the confined space is exhausted away from workers on the outside.

How are fire and explosion prevented?

Work where a flame is used or a source of ignition may be produced (hot work) should not normally be performed in a confined space unless:

- All flammable gases, liquids and vapors are removed before the start of any hot work. Mechanical ventilation is usually used to
    1. Keep the concentration of any explosive or flammable hazardous substance less than 10% of its Lower Explosive Limit AND
    2. Make sure that the oxygen content in the confined space is not enriched. Oxygen content should be less than 23% but maintained at levels greater than 19.5%. (These numbers can vary slightly from jurisdiction to jurisdiction.)

- Surfaces coated with combustible material should be cleaned or shielded to prevent ignition.
- Do not bring fuel or fuel containers into the confined space (e.g., gasoline, propane), if possible. Ensure welding equipment is in good condition.
- Where appropriate, use spark-resistant tools, and make sure all equipment is bonded or grounded properly.

While doing the hot work, the concentrations of oxygen and combustible materials must be monitored to make sure certain that the oxygen levels remain in the proper range and the levels of the flammable products combustible materials do not get higher than 10% of the Lower Explosive Limit. In special cases it may not be possible, and additional precautions must be taken to ensure the safety of the worker prior to entering the confined space.

If potential flammable atmosphere hazards are identified during the initial testing, the air in the confined space should be cleaned or purged, ventilated and then tested again before entry to the confined space is allowed. Only after the air testing is within allowable limits should entry occur as the gases used for purging can also be extremely hazardous.

How are energy sources controlled?

All potentially hazardous energy sources such as electrical, mechanical, hydraulic, pneumatic, chemical, or thermal must be de-energized (or isolated) and locked out prior to entry to the confined space so that equipment cannot be turned on unintentionally accidentally. If lock out or tag out is not possible, the hazardous energy must be controlled in a way that eliminates or minimizes worker exposure to the hazards before workers are allowed to enter the confined space. It is important that any method of control other than isolation and lockout must be evaluated and the effectiveness for controlling the hazardous energy must be demonstrated.

What are other safety precautions?

Many other situations or hazards may be present in a confined space. Be sure that all hazards are controlled, for example:

- Any liquids or free-flowing solids should be removed from the confined space to eliminate the risk of drowning or suffocation.
- All pipes should be physically disconnected or isolation blanks bolted in place. Closing valves is not sufficient.
- Use two blocking valves, with an open vent or bleed valve between the blocking valves when isolating pipelines or similar conveyances to prevent entry of materials and hazardous contaminants.
- A barrier is present to prevent any liquids or free-flowing solids from entering the confined space.

MCN401: Industrial Safety Engineering

Module 3_Lecture #4

Relevant Indian Standards and the National Building Code provisions on construction safety

1) **SP70:2001- Handbook on construction safety practices**

This Handbook on Construction Safety Practices has been prepared for site engineers, project managers and engineers-in-charge of buildings and civil works projects. It is based on the Indian Standards on the subject and is written in a readable style for easy reference by users.

Users should be conversant with technical as well as administrative/ legal aspects of safety, the former stem out of the standards and the latter from labour laws, contract document and judicial pronouncements. This Handbook deals with only the technical aspects of safety in construction.

2) **NBC 2016 (National Building Code of India)-**

- Part 4: Fire and Life Safety
- Part 7: Construction management, Practices and Safety (IS SP7-NBC (2016))

Part 4 at a glance

Fire and life Safety

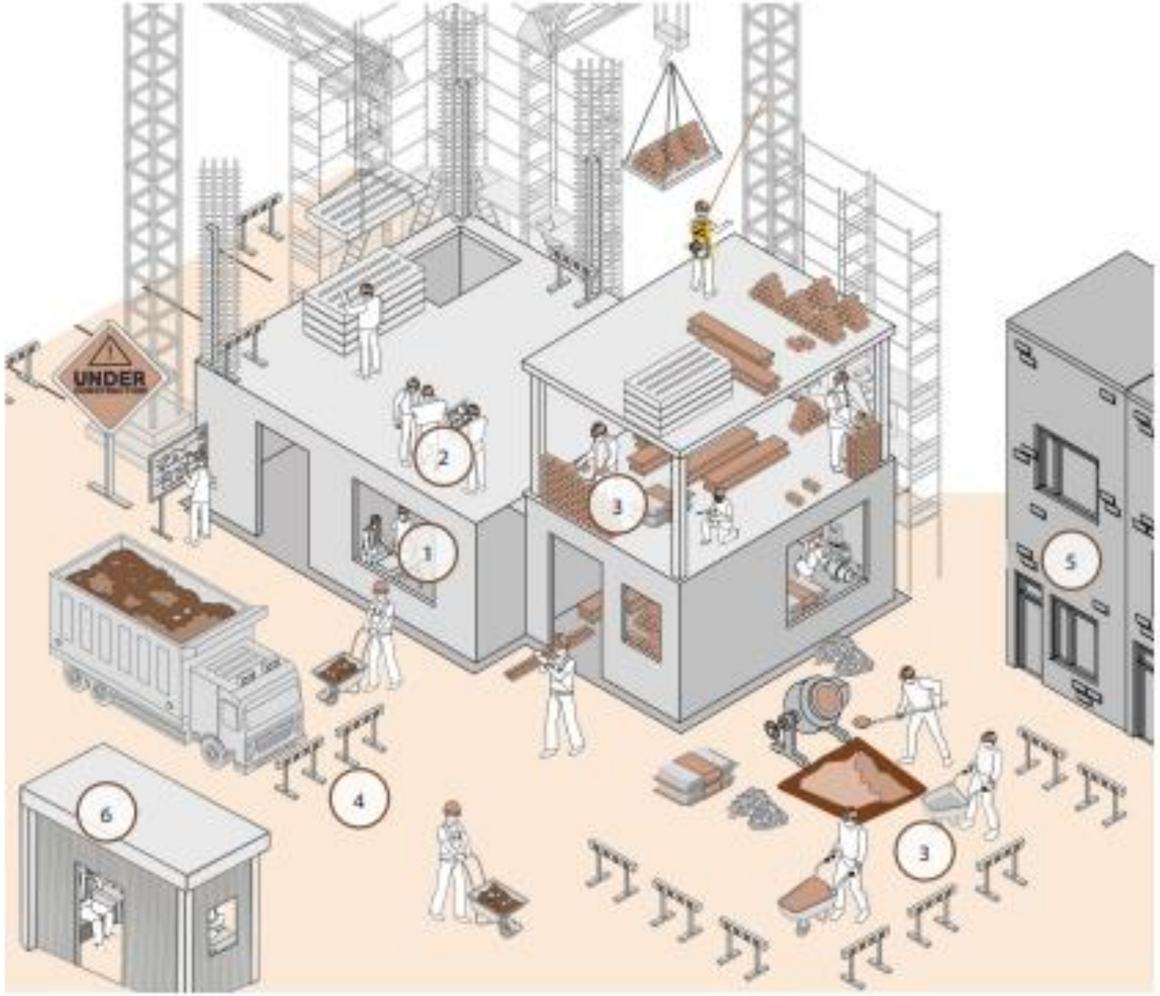
Fire Prevention	Life Safety	Fire Protection
• Classification of buildings based on occupancy, from fire safety point of view • Demarcation of fire zone • Types of building construction • Openings in fire resistant walls and floors • Electrical installations • Escape lighting and exit signage • Air conditioning, ventilation and smoke control • Heating • Glazing • Surface interior finishes • Fire Command Centre (FCC)	• General exit requirements • Occupant load • Egress components – Exit access – Exit – Exit discharge • Compartmentation • Smoke control • Gas supply • Hazardous areas, gaseous, oil storage yard, etc • Fire Officer • Fire drills and fire orders	• Requirements for firefighting installations (refer Table 7) • Maintenance of firefighting installation and systems

Additional occupancy wise requirements

Additional fire safety requirements for high rise building, atrium, commercial kitchen, car parking facilities, metro stations, metro trainways and measures for venting in industrial buildings, are also covered in this Part of NBC 2016.

All buildings shall satisfy minimum requirements for safety of life from fire, smoke, fumes or panic arising from these or similar causes.

Part 7 at a glance



1) Construction management (time, cost, quality, health and safety)
2) Construction planning and site management
3) Construction practices
4) Safety in construction
5) Repairs, retrofitting and strengthening of buildings
6) Habitat and welfare requirements for workers

Standards relating to construction project management functions and construction practices are also refered in this Section.

For more details on Part 7, please refer to NBC 2016

Relevant Indian Standards and the National Building Code provisions on construction safety

3) Safety, Health and Environment Handbook 2019

This Hand book in conjunction of emergency action plan intend to define minimum requirement of safety, health and environmental management system to be implemented on in CPWD works to maintain high standards of SHE at construction sites. . It is intended to be used by engineers, architects and contractors during planning and execution stages.

Civil Engineering Construction	
IS 875:1987	Structural safety of building: Loading Standards Part 1-5
IS 1905:1987	Structural safety of buildings : Masonry Walls
IS 4014:1967	Code of practice for steel tubular scaffolding - 2 parts
IS 4138 :1977	Safety code for working in compressed air (first revision)
IS 4912 :1978	Safety requirements for floor and wall openings, railings and toe boards (first revision)
IS 7293:1974	Safety code for working with construction machinery
IS 7969:1975	Safety code for handling and storage of building materials
IS 9944:1992 IS	Recommendations on safe working load for natural and man-made fibre rope slings
11972:1987	Code of practise safety for protective barriers in and around building
IS 7293:1974	Safety code for working with construction machinery
IS 7969:1975	Safety code for handling and storage of building materials

MODULE 4

What hazards exist?

- Crushed by or drawn into equipment
- Struck by moving parts
- Struck by failed components or particles

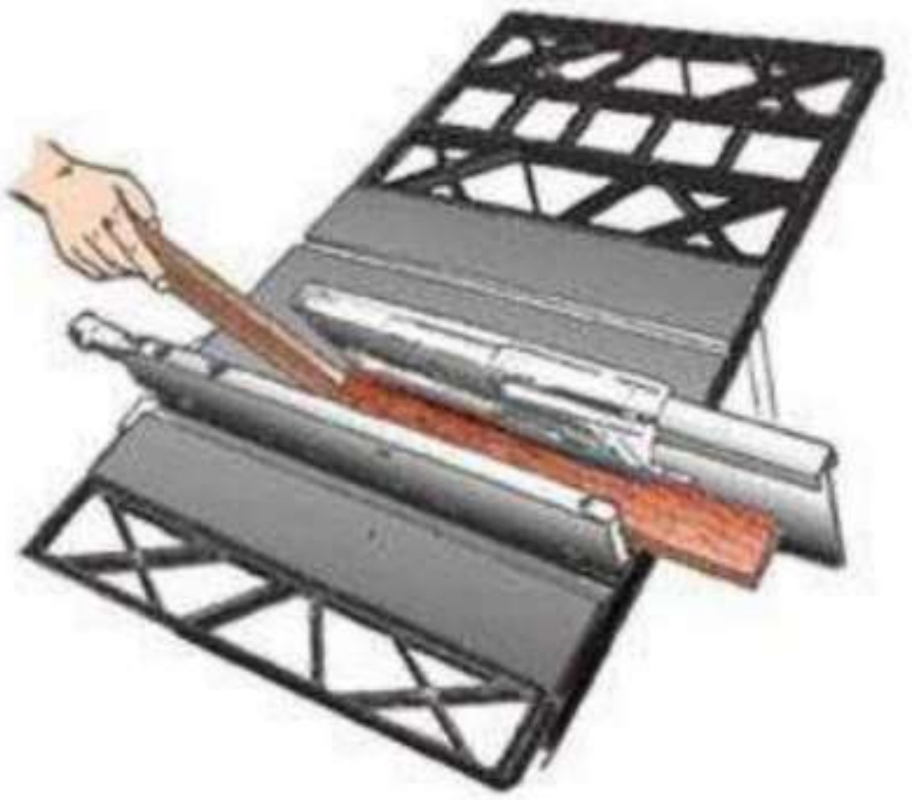
Key parts of machines

1. **Point of operation**: where work is performed on the material, such as cutting, shaping, boring, or forming of stock.
2. **Power Transmission Device:** transmits energy to the part of the machine performing the work
   - Includes flywheels, pulleys, belts, connecting rods, couplings, cams, spindles, chains, cranks, and gears.

Key parts of machines

3. **Operation Controls**: Control mechanisms
4. **Other moving parts**: can include reciprocating, rotating, and transverse moving parts, feed mechanisms, and auxiliary parts of the machine

- Point of Operation - work such as bending, punching, cutting on the material – P.O.O.
- Nip point - location where machine pieces come together such as belts and a pulley, two in-running rollers, etc.



Hazards to be Guarded

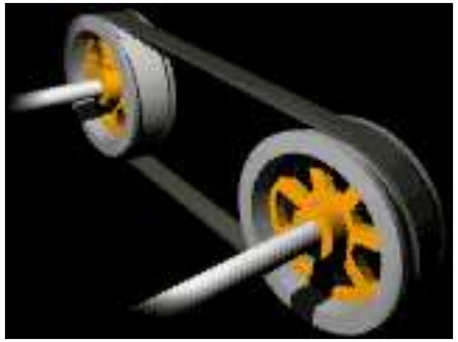
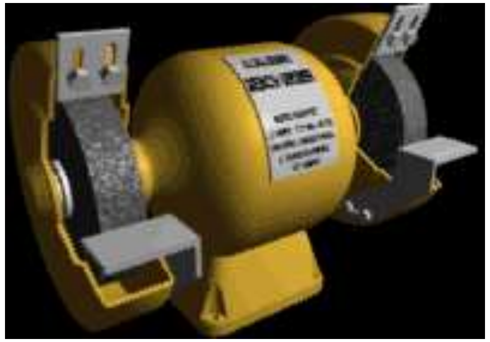
- Things to guard include
  - In-running nip points
  - Rotating equipment
  - Flying chips or sparks
  - Belts or gears
  - Parts that impact or shear

Rotating Parts

- Can grip hair or clothing
- Can force the body into a dangerous position
- Projecting pieces increase risk

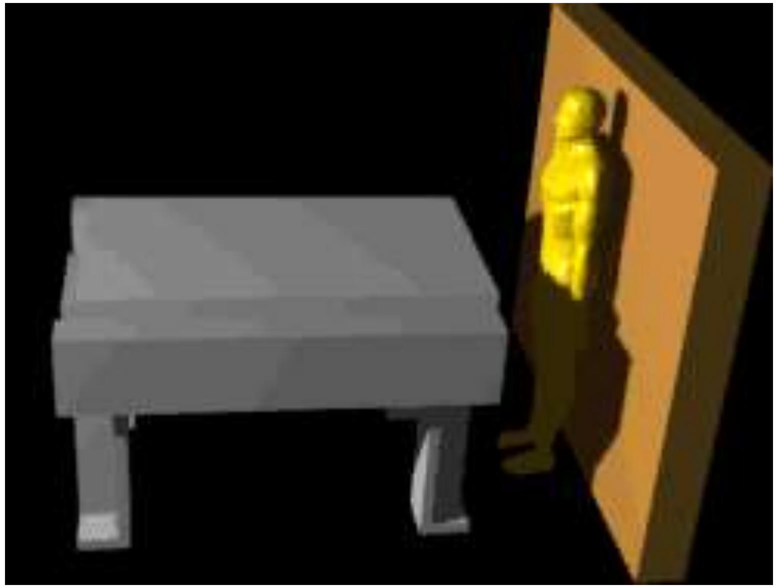
In-Running Nip Points

- Between 2 rotating parts
- Between rotating and tangential parts
- Between rotating and fixed parts which shear, crush, or abrade

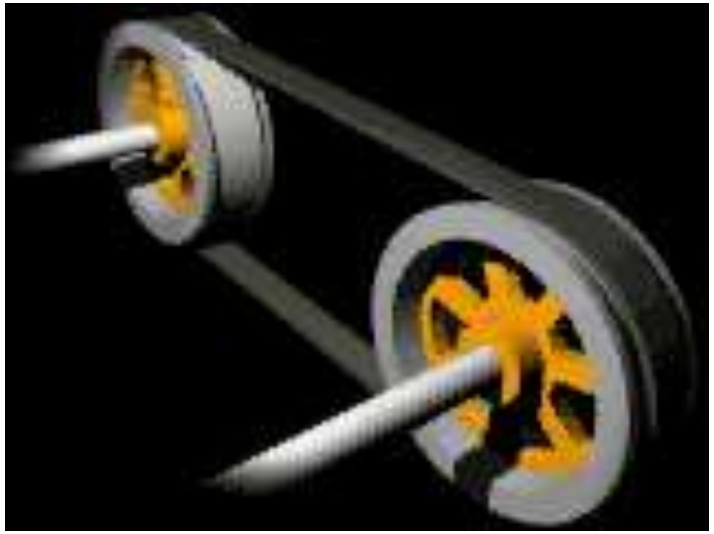
Reciprocating Parts

- Risk of being struck between stationary and moving part



Transverse motion

- Continuous straight line motion
- Worker struck or caught in pinch or shear point

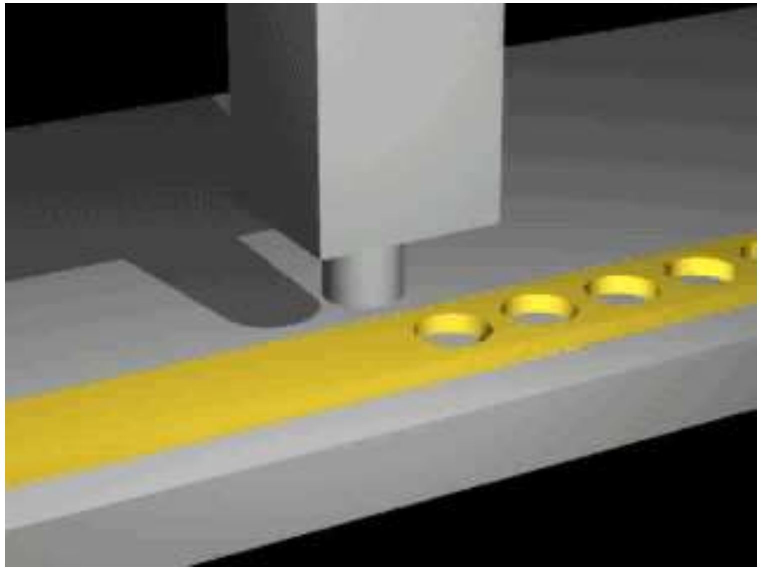


Cutting action

- Direct injury from cutting action
- Flying chips or sparks
- Saws, drills, lathes, mills

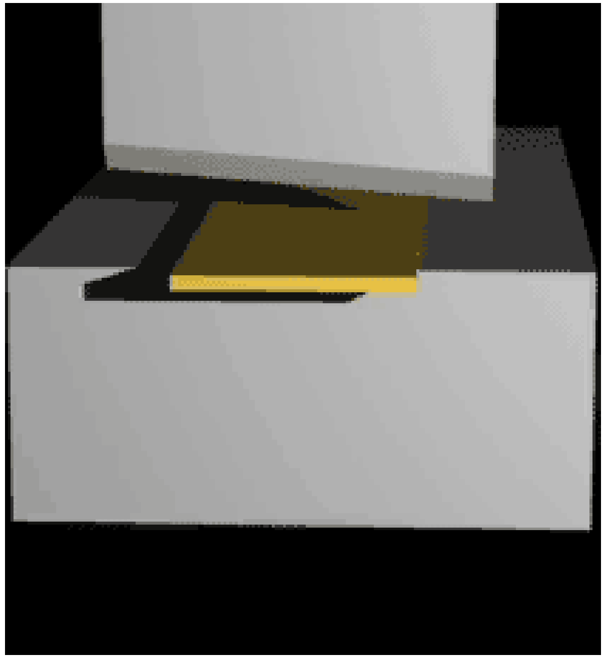
Punching action

- Ram stamps materials
- Danger at point of operation



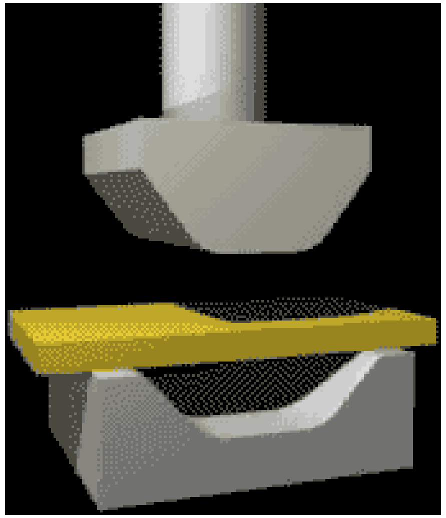
Shearing action

- Powered blade that shears materials
- Hazard at point of operation



Bending action

- Power applied to a slide to stamp/shape materials
- Hazard at point of operation



Guarding Principles

- **Prevent contact** between hazardous moving parts and body or clothing
- **Secure guard:** not easily removed
- **Protect from objects** falling into machinery
- **No new hazards:** sharp/rough edges
- **No interference** with job/comfort/speed
- **Allow safe lubrication:** without removing guards if possible

Principles of Machine Safety

- Unless a particular hazard is removed, the risk associated with such a hazard can never be completely eliminated.
- The approach most commonly used is referred to as the hierarchy of controls, from preferred to least desirable, as follows:
- **(a) elimination;**
- **(b) substitution;**
- **(c) engineering controls;**
- **(d) administrative (procedural) controls; and**
- **(e) personal protective equipment (PPE).**

Machinery Guards

Guarding

- A guard can perform several functions: it can deny bodily access, contain ejected parts, tools, off-cuts or swath, prevent emissions escaping or form part of a safe working platform.
- Guarding is commonly used with machinery and equipment to prevent access to:
- • rotating end drums of belt conveyors
- • moving augers of auger conveyors
- • rotating shafts
- • moving parts that do not require regular adjustment
- • machine transmissions, such as pulley and belt drives,
- chain drives, exposed drive gears
- • any dangerous moving parts, machines or equipment.

Part Two: Safeguarding

There are many ways to safeguard machines!

Determine the appropriate safeguarding method.

Consider:

- the type of operation and material
- the size or shape of stock
- the method of handling
- the physical layout of the work area
- production requirements/limitations

Part Two: Safeguarding

1. Guards

Fixed

Interlocked

Adjustable

Self-adjusting

Part Two: Safeguarding

2. Devices

- Presence Sensing
- Pullback
- Restraint
- Safety Controls
- Gates

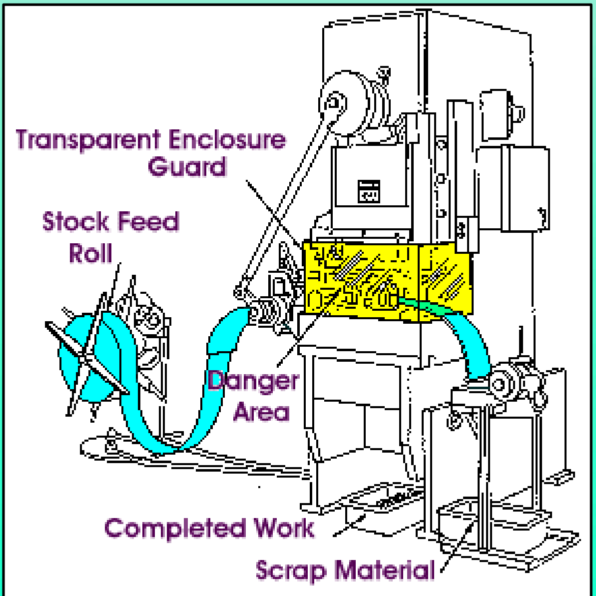
Rockford Systems, Inc.

Part Two: Safeguarding

3. Location/Distance

4. Feeding/Ejection Methods

Automatic/Semi-Auto feed
Automatic/Semi-Auto ejection
Robotics



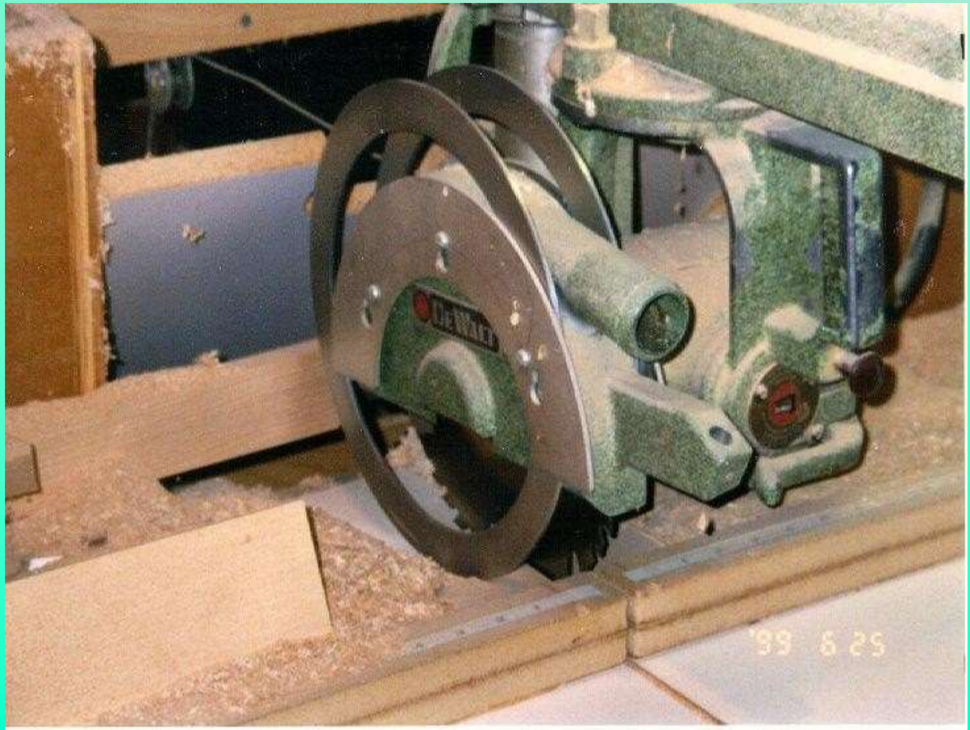
Power Press with Automatic Feed

Effective Safeguarding

- Must be in conformity with any appropriate standards.
- Must not present a hazard in itself nor create interference.
- Allows safe maintenance and lubrication.

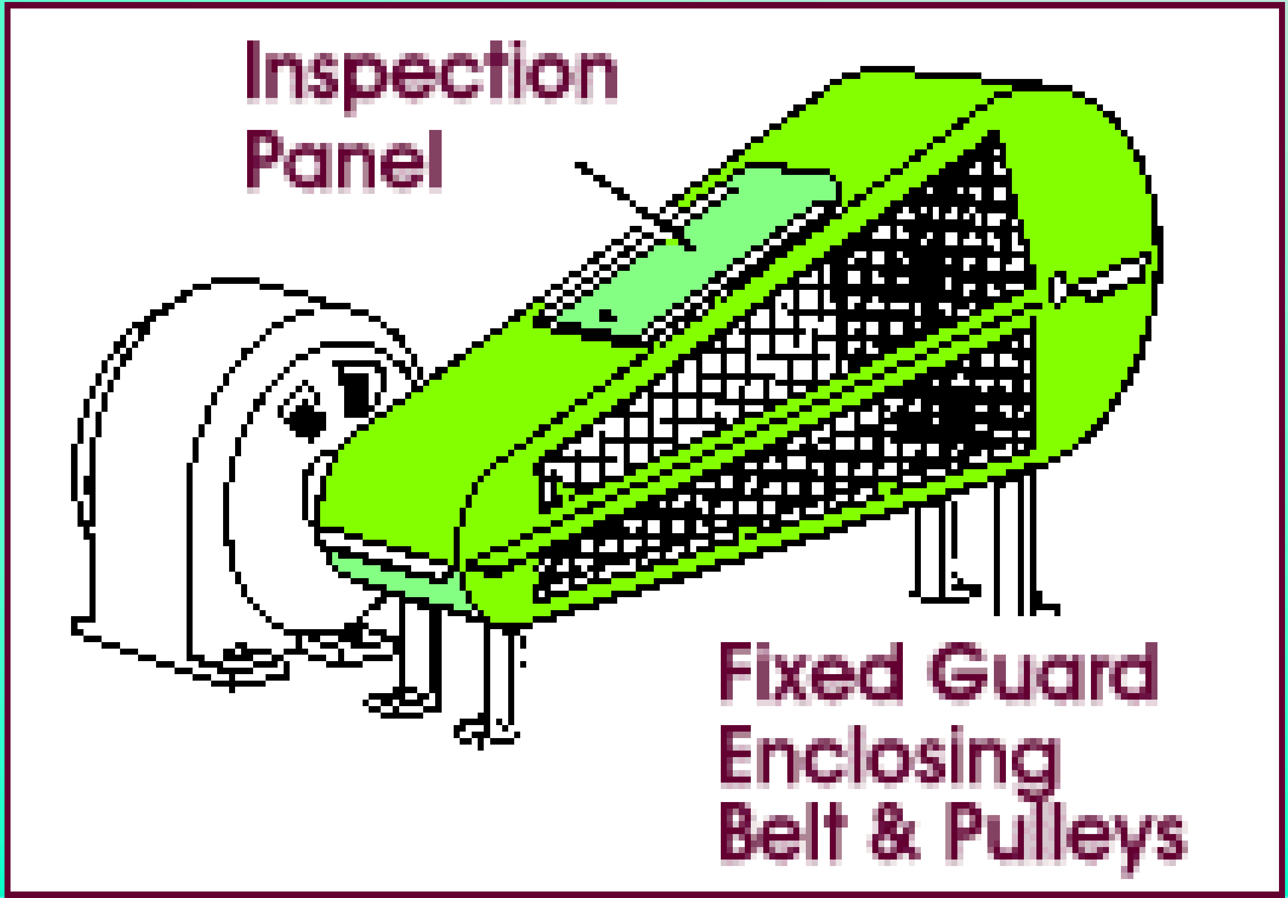
Effective Safeguarding

- Must not allow product or objects to fall into moving parts or onto people.
- Get Buy-in from Operators, PM Tech, Lube and Maintenance Techs.



First Safeguarding Strategy: Guards

Guards are barriers which prevent access to danger areas.



First Safeguarding Strategy: Guards

Fixed Guard Characteristics:

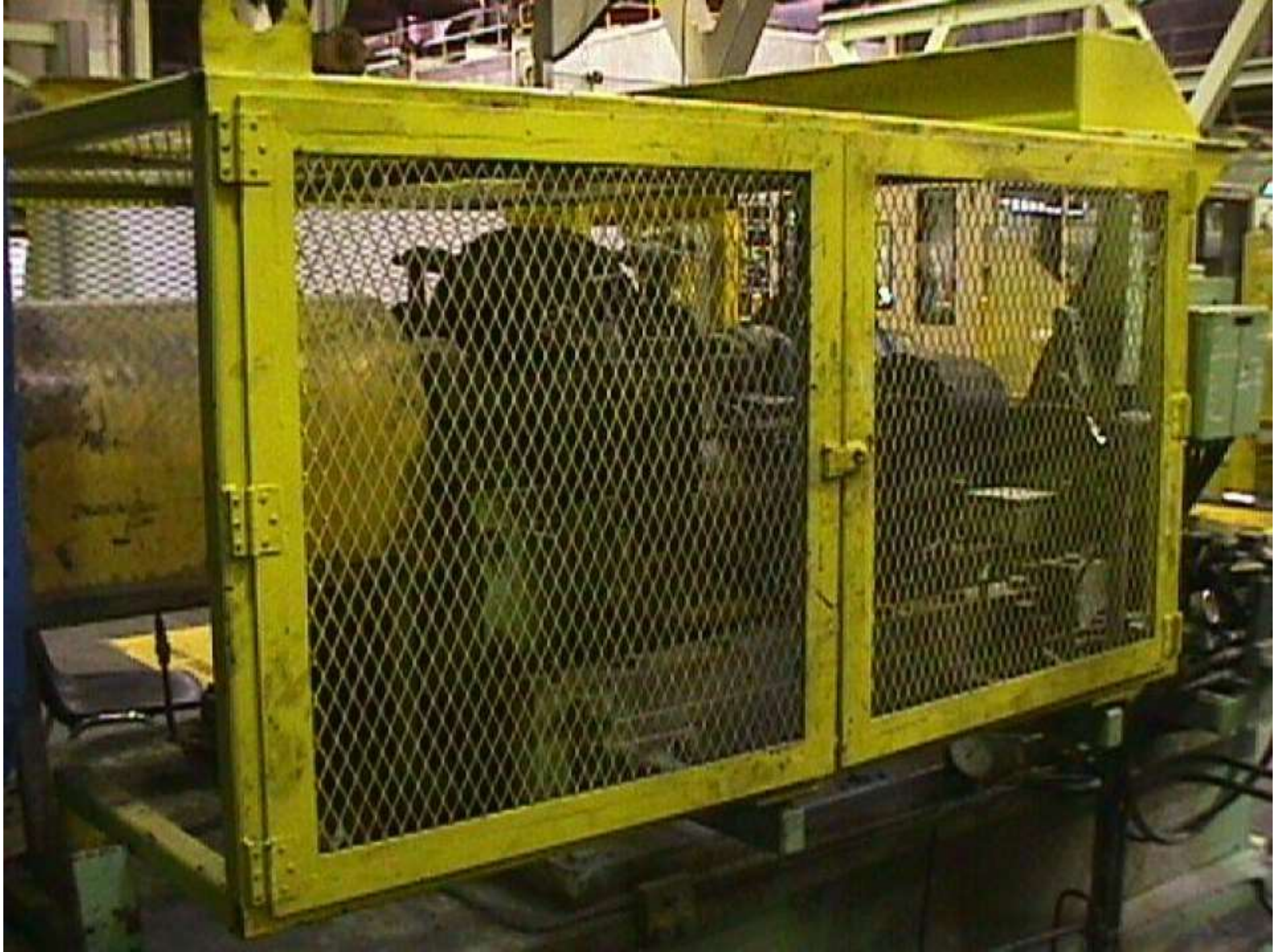
- A permanent part of the machine. Tools are needed for removal.
- Not dependent upon moving parts to perform its intended function.
- Constructed of sheet metal, screen, wire cloth, bars, plastic, or substantial material.
- Usually preferable to all other types because of its simplicity and permanence.

Part Two: Safeguarding

As a general rule, power transmission apparatus is best protected by <u>fixed guards</u> that enclose the danger areas.

Enclosed shaft end


428
Enclosed chain &
sprocket



First Safeguarding Strategy: Guards

Interlocked Guard Characteristics:

When this type of guard is opened/removed:

- The tripping mechanism and/or power automatically shuts off or disengages.
- The machine cannot cycle or be started until the guard is back in place.

First Safeguarding Strategy: Guards

Interlocked Guard Characteristics (continued):

- They may use electrical, mechanical, hydraulic, or pneumatic power or any combination of these.
- Replacing the guard must not automatically restart the machine.
- PM is important because sometimes they fail and sometimes they are sabotaged!

Interlocked guarding can be defeated!

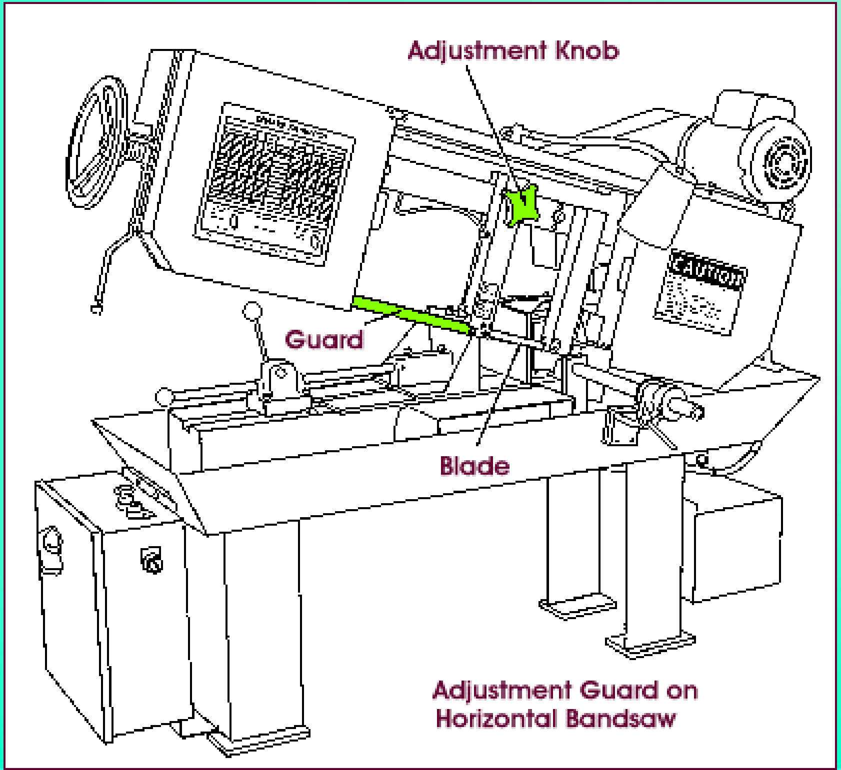
This was taped down.

Good opportunity for RCA.

First Safeguarding Strategy: Guards

Adjustable Guards

– These guards allow flexibility in accommodating various sizes of stock



Adjustment Guard on Horizontal Bandsaw

First Safeguarding Strategy: Guards

Self-Adjusting Guards

The openings of these guards are determined by the movement of the stock.

- As the operator moves the stock into the danger area, the guard is pushed away, providing an opening which is only large enough to admit the stock.
- After the stock is removed, the guard returns to the rest position.

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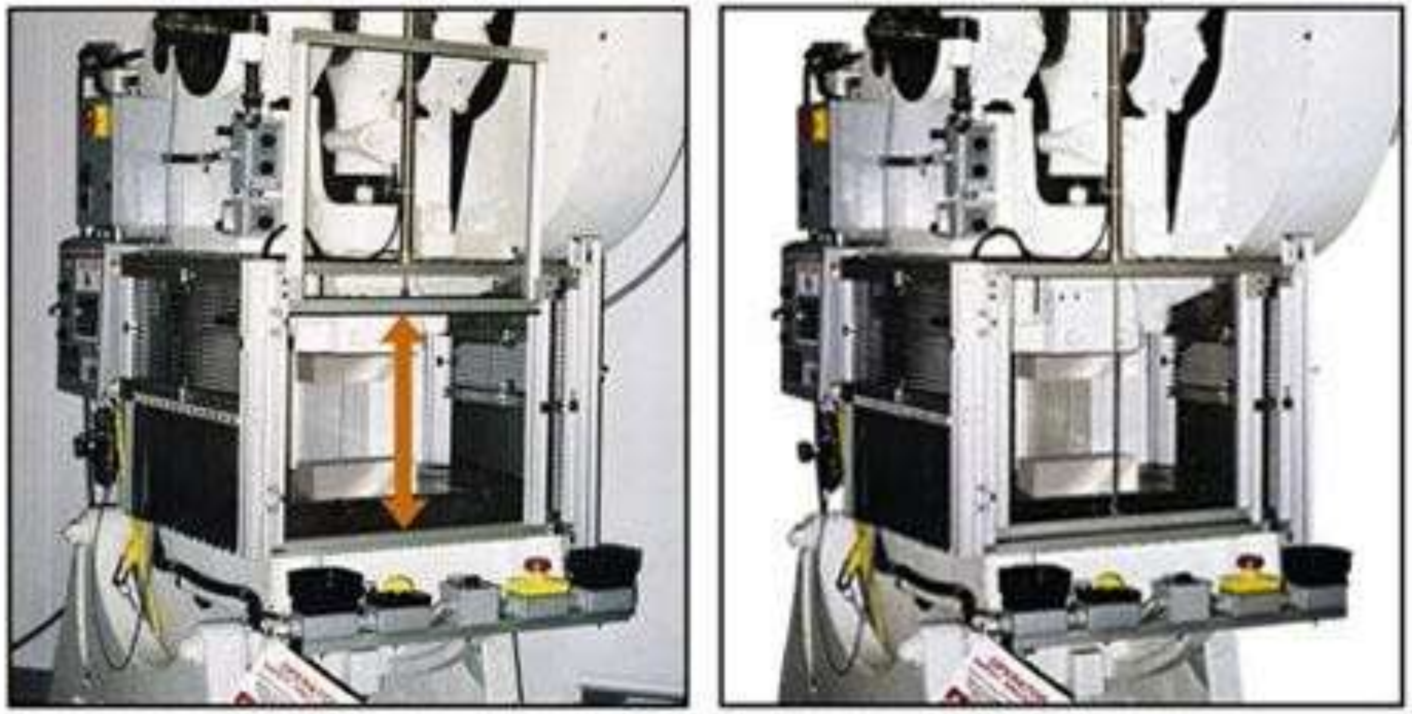
Second Safeguarding Strategy: Devices

A safety device may perform one of several functions.



Gate Open Gate Closed

Rockford Systems, Inc.

Second Safeguarding Strategy: Devices

- **Presence-Sensing Devices**

  Photoelectric (optical)

  – Uses a system of light sources and controls which can interrupt the machine's operating cycle.

  Radiofrequency (capacitance)

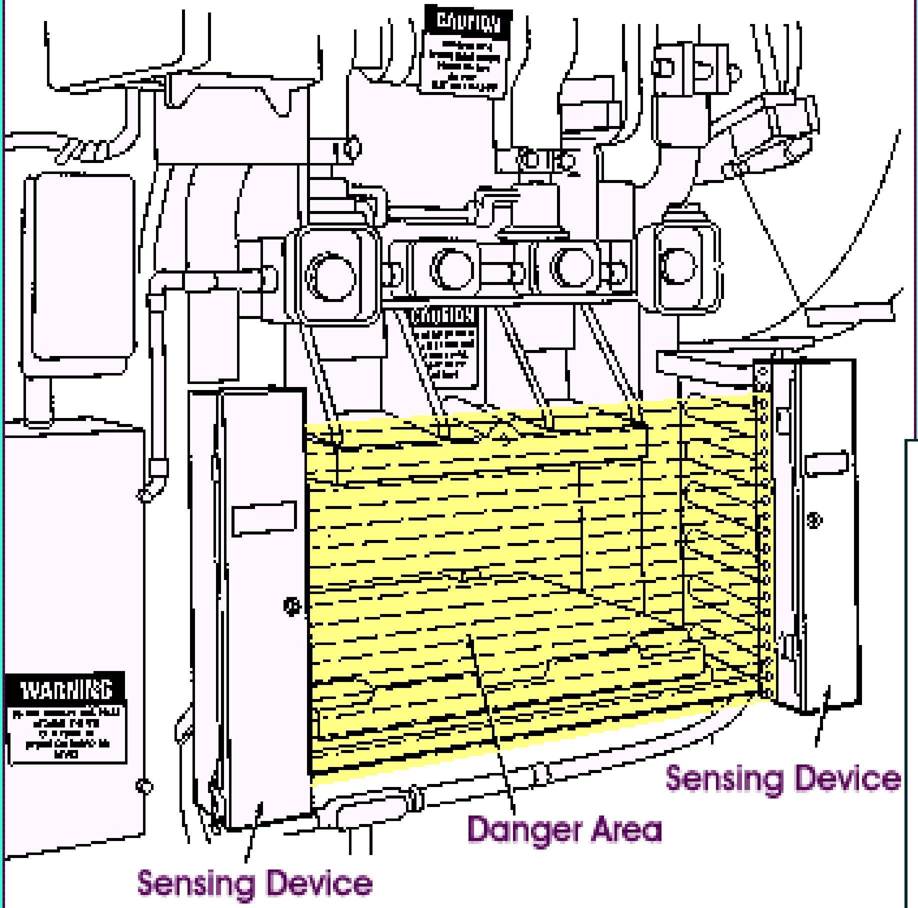
  – Uses a radio beam that is part of the machine control circuit.

  – When the capacitance field is broken, the machine will stop or will not activate.

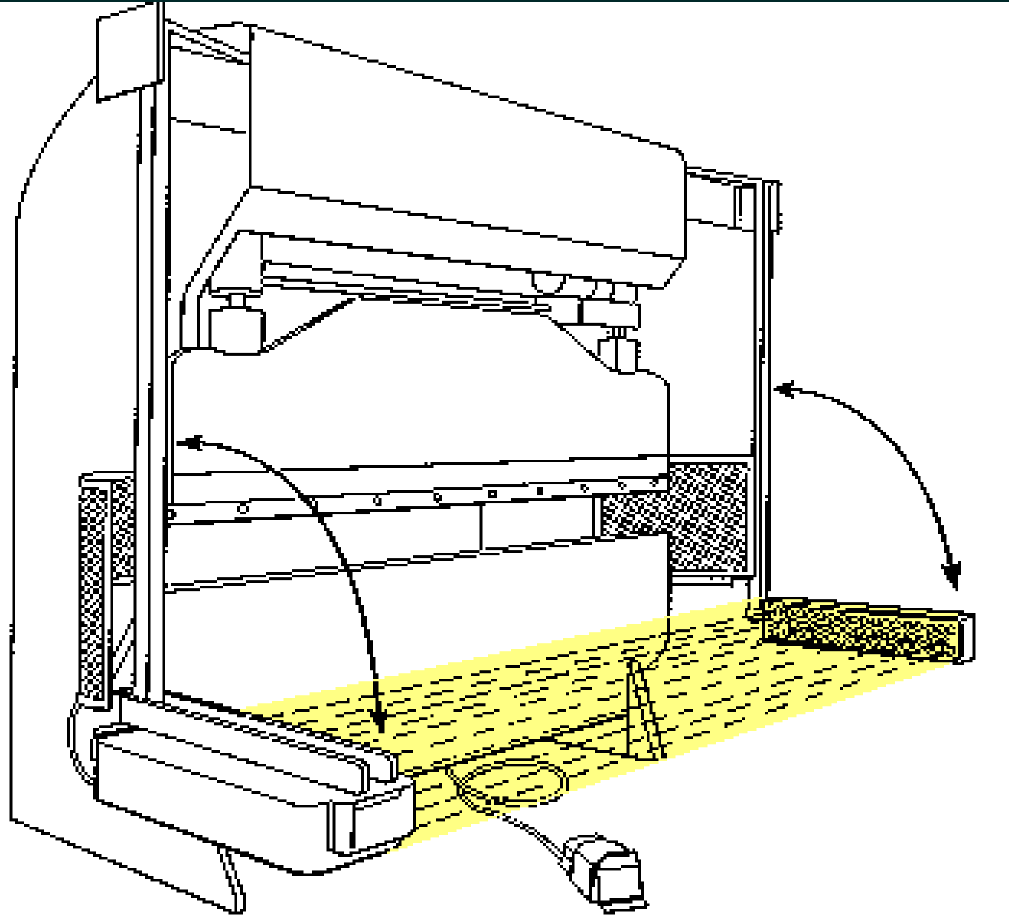
Second Safeguarding Strategy: Devices

It may stop the machine if a hand or any part of the body is inadvertently placed in the danger area.

Equipment Resale, Inc



Photoelectric Presence-Sensing Device on Power Press

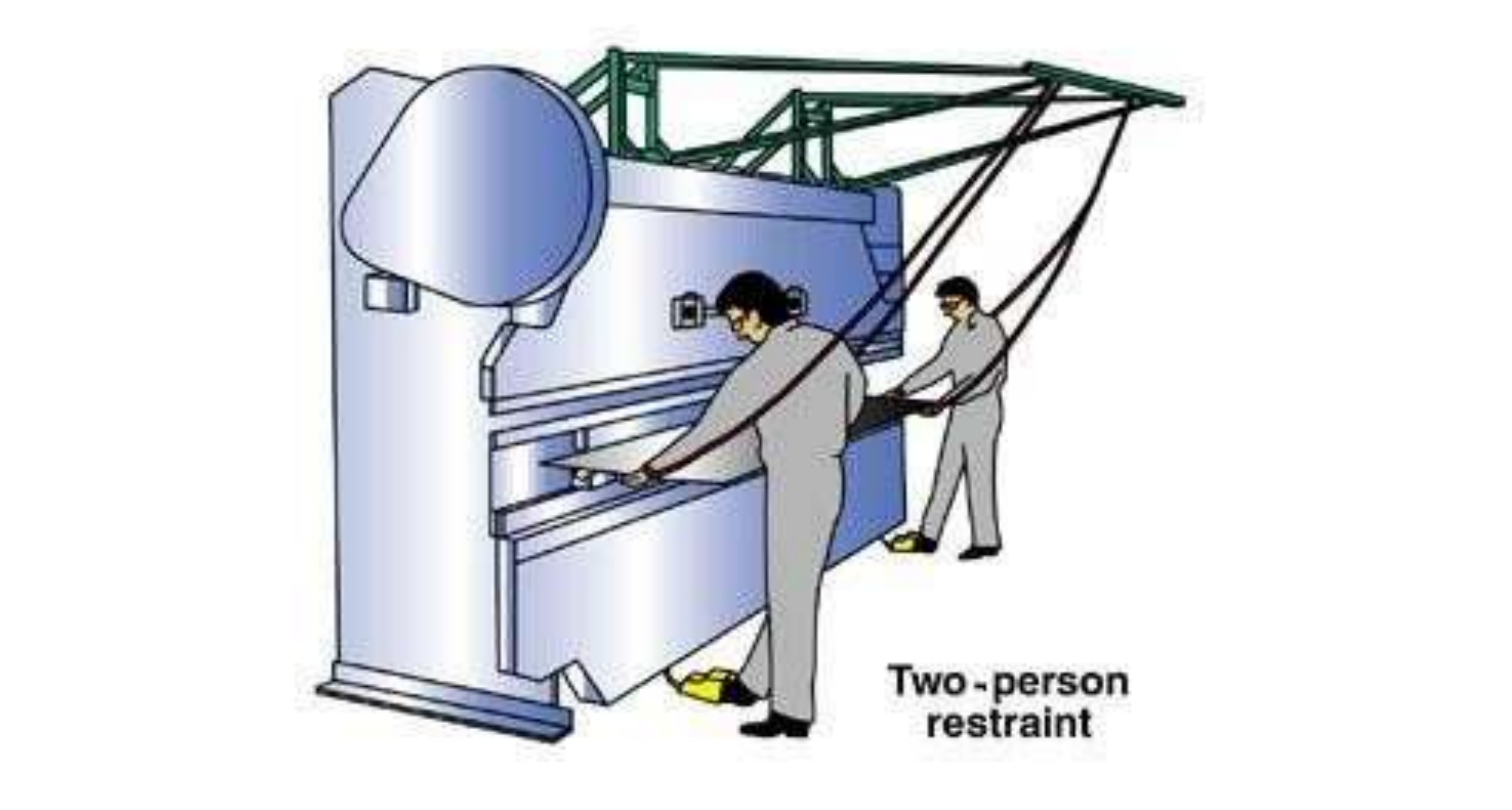


Photoelectric Presence-Sensing Device on Press Brake

Second Safeguarding Strategy: Devices

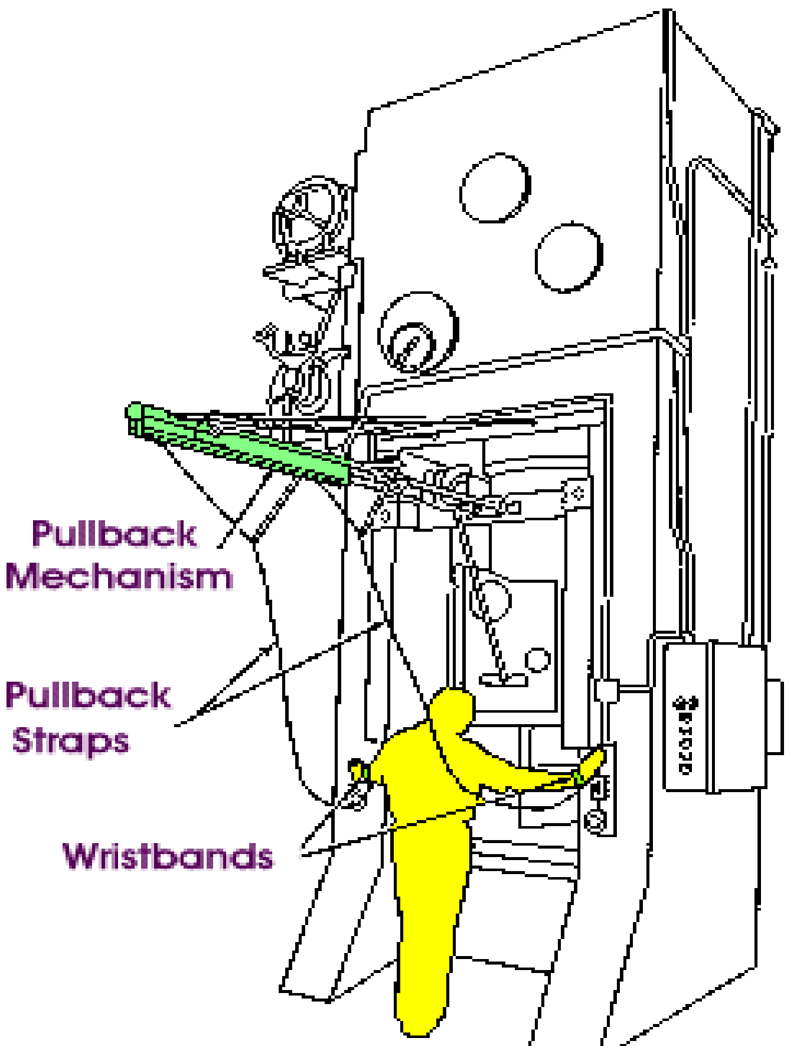
- **Restraint**
  - The restraint (holdout) device utilizes cables or straps that are attached to the operator's hands at a fixed point
  - The cables or straps must be adjusted to let the operator's hands travel within a predetermined safe area - there is no extending or retracting action involved

Second Safeguarding Strategy: Devices



Second Safeguarding Strategy: Devices

- **Pullback**
  - Pullback devices utilize a series of cables attached to the operator's hands, wrists, and/or arms
  - This type of device is primarily used on machines with stroking action
  - When the slide/ram is up between cycles, the operator is allowed access to the point of operation

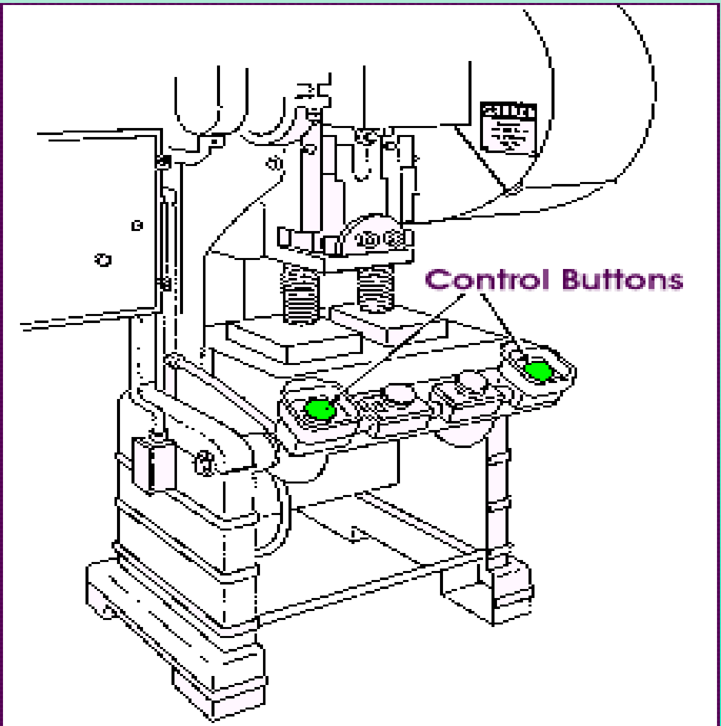


Pullback Device on a Power Press

Identify the Action

Second Safeguarding Strategy: Devices

- **Two Hand Controls**
  - Requires constant, concurrent pressure by the operator to activate the machine
  - With this type of device, the operator's hands are required to be at a safe location (on the control buttons) and at a safe distance from the danger area



Two-hand Control Buttons on Part-revolution Clutch Power Press

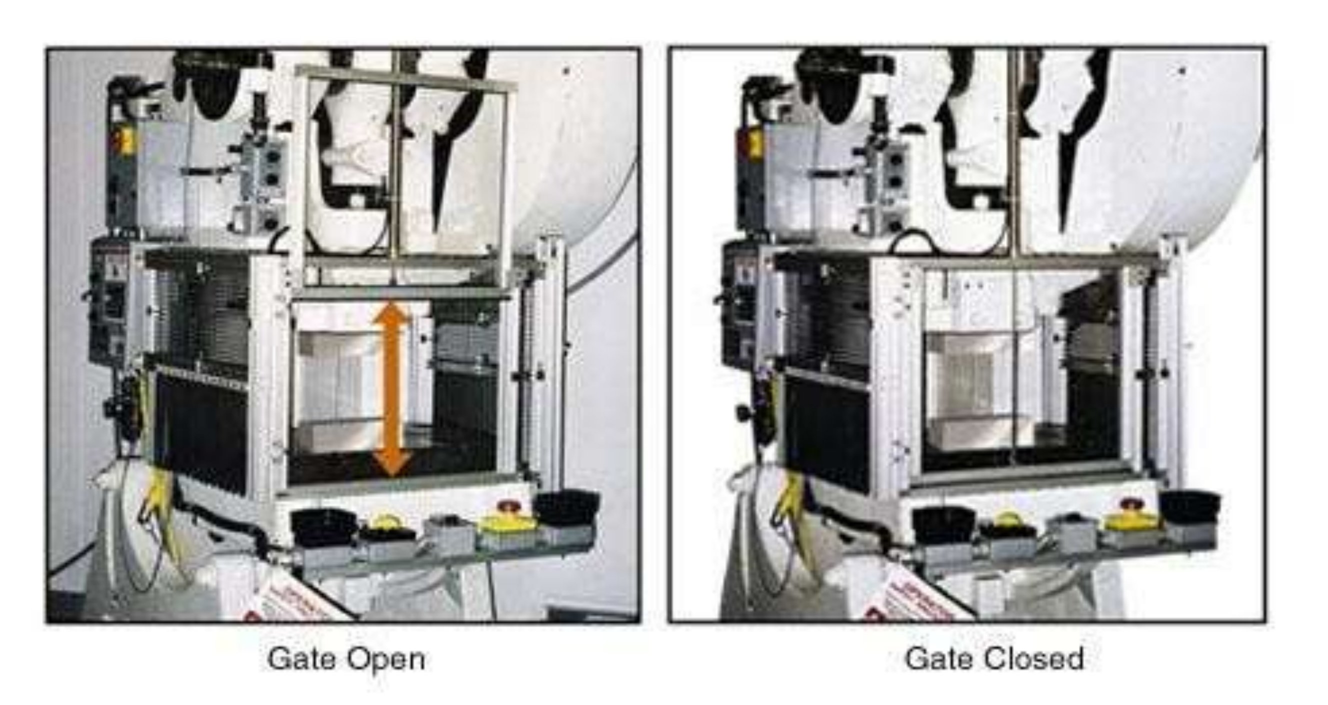
Second Safeguarding Strategy: Devices

Second Safeguarding Strategy: Devices

- **Two Hand Trips**
  - This device requires concurrent application of both the operator's control buttons to activate the machine cycle, after which the hands are free.
  - Must be far enough away to prevent **intentional** contact.

Second Safeguarding Strategy: Devices

- **Gates**
- Provide a barrier which is synchronized with the operating cycle of the machine in order to prevent entry to the danger area during the hazardous part of the cycle



Rockford Systems, Inc.

First Safeguarding Strategy: Guards

Interlocked guards:

- Vertical balers built to ANSI Z245.2 *American National Standard for Refuse Collection, Processing, and Disposal Equipment-Stationary Compactors-Safety Requirements* do not comply with Title 8 CCR 4353(h).

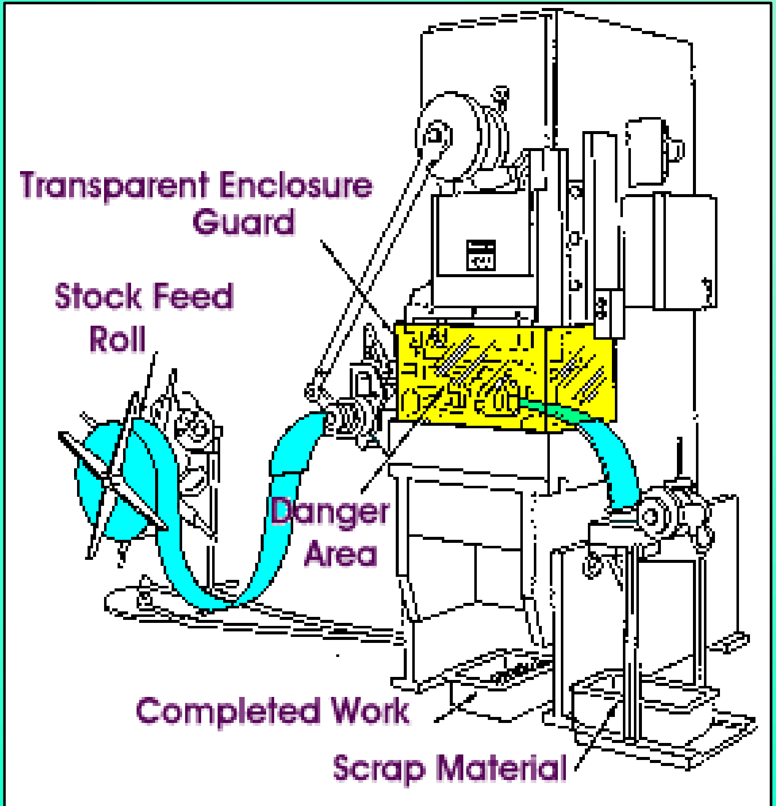
Another Safeguarding Strategy

- **Guarding by Location/Distance**
  - The machine or its dangerous moving parts are positioned so that hazardous areas are not accessible or do not present a hazard during normal operation
    - walls or other barricades (fences)
    - height (above worker)
    - size of stock (single end feeding, punching)

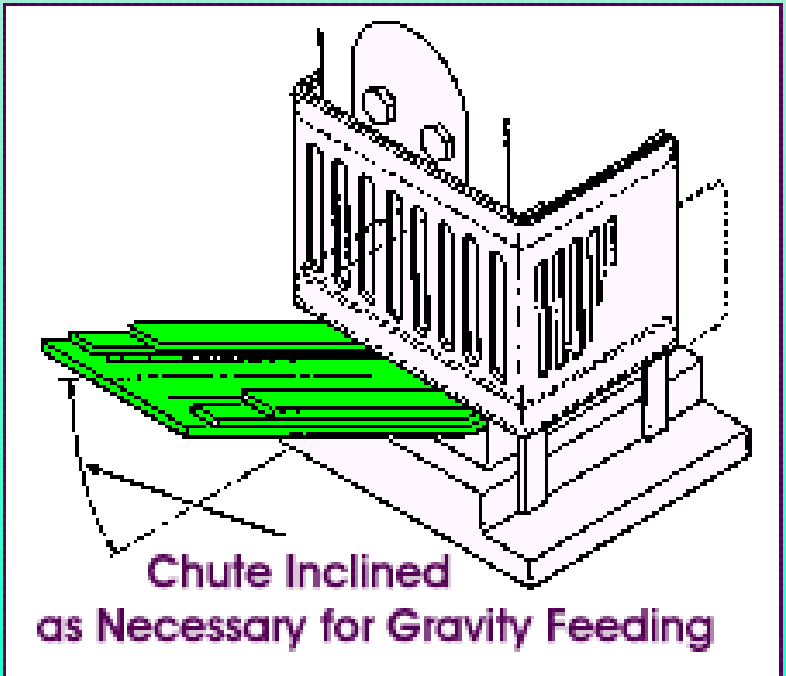
Is this adequate guarding by location?

Another Safeguarding Strategy

- **Auto/Semi-auto Feeding and Ejection**
  - Automatic and Semi-automatic Feeding



Power Press with Automatic Feed

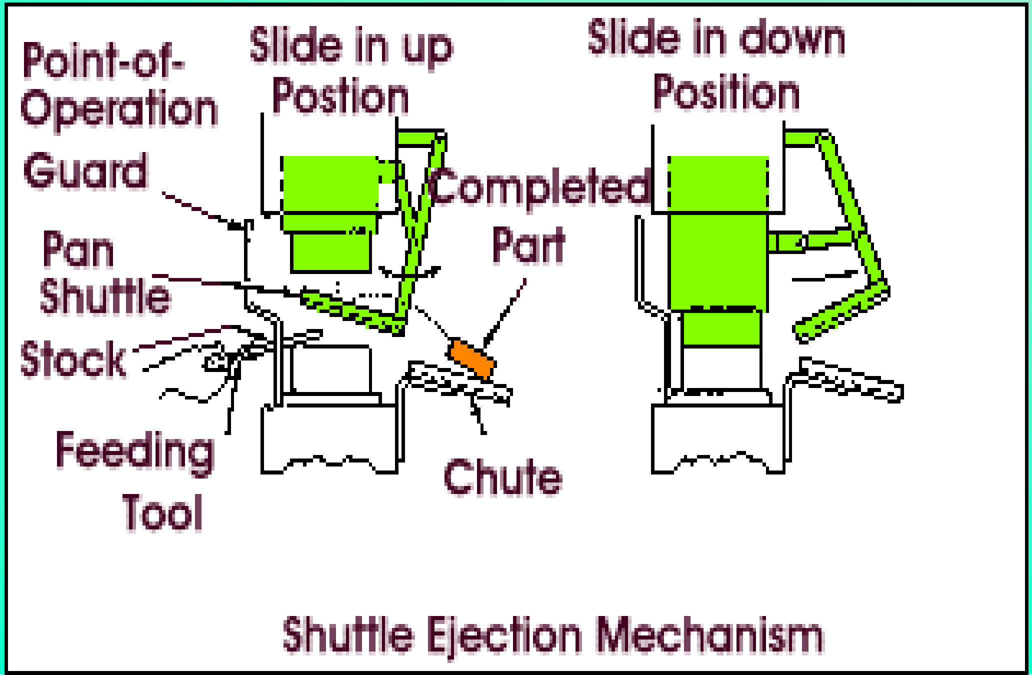


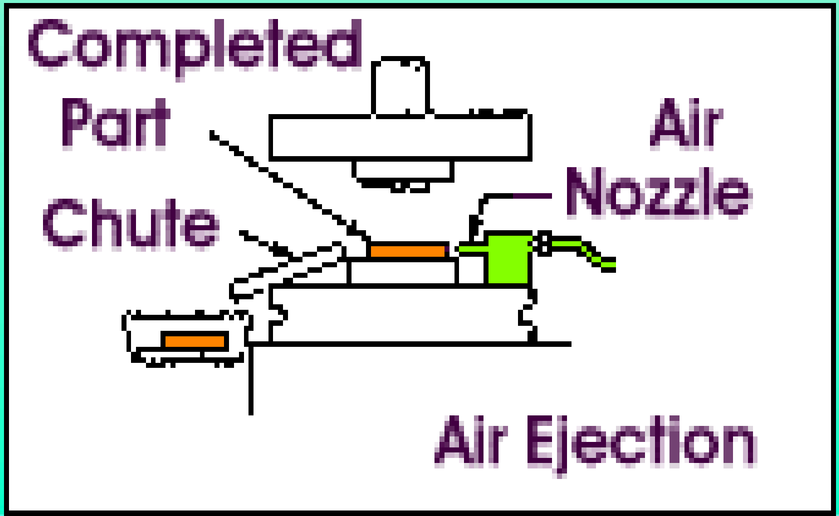
Power Press with Chute Feed

Another Safeguarding Strategy

Feeding and Ejection

– Automatic Ejection

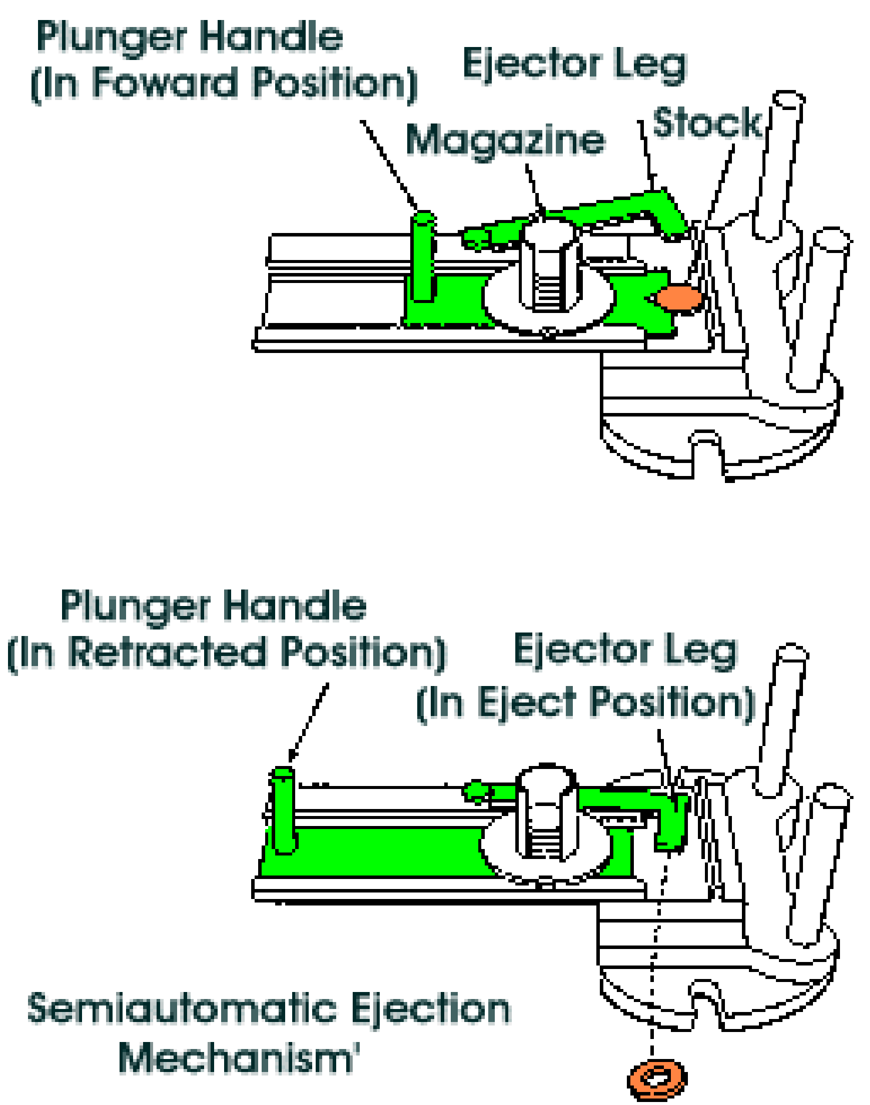




Another Safeguarding Strategy

Feeding and Ejection

- Semiautomatic Ejection

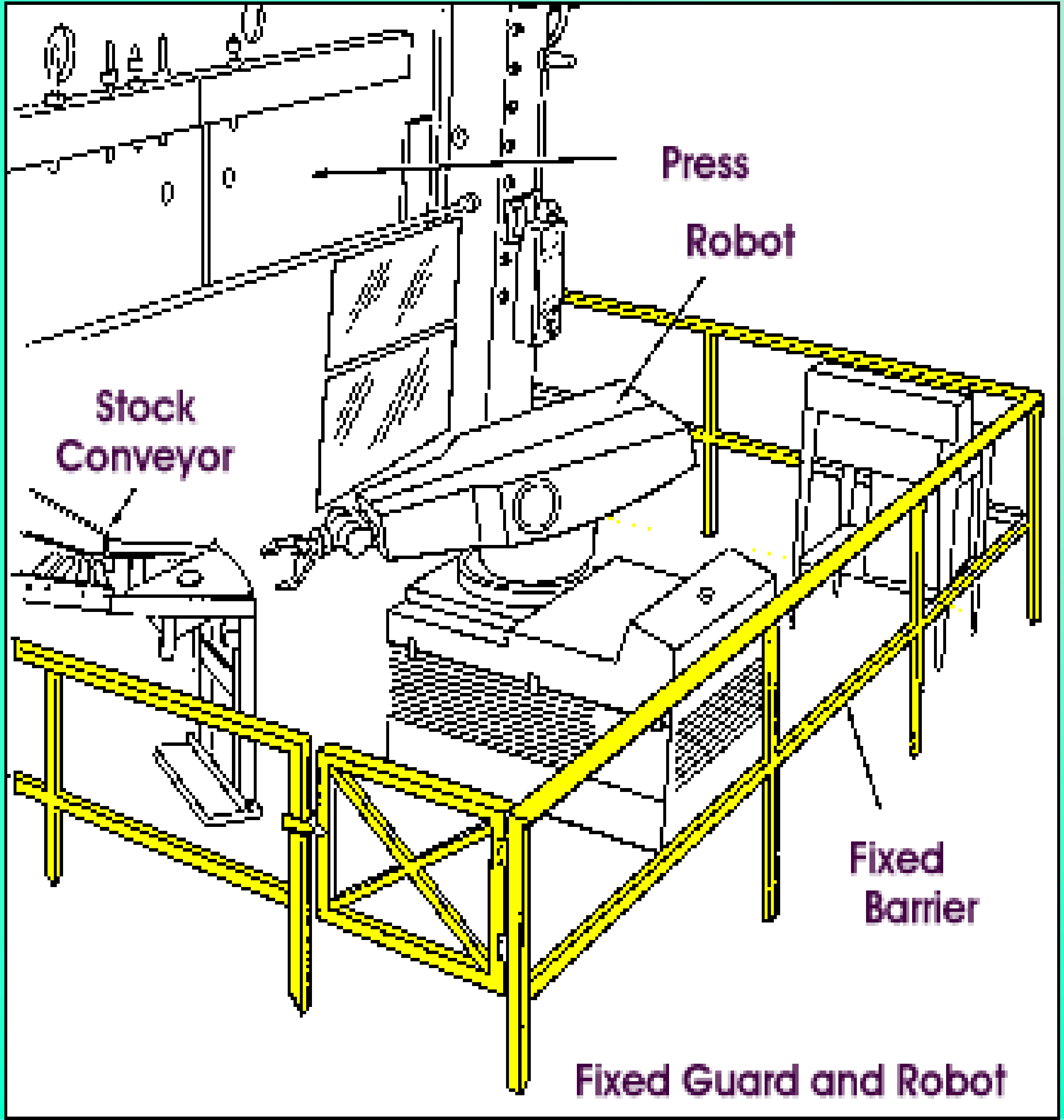


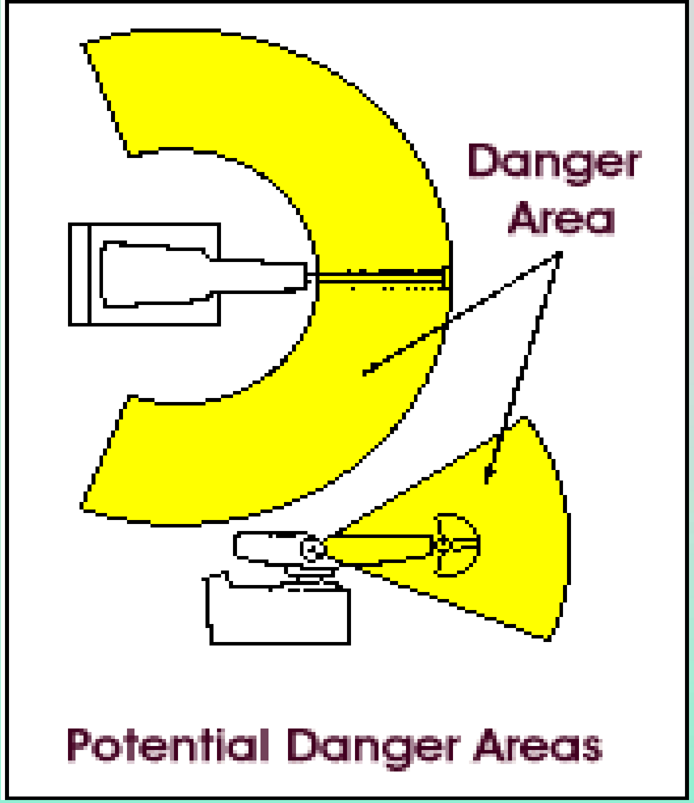
Semiautomatic Ejection Mechanism'

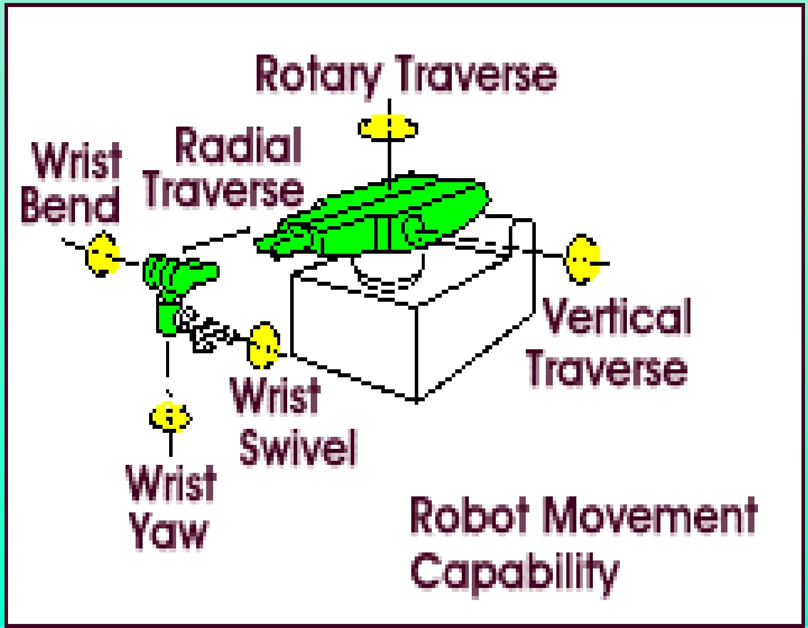
Another Safeguarding Strategy???

- **Robotics**
  - Machines that load and unload stock, assemble parts, transfer objects, and perform other tasks
  - They perform work otherwise done by the operator
  - Best used in high production processes requiring repeated routines

Robotics


Press
Robot
Stock Conveyor
Fixed Barrier
Fixed Guard and Robot


Danger Area
Potential Danger Areas

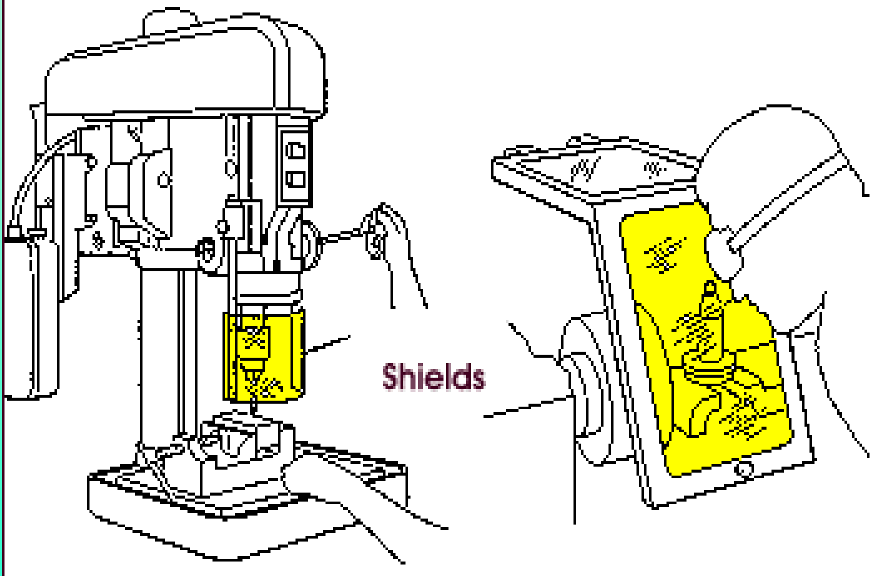

Rotary Traverse
Radial Traverse
Wrist Bend
Vertical Traverse
Wrist Swivel
Wrist Yaw
Robot Movement Capability

Miscellaneous Aids

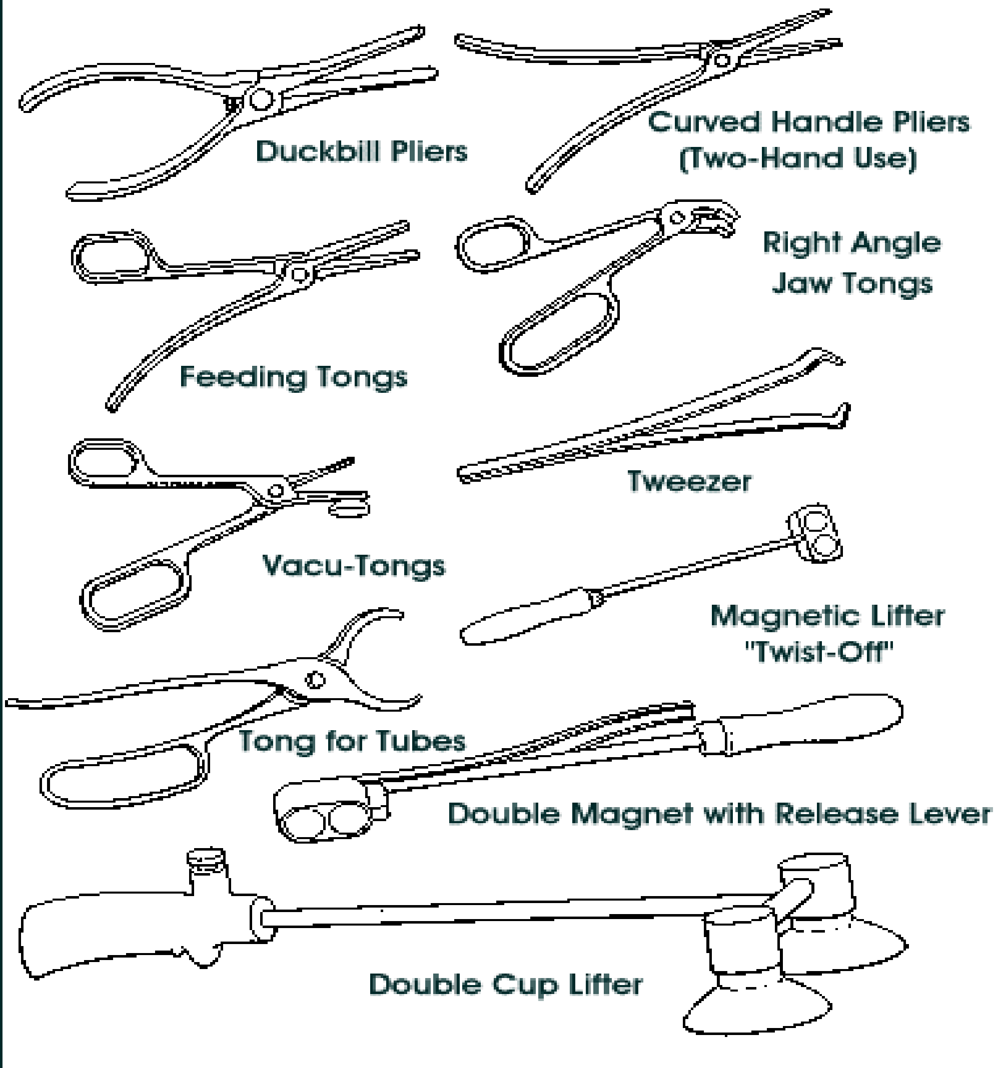
Does not give complete protection from machine hazards, but may provide the operator with an extra margin of safety.

Examples:

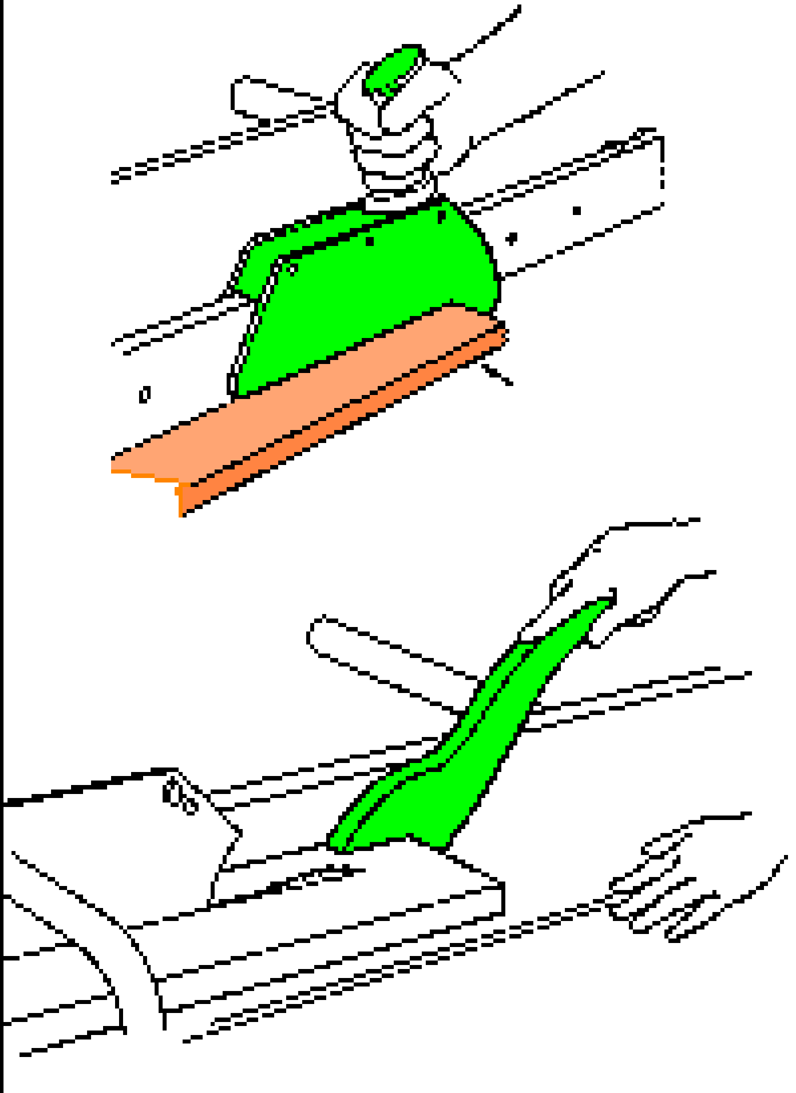
- Awareness barriers
- Shields
- Holding tools
- Push sticks or blocks



Transparent Shields on Drill and Lathe



Holding Tools



Push Stick and Block

*Mechanical Power Presses

- Mechanical Power Presses are machines that transmit force to cut, form, or assemble metal or other materials through tools or dies attached to or operated by slides.
- 3 types of Mechanical Power Presses
  - Mechanical
  - Hydraulic
  - Pneumatic

- A Mechanical Press is a machine that exerts pressure to form or shape or cut materials or extract liquids or compress solids.
- A Press is a mechanically powered machine that punches, shears, forms or assembles metal or other materials by means of cutting, shaping or combination of dies attached to slides or rams.
- A Press consists of a stationary bed (or anvil), and a slide (or slides) having a controlled reciprocating motion toward and away from the bed surface, the slide being guided in a defined path by the frame of the press.

- Major components of a Mechanical Press are;
  - The Frame
  - Motor
  - Flywheel
  - Crankshaft
  - Clutch
  - Brake

- Main Hazard
  - **<u>AMPUTAIONS</u>**
    - Placing hand into point of operations
    - Unguarded or inadequately guarded presses
    - Deactivating or over-riding safeguards
- Safeguards most commonly used:
  - Barrier guards attached to fixed surfaces
  - Presence-Sensing devices
    - Radio Frequency Sensors
    - Light Curtains
    - Pullback Devices
    - Fixed Guards

*Safety in Turning

Safety Precautions

- Lathe hazardous if not operated properly
- Important to keep machine and surrounding area clean and tidy
- Accidents usually caused by carelessness

Safety Precautions

- Always wear approved safety glasses
- Rollup sleeves, remove tie and tuck in loose clothing
- Never wear ring or watch

Safety Precautions

- Do not operate lathe until understand controls
- Never operate machine if safety guards removed
- Stop lathe before measure work or clean, oil or adjust machine
- Do not use rag to clean work or machine when in operation
  - Rag can get caught and drag in hand

Safety Precautions

- Never attempt to stop a lathe chuck or driveplate by hand
- Be sure chuck or faceplate mounted securely before starting
  - If loose, becomes dangerous missile
- Always remove chuck wrench after use
  - Fly out and injure someone
  - Become jammed, damaging wrench or lathe

Safety Precautions

- Move carriage to farthest position of cut and revolve lathe spindle one turn by hand
  - Ensure all parts clear without jamming
  - Prevent accident and damage to lathe
- Keep floor around machine free from grease, oil, metal cuttings, tools and workpieces
  - Oil and grease can cause falls
  - Objects on floor become tripping hazards

Safety Precautions

- Avoid horseplay at all times
- Always remove chips with brush
  - Chips can cause cuts if use hands
  - Chips become embedded if use cloths
- Always remove sharp toolbit from toolholder when polishing, filing, cleaning, or making adjustments

Safety Precautions When Dealing With Boring

- Handling boring mills is a complex job that requires specialist precaution aimed at protecting yourself, your colleagues, and your staff from bodily injuries.
- Use the right tool for the right job
  - ✓One of the primary causes of industrial injuries is broken drilling heads. By having the right tooling edge matched with the right operational spindle speed for the right work piece, the chances of industrial accidents are greatly reduced

- Always have protective clothing
  - ✓There is a need to have the right protective gear on. This minimizes the chances of industrial accidents, since your body is always covered in the right clothing.
  - ✓For a safer operational environment, the clothing used should be tight enough to protect you from having loose hangings that can be easily trapped in the revolving mill parts. Protective optical ware should also be used at all times to protect your eyes from exposure to work piece off-cuts.

- Know your machine
  - ✓Having proper technical knowhow about your machine gives you a competitive edge in increasing your safety.
  - ✓In fact, less experienced boring machine users have been proven to be thrice as likely as their experienced peers to cause machine-related accidents.
  - ✓Therefore, only personnel with the right skills should be granted the green light to work with the boring mills.

- Service your machines regularly
  - ✓Regular repairing and servicing of your boring tools give them a precise way of delivering on your expectations.
  - ✓It also safeguards your company from technical breakdowns resulting from poorly maintained boring tools.

*Safety in Milling

DO NOT use this machine unless you have been instructed in its safe use and operation and have been given permission

PERSONAL PROTECTIVE EQUIPMENT

Safety glasses must be worn at all times in work areas.

Long and loose hair must be contained.

Gloves must not be worn when using this machine.

Sturdy footwear must be worn at all times in work areas.

Close fitting/protective clothing must be worn.

Rings and jewellery must not be worn.

PRE-OPERATIONAL SAFETY CHECKS

- ✓ Locate and ensure you are familiar with all machine operations and controls.
- ✓ Ensure all guards are fitted, secure and functional. Do not operate if guards are missing or faulty.
- ✓ Check workspaces and walkways to ensure no slip/trip hazards are present.
- ✓ Ensure cutter is in good condition and securely mounted.
- ✓ Check coolant delivery system to allow for sufficient flow of coolant.

OPERATIONAL SAFETY CHECKS

- ✓ Keep clear of moving machine parts.
- ✓ Follow correct clamping procedures. Keep overhangs as small as possible and check workpiece is secure.
- ✓ Set the correct speed to suit the cutter diameter, the depth of cut and the material.

ENDING OPERATIONS AND CLEANING UP

- ✓ Switch off the machine when work completed.
- ✓ Remove milling cutters and store them safely.
- ✓ Before making adjustments and measurements or cleaning swarf accumulations, switch off and bring the machine to a complete standstill.
- ✓ Leave the machine and work area in a safe, clean and tidy state.

POTENTIAL HAZARDS AND INJURIES

- ⓘ Sharp cutters.
- ⓘ Hair/clothing getting caught in moving machine parts.
- ⓘ Eye injuries.
- ⓘ Skin irritation.
- ⓘ Metal splinters and burrs.
- ⓘ Flying debris.

DON'T

- ✘ Do not use faulty equipment. Immediately report suspect machinery.
- ✘ Never leave the machine running unattended.
- ✘ Do not leave equipment on top of the machine.

*Safety in Grinding Machines

- **GRINDING MACHINES**

Grinding is a material removal and surface generating process used to shape and finish components made of metals.

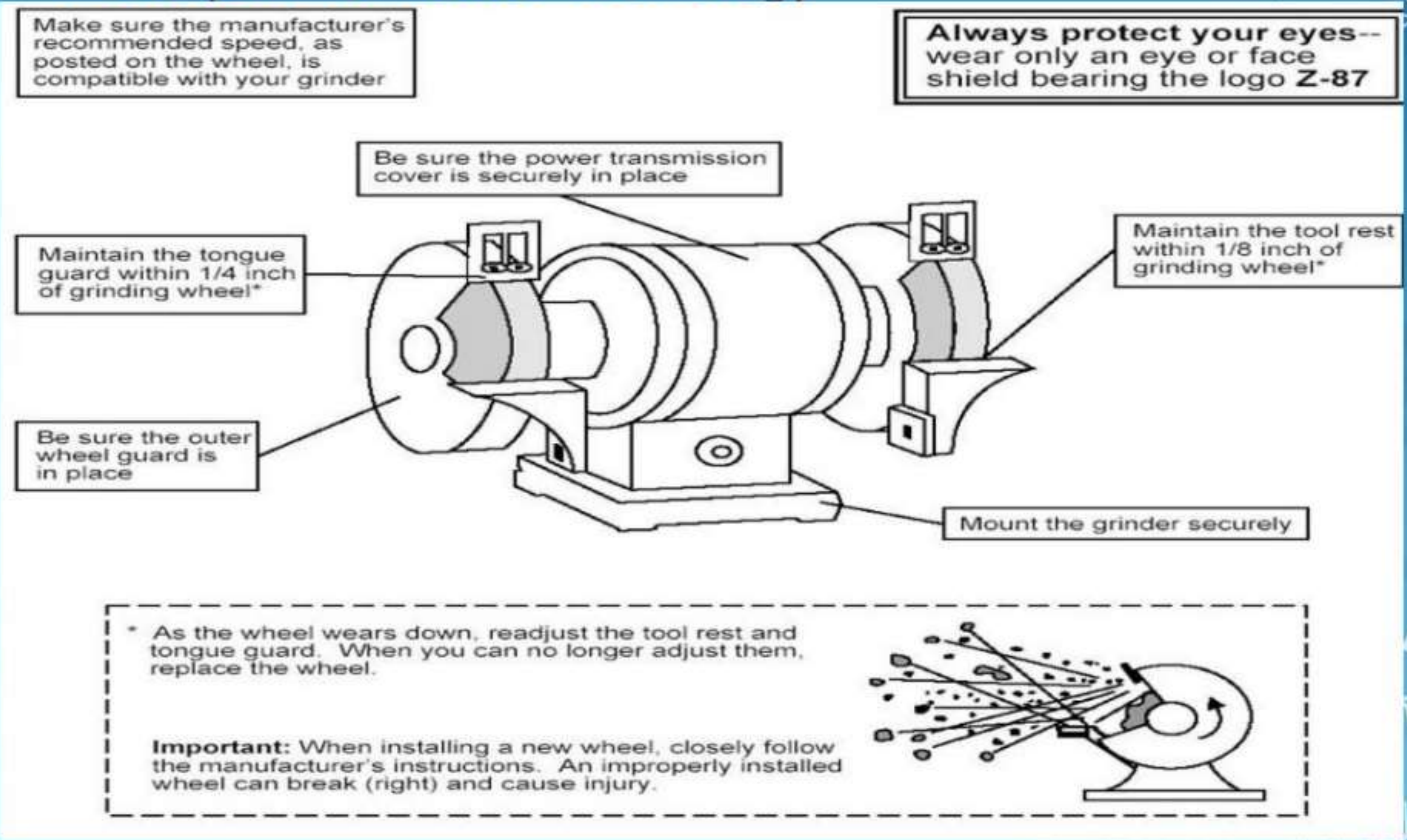
SAFETY PRECAUTIONS

- Grinding machines are used daily in a machine shop. To avoid injuries follow the safety precautions listed below.

- Wear goggles for all grinding machine operations.
- Check grinding wheels for cracks before mounting.
- Never operate grinding wheels at speeds in excess of the recommended speed.

- Never adjust the workpiece or work devices when the machine is operating.
- Do not exceed recommended depth of cut for the grinding wheel or machine.
- Remove workpiece from grinding wheel before turning machine off.
- Use proper wheel guards on all grinding machines.
- On Grinders, adjust tool rest 1/16 to 1/8 inch from the wheel.

The graphic below is courtesy of the Safety, Health,Environmental Technology



Personal Protective Equipment

Safety glasses must be worn at all times in work areas.

Sturdy footwear must be worn at all times in work areas.

Rings and jewellery must not be worn.

Long and loose hair must be contained.

Close fitting/protective clothing must be worn.

Hearing protection must be used when using this machine.

- **HOUSEKEEPING**
- Switch off the grinder.
- Leave the machine in a safe, clean and tidy state.

- **POTENTIAL HAZARDS**
- Hot Metal Sparks.
- Noise.
- Sharp edges and burrs.
- Entanglement.
- Wheels ‘run on’ after switching off.
- Eye injuries.

*Safety in Gas Welding

* Most farms and small shops have some type of equipment for welding and cutting metals.
* Acetylene is the most commonly used fuel gas. Acetylene is very flammable and hazardous, and can ignite at a wide range of concentrations.
* Oxygen won't burn or explode, but it helps other objects burn at greater rates.
* Gases are stored in cylinders which can rupture. A cylinder containing compressed gas can shoot through the air like a rocket if its valve is

*Storage and Handling

- Keep cylinders away from physical damage, heat, and tampering.
- Securely chain equipment to prevent falling.
- Store away from flammable and combustible materials.
- Store extra gas and oxygen cylinders separately.
- Store in an upright position.
- Close cylinder valves before moving.
- Protective caps or regulators should be kept in place.
- Roll cylinders on bottom edges to move—***Do not drag.***
- Allow very little movement when transporting.

*General Gas Welding Safety Tips

- Inspect equipment for leaks at all connections using approved leak-test solution.
- Inspect hoses for leaks and worn places.
- Replace bad hoses.
- Protect hoses and cylinders from sparks, flames, and hot metal.
- Use a flint lighter to ignite the flame.
- Stand to the side (away from the regulators) when opening cylinder valves.
- Open cylinder valves very slowly to keep sudden high pressures from exploding the regulators.
- Only open the acetylene cylinder valve ¼-¾ turn; leave wrench in place so the cylinder can be quickly closed in an emergency.
- Open and light acetylene first, then open and adjust oxygen to a neutral flame.
- Follow the manufacturer's recommendations for shutting off the torch. If the guidelines are not readily available, the commonly accepted practice is to close the oxygen valve first.
- When finished, close cylinder valves, bleed the lines to take pressure off regulators, neatly coil hoses, and replace equipment.
- Have a fire extinguisher easily accessible at the welding site.

*Personal Protective Equipment

- Infrared radiation is a cause of retinal burning and cataracts. Protect your eyes with safety glasses.
- Protect your body from welding spatter and optical radiation hazards with protective clothing. Such as:
    - Woolen or heavy cotton clothing
    - Flame-proof apron
    - Welding gloves
    - Properly fitted clothing that is not frayed or worn
    - Shirts should have long sleeves
    - Pants should be straight legged and covering shoes when arc welding
    - Fire-resistant welder’s cap or shoulder covers are needed for overhead work
- Check protective clothing equipment before each use to make sure it is in good condition.
- Keep clothes free of grease and oil.

Proper Ventilation

- Be sure there is adequate ventilation available when welding in confined areas or where there are barriers to air movement. Natural drafts, fans, and positioning of the head can help keep fumes away from the welder's face.
- **VENTILATION IS SUFFICIENT IF**:**
  - The room or welding area contains at least 10,000 cubic feet for each welder.
  - The ceiling height is not less than 16 feet.
  - Cross ventilation is not blocked by partitions, equipment, or other structural barriers.
  - Welding is not done in a confined space.
- **If these space requirements are not met then the area needs to be equipped with mechanical ventilating equipment that exhausts at least 2000 cfm of air for each welder, except where local exhaust hoods or booths, or air-line respirators are used.

*Safety in Arc Welding

What is Arc Welding?

- Arc welding is most commonly used to join two pieces of metal
  - *The welder creates an electric arc that melts the base metals and filler metal (consumable) together so that they all fuse into one solid piece of metal*

Steel Pipe – Tack Welded

Root Pass or "Stringer Bead"

Final weld after several beads are made

Arc Welding Safety

- Protect yourself and others from potential hazards including:
  - *Fumes and Gases*
  - *Electric Shock*
  - *Arc Rays*
  - *Fire and Explosion Hazards*
  - *Noise*
  - *Hot objects*

Fumes and Gases

- Fumes and gases can be hazardous to your health
- Keep your head out of the fumes
- Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases from your breathing zone and the general area
- See product labeling and MSDS for ventilation and respirator requirements

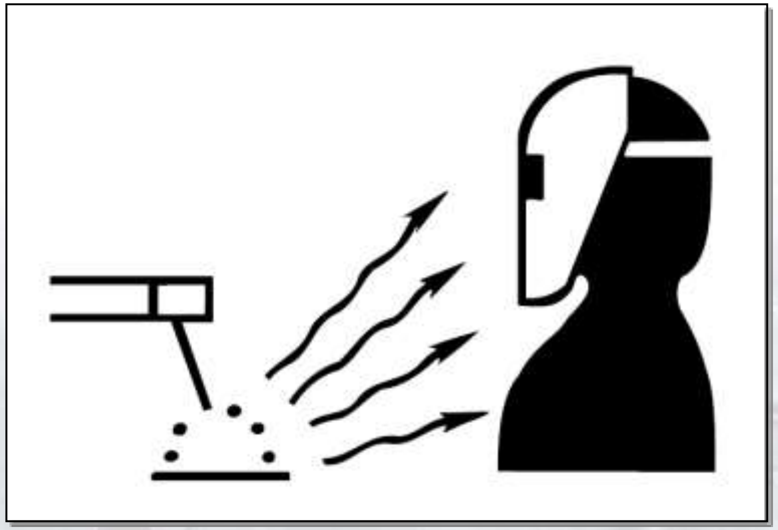
Electric Shock

- Electric shock can kill
- Do not touch live electrical parts
  - *Primary Voltage –230, 460 volt input power*
  - *Secondary Voltage – 6 to 100 volts for welding*
- Insulate yourself from work and ground
- Follow all warnings on welding equipment

Do not make repairs yourself, alert your instructor immediately!

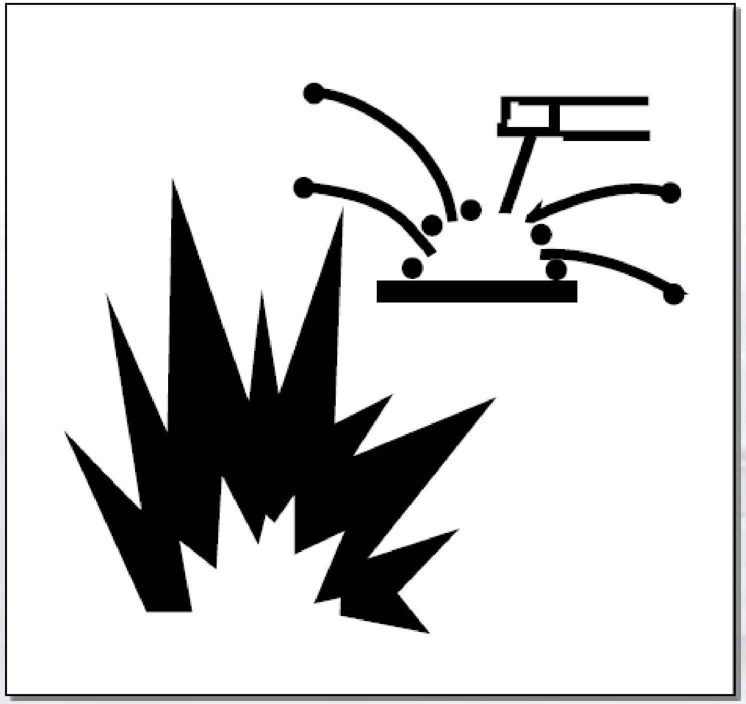
Arc Rays

- *Arc rays can injure eyes and burn skin*
- *The welding arc is brighter than the sun*
- *Precaution must be taken to protect your eyes and skin from UV radiation*
- *Wear correct eye and body protection*



Fire and Explosion Hazards

- Welding sparks can cause fires and explosions
- Sparks and spatter from the welding arc can spray up to 35 feet from your work
- Flammable materials should be removed from the welding area or shielded from sparks and spatter
- Have a fire extinguisher ready
- Inspect area for fires 30 minutes after welding



Noise

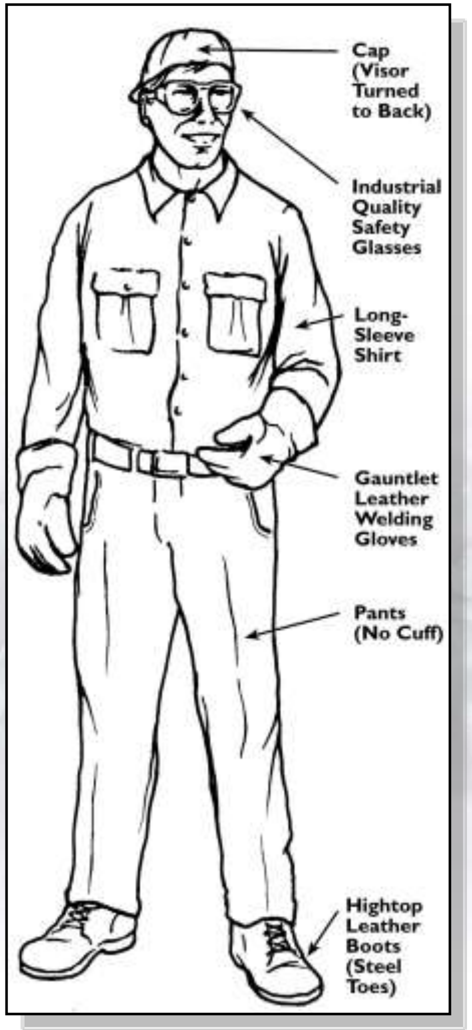
- Loud noises can damage your hearing
- Keep loud noises at a safe level by using proper hearing protection such as:
  - *Ear plugs*
  - *Ear muffs*

Protective Clothing

Welders must wear protective clothing for

- *Protection from sparks, spatter and UV radiation*
- *Insulation from electric shock*

- Protective clothing includes …
  - *Fire-proof clothing without rolled sleeves, cuffs or frays*
  - *Work boots*
  - *Welding gloves, jackets, bibs, and fire-proof pants*
  - *Welding cap, helmet and safety glasses*
  - *Ear protection – ear plugs and muffs*



Clamp storage

- Always store clamps away from heat in a secure, safe, dry place.
- When possible, separate clamp heads to prevent them from sticking together.
- Consider investing in clamp racks or carts to keep clamps stored properly.

MODULE 5

INTRODUCTION

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

DEFINITION

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

Chemical hazards

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

Chemical hazards

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

HAZARDOUS WASTE RULES

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

TYPES OF HAZARDS

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

1. BIOLOGICAL HAZARDS

- A biological hazard is one originating from an organism that is foreign to the organism being affected.
- Many biological hazards are associated with food, including certain viruses, parasites, fungi, bacteria, and plant and seafood toxins.
- Disease in human can come from biological hazards in the form of infection by bacteria, antigents, car, plane, bus, viruses and parasites.

2. CHEMICAL HAZARDS

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

3. MECHANICAL HAZARDS

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

4. PHYSICAL HAZARDS

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

5. ELECTRICAL HAZARDS

Electrical injuries consist of four main types:

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

CONTD….

An worker will receive a shock when he/she:

i. Touches two wires at different voltages at the same time.
ii. Touches phase and neutral wire at a time
iii. Touches the phase standing on the ground
iv. Touches the phase having wet cloth, high humidity and perspiration.

6. FIRE AND DUST HAZARDS

Source of dust hazards in pharmaceutical industries

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

Methods of controlling dust

- Filtration
- Inertial separator
- Electrostatic separator

TYPES OF FIRE HAZARDS

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

What is Fire Extinguisher ?

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

Things to remember before installation of fire extinguishers.

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

Water Based Fire Extinguisher

- Water is the primary liquid used in these extinguishers, although sometimes other additives are also included.
- A drawback for pure water fire extinguishers is that it is not suitable for use in freezing conditions since the water inside will freeze and render the extinguisher unusable. Certain types of water fire extinguishers contain antifreeze which will allow the extinguisher to be used in freezing conditions.
- Water type fire extinguishers can also sometimes contain wetting agents which are designed to help increase its effectiveness against fire.
- These extinguishers are intended primarily for use on Class A fires.
- Water mist extinguishers are a type of water fire extinguisher that uses distilled water and discharges it as a fine spray instead of a solid stream. Water mist extinguishers are used where contaminants in unregulated water sources can cause excessive damage to personnel or equipment.
- Typical applications include operating rooms, museums, and book collections.

Carbon Dioxide type Fire Extinguisher

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

A B C Type Dry Powder

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

Dry Powder

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

Foam Based Extinguisher

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

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

Clean Agent Fire Extinguisher

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

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

Other Fire Extinguisher

- Sand Bucket
- Water Bucket

DOW Fire & Explosion Index

Summary

- Originated due to poor loss (accident) record in 1966
- One of the first "chemical plant" hazard analysis systems
- Unique Features
  - Maximum Probable Property Damage
  - Maximum Probable Days Outage
- Continues to be upgraded in use and application
- Fill out like a "Tax Form"

DOW Fire & Explosion Index

F & EI

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

DOW Fire & Explosion Index

QUANTIFY	The expected damage of potential fire & explosion incidents in realistic terms
IDENTIFY	Equipment that would likely contribute to the creation or escalation of an incident
COMMUNICATE	The fire & explosion potential to design teams and plant personnel

DOW Fire & Explosion Index

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

DOW Fire & Explosion Index

LOSS CONTROL CREDITS

Are features that have proved beneficial in preventing serious incidents and reducing the magnitude of a particular incident

* Process Control
* Material Isolation
* Fire Protection

DOW Fire & Explosion Index

Actual Maximum Probable Property Damage

Represents the property damage that could result from an incident of reasonable magnitude with adequate functioning of protective equipment

Maximum Probable Days Outage

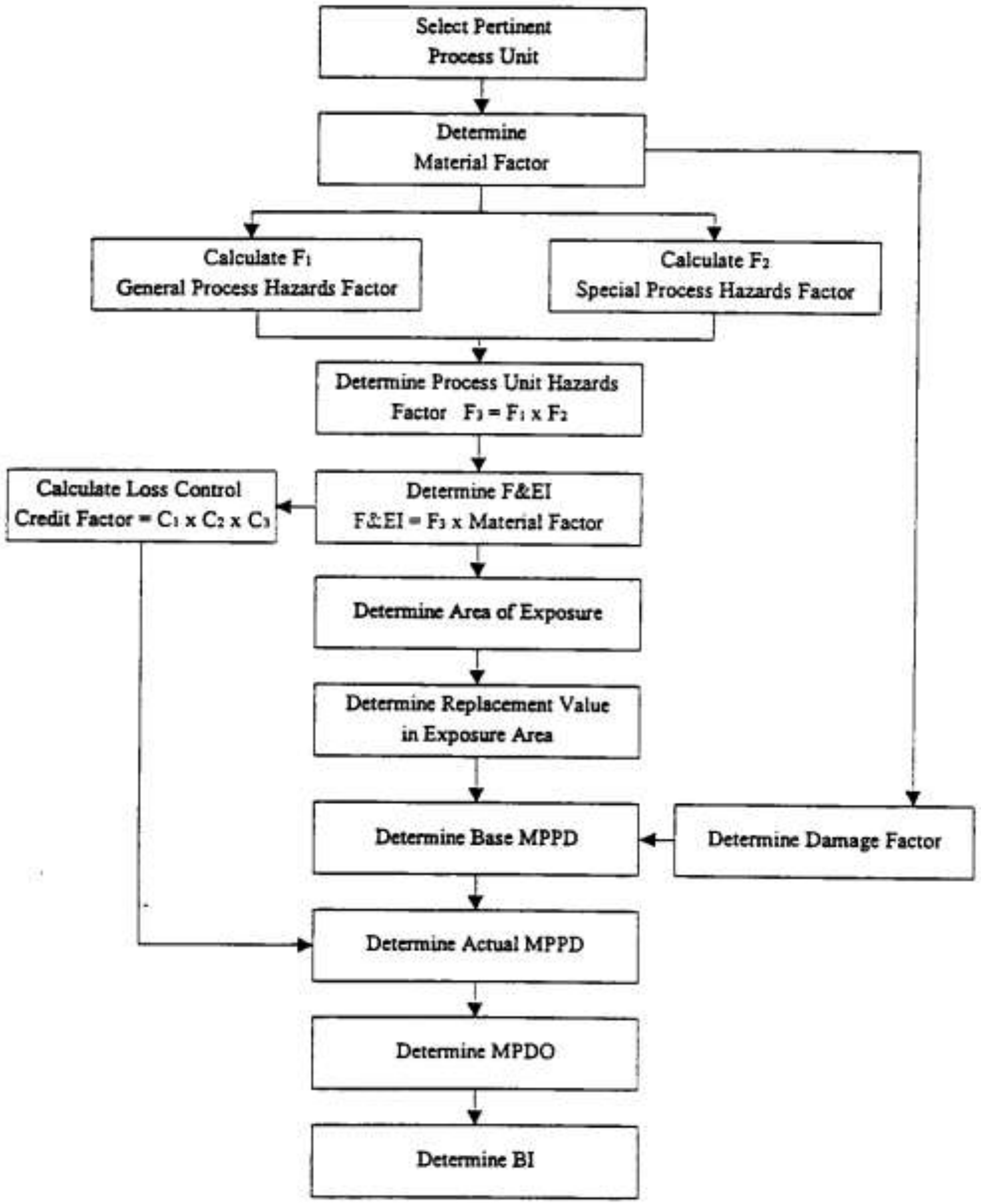
Time required to rebuild the plant to its original capacity

Business Interruption

The lost profit to the company due to an incident

FIGURE 1

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



DOW Fire & Explosion Index

Items Required to Develop an F & EI

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

DOW Fire & Explosion Index

IDENTIFY PERTINENT PROCESS UNIT

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

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

Not all unit operation need to be analyzed.
Knowledge of the process is essential

DOW Fire & Explosion Index

MATERIAL FACTOR

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

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

DOW Fire & Explosion Index

TABLE 1

MATERIAL FACTOR DETERMINATION GUIDE

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

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

DOW Fire & Explosion Index

MATERIAL FACTOR TEMPERATURE ADJUSTMENT

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

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

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

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

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

FIRE & EXPLOSION INDEX

AREA / COUNTRY	DIVISION	LOCATION	DATE
SITE	MANUFACTURING UNIT	PROCESS UNIT	

PREPARED BY:	APPROVED BY: (Superintendent)	BUILDING
REVIEWED BY: (Management)	REVIEWED BY: (Technology Center)	REVIEWED BY: (Safety & Loss Prevention)

MATERIALS IN PROCESS UNIT

STATE OF OPERATION
__ DESIGN __ START UP __ NORMAL OPERATION __ SHUTDOWN

BASIC MATERIAL(S) FOR MATERIAL FACTOR

MATERIAL FACTOR (See Table 1 or Appendices A or B) Note requirements when unit temperature over 140 °F (60 °C)

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

(1) For no penalty use 0.00.

DOW Fire & Explosion Index

CONTRIBUTING HAZARD FACTORS

Evaluate the process unit to eliminate over estimating penalties

- General Process Hazards (F_1)
- Special Process Hazards (F_2)

DOW Fire & Explosion Index

GENERAL PROCESS HAZARDS

F_1

Penalties for:

Exothermic/Endothermic

Material Handling & Transfer

Enclosed processes

Access

Drainage and spill control

F & EI workbook has various penalties

DOW Fire & Explosion Index

SPECIAL PROCESS HAZARDS
F_2

Penalties for:

Toxic materials ($0.2 \times N_H$)

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

Dust explosions

Operating in flammable range

Low temperature operation

Corrosion & Erosion

Leakage

Rotating equipment

F & EI workbook has various penalties

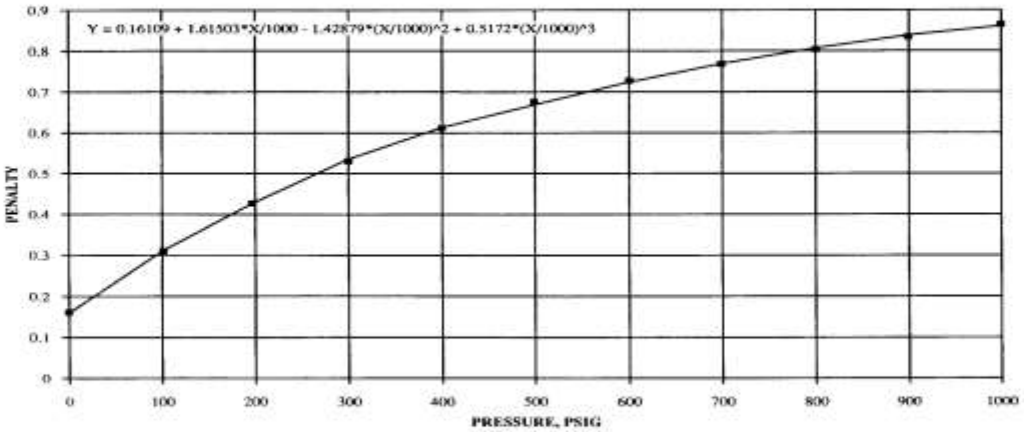
DOW Fire & Explosion Index

SPECIAL PROCESS HAZARDS

F_2

Pressure Penalty

FIGURE 2 - PRESSURE PENALTY FOR FLAMMABLE & COMBUSTIBLE LIQUIDS



For kPa multiply by 6.895.

TABLE 4

HIGH PRESSURE PENALTY FOR FLAMMABLE & COMBUSTIBLE LIQUIDS		
Pressure psig	**Pressure kPa gauge**	**Penalty**
1,000	6,895	0.86
1,500	10,343	0.92
2,000	13,790	0.96
2,500	17,238	0.98
3,000 to 10,000	20,685 to 68,950	1.00
> 10,000	> 68,950	1.50

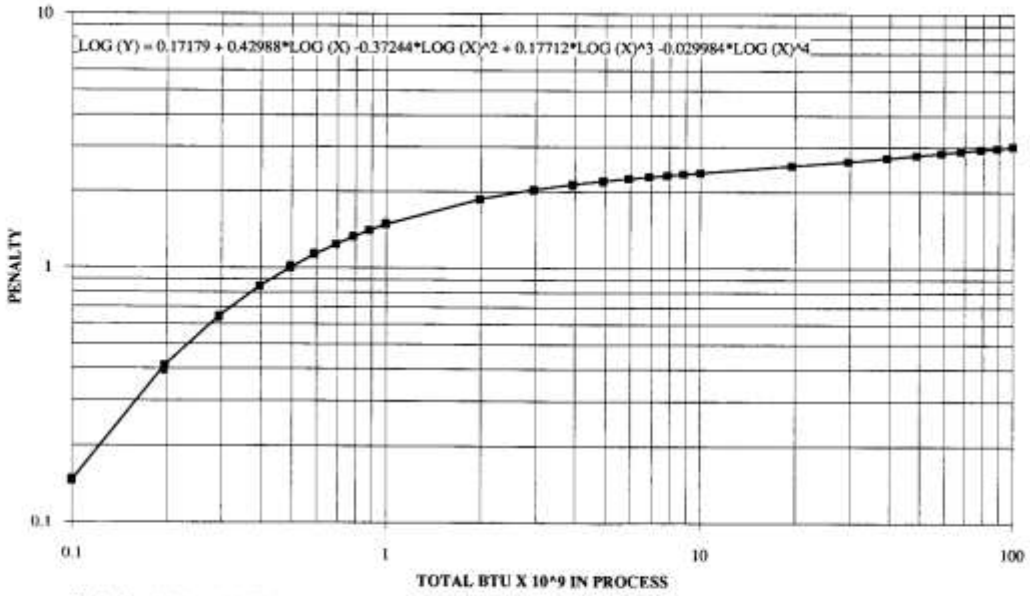
DOW Fire & Explosion Index

SPECIAL PROCESS HAZARDS

F_2

Quantity of Flammable/Unstable material

FIGURE 3 - LIQUIDS OR GASES IN PROCESS



For kcal multiply by 0.2520. For Joules (J) multiply by 1.05506 x 10^3.

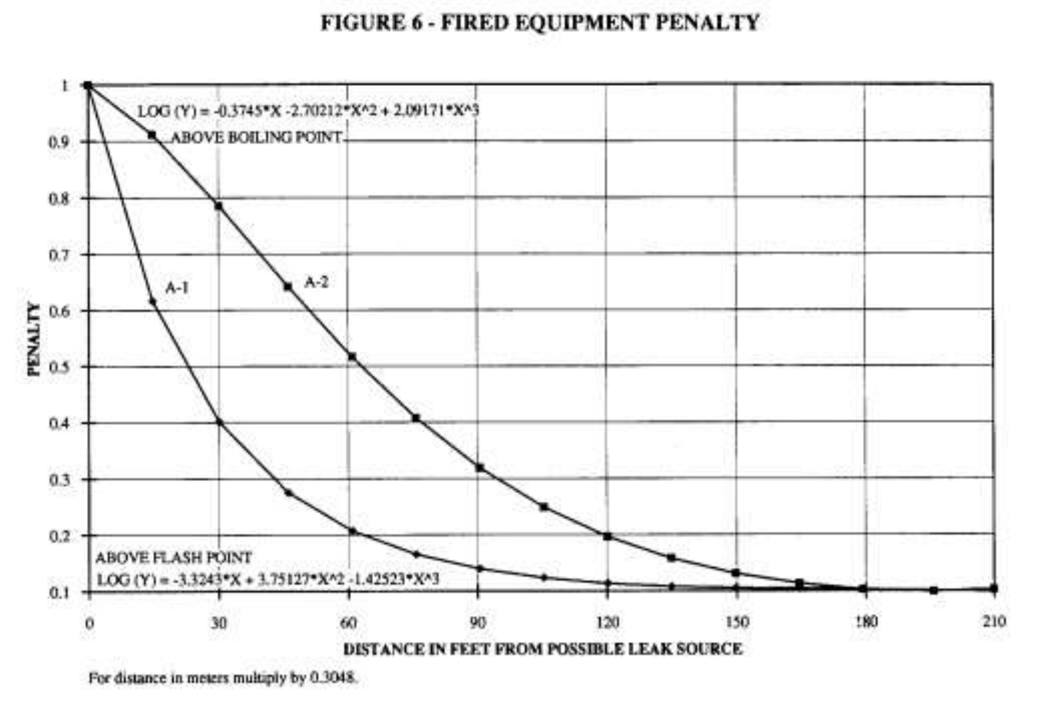
Separate figures for process, storage and solids

DOW Fire & Explosion Index

SPECIAL PROCESS HAZARDS

F_2

Use of fired equipment



Curve A-1 Release above flash point or combustible dust

Curve A-2 Released above boiling point

DOW Fire & Explosion Index

UNIT HAZARD FACTOR (F3)

$$F_3 = F_1 \text{ X } F_2$$

$$F \ \& \ EI = \text{Material Factor X } F_3$$

DOW Fire & Explosion Index

F & EI USED TO DETERMINE

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

DOW Fire & Explosion Index

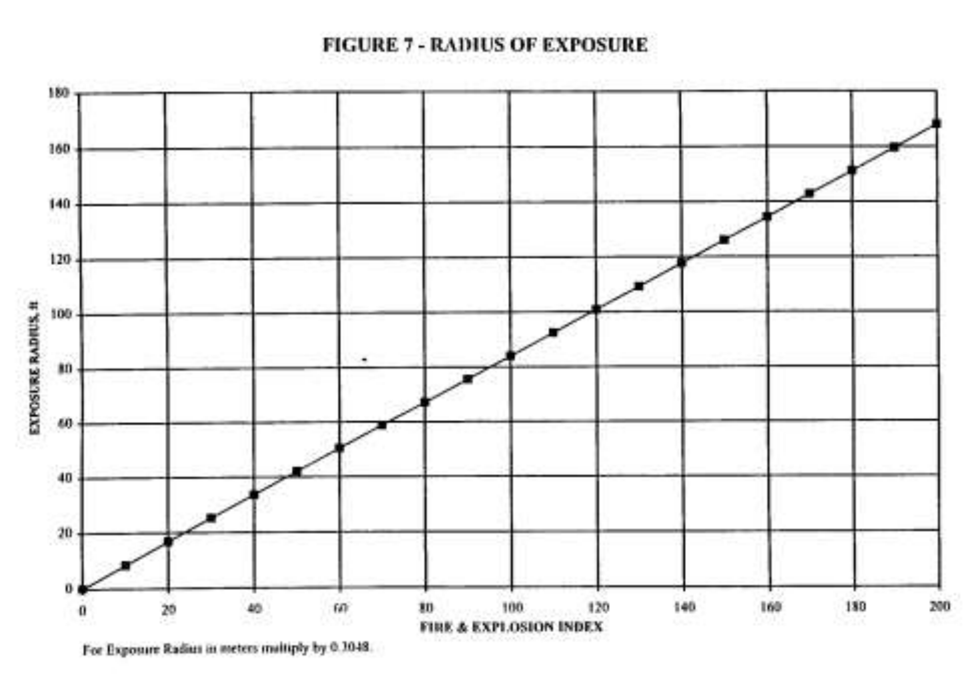
F & EI	Degree of Hazard
1 - 60	Light
61 - 96	Moderate
97 - 127	Intermediate
128* - 158	Heavy
159+	Severe

* Trigger for more detailed PHA

DOW Fire & Explosion Index

Area of Exposure

Exposure radius from empirical relationship

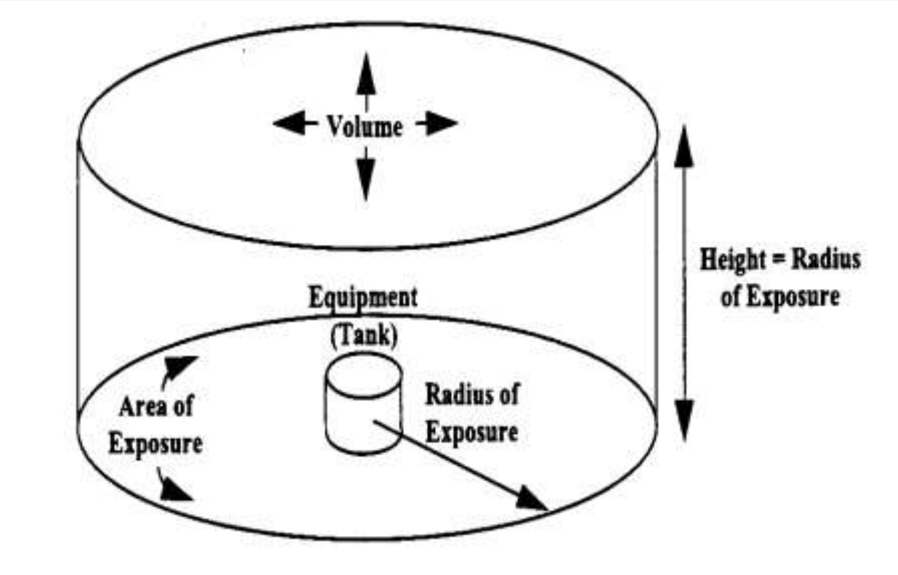


Determined from spills of flammable materials 3 in. deep as well as potential vapor air mixtures

DOW Fire & Explosion Index

Volume of Exposure

Calculate volume as a cylinder with height equal to radius

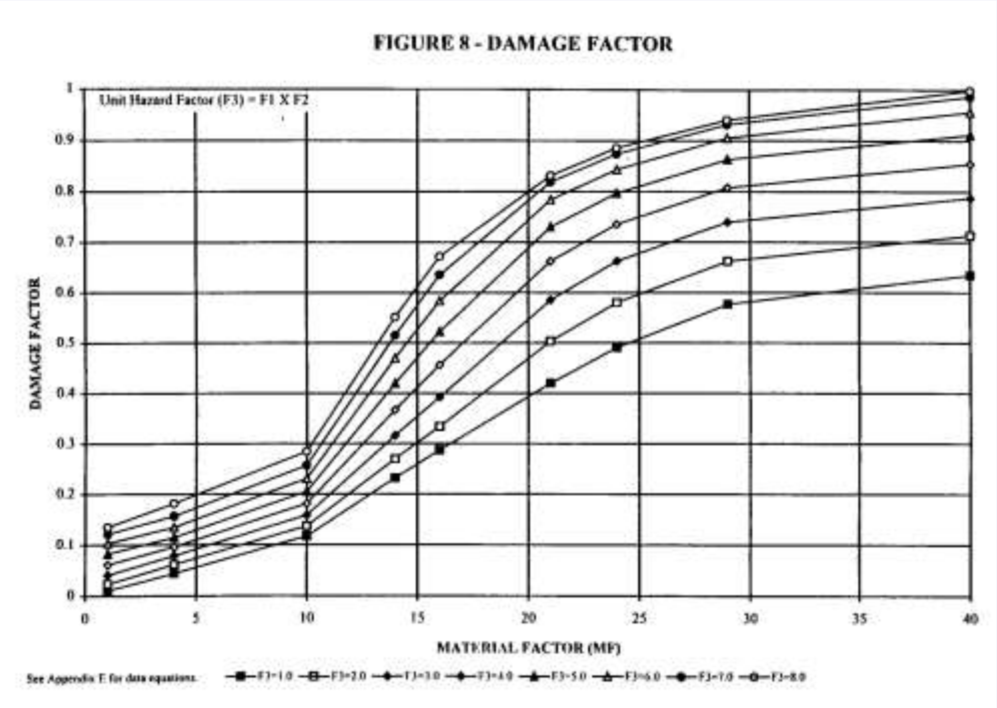


Determine replacement value of equipment in the area (volume)

DOW Fire & Explosion Index

Damage Factor

Determine damage factor from empirical relationship of Unit Hazard (F_3) and Material Factor (MF)



DOW Fire & Explosion Index

BASE MAXIMUM PROBABLE PROPERTY DAMAGE

Base Maximum Probable Property Damage (Base MPPD)

=

Value of the area of exposure

X

Damage Factor

DOW Fire & Explosion Index

LOSS CONTROL CREDIT FACTORS

LOSS CONTROL CREDIT FACTORS

1. Process Control Credit Factor (C_1)

Feature	Credit Factor Range	Credit Factor Used(2)	Feature	Credit Factor Range	Credit Factor Used(2)
a. Emergency Power	0.98		f. Inert Gas	0.94 to 0.96	
b. Cooling	0.97 to 0.99		g. Operating Instructions/Procedures	0.91 to 0.99	
c. Explosion Control	0.84 to 0.98		h. Reactive Chemical Review	0.91 to 0.98	
d. Emergency Shutdown	0.96 to 0.99		i. Other Process Hazard Analysis	0.91 to 0.98	
e. Computer Control	0.93 to 0.99				

C_1 Value(3) ☐

2. Material Isolation Credit Factor (C_2)

Feature	Credit Factor Range	Credit Factor Used(2)	Feature	Credit Factor Range	Credit Factor Used(2)
a. Remote Control Valves	0.96 to 0.98		c. Drainage	0.91 to 0.97	
b. Dump/Blowdown	0.96 to 0.98		d. Interlock	0.98	

C_2 Value(3) ☐

3. Fire Protection Credit Factor (C_3)

Feature	Credit Factor Range	Credit Factor Used(2)	Feature	Credit Factor Range	Credit Factor Used(2)
a. Leak Detection	0.94 to 0.98		f. Water Curtains	0.97 to 0.98	
b. Structural Steel	0.95 to 0.98		g. Foam	0.92 to 0.97	
c. Fire Water Supply	0.94 to 0.97		h. Hand Extinguishers/Monitors	0.93 to 0.98	
d. Special Systems	0.91		i. Cable Protection	0.94 to 0.98	
e. Sprinkler Systems	0.74 to 0.97				

C_3 Value(3) ☐

Loss Control Credit Factor = $C_1 \times C_2 \times C_{3(3)}$ = ☐ (Enter on line 7 below)

F & EI workbook has various credits

DOW Fire & Explosion Index

ACTUAL MAXIMUM PROBABLE PROPERTY DAMAGE

Actual Maximum Probable Property Damage (Actual MPPD)

=

Base MPPD

X

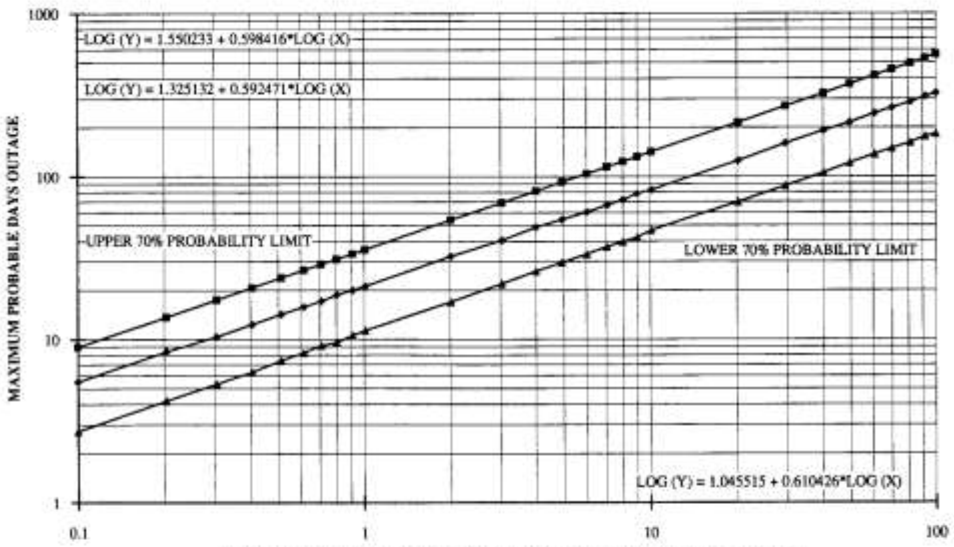
Credit Factor

DOW Fire & Explosion Index

MAXIMUM PROBABLE DAYS OUTAGE (MPDO)

Maximum Probable Days Outage (MPDO) determined empirically from actual MPPD

FIGURE 9 - MAXIMUM PROBABLE DAYS OUTAGE (MPDO)



For update to 1993 basis multiply by 359.9/318.4 = 1.130, based on Chemical Engineering Plant Cost Index.

DOW Fire & Explosion Index

BUSINESS INTERRUPTION

Business Interruption (BI)

=

Maximum Probable Days Outage (MPDO)

X

{Lost Profit before tax/day

+

Fixed Cost/day}

DOW Fire & Explosion Index

RISK ANALYSIS

PROCESS UNIT RISK ANALYSIS SUMMARY

1. Fire & Explosion Index (F&EI) .... (See Front)		
2. Radius of Exposure ....(Figure 7)	ft or m	
3. Area of Exposure..	ft^2 or m^2	
4. Value of Area of Exposure		$MM
5. Damage Factor ....(Figure 8)		
6. Base Maximum Probable Property Damage – (Base MPPD) [4 x 5]		$MM
7. Loss Control Credit Factor..............................(See Above)		
8. Actual Maximum Probable Property Damage – (Actual MPPD) [6 x 7]		$MM
9. Maximum Probable Days Outage – (MPDO)......(Figure 9)	days	
10. Business Interruption – (BI)		$MM

(2) For no credit factor enter 1.00. (3) Product of all factors used.
Refer to *Fire & Explosion Index Hazard Classification Guide* for details.

DOW Fire & Explosion Index

WHAT CAN I DO TO LOWER THE RISK?

* Reduce the Hazards (most impact)

* Add Loss Control Features (Least impact)

* Increase spacing (plant layout)

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

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

DOW Fire & Explosion Index

The DOW F & EI system challenges you to determine how much risk you are willing to accept.

What Is Preliminary Hazard Analysis

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

Characteristics Of PHA

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

Advantages And Disadvantages Of PHA

- **Advantages**
  - Helps ensure that the system is safe
  - Modifications are less expensive and easier to implement in the earlier stages of design
  - Decreases design time by reducing the number of surprises
- **Disadvantages**
  - Hazards must be foreseen by the analysts
  - The effects of interactions between hazards are not easily recognized

Steps To Carrying Out Preliminary Hazard Analysis (PHA)

1. **PHA prerequisites:** This involves, establishing a PHA team, description of the system to be analysed, and collection of risk information from previous system.
2. **Hazard identification:** This is where all hazards and possible accidental events must be identified. All part of the system should be considered at this stage. All findings should be recorded.
   - Note: No hazards are too insignificant to be recorded.

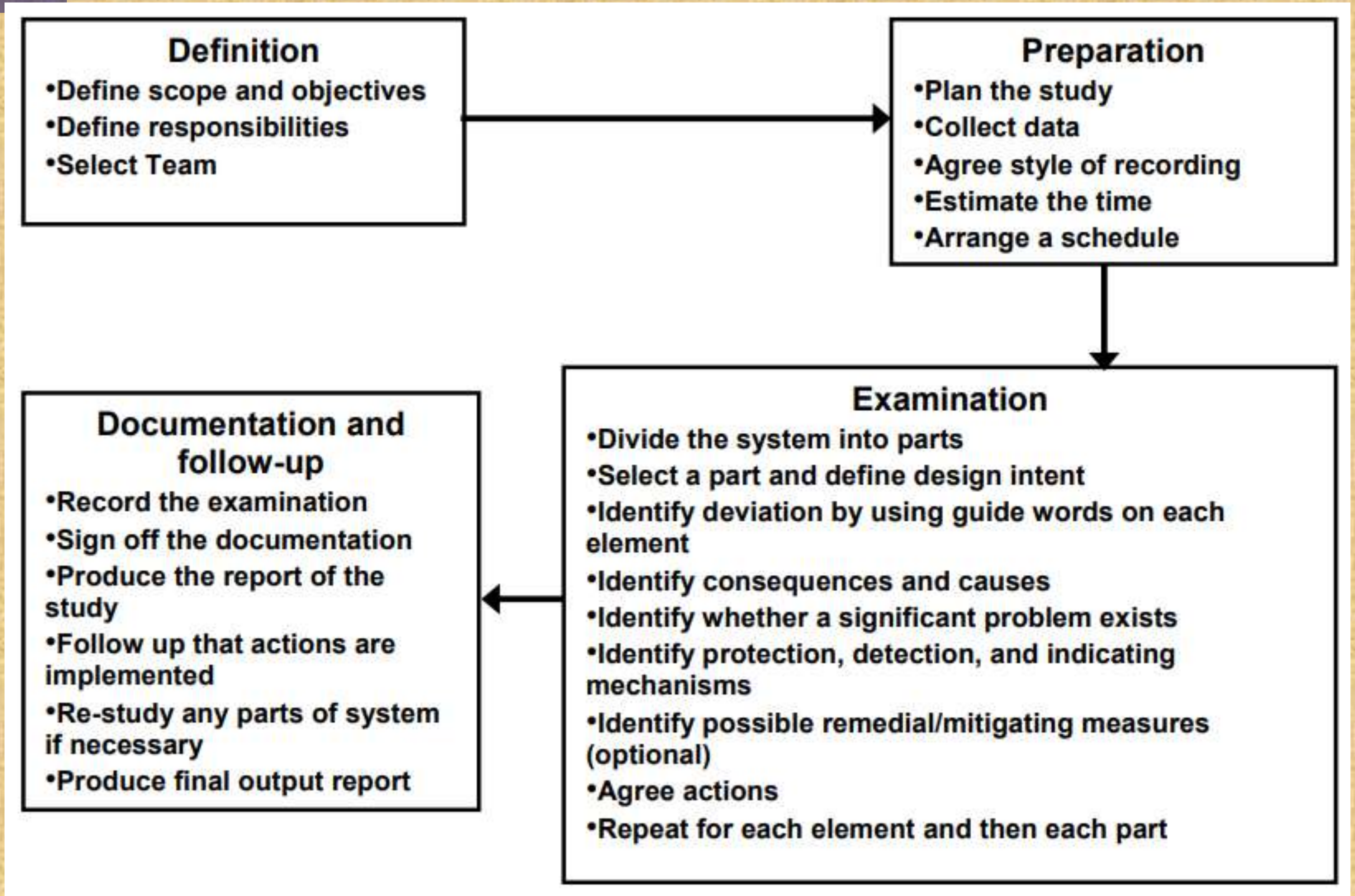
3. **Consequence and frequency estimation:** To determine the risk level, we have to estimate the frequency and the severity of each accidental event. At this stage, the consequence and frequency of every hazard is considered.
4. **Risk ranking and follow-up actions:** Risk is established as a combination of a given event/consequence and a severity of the same event/consequence. This will enable a ranking of the events/consequences in a risk matrix. This ranking level will determine the follow up actions necessary for the risk.

Hazard & Operability Analysis (HAZOP)

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

HAZOP Methodology

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



Definition Phase

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

Preparation Phase

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

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

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

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

Examination Phase

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

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

Documentation & Follow-up Phase

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

Risk Review

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

Risk Communication

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

Chemical hazards

Types of Chemical Hazards

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

Chemical hazards

- Respiratory fibro gens
- Carcinogens

Chemical hazards

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

Chemical hazards

- Sensitizers: generally sensitizers may not on first contact result in any ill effects, although cellular changes can be induced and the body's immune system affected (some chemicals may act as primary irritants as well as sensitizers).

Chemical hazards

- Anesthetic and Narcotic: anesthetic and narcotic e.g. hydrocarbons and certain derivatives such as the various chlorinated solvents or other, exert a depressant action on the central nervous system i.e. Aliphatic alcohols, petroleum etc.

Chemical hazards

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

Chemical hazards

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

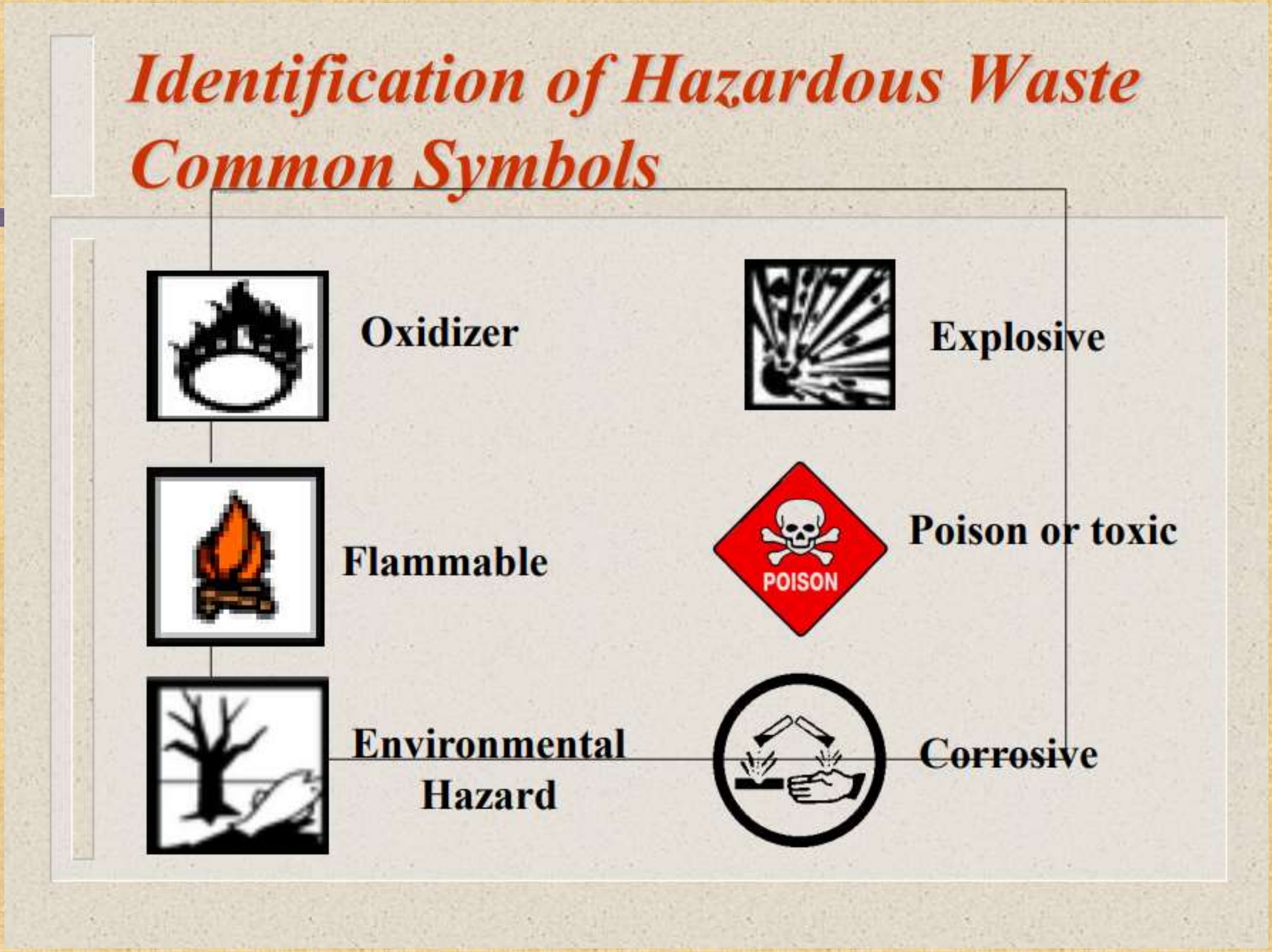
Chemical hazards

- Carcinogens: Cancer is a disorder of the body's control of the growth of cells. The diseases may be a genetic or influenced by life style or exposure to certain chemicals, termed carcinogens i.e. Coal tar pitch dust, Asbestos etc.

- asd

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

- asd


Identification of Hazardous Waste
Common Symbols
Oxidizer
Explosive
Flammable
POISON
Poison or toxic
Environmental
Hazard
Corrosive

Controlling Chemical Hazards

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

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

Hazardous Properties of Chemicals

Chemical hazards

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

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

Chemical hazards

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

Chemical hazards

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

Chemical hazards

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


Material
Safety
Data
Sheets
MSDS
Material

What is MSDS

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

Identification of the substance or mixture and of the supplier

- Identification of Chemical/Mixture

- Other means of identification.

- Supplier's details (including name, address, phone number, etc.)

- Emergency Phone No.

Hazards identification

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

Hazard Class

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

Hazard Class :

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

Composition/information on ingredients

Substance

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

Composition/information on ingredients..contd...

Mixture

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

CAS No.

CAS Registry Number-

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

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

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

Section 4 :

First aid measures

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

- ✓Most important symptoms/effects, acute and delayed.

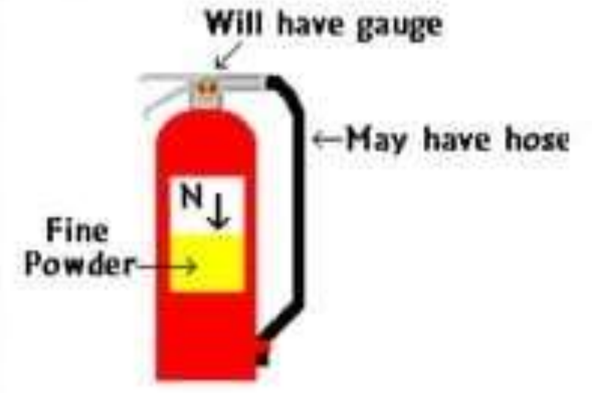
- ✓Indication of immediate medical attention and special treatment needed

Firefighting measures

- Suitable (and unsuitable) extinguishing media.

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

- Special Protective equipment and precautions for firefighters



Accidental release measures

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

Handling and storage

- Precautions for safe handling.
- Condition for safe storage including any incompatibilities

Section 8 :

Exposure controls/personal protection.

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

TLV –TWA　　　　TLV-STEL

✓Appropriate engineering controls.

✓Individual Protection measures : Personal Protective Equipment

Eye protection
Skin Protection
Respiratory Protection

Definition of Key Words

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

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

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

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

Section 9 :

Physical and Chemical Properties

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

Physical and Chemical Properties contd..

- ✓Lower Flammability Limit: %
- ✓Upper Flammability Limit: %
- ✓Specific Gravity: @ 20oC
- ✓% Volatile:
- ✓Evaporation Rate (Water=1):
- ✓Viscosity: cP @ 25oC
- ✓Octanol/Water Partition Coefficient: log Kow:
- ✓pH:

Definitions

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

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

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

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

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

Stability and Reactivity

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

Section 11 :

Toxicological information

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

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

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

✓Target Organ Effects

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

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

Definition :

Routes of entry -- A hazardous materials may enter the body through the skin or the eye, by inhalation, or ingestion.

Acute health effects -- The adverse health effects from short-term exposure.

Chronic health effects -- The detrimental health conditions which may result from long-term exposure.

Symptoms of exposure -- A description of how a victim of exposure might look or act like.

Medical conditions aggravated by exposure -- These terms are not easily recognized by non-medical personnel.

Target organs -- Some materials harm a particular organ of the body, (heart, liver, brain, etc).

Definition :

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

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

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

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

Acute Oral Toxicity

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

Ecological information

Ecotoxicity (aquatic and terrestrial, where available).

Persistence and degradability.

Bioaccumulative potential.

Mobility in soil.

Disposal considerations

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

Transport information

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

Transport information contd...

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

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

Transport Pictograms :

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

Transport Pictograms :

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

Regulatory information

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

Section 16 :

Other Information

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

Health:
Flammability:
Reactivity:
Special Hazard

Revision Indicator: