HEALTH, SAFETY AND ENVIRONMENT

NSQF LEVEL - 3

TRADE THEORY

SECTOR : HEALTHCARE

(As per revised syllabus July 2022 - 1200 hrs)

Directorate General of Training

DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
GOVERNMENT OF INDIA

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

Post Box No. 3142, CTI Campus, Guindy, Chennai - 600 032

Sector : **Healthcare**

Duration : **1 - Year**

Trade : **Health, Safety and Environment - Trade Theory - NSQF level 3 (Revised 2022)**

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FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by 2020 to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Mentor Councils comprising various stakeholder's viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai has now come up with instructional material to suit the revised curriculum for **Health, Safety and Environment - Trade Theory - NSQF Level - 3 (Revised 2022) in Healthcare Sector** under **Annual Pattern.** The NSQF Level - 3 (Revised 2022) Trade Practical will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 3 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 3 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

The Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

Addl.Secretary/Director General (Training)
Ministry of Skill Development & Entrepreneurship,
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New Delhi - 110 001

PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Directorate General of Training, Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of the Federal Republic of Germany. The prime objective of this institute is to develop and provide instructional materials for various trades as per the prescribed syllabi under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main objective of Vocational Training under NCVT/NAC in India, which is to help an individual to master skills to do a job. The instructional materials are generated in the form of Instructional Media Packages (IMPs). An IMP consists of Theory book, Practical book, Test and Assignment book, Instructor Guide, Audio Visual Aid (Wall charts and Transparencies) and other support materials.

The trade practical book consists of series of exercises to be completed by the trainees in the workshop. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and assignments will enable the instructor to give assignments for the evaluation of the performance of a trainee. The wall charts and transparencies are unique, as they not only help the instructor to effectively present a topic but also help him to assess the trainee's understanding. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirements, day to day lessons and demonstrations.

IMPs also deals with the complex skills required to be developed for effective team work. Necessary care has also been taken to include important skill areas of allied trades as prescribed in the syllabus.

The availability of a complete Instructional Media Package in an institute helps both the trainer and management to impart effective training.

The IMPs are the outcome of collective efforts of the staff members of NIMI and the members of the Media Development Committees specially drawn from Public and Private sector industries, various training institutes under the Directorate General of Training (DGT), Government and Private ITIs.

NIMI would like to take this opportunity to convey sincere thanks to the Directors of Employment & Training of various State Governments, Training Departments of Industries both in the Public and Private sectors, Officers of DGT and DGT field institutes, proof readers, individual media developers and coordinators, but for whose active support NIMI would not have been able to bring out this materials.

Chennai - 600 032 **EXECUTIVE DIRECTOR**

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisations to bring out this Instructional Material **(Trade Theory)** for the trade of **Health, Safety and Environment** under **Healthcare** Sector for ITIs.

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NIMI records its appreciation for the Data Entry, CAD, DTP operators for their excellent and devoted services in the process of development of this Instructional Material.

NIMI also acknowledges with thanks the invaluable efforts rendered by all other NIMI staff who have contributed towards the development of this Instructional Material.

NIMI is also grateful to everyone who has directly or indirectly helped in developing this Instructional Material.

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intented to be used in practical workshop . It consists of a series of practical exercises to be completed by the trainees during the Course of the **Health, Safety and Environment** Trade supplemented and supported by instructions/ informations to assist in performing the exercises. These exercises are designed to ensure that all the skills in compliance with NSQF LEVEL - 3 (Revised 2022) syllabus are covered.

The manual is divided into ten modules.

		Hours
Module 1	Hazard Management in Factories	225 Hrs
Module 2	Safety Management in Industry	60 Hrs
Module 3	Factory Act and Laws	45 Hrs
Module 4	Environment Management and Social Welfare	90 Hrs
Module 5	Fire Hazard and Safety	45 Hrs
Module 6	Supply Management Systems for Safety	90 Hrs
Module 7	Personal Protective Suits	105 Hrs
Module 8	Safety Management Systems in Engineering Industry	290 Hrs
Module 9	Electrical Safety in Industry	100 Hrs
Module 10	Storage and Occupational Hazards	150 Hrs
	Total	1200 Hrs

The skill training in the shop floor is planned through a series of practical exercises centred around some practical project. However, there are few instances where the individual exercise does not form a part of project.

While developing the practical manual a sincere effort was made to prepare each exercise which will be easy to understand and carry out even by below average trainee. However the development team accept that there is a scope for further improvement. NIMI looks forward to the suggestions from the experienced training faculty for improving the manual.

TRADE THEORY

The manual of trade theory consists of theoretical information for the Course of the **Health, Safety and Environment** Trade. The contents are sequenced according to the practical exercise contained in NSQF LEVEL - 3 (Revised 2022) syllabus on Trade practical. Attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This correlation is maintained to help the trainees to develop the perceptional capabilities for performing the skills.

The Trade Theory has to be taught and learnt along with the corresponding exercise contained in the manual on trade practical. The indications about the corresponding practical exercises are given in every sheet of this manual.

It will be preferable to teach/learn the trade theory connected to each exercise atleast one class before performing the related skills in the shop floor. The trade theory is to be treated as an integrated part of each exercise.

The material is not for the purpose of self learning and should be considered as supplementary to class room instruction

CONTENTS

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

S.No.	Exercise Outcome	Exercise No
1	Identify accident prone areas and adopt methods for reducing accidents following safety precautions. (NOS: MIN/N1702, MIN/N1703, MIN/N1704, MIN/N1705, HSC/N9913, HSC/N9902, HSC/N9903)	1.1.01 - 1.1.08
2	Identify and apply safety policy in an industry and List out the duties and implement Safety Targets, Objectives, Standards, Practices and Performances. (NOS: MIN/N1702, MIN/N1703, MIN/N1704, MIN/N1705, HSC/N9913, HSC/N9902, HSC/N9903)	1.1.09 - 1.1.12
3	Identify marking and evaluate performance of explosives. (NOS: MIN/N0416, MIN/N0417, MIN0418)	1.1.13 - 1.2.16
4	Prepare profile with an appropriate accuracy as per safety precaution in workshop. (NOS: MIN/N9417)	1.2.17 - 1.2.18
5	Select the construction site for visit, plan and prepare the report. (NOS: MIN/N9418)	1.2.19 - 1.3.22
6	Select, plan, and implement safety and Health objectives, targets and performance standards. (MIN/N1702, MIN/N1703, MIN/N1704, MIN/N1705, HSC/N9913, HSC/N9902, HSC/N9903)	1.3.23 - 1.3.25
7	Identify causes of fire, techniques of fire extinguishing methods and other hazards. (NOS: MIN/N1702, MIN/N1703, MIN/N1704, MIN/N1705, HSC/N9913, HSC/N9902, HSC/N9903)	1.4.26 - 1.4.28
8	Plan and execute hose and hose fittings. (NOS: MIN/N9419)	1.5.29
9	Select and prepare the hydrant and pump system for proper application. (NOS: MIN/N9420)	1.5.30 - 1.5.35
10	Identify & select respiratory personal protective devices & carry out its maintenance. (NOS: MIN/N0901, HSC/N9913, HSC/N9902, HSC/N9903)	1.6.36 - 1.6.40
11	Measure the effect of radiation and control the radiation on human body. (NOS: MIN/N9421)	1.6.41 - 1.6.42
12	Identify parameters governing the safety in construction and its impact on environment. (NOS: MIN/N9422)	1.7.43 - 1.7.49
13	Identify various techniques of earthing standards and earth fault protection. (NOS: MIN/N3102)	1.7.50 - 1.7.53
14	Plan and apply methods of plant design and housekeeping. (NOS: MIN/N9423)	1.8.54 - 1.8.58
15	Check and verify various industrial Hazards in process of melting (Furnaces), Casing and Forging. (NOS: HCS/N2204)	1.8.59
16	Identify various types of water relay management systems. (NOS: MIN/N9424)	1.8.60 - 1.8.63
17	Execute the risk analysis exercise. (NOS: MIN/N9425)	1.8.64 - 1.8.66
18	Select and use PPE, care and maintain the same. (NOS: HCS/N9913, HCS/N9902, HCS/N9903)	1.9.67 - 1.9.69
19	Apply the method of bulk storage system of LPG/CNG. (NOS: MIN/N9426)	1.9.70
20	Prepare case study on major Chemical Disasters. (NOS: MIN/N9428)	1.9.71
21	Practice Bio Medical Waste and E- Management (NOS: MIN/N9428)	1.10.72 - 1.10.76
22	Demonstrate Process to control noise pollution. (NOS: MIN/N1702, MIN/N1703, MIN/N1704,)	1.10.78 - 1.10.79

SYLLABUS FOR HEALTH, SAFETY & ENVIRONMENT

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With inidcative hour)	Professional Knowledge (Trade Theory)
Professional Skill 70 Hrs; Professional Knowledge 22 Hrs	Identify accident prone areas and adopt methods for reducing accidents following safety precautions. (NOS: MIN/N1702, MIN/N1703, MIN/N1704, MIN/N1705, HSC/N9913, HSC/N9902, HSC/N9903)	1 Familiarisation with the Institute, Documentation of Student, Issuance of Dress, Books, Hostel Accom - modation (If required) and Store. (04 hrs.) 2 Importance of trade training, Equipment used in the trade, types of work done by the trainees in the trade. (8 hrs.) 3 Introduction to safety equipment and their uses. Introduction of first aid, Road safety, operation of Electrical mains. (8 hrs.) 4 Knowledge of General Safety, Occupational health and hygiene. (10 hrs.)	**Incident Command:** Types of Incident. Analyse possible hazards and emergencies. HAZARD: Introduction to Hazard, Causes, Identification, Vulnerability analysis, Risk analysis, Evaluation & Control of Hazard. HAZOP Analysis, Sources for Information on Hazard Evaluation. Preparative work (Obtain basic information, information should be converted into suitable form, Plan the sequence & meeting schedule), Team composition & approach. Methodology, Advantages of HAZOP Study Limitation of HAZOP study.
		5 Site visit for Hazard identification and Evaluation. (10 hrs.) 6 Study of Risk at work site and preparation and initiation of reports. (10 hrs.) 7 Emergency response functional drill - viz. Medical Response, Evacuation drill, etc. (10 hrs.)	**Risk Analysis:** Definition of Risk, Risk Analysis, Introduction to Failure Mode & Effect Analysis (FMEA), Fault Tree Analysis (FTA), Event Tree Analysis (ETA).
		8 Visit to accident prone area Practical usages of Safety belt helmet gloves, and goggles. (10 hrs.)	**Accident:** Definition of Accidents, Classification of Accidents, need for the Analysis of Accidents, Methods Adopted for Reducing Accidents, Investigation of Accidents, Safety Slogans Principles of Accident (Heinrich theory), Accident ratio study, identification of unsafe mechanical/ physical conditions, identification of unsafe acts. Frequency Rate, Prevention Methods. (22 hrs.)
Professional Skill 60 Hrs; Professional Knowledge 16 Hrs	Identify and apply safety policy in an industry and List out the duties and implement. Safety Targets, Objectives, Standards, Practices and Performances. (NOS: MIN/N1702, MIN/N1703, MIN/N1704, MIN/N1705, HSC/N9913, HSC/N9902,	9 Carry out the plant safety inspection with the help of check list. (15 hrs.) 10 Visit to industrial unit and review of prevailing safety Practices (15 hrs.)	**Preparation & Assessment of Safety Audit:** Introduction to Safety Checklist, Plant Safety Inspection, Safety Precautions adopted in the Plant, Safety Tag System, Safety Audit Report Objective of safety audit, type of audit, Audit team, Elements of safety audit, Method of audit, audit steps, concept and lay out of audit report.

	HSC/N9903)	11 Visit to industrial unit to observe prevailing safety provision, their condition, welfare measures include medical facilities, crèches and religious places. (15 hrs.) 12 Awareness about various compensations and Documentation. (15 hrs.)	**Safety Concept:** Introduction to Safety Management, Safety Policy, Safety Committee, Safety Review, Responsibility of Management, Safety Officers Duties & Responsibilities, Safety Targets, Objectives, Standards, Practices and Performances. Motivation & Communication as part of Safety Programme. Duties & responsibility of an owner, Duties and responsibilities of a worker, Role of a supervisor Role of a safety engineer ILO Convention: Introduction of ILO and Conventions. (16 hrs.)
Professional Skill 40 Hrs; Professional Knowledge 10 Hrs	Identify marking and evaluate performance of explosives. (NOS: MIN/N0416, MIN/N0417, MIN0418)	13 Display of explosives, their identification and marking as per explosives act. (10 hrs.) 14 Hands on experience with Hand and power tools. (10 hrs.) 15 Measurement of Heat, Illumination and Noise Demonstration. (10 hrs.) 16 Determination of related electrical experiments. (10 hrs.)	**Factories Act 1948 (Amended)**: - Health - Cleanness, Disposal of Waste, Ventilation and Temperatures, Dust & Fumes, Drinking Water, Lighting, Latrines & urinals. Safety - Fencing of machineries, Work on or near machinery in motion, Hoists and lifts, Pressure plants, Floors, Stairs and means of escape, Protection against fumes & gases, Safety offers. Welfare - Washing facilities in Dry clothing, Storing, Sitting, First Aid Appliances, Canteen, Shelters for rest & lunch, Creches, Welfare offers, Right & Obligation of workers. (10 hrs.)
Professional Skill 20 Hrs; Professional Knowledge 06 Hrs	Prepare profile with an appropriate accuracy as per safety precaution in workshop. (NOS: MIN/N9417)	17 Visit to workshop and steel furniture houses to witness various processes during production and safety. Precaution adopted. (10 hrs.) 18 Visit to construction site to witness construction and safety precaution observed. (10 hrs.)	Welfare & Training: General Provision, Drinking Water, Sanitary & Washing, Cloakrooms, Facilities for Food & Drink, Shelters & Living Accommodation, Information & Training. (06 hrs.)
Professional Skill 50 Hrs; Professional Knowledge 18 Hrs	Select the construction site for visit, plan and prepare the report. (NOS: MIN/N9418)	19 Construction Site Visit Practices of good House Keeping and Study of egress and safe access. (10 hrs.) 20 Construction Site Visit and identifying of causes of accident during material handling. (08 hrs.) 21 Construction Site Visit, Pitching of ladders, proper use of safety belt and preparation of work permit. (07 hrs.)	**Environment Protection:** Safety and Protection of existing environment, Principles & Practices in Prevention & Control of Pollution, Water Pollution, **Climate Changes:** Introduction, Green House Gases: an overview, the role of carbon Dioxide, Methen, co2 emissions, carbon cycling, Global Warming. • Components of climate change • Factors effecting climate change • Causes for rising emissions • How to prevent climate change • Harmful impact of climate change • Ways to help environment (18 hrs.)

		22 Visit to excavation Site, identification and discussion with site engineer about safety precaution taken. (15 hrs.)	**Social Security Legislation:** Social Security Legislation, Introduction to Workman's Compensation Act, Contract Labour Regulation Act.
Professional Skill 20 Hrs; Professional Knowledge 06 Hrs	Select, plan, and implement safety and Health objectives, targets and performance standards. (MIN/N1702, MIN/N1703, MIN/N1704, MIN/N1705, HSC/N9913, HSC/N9902, HSC/N9903)	23 Developing a workplace Safety and Health Policy. (7 hrs.) 24 Planning – safety and Health objectives and Targets, performance standards. (6 hrs.) 25 Implementation and Operation Structure and responsibilities, individual responsibilities, Safety Consultation. (7 hrs.)	Miscellaneous Acts & Rules Explosives Act 1884 and Rules. General provision of Gas Cylinders Rules, The Building and other Construction Worker's Welfare Cess Act & Rules 1996. Environment Protection Legislation: Introduction to Prevention and Control of Pollution Act 1981 and 1982, Environment Protection Act 1986. (6 hrs.)
Professional Skill 20 Hrs; Professional Knowledge 10 Hrs	Identify causes of fire, techniques of fire extinguishing methods and other hazards. (NOS: MIN/N1702, MIN/N1703, MIN/N1704, MIN/N1705, HSC/N9913, HSC/N9902, HSC/N9903)	**Fire and other Hazards:** 26 General causes and classification of fire, Detection of fire, extinguishing methods, firefighting installations with and without water. (7 hrs.) 27 Machine guards and its types, automation. (6 hrs.) 28 High pressure hazards, safety, emptying, inspecting, repairing, hydraulic and non-destructive testing, hazards and control in mines. (7 hrs.)	**Anatomy of Fire:** Definition of Combustion, Elements of Combustion, Products of Combustion, Heat of reaction and calorific value, Flash point, Fire point, Ignition temperature and spontaneous combustion. Fire Triangle, fire tetrahedron, fire pyramid, source of heat, (Chemical, mechanical, Electrical, Nuclear etc.), Classification of fire and method of fire extinguishment, oxygen and its effects on combustion, maintenance, method of operation, Halon and its detrimental effect on environment. Alternatives of Halon. Types of fire extinguishing agents, Rating system for portable fire extinguishers, Limitation of fire extinguishers, inspection requirement. (10 hrs.)
Professional Skill 20 Hrs; Professional Knowledge 06 Hrs	Plan and execute hose and hose fittings. (NOS: MIN/N9419)	29 Hose drill a hose pick up b hose laying c hose joining d hose replacement at different position (20 hrs.)	Hose & Pumps, Water Tender: Fire Service Hose & Hose Fittings, Fixed Fire Fighting Installations Ropes & lines, Practical Fireman ship, Small & Special Gears, Water Tender. Types of fire hoses, its construction, caused of decay care & maintenance Types of hose fittings, identification and use of hose fittings. Types of FFF installations Testing care & maintenance. (06 hrs.)
Professional Skill 20 Hrs; Professional Knowledge 06 Hrs	Select and prepare the hydrant and pump system for proper application. (NOS: MIN/N9420)	30 Familiarization and demonstration of Hydrant and its associated equipment. (03 hrs.) 31 Practical pump operation, fault finding of primary failure, method of ladder pitching & climbing Application of Arm Hold and Leg Lock. (04 hrs.) 32 Identify Appropriate Action. (03 hrs.)	**Hydrant, Detectors & Ladders:** Introduction to Hydrant & Hydrant Fittings, Water Supply requirements for firefighting, Introductions to pump & Primers, Detectors & Ladders.(06 hrs.)

		33 Risk assessment records and control. (04 hrs.) 34 A simple Risk estimation example – Hazards, remedial measures. (03 hrs.) 35 Motivation of employees, Insurance coverage of Industrial plant & personnel. (03 hrs.)	
Professional Skill 40 Hrs; Professional Knowledge 10 Hrs	Identify & select respiratory personal protective devices & carry out its maintenance. (NOS: MIN/N0901, HSC/N9913, HSC/N9902, HSC/N9903)	36 First Aid Procedures with Disaster Management (08 hrs.) 37 Stages in plant life and unsafe condition in factories. (08 hrs.) 38 Maintenance & safety, basics safety programming, safety department, Rules and regulation of safety department. (08 hrs.) 39 Responsibility of management for safety in plant, safeguards the public. (08 hrs.) 40 Responsibility of government, Social organization and public authorities. (8 hrs.)	Public Health and Emergency situation Management - Basic Introduction to Incident Control Systems in public health emergency situations Breathing Sets: Classification of Respiratory Personal Protective Devices, Selection of Respiratory Personal Protective Devices, Instruction & Training in the use, Maintenance and Care of Self Containing Breathing Apparatus. Resuscitation & First Aid: Burns, Fractures, Toxic Ingestion, Bleeding, Wounds and Bandaging, Artificial Respiration, Techniques of Resuscitation.(10 hrs.)
Professional Skill 20 Hrs; Professional Knowledge 06 Hrs	Measure the effect of radiation and control the radiation on human body. (NOS: MIN/N9421)	**Radiation and Industrial Hazards:** 41 Types and effects of radiation on human body, Measurement and detection of radiation intensity. (10 hrs.) 42 Effects of radiation on human body, Measurement – disposal of radioactive waste, Control of radiation. (10 hrs.)	Introduction to Radiation and Industrial Hazards. (6 hrs.)
Professional Skill 60 Hrs; Professional Knowledge 16 Hrs	Identify parameters governing the safety in construction and its impact on environment. (NOS: MIN/N9422)	43 Scope and Importance; need for public awareness about our environment. (8 hrs.) 44 Economic and social security; Environment impact of transportation. (8 hrs.) 45 Environmental impact assessment (EIA) — purpose, procedure and benefits of EIA; Biodiversity and its conservation. (8 hrs.) 46 Global warming and greenhouse effect, urbanization, acid rain. (8hrs.) 47 Demonstration of health and environment effect through chart. (10 hrs.)	**Basic Philosophy of Safety:** Peculiarities & Parameters governing the safety in construction e.g. Site Planning, Layout, Safe Access / Egress. Construction Industry: General safety precautions related to construction industry, Safety in the use of Construction Machinery. Industrial Lighting: Introduction to Lighting, Ventilation, Heat Stress, Cold Stress, Noise & Vibration. (16 hrs.)

		48 Case studies, population explosion, family welfare programmers-HI V/ AIDS, women and child welfare. (10 hrs.) 49 Environmental pollution - causes, Effects and control measures of air pollution, water pollution, soil pollution. (8 hrs.)	
Professional Skill 20 Hrs; Professional Knowledge 06 Hrs	Identify various techniques of earthing standards and earth fault protection. (NOS: MIN/N3102)	**Electrical Hazards and Hazards in Construction Industry:** 50 Safe limits of amperages, voltages, distance from lines, etc., Joints and connections, Overload and Short circuit protection. (06 hrs.) 51 Earthing standards and earth fault protection, Protection against voltage fluctuations, Effects of shock on human body Hazards from Borrowed neutrals. (05 hrs.) 52 Electrical equipment in hazardous atmosphere. (05 hrs.) 53 Criteria in their selection. Installation, maintenance. (04 hrs.)	**Electrical Safety:** Electrical Hazards, Static Electricity. Identification and Zoning of Hazardous area, Classification of products. (06 hrs.)
Professional Skill 45 Hrs; Professional Knowledge 10 Hrs	Plan and apply methods of plant design and house keeping. (NOS: MIN/ N9423)	**Plant design and Housekeeping:** 54 Plant layout, design and safe distance, Ventilation and heat stress, Significance of ventilation, Natural ventilation. (10 hrs.) 55 Mechanical ventilation Air conditioning. (09 hrs.) 56 Safety and good housekeeping, Disposal of scrap and other trade wastes. (10 hrs.) 57 Spillage prevention, Use of colour as an aid of housekeeping, Cleaning methods. (08 hrs.) 58 Inspection and Checklists, Advantages of good houses. (08 hrs.)	**Excavations, Demolitions & Structural Frames:** Safety related to Excavation, Demolitions Framework & Concrete Work, Pile Driving and Work over Water (10 hrs.)
Professional Skill 45 Hrs; Professional Knowledge 12 Hrs	Check and verify various industrial Hazards in process of melting (Furnaces), Casing and Forging. (NOS: HCS/N2204)	59 Demonstration of prevailing condition in industry about Drinking Water Sanitary & Washing, Cloakrooms Facilities for Food & Drink Shelters & Living Accommodation. (22 hrs.) Disaster management floods, earthquake, cyclone, and slides, role of individual in prevention of pollution. (23 hrs.)	Safety in Melting, Boilers: Hazards in process of melting (Furnaces), Casing, and Forging. Automatic Manufacturing Activity - Machining, Chipping, Grinding, Safety Precautions in use of Boilers. Precautions in Processes: Precautions in processes and operations involving Explosive, Toxic Substances, Dusts, Gases, Vapour Clouds Formation and Combating, Workplace Exposure Limit, Control Measures. (12 hrs.)

Professional Skill 45 Hrs; Professional Knowledge 10 Hrs	Identify various types of water relay management systems. (NOS: MIN/N9424)	60 Maintenance of ladders and trolleys. (12 hrs.) 61 Design of turntable ladders, water tender and special equipment. (12hrs.) 62 Identify Types of water relay system. (09 hrs.) 63 Arrangements of water relay system. (12 hrs.)	**Safety in The Engineering Industry:** Introduction to Machine Operations & Guarding, Safety in the use of Machines, Safety precautions while using Hand Tools & Power Tools, Selection, Maintenance & Care of Hand and power tool. (10 hrs.)
Professional Skill 65 Hrs; Professional Knowledge 18 Hrs	Execute the risk analysis exercise. (NOS: MIN/N9425)	**Principles of accidents prevention:** 64 Definition: Incident, accident, injury, dangerous occurrences, unsafe acts, unsafe conditions, hazards, error, oversight, mistakes, etc. (20 hrs.) 65 Accident Prevention: Theories / Models of accident occurrences, Principles of accident prevention. (23 hrs.) 66 Accident and Financial implications, Hazard identification and analysis, fault tree analysis, Job safety analysis, examples, Plant safety inspection objectives and types check procedure inspection. (22 hrs.)	**Chemical Compatibility & Transportation:** Chemicals Compatibility considerations, Transportation of Chemicals, Toxic / Flammable / Explosive / Radioactive Substances by all modes - safety precautions, Use of material Safety Data Sheets. (18 hrs.)
Professional Skill 50 Hrs; Professional Knowledge 12 Hrs	Select and use PPE, care and maintain the same. (NOS: HCS/N9913, HCS/N9902, HCS/N9903)	67 Body structure and Functions, Position of causality, the unconscious casualty, fracture and dislocation, Injuries in muscles and joints, Bleeding, Burns, Scalds and accidents caused by electricity, Respiratory problems, Rescue and Transport of Casualty. (18 hrs.) 68 Cardiac massage, poisoning, wounds. (18 hrs.) 69 Personal Protective Equipment: Need, selection, supply, use, care and maintenance, Personal protective devices for head, ear, face, eye, foot, knee and body protection, Respiratory personal protective devices. (14 hrs.)	**Personal Protective Equipment:** Need for Personal Protection Equipment, Selection, Use, Care & Maintenance of Respiratory and Non-respiratory Personal Protective Equipment, Non-respiratory Protective Devices- Head Protection, Ear Protection, Face and Eye Protection, Hand Protection, Foot Protection, Body Protection. (12 hrs.)
Professional Skill 30 Hrs; Professional Knowledge 06 Hrs	Apply the method of bulk storage system of LPG/ CNG. (NOS: MIN/ N9426)	70 Visit to LPG/ CNG storage Site. (20 hrs.)	**Bulk Storage:** General Consideration, Types of Storage, Layout of storages with specific reference to LPG, CNG, Chlorine, Ammonia. (06 hrs.)
Professional Skill 20 Hrs; Professional Knowledge 10 Hrs	Prepare case study on major Chemical Disasters. (NOS: MIN/ N9428)	71 Preparation of Case study of Major Chemical Disasters. (20 hrs.)	**Occupational Hazards & Dangerous Chemicals:** Introduction to Occupational Health Hazards & Dangerous Properties of Chemicals, Dust, Gases, Fumes, Mist, Vapours, Smoke and Aerosols, Concepts of Threshold Limit Values, Classification of Hazards Chemicals Accident

			Prevention & major Case Studies: Major Industrial Accidents due to Chemicals (Bhopal Gas Tragedy) Emergency Planning, Major Industrial Disaster Case Studies. (10 hrs.)
Professional Skill 80 Hrs; Professional Knowledge 20 Hrs	Practice Bio Medical Waste and E-Management (NOS: MIN/ N9428)	**Bio Medical Waste and E-Management** 72 Techniques of segregation, packaging, storage, transport of infectious waste. (20 hrs.) 73 Techniques of Biomedical waste management. (15 hrs.) 74 Treatment method- Autoclave, Hydroclave, Microwave, Chemical Disinfection, Solidification and stabilization, Bioremediation, (18 hrs.) 75 Accumulation and storage of hazardous waste, (12 hrs.) 76 Land disposal of hazardous waste, (13 hrs.)	Bio Medical Waste and E- Management (a)Introduction: various aspects of hazardous waste, biomedical waste and E-waste e.g. collection, segregation, recovery, labeling requirements, storage areas, treatment and disposal facilities. (b)Sources, Composition and characteristic of hazardous waste, Hazardous Waste (Management and Handling) Rules, 1989 and amendments, Federal Hazardous Waste Regulations under RCRA, Superfund, CERCLA and SARA. Toxicology, public health impact, Protocols, issues and challenges in transportation of hazardous waste. (c) Characterization of medical waste- Bio-medical wastes (Management and Handling) Rules, 1998, Amendments and guidelines, segregation, packaging, storage, transport of infectious waste. Techniques of Biomedical waste management. Health and safety rules. Protocols, issues and challenges in transportation of Biomedical waste. (d) Treatment method- Autoclave, Hydroclave, Microwave, Chemical Disinfection, Solidification and stabilization, Bioremediation, Thermal Conversion Technologies, accumulation and storage of hazardous waste, land disposal of hazardous waste, other treatment and disposal method. Common Hazardous Waste Treatment facilities (TSDF) (e) E-waste: Introduction, toxicity due to hazardous substances in e-waste and their impacts, domestic e-waste disposal, e-waste management, technologies for recovery of resource from electronic waste, guidelines for environmentally sound management of e-waste, occupational and environmental health perspectives of recycling e-waste in India. (20 hrs.)
Professional Skill 20 Hrs; Professional Knowledge 04 Hrs	Demonstrate Process to control noise pollution (NOS:MIN/N1702, MIN/N1703, MIN/ N1704,)	78 Practice Measurement of noise (12 hrs.) 79 Process to control noise pollution (08 hrs.)	**Noise Pollution:** Its causes, types, sources, effects on Human health, how to control noise pollution. (04 hrs.)
Project work/ Industrial visit			

Hazard management in factories

Objectives: At the end of this lesson you shall be able to
- **describe the types of incident and managing workplace incidents**
- **explain on hazard analysis and risk assessment strategies at factories**
- **describe HAZOP anlaysis and sources for information on hazard evaluation.**

1 **Types of incidents:**

a Employee injury incident.

b Environmental incident.

c Property damage incident.

d Vehicle incident.

e Fire incident.

2 **Managing workplace Incidents:** The moment an employee injury occurs, it initiates a sequence of events that can last for weeks or even months. But the first 24 hours after an injury are the most crucial. To respond effectively to an incident, the majority of the action items should occur within 24 hours.

As promised, here are seven steps that must be checked off during this first 24 hours after an injury. Think of a sound workplace incident report protocol as another layer of insurance for the firm:

1 **Have a plan in place and share It:** To aid in educating your staff about workplace injuries, your company should create and post a written, 24-hour response plan for employees and supervisors to follow. Training on the plan will build confidence for both employees and supervisors.

2 **Examine the Incident:** Immediate assessing of the injury and facilitating appropriate and personal treatment is crucial. Determine the type and severity of the injury. Ideally, a staff member trained in first aid can assess the severity of the injury and the appropriate action needed.

3 **Have all types of workplace incident report forms ready to roll:** Give the injured employee forms to take to the doctor. These forms allow the doctor to authorize return to work and note any temporary restrictions an employee may have.

4 **Visit the Doctor - Don't Delay Unnecessarily!:** For injuries that usually result in the most lost time and highest claims costs, such as sprains, strains, neck and back injuries, appropriate medical care is most likely a prompt visit to a clinic or a doctor well-versed in evidence-based occupational health care delivery. An established clinic relationship facilitates prompt and appropriate treatment for injured workers.

5 **Show You Care:** Communicate care and concern as soon as possible, letting the injured employee know that you care about his well-being and you want him back on the job as soon as he's able.

6 **Report While the Details are Fresh:** It's important that a workplace incident report and related documentation is shared with appropriate parties immediately. Ensure that injury reporting is quick across all levels (supervisor, injury management coordinator, and insurance carriers). Timely reporting is one important result of effective training and results in rapid return to work and minimized indemnity claims.

7 **Check In with Your Employee:** Follow up with the injured employee by finding out how the doctor's visit, and how he's doing. Hear from worker what the doctor had to say. Together, you can begin formulating an appropriate return to work plan.

Claims that stretch out are more expensive than claims that are managed quickly. What's more, a fast and transparent claims and injury management process demonstrates to an injured employee that he want back in the pink as soon as possible.

8 **Analyse possible hazards and emergencies:** Industrial plants deal with materials, which are generally hazardous in nature by virtue of their intrinsic chemical properties or their operating temperatures or pressures or a combination of these. Fire, explosion, toxic release or combinations of these are the hazards associated with industrial plants using hazardous chemicals. More comprehensive, systematic and sophisticated methods of Safety Engineering, such as, Hazard Analysis and Quantitative Risk Assessment have now been developed to improve upon the integrity, reliability and safety of industrial plants.

The primary emphasis in safety engineering is to reduce risk to human life, property and environment. Some of the more important methods used to achieve this are:

a Quantitative Risk Analysis: Provides a relative measure of the likelihood and severity of various possible hazardous events by critically examining the plant process and design.

b Work Safety Analysis: The technique discerns whether the plant layout and operating procedures in practice have any inherent infirmities.

c Safety Audit: Takes a careful look at plant operating conditions, work practices and work environments to detect unsafe conditions.

Together, these three broad tools attempt to minimize the chances of accidents occurring.

9 **Process Hazard Analysis:** Process Hazard Analysis (PHA) is a thorough, orderly, and systematic approach for identifying, evaluating, and controlling the hazards of processes.

The process hazard analysis methodology selected must be appropriate to the complexity of the process and must identify, evaluate, and control the hazards involved in the process.

The process hazard analysis shall address the following:

- The hazards of the process
- The identification of any previous incident that had a likely potential for catastrophic consequences
- Engineering and administrative controls applicable to the hazards and their interrelationships
- Consequences of failure of engineering and administrative controls
- Stationary source siting
- Human factors and
- A qualitative evaluation of a range of the possible safety and health effects of failure of controls.

A process Hazard Analysis (PHA) team includes process safety specialist, engineers, operators, supervisors and other workers who have knowledge of the standards, codes, specifications and regulations which apply to the process being studied.

PHA Services

- Hazard and Operability Study (HAZOP)
- Hazard Identification Study (HAZID)
- Bow-Tie Analysis
- What-If Analysis
- Quantitative Risk Assessment (QRA).

HAZOP: HAZOP study is to carefully review a process or operation in a systematic manner to determine whether deviations from the design or operational intent can lead to undesirable consequences. This technique can be used for continuous or batch processes and can be adopted to evaluate written procedures. The HAZOP team lists potential causes and consequences of the deviation as well as existing safeguards protecting against the deviation. When the team determines that inadequate safeguards exist for a credible deviation, it usually recommends the action be taken to reduce the risk.

Objective of carrying out a HAZOP study

- To check a design
- To decide whether and where to build
- To decide whether to buy a piece of equipment
- To obtain a list of questions to put to a supplier
- To check running instructions
- To improve the safety of existing facilities

HAZOP Team: In addition to the Chairman and scribe, the HAZOP team comprises of the following personnel:

- Design consultant / Project Manager
- Production Manager
- Chemical engineer / Chemist
- Maintenance Manager
- Electrical Engineer
- Instrument Engineer
- Quality Control Engineer

Role of Risk analysis in the HAZOP study

- Facilitate/lead the team to carry out highly structured and systematic examination sessions
- Use of standard guide words and suitable simulation tool
- Control the discussion so that meaningful results are obtained
- Record the discussions and submit the report to the management

QRA: Quantitative Risk Analysis is proven as a valuable management tool in assessing the overall safety performance of a Chemical Process Industry.

Objective of QRA

- To identify, quantify and assess the risk from the facility from the storage and handling of chemical products
- To identify, quantify and assess the risk to nearby facilities / installations.
- To suggest recommendations in order to reduce the risk to human life, assets, environment and business interruptions to as low as reasonably practicable.

Risk Analysis techniques provide advanced quantitative means to supplement other hazard identification, analysis, assessment, control and management methods to identify the potential for such incidents and to evaluate control strategies.

QRA is widely used in assessing the risk in Oil & Gas Installations especially refineries, tank farms, cross country pipelines, bottling plants, terminals etc.

Risk Assessment procedure: Hazard Identification is a critical step in Risk Analysis. Many aids are available, including What-if Analysis, Hazard and Operability (HAZOP) Studies, Failure Mode and Effects Analysis (FMEA), and Preliminary Hazard Analysis (PHA) etc.,

Assessment of risks is based on the consequences and likelihood

- Consequence Estimation is the methodology used to determine the potential for damage or injury from specific incidents. E.g.: Jet fire distances, BLEVE etc.,

- Likelihood assessment is the methodology used to estimate the frequency or probability of occurrence of an incident.

Risks are quantified using this study and ranked accordingly based on their severity and probability. Acceptability of the estimated risk must then be judged based upon criteria appropriate to the particular situation. Wherever possible, additional risk control measures are to be adopted to reduce the risk levels.

HAZID: HAZID (Hazard Identification) is a qualitative technique for the early identification of potential hazards and threats effecting people, the environment, assets or reputation. The major benefit of a HAZID study is to provide essential input to project development decisions. It is a means of identifying and describing HSE hazards and threats at the earliest practicable stage of a development or venture.

Methodology: The study method is a combination of identification, analysis and brainstorming by the HAZID team members. Guidewords are used in order to identify possible potential and hazardous effects as well as threats. Furthermore the team analyses the appropriate controls that should put in place in order to prevent or control each identified threat. The analysis of HAZID will be conducted on a session basis, grouping the processes with the PFD (Process Flow Diagram) and plant layout into a series of sections where the various sources will have similar characteristics and hence consequences.

HAZID Team: The HAZID team comprises of the personnel, similar to HAZOP

Role of risk assessment in the HAZID study

Facilitate/lead the team to carry out highly structured and systematic examination sessions

- Use of standard guide words and suitable simulation tool
- Control the discussion so that meaningful results are obtained
- Record the discussions and submit the report to the management

Benefits of Carrying out HAZID

- Identify opportunities for inherent safety
- Identify Fire, explosion, toxic release scenarios and measure to prevent it.
- Any special preparations required to be taken to handle these can be pre - planned.
- Any specific process modifications if required can be established at an early stage.
- Prepares the system & team, ready and confident to go ahead for commissioning. Avoids major surprises.
- Hazards involved in operating each equipments can be enlisted at the beginning, leading to better process mapping & better control in future to getting OSHAS / ISO approvals.
- The major benefit of HAZID is early identification and assessment of the critical health, safety and environmental hazards provides essential input to the project development decisions. (Fig 1)

Bow tie analysis is a hazard analysis technique which is combination of fault tree analysis (FTA) and event tree analysis (ETA). Fault tree analysis (FTA) is identifying basic events that can lead to an accident event, where as Event tree analysis (ETA) is identifying the event sequences from initiating events to accident scenarios.

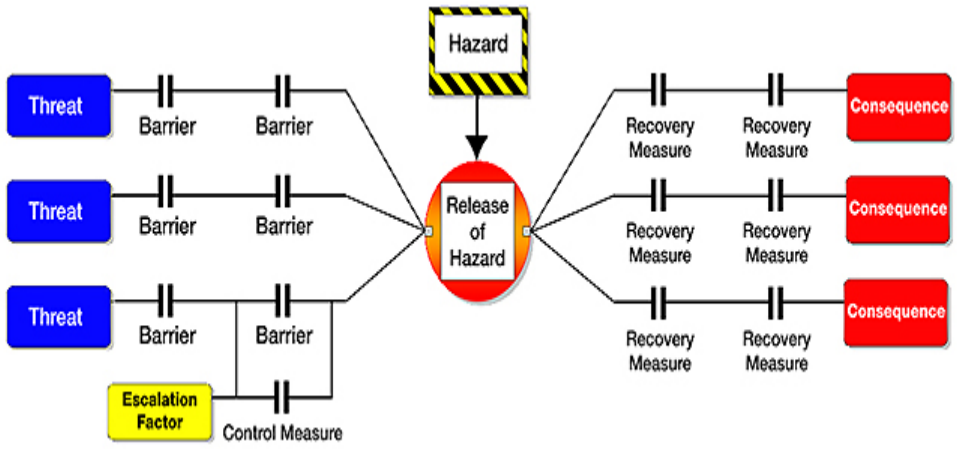
Benefits of Bow Tie Analysis

- Highly effective for initial Process Hazard Analysis
- Ensures identification of high probability-high consequence events
- Combined application of a high-level fault/event trees
- Representation of the causes of a hazardous scenario event, likely outcomes, and the measures in place to prevent, mitigate, or control hazards
- Existing safeguards (barriers) identified and evaluated
- Typical cause scenarios identified and depicted on the pre-event side (left side) of the bow-tie diagram
- Credible consequences and scenario outcomes are depicted on the post-event side (right side) of the diagram
- Associated barrier safeguards included

What if analysis: The purpose of a What-If Analysis is to identify hazards, hazardous situations, or specific event sequences that could produce undesirable consequences. An experienced group of people identifies possible abnormal situations, their consequences, and existing safeguards, and then suggests alternatives for risk reduction where obvious improvement opportunities are identified or where Safeguards are judged to be inadequate. The method can involve examination of possible deviations from the design, construction, modification, or operating intent. It requires a basic understanding of the process intention, along with the ability to mentally combine possible deviations from the design intent that could result in an incident. This is a powerful technique if the staff is experienced; otherwise, the results are likely to be incomplete

- Baseline Data Development
  - Establish Requirements
  - Develop Activity Definition
  - Characterize systems and facilities
- Process Hazard Screening
  - Use Comprehensive checklists
  - Apply to each Operation/System/Facility
  - Identify Applicable Hazards

Fig 1



- Perform Hazard Analysis
  - Develop Hazard Analysis Tables
  - Identify important controls
  - Perform Preliminary Ranking of Controls
  - Select Accidents for Further Analysis
- Perform Design Basis Accident Analysis
  - Performance Probabilistic and Deterministic Analysis of Selected Accidents
  - Quantify Frequency and Accidents
  - Identification of Most Significant
  - Controls, Develop controls
  - Complete document

Hazard Identification

Objectives: At the end of this lesson you shall be able to
- **explain the meaning of hazard**
- **state the types of hazards and its identification**
- **describe the how to evaluate and control the hazards.**

Hazard

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

Harm

Physical injury or damage to health.

Different types of hazard

A common way to classify hazards is by category:

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

Fig 1 represents a mark or discoloration on surface caused by blood.

Fig 2 represents a biological stain caused due to fungi, bacteria and virus.

Fig 3 represents a mark or discoloration on skin caused due to insect.

Fig 4 represents a stain caused due to the contamination of plants.

Fig 1

BLOOD STAINS

HSN110111

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

Fig 5 represents a hazard caused due to the toxic usage of the chemicals at work-area

- **Ergonomic** - repetitive movements, improper set up of workstation, poor design of equipment, workstation design, (postural) or workflow, manual handling, repetitive movement etc.,

Fig 2

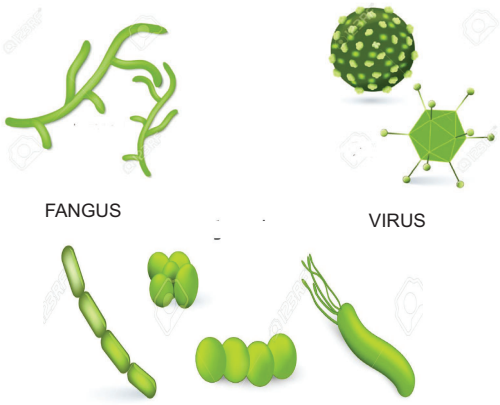


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Fig 3

DISCOOLARATION ON SKIN CAUSES

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Fig 4

CONTAMINATION OF PLANTS

HSN110114

- **Physical** - Slippery floors, objects in walkways, unsafe or misused machinery, excessive noise, poor lighting, fire. radiation, magnetic fields, pressure extremes (high pressure or vacuum), noise, etc.,
- **Psychological** - Shift work, workload, dealing with the public, harassment, discrimination, threat of danger, constant low-level noise, stress.stress, violence, etc.,
- **Safety** - slipping/tripping hazards, inappropriate machine guarding, equipment malfunctions or breakdowns.Fig 6 & 7 represents the hazard caused due to the improper work postures or improper set up at work-area.

Fig 5

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Fig 6

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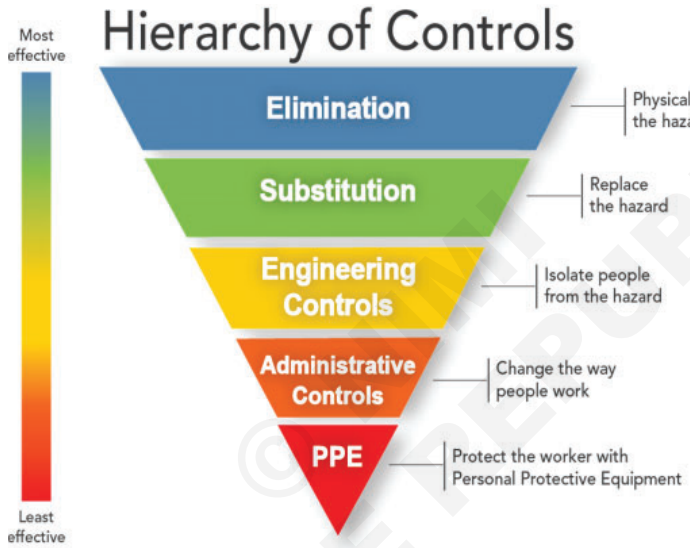
Fig 7



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Risk analysis

Objectives: At the end of this lesson you shall be able to
- **explain the meaning of risk**
- **brief about risk analysis**
- **describe about Failure Mode &Effect Analysis (FMEA), Fault TreeAnalysis (FTA), Event Tree Analysis (ETA).**

Risk: Risk is the chance or probability that a person will be harmed or experience an adverse health effect if exposed to a hazard.

Factors that influence the degree or likelihood of risk are:

- The nature of the exposure: how much a person is exposed to a (e.g., several)
- How the person is exposed (e.g., breathing in a vapour, skin contact), and
- The severity of the effect. For example, one substance may cause skin cancer, while another may cause skin irritation. Cancer is a much more serious effect than irritation.

Risk analysis

1 **Identify hazards, i.e. anything that may cause harm:** Employers have a duty to assess the health and safety risks faced by their workers. The employer must systematically check for possible physical, mental, chemical and biological hazards. (Fig 1 Types of hazards.

Fig 1

Safety Hazards | Biological Hazards | Physical Hazards | Ergonomic Hazards | Chemical Hazards

HSN110511

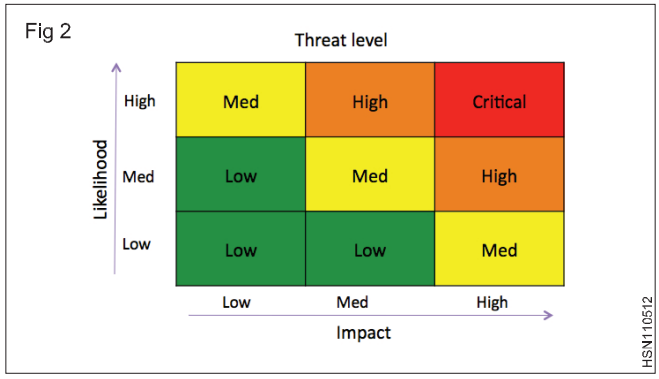
2 **Decide who may be harmed, and how:** Identifying who is at risk starts within the organisation. Employers must also assess risks faced workers, staff, visitors, clients and other members of the public on their premises.

Employers must review work routines in all the different locations and situations where their staff are employed. For example:

In a supermarket, hazards are found in the repetitive tasks at the checkout, in lifting loads, and in slips and trips from spillages and obstacles in the shop and storerooms. Staff face the risk of violence from customers and intruders, especially in the evenings.

3 **Assess the risks and take action:** This means employers must consider how likely it is that each hazard could cause harm. This will determine whether or not employer should reduce the level of risk. Even after all precautions have been taken, some risk usually remains. Employers must decide for each remaining hazard whether the risk remains high, medium or low. (Fig 2)

Fig 2



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4 **Make a record of the findings:** This record should include details of any hazards noted in the risk assessment, and action taken to reduce or eliminate risk.This record provides proof that the assessment was carried out, and is used as the basis for a later review of working practices.

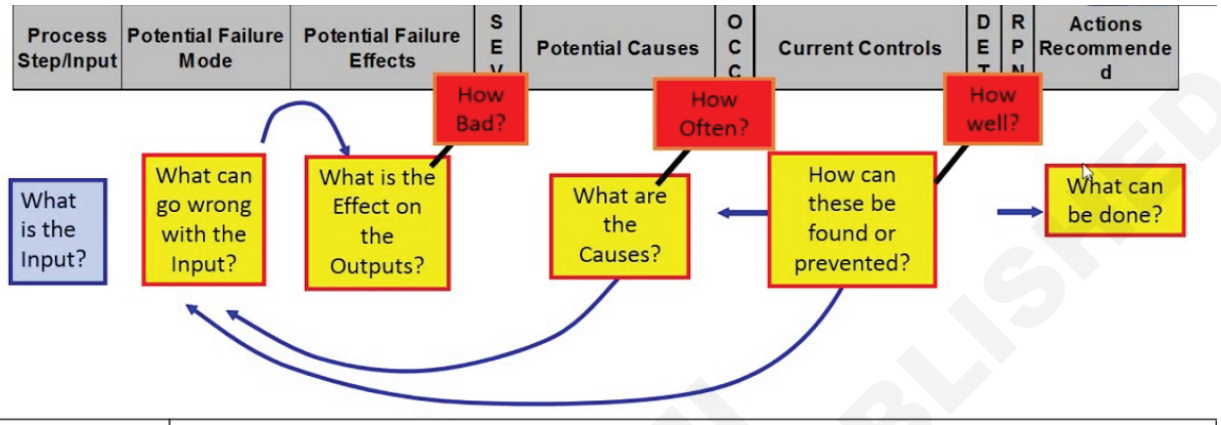
5 **Review the risk assessment**

A risk assessment must be kept under review in order to:

- Ensure that agreed safe working practices continue to be applied (e.g. that management's safety instructions are respected by supervisors and line managers); and
- Take account of any new working practices, new machinery or more demanding work targets.

Failure mode and effects analysis (FMEA) (Fig 3 - FMEA Approach): Failure Mode and Effects Analysis (FMEA) is a model used to prioritize potential defects based on their severity, expected frequency, and likelihood of detection.

Fig 3



Severity	It is the value associated with the most serious effect for a give failure mode.
Occurrence	Occurrence is likelihood that a specified cause of failure will occur
Detection	Detection is the rank associated with the best detection control listed in standard

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- Failure modes" means the ways, or modes, in which something might fail. Failures are any errors or defects, especially ones that affect the customer, and can be potential or actual.
- "Effects analysis" refers to studying the consequences of those failures.

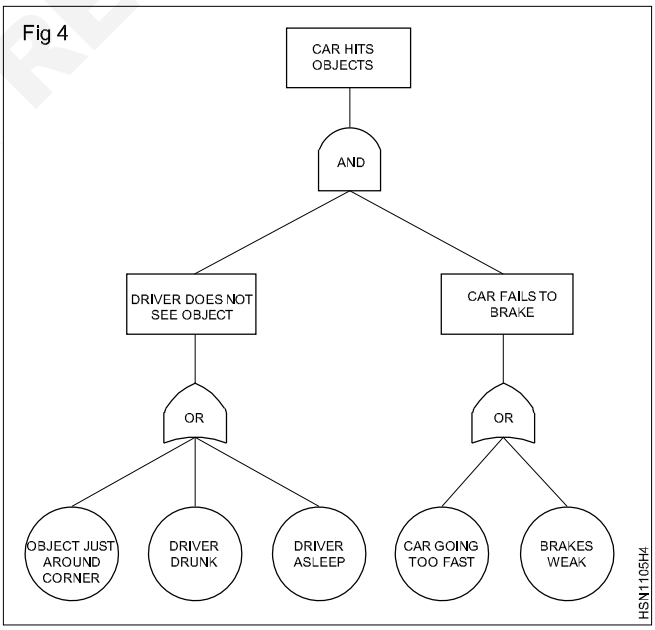
Failures are prioritized according to how serious their consequences are, how frequently they occur, and how easily they can be detected. The purpose of the FMEA is to take actions to eliminate or reduce failures, starting with the highest-priority ones.

Faul Tree analysis (Fig 4 - FTA example): A fault tree diagram is used to conduct fault tree analysis (or FTA). Fault tree analysis helps determine the cause of failure or test the reliability of a system by stepping through a series of events logically.

A fault tree creates a visual record of a system that shows the logical relationships between events and causes lead that lead to failure. A fault tree diagram will help prioritize issues to fix that contribute to a failure.

There are two basic types of fault tree diagram notations: events and logic gates. The primary or basic failure event is usually denoted with a circle. An external event is usually depicted with a symbol that looks like a house. It's an event that is normal and guaranteed or expected to occur. Undeveloped event usually denotes something that needs

Fig 4



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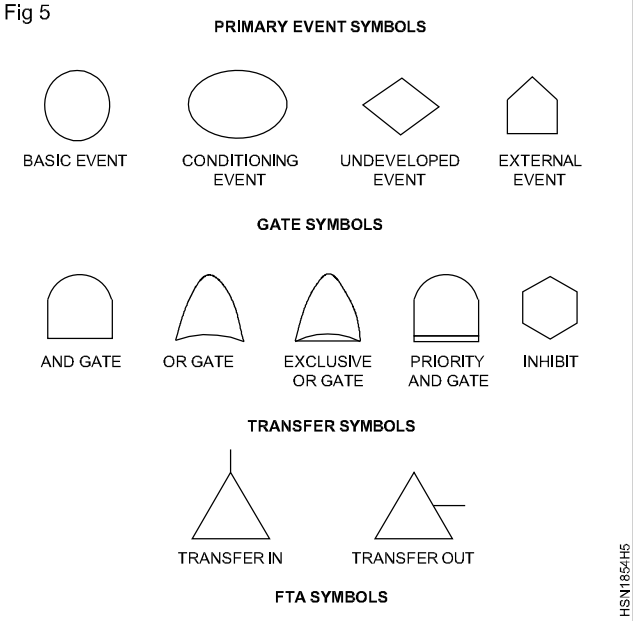
no further breakdown or investigation or an event for which no further analysis is possible because of a lack of information. A conditioning event is a restriction on a logic gate in the diagram. These gate symbols describe the Boolean relationship between outcomes.

Gate symbols can be the following: (Fig 5 - FTA Symbols)

- OR gate - An event occurs as long as at least one of the input events takes place

Fig 5



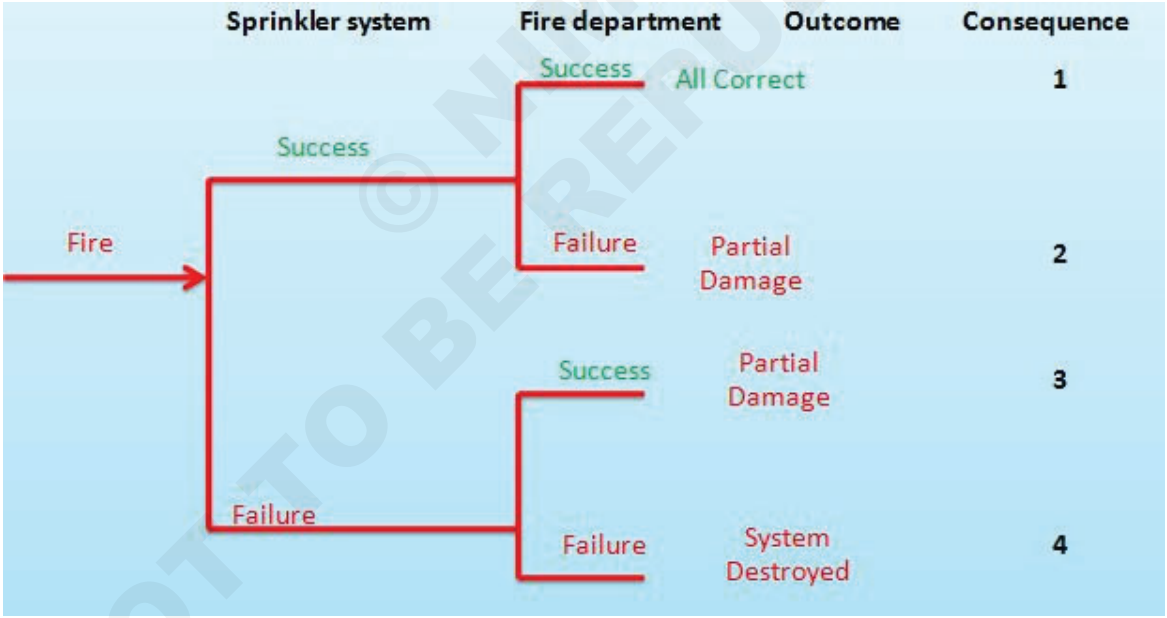
- AND gate - An event occurs only if all input conditions are met
- Exclusive OR gate - An event occurs only if one of the input conditions is met, not if all conditions are met
- Priority AND gate - This is probably the most restrictive scenario when an event occurs only after a specific sequence of conditions
- Inhibit gate - An event will only occur if all input events take place as well as whatever is described in a conditional event

Event Tree Analysis

Event tree analysis (ETA) is also a logical model for both failure and success responses from individual factor. The model has a number of pathways for analyzing probabilities of results and the analysis of the whole structure.

An event tree begins with an initiating event, such as a component failure, increase in temperature/pressure or a release of a hazardous substance. The consequences of the event are followed through a series of possible paths. Each path is assigned a probability of occurrence and the probability of the various possible outcomes can be calculated. (Fig 6)

Fig 6



Accident prevention and safety

Objectives: At the end of this lesson you shall be able to
- **list some common reasons of accidents at site**
- **list common accidents and prevention methods**
- **describe the ways to stay healthy and hygienic.**

Definition

An accident is a specific, unpredictable, unusual and unintended external action which occurs in a particular time and place, with no apparent and deliberate cause but with marked effects.

Frequently occurring accidents/hazards on Workshop

Some of the more frequently encountered hazards include:
Electrical hazards (Fig 1)

Fig 1

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Hazard due to scissors and needle (Fig 2)

Fig 2

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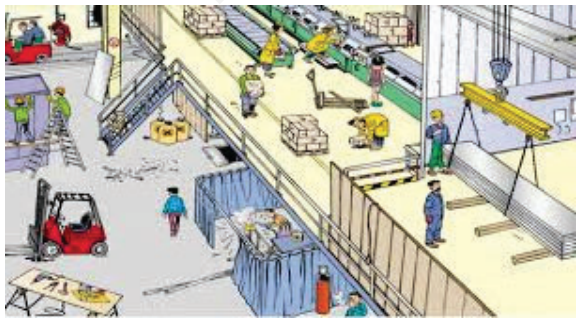
Falling object hazards (Fig 3)

Fig 3



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Hazard due to Equipment failure (Fig 4)

Fig 4

HSN110814

Fire Hazard (Fig 5)

Fig 5

HSN110815

Physical Accidents (Fig 6)

Fig 6

HSN110816

Collision or fall (Fig 7)

Basic Principles -Heinrich theory

The occurrence of an injury invariably results from a completed sequence of factors - one factor being the accident itself." That sums up Heinrich's domino theory. He believed the following five factors must be present for an accident to occur:

Fig 7

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1 Ancestry and social environment

2 Fault of person

3 Unsafe act or mechanical or physical hazard

4 The accident

5 The injury

"Unsafe act or mechanical or physical hazard" lines up with Heinrich's theory and arguably most controversial, axiom: "The unsafe acts of persons are responsible for the majority of accidents." According to Heinrich, 88 percent of accidents are caused by unsafe acts of persons and 10 percent by unsafe machines (with 2 percent being unavoidable).

In refuting Heinrich's work, Manuele singled out the 88-10-2 ratio of accident causation as having the most influence and causing the most harm to the safety profession. Why harm? Because when basing safety efforts on the premise that man failure causes the most accidents, the preventive efforts are directed at the worker rather than on the operating system in which the work is done".

List of Common Accidents at Workplace and Prevention Methods

1 Accidents due to slip, trip and fall (Fig 8)

Fig 8

HSN110818

Slip, trips and falls account for 1/3rd of all personal injuries in the workplace and are a top cause of workers' compensation claims. The types of injuries incurred from slips, trips and falls include head and back injuries, broken bones, cuts and lacerations, sprains and pulled muscles.

The most common reasons for falls in the workplace are:

- Slips-- Wet or oily surfaces, occasional spills, weather hazards, loose rugs or mats and flooring that lacks the appropriate degree of traction.
- Trips-- Obstructed view, poor lighting, clutter, wrinkled carpeting, uncovered cables, uneven walking surfaces and bottom drawers not being closed.

There are three keys to preventing workplace accidents due to slips, trips and falls: good housekeeping, quality walking surfaces and proper footwear.

2 Being Caught In or Struck By Moving Machinery (Fig 9)

Fig 9

HSN110819

Machinery that's not properly guarded is a potentially grisly safety hazard. When body parts get caught in or struck by exposed moving parts or flying objects from machines without protective guards, the results are often disastrous. The long and horrifying list of machinery-related injuries includes crushed hands and arms, severed fingers, blindness and worse.

Most mechanical hazards occur in these three places:

- The Point of Operation-- Where work is performed on the material: cutting, shaping, boring or forming of stock.
- Power Transmission Apparatus-- Components of the mechanical system transmitting energy to the part of the machine performing the work: flywheels, pulleys, belts, connecting rods, couplings, cams, spindles, chains, cranks and gears.
- Other Moving Parts-- All parts of the machine that move while the machine is working: reciprocating, rotating and transverse moving parts, feed mechanisms and auxiliary parts of the machine.

The golden rule in preventing mechanical hazards is to remember that any machine part, function or process that may cause injury must be safeguarded. Also, existing hazards must be controlled or eliminated and proper operator training and protective clothing must be provided.

3 Transportation and Vehicle-Related Accidents (Fig 10)

Vehicle-related accidents are the most common cause of fatal injuries in the agriculture industry, but they can be equally catastrophic in industrial or manufacturing environments as well.

Fig 10

HSN11081A

There are two distinct kinds of vehicle-related accidents.

- On The Road-- Workers can be injured or killed after being struck by a vehicle while repairing roads or other work in traffic zones.
- In The Workplace --Operators of vehicles and equipment can be injured or cause injury to pedestrians.

Avoiding workplace transportation accidents begin with assessing who is at risk, as well as where and when these accidents most commonly occur. Only then are prevention measures, such as vehicle/worker orientation and safe systems of work, more easily established. workplace design; ensuring layout routes always segregate pedestrians and vehicles and make any obstructions clearly visible. Directions, speed limit and priority signs are also helpful.

4 Fire and Explosions (Fig 11)

Fig 11

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Unexpected explosions and fires in the workplace are frequently caused by risk factors such as faulty gas lines, poor pipefitting, improperly stored combustible materials or open flames. The resulting injuries incurred include damage to the respiratory system, varying degrees of burns and potential disfigurement. Explosions and fires account for 3% of workplace injuries and have the highest casualty rate of all probable workplace accidents.

There are four types of injuries commonly associated with fires and explosions:

- Primary Blast Injuries-- Occurs due to the effects of pressure on body tissues, affecting ears, lungs and the GI tract.
- Secondary Blast Injuries-- Occurs when flying objects strike nearby workers.
- Tertiary Blast Injuries-- High-energy explosions can lift someone off the ground and cause them to fly into surrounding objects.
- Quaternary Blast Injuries-- Everything else that happens as a result of an explosion: crush injuries, burns and inhalation of toxic substances.

Every workplace should have a clearly communicated evacuation plan and an effective alert system in place to quickly inform everyone of hazards and emergency situations.

5 Overexertion and Repetitive Stress Injuries: Although more subtle than a catastrophic explosion, musculoskeletal disorders are the most costly workplace injuries. These kinds of injuries contribute to loss of productivity, millions in direct costs and millions in annual health benefit payout costs.

Overexertion injuries are related to pulling, lifting, pushing, holding, carrying and throwing. Similarly, RSIs (Repetitive Stress Injuries) are the fasting growing category of workplace injury and comprise more than 100 different types of job-induced injuries from wear and tear on the body. Both overexertion and RSIs are severe enough to inhibit simple activities with crippling and debilitating pain, not to mention severe impairment of movement. They may even eventually permanently impair a worker's ability to perform his or her job.

Causes of overexertion and RSIs, include

- Improper Lifting-- Bending at the waist instead of at the knees when carrying or moving heavy objects.
- Manually Lifting Heavy Objects --Especially objects weighing over 50 pounds, without the assistance of a co-worker or lifting device (manual or mechanical).
- No Breaks --With repetitive work, short breaks should be required, or the work may eventually result in too much wear and tear on the body.
- Speeding Up the Line --Automation has created work conditions that are faster and often reduced to limited, repetitive tasks.
- Intensive Keying --Constant typing and clicking strains muscles and tendons.

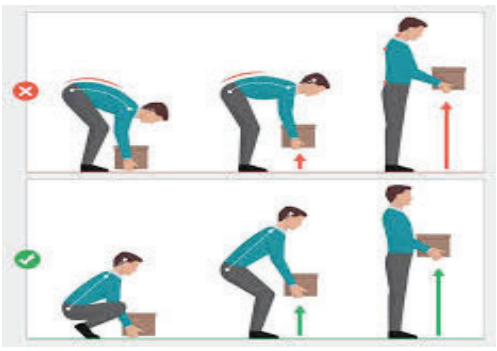
Ergonomics at Workplace

The science of adjusting the job to fit the body's needs -- provides injury prevention solutions that are simple and relatively inexpensive. Workers assigned to tasks that overexert or require repetitive motion should be required to take frequent short breaks to rest and stretch. Manual or mechanical lifting equipment should be provided, especially in cases where the items lifted are over 50 pounds. Varying workers tasks to break up the repetitiveness is also beneficial.

Maintaining health and hygienic at workplace

Traditionally, health is defined as the absence of illness. WHO defines health in this positive way: (Fig 12)

Fig 12



Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity"

Maintaining clean environment at work

- Designate storage space for everything.
- Provide sufficient housekeeping tools, including brooms, clean rags, and spill absorbers.
- Define areas for scrap storage and schedule regular collection, removal, and disposal.
- Assign clean-up responsibilities and make sure work sites are cleaned and cleared before quitting time.

Hygiene - It is a set of practices performed for preservation of health. It is maintained in personal, home, food and workplace.

Personal Hygiene - The cornerstone of hygiene. The body is the source and entry point of many illnesses. Appropriate personal hygiene can prevent all sorts of diseases

Hygiene at home - When you spend your time at home you may as well maintain hygiene as the air you breathe can affect your breath.

Food - Whether in the home, in industry or in catering, food hygiene should be second nature at this time when new food risks are sharply on the increase

Instilling hygiene rules and basics - These should rapidly become second nature and act as a safeguard for the health of the population at large. Setting an example, repetition and education are most important in successfully applying personal, domestic, food or pet hygiene. Hygiene is essentially a healthy attitude towards life in general, including a balanced diet, a well ordered lifestyle, balanced sleeping patterns and avoiding smoking, alcohol and drugs. Living hygienically is the first step towards a healthier society.

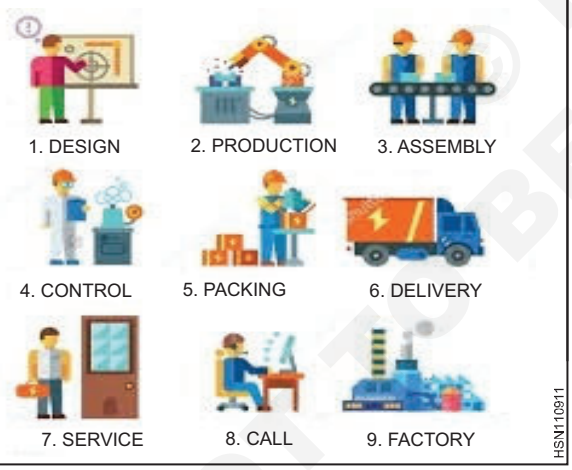
Identify and apply safety policy in an industry

Objectives: At the end of this lesson you shall be able to
- **state the safety audit checks carried out during plant inspection**
- **describe the method of safety audit policy preparation and assessment routes**
- **state the duties and implement safety targets, standards and practices within the industry.**

Objective of Safety audits: It is recommended that a team be established to conduct safety audit. Each team should be comprised of at least three to five people representing a variety of departments. To ensure neutrality and objectivity, it is suggested that team members should not audit their own department. Audits may also be conducted by qualified consultants. Audit Team members should review all existing safety program material in advance of the safety audit.

Safety Audits are conducted for the purpose of health, safety, and fire hazard identification. During these surveys, assessments are made for compliance to applicable regulations and fire codes as well as the detection of unsafe hazards. Audits also provide an evaluation of workplace compliance to Occupational Safety and Health Administration (OSHA) standards relating workplace and worker safety. (Fig 1 Safety audits necessary at different points in the industry)

Fig 1



Plant Safety Inspection: Audits of work sites are conducted for the purpose of health, safety, and fire hazard identification. During these surveys, assessments are made for compliance to applicable building and fire codes and the detection of unsafe hazards.

Work site audits also provide standards relating to ergonomics, respirator use, hearing conservation, blood-borne pathogens and use of personal protective equipment. Conducting a single annual comprehensive safety audit can actually hide the facts and hazards that you may want to discover. The single annual audit approach may tend to create a safety "ramp up" effect, by managers and supervisors, as the audit time approaches.

A better approach may be to schedule various specific safety audits throughout the year on a ten month schedule. The eleventh month should be reserved for a comprehensive annual audit.

Method of safety audit

Safety Audits are primarily to check the effectiveness of the various programs, they do not take the place of regular facility inspections. Facility safety inspections for hazards and their control should be performed on a weekly basis by supervisors and on a monthly basis by management. (Fig 2 Workplace safety audit).

Fig 2

Elements of Safety audit: There are four basic questions a safety audit should answer. The persons or team designated to conduct the audits should take a fact finding approach to gather data. These auditors should be familiar with both the company program and the various local, state and federal requirements.

All safety audit comments, recommendations and corrective actions should focus on these four questions:

1 Does the industry cover all regulatory and best industry practice requirements?

2 Are the industry requirements being met?

3 Is there documented proof of compliance?

4 Is employee training effective - can and do they apply specific safe behaviors?

Safety Audit Preparation

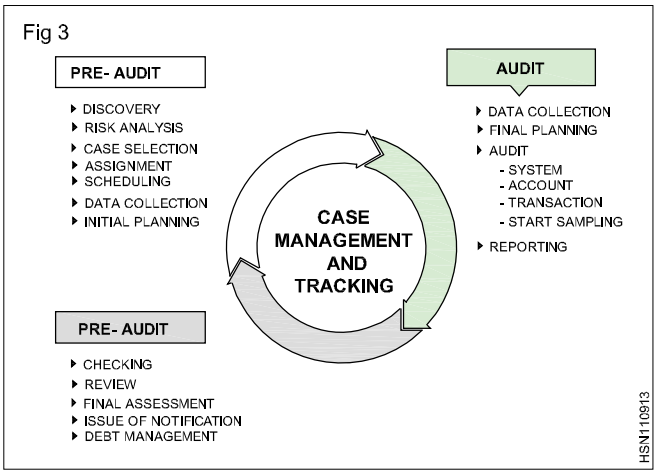
1 One week prior to the audit, inform all affected managers and supervisors. They should be directed to have all records, documents and procedures available when the audit starts.

2 Review all past program area audits and corrective action recommendations.

3 Review all company, local, state and federal requirements for the specific program. Become familiar with the document, inspection and training requirements.

4 Determine the scope of the audit. This can be based on accident and inspection reports and input from various managers. Set a start and stop time & date for the audit. (Fig 3 Audit preparation and tracking)

Fig 3



Concept and layout of audit report: A fact finding event is used to gather all applicable information. Auditors should make an effort not to form an opinion or make evaluative comments during this phase.

a **A Team Approach:** If a safety audit team is used, make assignments to each person that defines their area of inspection. Ensure they have the proper program background information and documents.

Safety Audit Areas - most audits can be broken down into these areas:

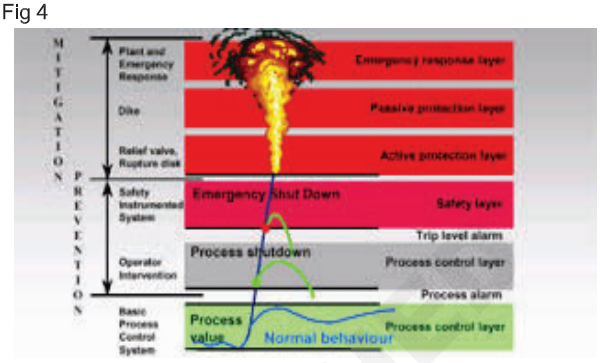
b **Employee knowledge:** OSHA standards require "effective training" - an effective program ensures that employees have the knowledge required to operate in a safe manner on a daily basis. The level of knowledge required depends on the specific activities in which the employee is involved and their specific duties and responsibilities. Generally, managers and supervisors should have a higher level of knowledge than general employees. This includes practical knowledge of program administration, management and training.

They should be able to discuss all elements of each program that affects their assigned employees. Many programs divide employees into these two groups- authorized employees and affected employees. Authorized employees must have a high level of working knowledge involving hazard identification and hazard control procedures. Determining employee level of knowledge can be achieved though written quizzes, formal interviews or informal questions in the workplace.

Safety Precautions adopted in the Plant: This part of the safety audit review checks the implementation and management of specific program requirements. This section asks these and other similar questions:

- Is there a person assigned and trained to manage the program?
- Are specific duties and responsibilities assigned?
- Are sufficient assets provided?
- Is there an effective and on-going employee training program? (Fig 4 Safety System Displays)

Fig 4



Safety Audit Report

1 **Record & Document Review:** Missing or incomplete documents or records are a good indication that a program that is not working as designed. Records are the company's only means of proving that specific regulatory requirements have been met. Record review also includes a look at the results, recommendations and corrective actions from the last program audit.

2 **Equipment and Material:** This area of a safety audit inspects the material condition and applicability of the equipment for hazard control in a specific program. Examples of audit questions for this area are:

- Is the equipment in a safe condition?
- Is there adequate equipment to conduct tasks safely?
- Is personal protective equipment used and stored properly?
- Is equipment, such as exit lights, emergency lights, fire extinguishers, material storage and handling equipment designed and staged to control hazards effectively?

3 **General Area Walk-Through:** A general walk-though of work areas can provide additional insight into the effectiveness of safety programs. Auditors should take written notes of unsafe conditions and unsafe acts observed during the walk-through.

Findings of the safety audit: After all documents, written programs, procedures, work practices and equipment have been inspected, gather your team and material together to formulate a concise report that details all areas of the program. Remember to focus on the four basic questions mentioned earlier. Each program requirement should be addressed with deficiencies noted. Include comments of a positive nature for each element that is being effectively managed. (Fig 5 Assessment of safety audit)

Fig 5

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Recommendations from the safety audit

Develop recommended actions for each deficient condition of the program. Careful forethought should be applied to ensure that this is not a process that simply makes more rules, additional record keeping requirement or makes production tasks more difficult. Examine the manner and means in which the current deficient elements are managed to determine if there is a simpler procedure that can be employed.

Corrective Actions from the safety audit

Development of corrective action should involve the managers and supervisor who will be required to execute the corrections. Set priorities based on level of hazard. All corrective actions should be assigned a completion and review date. Records of completed corrective actions should be reviewed through the normal management chain and then be filed for use during the next audit. (Table 1 Corrective action report)

Table - 1 Corrective action port log quality management system

CORRECTIVE ACTION REPORT NO.	OPEN DATE	ISSUED TO	DESCRIPTION	DUE DATE	CLOSEOUT DATE

Publish the Safety Audit results

It is essential to let all supervisors and manager know the basic findings and recommendations. Don't forget to acknowledge those departments, managers and supervisors who are properly executing their responsibilities. After a few audits, everyone will want to show up on the plus side of the results, making the safety mangers job much easier).

Table 2 Safety Audit Guidelines/ Checklist)

	Safety Walk	Safety Inspection	Safety Audit
Frequency	Minimum weekly	monthly	3 - 4 Years
Duration	1 hour	1 day	3 - 4 Days
Aim	• Housekeeping • Unsafe acts/ conditions	• Housekeeping • Unsafe acts/ conditions • Questionnaires Equipment Procedures	• Housekeeping • Unsafe acts/ conditions • Questionnaires Equipment Procedures
By whom: Staff member Foreman Plant Manager afty Enineer Specialist Engineer	 X X	 X X X X	 X X X
Monitoring Follow up	One Management step higher than above		

Standard practices and performance measures of industrial safety

Objectives: At the end of this lesson you shall be able to

- **describe the Safety Management, Safety Policy, Safety Practices, Standards and Performance measurement of safety aids in an organization**
- **state the duties & responsibility of an employer, worker, Role of a supervisor and safety engineer in the organization**
- **define the ILO conventions and standards pertaining to safety of an employee.**

1 Introduction to safety management: A safety and health management system means the part of the Organisation's management system which covers:

- The health and safety work organisation and policy in a company
- The planning process for accident and ill health prevention
- The line management responsibilities and
- The practices, procedures and resources for developing and implementing, reviewing and maintaining the occupational safety and health policy.

The key elements of a successful safety and health management system are:

a Safety Policy (Fig 1)

Fig 1

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- The workplace should prepare an occupational safety and health policy programme as part of the preparation of the Safety Statement required by Section 20 of the Safety, Health and Welfare at Work Act 2005.
- Effective safety and health policies should set a clear direction for the organisation to follow.
- They will contribute to all aspects of business performance as part of a demonstrable commitment to continuous improvement.
- Responsibilities to people and the working environment will be met in a way that fulfils the spirit and letter of the law.
- Cost-effective approaches to preserving and developing human and physical resources will reduce financial losses and liabilities.

The workplace should formulate a plan to fulfil its safety and health policy as set out in the Safety Statement. An effective management structure and arrangements should be put in place for delivering the policy. Safety and health objectives and targets should be set for all managers and employees.

b Implementation and operation: For effective implementation, organisations should develop the capabilities and support mechanisms necessary to achieve the safety and health policy, objectives and targets. All staff should be motivated and empowered to work safely and to protect their long-term health, not simply to avoid accidents. These arrangements should be:

- Underpinned by effective staff involvement and participation through appropriate consultation, the use of the safety committee where it exists and the safety representation system and,
- Sustained by effective communication and the promotion of competence, which allows all employees and their representatives to make a responsible and informed contribution to the safety and health effort.

c Measuring performance within an organisation

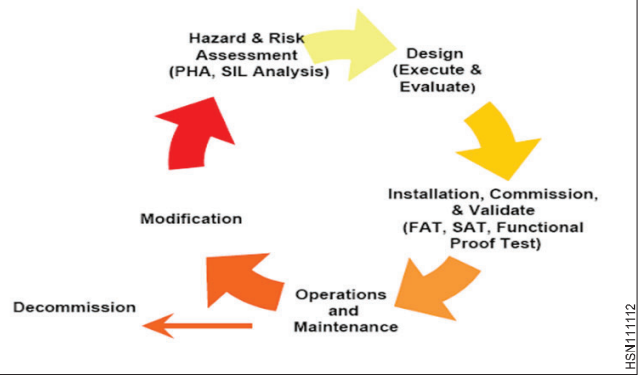
The organisation should measure, monitor and evaluate safety and health performance.

- Performance can be measured against agreed standards to reveal when and where improvement is needed.
- Active self-monitoring reveals how effectively the safety and health management system is functioning.
- Self-monitoring looks at both hardware (premises, plant and substances) and software (people, procedures and systems, including individual behaviour and performance).
- If controls fail, reactive monitoring should find out why they failed, by investigating the accidents, ill health or incidents, which could have caused harm or loss.
- The objectives of active and reactive monitoring are:

i To determine the immediate causes of substandard performance

ii To identify any underlying causes and implications for the design and operation of the safety and health management system.(Fig 2 Safety Assessment System)

Fig 2



d Auditing and reviewing performance: The organisation should review and improve its safety and health management system continuously, so that it's overall safety and health performance improves constantly. There should be a systematic review of performance based on data from monitoring and from independent audits of the whole safety and health management system. These form the basis of complying with the organisation's responsibilities under the 2005 Act and other statutory provisions. Performance should be assessed by:

- Internal reference to key performance indicators
- External comparison with the performance of business competitors and best practice in the organisation's employment sector.

Many companies now report on how well they have performed on worker safety and health in their annual reports and how they have fulfilled their responsibilities with regard to preparing and implementing their Safety Statements. In addition, employers have greater responsibilities under Section 80 of the 2005 Act on 'Liability of Directors and Officers of Undertakings' that requires them to be in a position to prove they have pro-actively managed the safety and health of their workers.

2 Role and safety responsibilities for supervisors: Supervisors are responsible for a great deal of what goes on day to day in the workplace; Supervisors must ensure a safe and healthful workplace for employees. Employees must be able to report unsafe or unhealthful workplace conditions or hazards to a supervisor without fear of reprisal.

The following is a list of primary responsibilities that supervisors have in the area of occupational safety and health for all employees under their supervision.

a Conduct orientation and training of employees: Train and instruct employees so they can perform their work safely. Know what personal protective equipment is needed for each task and how this equipment must be properly used, stored and maintained.

b Enforce safe work practices: It's the supervisors responsibility to enforce safe work practices and procedures; failure to do so is an invitation for accidents to occur.

c Correct unsafe conditions: Supervisors' must take immediate steps to correct unsafe or unhealthful workplace conditions or hazards within their authority and ability to do so. When an unsafe or unhealthful workplace condition or hazard cannot be immediately corrected, the supervisor must take temporary precautionary measures. Supervisors must follow-up to ensure that corrective measures are completed in a timely manner to address the hazard.

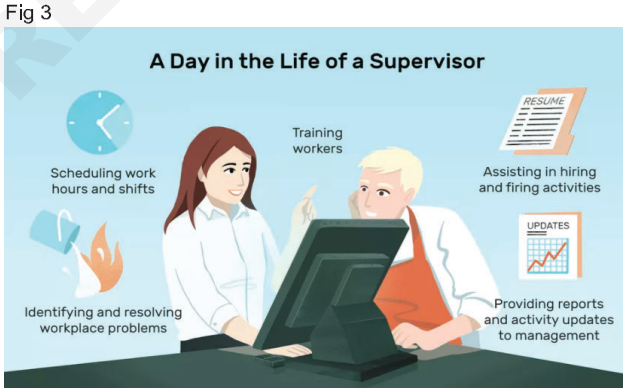
d Prevent lingering unsafe or unhealthful workplace conditions or hazards: Many near miss incidents are caused by unsafe or unhealthful workplace conditions or hazards. It's the supervisor's responsibility to train and periodically remind employees of what to look for and how to correct or report unsafe conditions or hazards. If a hazard is identified, the supervisor must act.

e Investigate workplace accidents: Supervisors are responsible for conducting accident investigations and for ensuring that all occupationally injured employees report to the Occupational Medical Service (OMS) immediately. Note: NIH Policy requires all injuries, including those sustained by contractors, to be reported to OMS.

f Promote quick return to work: Employees must be encouraged to return to work as soon as possible. The longer an employee is away from work, the less likely he or she will actually return. (Fig 3 Role of a supervisor)

3 Duties of employers:

Fig 3



1 Make sure that work areas, machinery and equipment are kept in a safe condition.

2 Organise ways of working safely.

3 Provide information, instruction, training and supervision of employees so they can work safely.

4 Make sure that employees are aware of potential hazards.

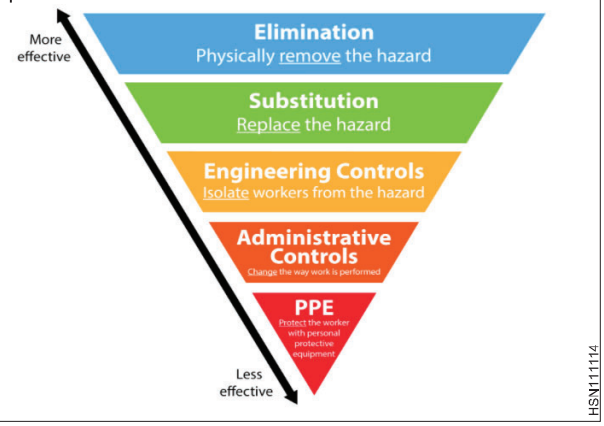
4 Duties and responsibilities of worker

Follow all lawful employer safety and health rules and regulations, and wear or use required protective equipment while working. Report hazardous conditions to the employer. Report any job-related injury or illness to the employer, and seek treatment promptly.

5 **Role and responsibilites of safety engineer:** Safety engineers must be personally pleasant, intelligent, and ruthless with themselves and their organization.

Safety engineers also must work in a team that includes other engineering specialties, quality assurance, quality improvement, regulatory compliance specialists, educators and lawyers. Safety often works well in a true matrix-management organization, in which safety is a managed discipline integrated into a project plan. (Fig 4 Safety Control Meaures)

Fig 4



6 **ILO conventions related to safety management in industry:** Occupational safety research is the study of the incidence, characteristics, causes and prevention of workplace injury. Beginning with the pioneering work of John Gordon (1949) and William Haddon, Jr. (Haddon, Suchman and Klein 1964), and increasingly in the 1980s and 1990s, injury has been viewed as a public health problem to which the public health approach, historically successful against disease, could be applied. Epidemiology, the science of public health, has been applied to injury, including occupational injury. The epidemiological model describes the relationship between the agent (the environmental entity or phenomenon that is the necessary cause of the disease or injury), the host (the affected person) and the environment. Haddon recognized that the various forms of energy-mechanical, thermal, radiant, chemical or electrical-were the "agents" of injury, analogous to the micro-organisms that cause infectious illnesses. Researchers and practitioners from multiple disciplines-primarily epidemiology, engineering, ergonomics, biomechanics, behavioural psychology, safety management and industrial hygiene-are engaged in the study of the factors associated with the worker (the host); the environment; the type and source of energy involved (the agent); and the tools, machines and tasks (the vehicles) that combine to cause or contribute to workplace injury.

a **Two complementary approaches**

Public health and safety analysis: The public health approach is one model which provides a framework for occupational safety research. The public health approach involves:

- Identification, characterization and description of injury cases, hazards and exposures through surveillance
- In-depth analysis of specified injury problems in specified worker populations in order to identify, quantify and compare risk and causal factors
- Identification and development of prevention strategies and interventions
- Evaluation of preventive strategies in laboratory and field experiments
- Communication of information on risk and the development of strategies and programmes for reducing risk and preventing injuries.

b **The Public health approach to occupational safety research:** The public health approach to occupational safety research, and the areas where safety analysis fits into this approach in order to provide both a general overview of the field and some insight into future opportunities and challenges. A secondary intent is to discuss (1) the relationship of occupational safety research to safety management, regulation and technology transfer, and (2) the impact of advancing technology on occupational safety research and communication.

c **Surveillance:** The public health approach to occupational safety research begins with epidemiological surveillance, which has been defined as "the ongoing systematic collection, analysis and the interpretation of health data in the process of describing and monitoring a health event" (CDC 1988).

Surveillance can provide information about injuries by various demographic categories, including the worker's gender, ethnicity, age, occupation and industry, in addition to information relating to the time and place of injury and sometimes the circumstances surrounding the incident. With such basic case information and employment information to provide denominators for the calculation of rates, researchers have been able to describe risk in terms of (1) the frequency of injuries, which helps define the scope or extent of a problem, and (2) the rate of injury (expressed as the number of injuries or deaths per 100,000 workers), which helps define the relative risk faced by certain types of workers in certain circumstances.

Safety analysis techniques such as hazard analysis, job/task analysis, fault-tree analysis and other systems safety engineering tools can also be used to define risks and causes, and to predict or assign probabilities to various failure modes that might eventuate in injury to workers.

e **Developing prevention strategies and interventions**

- As risk and causal factors are identified and characterized, and the relative importance of multiple risk factors is discerned, opportunities for prevention may become apparent. With insight into risk and causal factors, occupational safety researchers and practitioners can consider possible prevention strategies aimed at reducing risk, or consider interventions to interrupt the causal sequence of accidents.

- Currently, there are a wide range of protective technologies and strategies that have already been applied to worker protection, and might be more broadly applied with beneficial results.

The goal of occupational safety research is the identification, development and implementation of effective preventive strategies to reduce the risk of injury to workers.

Haddon (1973) postulated ten basic, generalized strategies for reducing damage due to environmental or workplace hazards.

g Evaluating and demonstrating prevention strategies and interventions

A crucial step that is often omitted from the safety research process is the formal evaluation of potential prevention strategies and interventions to ensure that they work in controlled laboratory settings and in actual workplace environments before they are widely or universally implemented. Evaluation is important not just for engineering controls and modifications, but also for tasks, processes, procedures, regulations, training programmes and safety information products-that is, any strategy, intervention or modification aimed at eliminating or reducing risk.

h Occupational injury risk and prevention information

When effective preventive strategies are identified or developed, they are the keys to implementing the strategies. Occupational safety research produces two types of information that are useful to individuals and organizations outside the research community: risk information and prevention information.

- Risk messages may include the notification that risk exists; information about the scope or nature of risk; information about the individuals or populations at risk; information about when, where, how and why the risk exists; and information about the factors that influence or contribute to risk and their relative importance. Risk information is a principal product of surveillance and analytical research.
- Prevention messages include information on methods of reducing risk and may cover a broad range of strategies and interventions.

i Motivation and communication

Research is needed into the diffusion and practical application of occupational safety research findings. The communication of safety information is rarely evaluated to determine what methods, messages, channels and formats are effective in given situations for specific groups. The growing need for communication of information related to health has given rise to several approaches applicable to the communication of safety information. Health education, health communication, health promotion, risk communication and social marketing are some of the areas where communication activities are being systematized and studied scientifically.

j Relationship of research findings to safety management

Safety practitioners and managers must be aware of current research findings that have practical implications for workplace safety. New risk or prevention information may require review and modification of existing programmes and procedures.

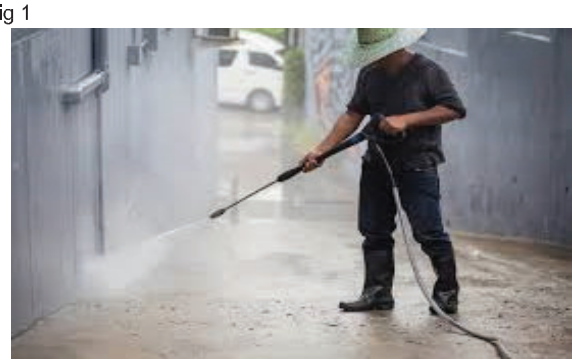
Safety Precautions to be followed in industry as per factories act

Objectives: At the end of this lesson you shall be able to

- **describe the health related aspects inside factories like Cleanliness, Disposal of Waste, Ventilation and Temperatures, Dust & Fumes, Drinking Water, Lighting, Latrines & urinals**
- **describe the safety related aspects in factories like fencing of machineries, Work on or near machinery in motion, Hoists and lifts, Pressure plants, Floors, Stairs and means of escape**
- **state the basic facilities like protection against fumes & gases, Safety offers**
- **state the ILO conventions and standards pertaining to Factories Act, 1948.**

1 Cleanliness: (Fig 1)

Fig 1



- Every factory shall be kept clean and free from effluvial arising from any drain, privy or other nuisance, and in particular-

  a accumulation of dirt and refuse shall be removed daily by sweeping or by any other effective method from the floors and benches of workrooms and from staircases and passages and disposed of in a suitable manner;

  b the floor of every workroom shall be cleaned at least once in every week by washing, using disinfectant where necessary, or by some other effective method;

  c where a floor is liable to become wet in the course of any manufacturing process to such effective means of drainage shall be provided as maintained;

- all inside walls and partitions, all ceilings or tops of rooms and all walls, sides and tops of passages and staircases shall be repainted or revarnished at least once in every period of five years;

  i where they are painted with washable water paint, be repainted with at least one coat of such paint at least once in every period ofthree years and washed at least once in every period of six months;

  ii where they are painted or varnished or where they have smooth impervious surfaces, be cleaned at least one in every period of fourteen months by such methods as may be prescribed;

  iii in any other case, be kept whitewashed, or colour washed, and the whitewashing or colourwashing shall be carried out at least once in every period of fourteen months;

d all doors and window-frames and other wooden or metallic framework and shutters shall be kept painted or varnished and the painting or varnishing shall be carried out at least once in every period of five years;

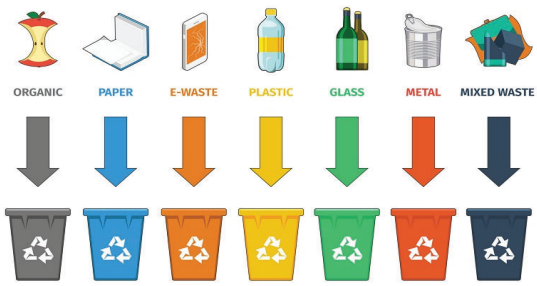
e the dates on which the processes required by clause 'd' are carried out shall be entered in the prescribed register.

f If, in view of the nature of the operations carried on in a factory or class or description of factories or any part of a factory or class or description of factories, it is not possible for the occupier to comply with all or any of the provisions of sub-section (1), the State Government may by order exempt such factory or class or description of factories or part from any of the provisions of that sub-section and specify alternative methods for keeping the factory in a clean state.

2 Disposal of wastes and effluents (Fig 2):

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

Fig 2



- The State Government may make rules prescribing the arrangements to be made under sub-section (1) or requiring that the arrangements made in accordance with sub-section (1) shall be approved by such authority as may be prescribed.

3 Ventilation and temperature: (Fig 3)

- sor securing and maintaining in every workroom-

a adequate ventilation by the circulation of fresh air, and

Fig 3

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Fig 4

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b such a temperature as will secure to workers therein reasonable conditions of comfort and prevent injury to health; and in particular,

i walls and roofs shall be of such material and so designed that such temperature shall not be exceeded but kept as low as practicable;

ii where the nature of the work carried on in the factories involves, or is likely to involve, the production of excessively high temperature, such adequate measures as are practicable shall be taken to protect the workers therefrom, by separating the process, which produces such temperature from the workroom, by insulating the hot parts or by other effective means.

- The State Government may prescribe a standard of adequate ventilation and reasonable temperature for any factory or class or description of factories or parts thereof and direct that proper measuring instruments, at such places.
- If it appears to the Chief Inspector that excessively high temperature in any factory can be reduced by the adoption of suitable measures, an order in writing specifying the measures which, in his opinion should be adopted, and requiring them to be carried out before a specified date.

4 Protection against dust and fumes:

- In every factory in which, by reason of the manufacturing process carried on, there is given off any dust or fume or other impurity effective measures shall be taken to prevent its inhalation and accumulation in any workroom, and if any exhaust appliance is necessary for this purpose.
- In any factory no stationary internal combustion engine shall be operated unless the exhaust is conducted into the open air.

5 Artificial humidification (Fig 4)

- In respect of all factories in which the humidity of the air is artificially increased, the State Government may make rules.

a prescribing standards of humidification;

b regulating the methods used for artificially increasing the humidity of the air;

c directing prescribed tests for determining the humidity of the air to be correctly carried out and recorded;

d prescribing methods to be adopted for securing adequate ventilation and cooling of the air in the workrooms.

In any factory in which the humidity of the air is artificially increased, the water used for the purpose shall be taken from a public supply, or other source of drinking water, or shall he effectively purified before it is so used.

If it appears to an Inspector that the water used in a factory for increasing humidity which is required to be effectively purified under sub-section (2) is not effectively purified he may serve on the manager of the factory an order in writing, specifying the measures which in his opinion should be adopted, and requiring them to be carried out before specified date.

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

- Without prejudice to the generality of sub-section (1), there shall be in every workroom of a factory in existence on the date of commencement of this Act at least 9.9 cubic metres and of a factory built after the commencement ofthis Act at least 14.2 cubic metres of space for every worker employed therein, and for the purposes of this sub-section no account shall be taken of any space which is more than 4.2 metres above the level of the floor of the room.
- If the Chief Inspector by order in writing so requires, there shall be posted in each workroom of a factory a notice specifying the maximum number of workers who may, in compliance with the Provisions of this section, be employed in the room.
- The Chief Inspector may, by order in writing exempt, subject to such conditions, if any, as he may thing fit to impose, any workroom from the provisions of this section, if he is satisfied that compliance therewith in respect of the room is unnecessary in the interest of the health of the workers employed therein.

7 Industrial lighting arrangement: (Fig 5)

- In every part of a factory where workers are working or passing, there shall be provided and maintained sufficient and suitable lighting, natural or artificial, or both.

Fig 5

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- In every factory all glazed windows and skylights used for the lighting of the workroom shall be kept clean on both the inner and outer surfaces and, so far as compliance with the provisions of any rules made under sub-section (3) of section 13 will allow, free from obstruction.
- In every factory effective provision shall, so far as is practicable, be made for the prevention of-
  - a glare, either directly from a source of light or by reflection from a smooth or polished surface;
  - b the formation of shadows to such an extent as to cause eye-strain or the risk of accident to any worker.
- The State Government may prescribe standards of sufficient and suitable lighting for factories or for any class or description of factories or for any manufacturing process.

8 Drinking water

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

a All such points shall be legibly marked "drinking water" in a language understood by a majority of the workers employed in the factory and no such points shall be situated within 1[six metres of any washing place, urinal, latrine, spittoon, open drain carrying sullage or effluent or any other source of contamination unless a shorter distance is approved in writing by the Chief Inspector.

b In every factory wherein more than two hundred and fifty workers are ordinarily employed, provisions shall be made for cooling drinking water during hot weather by effective means and for distribution thereof.

c In respect of all factories or any class or description of factories the State Government may make rules for securing compliance with the provisions of sub-sections (1), (2) and (3) and for the examination by prescribed authorities of the supply and distribution of drinking water in factories.

9 Latrines and urinals

- In every factory-
  - a sufficient latrine and urinal accommodation of prescribed types shall be provided conveniently situated and accessible to workers at all times while they are at the factory;
  - b separate enclosed accommodation shall be provided for male and female workers;
  - c such accommodation shall be adequately lighted and ventilated and no latrine or urinal shall, unless specially exempted in writing by the Chief Inspector, communicate with any workroom except through an intervening open space or ventilated passage;
  - d all such accommodation shall be maintained in a clean and sanitary condition at all times;
  - e sweepers shall be employed whose primary duty it would be to keep clean all latrines, urinals and washing places.
- In every factory wherein more than twohundred and fifty workers are ordinarily employed-
  - a all latrine and urinal accommodation shall be of prescribed sanitary types;
  - b the floors and internal walls, up to a height of ninety centimetres of the latrines and urinals and the sanitary blocks shall be laid in glazed tiles or otherwise finished to provide a smooth polished impervious surface;
  - c without prejudice to the provisions of clauses (d) and (e) of sub-section (1), the fioors, portions of the walls and blocks so laid or finished and the sanitary pans of latrines and urinals shall be thoroughly washed and cleaned at least once in every seven days with suitable detergents or disinfectants or with both.
- The State Government may prescribe the number of latrines and urinals to be provided in any factory in proportion to the number of male and female workers ordinarily employed therein, and provide for such further matters in respect of sanitation in factories, including the obligation of workers in this regard, as it considers necessary in the interest of the health of the workers employed therein.

10 Spittoons

- In every factory there shall be provided a sufficient number of spittoons in convenient places and they shall be maintained in a clean and hygienic condition.
- The State Government may make rules prescribing the type and numbers of spittoons to be provided and their location in any factory and provide for such further matters relating to their maintenance in a clean and hygienic condition.
- No person shall spit within the premises of a factory except in the spittoons provided for the purpose and a notice containing this provision and the penalty for its violation shall be prominently displayed at suitable places in the premises.

- Whoever spits in contravention of sub-section (3) shall be punishable with fine not exceeding five rupees.

11 Fencing of machinery

- In every factory the following, namely-

  i every moving part of a prime-mover and every fiywheel connected to a prime-mover, whether the prime-mover or flywheel is in the engine-house or not;

  ii the headrace and tailrace of every water-wheel and water-turbine;

  iii any part of a stock bar which projects beyond the head stock of a lathe; and

  iv unless they are in such position or of such construction as to be safe to every person employed in the factory as they would be if they were securely fenced, the following, namely:-

  a every part of an electric generator, a motor or rotary convertor;

  b every part of transmission machinery; and

  c every dangerous part of any other machinery; shall be securely fenced by safeguards of a substantial construction which shall be constantly maintained and kept in position while the parts of machinery they are fencing, are in motion or in use:

Provided that for the purpose of determining whether any part of machinery in such position or is of such construction as to be safe as aforesaid, account shall not be taken of any occasion when-

  i it is necessary to make an examination of any part of the machinery aforesaid while it is in motion or, as a result of such examination to carry out lubrication or other adjusting operation while the machinery is in motion, being an examination of operation which it is necessary to be carried out while that part of the machinery is in motion. or

  ii in the case of any part of a transmission machinery used in such process as may be prescribed (being a process of a continuous nature, the carrying on of which shall be or is likely to be substantially interfered with by the stoppage of that part of the machinery), it is necessary to make an examination of such part of the machinery while it is in motion or, as a result of such examination, to carry out any mounting or shipping of belts or lubrication, or other adjusting operation while tlle machinery is in motion, and such examination or operation is made or carried out in accordance with the provisions of sub-section (1) of section 22.

- The State Government may by rules prescribe such further precautions as it may consider necessary in respect of any particular machinery or part thereof or exempt, subject to such condition as may be prescribed, for securing the safety of the workers, any particular machinery or part thereof from the Provisions of this section.

12 Work on or near machinery in motion

- Where in any factory it becomes necessary to examine any part of machinery referred to in section 21, while the machinery is in motion, or, as a result of such examination, to carry out-

  a in a case referred to in clause (i) of the proviso to sub-section (1) of section 21, lubrication or other adjusting operation; or

  b in a case referred to in clause (ii) of the proviso aforesaid, any mounting or shipping of belts or lubrication or other adjusting operation,

while the machinery is in motion, such - examination or operation shall be made or carried out only by a specially trained adult male worker wearing tight fitting clothing (which shall be supplied by the occupier) whose name has been recorded in the register prescribed in this behalf and who has been furnished with a certificate of his appointment, and while he is so engaged.

- such worker shall not handle a belt at a moving pulley unless-

  i the belt is not more than fifteen centimetres in width;

  ii the pulley is normally for the purpose of drive and not merely a fiy-wheel or balance wheel (in which case belt is not permissible);

  iii the belt joint is either laced or fiush with the belt;

  iv the belt, including the joint and the pulley rim, are in good repair;

  v there is reasonable clearance between the pulley and any fixed plant or structure;

  vi secure foothold and, where necessary, secure handhold, are provided for the operator; and

  vii any ladder in use for carrying out any examination or operation aforesaid is securely fixed or lashed or is firmly held by a second person ;

- without prejudice to any other provision of this Act relating to the fencing of machinery, every set screw, bolt and key on any revolving shaft, spindle, wheel or pinions and all spur, worm and other toothed or friction gearing in motion with which such worker would otherwise be liable to come into contact, shall be securely fenced to prevent such contact.

- No woman or young person shall be allowed to clean, lubricate or adjust any part of a prime-mover or of any transmission machinery while prime-mover or transmission machinery is in motion. The woman or young person to risk of injury from any moving part either of that machine or of any adjacent machinery.

- The State Government may, by notification in the Official Gazette prohibit, in any specified factory or class or description of factories, the cleaning, lubricating or adjusting by any person of specified parts of machinery when those palts are in motion.

13 Employment of young person's on dangerous machines

- No young person shall be required or allowed to work at any machine to which this section applies, unless he has been fully instructed as to the dangers arising in connection with the machine and the precautions to be observed, and-

  a has received sufficient training in work at the machine, or (b) is under adequate supervision by a person who has a thorough knowledge and experience of the machine.

- Sub-section (1) shall apply to such machines as may be prescribed by the State Government, being machines which in its opinion are of such a dangerous character that young persons ought not to work at them unless the foregoing requirements are complied with.

14 Striking gear and devices for cutting off power

- In every factory-

  a suitable striking gear or other efficient mechanical appliance shall be provided and maintained and used to move driving belts to and from fast and loose pulleys, so as to prevent the belt from creeping back on to the first pulley;

  b driving belts when not in use shall not be allowed to rest or ride upon shafting in motion.

- In every factory suitable devices for cutting off power in emergencies from running machinery shall be provided and maintained in every workroom:

Provided that in respect of factories in operation before the commencement of this Act, the provisions of this sub-section shall apply only to workrooms in which electricity is used as power.

- When a device, which can inadvertently shift from "off" to "on" position, is provided in a factory- to cut off power, arrangements shall be provided for locking the device in safe position to prevent accidental starting of the transmission machinery or other machines to which the device it fitted.

15 Self-acting machines: No traversing part of a self-acting machine in any factory and no material carried thereon shall, if the space over which it runs is a space over which any person is liable to pass, whether in the course of his employment or otherwise, be allowed to run on its outwards or inward traverse within a distance forty-five centimetres from any fixed structure which is not part of the machine:

Provided that the Chief Inspector may permit the continued use of a machine installed before the commencement of this Act which does not comply with the requirements of this section on such conditions for ensuring safety as he may think fit to impose.

Casing of new machinery

- In all machinery driven by power and installed in any factory after the commencement of this Act,-

- (a) every set screw, bolt or key on any revolving shaft, spindle, wheel or pinion shall be so sunk, encased or otherwise effectively guarded as to prevent danger;

- (b) all spur, worm and other toothed or friction gearing which does not require frequent adjustment while in motion shall be completely encased, unless it is so situated as to be as safe as it would be if it were completely encased.

- Whoever sells or lets on hire or, agent of a seller or hirer, causes or procures to be sold or let on hire, for use in a factory any machinery driven by power which does not comply with the provisions of sub-section (1) or any rules made under sub-section (3), shall be punishable with imprisonment for a term which may extend to three months or with fine which may extend to five hundred rupees or with both.

The State Government may make rules specifying further safeguards to be provided in respect of any other dangerous part of any particular machine or class or description of machines.

16 Prohibition of employment of women and children near cotton-openers: No woman or child shall be employed in any part of a factory for pressing cotton in which a cotton-opener is at work:

Provided that if the feed-end of a cotton-opener is in a room separated from the delivery end by a partition extending to the roof or to such height as the Inspector may in any particular case specify in writing, women and children may be employed on the side of the partition where the feed-end is situated.

17 Hoist and lifts

- In every factory-

  a every hoist and lift shall be-

i of good mechanical construction, sound material and adequate strength;

ii properly maintained, and shall be thoroughly examined by a competent person at least once in every period of six months, and a register shall be kept containing the prescribed particulars of every such examination;

b every hoistway and liftway shall be sufficiently protected by an enclosure fitted with gates, and the hoist or lift and every such enclosure shall be so constructed as to prevent any person or thing from being trapped between any part of the hoist or lift and any fixed structure or moving part;

c the maximum safe working load shall be plainly marked on every hoist or lift, and no load greater than such load shall be carried thereon;

d the cage of every hoist or lift used for carrying persons shall be fitted with a gate on each side from which access is afforded to a landing;

e every gate referred to in clause (b) or clause (d) shall be fitted with inter-locking or other efficient device to secure that the gate cannot be opened except when

the cage is at the landing and that the cage cannot be moved unless the gate is closed.

Hoist and lifts (Fig 6)

- The following additional requirements shall apply to hoists and lifts used for carrying persons and installed or reconstructed in a factory after the commencement of this Act, namely:-

  a where the cage is supported by rope or chain, there shall be at least two ropes or chains separately

Fig 6

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  connected with the cage and balance weight, and each rope or chain with its attachments shall be capable of carrying the whole weight of the cage together with its maximum load;

  b efficient devices shall be provided and maintained capable of supporting the cage together with its maximum load in the event of breakage of the ropes, chains or attachments;

  c an efficient automatic device shall be provided and maintained to prevent the cage from over-running.

- The Chief Inspector may permit the continued use of a hoist or lift installed in a factory before the commencement of this Act which does not fully comply with the provisions of sub-section (1) upon such conditions for ensuring safety as he may think fit to impose.

- The State Government may, if in respect of any class or description of hoist or lift, is of opinion that it would be unreasonable to enforce any requirements of sub-sections (1) and (2), by order direct that such requirement shall not apply to such class or description of hoist or lift.

Explanation: For the purposes of this section, no lifting machine or appliance shall be deemed to be a hoist or lift unless it has a platform or cage, the direction or movement of which is restricted by a guide or guides.

18 Lifting machines, chains, ropes and lifting tackles

- In any factory the following provisions shall be complied with in respect of every lifting machine (other than a hoist and lift) and every chain, rope and lifting tackle for the purpose of raising or lowering persons, goods or materials:-

  a all parts, including the working gear, whether fixed or movable, of every lifting machine and every chain, rope or lifting tackle shall be-

    i of good construction, sound material and adequate strength and free from defects;

    ii properly maintained; and

    iii thoroughly examined by a competent person at least once in every period of twelve months, or at such intervals as the Chief Inspector may specify in writing, and a register shall be kept containing the prescribed particulars of every such examination;

  b no lifting machine and no chain, rope or lifting tackle shall, except for the purpose of test, be loaded beyond the safe working load which shall be plainly marked there on together with an identification mark and duly entered in the prescribed register; and where this is not practicable, a table showing the safe working load of every kind and size of lifting machine or chain, rope of lifting tackle in use, shall be displayed in prominent position on the premises;

  c while any person is employed or working on or near the wheel track of a travelling crane in any place where he would be liable to be struck by the crane, effective measures shall be taken to ensure that the crane does not approach within six metres of that place.

- The State Government may make rules in respect of any lifting machine or any chain, rope or lifting tackle used in factories-

  a prescribing further requirements to be compiled with in addition to those set out in this section ;

  b providing for exemption from compliance with all or any of the requirements of this section, where in its opinion, such compliance is unnecessary or impracticable.

For the purposes of this section a lifting machine or a chain, rope or lifting tackle shall be deemed to have been thoroughly examined if a visual examination supplemented, if necessary, by other means and by the dismantling of parts of the gear, has been carried out as carefully as the conditions permit in order to arrive at a reliable conclusion as to the safety of the parts examined.

Explanation: In this section

a "lifting machine" means a crane, crab, winch, teagle, pully block, gin wheel, transporter or runway;

b "lifting tackle" means any chain sling, rope sling, hook, shackle, swivel, coupling, socket, clamp, tray or similar appliance, whether fixed or movable, used in connection with the raising or lowering of persons, or loads by use lifting machines.

19 Revolving machinery

- In every factory in which the process of grinding is carried on there shall be permanently affixed to or placed ear each machine in use a notice indicating the

maximum safe working peripheral speed of every grindstone or abrasive wheel, the speed of the shaft or spindle upon which the wheel is mounted, and the diameter of the pulley upon such shaft or spindle necessary to secure such safe working peripheral speed.

- The speeds indicated in notices under sub-section (1) shall not be exceeded.
- Effective measure shall be taken in every factory to ensure that the safe working peripheral speed of every revolving vessel, cage, basket, flywheel pulley, disc or similar appliance driven by power is not exceeded.

20 Pressure plant

- If in any factory, any plant or machinery or any part thereof is operated at a pressure above atmospheric pressure, effective measures shall be taken to ensure that the safe working pressure of such plant or machinery or part is not exceeded.
- The State Government may make rules providing for the examination and testing of any plant or machinery such as is referred to in sub-section (1) and prescribing such other safety measures in relation thereto as may in its opinion, be necessary in any factory or class or description of factories.
- The State Government may, by rules, exempt, subject to such conditions as may be specified therein, any part of any plant or machinery referred to in sub-section (1) from the provisions of this section.

Pressure Plant (Fig 7)

21 Floors, stairs and means of access

- In every factory-

a all floors, steps, stairs, passengers and gangways shall be of sound construction, and properly maintained and shall be kept free from obstructions and substances likely to cause persons to slip and where it is necessary to ensure safety, steps, stairs, passages and gangways shall be provided with substantial handrails;

b there shall, so far as is reasonably practicable, be provided, and maintained safe means of access to every place at which any person is at any time required to work;

c when any person has to work at a height from where he is likely to fall, provision shall be made, so far as is reasonably practicable, by fencing or otherwise, to ensure the safety of the person so working.

Pits, sumps & openings in floors

(1) In every factory every fixed vessel, sump, tank, pit or opening in the ground or in a floor which, by reason of its depth, situation, construction or contents, is or may be a source of danger, shall be either securely covered or securely fenced.

The State Government may, by order in writing, exempt, subject to such conditions as may be prescribed, any factory or class or description of factories in respect of any vessel, sump, tank, pit or opening from compliance with the provisions of this section.

Fig 7

Excessive weights

- No person shall be employed in any factory to lift, carry or move any load so heavy as to be likely to cause him an injury.
- The State Government may make rules prescribing the maximum weights which may be lifted, carried or moved by adult men, adult women, adolescents and children employed in factories or in any class or description of factories or in carrying on in any specified process.

Protection of eyes

In respect of any such manufacturing process carried on in any factory as may be prescribed, being a process which involves-

a risk of injury to the eyes from particles or fragments thrown off in the course of the process, or

b risk to the eyes by reason of exposure to excessive light, the State Government may by rules require that effective screens or suitable goggles shall be provided for the protection of persons employed on, or in the immediate vicinity of, the process.

22 Precautions against dangerous fumes & gases

- No person shall be required or allowed to enter any chamber, tank, vat, pit, pipe, flue or other confined space in any factory in which any gas, fume, vapour or dust is likely to be present to such an extent as to involve risk to persons being overcome thereby, unless it is provided with a manhole of adequate size or other effective means of egress.
- No person shall be required or allowed to enter any confined space as is referred to in sub-section (1), until all practicable measures have been taken to remove any gas, fume, vapour or dust, which may be present so as to bring its level within the permissible limits and to prevent any ingress of such gas, fume, vapour or dust and unless-

a a certificate in writing has been given by a competent person, based on a test carried out by himself that the

space is reasonably free from dangerous gas, fume, vapour or dust: or

b such person is wearing suitable breathing apparatus and a belt securely attached to a rope the free end of which is held by a person outside the confined space.

Protection against fumes (Fig 8)

23 Precautions regarding the use of portable electric light

- In any factory-

  a no portable electric light or any other electric appliance of voltage exceeding twenty-four volts shall be permitted for use inside any chamber, tank, vat, pit, pipe, flue or other confined space unless adequate safety devices are provided; and

  b if any inflammable gas, fume or dust is likely to be present in such chambers tank, vat, pipe, flue or other confined space, no lamp or light other than that of flame-proof construction shall be permitted to be used therein.

24 Explosive or inflammable dust & gas

Fig 8

HSN111317

- Where in any factory any manufacturing process produces dust, gas, fume or vapour of such character and to such extent as to be likely to explode on ignition, all practicable measures shall be taken to prevent any such explosion by-

a effective enclosure of the plant or machinery used in the process;

b removal or prevention of the accumulation of such dust, gas, fume or vapour;

c exclusion or effective enclosure of all possible sources of ignition.

- Where in any factory the plant or machinery used in a process such as is referred to in sub-section (1), is not so constructed as to withstand the probable pressure which such an explosion as aforesaid would produce, all practicable measures shall be taken to restrict the spread and effects of the explosion by the provision in the plant or machinery of chokes, baffles, vents or other effective appliances.

- Where any part of the plant or machinery in a factory contains any explosive or inflammable gas or vapour under pressure greater than atmospheric pressure, that part shall not be opened except in accordance with the following provisions, namely:-

  a before the fastening of any joint of any pipe connected with the part or the fastening of the cover of any opening into the part is loosened, any flow of the gas or vapour into the part of any such pipe shall be effectively stopped by a stop-valve or other means;

  b before any such fastening as aforesaid is removed, all practicable measures shall be taken to reduce the pressure of the gas or vapour in the part or pipe to a atmospheric pressure;

  c where any such fastening as aforesaid has been loosened or removed effective measures shall be taken to prevent any explosive or inflammable gas or vapour from entering the part or pipe until the fastening has been secured, or, as the case may be, securely replaced:

  Provided that the provisions of this sub-section shall not apply in the case of plant or machinery installed in the open air.

- No plant, tank or vessel which contains or has contained any explosive or inflammable substance shall be subjected, in any factory, to any welding, brazing, soldering or cutting operation which involves the application of heat unless adequate measures have first been taken to remove such substance and any fumes arising therefrom or to render such substance and fumes non- explosive or non-inflammable and no such substance shall be allowed to enter such plant, tank or vessel after any such operation until the metal has cooled sufficiently to prevent any risk of igniting the substance.

- The State Government may by rules exempt, subject to such conditions as may be prescribed, any factory or class or description of factories from compliance with all or any of the provisions of this section.

25 Precautions in case of fire

- In every factory, all practicable measures shall be taken to prevent outbreak of fire and its spread, both internally and externally, and to provide and maintain-

  a safe means of escape for all persons in the event of a fire, and

b the necessary equipment and facilities for extinguishing fire.

- Effective measures shall be taken to ensure that in every factory all the workers are familiar with the means of escape in case of fire and have been adequately trained in the routine to be following in such cases.

- The State Government may make rules, in respect of any factory or class or description of factories, requiring the measures to be adopted to give effect to the provisions of sub-sections (1) and (2).
- Notwithstanding anything contained in clause (a) of sub-section (1) or sub-section (2), if the Chief Inspector, having regard to the nature of the work carried on in any factory, the construction of such factory, special risk to life or safety, or any other circumstances, is of the opinion that the measures provided in the factory, whether as prescribed or not, for the purposes of clause (a) of sub-section (1) or sub-section (2), are inadequate, he may, by order in writing, require that such additional measures as he may consider reasonable and necessary, be provided in the factory before such date as is specified in the order.

Fire Safety (Fig 9)

Fig 9

HSN111318

26 Power to require specifications of defective parts or tests of stability (Fig 10)

If it appears to the Inspector that any building or part of a building or any part of the ways, machinery or plant in a factory is in such a condition that it may be dangerous to human life or safety, he may serve on the occupier or manager or both of the factory an order in writing requiring him before a specified date-

a to furnish such drawings, specifications and other particulars as may be necessary to determine whether such buildings, ways, machinery or plant can be used with safety, or

Fig 10

HSN111319

b to carry out such tests in such manner as may be specified in the order, and to inform the Inspector of the results thereof. (Fig 11)

Fig 11

HSN111131A

Prepare profile with an appropriate accuracy as per safety precaution in workshop

Objectives: At the end of this lesson you shall be able to
- **describe the employee welfare measures like general provision, Drinking Water, Sanitary & washing in the industry**
- **describe the employee welfare measures like cloakrooms, facilities for food & drink, shelters & living accommodation in the industry**
- **state the basic information about employees working in the industry and suitable training for the same.**

Welfare facilities are an essential part of good working conditions. Good welfare facilities contribute not only to the welfare of workers, but also to production and better relations. If workers are denied facilities to meet their needs, problems will eventually result. The cost of welfare facilities is usually lower if the enterprise provides them than if workers pay for them individually.

1 **Sanitary facilities:** The workplace should have good sanitary facilities. Clean toilets, washing facilities and shower rooms are important. It is necessary to provide a sufficient number of such facilities and to keep them clean.

For example, in Indonesia, it is prescribed to have one toilet at a workplace with less than 15 workers; one toilet for every 15 workers in workplaces with less than 100 workers; six toilets in workplaces with more than 100 workers; 12 toilets in workplaces with more than 200 workers; and six more toilets for every extra 100 workers. Urinals may be provided for men. Toilets should be separate for men and women. In addition, one wash basin is needed for every 30 workers.

These sanitary facilities are necessary for workers' well-being and to prevent disease. Well-maintained sanitary facilities help to improve productivity because healthy workers are more efficient and there will also be less absenteeism.

a **Cleaning toilets (Fig 1):** In a small engineering factory with about 25 workers the toilets for workers were in an unhygienic condition. Rubbish and cigarette butts were scattered around and the toilets were often clogged. The manager tried to persuade the workers to use the toilets properly, but found it difficult. As a solution, he made a special arrangement among the workers themselves, dividing them into four groups and asking each group to be responsible Fig 1: One of the factory toilets cleaned and in good order, with a cigarette bin.in turn for cleaning the toilets each week. At the same time, the manager provided a cigarette bin made from metal in each toilet.

The cost incurred was practically nil. Tools and other equipment for cleaning were already available. The bins were manufactured using scrap material. The manager proposed giving a monthly award to the group which could best keep the lavatory in good condition. This also helped change the attitude of the workers in maintaining clean toilets.

Fig 1

HSN121711

b **Repair of sanitary facilities (Fig 2):** Sanitary facilities were in a bad state in a textile mill in Sri Lanka, which employed about 100 men and about 150 women in three shifts. The toilets were broken and clogged and the flushes were often not working. The floors and walls were broken, the smell was disagreeable and the doors could hardly be closed. Some of the toilets could not be used at all for a long period of time. The increasing number of employees in the mill further aggravated the situation. The displeasure among the workers grew to such an extent that it resulted in a go-slow and hence a decrease in production. Considering the number of toilets which were not working, it was clear that the regulatory standard of one toilet for every 25 male or female workers was not met.

Fig 2

HSN121712

A labour was engaged for each of the two shift periods between 6 a.m. and 10 p.m. to clean the toilets. The repair and buildings of the toilet facilities pleased the workers tremendously. There was better morale and more co-operation with the management, repaired and better maintained, with the walls repaired.

c Waste bins in toilets (Fig 3): Fig 3 shows toilets provided in sufficient number and with clean wash basins

In a pump manufacturing factory which employed 25 workers in Madras, India, the toilets were not clean. The walls were stained and cigarette butts often remained for days. When the manager improved the lighting of the workrooms by painting the walls and ceilings white, he also painted the walls of the toilets in the factory. He assigned to a particular employee the job of cleaning the toilets regularly. In addition, he put metal waste bins in all the toilets. The white walls and waste bins changed the image of the toilets. The cost was minimal as the paint was left over from that prepared for the whole factory and the waste bins were made from waste materials.

Fig 3

HSN121713

d Cloakroom (Fig 4): The cleaning and repair of the room cost about Rs. 3000/- The purchase and installation of cupboards cost approximately Rs. 24000. The indirect cost in terms of wages of workers who assisted in the provision of the changing room and the installation of the cupboards was about Rs. 1500. The management noted that the provision of the changing room also contributed to better relations among workers and co-operation with the management. Favorable effects were also seen by increased production. Fig 4: Cloak room with cupboards for all the workers.

e Toilets with washing facilities (Fig 5)

Fig 5 shows a toilet covered with tiles & a waste-binIn a garment factory in Jakarta, the toilets and washing facilities were insufficient in number and poor in quality. The toilets were often clogged. Repair was always slow. There was no running water to wash hands after using the toilets or after work. The workers often had to queue during breaks due to the small number of usable toilets. To improve their hygienic conditions. Water tanks were installed when the tile work was completed. A small plastic waste bin was provided in each toilet. The workers, mostly female, welcomed the clean toilets.

Fig 4

HSN121714

Fig 5

HSN1217715

2 Facilities for beverages and meals: Facilities for beverages and meals are basic necessities. Drinking water is essential for all types of work. Especially when working in a hot environment, much water is lost in the form of sweat or evaporation from the skin. Water loss in a hot climate can easily amount to several litres per shift. Workers, if not provided with drinking facilities, will have to make arrangements themselves or leave the workplace quite often looking for water.

When only unhygienic water is available, this can lead to frequent disease. If workers become dehydrated, they rapidly tire and become less productive. Therefore clean water should be provided in sufficient quantities near the worksite.

a Cool drinking water: In a medium-sized steel rolling mill in Calcutta, India, about 50 people were directly engaged in rolling mill operations. Due to the heat and heavy workloads, these workers perspired excessively. However, no potable water was available near the mill to replace their water loss. The management decided to provide water vessels with taps at the workplace. Two covered stainless-steel vessels with taps, two stainless-steel pots fitted with extension rods, two stainless-steel glasses and a wooden stand were purchased. An attendant was given the job of serving the drinking water to mill operators. At each shift the attendant would fill the vessels with cool drinking water from a water cooler of the canteen.

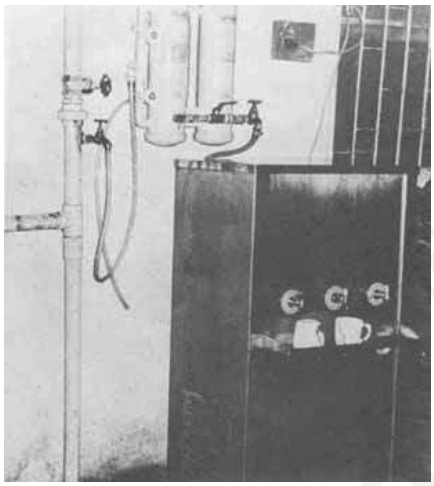
The pots with the extension rods were used to distribute water among the workers. Any of the workers could also go to the vessel and get water in the stainless-steel glass

from the tap and drink the water without contamination. They appreciated the management's efforts. The workers were also recommended to make up for loss of salt by taking an adequate meal. This arrangement helped reduce the occurrence of heat disorders.

b Providing filtered drinking water: In a medium-sized food products factory in Thailand, workers would drink water carried to the workplace in bottles or directly from water taps. The quality of drinking water was doubtful. The manager attended a training course on improving working conditions and productivity for small and medium-sized enterprises and learned that provision of clean drinking water was essential as a basis to improve working conditions and decided to provide similar facilities in his own enterprise. When he compared prices for such facilities, he found that filtering facilities were not particularly expensive. He purchased equipment for filtering drinking water and keeping it cool. This was placed near the workroom where most workers were working. All the workers welcomed the manager's action. Fig 6 shows Water cooler with filtering device.

c Provision of a tea-break corner

Fig 6



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- In a medium-sized engineering plant in Indonesia, workers had no place to have tea and snacks during breaks. There were two 10-minute breaks a day, but the workers had to stay near the production lines. A 7.5 square metre space in the corner was designated as a gathering place during the tea breaks.
- The partitions were constructed by the workers themselves. (Fig 7) A canteen using existing facilities.
- The closest available place to eat was about 1.5 kilometres away from a foundry in the Philippines employing 30 workers.
- The workers were habitually late in returning from lunch and were hot and tired as well. Productivity in the afternoon was low. It was therefore decided to provide a canteen.

Fig 7

HSN121717

d Subsidized meals available at a food stand (Fig 8): In an engineering factory in Thailand, most workers had difficulty getting their meals because few restaurants were located in that area. There were about 300 workers operating in three shifts. The management decided to utilise canteen facilities built several years earlier but which remained unused. The management invited an outside agent to sell food at low prices, with the factory paying for gas, water and electricity and providing rice.

Fig 8

HSN121718

The morale of the workers increased, and relations between the management and workers improved significantly. The direct cost for the canteen was nil as such facilities were already available.

e A lunchroom

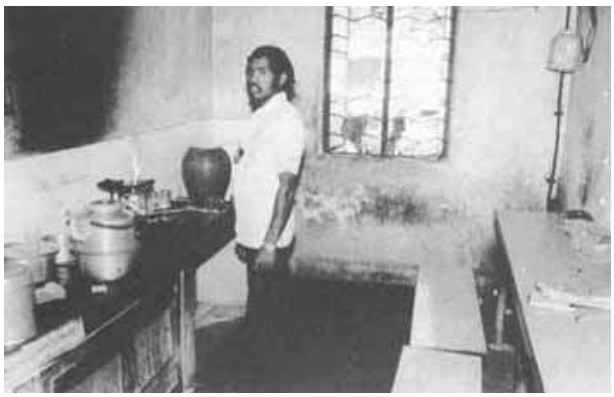
In an engineering enterprise with about 50 workers in Sri Lanka, the workers eat their lunches at various places on the shop-floor. An unused room was provided as a lunchroom. About Rs. 2500 was needed to clear the room and add tables, chairs and washing facilities. About two work hours per day were required to keep the room clean. This separate eating facility not only solved a problem for the workers but also meant that the work areas were much cleaner. The problem of scavenging was reduced.

f Supplying tea and snacks

The total cost incurred by the company to provide a kitchen platform, furniture and kitchenware was less than US$ 1,200. There was no recurring expenditure for the company

except the two hours of work by two workmen per day which was equivalent to approximately Rs. 150 in terms of wages. (Fig 9) A space for tea breaks with furniture and kitchenware

Fig 9



3 **Recreation, child care, and transport facilities:** Enterprise-based welfare services not only include directly work-related services, but also those aimed at amenities for everyday life outside working hours. They include child care facilities, recreational facilities and transport. What an enterprise can do in these respects may be limited, but these facilities, if available, can greatly help create the feeling that management is interested in the workers as people. In fact, not only large enterprises but also many small and medium-sized enterprises provide these facilities in various forms.

As an example of such facilities available at very low cost, recreational facilities may be mentioned. Many workers enjoy spending their time in sports or other recreational activities during their lunch break or after work. This is healthy and increases the spirit of friendship. It helps workers feel that they are attached to the enterprise and have common interests as fellow workers. Recreational facilities are often very inexpensive. A basketball hoop or volleyball net in a courtyard, or board games, may be all that is necessary. Smaller enterprises can benefit perhaps even more from these facilities as a greater proportion of the workers can participate.

4 **Sports facilities utilizing available space:** In a foundry which employed 30 workers in the Philippines, a high turnover rate among predominantly young male workers was a problem. It was attributed to the work climate and monotonous conditions during breaks. This became clear when a production supervisor interviewed workers about the reason for the rapid turnover. The average length of employment was only four months, implying a turnover rate of 300 per cent a year. Both past and present workers suggested setting up recreational facilities.

At a meeting, it was decided to provide a basketball court and a Ping-Pong table. This could be done easily as space was available within the foundry premises. All personnel were urged to participate in the activities during work breaks. (Fig 10) Recreational activities at industry with the available space.

Fig 10

5 **Employee training:** Employers are required to decide on training priorities, to choose training methods, provide the necessary resources and to provide training during working hours.

- All employees should receive a company induction which covers emergency procedures and an ongoing system of training to ensure that they can perform their tasks safely,
- Senior managers should be trained in managing health and safety and be aware of their health and safety responsibilities,
- Health and safety meetings are an opportunity for all mangers to discuss health and safety issues, audit findings, risk assessments, accident records and sickness absence reports,
- Regular health and safety inspections, feedback and recommendation reports should be fed to senior managers and board members
- Preventative and protective measures taken by the organization should be communicated to all staff. Increased communication can be attained by providing all staff with access to company email.

6 **Employee records:** Employers should keep a record of any individual's training, stored appropriately, "Data Protection" compliant in the employee's personnel files.

This will help to identify when refresher training is needed in the future. Particular training will be required for those employees changing jobs or taking extra responsibilities, new employees, agency workers, vulnerable groups such as young workers and health and safety representatives. A comprehensive Company Training Matrix including health and safety requirements would be a useful management tool.

Standards, target and performance measures to ensure health and safety of the workers in the industry

Objectives: At the end of this lesson you shall be able to
- **describe the safety and protection of existing environment**
- **explain the principles & practices in prevention**
- **state methods for controlling Pollution, Water Pollution**
- **describe on hazardous Waste Management.**

1 Pollution prevention in industrial processes: The possibilities of P2 strategies are still being implemented at the corporate level, but benefits are already being realized by many companies. If companies invest in P2 methods early in their development, they realize greater gains not too far down the road. Additionally, if companies do not produce waste, they do not have to worry about properly disposing of it. Thus, P2 is a proactive measure taken to reduce costs in the long run that would have been dedicated to disposal and elimination of waste.

There are two main ways to reduce waste through P2: increased efficiency and technology improvements. Waste reduction at the source implies the same amount of input raw materials with less waste and more output of the product. Technology improvements imply changes to the production process that reduce the amount of output waste, such as an improved recycling process.

One strategy is "in-process recycling. "Though it is not the most efficient form of "reduction at the source," recycling is very profitable due to its ease of process. By engaging in recycling practices, industries not only cut down on the amount of material discarded as environmentally-hazardous waste, but they also increase profitability by reducing the amount of raw material purchased.

The most widespread strategy is "reduction at the source," which is the idea that byproducts of production can be reduced through efficient and careful use of natural resources. This method reduces the amount of dangerous pollutants present in waste before the waste is released. In turn, this creates a safer environment free of hazardous waste. This idea ties strongly into the benefits to corporations of investing in newer, more efficient technology. (Fig 1)

The P2 program task force has 5 main goals:

1 create feasible P2 objectives and corresponding time frames

2 provide training to the individuals involved in the effort

3 oversee the program's main tasks and measure progress

4 evaluate the progress of the effort

5 maintain the program's goals long term

Fig 1

a Voluntary approach: Voluntary approaches to P2 are on the rise. Governmental organization often collaborates with businesses and regulatory agencies to create a structure of guidelines. There are four types of voluntary approach programs:

i Public voluntary programs,

ii Negotiated agreements,

iii Unilateral commitments, and

iv Private agreements.

Environmental authorities collaborate and create specific guidelines. Companies are then invited to follow these procedures on a strictly voluntary basis.

Negotiated agreements are created through collaboration between public authorities and industry authorities. The agreement establishes bargains that are beneficial to the industry.

Unilateral commitments are established by industry authorities alone, and the guidelines they set are self-regulated.

Private agreements are established between "polluters" and other affected parties.

The regulations set forth create a compromise regarding a variety of pollution regulation strategies.(Fig 2)

There are a few keys to a successful voluntary approach. First, the program needs a dependable source of funding (from the government, usually). The program also needs a dynamic relationship with the targeted industries. This creates a base of trust between all involved in the agreement. In terms of regulation, the program should be

Fig 2

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monitored by a reliable source. In order to assure that the program will establish itself long term, there should be visible benefits to the participants and obvious results to the greater community. The long-term establishment of the program also comes from setting attainable goals to measure progress.

2 Governmental approach: EPA has published waste minimization guidelines that comprise 5 major steps:

1 Organizing the primary task force

2 Assessing the current pollution situation

3 Evaluating the feasibility of different program options

4. Reporting and planning the preparations based upon the analysis

5 Implementing the program.

a Waste Reduction algorithms: The EPA makes available software that employs the Waste Reduction Algorithm. They use the acronym WAR for this method and state "the goal of WAR is to reduce environmental and related human health impacts at the design stage. The WAR tracks pollutants through the entire production process in order to obtain accurate measurements.

b Industrial efforts: By maximizing P2 opportunities, some companies choose to redesign their entire industrial process. Managers focus more on what enters and moves through the entire process, instead of only focusing on the output. Overall, the P2 strategies that financially benefit companies are the most likely to be implemented. However, since P2 has only recently been realized as a cost benefit, many corporations have not adopted significant measures to realize the potential gain.

c Potential benefits: Pollution prevention can also be viewed as a form of environmental entrepreneurship, as companies see opportunities to reduce costs of waste treatment, storage, and disposal. For example, 3M has accrued a savings of over $750 million since 1973 due to their implementation of P2 incentives. If implemented correctly; P2 strategies can result in an increase in process yield. By reducing the amount of pollution released, companies can avoid some of the liability costs accrued when large amounts of pollution are released and contaminate the land on which the facility is located.

According to EPA, there are some everyday steps that can be taken to prevent pollution:

- Use paper in limited quantities, and print double-sided. Also, look for paper that has been made with recycled materials.
- Look for products made with recycled materials. Bring reusable bags in which to carry purchased goods in order to reduce the number of disposed paper/plastic bags.
- Use water sparingly by installing water-efficient shower heads and faucets, and install energy-efficient appliances. Make sure that sinks and hoses are not dripping. Do not excessively water plants.
- Use transportation efficiently, and utilize mass transportation when possible. Recycling used motor oil is also a way to eliminate the disposal of a hazardous material.
- Eating locally produced foods reduces the amount of fuel required for the food's transportation. (Fig 3)

Fig 3

HSN121913

Additional examples of P2 include using energy efficient machinery, developing clean-burning fuel, reducing the amount of chemicals released into water sources, creating a production process that results in a reduced amount of waste, and utilizing water conservation techniques.

3 Water pollution: Water pollution is the contamination of water bodies, usually as a result of human activities. Water bodies include for example lakes, rivers, oceans, aquifers and groundwater. Water pollution results when contaminants are introduced into the natural environment. For example, releasing inadequately treated wastewater into natural water bodies can lead to degradation of aquatic ecosystems. In turn, this can lead to public problems for people living downstream. Water pollution is the leading worldwide cause of death and disease, e.g. due to water-borne diseases.

Sources of water pollution are either point sources or non-point sources.

iPoint sources have one identifiable cause of the pollution, such as a storm drain or a wastewater treatment plant.

iiNon-point sources are more diffuse, such as agricultural runoff.

The effects can damage individual species and impact the natural biological communities they are part of.

Water pollution is measured by analyzing water samples. Physical, chemical and biological tests can be conducted. Control of water pollution requires appropriate infrastructure and management plans. The infrastructure may include wastewater treatment plants. Sewage treatment plants and industrial wastewater treatment plants are usually required to protect water bodies from untreated wastewater.

Agricultural wastewater treatment for farms and erosion control at construction sites can also help prevent water pollution. Nature-based solutions are another approach to prevent water pollution. Effective control of urban runoff includes reducing speed and quantity of flow. In the United States, best management practices for water pollution include approaches to reduce the quantity of water and improve water quality. (Fig 4)

Fig 4

HSN121914

a Control of water pollution in industry: Some industrial facilities generate wastewater that is similar to domestic sewage and can be treated by sewage treatment plants. Industries that generate wastewater with high concentrations of organic matter (e.g. oil and grease), toxic pollutants (e.g. heavy metals, volatile organic compounds) or nutrients such as ammonia, need specialized treatment systems. Some industries install a pre-treatment system to remove some pollutants (e.g., toxic compounds), and then discharge the partially treated wastewater to the municipal sewer system. Industries generating large volumes of wastewater typically operate their own treatment systems.

Some industries have been successful at redesigning their manufacturing processes to reduce or eliminate pollutants, through a process called pollution prevention.

To remove heat from wastewater generated by power plants or manufacturing plants the following technologies are used:

- Cooling ponds, man-made bodies of water designed for cooling by evaporation, convection, and radiation
- Cooling towers, which transfer waste heat to the atmosphere through evaporation or heat transfer
- Cogeneration, a process where waste heat is recycled for domestic or industrial heating purposes.

4 Hazardous waste management: Hazardous-waste management, the collection, treatment, and disposal

Fig 5

HSN121915

of waste material that, when improperly handled, can cause substantial harm to human health and safety or to the environment. Hazardous wastes can take the form of solids, liquids, sludge or contained gases, and they are generated primarily by chemical production, manufacturing, and other industrial activities.

They may cause damage during inadequate storage, transportation, treatment, or disposal operations. Improper hazardous-waste storage or disposal frequently contaminates surface and groundwater supplies. In an effort to remedy existing problems and to prevent future harm from hazardous wastes, governments closely regulate the practice of hazardous-waste management.

a Hazardous-waste characteristics: Hazardous wastes are classified on the basis of their biological, chemical, and physical properties. These properties generate materials that are toxic, reactive, ignitable, corrosive, infectious, or radioactive. Toxic wastes are poisons, even in very small or trace amounts. They may have acute effects, causing death or violent illness, or they may have chronic effects, slowly causing irreparable harm. Some are carcinogenic, causing cancer after many years of exposure. Others are mutagenic, causing major biological changes in the offspring of exposed humans and wildlife. Reactive wastes are chemically unstable and react violently with air or water. They cause explosions or form toxic vapors. Ignitable wastes burn at relatively low temperatures and may cause an immediate fire hazard. Corrosive wastes include strong acidic or alkaline substances. They destroy solid material and living tissue upon contact, by chemical reaction. (Fig 6)

Fig 6

HSN121916

Environment management and social welfare

Objectives: At the end of this exercise you shall be able to
- **state the significance of greenhouse gases and causes for global warming**
- **list out the various factors influencing climatic change**
- **state the possible ways to help environment and manage eco-system.**

Greenhouse gases - An overview: Gases that trap heat in the atmosphere are called greenhouse gases. This section provides information on emissions and removals of the main greenhouse gases to and from the atmosphere. For more information on the other climate forcers, such as black carbon, please visit the Climate Change Indicators: Climate Forcing page.

- **Carbon dioxide (CO2):** Carbon dioxide enters the atmosphere through burning fossil fuels (coal, natural gas, and oil), solid waste, trees and other biological materials, and also as a result of certain chemical reactions (e.g., manufacture of cement). Carbon dioxide is removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle.
- **Methane (CH4):** Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices, land use and by the decay of organic waste in municipal solid waste landfills.
- **Nitrous oxide (N2O):** Nitrous oxide is emitted during agricultural, land use, industrial activities, combustion of fossil fuels and solid waste, as well as during treatment of wastewater.
- **Fluorinated gases:** Hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen drifluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes.

Global warming

- 2011-2020 was the warmest decade recorded, with global average temperature reaching 1.1°C above pre-industrial levels in 2019. Human-induced global warming is presently increasing at a rate of 0.2°C per decade. In increase of 2°C compared to the temperature in pre-industrial times is associated with serious negative impacts on to the natural environment and human health and wellbeing, including a much higher risk that dangerous and possibly catastrophic changes in the global environment will occur. For this reason, the international community has recognised the need to keep warming well below 2°C and pursue efforts to limit it to 1.5°C

Causes for rising emissions

- Burning coal, oil and gas produces carbon dioxide and nitrous oxide.
- Cutting down forests (deforestation). Trees help to regulate the climate by absorbing CO2 from the atmosphere. When they are cut down, that beneficial effect is lost and the carbon stored in the trees is released into the atmosphere, adding to the greenhouse effect.
- Increasing livestock farming. Cows and sheep produce large amounts of methane when they digest their food.
- Fertilisers containing nitrogen produce nitrous oxide emissions.
- Fluorinated gases are emitted from equipment and products that use these gases. Such emissions have a very strong warming effect, up to 23 000 times greater than CO2.

Components of climate change: Climate change has already begun to impact our planet in more ways than we can think. Temperatures continue to rise throughout the planet and we are experiencing changes in precipitation patterns as we have never seen before. The main cause of these catastrophic effects on our planet is pollution.

Harmful effect of climate change: The layer of Greenhouse Gases (GHG), including carbon dioxide (CO2),, methane, nitrous oxide and others, in their optimum concentration in Earth's atmosphere, acts like a protective blanket which maintains its temperature and the natural ecosystem.

Lately, anthropogenic (human induced) activities, mainly burning of fossil fuels, have resulted in increasing the concentration of these gases which in turn trap extra heat and increase Earth's average temperature leading to climate change.

This in turn leads to a wide ranging impact including sea level rise, melting of snow and glaciers, changes in weather patterns, increased frequency and intensity of extreme events and natural disasters etc.

Factors affecting climate change: Fortunately, there are always things that we can do to fight against climate change. Saving the environment starts with us and it is our responsibility to act against these terrible changes to preserve the planet for future generations.

Prevention of climate change and best ways to help environment

1 **Make your commute green:** Millions of people drive to work every day. It is simply unavoidable in our modern-day society. However, the downside to this is that millions of cars emit greenhouse gases that destroy our atmosphere. Vehicle emissions are a close second when it comes to the top causes of climate change.

There are always other options that you can utilize to make your commute to work eco-friendly. For starters, taking public transportation to work is a great way to cut out emissions. Riding your bike to work is also incredibly helpful to the environment and is a great method to get exercise.

2 Be more conservative with energy usage

Becoming more energy efficient is a great way to prevent pollution. It causes the power plants to expend less energy that can lead to the production of greenhouse gasses. This means that you should do what you can to cut down on energy usage in your household.

Make sure to turn off lights and unplug devices that you are not using anymore when you are done with them. Replace your light bulbs with energy-efficient light bulbs to help you save electricity too.

3 Get active and vote

One of the best ways to improve climate change is to help those who will fight against it get into office. This means voting for legislation and politicians that aid against the detrimental effects of climate change. Many corporations have politicians on their payroll and use them to lobby against legislation that would require more regulations against them. Voting the right people into office will help pass legislation that allows us to fight against these corporations that are mainly to blame for climate change.

4 Recycle

Manufacturing plants emit a large number of greenhouse gasses per year. It is unavoidable in the production of goods that we use on a regular basis. However, a cleaner alternative would be to invest in recycling. Recycling is a cost-effective and eco-friendly process that eliminates waste and doesn't emit greenhouse gasses into the environment.

Be sure to collect your discarded paper, glass, plastic, and electronics to your local recycling centre. The professionals will take these items to a processing plant where they will be remade into other recyclable materials again.

5 Educate yourself and others

The importance of educating others about climate change cannot be overstated in our modern society. There are many platforms for us to utilize that can allow us to spread our message easily.

Whether you use word of mouth or social media, there are always ways to educate others on what climate change is doing to our planet. You can help protect the planet by educating others about the dangers of climate change and how to act against it.

6 Encourage the use of renewable energies

Focusing your efforts to spread awareness about renewable energy is the best way to create a positive impact in your community. By informing others about how renewable energy is better than utilizing fossil fuels, you will sway others into investing in the idea.

Social security legislation

Objectives: At the end of this lesson you shall be able to
- **state the social security legislation**
- **describe the basic concepts about workman's compensation act**
- **state on contract labor regulation act.**

1 Social security legislation

Social Security for employees is a concept which over time has gained importance in the industrialized countries. Broadly, it can be defined as measures providing protection to working class against contingencies like retirement, resignation, retrenchment, maternity, old age, unemployment, death, disablement and other similar conditions.

With reference to India, the Constitution levies responsibility on the State to provide social security to citizens of the country. The State, here, discharges duty as an agent of the society in order to help those who are in adverse situations or otherwise needs protection owing to above mentioned contingencies. Article 41, 42 and 43 of the Constitution do talk about the same. Also, the Concurrent List of the Constitution of India mentions issues like-

- Social Security and insurance, employment and unemployment.
- Welfare of Labour including conditions of work, provident funds, employers' liability, workmen's compensation, invalidity and old age pension and maternity benefits.

Drawing from the Constitution of India and ILO Convention on Social Security1 (ratified by India in 1964), some of the legislations that have been enacted for social security are Employees' State Insurance Act, 1948, Workmen's Compensation Act, 1923, Employees' Provident Fund and Miscellaneous Provisions Act, 1952, Maternity Benefit Act, 1961, Payment of Gratuity Act, 1972, etc. A social security division has also been set up under the Ministry of Labour and Employment which mainly focuses on framing policies for social security for the workers of organized sector.

Apart from above mentioned enactments, since the last decade the government has initialized efforts to extend the benefits to the unorganized sector too. Legislative enactments like the National Rural Employment Guarantee Act, 2005, Unorganized Sector Workers' Social Security Act, 2008 and the Domestic Workers (Registration, social security and welfare) Act, 2008 are examples of the same.

The National Rural Employment Guarantee Act, 2005 aim at curbing unemployment or unproductive employment in rural areas. It focuses on enhancing livelihood security to rural people, as it guarantees productive wage employment for at least 100 days in a year. The Fiscal budget, this year, has also hiked the allocation to its job guarantee scheme NREGA by 144% and also the beneficiaries under the scheme would, henceforth, be entitled for a minimum wage of Rs. 100 per day.

Also, there is Unorganized Workers' Social Security Act, 2008, which targets at extending social security measures to unorganized sector workers. The law thereby aims at extending to workers in informal sector status and benefits similar to that of formal sector workers.

On the same lines, Domestic Workers Act, 2008 has also been enacted. The legislation aims at regulating payment and working conditions of domestic workers and entitles every registered domestic worker to receive pension, maternity benefits and paid leave that is a paid weekly off. These legislations for organized and unorganized sector workers need to be bestowed attention because this will help improve their productivity and industrial relations and thus ensure development of the country.

Introduction to workman's compensation Act

The proper beginning of social security in India started with the passing of the Workmen's Compensation Act. Before this Act, it was very difficult for any injured workman to get any compensation or recovery of damage during his job. There were rare occasions when the employers were liable for compensation.

Prior to passing of this Act there was only one enactment to provide compensation to workers and it was the Indian Fatal Accident Act, 1885. Only in rare cases the dependents of a deceased worker could claim damages. If it was proved in court that accident was occurred due to wrongful act or negligence of worker, compensation could not claim. Then in 1921, government made proposals for the grant of compensation and circulated them for opinion.

The proposals received public support and as a result, the Workmen's Compensation Act was passed in the March 1923 and was put into force on July 1st, 1924. With the growing complexity of Indian industries, increasing use of machinery and consequent danger to workmen, it was felt that there should be a legislation to protect the workmen from hardship arising from accident.1 It was also a ground to consider about the enactment.

This legislation was constituted to provide monetary compensation to industrial workers at the time of injury, accident or occupational disease. Industrial workers had to work in dangerous and unsafe working conditions. There was even not any certainty of their lives so it was necessary to provide them protection against various hazards and this Act was a source of protection for them.

The Workmen's Compensation Act is a mechanism for providing relief to victims of work-connected injuries. It places the cost of these injuries only upon the employer which ultimately lies on consumers of product whose wants call his business into existence.

Since the passing of this legislation, a lot of amendments have been made in this Act to make it up to date. The Act was subsequently amended in 1987, 2000 and in 2008. Recently in August 8, 2008, Union Cabinet gave its approval to present the Workmen's Compensation Act (Amended) Bill 2008 in Parliament and the amendments are as follow:

i The approval is given to the recommendation of Second National Labour 89 Commission to change the name of the Act to make it gender neutral. The term 'workmen' is substituted by the term 'employees'.

ii The restricted clauses in schedule II are removed to make the Act applicable to all classes of employees.

iii This amendment enables the central government to revise the wage celling and enactment of funeral expenses from time to time.

Objective of the Act

The main objective of the Act is to make provision for the payment of compensation in case of injury caused by accident arising out and in course of employment. It provides a kind of guarantee against the various hazards of employment.

Second objective of the Act is to impose an obligation upon employers to pay compensation to workers and make them satisfied that they will get necessary help at the time of problem. The Act also ensures the dependents of the workers that financial help will be provided to them as compensation after the death of bread winner.

So compensation is not the only benefit given through this Act but it also provides a greater freedom to a workman from anxiety arise out of accidents which makes the industries more attractive place to work.

Scope and coverage

The Act extends to whole of India except the state of Jammu and Kashmir. According to this Act it is not necessary that accident should have been caused by some wrongful act of employee but it is given to every employee who received any mis-happening. It applies to all persons covered under the definition of the workmen given in section 2(1) of the Act.

It includes all persons employed in factories, railway, mines, plantation, mechanically propelled vehicles, construction works and certain other hazardous occupations. Before 1984, the persons getting the wages not exceeded 1,000 per month were under the coverage area of this Act but after 1984 amendment the wage limit under this Act and restricted provisions of schedule II for the coverage of certain 90 category of workers have been abolished.

Presently, all the permanent workers are covered by the Act yet the members of armed force are exempted from the criteria of the Act. State government is empowered to add any class of factories or establishment in schedule II but if Employees' State Insurance Act is existed in any establishment then Workmen's Compensation Act cannot be applicable there.

Risk covered

Under the Workmen's Compensation Act, all the injuries emerging out of, during the course of job or any occupational disease are covered. Apart from it, the Act also compensate for economic loss and medical expenses. In 2010, it is approved by parliament that medical expenses will be given to every worker without any wage ceiling.

Various diseases for which compensation is given is mentioned in Schedule III which is revised time to time with the growing complexity of modern life and emerging diseases. ILO revised the list of diseases according to international phenomena and India also try to substituted its list according to ILO list.

Exemption

There are some conditions for which no compensation will be paid to affected worker. If any injury or disablement does not continue more than three days, except the death, no compensation will be payable to the worker.

During the work, if any worker is working under the influence of drink or if he do willful disobedience of rules and regulations formulated for his safety and health or if he avoids safety guards he will not able to claim any kind of compensation.

Another condition is that if a workman does not present for medical treatment or examination immediately after the mis-happening he will not entitled for the compensation. So in hazardous work a workman has to work in the several safety measures, and disregard of such measures can be harmful or dangerous for him.

Contract labor (Regulation and Abolition) Act

The Contract Labor (Regulation and Abolition) Act, 19701 was enacted to regulate the employment of contract labor in certain establishments and to provide for its abolition in certain circumstances.

Applicability: The act is applicable to:

a Every establishment in which twenty or more workmen are employed or were employed on any day of the preceding twelve months as contract labor;

b Every contractor who employs or who employed on any day of the preceding twelve months" twenty or more workmen.

Non- applicability:

An establishment which performs an intermittent or casual nature of work.

- The appropriate Government shall decide upon the intermittent or casual nature of work after consultation with the Central Board/ State Board.

Liabilities and responsibilities of principal employer:

The Principal Employer shall provide the essential amenities like Canteen (above 100 contract labors), rest rooms, drinking water facilities and first aid facilities if the same is not provided by the Contractor (Sec 16 to 19).

The expenses incurred on amenities by the Principal employer may be recovered from the contractor either by deduction of any amount payable to the contractor under any contract or as a debt payable by the contractor (Section 20).

The Principal employer must ensure the disbursement of wages through Contractor within the expiry of prescribed period by nominating a representative. If the Contractor fails to make payment or makes short payment then, the principal employer shall be liable to make payment of wages in full or the unpaid balance and recover the amount so paid from the Contractor (Section 21).

Compliances under the Act

Principal employer

a Within 15 days of commencement or completion of each contract work under each contractor, submit a return to the inspector, intimating the actual dates of commencement and completion of such contract work.

b Submit annual returns to the registering officer concerned not later than, 15th February following end of the year to which it relates.

Contractor: File half yearly returns with the concerned Licensing Officer not later than 30 days from the close of the half year.

Recent amendments

Threshold for applicability of the Contract Labor (Regulation and Abolition) Act, 1970 increased from 20 to 50 in Maharashtra.

The Government of Maharashtra, has, vide notification dated January 05, 2017, increased the threshold for applicability of the Contract Labor (Regulation and Abolition) Act, 1970 ("CLRA") in the State of Maharashtra.

The CLRA and compliances there under (obtaining registration as a principal employer or securing a license as a contractor, maintaining registers, etc.) shall now be applicable only if an establishment engages 50 (fifty) or more workmen as contract labor in the preceding 12 (twelve) months or if a contractor employs 50 (fifty) or more workmen as contract labor in the preceding 12 (twelve) months.

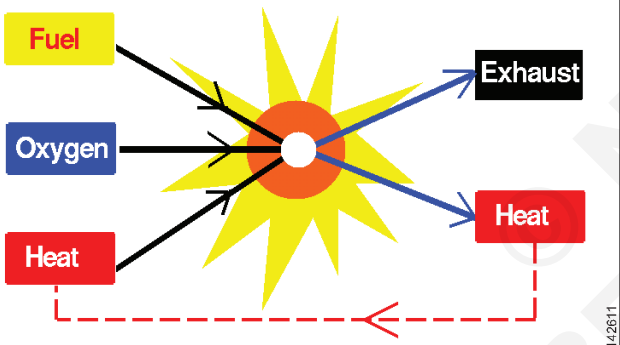
Anatomy of fire

Objectives: At the end of this lesson you shall be able to

- **define combustion and list out about elements and products of combustion**
- **explain about heat of reaction and calorific value, Flash point, Fire point, Ignition temperature and spontaneous combustion**
- **describe fire triangle, fire tetrahedron, fire pyramid and source of heat**
- **explain about the classification of Fire and method of fire extinguishment**
- **explain about the Mode of heat transfer.**

Combustion: Combustion, or burning, is a high-temperature exothermic redox chemical reaction between a fuel and an oxidant, usually atmospheric oxygen, that produces oxidized, often gaseous products, in a mixture termed as smoke. When fuel and oxygen react it releases the heat and light energy. Heat and light energy then result in the flame. So, the formula for Combustion reaction is Hydrocarbon + Oxygen = Heat energy. (Fig 1)

Fig 1



Elements of combustion: Three basic elements are required for combustion to occur:

- '"Fuel"' (a combustible material)
- '"Oxygen"' in sufficient quantity to support combustion
- Sufficient '"heat"' to bring the fuel to its ignition temperature and keep it there.

Fuel: The most common combustible materials or fuels used in heating boilers are oil and gas. These materials supply a rather large amount of heat. The basic combustible elements in these fuels are hydrogen and carbon. Fuels exist as solids, liquids, and gases.

All types of fuels contain carbon, hydrogen, and sulfur. The hydrocarbons readily combine with oxygen to produce a different compound and release heat. Fuels produce different amounts of heat and different byproducts when combusted.

Oxygen: The oxygen needed to support combustion comes from the air that surrounds us. Air is a mixture of gases consisting mainly of about 21 percent oxygen and about 78 percent nitrogen of volume. The remaining 1 percent consists of small amounts of argon, carbon dioxide, and other gases.

Heat: The "ignition temperature" is the temperature that will start a fuel to rapidly ignite with oxygen causing combustion to take place. A chemist would call this process "oxidation". Combustion is a form of oxidation that produces heat and light.

There are many types of products of combustion present in the environment, including:

- Carbon dioxide - This is organic matter composed of carbon. It is hazardous to living organisms because it can cause suffocation.
- Hydrogen chloride - This is produced when burning materials that contain chlorine, such as PVC. It is corrosive to skin, membranes and air passages as well as non-organic material, such as buildings, machine parts and equipment.
- Carbon monoxide - This is generated from combustion without oxygen. This gas is highly toxic and prevents oxygen uptake. It can cause unconsciousness and even death in only a few seconds.
- Nitrogen oxide - This is produced through incineration of materials that contain nitrogen, like chipboard. It is both toxic and corrosive.

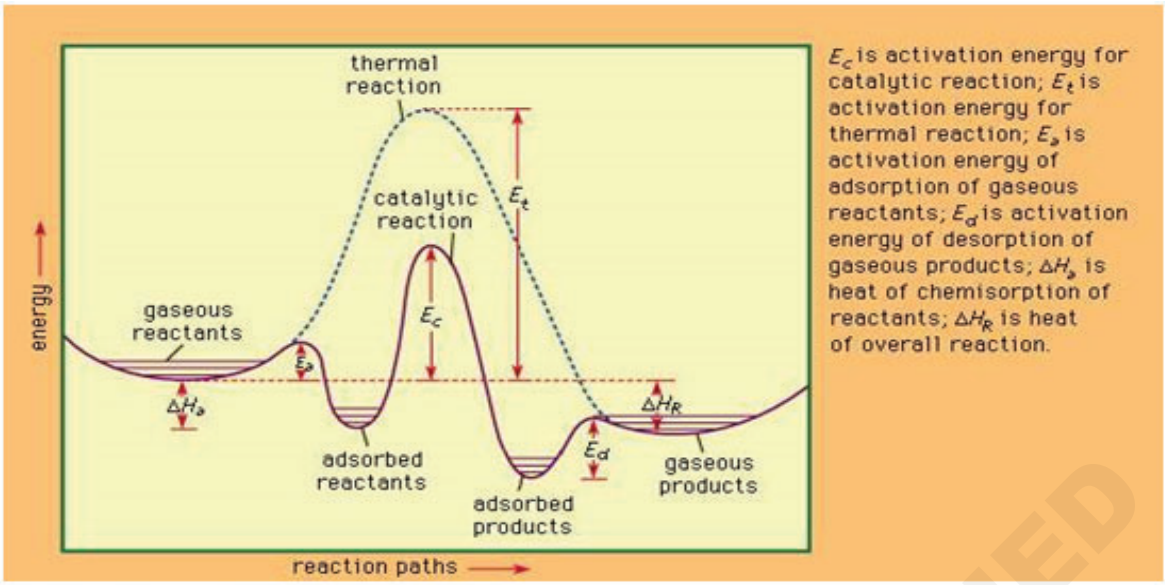
Heat of reaction Fig 2): Heat of reaction, the amount of heat that must be added or removed during a chemical reaction in order to keep all of the substances present at the same temperature.

Calorific value: The heating value (or energy value or calorific value) of a substance, usually a fuel or food (see food energy), is the amount of heat released during the combustion of a specified amount of it.

The calorific value is the total energy released as heat when a substance undergoes complete combustion with oxygen under standard conditions. The chemical reaction is typically a hydrocarbon or other organic molecule reacting with oxygen to form carbon dioxide and water and release heat. It may be expressed with the quantities:

- Energy/mole of fuel
- Energy/mass of fuel
- Energy/volume of the fuel

Fig 2



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There are two kinds of heat of combustion, called higher and lower heating value, depending on how much the products are allowed to cool and whether compounds like H2O are allowed to condense.

Flash & Fire point: Flash point, the lowest temperature at which a liquid (usually a petroleum product) will form a vapour in the air near its surface that will "flash," or briefly ignite, on exposure to an open flame.

The flash point is a general indication of the flammability or combustibility of a liquid. Below the flash point, insufficient vapour is available to support combustion. At some temperature above the flash point, the liquid will produce enough vapour to support combustion. This temperature is known as the fire point.

Ignition temperature

- The ignition temperature of a substance is the least temperature at which the substance starts combustion.
- Substances which spontaneously ignite in a normal atmosphere at naturally ambient temperatures are termed pyrophoric. (Fig 3)

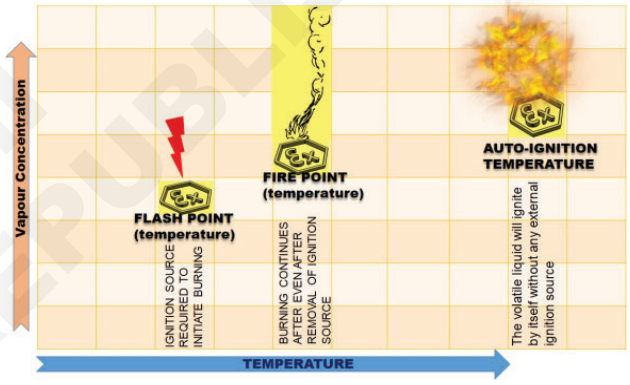
Spontaneous combustion: As the name suggests the combustion occurs spontaneously. This means that it requires no external energy for the combustion to start. It happens due to self-heating. A substance with low-ignition temperatures gets heated and this heat is unable to escape.

The temperature rises above ignition point and in the presence of sufficient oxygen combustion will happen. The reaction of alkali metals with water is an example.

Fire triangle (Fig 4): The combustion triangle or fire triangle is the three components required for igniting and sustaining a fire. Oxygen, fuel, and heat are the three ingredients of a fire triangle.

The combustion triangle or fire triangle might seem like a simple concept, but it is a scientific principle that all people need to know. Understanding how fire is able to sustain

Fig 3



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itself is important background information in situations where you need to use fire safety equipment.

If even one of the components is removed, the fire triangle collapses and the fire is extinguished. Let us explore the components in detail:

Heat: A heat source is necessary for ignition to occur and different materials have different 'flash points' or the lowest temperatures at which they can ignite.

Fig 4

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Combustion reactions, however, also produce heat as they burn, which further increases the fuels' temperature. The heat may be cooled by applying water, but this is only possible for some types of fire.

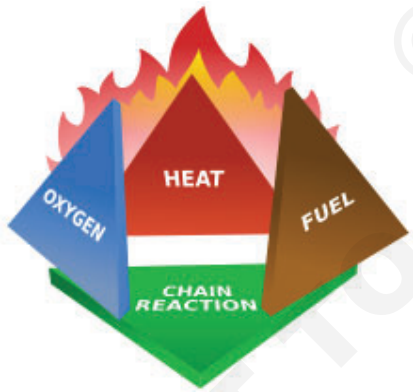
Fuel: Fire cannot start if there isn't any material available to burn. Businesses and homes alike are full of flammable materials including fabrics, wood, oil, and paper. Any of these materials can serve as fuel for a fire.

Some of the materials burn more easily compared to others. Fuel is probably the hardest 'side' of the fire triangle you can remove, so it is advisable to ensure that they are appropriately stored so that they don't become a fire hazard.

Oxygen: Oxygen is needed to sustain the combustion reaction since it reacts with the burning fuel to release carbon dioxide and heat. The atmosphere of the earth consists of 21 per cent oxygen, which means that there's enough to trigger a fire as long as the other two components are present.Some fire extinguishers and fire blankets remove the oxygen 'side' of the triangle by displacing or removing it thus causing suffocation and ceasing the combustion reaction.

Fire tetrahedron (Fig 5): The Triangle of Combustion symbolised the concept of fire for a long time and represented heat, fuel, and oxygen. Further research into fire led to the conclusion that a fourth element was a necessary component of fire, which is a chemical chain reaction. The fire triangle was subsequently changed to a fire tetrahedron (also referred to as fire diamond, pyramid, or combustion triangle) to reflect the fourth element.

Fig 5



A tetrahedron is best described as a pyramid, which is a solid with four plane faces. All the four elements essentially must be present for the occurrence of fire i.e. oxygen, heat, fuel, and a chemical chain reaction. If you remove any of the essential elements, the fire will be extinguished.

The four elements are oxygen for sustaining combustion, enough heat for raising the material to the ignition temperature, combustible material or fuel, and a subsequent exothermic chain reaction in the material.

Although there are many specific types of energy, the two major forms are Kinetic Energy and Potential Energy.

- Kinetic energy is the energy in moving objects or mass. Examples include mechanical energy, electrical energy etc.
- Potential energy is any form of energy that has stored potential that can be put to future use. Examples include nuclear energy, chemical energy, etc.

Chemical energy: Chemical energy is energy stored in the bonds of chemical compounds (atoms and molecules).Chemical energy is released in a chemical reaction, often in the form of heat. For example, we use the chemical energy in fuels like wood, coal by burning them.

Electrical energy: Electrical energy is the energy carried by moving electrons in an electric conductor. It is one of the most common and useful forms of energy. Example - Lightening. Other forms of energy are also converted to electrical energy. For example, power plants convert chemical energy stored in fuels like coal into electricity through various changes in its form.

Mechanical energy: Mechanical energy is the energy a substance or system has because of its motion. For example machines use mechanical energy to do work.

Thermal energy: Thermal energy is the energy a substance or system has related to its temperature, i.e., the energy of moving or vibrating molecules. For example, we use the solar radiation to cook food.

Nuclear energy: Nuclear energy is the energy that is trapped inside each atom. Nuclear energy can be produced either by the fusion (combining atoms) or fission (splitting of atoms) process. The fission process is the widely used method.

Classification of fire: Fire class is a term used to denote the type of fire, in relation to the combustion materials, that has (or could be) ignited. This affects the type of suppression or extinguishing materials that can be used. Class letters are often assigned to the different types of fire, but these differ between territories. There are separate standards in the United States, Europe, and Australia.

Ordinary combustibles: Class A fires consist of ordinary combustibles such as wood, paper, fabric, and most kinds of trash. They may be extinguished by water, wet chemical suppression, or dry powder

Flammable liquid and gas

- These are fires whose fuel is flammable or combustible liquid or gas. The US system designates all such fires "Class B". In the European/Australian system, flammable liquids are designated "Class B" having flash point less than 100 °C, while burning gases are separately designated "Class C".
- These fires follow the same basic fire tetrahedron (heat, fuel, oxygen, chemical reaction) as ordinary combustible fires, except that the fuel in question is a flammable liquid such as gasoline, or gas such as natural gas. A solid stream of water should never be used to extinguish this type because it can cause the fuel to scatter, spreading the flames.
- The most effective way to extinguish a liquid or gas fueled fire is by inhibiting the chemical chain reaction of the fire, which is done by dry chemical and Halon

extinguishing agents, although smothering with CO2 or, for liquids, foam is also effective. Halon has fallen out of favor in recent times (except for aircraft fire extinguishment systems) because it is an ozone-depleting material.

Electrical: Electrical fires are fires involving potentially energized electrical equipment. The US system designates these "Class C"the Australian system designates them "Class E". This sort of fire may be caused by short-circuiting machinery or overloaded electrical cables. These fires can be a severe hazard to firefighters using water or other conductive agents, as electricity may be conducted from the fire, through water, to the firefighter's body, and then earth. Electrical shocks have caused many firefighter deaths.

Metal: Class D fires involve combustible metals - especially alkali metals like lithium and potassium, alkaline earth metals such as magnesium, and group 4 elements such as titanium and zirconium.

Cooking oils and fats (kitchen fires): Class K fires involve unsaturated cooking oils in well-insulated cooking appliances located in commercial kitchens.

Fire extinguishing method: If the three parts of the 'fire triangle' are kept in mind, extinguishing a small blaze should be a matter of common sense. The principles of fire extinction state that a fire will be put out if one of the three elements are removed, and this can be done using three different approaches, as detailed below.

Cooling: Removing the heat is one of the most effective methods of fire extinction available, which is why water is a popular extinguishing material. The fire will go out so long as the heat generated by the fire is less than that which is absorbed by the water.

Remember: water is not an appropriate extinguishing material to use on electrical fires, as well as those caused by cooking oils/fats or other flammable liquids.

Starving: While cooling removes the heat/ignition element of the 'fire triangle', starving the blaze of its fuel source approaches extinction from a different angle. A raging fire will burn itself such as a bonfire out in the open that isn't in contact with any other wood or dry grass. Similarly, a gas fire will immediately extinguish if the gas supply is cut off.

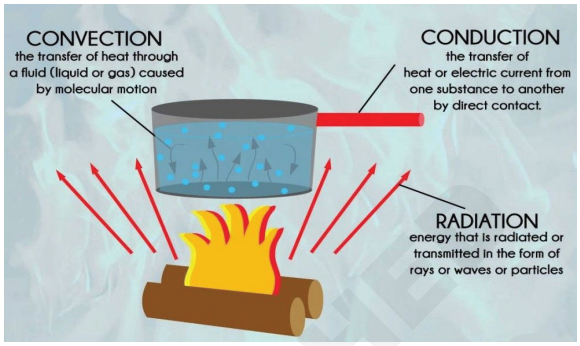
Smothering: As the other key component present in the chemical reaction that causes combustion, removing oxygen from the equation is the final way of extinguishing a fire.

Smothering is a technique that is mostly applicable to solid fuel fires, although some materials may contain enough oxygen within their own chemical makeup to keep the blaze burning.

Modes of heat transfer: conduction, convection and radiation. Heat is a form of energy that is transferred from hot to cold body or from higher to lower temperature. Total heat transfer is equal to the sum of heat transferred by all three modes of heat transfer: Conduction, Convection and Radiation.

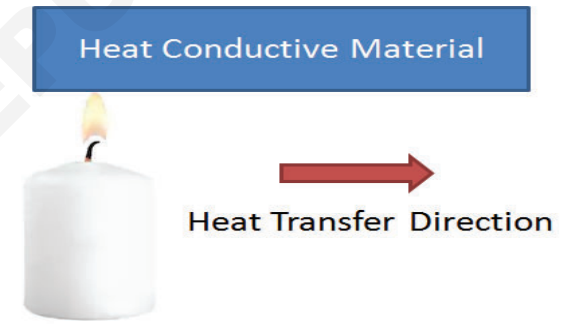
Conductive Heat Transfer (Fig 6): Transfer of heat within thermally conductive body or between thermally contacted bodies due to temperature difference is known as conductive heat transfer. Conduction heat transfer between solid bodies occurs due to molecular excitement.

Fig 6



As shown in the image, when a conductive metal plate is heated at one end. Transfer of heat takes place from the high to low temperature area due to molecular excitement. Conduction heat transfer takes place in thermally conductive bodies. (Fig 7)

Fig 7



Rate of conduction heat transfer is directly proportional to material thermal conductivity. For example, considering all other parameters equal. The rate of heat transfer will be higher in copper compared to plastic material.

Convection heat transfer: Convective heat transfer involves transfer of heat from one place to another by the movement of fluids (Air or liquid). When molecules move from one place to another they carry heat with them.

As shown in the image, when water is heated in a bowl. Transfer of heat takes place due to motion of molecules from heated bottom surface to relatively cold top surface. (Fig 8)

Radiation heat transfer: Radiation heat transfer is the transfer of heat from one body to another in the form of electromagnetic waves. Most of these waves lie in the infrared region. Unlike Conduction and Convection, Radiation heat transfer does not require any solid, liquid or gas. For example transfer of heat from sun to earth takes place through vacuum space. (Fig 9)

Fig 8

Transfer of heat through a fluid caused by motion

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Fig 9

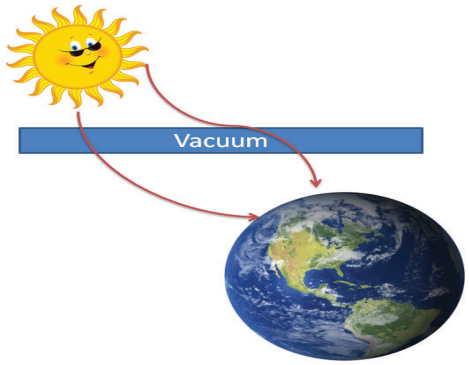

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Image	Description	Europe (European Standard EN 2)	United States	Australian	Suitable suppression
	Combustible materials (wood, paper, fabric, refuse)	Class A	Class A	Class A	Most suppression techniques
	Cooking oils and fats	Class F	Class K	Class F	Suppression by removal of oxygen or water mist
	Electrical fire	not classified (formerly Class E)	Class C	Class E	As ordinary combustibles, but conductive agents like water not to be used
	Flammable gases	Class C	Class B	Class C	Inhibiting chemical chain reaction, such as dry chemical or Halon
	Flammable liquids	Class B	Class B	Class B	Inhibiting chemical chain reaction, such as dry chemical or Halon
	Flammable metals	Class D	Class D	Class D	Specialist suppression required

Classificatin of fire & Extinguishers

Objectives: At the end of this lesson you shall be able to

- **discuss about Classification of Fire**
- **explain about types of extinguishers, maintenance and method of operation**
- **give an outline on Halon , its detrimental effect on environment and alternatives of Halon**
- **explain about the types of fire extinguishing agents**
- **discuss about the Rating system for portable fire extinguishers, Limitation of fire extinguishers, inspection requirement.**

Classification of fire

Class A: Class A fires involve common combustibles such as wood, paper, cloth, rubber, trash and plastics. They are common in typical commercial and home settings, but can occur anywhere these types of materials are found.

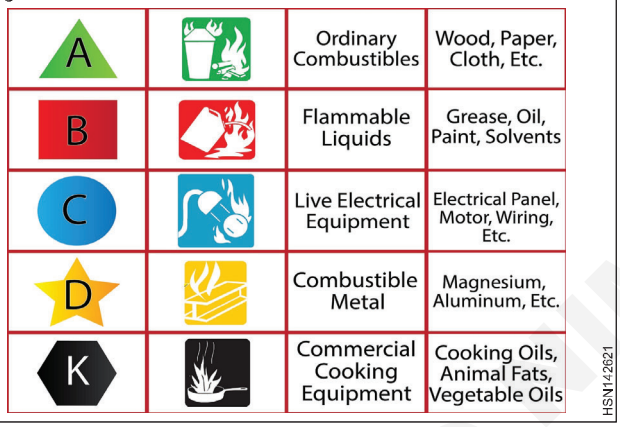
Class B: Class B fires involve flammable liquids' gases, solvents, oil, gasoline, paint, lacquers, tars and other synthetic or oil-based products. Class B fires often spread rapidly and, unless properly secured, can reflash after the flames are extinguished.

Class C: Class C fires involve energized electrical equipment, such as wiring, controls, motors, data processing panels or appliances. They can be caused by a spark, power surge or short circuit and typically occur in locations that are difficult to reach and see.

Class D: Class D fires involve combustible metals such as magnesium and sodium. Combustible metal fires are unique industrial hazards which require special dry powder agents.

Class K: Class K fires involve combustible cooking media such as oils and grease commonly found in commercial kitchens. The new cooking media formulations used form commercial food preparation require a special wet chemical extinguishing agent that is specially suited for extinguishing and suppressing these extremely hot fires that have the ability to reflash. (Fig 1)

Fig 1



Types of extinguishers

Water fire extinguishers: Water extinguishers are only suitable for Class A fires consisting of paper, wood, straw, coal, rubber, solid plastics and soft furnishings. They are the simplest, most common, and least expensive type of extinguisher, costing from around £25 for 3- or 6-litre, to £35 for 9-litre ordinary models, and £50 for freeze-protected extinguishers. Some have an additive to make the water more effective and reduce the required size and weight of the extinguisher - these are a little more expensive.

Water extinguishers are the easiest to maintain variety and the least hazardous, since they only contain water. They cool the fire by soaking it and the materials with water. This extinguishes the flames, absorbing heat from burning objects.

They are often found in shops, offices, retail premises, schools, hotels, warehouses and domestic premises. They may have spray or jet nozzles and are usually able to put out a fire completely. A drawback is that they cannot be used on burning fat or oil (Class F), burning metals (Class D), burning liquids (Class B) or electrical appliance fires.

Water mist extinguishers: They work by cooling the fire and reducing the oxygen supply. These devices are likely to replace wet chemical extinguishers for the extinction of deep fat fryer fires, and leave no residue or collateral damage. Like water extinguishers, they are recyclable and do not contain any chemicals. However, they cannot be used on Class D fires (metals).

Water mist extinguishers are more expensive than water extinguishers, costing from around £50 for 1 litre to £100 for 6 litres.

Water spray fire extinguishers: Available in three and six litres water spray fire extinguishers are suitable to fires involving organic solid materials such as wood, cloth, paper, plastics or coal. Use on burning fat or oil or on electrical appliances is a big no-no.

Use involves pointing the jet at the base of the flames and moving it constantly and steadily across the fire until extinguished.

A jet nozzle is eschewed in favour of a spray nozzle, which creates a fine spray courtesy of the higher pressure. Hitting a broader surface area this extracts heat more rapidly. Surfactants can be added to help the water penetrate further into burning material.

Foam extinguishers: The foam smothers the fire in solids and liquids (Class A and B), but not in burning fats or cooking oils (Class F). They can be used on some electrical fires if they have been tested and if fired from 1 metre away. However, they leave a residue that has to be cleaned up, and they are more expensive than water extinguishers, at around £25 for 1 litre and £55 for 9 litres.

Dry powder extinguishers: These are suitable for fighting burning solids, liquids and gases (Class A, B and C fires). **Specialist powder extinguishers** are designed to tackle type D fires involving combustible metals such as lithium, magnesium, or aluminium.

They work by the powder forming a crust which smothers the fire and stops it from spreading.

Disadvantages are that the powder does not soak into materials and does not have an effective cooling effect on the fire, which can result in the fire reigniting. The powder is hazardous if inhaled, so they should be used in well-ventilated areas and are not suitable for offices and domestic premises. The powder damages soft furnishings, machinery, etc, and needs a lot of cleaning up after use. They cannot be used on chip pan fires (Class F).

They are generally inexpensive and powerful and come in 1, 2, 4, 6 and 9-kg sizes. A 1kg model can cost as little as £15, while 9kg will cost around £35.

CO_2 extinguishers: These contain only pressurised carbon dioxide gas and therefore leave no residue. They are suitable for use on fires involving burning liquids (Class B), and electrical fires, such as of large computer equipment, so are practical in offices. CO_2 works by suffocating the fire and does not cause damage to the electrical items or cause the system to short circuit.

However, CO_2 extinguishers get very cold during discharge, and those that are not fitted with double-lined, frost-free swivel horns may cause fingers to freeze to the horn during deployment. They can asphyxiate in confined spaces, and they are not suitable for deep fat fryers, as the strong jet from the extinguisher can carry the burning fat out of the

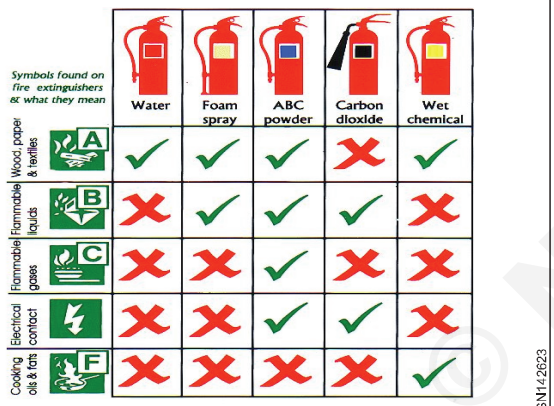
fryer. Fires can quickly re-ignite once the CO_2 has dissipated into the atmosphere, so they do not offer post-fire security.

CO_2 extinguishers are quite expensive. A 2kg model costs around £33, while a 5kg model, suitable for server rooms and factories, costs from £65.

Wet chemical extinguishers: These are the only extinguishers apart from water mist suitable for Class F fires (fats and cooking oils) and are mainly used in kitchens with deep fat fryers. They can also be used on Class A and some can be used on Class B fires. They consist of a pressurised solution of alkali salts in water, which, when operated, creates a fine mist, cooling the flames and preventing splashing. More expensive than some others, they cost around £35 for 2-litre, £70 for 3-litre and £110 for 6-litre sizes.

Fire extinguisher maintainance (Fig 2): Fire extinguisher maintenance is important for everyone's safety.

Fig 2



You must ensure that:

- The extinguisher is not blocked by equipment, coats or other objects that could interfere with access in an emergency.
- The pressure is at the recommended level. On extinguishers equipped with a gauge (such as that shown on the right), the needle should be in the green zone - not too high and not too low.
- The nozzle or other parts are not hindered in any way.
- The pin and tamper seal (if it has one) are intact.
- There are no dents, leaks, rust, chemical deposits and/or other signs of abuse/wear. Wipe off any corrosive chemicals, oil, gunk etc. that may have deposited on the extinguisher.

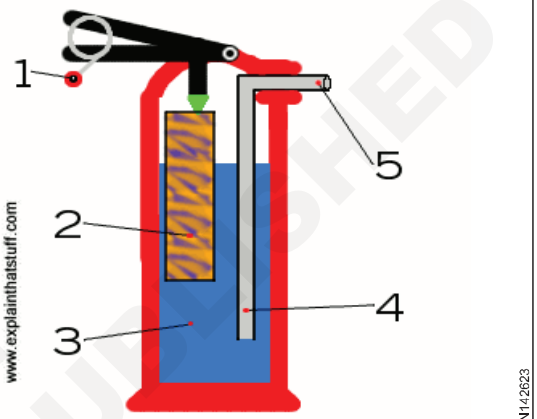
Some manufacturers recommend shaking your dry chemical extinguishers once a month to prevent the powder from settling/packing.

Fire extinguishers should be pressure tested (a process called hydrostatic testing) after a number of years to ensure that the cylinder is safe to use. Consult your owner's manual, extinguisher label or the manufacturer to see when yours may need such testing.

If the extinguisher is damaged or needs recharging, replace it immediately.

Fire extinguisher operation method (Fig 3): Inside, a fire extinguisher is quite like a giant aerosol can, often with two different substances inside. One of them is a solid, liquid, or gas substance for fighting the fire. The other one is called a propellant and is a pressurized chemical that makes the fire-fighting substance come out when you press the extinguisher handle. Next time you see a fire extinguisher, take a good look. Have you noticed that fire extinguishers are always really strong steel canisters? That because the **propellant** is stored inside at a high pressure. Strong canisters are needed to stop the extinguishers exploding!

Fig 3



Water extinguishers: A water extinguisher is like a giant water pistol, but instead of using pressure from your finger to fire out the water, it uses pressure from a trapped gas.

1 A ring or pin on the handle stops the fire extinguisher from being set off by accident. It also acts as a tamper-proof seal: if the ring is broken or missing, you know the extinguisher needs to be checked.

2 Inside the sturdy steel case, there's a canister containing high-pressure gas (orange with blue hashing).

3 Most of the extinguisher is filled with water (blue).

4 A tube runs right up the inside of the tube to a nozzle outside (gray).

5 The nozzle often ends in a piece of bendy plastic so you can easily direct it toward the base of a fire.

6 To operate the extinguisher, you pull the ring and press the handle.

7 Pressing the handle opens a valve (shown here as a green arrow) that releases the pressurized gas from the canister.

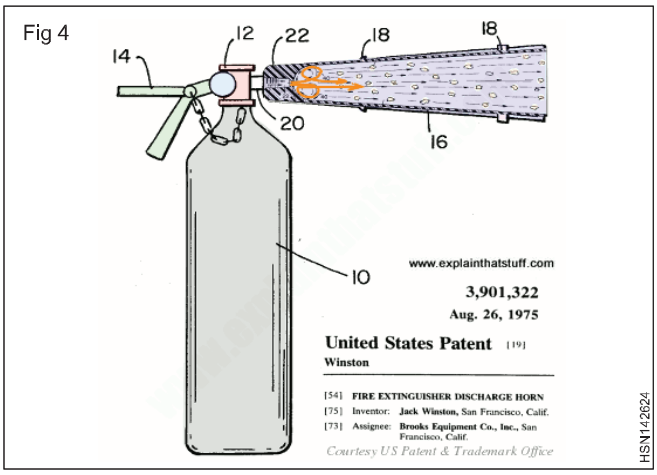
8 The gas immediately expands and fills the inside of the extinguisher, pushing the water downward

9 As the water is pushed down, it rises up the tube

10 A jet of water emerges from the nozzle.

Carbon dioxide extinguishers (Fig 4): The most noticeable difference between a water extinguisher and one that fires carbon dioxide is the large, black, cone-shaped horn, which allows the carbon dioxide gas to expand, cool, and turn into a mixture of frozen "snow" and gas.

Fig 4



The horn has to be designed very carefully to stop two major potential problems: it has to allow the CO2 to exit at high speed, so any snow that forms doesn't block it up, and it has to mix up the gas in a fairly turbulent way to stop it firing air from the horn at the fire as well (which would effectively make the fire burn more strongly). The original numbering of the key parts:

- 10. Tank containing pressurized liquid carbon dioxide.
- 12. Valve.
- 14. Trigger.
- 16. Discharge horn made of plastic that can survive low temperatures without cracking.
- 18. Reinforcing bands wrap around horn at intervals.
- 20. Nipple with a screw thread to which the horn attaches.

As the carbon dioxide enters the horn, it swirls around in a turbulent flow (orange arrows) forming snow (orange blobs) and gas. The swirling turbulence stops dead air zones forming in the horn, which in turn prevents air being swept down the horn toward the fire.

Halon: Halon is a "Clean Agent." The National Fire Protection Association defines, a "Clean Agent" as "an electrically non-conducting, volatile, or gaseous fire extinguishant that does not leave a residue upon evaporation."

Halon is a liquefied, compressed gas that stops the spread of fire by chemically disrupting combustion. Halon 1211 (a liquid streaming agent) and Halon 1301 (a gaseous flooding agent) leave no residue and are remarkably safe for human exposure. Halon is rated for class "B" (flammable liquids) and "C" (electrical fires), but it is also effective on class "A" (common combustibles) fires. Halon 1211 and Halon 1301 are low-toxicity, chemically stable compounds that, as long as they remain contained in cylinders, are easily recyclable.

Alternatives to halon fire suppression systems: The fire suppression industry has worked to quickly produce a number of more environmentally friendly agents that are less harmful to the ozone layer and less likely to cause damage based on instability and likelihood of injury to individuals. Some examples of newly approved agents to be used in commercial buildings include:

- Carbon-based agents (such as Perfluorohexane)
- Carbon dioxide
- FM-200 (Heptafluoropropane)

Such agents are powders or foams that are based on a process of heat absorption, which helps protect areas with sensitive materials that could be destroyed by water just as easily as by fire. Such areas of your building could include:

- Filing & documents
- Archives
- Server rooms
- Rooms with valuable electronic
- Military operations
- Oil and gas production facilities
- Data centers
- And more

These alternatives are also environmentally approved and less of a danger chemically to anyone in the area.

Extinguishing agents

Dry chemical: This agent is made up of very small particles of sodium bicarbonate, potassium bicarbonate, or ammonium phosphate with additives to help enhance flow and prevent packing and caking. Extinguishers with sodium bicarbonate and potassium bicarbonate are rated for Class B and Class C fires. Extinguishers with ammonium phosphate are rated for Class A, B, and C fires.

Wet chemical: This is agent is a water solution with additives that chemically react with fats in a cooking-oil fire, creating a thick foam blanket that will float on the surface of the oil. These extinguishers are intended for Class K fires.

Clean agent: This electrically nonconductive extinguishing agent, evaporates and leaves no residue behind. The currently acceptable clean agents used in extinguishers include halocarbons, such as Halotron I and FE36, Halon 1211, and carbon dioxide. Carbon dioxide extinguishers are rated for Class B and C fires. Extinguishers containing halocarbons and Halon 1211 are rated for Class B and C fires, while larger units are rated for Class A fires.

Water stream (extinguisher): This is an extinguisher with a 2.5 gallon capacity, containing tap water or a loaded stream charge that is discharged through a hose as a solid stream. This type of extinguisher is rated 2-A for use on Class A fires only.

Water mist (extinguisher): An extinguisher with a special nozzle for discharging de-ionized water as a fine mist. This type of extinguisher is rated for Class A and C fires.

Foam: This extinguishing agent is either aqueous film-forming foam (AFFF) or film-forming fluoroprotein (FFFP) foam. Extinguishers containing foam solution have a hose with a special nozzle that introduces air to the solution, which creates foam as it leaves the extinguisher. Foam extinguishers are intended for Class B fires.

Dry Powder: This extinguishing agent is made up of powder or granular particles that are intended for the extinguishment of Class D combustible metal fires. Typical dry powder agents include sodium chloride, graphite, and copper. Extinguishers containing dry powder are listed for the extinguishment of specific combustible metals.

Rating system of portable fire extinguishers

Trash - wood - paper (Fig 5A): Fire extinguishers with a Class A rating are effective against fires involving paper, wood, textiles, and plastics. The primary chemical used to fight these fires is Monoammonium phosphate, because of its ability to smother fires in these types of materials.

Liquids (Fig 5B): Fire extinguishers with a Class B rating are effective against flammable liquid fires. These can be fires where cooking liquids, oil, gasoline, kerosene, or paint have become ignited. Two commonly used chemicals are effective in fighting these types of fires. Monoammonium phosphate effectively smothers the fire, while sodium bicarbonate induces a chemical reaction which extinguishes the fire.

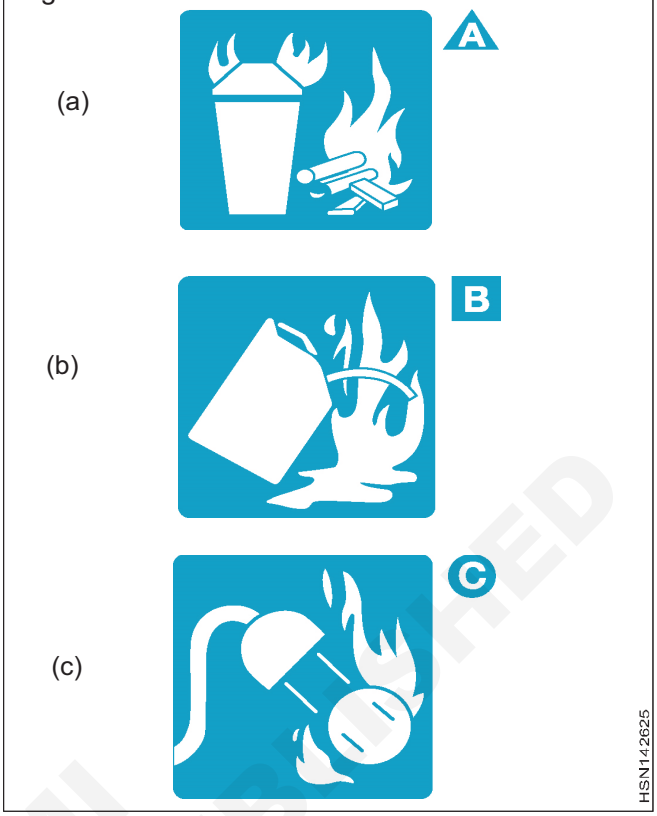
Electrical equipment (Fig 5C): Fire extinguishers with a Class C rating are suitable for fires in "live" electrical equipment. Both monoammonium phosphate and sodium bicarbonate are commonly used to fight this type of fire because of their nonconductive properties.

Fire extinguisher ratings: Fire extinguishers are classified by fire type. The A, B, C rating system defines the kinds of burning materials each fire extinguisher is designed to fight. The number in front of the A, B, or C indicates the rating size of fire the unit can extinguish.

To achieve a Class "A" rating, the extinguisher must be capable of putting out the wood crib, wood panel and excelsior (shredded paper) tests. Ratings are based on the size of the material that can be repeatedly extinguished.

Rating	Wood Crib (inches) l	Wood Pane (Feet)	Excelsior (lbs)
1-A	20 x 20 x 20	8 x 8	6
2-A	25 x 26 x 26	10 x 10	12
3-A	30 x 30 x 30	12 x 12	18
4-A	33 x 30 x 30	14 x 14	24
6-A	38x 38 x 38	17 x 17	36
10-A	48 x 48 x 48	17 x 17	36

Fig 5



To achieve a class "B" rating, the extinguisher must repeatedly put out a flaming liquid fire. Ratings are based on the size of the fire.

Rating	Pan Size (sq ft)	Gallons of Heptane
1-B	2.5	3.25
2-B	5.0	6.25
5-B	12.5	15.5
10-B	25.0	31.0
20-B	50.0	65.0
30-B	75.0	95.0
40-B	100.0	125.0

To achieve the Class "C" rating the extinguisher and contents must pass certain electrical conductivity measurements in accordance with UL711 and UL299.

Limitations of fire extinguisher

Water-fire extinguishers

Disadvantages

- Only once can be used.
- Not suitable for combustion of electrical and metallic tools.
- Cannot be placed where the temperature is cold and can freeze.
- Cannot control and remove large fires.

Dry-type fire extinguishers

Disadvantages

- Only once can be used.
- Its debts can cause damage to certain materials such as car engine, food stuff and so on.
- Cannot remove metal fire.
- Cannot be placed where the temperature is cold and can freeze
- The flour can be frozen if placed in a cool place.

Gas fire extinguishers

Disadvantages

- Only once can be used
- The cylindrical object does not match gas content, its overall weight is 5.3 kg but contains only 2.2 kg of gas.
- The contents of the gas are invisible and should be weighed from time to time to avoid a deficiency of 10%
- It is not appropriate to remove fire type A, B & D
- Cannot control or erase large fire

Foam-type fire extinguishers

Disadvantages

- Can only be used once
- Cannot erase electric fire
- Cannot remove class A, C and D fire
- If the mixing of the chemical is incorrect, the foam cannot effectively remove the fire
- Not suitable for use with dry powder fire extinguisher as the powder breaks the foam.

Fire extinguisher inspection tag requirements

Fire extinguishers are a standard feature in many public buildings and private homes. One way to help ensure they will work properly when needed is to follow the federally-mandated inspection schedule. These inspections are supposed to be recorded on a hang tag attached to each fire extinguisher.

In addition to a list of the inspections and the dates they were performed, the inspection tags typically include a description of the extinguisher, including the make and model number. Checking to ensure the tags are present and contain accurate, up-to-date information is an important element of most building safety inspections.

Codes and standards

The primary federal requirements for fire extinguisher inspections are specified by the National Fire Protection Agency in NFPA 10: Standard for Portable Fire Extinguishers. Additional standards are contained in OSHA and state codes.

Despite variations in the style of fire extinguishers and the fire-suppression materials they contain, NFPA 10 requires all portable extinguishers to undergo four primary categories of inspections: monthly, annual maintenance, six-year and periodic hydrostatic materials inspections. All inspections must be recorded on one or more tags on the fire extinguisher; it is advisable to keep a separate inspection log as well.

Monthly visual inspections

Monthly and annual inspections are the best ways to ensure your fire extinguisher operates effectively and is stored and mounted properly. The monthly inspections are visual only and can be performed by the homeowner or a company's maintenance or safety personnel. These inspections ensure the extinguisher is undamaged, the hose is not blocked, the safety seal is unbroken and the operating instructions are legible.

They also include a check of the pressure gauge to verify the device is fully charged. The month and year of these inspections, along with the initials of the person performing them, are recorded on the extinguisher's hang tag.

Annual maintenance of fire extinguishers

Annual inspections are more thorough and must be done and certified by a professional, since annual maintenance must include an examination of the mechanical parts, the fire-suppression agent and the delivery system. The certification of these inspections must be recorded on the fire extinguisher tag, including the inspection date and the inspector's initials.

Six-year inspections

Six-year maintenance inspections are much like the annual inspections. The main difference is that during the six-year inspections, stored-pressure fire extinguishers are emptied of contents. A licensed professional must examine the mechanics, outlet hose and delivery system, after which the extinguisher is refilled, re-pressurized and marked with a tamper-resistant seal.

These six-year inspections must be recorded on the regular hang tag and on a separate metallic label attached to the body of the extinguisher. Notations must include the month and date of the inspection, as well as the inspector's name and company affiliation.

Hose fitting standards and hydrant pump system for proper application

Objectives: At the end of this lesson you shall be able to
- **list the different types of hose and hose fittings utilized for industrial applications,**
- **explain water tender**
- **describe care and maintenance of hose and its couplings after use.**

1 Fire hose (Fig 1): A fire hose (or firehouse) is a high-pressure hose that carries water or other fire retardant (such as foam) to a fire to extinguish it. Outdoors, it attaches either to a fire engine or a fire hydrant. Indoors, it can permanently attach to a building's standpipe or plumbing system. The usual working pressure of a firehouse can vary between 8 and 20 bar (800 and 2,000 kPa; 116 and 290 psi) while per the NFPA 1961 Fire Hose Standard, its bursting pressure is in excess of 110 bar. Hose is one of the basic, essential pieces of fire-fighting equipment. It is necessary to convey water either from an open water supply, or pressurized water supply. Hoses are divided into two categories, based on their use: suction hose, and delivery hose.

Fig 1

HSN142631

Types of fire hose; its construction

Type 1: Lined hose without external jacket treatment: Such hose absorbs liquid into reinforcement jacket and requires drying after use.

Type 2: Coated lined hose: This has a thin, elastic outer coating that reduces liquid absorption into the jacket and may slightly improve abrasion resistance.

Type 3: Covered lined hose: Covered lined hose has a thicker elastic cover that prevents liquid absorption but also adds substantial improvements to abrasion and heat resistance.

There are several types of hose designed specifically for the fire service. Those designed to operate under positive pressure are called discharge hoses; they include: attack hose, supply hose, relay hose, forestry hose, and booster hose. Those designed to operate under negative pressure are called suction hoses.

a Care & Maintenance: After use, a fire hose is usually hung to dry, because standing water that remains in a hose for a long time can deteriorate the material and render it unreliable or unusable. Therefore, the typical fire station often has a high structure to accommodate the length of a hose for such preventive maintenance, known as a hose tower.

Fig 2

HSN142632

2 Water tender (Fig 3): A water tender, also known as a tanker in some regions (not to be confused with an air tanker), is a specialized firefighting apparatus designed for transporting water from a water source to a fire scene. Water tenders are capable of drafting water from a stream, lake or hydrant.

Fig 3

HSN142633

Water tenders are used when there is no working fire hydrant within reach of other fire equipment, potentially supplying the fire engine(s) with a very rapid connection. Most water tenders are designed to carry loads approx. 3800 litres or more.

Typically water tenders support engines and/or trucks like aerials during fires and hazardous material incidents. Some water tenders carry firefighting equipment and crew much like an engine.

These water tenders are able to operate relatively independently. Some water tenders actually combine a fire engine and water tender. This kind of unit may have seats for up to six firefighters, a water tank of more than approx. 11 000 litres, and basic equipment for firefighting and rescue.

Name of the trade	Definition
Attack	Attack hose is a fabric-covered, flexible hose used to bring water from the fire pumper to the nozzle. This hose ranges in nominal inside diameter from 1.5 to 3 in (38 to 76 mm) and is designed to operate at pressures up to about 400 psi (2,760 kPa). The standard length is 50 ft (15.24 m).
Supply and relay hoses	Supply and relay hoses are large-diameter, fabric-covered, flexible hoses used to bring water from a distant hydrant to the fire pumper, or to relay water from one pumper to another over a long distance. These hoses range in nominal inside diameter from 3.5 to 5.0 in (89 to 127 mm). They are designed to operate at pressures up to about 300 psi (2,070 kPa) for the smaller diameters and up to 200 psi (1,380 kPa) for the larger diameters. The standard length is 100 ft (30.48 m).[11]
Forestry hose	Forestry hose is a fabric-covered, flexible hose used to fight fires in grass, brush, and trees where a lightweight hose is needed to maneuver it over steep or rough terrain. Forestry hose comes in 1.0 and 1.5 in (25 and 38 mm) nominal inside diameters and is designed to operate at pressures up to about 450 psi (3,100 kPa). The standard length is 100 ft (30.48 m).
Booster hose	Booster hose is a rubber-covered, thick-walled, flexible hose used to fight small fires. It retains its round cross-section when it is not under pressure and is usually carried on a reel on the fire pumper, rather than being stored flat. Booster hose comes in 0.75 and 1.0 in (19 and 25 mm) nominal inside diameters and is designed to operate at pressures up to 800 psi (5,520 kPa). The standard length is 100 ft (30.48 m).
Suction hose	Suction hose, sometimes called hard-suction hose, is usually a rubber-covered, semi-rigid hose with internal, metal reinforcements. It is used to suck water out of unpressurized sources, such as ponds or rivers. Hard-suction hose comprises multiple layers of rubber and woven fabric encapsulating an internal helix of steel wire. Some very flexible hard-suction hoses use a thin, polyvinyl chloride cover with a polyvinyl chloride plastic helix. Suction hose anges in nominal inside diameter from 2.5 to 6.0 in (64 to 152 mm). The standard length is 10 ft (3.05 m).

A water tender typically carries some firefighting equipment. There are various national standards and recommendations on equipment to be carried on water tenders. Some water tenders may carry various kinds of hoses and spray nozzles for use in forest, building, or industrial fires, as well as a portable water tank.

In addition, tools like axes, flashlights, chemical portable fire extinguishers, a water extinguisher, an SCBA (Self-Contained Breathing Apparatus), a first aid kit, adapters, and a hydrant wrench can be required.

3 Types of hose fittings (Fig 4): A hose coupling is a connector on the end of a hose to connect (or couple) it with another hose or with a tap or a hose appliance, such as an irrigation sprinkler. It is usually made of steel, brass, stainless steel, aluminum or plastic. Due to the great variety of the designs and the number of countries in which they were created, it is difficult to trace the origin of many. Patents that cover designs similar to those below include:

National Hose thread (NH), also known as National Standard Thread (NST). It is the most common type of fire hose coupling used in the United States. The male and female straight (non-tapered) threads screw together and the connection is sealed with a gasket.

Fig 4

UNI: UNI Fire Fittings are used in Italy, and available in several sizes, including UNI 25, UNI 45, and UNI 70.

a Selecting the correct hose, tubing and fitting: The proper selection of hose and tubing size, material and configuration - along with the correct fittings and flanges - is imperative in the design of all processing equipment. Fitting selection comes down to a popular and well-known acronym dictated by the system's requirements. STAMP: Size, Temperature, Application, Media and Pressure. Each of these five considerations must be taken into account for accurate system design and configuration. STAMPED: E for the Ends (i.e., couplings) and D for Delivery (i.e., volume and velocity).

The couplings are obviously the fitting selection, and the compatibility of media volume and velocity are highly important to a process system. Volume is the amount of fluid flow per unit time and is typically measured in gallons per minute (GPM), while velocity is the distance that a fluid travels per unit time, measured as feet per second.

These are key considerations when selecting hose or tubing material and length, as well as wall thickness and burst pressure rating. Then there is the choice of the proper fitting connection. The system is only as good as the compatibility of the fitting and hose or tubing.

The wrong fitting style, material or installation can cause catastrophic system failure and even become a safety issue. At the very least, it will cause leaks, and system leaks are not a small problem. Millions of gallons of hydraulic fluid are wasted each year, mostly due to system leaks.

Hoses, tubing and fittings are the critical elements of all hydraulic systems. They transmit fluid from the pump to valves, actuators and motors, and generate the force and motion to make the system work.

The importance of selecting the correct hose, tubing and coupling is what allows a processing system to be repeatable and reliable, while reducing or even eliminating costly downtime.

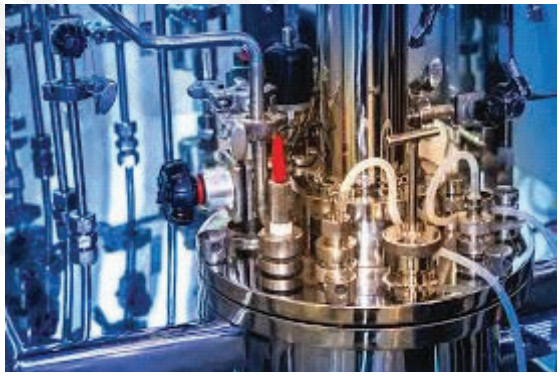
The correct sizes, materials and configurations are what ensure system dependability. Proper selection of the hose or tubing is crucial. But not matching it to the compatible fitting that is specific to the application will only increase the chances of system failure. For hose and tubing, first understand the compatibility of the fluid that is to be transferred with the material of the hose or tube and its required pressure.

Consider the media or material that is to be transferred the chemical resistance of the hose or tubing, and the working pressure and temperature. Select hose and tubing that meets the required ratings for standard operating pressure, burst test and impulse life.

Proper hose and tubing selection lowers cost of ownership and avoids downtime and unscheduled maintenance, which ultimately maximizes uptime and improves ROI of the system.

(Fig 5 -Hydraulic Hose tube & fittings)

Fig 5



HSN142635

b Testing care and maintenance

For the compatible fitting, as with hose and tubing, there are a number of important factors to consider, including:

- Attachment (i.e., a crimped hydraulic fitting for a hose, and a compression fitting for tubing)
- Fitting configuration (straight, elbow, tee, etc.)
- Flow
- Compatible material of hose or tubing
- Size of hose or tubing (in some cases consider wall thickness)
- Vibration
- Working pressure (maximum PSI)

Additionally, consider whether an elastomeric seal is to be used, such as an O-ring or gasket. Critical components in O-ring face seal fittings and most flange assemblies are an elastomeric seal.

The O-ring material selection is dependent on the factors mentioned above, particularly chemical compatibility of the media being transferred and system pressure. Flange connections are often used in applications that will encounter exceptionally high pressures in larger diameter tubing or piping.

They can be bolted together to mate two sections of pipe (tubing or hose) or bolted or screwed into the component to secure a flange fitting or section of pipe.

Regardless of pressure, it is also important to consider flanges where there may be a need to disassemble the connection for easy access to modify, clean or inspect the system.

Certain flanges may also be permanently welded together or onto the port section of the component (e.g., motor housing, valve port, etc.). The most common flange sizes range from ½-2 ½ inches, and in processing systems they are SAE O-ring flange code 61 or 62. Flange connections are frequently found in injection molding machinery, chemical processing and food and beverage processing. Fig 6 Proper Care and Maintenance of Fire Hose. (Fig 6 Sanitary lines and fittings.)

Fig 6

HSN142636

In many process applications - especially food and pharmaceuticals - sanitary lines and fittings must be used whenever the system is carrying product (media) that cannot be contaminated by bacteria.

As required by the Food and Drug Administration, sanitary or hygienic fittings and tubing must be cleanable, either manually or by clean-in-place (CIP) processes. CIP refers to the cleaning of tubing, pipes, filters, fittings and the entire interior of process equipment without disassembly. Sanitary system components must be corrosion-resistant and be free from pockets, threading or tight bends where bacteria can form or be trapped. Most sanitary system components are made of specific stainless steel alloys. In addition, sanitary tube fittings must have surface finishes rated by its Roughness Average (Ra).

Even stainless steel can harbor bacteria in microscopic peaks and valleys in the surface finish. Therefore, sanitary fittings are specially polished to reduce, or sometimes completely remove, this surface roughness. (Fig 7)

Fig 7

HSN142637

Hydrant, detectors & ladders

Objectives: At the end of this lesson you shall be able to
- **state different types of hydrant utilized for industrial applications**
- **state the water requirements for firefighting**
- **describe the pump system for proper application.**

1 Fire Hydrant (Fig 1)

Fig 1

A fire hydrant is a connection point by which firefighters can tap into a water supply. It is a component of active fire protection. Most fire hydrant valves are not designed to throttle the water flow; they are designed to be operated full-on or full-off. The valving arrangement of most dry-barrel hydrants is for the drain valve to be open at anything other than full operation.

Usage at partial-opening can consequently result in considerable flow directly into the soil surrounding the hydrant, which, over time, can cause severe scouring.

Gate or butterfly valves can be installed directly onto the hydrant orifices to control individual outputs and allow for changing equipment connections without turning off the flow to other orifices.

It is good practice to install valves on all orifices before using a hydrant as the protective caps are unreliable and can cause major injury if they fail.

When operating a hydrant, a firefighter typically wears appropriate personal protective equipment, such as gloves and a helmet with face shield worn.

High-pressure water coursing through a potentially aging and corroding hydrant could cause a failure, injuring the firefighter operating the hydrant or bystanders. The hydrants need to be visible and accessible in an emergency.

Since fire hydrants are one of the most accessible parts of a water distribution system, they are often used for attaching pressure gauges or loggers or monitor system water pressure.

Automatic flushing devices are often attached to hydrants to maintain chlorination levels in areas of low usage.

Hydrants are also used as an easy above-ground access point by leak detection devices to locate leaks from the sound they make.

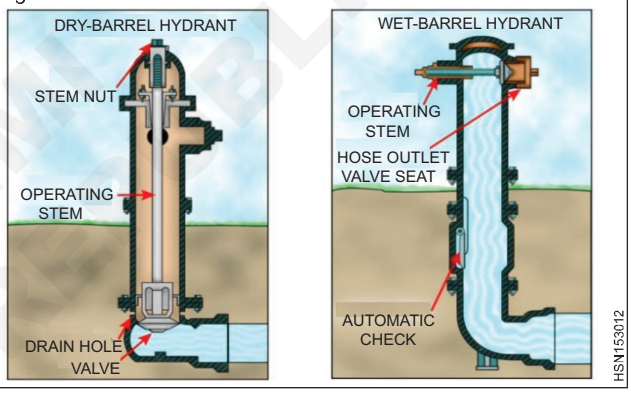
Fire hydrants may be used to supply water to riot control vehicles. These vehicles use a high-pressure water cannon to discourage rioting.

a Types of fire hydrant (Fig 2)

i Dry - Barrel hydrant

ii Wet - Barrel hydrant

Fig 2



2 Water requirements for fire fighting

It is recommended that generally for towns/cities, water for fire-fighting should be provided at the scale of 1800-L/min for every 50 000 population or part thereof for towns up to 3 lacs population and an additional 1800-L/min for every 1 lac population of more than 3 lacs

3 Detectors & Ladders

A fire escape is a special kind of emergency exit, usually mounted to the outside of a building or occasionally inside but separate from the main areas of the building. It provides a method of escape in the event of a fire or other emergency that makes the stairwells inside a building inaccessible. Fire escapes are most often found on multiple-story residential buildings, such as apartment buildings. The improved building codes incorporating fire detectors, technologically advanced firefighting equipment, which includes better communications and the reach of fire fighting ladder trucks, and more importantly fire sprinklers.

A fire escape consists of a number of horizontal platforms, one at each story of a building, with ladders or stairs connecting them. The platform and stairs are usually open steel gratings, to prevent the build-up of ice, snow, and

leaves. Railings are usually provided on each of the levels, but as fire escapes are designed for emergency use only, these railings often do not need to meet the same standards as railings in other contexts.

The ladder from the lowest level of the fire escape to the ground may be fixed, but more commonly it swings down on a hinge or slides down along a track.

The moveable designs allow occupants to safely reach the ground in the event of a fire but prevent people from accessing the fire escape from the ground at other times

Exit from the interior of a building to the fire escape may be provided by a fire exit door, but in most cases the only exit is through a window.

When there is a door, it is often fitted with a fire alarm to prevent other uses of the fire escape, and to prevent unauthorized entry. As many fire escapes were built before the advent of electronic fire alarms, fire escapes in older buildings have often needed to be retrofitted with alarms for this purpose.

An alternate form of rapid-exit fire escape developed in the early 1900s was a long canvas tube suspended below a large funnel outside the window of a tall building. This escape tube could be rapidly deployed from a window and hung down to street level, though it was large and bulky to store inside the building.

A modern type of evacuation slide is the vertical spiral escape chute, which is a common means of evacuation for buildings and other structures.

Breathing sets, resuscitation and first aid

Objectives: At the end of this lesson you shall be able to
- **describe the public health and emergency situation management and incident control system**
- **identify the respiratory personal protective equipment for employees**
- **state the basic knowledge on the selection and usage**
- **acquire the basic information on care and maintenance of respiratory PPE**
- **understand the resuscitation & first aid processes available for our immediate safety**.

1 Public Health and Emergency situation Management

Public health and, of course, emergency management have long histories of engagement in disasters and complex emergencies.

Before public health practitioners worked from emergency operations centers (EOCs) or had even heard of an IMS, they were leading or supporting response efforts in numerous infectious disease emergencies, such as those caused by yellow fever, smallpox, and HIV/AIDS, as well as environmental and technological catastrophes, including hurricanes, floods, and industrial chemical releases.

Similarly, the field of emergency management, defined here as "the managerial function charged with creating the framework within which communities reduce vulnerability to hazards and cope with disasters, has long been oriented toward an array of emergencies, including but not limited to public health events.

The modern emergency management is a younger field than is public health, it has become an increasingly professionalized field with its own disciplinary knowledge, professional associations, credentialing, and university-based programs of study.

For much of their respective histories, interactions between public health and emergency management were rare, and for decades little attempt was made to coordinate or align their missions.

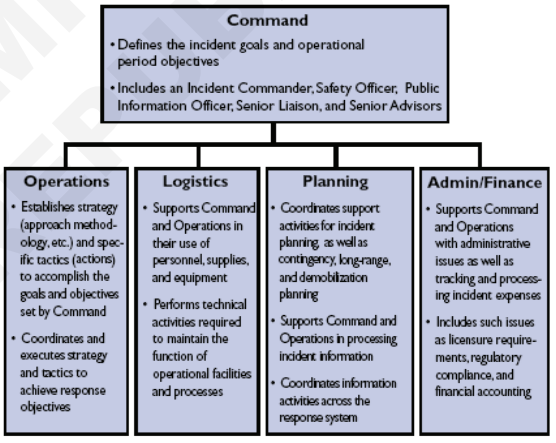
The various efforts have been accompanied by the establishment and refinement of national-level doctrine codifying the relationship between public health and emergency management in such documents as the *National Response Framework.*

Public health and emergency management have also come together in the professional associations of each field. For example, the International Association of Emergency Managers has organized several caucuses addressing the ramifications of a range of health-related emergencies. Similarly, the National Emergency Management Association has partnered with the Association of State and Territorial Health Officials to form a joint policy work group.

This group coordinates federal grant program activities between emergency management agencies and public health departments and aligns exercise requirements across multiple programs, among other things.

2 Basic Introduction to Incident Control Systems in public health (ICS): The ICS provides guidance for how to organize assets to respond to an incident (system description) and processes to manage the response through its successive stages (concept of operations). All response assets are organized into five functional areas: Command, Operations, Planning, Logistics, and Administration/Finance. (Fig 1)

Fig 1



The ICS, as described in NIMS, refers to the combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure and designed to aid in the management of resources during incident response. The ICS is based on eight concepts that contribute to the successful application of this system.

Incident Command System Core Concepts

- **Common terminology** - use of similar terms and definitions for resource descriptions, organizational functions, and incident facilities across disciplines.
- **Integrated communications** - ability to send and receive information within an organization, as well as externally to other disciplines.
- **Modular organization** - response resources are organized according to their responsibilities. Assets within each functional unit may be expanded or contracted based on the requirements of the event.

- **Unified command structure** - multiple disciplines work through their designated managers to establish common objectives and strategies to prevent conflict or duplication of effort.
- **Manageable span of control** - response organization is structured so that each supervisory level oversees an appropriate number of assets (varies based on size and complexity of the event) so it can maintain effective supervision.
- **Consolidated action plans** - a single, formal documentation of incident goals, objectives, and strategies defined by unified incident command.
- **Comprehensive resource management** - systems in place to describe, maintain, identify, request, and track resources.
- **Pre-designated incident facilities** - assignment of locations where expected critical incident-related functions will occur.

First Aid -

a Golden rules of first aid

- Do the first thing first; this includes assessing the situation for any immediate danger, quickly and methodically without panicking, giving priority to the most urgent situation / condition.
- Remove the victim from the cause of injury or the cause of injury from the victim.
- Resuscitate the victim, if necessary and carry out general treatment of unconsciousness.
- Loosen all tight clothing or materials around the victim's neck waist, wrist, etc.
- Arrest bleeding, cover all wounds, burns or scalds and immobilize all fractures.
- Do not allow people to crowd a victim and do not move a victim unless you really have to (dangerous environment, risk of falling debris, explosion etc)
- Reassure the victim and get help as soon as possible.
- Improvise all necessary materials, which are not readily available.
- Guide against or treat for shock.
- Dispose/transport the victim properly.

b Principles of First Aid

The key guiding principles and purpose of first aid is often denoted by 3 Ps.

- Prevent further injuries,
- Preserve life & 3. Promote recovery.
- Unable to breath
- Loss of consciousness ƒ General pallor (paleness)
- Difficulty in breathing ƒ May be no visible breathing

c Signs and Symptoms

- Unable to breath
- Loss of consciousness
- General pallor (paleness)
- Difficulty in breathing
- May be no visible breathing

d First aid practices for respiratory issues

1 Shout for help (depend on the condition).

2 Determine the consciousness of the causality by taping the victim on the shoulder and asking loudly "Are you oky!".

3 Assess and ensure that patient air way is clear.

4 Place the patient flat on his back with the head turned to one side.

5 Remove any thing which is preventing the taking in of air (Remove constraints from the neck).

6 Kneel beside the patient's head place one hand under his neck and the other hand under his lower Jaw extend his head and neck gently back ward. This prevents the tongue from falling back in to the throat.

7 Place your cheek and ear close to the victim's mouth and Nose. Look at the victim's chest to see if it rises, falls, and listen and fell for air to be exhaled for about 5 seconds.

8 If there is no breathing pinch the victim's nostrils shut with thumb and index finger of your hand that is pressing on the victim's forehead. This action prevents leakage of air when the lungs are inflated through the mouth.

9 Take very deep breath and hold it.

10 Fit your mouth tightly over the patients open mouth and forcibly in to the lungs.

11 While carrying out respiration, check the patient's pulse every 2 or 3 minutes to ensure the heart has not stopped.

12 Continue the breathing procedure at the rate 12 to 18 breaths per minute until the chest is seen to rise and the patient is breathing for himself or until is certain his is dead.

13 If a patient is child, our mouth should cover both his nose and mouth. Very gentle breathing should be used and the younger the child, the gentler this should continues at a rate of 25 breaths per minute. Once the patient can breathe by himself/herself place him/her in what is called the recovery position.

e Wounds and Bandaging

Wound is breaking in continuity to tissue of body, either internal or External.

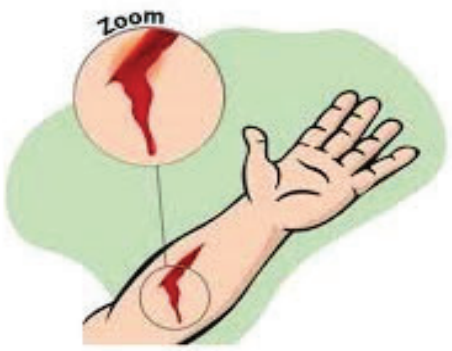
Classification of Wound

a Open: An open Wound is a break in the skin or mucous membrane

b Closed: A closed wound involves injury to underlying tissue without a break in the skin or mucous membrane.

Types of Wounds (Fig 2)

Fig 2



Type of a Wound

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- Abrasions
- Incisions
- Lacerated
- Punctures
- Avulsions

f Common Causes: Cause or resulting in open wounds from: Motor accidents, Fall, Mishandling of sharp objects, tools and machineries.

g Prevention of contamination and infection

- Hand washing before and after wound care (when possible)
- By avoiding contaminates,
- By using lean materials as much as possible E.g. cotton gauze, towels etc...
- Wash in and around the victim's wound to remove bacteria and other foreign Matters
- Wash the wound thoroughly by flushing with clean water, preferable running tab water
- Apply a dry sterile bandage or clean dressing and secure it firmly in place
- Small wounds even can be taken care at home
- If their is infection refer the victim to the health center

h Bandaging: Bandaging is made from flannel, elastic net or special paper cotton cloth,

Bandages are used

1 To hold splint in proper place

2 To maintain direct pressure over dressing to control bleeding.

3 To retain dressings and splints in position

4 To prevent or reduce swellings

5 To restrict movement etc -Bandage should never be used directly over a wound -Bandaging a wound should be applied firmly enough to keep dressing and splints in position.

i The common types of bandages (Fig 3)

Triangular bandages o Roller gauze bandage o Elastic and T- blinder bandage o Many tailed abdominal bandage.

Fig 3

Types of a bandage

HSN163625

j Bleeding: Defusing or oozing of blood from blood vessels (Hemorrhage).

k Types of bleeding (Fig 4)

Fig 4

Typical dressing for a bleed

HSN163626

1 Arterial bleeding- bright red in color, flow from the wound inside,

2 Blood loss *f* Venous bleeding - dark red in color, flow is steady,

3 Capillary bleeding -oozing from bed of capillaries, red in color, usually less bright than arterial blood with slow flow. Methods of controlling bleeding externally,

4 Direct pressure- using compresses - Pressure bandage can be placed to hold pads of cloth.

5 Put a thick pad of cloth held between the hand and wound.

6 Elevation The injured part of the body should be raised about the victim's heart,

7 Applying pressure on the supplying artery specially on brachial artery in severe bleeding.

l Fracture

It Is a breakage of bone tissue or discontinuation of bone tissue due to different causes or accidents.

m Possible cause

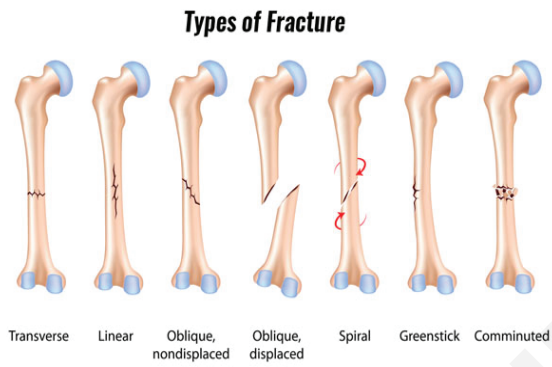
1 Accident / trauma,

2 Pathological due to bone infection,

3 Tumor of the bone

n Types of Fracture (Fig 5)

Fig 5



• closed • open • compound/complicated

Signs and symptoms of fracture:

Pain - protruding of the parts,

Swelling - mispositions

Deformity - Unable to function

Numbness or tingling sensation

Patient may shout due to

Discoloration severe pain

p Complications

Immediate complications: Hemorrhage/ bleeding - Severe pain - Hypotension (shock) due to bleeding Late complications: o Disability o Disfiguring o Deformity o Malunion o Delay in union

q General First aid management of fracture

- Assess carefully but by fast
- Check respiratory condition
- Check bleeding / hemorrhage
- Consider the amount of loss
- Determine and arrange referral
- Asphyxia, bleeding, and severe wounds must be dealt with before treating any fracture
- Support the injured part with supporting device; immobilize the fracture, bandaging and use splints
- Refer the patient to hospital urgently.

r Burns (Fig 6)

Fig 6

- The burn penetrates all layers of the skin.
- The skin is leathery or charred looking, with white, brown, or black patches.
- The person is an infant or a senior.

s For All Burns

Stop Burning Immediately

- Put out fire or stop the person's contact with hot liquid, steam, or other material.
- Help the person "stop, drop, and roll" to smother flames.
- Remove smoldering material from the person.
- Remove hot or burned clothing. If clothing sticks to skin, cut or tear around it.

Remove Constrictive Clothing Immediately

- Take off jewelry, belts, and tight clothing. Burns can swell quickly.

Then take the following steps

t For First-Degree Burns (Affecting Top Layer of Skin)

1 Cool Burn

a Hold burned skin under cool (not cold) running water or immerse in cool water until the pain subsides.

b Use compresses if running water isn't available.

2 Protect Burn

a Cover with sterile, non-adhesive bandage or clean cloth.

b Do not apply butter, oil, lotions, or creams (especially if they contain fragrance). Apply a petroleum-based ointment two to three times per day.

3 Treat Pain

a Give over-the-counter pain reliever such asacetaminophen (Panadol, Tylenol),ibuprofen (Advil, Motrin, Nuprin), ornaproxen (Aleve, Naprosyn).

u Techniques of Resuscitation (Fig 7)

Fig 7

HSN163629

Resuscitation

1 High-Frequency Chest Compressions. High-frequency chest compression (typically at a frequency >120 per minute) has been studied as a technique for improving resuscitation from cardiac arrest. ...

2 Open-Chest CPR.

3 Interposed Abdominal Compression-CPR.

4 "Cough" CPR & Prone CPR.

5 Primordial Thump & Percussion Pacing

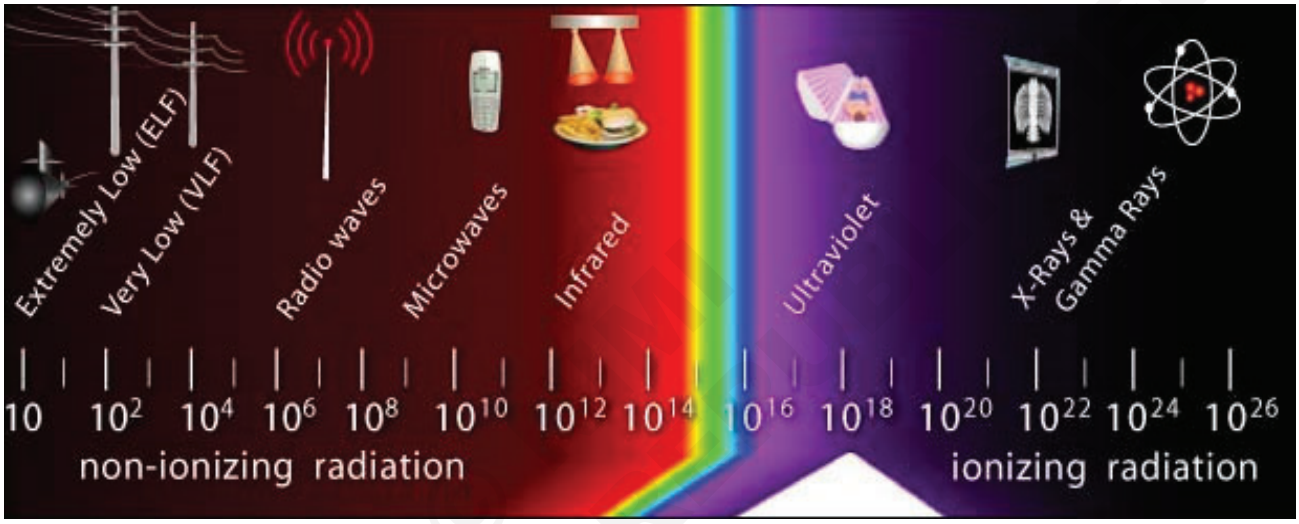
Safety management systems in engineering industry

Objectives: At the end of this lesson you shall be able to
- **list out the significance of various industrial hazards and types of radiation**
- **state the radiation hazards and it's relevant causes**
- **describe radiation hazard management techniques in the workplace.**

Radiation Hazards: Radiation is the transfer of energy through space from an emitting source.

The term radiation simply means the emission of energy as particles or waves. The most popular usage of the term generally refers to electromagnetic radiation (EMR), which covers a spectrum that ranges from low frequency radio waves upward through high frequency gamma waves as shown below Fig 1.

Fig 1



Measurement of Radiation: There are many different terms in use that define units for measuring radiation under various circumstances.

The sievert, which is expressed in units of energy per unit of mass, or joules per kilogram, is the most popular modern unit for measuring radiation. It expresses the absorbed dose of radiation, corrected for how harmful that particular type of radiation is to human tissue. The rem (acronym for Roentgen equivalent man) is just a smaller portion of the sievert. One sievert is equal to one hundred rems.

Types of Radiation: Humans on planet Earth are exposed to radiation from natural sources every day. It's been estimated that the average human receives about 3mSv (millisievert) per year from naturally occurring radioactive materials and cosmic radiation from outer space. The two main types of radiation are non-ionizing radiation and ionizing radiation.

Non-ionizing radiation is radiation that has a lower frequency, or longer wavelength, in the EMR spectrum. These frequencies range from that of power lines, radios, and cell phones, up to visible light.

Non-ionizing radiation is not powerful enough to break the chemical bonds in molecules. In general, it is not harmful to human health as radiation per se, but could be harmful in terms of the transfer of heat energy.

An example of an emitter of non-ionizing radiation is a microwave oven.

Ionizing radiation is of higher frequency on the EMR spectrum than non-ionizing radiation. These frequencies range from visible light to gamma rays and x-rays. Ionizing radiation is generally considered to be more hazardous to human health than non-ionizing radiation because it can remove electrons from atoms. This means that it can damage living tissue and DNA.

There are four basic types of ionizing radiation: Alpha, beta, gamma and x-ray, and neutron particles. All of these types of radiation are caused by the activity of unstable atoms.

Alpha radiation comes from the decay of heavy atoms such as uranium and radon. This radiation is in the form of particles, which are produced when an atom ejects two protons and two neutrons from its nucleus in the form of one subatomic fragment. Alpha radiation can't penetrate the skin, but it can be inhaled, swallowed, or can enter through a cut. After entering the tissues, it can cause a great deal of damage, possibly even cancer.

Like alpha radiation, beta radiation is caused by particles. However, these particles are negatively charged, and are smaller than alpha particles. They are emitted by smaller unstable atoms such as hydrogen-3, also called tritium, and Carbon-14.

Beta particles can penetrate human tissue more easily than alpha particles and, at high energy, can even penetrate the skin. However, they are less harmful than alpha particles to human tissue because the ionizations they produce are more widely spaced. Like alpha particles, they are most harmful when inhaled or swallowed.

Gamma rays and X- rays, unlike alpha and beta radiation, don't consist of particles, but are packets of pure energy known as photons. Gamma rays, which originate inside the atom's nucleus, are very high-energy waves that can penetrate the whole body.

They can cause changes in tissue and DNA, and it takes a dense layer of lead or concrete to stop them. Cobalt-60 and radium-266 are examples of elements that emit gamma rays.

X-rays are less penetrating than gamma rays and are lower in energy. The risk of damage to living tissue from x-rays used in medical diagnostic testing is very limited.

However, one CT (computed tomography) scan emits a much larger amount of radiation. One CT scan emits about as much radiation as 200 chest x-rays.

Neutron particles travel at high speeds and can cause the objects with which they interact to become radioactive.

Neutron radiation occurs primarily in nuclear reactors and is emitted as a result of induced nuclear fission.

What exactly is radiation?

Simply put, radiation is energy that travels through the air. While there are many types of radiation, they all fall into one of two classes: ionizing or non-ionizing. The primary difference between the two is that ionizing radiation is able to change the atoms to which it is exposed by removing electrons. That's an important distinction, because human cells are made up of atoms, so they can be affected by ionizing radiation.

Although non-ionizing radiation can cause atoms to move or vibrate, it cannot remove electrons. Non-ionizing radiation is all around us - in forms as diverse as radio waves and visible light - and we use many of those forms in our daily life. When you put a sandwich in a microwave oven, non-ionizing radiation causes the atoms in the sandwich to vibrate and warm up. While the temperature and texture of the sandwich changes, its atoms remain the same, so it's safe to eat.

Similarly, when you place a call with a cell phone, non-ionizing radio waves travel from the phone to the nearest tower to connect you with other towers and, eventually, the person you're calling.

When people talk about the hazards of radiation, they're generally referring to ionizing radiation. It's called that because when it removes electrons from atoms, it creates charged particles that are known as ions. If ions are used in a controlled manner, they can serve very useful purposes, whether that's generating electricity or wiping out cancer cells in the body. But when the body is exposed in other ways, those useful ions can become quite damaging.

There are three basic types of ionizing radiation: alpha particles, beta particles, and a group that includes gamma rays and x-rays. Each operates at different frequencies and has different effects.

For example, when used with special film, x-rays can be sent through an object such as person's arm or a welded pipe. Areas in the object that are denser will absorb the x-rays, so fewer of them will reach the film, which creates a lighter image. The resulting dark areas can pinpoint problems such as fractures, whether that's in a pipe or a human bone.

How does radiation affect people?

While all forms of ionizing radiation can have significant health effects, the potential impact depends upon the type of radiation and the amount to which a person is exposed. The different types of radiation affect different kinds of tissue in the body, primarily because of the amount of energy involved and the nature of each type of radiation. As an example, if a person is exposed to equal amounts of alpha and gamma radiation, the alpha particles will concentrate their energy in a much smaller area, and the gamma rays will spread out.

Ionizing radiation can affect any type of living tissue in humans. The severity of the damage from radiation depends upon both the amount of radiation being received and the amount of time involved. What are known as stochastic health effects are those that result from long-term exposure to low levels of ionizing radiation.

The most common of these is the various forms of cancer. A healthy body is able to regulate the growth of new cells and repair those that have been damaged. But when radiation causes damage that affects those regulation and repair processes, cells can grow at an uncontrolled rate. That uncontrolled growth is what we call cancer.

Another type of stochastic effect involves changes to DNA, which is the set of instructions that tells our cells how to form and behave. Changing DNA creates what are known as mutations. Some mutations affect only the individual who has been exposed to radiation, while others can be passed on through the womb to children.

Non-stochastic health effects are usually the result of exposure to significantly higher levels of radiation, often for a very short time. The effects include burns and what's known as radiation "poisoning," which can be fatal. High doses of radiation can destroy bone marrow, shut down the nervous and/or digestive system, and lead to the loss of limbs.

Radiation in the workplace

In industrial settings, radiation can be used in testing devices, for sterilization of products, for determining the level of moisture in soils, in weapons production, and in

nuclear power plants. None of those uses is inherently dangerous, as long as all of the required safety devices and processes are in place and used properly. Those who work with radiation need to understand the safety procedures, the consequences of failing to follow them, and actions to take in the event of an incident.

Fortunately, the radiation levels encountered in the workplace tend to be very small. In fact, the levels that are high enough to cause non-stochastic health effects don't occur in workplaces.

Being safe around radiation

Effective safety training focuses on the three ways workers can limit their exposure to radiation:

i maintaining a safe distance from the source,

iili miting the time around the source, and

iii using shielding to limit the exposure. Workers should also know what to do when something goes wrong.

Depending upon the work conditions and the type of radioactive material, other safety measures may also be needed. One example is the use of dosimeters that measure radiation on a cumulative basis and sound an alarm when specific thresholds are reached. If workers are around radioactive dust, respirators may be used to keep the dust from being inhaled. Gloves or other kinds of personal protective equipment may also be needed.

Like fire, radiation can be both a valuable tool and a serious danger. As with fire, there's no need to be afraid of radiation, but it's good to develop a healthy respect for its power and to follow practices that minimize the potential danger.

Basic philosopting of safety

Objectives: At the end of this lesson you shall be able to

- **list out about parameters governing safety in construction**
- **explain about general safety precautions related to construction industry and safety in the use of construction machinery**
- **state about the Industrial lighting**
- **describe lighting, ventilation, heat,stress, cold stress, noise vibration.**

1 Parameters governing safety in construction: Safety is a critical issue in the construction industry. Although it has been broadly researched from many perspectives, continuous improvement in safety performance is now facing challenges. A safety plateau or the stagnating improvement in safety performance has been observed in many countries or regions.

There are many factors affecting safety performance in the construction industry, mainly including individual factors (e.g. age and work experience) and organizational factors (e.g. technical and economic factors) . This research investigated the impact of two organizational factors and two individual factors on the safety outcomes of construction workers (Fig 1). The two organizational factors are: safety climate and organizational resilience. The two individual factors are individual resilience (IR) and interpersonal conflicts at work (ICW). The hierarchy of safety performance terminology used herein is provided in Fig 2.

- Safety climate: the shared perception of people toward safety in their work environment
- Organizational resilience: a capacity for positive response and healing capabilities to maintain normal operations and a high level of safety during stress and disturbance
- Individual resilience: people's proactive psychological capability that helps them to deal with adverse events and risks
- Interpersonal conflicts at work: negative interactions with others in the workplace

Fig 1

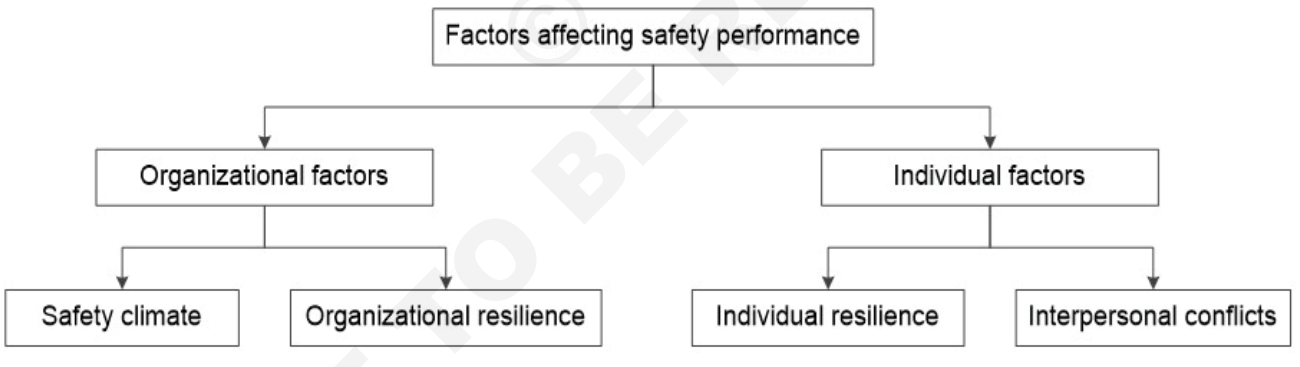
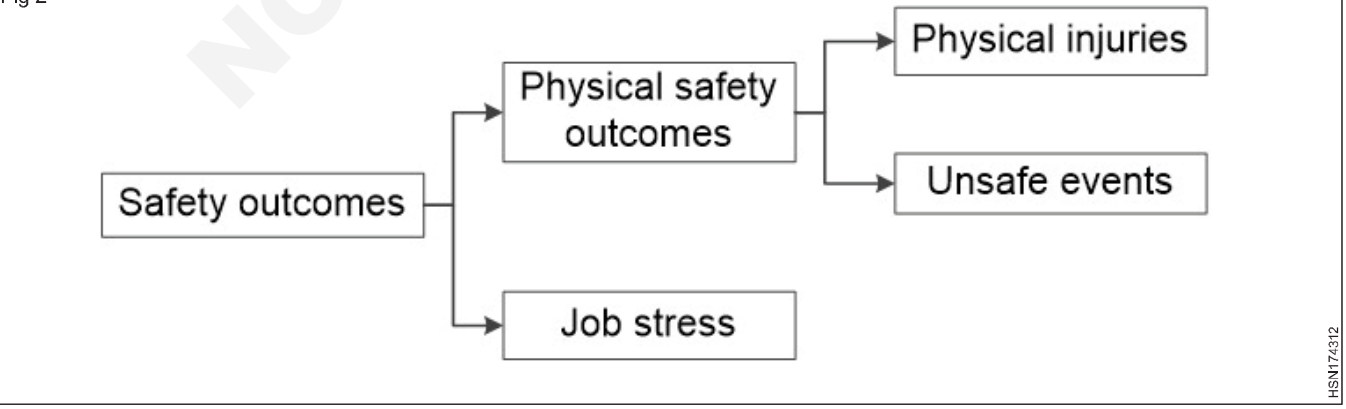


Fig 2



2 General safety precautions related to construction industry and safety in the use of construction machinery.

Hazards & Solutions: For construction, the 10 OSHA standards most frequently included in the agency's citations in FY 2004 were:

1 Scaffolding

2 Fall protection (scope, application, definitions)

3 Excavations (general requirements)

4 Ladders

5 Head protection

6 Excavations (requirements for protective systems)

7 Hazard communication

8 Fall protection (training requirements)

9 Construction (general safety and health provisions)

10 Electrical (wiring methods, design and protection)

a Scaffolding

Hazard: When scaffolds are not erected or used properly, fall hazards can occur. About 2.3 million construction workers frequently work on scaffolds. Protecting these workers from scaffold-related accidents would prevent an estimated 4,500 injuries and 50 fatalities each year.

Solutions

- Scaffold must be sound, rigid and sufficient to carry its own weight plus four times the maximum intended load without settling or displacement. It must be erected on solid footing.
- Unstable objects, such as barrels, boxes, loose bricks or concrete blocks must not be used to support scaffolds or planks.
- Scaffold must not be erected, moved, dismantled or altered except under the supervision of a competent person.
- Scaffold must be equipped with guardrails, midrails and toeboards.
- Scaffold accessories such as braces, brackets, trusses, screw legs or ladders that are damaged or weakened from any cause must be immediately repaired or replaced.
- Scaffold platforms must be tightly planked with scaffold plank grade material or equivalent.
- A "competent person" must inspect the scaffolding and, at designated intervals, reinspect it.
- Rigging on suspension scaffolds must be inspected by a competent person before each shift and after any occurrence that could affect structural integrity to ensure that all connections are tight and that no damage to the rigging has occurred since its last use.
- Synthetic and natural rope used in suspension scaffolding must be protected from heat-producing sources.
- Employees must be instructed about the hazards of using diagonal braces as fall protection.
- Scaffold can be accessed by using ladders and stairwells.
- Scaffolds must be at least 10 feet from electric power lines at all times. (Fig 3)

Fig 3

HSN174313

b Fall Protection

Hazard: Each year, falls consistently account for the greatest number of fatalities in the construction industry. A number of factors are often involved in falls, including unstable working surfaces, misuse or failure to use fall protection equipment and human error. Studies have shown that using guardrails, fall arrest systems, safety nets, covers and restraint systems can prevent many deaths and injuries from falls.

Solutions

- Consider using aerial lifts or elevated platforms to provide safer elevated working surfaces;
- Erect guardrail systems with toeboards and warning lines or install control line systems to protect workers near the edges of floors and roofs;
- Cover floor holes; and/or
- Use safety net systems or personal fall arrest systems (body harnesses). (Fig 4)

c Ladders

Hazard: Ladders and stairways are another source of injuries and fatalities among construction workers. OSHA estimates that there are 24,882 injuries and as many as 36 fatalities per year due to falls on stairways and ladders used in construction. Nearly half of these injuries were serious enough to require time off the job.

Fig 4

HSN174314

Solutions

- Use the correct ladder for the task.
- Have a competent person visually inspect a ladder before use for any defects such as:
- Structural damage, split/bent side rails, broken or missing rungs/steps/cleats and missing or damaged safety devices;
- Grease, dirt or other contaminants that could cause slips or falls;
- Paint or stickers (except warning labels) that could hide possible defects
- Make sure that ladders are long enough to safely reach the work area.
- Mark or tag ("Do Not Use") damaged or defective ladders for repair or replacement, or destroy them immediately.
- Never load ladders beyond the maximum intended load or beyond the manufacturer's rated capacity.
- Be sure the load rating can support the weight of the user, including materials and tools.
- Avoid using ladders with metallic components near electrical work and overhead power lines.

d Stairways

Hazard: Slips, trips and falls on stairways are a major source of injuries and fatalities among construction workers.

Solutions:

- Stairway treads and walkways must be free of dangerous objects, debris and materials.
- Slippery conditions on stairways and walkways must be corrected immediately.
- Make sure that treads cover the entire step and landing.
- Stairways having four or more risers or rising more than 30 inches must have at least one handrail. (Fig 5)

Fig 5

HSN174315

e Trenching

Hazard: Trench collapses cause dozens of fatalities and hundreds of injuries each year. Trenching deaths rose in 2003.

Solutions

- Never enter an unprotected trench.
- Always use a protective system for trenches feet deep or greater.
- Employ a registered professional engineer to design a protective system for trenches 20 feet deep or greater.
- Protective Systems:
- Sloping to protect workers by cutting back the trench wall at an angle inclined away from the excavation not steeper than a height/depth ratio of 11 2 :1, according to the sloping requirements for the type of soil.
- Shoring to protect workers by installing supports to prevent soil movement for trenches that do not exceed 20 feet in depth.
- Shielding to protect workers by using trench boxes or other types of supports to prevent soil cave-ins. (Fig 6)

Fig 6

HSN174316

- Always provide a way to exit a trench--such as a ladder, stairway or ramp--no more than 25 feet of lateral travel for employees in the trench.
- Keepspoils at least two feet back from the edge of a trench.
- Make sure that trenches are inspected by a competent person prior to entry and after any hazard-increasing event such as a rainstorm, vibrations or excessive surcharge loads.

f Cranes

Hazard: Significant and serious injuries may occur if cranes are not inspected before use and if they are not used properly. Often these injuries occur when a worker is struck by an overhead load or caught within the crane's swing radius. Many crane fatalities occur when the boom of a crane or its load line contact an overhead power line.

Solutions

- Check all crane controls to insure proper operation before use.
- Inspect wire rope, chains and hook for any damage.
- Know the weight of the load that the crane is to lift.
- Ensure that the load does not exceed the crane's rated capacity.
- Raise the load a few inches to verify balance and the effectiveness of the brake system.
- Check all rigging prior to use; do not wrap hoist ropes or chains around the load.
- Fully extend outriggers.
- Do not move a load over workers.
- Barricade accessible areas within the crane's swing radius.
- Watch for overhead electrical distribution and transmission lines and maintain a safe working clearance of at least 10 feet from energized electrical lines.

g Hazard Communication

Hazard: Failure to recognize the hazards associated with chemicals can cause chemical burns, respiratory problems, fires and explosions.

Solutions:

- Maintain a Material Safety Data Sheet (MSDS) for each chemical in the facility.
- Make this information accessible to employees at all times in a language or formats that are clearly understood by all affected personnel.
- Train employees on how to read and use the MSDS.
- Follow manufacturer's MSDS instructions for handling hazardous chemicals.
- Train employees about the risks of each hazardous chemical being used.
- Provide spill clean-up kits in areas where chemicals are stored.
- Have a written spill control plan.
- Train employees to clean up spills, protect themselves and properly dispose of used materials.
- Provide proper personal protective equipment and enforce its use.
- Store chemicals safely and securely.

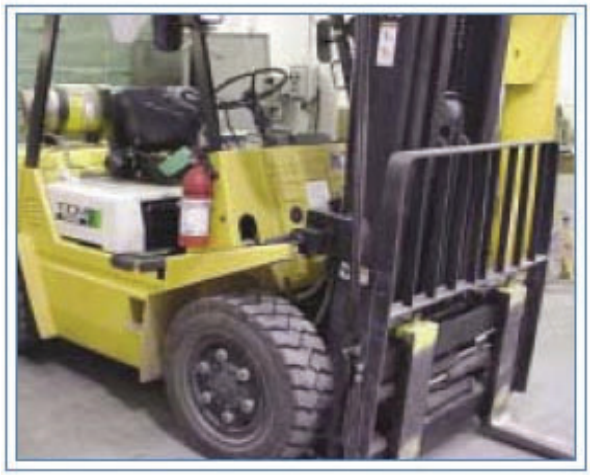
h Forklifts

Hazard: Approximately 100 employees are fatally injured and approximately 95,000 employees are injured every year while operating powered industrial trucks. Forklift turnover accounts for a significant number of these fatalities.

Solutions:

- Train and certify all operators to ensure that they operate forklifts safely.
- Do not allow any employee under 18 years old to operate a forklift.
- Properly maintain haulage equipment, including tires.
- Do not modify or make attachments that affect the capacity and safe operation of the forklift without written approval from the forklift's manufacturer.
- Examine forklift truck for defects before using.
- Follow safe operating procedures for picking up, moving, putting down and stacking loads.
- Drive safely--never exceed 5 mph and slow down in congested or slippery surface areas.
- Prohibit stunt driving and horseplay.
- Do not handle loads that are heavier than the capacity of the industrial truck.
- Remove unsafe or defective forklift trucks from service. (Fig 7)

Fig 7



- Operators shall always wear seatbelts.
- Avoid traveling with elevated loads.
- Assure that rollover protective structure is in place.
- Make certain that the reverse signal alarm is operational and audible above the surrounding noise level.

i Head Protection

Hazard: Serious head injuries can result from blows to the head.

Solution:

- Be sure that workers wear hard hats where there is a potential for objects falling from above, bumps to their heads from fixed objects, or accidental head contact with electrical hazards.

j Safety Checklists

The following checklists may help you take steps to avoid hazards that cause injuries, illnesses and fatalities. As always, be cautious and seek help if you are concerned about a potential hazard.

Personal Protective Equipment (PPE)

Eye and Face Protection

- Safety glasses or face shields are worn anytime work operations can cause foreign objects getting into the eye such as during welding, cutting, grinding, nailing (or when working with concrete and/or harmful chemicals or when exposed to flying particles).
- Eye and face protectors are selected based on anticipated hazards.
- Safety glasses or face shields are worn when exposed to any electrical hazards including work on energized electrical systems.

Foot Protection

- Construction workers should wear work shoes or boots with slip-resistant and puncture-resistant soles.
- Safety-toed footwear is worn to prevent crushed toes when working around heavy equipment or falling objects.

Hand Protection

- Gloves should fit snugly.
- Workers wear the right gloves for the job (for example, heavy-duty rubber gloves for concrete work, welding gloves for welding, insulated gloves and sleeves when exposed to electrical hazards).

Head Protection

- Workers shall wear hard hats where there is a potential for objects falling from above, bumps to their heads from fixed objects, or of accidental head contact with electrical hazards.
- Hard hats are routinely inspected for dents, cracks or deterioration.
- Hard hats are replaced after a heavy blow or electrical shock.
- Hard hats are maintained in good condition.

Scaffolding

- Scaffolds should be set on sound footing.
- Damaged parts that affect the strength of the scaffold are taken out of service.
- Scaffolds are not altered.
- All scaffolds should be fully planked.
- Scaffolds are not moved horizontally while workers are on them unless they are designed to be mobile and workers have been trained in the proper procedures.
- Employees are not permitted to work on scaffolds when covered with snow, ice, or other slippery materials.
- Scaffolds are not erected or moved within 10 feet of power lines.
- Employees are not permitted to work on scaffolds in bad weather or high winds unless a competent person has determined that it is safe to do so.
- Ladders, boxes, barrels, buckets or other makeshift platforms are not used to raise work height.
- Extra material is not allowed to build up on scaffold platforms.
- Scaffolds should not be loaded with more weight than they were designed to support.

Electrical Safety

- Work on new and existing energized (hot) electrical circuits is prohibited until all power is shut off and grounds are attached.
- An effective Lockout/Tagout system is in place.
- Frayed, damaged or worn electrical cords or cables are promptly replaced.
- All extension cords have grounding prongs.
- Protect flexible cords and cables from damage. Sharp corners and projections should be avoided.
- Use extension cord sets used with portable electric tools and appliances that are the three-wire type and designed for hard or extra-hard service. (Look for some of the following letters imprinted on the casing: S, ST, SO, STO.)
- All electrical tools and equipment are maintained in safe condition and checked regularly for defects and taken out of service if a defect is found.

- Do not bypass any protective system or device designed to protect employees from contact with electrical energy.
- Overhead electrical power lines are located and identified.
- Ensure that ladders, scaffolds, equipment or materials never come within 10 feet of electrical power lines.
- All electrical tools must be properly grounded unless they are of the double insulated type.
- Multiple plug adapters are prohibited.

Floor and Wall Openings

- Floor openings (12 inches or more) are guarded by a secured cover, a guardrail or equivalent on all sides (except at entrances to stairways).
- Toeboards are installed around the edges of permanent floor openings (where persons may pass below the opening).

Elevated Surfaces

- Signs are posted, when appropriate, showing the elevated surface load capacity.
- Surfaces elevated more than 48 inches above the floor or ground have standard guardrails.
- All elevated surfaces (beneath which people or machinery could be exposed to falling objects) have standard 4-inch toeboards.
- A permanent means of entry and exit with handrails is provided to elevated storage and work surfaces.
- Material is piled, stacked or racked in a way that prevents it from tipping, falling, collapsing, rolling or spreading.

Hazard Communication

- A list of hazardous substances used in the workplace is maintained and readily available at the worksite.
- There is a written hazard communication program addressing Material Safety Data Sheets (MSDS), labeling and employee training.
- Each container of a hazardous substance (vats, bottles, storage tanks) is labeled with product identity and a hazard warning(s) (communicating the specific health hazards and physical hazards).
- Material Safety Data Sheets are readily available at all times for each hazardous substance used.
- There is an effective employee training program for hazardous substances.

Crane Safety

- Cranes and derricks are restricted from operating within 10 feet of any electrical power line.
- The upper rotating structure supporting the boom and materials being handled is provided with an electrical ground while working near energized transmitter towers.
- Rated load capacities, operating speed and instructions are posted and visible to the operator.
- Cranes are equipped with a load chart.
- The operator understands and uses the load chart.
- The operator can determine the angle and length of the crane boom at all times.
- Crane machinery and other rigging equipment is inspected daily prior to use to make sure that it is in good condition.
- Accessible areas within the crane's swing radius are barricaded.
- Tag lines are used to prevent dangerous swing or spin of materials when raised or lowered by a crane or derrick.
- Illustrations of hand signals to crane and derrick operators are posted on the job site.
- The signal person uses correct signals for the crane operator to follow.
- Crane outriggers are extended when required.
- Crane platforms and walkways have antiskid surfaces.
- Broken, worn or damaged wire rope is removed from service.
- Guardrails, hand holds and steps are provided for safe and easy access to and from all areas of the crane.
- Load testing reports/certifications are available.
- Tower crane mast bolts are properly torqued to the manufacturer's specifications.
- Overload limits are tested and correctly set.
- The maximum acceptable load and the last test results are posted on the crane.
- Initial and annual inspections of all hoisting and rigging equipment are performed and reports are maintained.
- Only properly trained and qualified operators are allowed to work with hoisting and rigging equipment.

Forklifts

- Forklift truck operators are competent to operate these vehicles safely as demonstrated by their successful completion of training and evaluation.
- No employee under 18 years old is allowed to operate a forklift.
- Forklifts are inspected daily for proper condition of brakes, horns, steering, forks and tires.

- Powered industrial trucks (forklifts) meet the design and construction requirements established in American National Standards Institute (ANSI) for Powered Industrial Trucks, Part II ANSI B56.1-1969.
- Written approval from the truck manufacturer is obtained for any modification or additions which affect capacity and safe operation of the vehicle.
- Capacity, operation and maintenance instruction plates, tags or decals are changed to indicate any modifications or additions to the vehicle.
- Battery charging is conducted in areas specifically designated for that purpose.
- Material handling equipment is provided for handling batteries, including conveyors, overhead hoists or equivalent devices.
- Reinstalled batteries are properly positioned and secured in the truck.
- Smoking is prohibited in battery charging areas.
- Precautions are taken to prevent open flames, sparks or electric arcs in battery charging areas.
- Refresher training is provided and an evaluation is conducted whenever a forklift operator has been observed operating the vehicle in an unsafe manner and when an operator is assigned to drive a different type of truck.
- Load and forks are fully lowered, controls neutralized, power shut off and brakes set when a powered industrial truck is left unattended.
- There is sufficient headroom for the forklift and operator under overhead installations, lights, pipes, sprinkler systems, etc.
- Overhead guards are in place to protect the operator against falling objects.
- Trucks are operated at a safe speed.
- All loads are kept stable, safely arranged and fit within the rated capacity of the truck.
- Unsafe and defective trucks are removed from service.

3 Introduction to lighting, ventilation, heat, stress, cold stress, noise vibration.

a Noise: Noise also presents a fairly common workplace hazard: occupational hearing loss is the most common work-related injury. Noise is not the only source of occupational hearing loss; exposure to chemicals such as aromatic solvents and metals including lead, arsenic, and mercury can also cause hearing loss.

Naturally, noise is more of concern for certain occupations than others; musicians, mine workers and construction workers are exposed to higher and more constant levels of noise and therefore are at a higher risk of developing hearing loss. Since noise-induced hearing loss, while entirely preventable, is permanent and irreversible, it is vital that companies and their employees are aware of limits and prevention methods available.

b Cold stress: Overexposure to freezing conditions or extreme cold can result in a risk to many workers. Employees who work outdoors in the winter months such as fishers, hunters, divers, hydro and telecommunications linemen, construction workers, transportation workers, military personnel, emergency response workers, and those work in the refrigerated warehouse are especially vulnerable to cold.Effects of extreme cold working conditions include:

- Nonfreezing injuries - chilblains, trench foot
- Freezing injuries - frostbite and frostnip
- Hypothermia
- Lower work efficiency
- Higher accident rates
- Impaired performance of complex mental tasks
- Reduced muscular strength and stiffened joints
- Reduced mental alertness
- Impaired manual tasks because of sensitivity and dexterity of fingers

Use of personal protective equipment such as insulating clothes, gloves, boots, and masks, radiant heaters as a part of engineering controls and safe work practices are used to minimize the risk of cold injuries.

c Heat stress: Workers who are working in laundries, bakeries, restaurant kitchens, steel foundries, glass factories, brick-firing and ceramic plants, electrical utilities, smelters, and outdoor workers such as construction workers, firefighters, farmers, and mining workers are more vulnerable to exposure to extreme heat. Effects of heat stress include:

- Increased irritability
- Dehydration
- Heat stroke
- Chronic heat exhaustion
- Cramps, rashes, and burns
- Sweaty palms and dizziness
- Increased risk of other accidents
- Loss of concentration and ability to do mental tasks and heavy manual work
- Sleep disturbances, sickness, and susceptibility to minor injuries

Engineering controls such as air conditioning and ventilation, training to build up a level of tolerance to work

in extreme heat conditions and use of cooled protective clothing can help to reduce heat-related illnesses.

d Vibration: Vibration has long been recognized as a serious occupational hazard. Continuously repeated exposure to high levels of vibration results in injuries or illnesses. Vibration exposure is classified into two general types: hand-arm and whole-body vibration.

Hand-arm vibration causes direct injury to the fingers and hand and affects feeling, dexterity, and grip of the hand. It is a known causative factor for other ergonomic-related fatalities. Hand-arm vibration injury associated with use of appliances or equipment with vibration such as grinders, impact drills, chipping hammers, pavement breakers, dental tools, sanders, air-powered wrenches, and saws of all types.

Repeated long time use of vibrating machinery results in long term effect- independent vascular, neurosensory and musculoskeletal disorders of the hand and arm which is known as Hand-arm vibration Syndrome (HAVS).Whole-body vibration is one of the most common causes of lost time and production output and causes low back pain and injury and due to higher than expected levels of vibration. Whole-body vibration injuries associated with off-road vehicles in industries such as agriculture, forestry, mining, quarrying and with small-fast boats used off-shore.

A Combination of control measures such as redesigning the appliances to reduce vibration exposure, using machines that are designed to decrease the vibration transmitted to the operator, implementing speed limits, scheduling regular work breaks, posture changes or job rotation to reduce exposure time, providing training, information and supervision on adjusting and operating equipment can be used for successful vibration exposure reduction.

e Ventilation

Ventilation Fresh air is need respiration, to dilute and remove impurities and odours and to dissipate excess heat. Legislation requires that every enclosed workplace has effective and suitable ventilation, which provides a sufficient quantity of fresh or purified air. In many cases windows or other openings will provide sufficient ventilation. If they do not mechanical ventilation systems may have to be used. Replacement air should be as free of impurities as possible. Air inlets should be sited where they can draw fresh air; they should not therefore be sited near ant source of fumes or other impurities. Re-circulated air (e.g. in air conditioning systems) should be adequately filtered to remove impurities and the purified air should have some fresh air added. Care should be taken to ensure people are not exposed to drafts.

f Lighting

Lighting should be sufficient to enable to work, use facilities and move about safely and without eye strain and other ill health effects. Legislation requires that every workplace has suitable and sufficient lighting and it shall, as far as it is reasonable practicable, be by natural lighting.

Good lighting conditions involve:

Maximum provision of natural daylight.

Careful planning to minimise the effect of shadows.

Maximum control by individual workers of ambient lighting, (e.g. by the provision of desk lights).

Selection of suitable lighting for the task being performed, (e.g. very intricate work may need additional lighting).

Avoidance of dazzle or glare, including natural light, by the repositioning of the lighting or the workplace.

Additionally there should be suitable and sufficient emergency lighting where people are especially exposed to danger if the artificial lighting fails.

Electrical safety

Objectives: At the end of this lesson you shall be able to
- **list out the various techniques of earthing fault protection**
- **describe the risk assessment records and controls**
- **define the hazards and their preventive measures.**

1 **Electrical hazards:** Here are 7 of the most common electrical hazards in the workplace and tips on what you can do to mitigate these risks:

a **Overhead power lines:** Overhead powered and energized electrical lines have high voltages which can cause major burns and electrocution to workers. Remember to maintain a minimum distance of 10 feet from overhead power lines and nearby equipment. Conduct site surveys to ensure that nothing is stored under overhead power lines. Also, safety barriers and signs must be installed to warn nearby non-electrical workers of the hazards present in the area.

b **Damaged tools and equipment:** Exposure to damaged electrical tools and equipment can be very dangerous. Do not fix anything unless you are qualified to do so. Thoroughly check for cracks, cuts or abrasions on cables, wires, and cords.

c **Inadequate wiring and overloaded circuits:** Using wires with inappropriate size for the current can cause overheating and fires to occur. Use the correct wire suitable for the operation and the electrical load to work on. Use the correct extension cord designed for heavy-duty use. Also, do not overload an outlet and use proper circuit breakers. Perform regular fire risk assessments to identify areas at risk of of bad wiring and circuits.

d **Exposed electrical parts:** Examples of exposed electrical parts include temporary lighting, open power distribution units, and detached insulation parts on electrical cords. These hazards can cause potential shocks and burns. Secure these items with proper guarding mechanisms and always check for any exposed parts to be repaired immediately.

e **Improper grounding:** The most common OSHA electrical violation is the improper grounding of equipment. Proper grounding can eliminate unwanted voltage and reduce the risk of electrocution. Never remove the metallic ground pin as it is responsible for returning unwanted voltage to the ground.

f **Damaged insulation:** Defective or inadequate insulation is a hazard. Be aware of damaged insulation and report it immediately. Turn off all power sources before replacing damaged insulation and never attempt to cover them with electrical tape.

g **Wet Conditions:** Never operate electrical equipment in wet locations. Water greatly increases the risk of electrocution especially if the equipment has damaged insulation. Have a qualified electrician inspect electrical equipment that has gotten wet before energizing it.

Knowing your limits and applying the best electrical safety practices can help reduce the risk of electrical shock and death. It is safer to work within your scope of expertise instead of taking the risk of working beyond your capacity. If you are not confident to do the job, don't hesitate to call for help from an authorized person.

2 **Static Electricity:** Static electricity is an imbalance of electric charges within or on the surface of a material. The charge remains until it is able to move away by means of an electric current or electrical discharge. Static electricity is named in contrast with current electricity, which flows through wires or other conductors and transmits energy.

A static electric charge can be created whenever two surfaces contact and have worn and separated, and at least one of the surfaces has a high resistance to electric current (and is therefore an electrical insulator). The effects of static electricity are familiar to most people because people can feel, hear, and even see the spark as the excess charge is neutralized when brought close to a large electrical conductor (for example, a path to ground), or a region with an excess charge of the opposite polarity (positive or negative).

Causes: When two materials are in contact, electrons may move from one material to the other, which leaves an excess of positive charge on one material, and an equal negative charge on the other. When the materials are separated they retain this charge imbalance.

This is known as the triboelectric effect and results in one material becoming positively charged and the other negatively charged. The triboelectric effect is the main cause of static electricity as observed in everyday life,

Pressure-induced charge separation: Applied mechanical stress generates a separation of charge in certain types of crystals and ceramics molecules.

Heat-induced charge separation: Heating generates a separation of charge in the atoms or molecules of certain materials. All pyroelectric materials are also piezoelectric. The atomic or molecular properties of heat and pressure response are closely related.

Charge-induced charge separation: Charges of the same polarity are repelled and charges of the opposite polarity are attracted. The effect is most pronounced when the neutral object is an electrical conductor as the charges

are more free to move around. Careful grounding of part of an object with a charge-induced charge separation can permanently add or remove electrons, leaving the object with a global, permanent charge.

3 **Identification and Zoning of Hazardous area:** Places of work generally have power nominally supplied at 230 volt (single phase) and 400 volt (3 phase) although some larger workplaces will receive electricity at a higher supply voltage. The information below relates to workplaces using 230 and 400 volt supplies.

The main hazards with electricity are

- contact with live parts causing shock and burns
- faults which could cause fires;
- fire or explosion where electricity could be the source of ignition in a potentially flammable or explosive atmosphere,

a **Controlling the risk:** The risk of injury from electricity is strongly linked to where and how it is used and there is greater risk in wet and/or damp conditions.

b **Reduce the Voltage:** Often portable equipment is available that is powered from a 110 volt supply through a simple transformer and these are often centre tapped to earth so that the maximum voltage between a live conductor and earth (the most common cause of electric shocks from equipment) is limited to 55V.

Battery operated tools such as drills, screwdrivers etc can replace mains powered equipment.

- Temporary and hand held lighting can be provided at 12, 25, 50 or 110 volts.

c **Ensure Fuses are correctly fitted**

- The fuse protects the device from over current. It is designed to 'blow' and cut off the electricity when the current exceeds its rated capacity. It is important to ensure the correct fuse is used for the appliance. As a general guide 3 amp fuses are used in equipment up to 700 watts (W). For equipment with a rating greater than 700 watts (W) a 13-amp fuse will be required. Always read the manufacturer's instructions.

4 **Classification of products:** If equipment operating at 230 volts or higher is used, an RCD (residual current device) can provide additional safety. RCD's are supplementary protection devices, which do not prevent an electrical shock, but are able to limit the duration of some shocks by enabling the rapid disconnection of the electricity supply, when an electrical shock takes place.

RCD's are mandatory on all circuits supplying portable equipment and on certain other circuits where the hazard of electricity is exacerbated by the proximity of water. An RCD is a device which detects some, but not all, faults in the electrical system and rapidly switches off the supply. The best place for an RCD is built into the main switchboard or the socket-outlet, as this means that the supply cables are permanently protected. If this is not possible then a plug incorporating a RCD, or a plug-in RCD adaptor can be used to provide additional safety.

- RCD's for protecting people have a rated tripping current (sensitivity) of not more than 30 milliamps (mA).
- an RCD is a valuable safety device, never bypass it;
- If the RCD trips, it is a sign there is a fault. Check the system before using it again;
- If the RCD trips frequently and no fault can be found in the system, consult the manufacturer of the RCD; (Fig 1)
- The RCD has a test button to check that its mechanism is free and functioning and should be used regularly.

Electrical power distribution in construction industry

The 2008 National Rules for Electrical Installations (Incorporating Amendment No 1 2011) as published by the ETCI (ET 101) sets out rules for new installations rather than for installations existing prior to the publication of these rules.

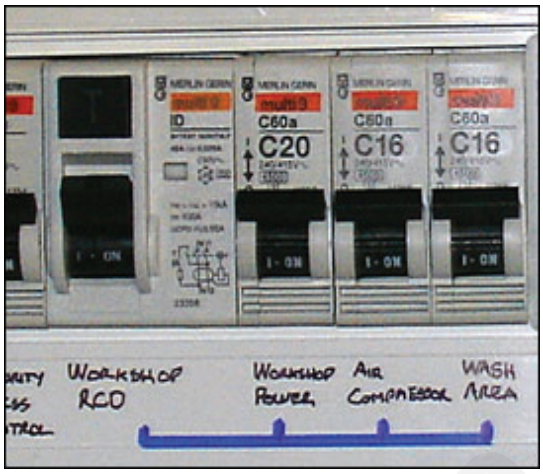
Part 531.2.1.3 point i) envisages a situation where type AC residual current devices (RCD's) are acceptable "where no significant DC current is present".

The HSA recognises that some DC element in the make-up of electrical consumption is becoming increasingly prevalent in many modern electrical installations. It is therefore expected that type A or Type B RCD's will become more common as preferred options for detecting residual currents than heretofore.

Preventative maintenance measures: All electrical equipment and installations should be maintained to prevent danger.

- This should include an appropriate system of visual inspection and, where necessary, testing. By concentrating on a simple, inexpensive system of looking for visible signs of damage or faults, most of the electrical risks can be controlled.
- It is recommended that fixed installations are inspected and tested periodically by a competent person. The frequency of inspections and any necessary testing will depend on the type of installation, how often it is used, and the environment in which it is used.
- Users can help by reporting any damage or defects they find.
- Ensure that people who are working with electricity are competent to do the job. Even simple tasks such as wiring a plug can lead to danger - ensure that people know what they are doing before they start.

Fig 1



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Examples of RCD (Residual circuit devices)

Excavations, demolitions and structural frames

Objectives: At the end of this lesson you shall be able to
- **list out the various safety measures of excavation work**
- **state the risk assessment records and controls during demolition and concrete work**
- **list out the hazards and their preventive measures at pile driving and work over water.**

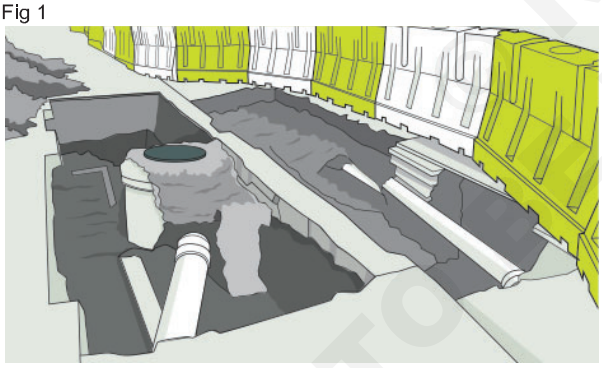
1 Excavation work: Excavation work generally means work involving the removal of soil or rock from a site to form an open face, hole or cavity, using tools, machinery or explosives.

Excavation work can occur anywhere, including
- on construction sites
- on business premises
- in public areas.

Excavation work includes
- open excavations
- potholing
- pit excavations
- trenches and retaining walls
- shafts and drives

a Open excavations (Fig 1)

Fig 1



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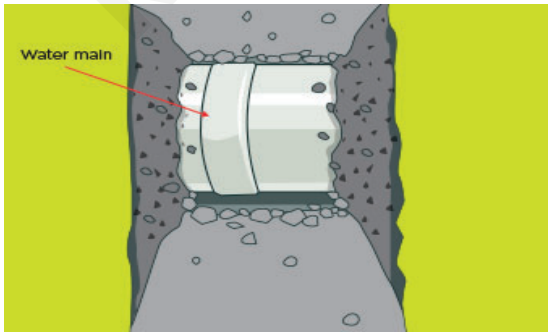
An excavation in open ground is an open excavation and can vary in shape and size.

c Pot holing (Fig 2)

Fig 2



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Pot hole

Potholing is usually a small excavation or inspection hole to find underground services.

d Pit excavations (Fig 3)

Fig 3

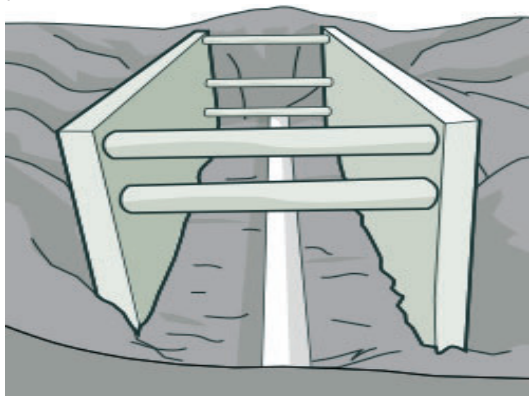
HSN185413

Pit excavations

Pit excavations are usually four-sided and deeper than the narrowest horizontal dimension at the surface. Pits are generally excavated to install manholes, pump stations, or underground tanks. They are also excavated to construct pile caps and other types of foundations or to access or locate existing services.

e Trenches and retaining walls (Fig 4)

Fig 4



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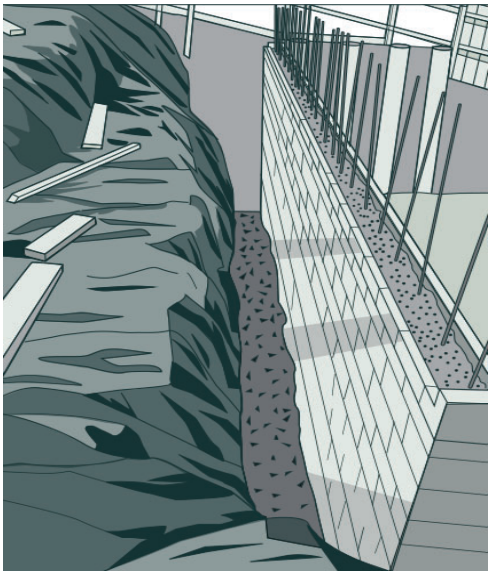
Trench

A trench is a long narrow excavation which is deeper than it is wide, and open to the surface along its length. Trenches are generally excavated to install or maintain underground services or to investigate what is beneath the surface.

When a retaining wall is built, an open excavation becomes a trench formed by an excavated face on one side, and a retaining wall on the other. Usually workers need to access this trench to work, for example for waterproofing the retaining wall.

Trench constructed by putting up a retaining wall (Fig 5)

Fig 5



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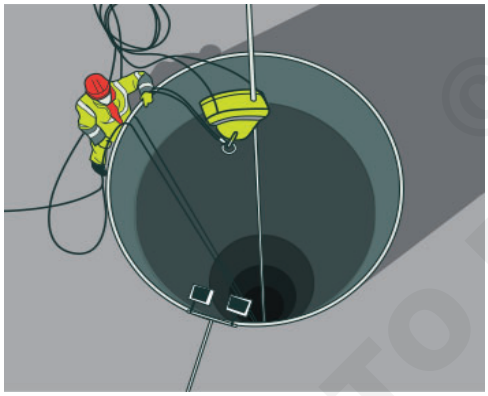
Trench constructed by putting up a retaining wall

f Shafts and drives (Fig 6)

Fig 6



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Shaft

Sinking a shaft involves constructing a vertical excavation with access and spoil removal from the top. Drives are small openings cut into the sides of trenches or shafts or elsewhere, for example, under roads. Cutting a drive is particularly hazardous as it introduces the risk of trapping workers with no alternative escape route.

Shafts and drives are often constructed to provide access or ventilation to a tunnel. Shallow shafts can be sunk for investigating or constructing foundations, dewatering, or providing openings to underground facilities.

2 Excavation Safety

To protect workers from injuries and fatalities, preventive measures should be implemented when workers begin excavating. According to OSHA, general safety measures to follow should cover the following:

1 Inspect trenches daily before work begins. Don't go near an unprotected trench.

2 Check weather conditions before work, be mindful of rain and storms.

3 Keep heavy equipment away from trench edges.

4 Be mindful of the location of utilities underground.

5 Always wear proper protective equipment.

6 Don't work beneath raised loads.

7 Conduct atmosphere tests. If low oxygen and toxic gases were detected, workers must not enter the trench.

8 Protective systems like benching, sloping, shoring and shielding must be created.

9 Planning and implementation of safety measures must be done by a competent person.

10 Use a checklist to perform regular self-inspections.

3 Demolitions Frame Work & Concrete Work (Fig 7)

Fig 7

HSN185417

Demolition work safety

Demolition is the dismantling, razing, destroying or wrecking of any building or structure or any part thereof. Demolition work involves many of the hazards associated with construction. However, demolition involves additional hazards due to unknown factors which makes demolition work particularly dangerous. These may include:

- Changes from the structure's design introduced during construction;
- Approved or unapproved modifications that altered the original design;
- Materials hidden within structural members, such as lead, asbestos, silica, and other chemicals or heavy metals requiring special material handling;
- Unknown strengths or weaknesses of construction materials, such as post-tensioned concrete;
- Hazards created by the demolition methods used.

Proper planning is essential to ensure a demolition operation is conducted with no accidents or injuries. This includes, but is not limited to:

- An engineering survey completed by a competent person before any demolition work takes place. This should include the condition of the structure and the possibility of an unplanned collapse.

- Locating, securing, and/or relocating any nearby utilities. For help, call 811 before you dig.
- Fire prevention and evacuation plan.
- First Aid and Emergency Medical Services.
- An assessment of health hazards completed before any demolition work takes place.

The employer must determine what Personal Protective Equipment (PPE) will be required. In demolition operations, PPE may include:

- Eye, face, head, hand, foot protection
- Respiratory protection
- Hearing protection
- Personal Fall Arrest Systems (PFAS)
- Other protective clothing (for example, cutting or welding operations)

It is not enough to provide PPE. Employees must be trained on the selection, use, fitting, inspection, maintenance, and storage of PPE.

4 Pile driving and work over water

In specifying the use of piles the designer should be aware of, and assess the risks from, the following principal hazards.

It is important that, where these risks cannot be eliminated or reduced during the design process and they are perceived as 'significant risks', details of them are passed to the principal contractor.

The prospective principal contractors must outline the control measures proposed in respect of these 'significant hazards' in the Construction Phase Plan. When a tender is accepted and the project reaches the construction phase the principal contractor must control the hazards and risks as outlined in his construction phase plan.

a Some possible hazards and risks

- Health hazards such as contact with contaminated risings or groundwater and contact with hazardous materials or dusts.
- Noise, vibration
- Contact with plant or machinery during lifting, slewing and pitching of piling elements. The movement of piling rigs etc.
- Plant instability caused by gradients, variable ground conditions, and/or inadequate bearing capacity
- Hazards of buried or overhead services
- Collapse of excavations, nearby structures etc.

b Considerations

The stability of the surrounding structures is a prime consideration. The method of piling used may well be influenced by this. All underground services should be located and made safe. A careful investigation should be undertaken to ensure there are no cellars, underground water courses, or ground conditions, which could lead to hazardous situations.

All workers on the operation should be trained in the particular method statement to be used.

All cranes, lifting appliances and lifting gear must have appropriate test certificates proving periodic statutory examination and must be adequate for the job in hand.

Such equipment should be placed on a firm level base and /or crane mats used. Consideration should be given to the risk of damage to lifting gear from sharp edges.

Noise and vibration are particular hazards and all persons associated with the operation should wear the appropriate protective clothing and equipment such as hard hats, eye and hearing protection.

Where it is necessary to raise or lower workers by crane such cranes should be fitted with a dead man's handle and all lowering should be done under power.

The workers should be carried in properly constructed cages which cannot spin or tip.

c Issues to be considered

Piling operation will need to take account of

- Ground conditions
- Identified buried features including cables and pipelines
- Stability of adjacent structures, both their foundations and superstructures. (Fig 8)

Fig 8

HSN185418

Piling work safety

Safety in melting and boilers

Objectives: At the end of this lesson you shall be able to
- **describe the various safety measures in melting industry and boilers,**
- **describe the risk assessment records and controls during the operation of boilers,**
- **explain the hazards and their preventive measures near boilers and melting industry**
- **explain the control measures for vapour clouds formation and workplace exposure Limit.**

1 Hazards in process of melting (Furnaces), Casing, and Forging

The main health risks that can be encountered in a foundry are:

- Electromagnetic radiation.
- Vision problems.
- Metal splashes.
- Injuries.
- Protective clothing.
- Do not walk backwards.
- Proper ventilation.
- Avoid moisture within the furnace.

a Main hazards while working with furnaces, kilns and oven are as under:

1 Burns due to contact with hot surfaces.

2 Burns due to contact with hot product, fuel or electricity.

3 Splashing or bubbling of molten metal.

4 Contact of cooling water with the molten metal or slag (e.g. induction furnace) and explosion due to sudden steam generation.

5 Fire or explosion due to leakage of fuel.

6 Carbon monoxide from fuel gas or products of combustion.

7 Explosion due to hydrogen.

b Precautions to be followed are as under:

1 Good insulation over hot metal surfaces.

2 Protective clothing for head, face, hands and feet.

3 Respirators, safety eye glass (plain or tinted) for protection against dust, fumes, toxic gases and glare.

4 Exhaust hoods and fans to draw dusts, fumes, gases etc.

5 Good ventilation to vent off hazardous waste generated from scrap charged alloys and fluxes.

6 Hot work permit before allowing any workers to enter any hot chamber. Insurances of cooling, fresh air ventilation and lighting necessary.

7 Interlocking to cut off fuel supply in case of flame failure.

8 Precautions while lighting fuel or burner to prevent flash back, fire or explosion.

9 Training and awareness programmes for workers.

10 Provisions of drinking water and shielding to avoid heat disorders.

11 Flameproof electric fitting with solvent drying ovens. PPE against eye and skin irritation or respiratory disorders.

12 Precautions against free silica, asbestos etc., while cleaning and maintaining furnaces. area monitoring and medical surveillance of such hazardous exposures.

c Steel manufacture, hazards and safety measures:

Iron occurs very abundantly constituting about 4.7% of the earth's crust. It is the fourth in abundance (first three are oxygen, silicon and aluminium) amongst all the elements. Amongst metals, its abundance is second only to aluminium.

The most important iron ores are iron oxides, carbonates and sulphides. Three commercial varieties of iron are cast iron, wrought iron and steel. They differ in their carbon and phosphorous content. Cast iron is the least pure form of iron containing 2.5 to 4.5% carbon with some sulphur, phosphorous, silicon and manganese. Wrought iron is the purest form of iron containing less than 0.5% carbon and other impurities.

2 Automatic manufacturing activity - grinding

A grinding machine, often shortened to grinder, is one of power tools or machine tools used.

For grinding, it is a type of machining using an abrasive wheel as the cutting tool. Each grain of abrasive on the wheel's surface cuts a small chip from the work piece via shear deformation. Grinding is used to finish work pieces that must show high surface quality (e.g., low surface roughness) and high accuracy of shape and dimension.

The grinding machine consists of a bed with a fixture to guide and hold the work piece, and a power-driven grinding

wheel spinning at the required speed. The grinding head can travel across a fixed work piece, or the work piece can be moved while the grind head stays in a fixed position.

Grinding machines remove material from the work piece by abrasion, which can generate substantial amounts of heat. To cool the work piece so that it does not overheat and go outside its tolerance, grinding machines incorporate a coolant. The coolant also benefits the machinist as the heat generated may cause burns.

a Automatic Manufacturing Activity - Machining & Chipping

- Cautions regarding the handling of cutting tool materials.
- Since carbide tool materials have high specific gravities, be careful to handle large products or large quantities as heavy materials.
- The thermal expansion of carbide tool materials is different from that of metal materials. Because of this, for shrink-fit or cooling-fit products, if the usage temperature is slightly higher (lower) than the specified temperature, cracking may occur.
- If cutting tool materials become corroded due to cutting fluid, lubricating agents, or other moisture, their strength will be reduced. Care should be taken regarding storage conditions.

3 Cautions regarding machining of cutting tool products (materials)

- For carbide tool materials, the strength may be slightly reduced due to the surface conditions. For finishing, always use a diamond grinder.

When cutting tool materials are ground or heated, dust or mist (smoke) occurs. If a lot of it is inhaled, swallowed, or comes in contact with the eyes or skin, it could result in injury to the body.

When machining, be careful to avoid exposing your body to the dust or mist; it is recommended that localized ventilation equipment be used and that a protective mask, protective goggles, and protective gloves be worn. In addition, if the dust, etc. comes in contact with your hands, wash them thoroughly with soap and water.

Do not drink or eat in the work area, and wash your hands before drinking or eating. Dust on clothes should not be shaken out; use a vacuum, etc. to remove the dust or wash the clothes in a washing machine.

If the cobalt contained in the cutting tool material is touched repeatedly or over a long period of time, it has been reported that it may affect the skin, respiratory organs, or heart

4 Precautions in control use of boilers

1 Hydraulic should be carried out at a defined pressure before the start of a boiler.

2 Check if the pump inlets are open at the start of a boiler.

3 Install an automatic ash removal system such as rotary valves in a boiler so as to prevent the accumulation of ash in a furnace or other equipment. The accumulation may result in the blockage or excessive heating of boiler parts resulting in its failure.

4 Pump priming must be done at the start of the boiler.

5 All loose and wrong connections must be checked and make sure to rectify the connections before starting your boiler.

6 A trained and a technical boiler operator must be hired for operating your boiler.

Precautions to be carried out regularly

1 Never operate boiler above the design pressure and check for the safe operation of Safety valves as well as fusible plugs.

2 Regular cleaning of the perforated line is necessary

3 Stainer must be installed before the pump & check for its proper functioning to remove dirt particles from boiler feed water as this prevents the blockage of a feed line.

4 Water must be treated before feeding it to the boiler to prevent the accumulation of dirt in a Boiler shell.

5 Regular inspection and maintenance of boiler including its accessories and valves to check for possible failures and cracks are necessary.

6 Make sure that the boiler vents are not restricted by any kind of obstruction such as cloth etc.

7 Always check for the leakages of steam, water, air and flue gases from any suspicious place.

8 Follow boiler manual for safe and efficient working of your boiler.

9 The panel should be cleaned regularly and should be kept in a cool and an isolated place away from your boiler.

10 Check if all the hot parts of the boiler are insulated, do not touch the parts with bare hands where the insulation is not provided.

11 Maintenance of both FD Fan and ID Fan is important and regularly check for greasing in all the movable parts for the ease of operation.

12 Regular cleaning of movable mechanical parts is necessary.

13 Do not increase the frequency of a drive above 50 Hz for the safe operation of motors.

14 Pressure switch and Pressure Gauge should be checked for their proper

Precautions to be carried out occasionally:

1 Occasionally clean the boiler tubes to prevent any ash deposition or scaling inside or outside the tubes. Failure to do so will affect the boiler efficiency and will eventually overheat the tubes leading to the tube leakage problems.

2 The ratio of primary and secondary air must be maintained in accordance with fuel feeding.

3 Periodically check burner operation back pressure and line pressure to prevent any thermal hazards.

Prevent the hazards existing in processes involving Explosive, Toxic Substances, Dusts & Gases

Dusts are solid particles ranging in size from below 1 µm up to around 100 µm, which may be or become airborne, depending on their origin, physical characteristics and ambient conditions.

5 Examples of hazardous dusts in the workplace include

a Mineral dusts from the extraction and processing of minerals (these often contain silica, which is particularly dangerous);

b Metallic dusts, such as lead and cadmium and their compounds;

c Other chemical dusts, such as bulk chemicals and pesticides;

d Vegetable dusts, such as wood, flour, cotton and tea, and pollens;

e Moulds and spores.

Asbestos is a mineral fibre, which is particularly dangerous, and is found, for example, in maintenance and demolition of buildings where it had been used as insulation material.

a Size fractions

In occupational hygiene, particle size is usually described in terms of the aerodynamic diameter, which is a measure of the particle's aerodynamic properties. Whether or not an airborne particle is inhaled depends on its aerodynamic diameter, the velocity of the surrounding air, and the persons' breathing rate.

How particles then proceed through the respiratory tract to the different regions of the lungs, and where they are likely to deposit, depend on the particle aerodynamic diameter, the airway dimensions and the breathing pattern. If a particle is soluble, it may dissolve wherever it deposits, and its components may then reach the blood stream and other organs and cause disease. This is the case, for example, of certain systemic poisons such as lead.

There are particles which do not dissolve, but cause local reactions leading to disease; in this instance, the site of deposition makes a difference. When a relatively large particle (say 30 µm) is inhaled, it is usually deposited in the nose or upper airways.

Finer particles may reach the gas-exchange region in the depths of the lungs, where removal mechanisms are less efficient. Certain substances, if deposited in this region, can cause serious disease, for example, free crystalline silica dust can cause silicosis. The smaller the aerodynamic diameter, the greater the probability that a particle will penetrate deep into the respiratory tract. Particles with an aerodynamic diameter > 10 µm are very unlikely to reach the gas-exchange region of the lung, but below that size, the proportion reaching the gas exchange region increases down to about 2 m. The depth of penetration of a fibre into the lung depends mainly on its diameter, not its length. As a consequence, fibres as long as 100 µm, have been found in the pulmonary spaces of the respiratory system.

Whenever exposure to airborne dust needs to be quantitatively evaluated, instruments must be used which select the right size range for the hazard concerned. There are conventions for the size ranges of particles to be measured; it is usual to collect either the inhalable fraction, i.e. everything that is likely to be inhaled, or the respirable fraction, i.e. the particles likely to reach the gas-exchange region of the lung. For example, if silica is present, it is necessary to measure the respirable fraction of the airborne dust.

b Dust generation

Mineral dusts are generated from parent rocks by any breaking down process, and vegetable dusts are produced by any dry treatment. Air movement around, into or out of granular or powdered material will disperse dust. Therefore handling methods for bulk materials, such as filling and emptying bags or transferring materials from one place to another, may constitute appreciable dust sources.

Coarse materials usually have a dust-sized component as a result of attrition. If dust clouds are seen in the air, it is almost certain that dust of potentially hazardous sizes is present. However, even if no dust cloud is visible, there may still be dangerous concentrations of dust present with a particle size invisible to the naked eye under normal lighting conditions.

Unless its generation is prevented or it is removed from the air, dust may move with ambient air and reach even persons who are remote from the source and whose exposure is unsuspected. Damp materials are less likely to release airborne dust, but of course this does not apply if they dry up later.

c Sources of exposure

Work processes likely to generate dust include the following:

1 Mining, quarrying, tunnelling, stone masonry, construction, and any process which breaks or separates solid material;

2 foundries and other metallurgical processes, especially the cleaning of casting and breaking of moulds;

3 Any process using abrasive blasting, such removal of paint and rust, cleaning of buildings and small objects, and etching of glass (N.B., use of sand for these processes is often unnecessary, and if uncontrolled can cause serious health impairment, and even fatalities, among the operators, even in a few months);

4 Manufacture of glass and ceramics;

5 Handling of powdered chemicals in the chemical, pesticide, rubber manufacturing and pharmaceutical industries;

6 Agricultural work involving exposure to soil, intensive animal husbandry, dry vegetable products, or agro-chemicals;

7 Food processing, especially where flour is used;

8 Any process involving weighing, bagging, bag-emptying or dry transport of powdered or friable materials.

d Fire and explosion

Any airborne flammable dust in sufficient concentrations can explode. Combustible dust on the ground may become airborne and increase and propagate an explosion which is started by flammable gas ignition.

Preventive measures include good housekeeping to prevent build-up of dust deposits, prevention of ignition, provision of explosion relief valves, dusting with non-flammable dusts, and confinement in low-oxygen environments.

e Recognizing and evaluating the problem

If any dusty process is being carried out, an assessment should be made to establish if people are at risk from dust exposure. This requires looking systematically at the workplace to see whether there is a problem and in general terms what could be done to prevent risk. The assessment should determine which hazardous materials are in use, in what amounts, and how much dust of which fraction may become airborne and lead to exposure, among other factors.

An initial "walk-through" survey of the workplace should be conducted. The controls in use should be examined to determine their effectiveness, and the eventual need for other or additional controls should be considered. Maintenance and cleaning procedures should be examined, to ensure that they are effective and do not give rise to excessive exposure.

The position of workers and the organization of their tasks should be appraised in view of the location and nature of the dust sources. The level of training and information of the workforce should also be assessed. It should be ensured that management favours work practices which reduce or eliminate risks. The advice from competent professionals, preferably occupational hygienists, should be sought; this is indispensable whenever dealing with complicated situations, or with hazardous substances.

Sampling for exposure assessment is usually carried out by means of a personal sampler, attached to the worker, and which consists of a pump (air mover) and a sampling head located in the worker's breathing zone. The sampling head consists of a filter holder, with a filter where the dust sample is collected, preceded by a pre-collector to separate the fraction of interest. Sampling heads should be designed to collect either the inhalable or respirable fraction of the airborne dust. The worker's average exposure during a shift or part of a shift, as laid down in the exposure limits, can then be estimated.

Other measurements may be helpful to understand where dust is coming from, or at what moment(s) of the work cycle it is being emitted.

These measurements may rely on fast-response direct-reading instruments, but simpler qualitative means such as forward light scattering (dust lamp) techniques to illuminate the dust, or smoke tubes to trace air movement, may be all that is needed. is emitted. There are systems that combine video imaging with dust concentration measurements, thus allowing the visualization of how exposure changes as workers perform their tasks. This is useful to evaluate the effectiveness of control systems and also to compare different controls (e.g. exhaust ventilation or wet methods).

f Control approaches and strategies

The prevention of occupational hazards is much more effective and usually cheaper if it is considered at the planning stage of any work process and workplace, rather than as control solutions of already existing hazardous situations.

This applies first to the planning of new processes or factories, to ensure that hazardous substances are only used if necessary.

If they are necessary, then emissions inside and outside the workplace, as well as waste generation, should be minimized, considering the whole life of the process and the products.

The workplace and the job should be planned so that hazardous exposure is either avoided or kept to an acceptable minimum.

Incentives should reward work practices which minimize exposure. The same considerations should apply to the introduction of new or modified processes and procedures. The order of priority should be to:

1 "Plan out" the exposure, by not using hazardous substances, or using them in such a way that no one is exposed;

2 If (1) does not completely prevent exposure, then prevent or minimize emission of the substances to the air;

3 If it is not possible to prevent exposure by any other method, then give personal protective equipment, including respiratory protective equipment (RPE), to the workers and other persons, as needed.

It is essential to adequately plan for supervision and maintenance, in order to ensure that controls are used and continue to be effective. Workplace control of exposure must be integrated with other measures, such as control of emissions to the atmosphere and waterways, and waste disposal, so that all these measures work together. Similarly, the control of any hazardous substance in the workplace should be part of an integrated control system encompassing other hazards, such as noise and heat, as well as the ergonomic design of tasks and workplaces.

Control of exposure to dusts, alongside other health and safety measures and environmental protection, should be a key priority of the top level management, and workers should continually be made aware that this is a

management priority. Incentive systems for supervisors and workers should be designed to encourage safe procedures and not just productivity.

g Elimination at the source

Elimination at the source can involve three different items:

i the production process,

ii the hazardous substance and

iii the work practices.

A production process can be changed by applying a production method which generates less dust. This is a sensible approach at the design stage of a production process or when production lines are changed due to the introduction of new product lines.

A hazardous substance may be eliminated by changing ithe process so that the substance is no longer needed, or by using a less hazardous substance as a substitute. It is, of course, necessary to assess all of the effects of the change, taking into account other hazards such as noise, and any effects on the performance of the product, particularly effects on its safety. If substances are changed, it will be necessary to assess and control any eventual new risks.

6 Control measures for vapour clouds formation and combating & Workplace Exposure Limit

The following control measures focus on actions and tactics that can be considered once a flammable material is in the vapour phase. Control measures for preventing vaporisation from an uncontained liquid will be considered under

iWhere flammable vapours are released under pressure, such as when escaping from a ruptured pressurised container, their temperature will drop rapidly. Because of this, even vapours that are lighter than air will sink to low-lying areas initially and therefore the highest concentrations of vapour will be found low to the ground and close to the release. As the temperature falls, the rate of release will reduce and in the case of some flammable vapours, ice will form at the point of release.

iiLiquefied pressurised releases from pipelines may take considerable time to depressurise following an emergency shutdown. When a vapour cloud is formed, particularly where the release is indoors, one option would be to prevent ventilation. This is not generally recommended as it will increase the concentration of flammable vapours and therefore increase likelihood of ignition. However, if the flammable vapours pose additional health effects such as being toxic (such as ammonia and hydrogen sulphide), ventilation may reduce the flammable hazard only to produce a much wider toxic hazard. In such instances, factors such as the total quantities of vapours, location of the incident, wind speed and direction will all contribute to determine the tactic that will take precedence.

Flammable vapours will only ignite when they encounter a source of ignition at concentrations within their flammable range. The precise range is specific to each substance; consequently, flammable vapours with a wide flammable range are more likely to create large ignitable vapour clouds than those with a narrow flammable range. At operational incidents, a vapour cloud at concentrations above its upper explosive limit (UEL) should still be regarded as a dangerous environment. A key control measure for flammable vapours is to reduce the concentration in air below the lower explosive limit (LEL) and prevent ignition. Vapours in an uncontrolled state will naturally spread and in doing so, dilute.

Ventilation: Good ventilation can assist in dispersing flammable vapours to minimize the size of any ignitable plumes. This approach will need to be weighed against the generation of a larger plume and the potential to find ignition sources. This depends on the LEL of the vapour.

Water sprays: Adding water in the form of fine spray or mist will create convection currents that will assist in dispersing flammable vapours. Water mist will also act as a good absorber of heat if ignition occurs. Most hydrocarbon fuel vapours have little or no solubility in water. Where vapours are water soluble, such as ammonia and hydrogen sulphide, water sprays may be used to dissolve the vapour cloud out of the air.

Weather: Strong winds can disperse flammable vapours and gases, rain can dissolve soluble gases (atmospheric scrubbing) and promote the mixing/dilution of any vapour plume.

Inerting gas: By replacing the air with a gas that does not support combustion, the risk of fire can be greatly reduced or eliminated. This will not only reduce the concentration of flammable vapours but also reduce the concentration of oxygen present. Portable monitoring equipment known as LEL meters or combustible gas detectors can be used to detect the presence of flammable vapours.

Once a flammable vapour cloud has formed, the options available to reduce this hazard are limited, until vapours have dissipated to a safe concentration.

Chemical protective clothing (CPC) is generally not suitable where heat, fire or flammable risks are present. Personal protective equipment (PPE) for emergency teams may need to be sufficient to protect wearers in the event of ignition of a vapour cloud that leads to a flash fire or uncontrolled vapour cloud explosion.

Safety in the engineering industry

Objectives: At the end of this lesson you shall be able to
- **layout the various safety measures in engineering machineries,**
- **explain about the risk assessment records and controls during the operation of machines**
- **maintain the machineries and care while using hand and power tools.**

1 Safety measures in engineering machines

Different workshops have different work practices and different machines; however, there are certain rules that apply to any mechanical workshop of the world.

- Always wear safety gear while working in the workshop. Hand gloves, safety shoes, helmets and eyeglasses are mandatory for workshops jobs like plumbing, machine fitting, welding or carpentry.
- Malfunctioning machines can occur any time. It could happen during the process of screw tightening or replacing the motor of the machine. Irrespective of the type of break down, never try to work on it while the machine is on and running.
- While dealing with vehicles, always ensure that common safety guidelines are observed. Pull the hand brake, choke the rear wheels, and fit fender covers. Always jack the vehicle on a hard surface else use spreading blocks for load spreading.
- Non-slip mats should be used in front of machines where necessary, and machines should be sensibly placed to avoid overcrowding and suitably anchored to vibration.
- Maintain all the service records of machines and equipment. It will not only save time but also help you to take care of repetitive break downs.
- All the tools and accessories must be kept back at their relevant places. Placing them anywhere will lead to chaos and inefficient working.
- Smoking and drinking should be prohibited in the workshop.
- The gangway through the workshop must be kept clear. Any grease or oil spillage must be cleaned on a regular basis.

a Safety and Fire Precautions

Workshops are prone to accidents in general but fire can be the most deadly. These are some of the rules and guidelines that help keep a check on injuries and accidents.

- Always take part in mock security drills. Workshops are enclosed structures, at the time of emergency you may find yourself stuck. Whenever mock security drills are conducted, participate in them because that is the best way to prepare you for emergencies.
- Before commencing any welding operations, make sure that an appropriate fire extinguisher is readily accessible. All the workers must know how to use fire extinguishers, although clear instructions are always written on them. Inflammable materials must always be accompanied with fire extinguishers.
- One must know the difference between water extinguishers and carbon dioxide extinguishers and when to use them as well. For electrical fires, water extinguishers should not be used. Proper training is advised so that no confusion arises at the time of emergency.
- Dealing with chemicals requires extra safety because chemicals have contagious effects and they can spread from one person to another. Washing hands, wearing gloves and masks, and using barrier creams are all advisable. At the very first glimpse of any skin or respiration disorder, consult a doctor.
- Working with toxic materials like lead, manganese, and nickel etc. also requires special attention because these materials have long term adverse effects on human health. Metalworking fluids can also cause health issues like occupational asthma. Ensure all the exhaust fans and respirators are working properly before you start working with chemically hazardous substances.
- Most importantly, every person inside the workshop must know the contact number of ambulance and fire services.

Above all, safety is the primary concern. Secondly, improving work efficiency with minimum hassles If the above mentioned safety guidelines and work rules are observed and followed carefully, one can achieve both the targets. It is always important to stay prepared for medical or accidental emergency because trouble never comes announced and that's what mechanical workshop safety rules do.

2 Safety measures to be followed in machine guarding

There shall be one or more methods of machine guarding provided to protect the operator and other employees in the machine area from hazards. Examples of guarding methods are:

- Barrier guards
- Two-hand tripping devices

- Electronic safety devices

Types of guards

1 Fixed guard- provides a barrier between a person and the point of opera, power train or other moving parts. These include fences, gates, and protective covers for blades, presses and all moving parts.

2 Interlocked guard - when opened or removed disengage the machine's power source. It cannot be restarted until the guard is replaced.

3 Adjustable guard - provide a barrier that can be adjusted to many different operations, such as varying sizes of stock.

4 Self-adjusting guard - barriers that move or self-adjust, according to the size or position of the workplace. The guard returns to its resting position when no material is passing through.

Affix guards to the machine where possible or secure it, The guard shall be such that it does not offer an accident hazard in itself. Point of operation is the area on a machine where work is actually performed upon the material being processed. The point of operation of machines whose operation exposes an employee to injury shall be guarded. The guarding device shall conform with any appropriate standards. If no specific standard exists then the design and construction of the guard will prevent the operator from having any part of his body in the danger zone during the operating cycle.

The following are some examples of machines requiring point of operation guarding:

- Guillotine cutters
- Shears
- Alligator shears
- Power presses
- Milling machines
- Power saws
- Jointers
- Portable power tools
- Forming rolls and calendars

Revolving drums, barrels, and containers shall be guarded by an enclosure that is interlocked with the drive mechanism so the barrel, drum or container cannot revolve unless the guard enclosure is in place. When the periphery of the blades of a fan Is less than seven feet above the floor or working level, the blades shall be guarded. The guard shall have openings not larger than one-half inch. Machines designed for a fixed location shall be securely anchored to prevent walking or moving.

a Simple Rules to Maximize Worker Safety

- Always be sure that moving mechanisms are clear of people and objects
- Be sure that workers are not wearing any jewellery or loose clothing that could get snagged in the machine
- Keep an eye on overheard moving parts, like pulleys, for potential hazards
- Check that guards are in place at all points where you could contact moving parts before turning the machine on
- Be aware of how to turn power on and off if you should have to do so quickly
- Read the manufacturer's instructions on how to operate the machine safely and correctly
- Feed material into the machine with push sticks, not your hands
- Take it easy. Rushing through a job is one of the major causes of accidents
- Make sure maintenance is performed when required. If you think your equipment might have missed its scheduled maintenance let your supervisor know.
- Use lockout/tagout procedures when a machine needs repair or maintenance. Turn the machine and the power to the machine off and tag it so that no one tries to use it.

3 Safety precautions to be taken care while using power tools

Appropriate personal protective equipment such as safety goggles and gloves must be worn to protect against hazards that may be encountered while using hand tools. Workplace floors shall be kept as clean and dry as possible to prevent accidental slips with or around dangerous hand tools.

Power tools must be fitted with guards and safety switches; they are extremely hazardous when used improperly. The types of power tools are determined by their power source: electric, pneumatic, liquid fuel, hydraulic, and powder-actuated.

To prevent hazards associated with the use of power tools, OSHA recommends that workers should observe the following general precautions:

- Never carry a tool by the cord or hose.
- Never yank the cord or the hose to disconnect it from the receptacle.
- Keep cords and hoses away from heat, oil, and sharp edges.
- Disconnect tools when not using them, before servicing and cleaning them, and when changing accessories such as blades, bits, and cutters.
- Keep all people not involved with the work at a safe distance from the work area.
- Secure work with clamps or a vise, freeing both hands to operate the tool.
- Avoid accidental starting. Do not hold fingers on the switch button while carrying a plugged-in tool.

- Maintain tools with care; keep them sharp and clean for best performance.
- Follow instructions in the user's manual for lubricating and changing accessories.
- Be sure to keep good footing and maintain good balance when operating power tools.
- Wear proper apparel for the task. Loose clothing, ties, or jewelry can become caught in moving parts.
- Remove all damaged portable electric tools from use and tag them: "Do Not Use."

a Safety precautions to be taken care while using hand tool

Hand tools are tools that are powered manually. Hand tools include anything from axes to wrenches. The greatest hazards posed by hand tools result from misuse and improper maintenance.

Some examples include the following:

- If a chisel is used as a screwdriver, the tip of the chisel may break and fly off, hitting the user or other employees.
- If a wooden handle on a tool, such as a hammer or an axe, is loose, splintered, or cracked, the head of the tool may fly off and strike the user or other employees.
- If the jaws of a wrench are sprung, the wrench might slip.
- If impact tools such as chisels, wedges, or drift pins have mushroomed heads, the heads might shatter on impact, sending sharp fragments flying toward the user or other employees.

The employer is responsible for the safe condition of tools and equipment used by employees. Employers shall not issue or permit the use of unsafe hand tools. Employees should be trained in the proper use and handling of tools and equipment.

Employees, when using saw blades, knives, or other tools, should direct the tools away from aisle areas and away from other employees working in close proximity. Knives and scissors must be sharp; dull tools can cause more hazards than sharp ones. Cracked saw blades must be removed from service. Wrenches must not be used when jaws are sprung to the point that slippage occurs. Impact tools such as drift pins, wedges, and chisels must be kept free of mushroomed heads. The wooden handles of tools must not be splintered. Iron or steel hand tools may produce sparks that can be an ignition source around flammable substances. Where this hazard exists, spark-resistant tools made of non-ferrous materials should be used where flammable gases, highly volatile liquids, and other explosive substances are stored or used.

4 Maintainenance of the selected machineries and care while using hand and power tools

Here are 10 quick and easy tips for safely working with hand and power tools.

- **Inspect your tools**- Never issue or use a damaged or defective hand or power tool. Always make sure they are in good working order before and after each use.
- **Pick the right tool**- Make sure you are using the correct tool for the task at hand. This also means using the right sized bits, blades and accessories on your power tools.
- **Wear your PPE**- Issue personal protective equipment to your employees and make sure they wear them properly. This comprises of items like safety goggles, hard hats, etc.
- **Don't alter your tools**- Never remove guards or disable safety devices on power tools. Don't paint or cover up your tools as this could prevent you from noticing chips or cracks.
- **Handle with care**- Tools are not toys. Never throw or toss a tool in the direction of or directly to a co-worker. Never use electrical cords to lower or lift a tool to get it to a workspace.
- **Keep your distance**- When working with hand and power tools be sure you have enough room to safely operate without coming into contact with other objects or co-workers.
- **Pick up after yourself**- Don't leave idle hand tools lying around the job site. They can lead to tripping or be accidentally knocking on someone's head.
- **Unplug and disconnect**- Don't leave electric power tools plugged in when not in use, when making adjustments such as replacing blades and bits, or loading fasteners.
- **Keep your workspace clean**- A cluttered floor can lead to accidental trips or falls which can be extremely dangerous when working with hand and power tools.
- **Get trained up-** Make sure you and your employees are thoroughly trained on the proper use of hand and power tools required for the task at hand.

Chemicals compatibility considerations & transportation

Objectives: At the end of this lesson you shall be able to
- **list the various safety measures followed during chemical transportation**
- **describe risk assessment records and controls during the handling of chemicals**
- **state about compatibility issues and precautions to be adopted during chemical usage**
- **maintain the Material Safety Data Sheets(MSDS) while using chemicals in the industry.**

1 Chemical safety data sheet or the material safety data sheet (MSDS)

A systematic approach to safety requires an efficient flow of information from the suppliers to the users of chemicals on potential hazards and correct safety precautions. In addressing the need for a written hazard communication programme, the ILO Code of Practice Safety in the Use of Chemicals at Work (ILO 1993) states, "The supplier should provide an employer with essential information about hazardous chemicals in the form of a chemical safety data sheet." This chemical safety data sheet or material safety data sheet (MSDS) describes the hazards of a material and provides instructions on how the material can be safely handled, used and stored.

MSDSs are produced by the manufacturer or importer of hazardous products. The manufacturer must provide distributors and other customers with MSDSs upon first purchase of a hazardous product and if the MSDS changes.

Distributors of hazardous chemicals must automatically provide MSDSs to commercial customers. Under the ILO Code of Practice, workers and their representatives should have a right to an MSDS and to receive the written information in forms or languages they easily understand. Because some of the required information might be intended for specialists, further clarification may be needed from the employer. The MSDS is only one source of information on a material and, therefore, it is best used along with technical bulletins, labels, training and other communications.

Criteria for the data sheets include information about the identity of the chemical, its supplier, classification, hazards, safety precautions and the relevant emergency procedures. The following discussion details the type of required information included in the 1992 ILO Code of Practice Safety in the Use of Chemicals at Work. While the Code is not intended to replace national laws, regulations or accepted standards, its practical recommendations are intended for all those who have a responsibility for ensuring the safe use of workplace chemicals.

The following description of chemical safety data sheet content corresponds with section 5.3 of the Code:

Chemical safety data sheets for hazardous chemicals should give information about the identity of the chemical, its supplier, classification, hazards, safety precautions and the relevant emergency procedures. The information to be included should be that established by the competent authority for the area in which the employer's premises are located, or by a body approved or recognized by that competent authority. Details of the type of information that should be required are given below.

a Chemical product and company identification

The name should be the same as that used on the label of the hazardous chemical, which may be the conventional chemical name or a commonly used trade name. Additional names may be used if these help identification. The full name, address and telephone number of the supplier should be included. An emergency telephone number should also be given, for contact in the event of an emergency. This number may be that of the company itself or of a recognized advisory body, so long as either can be contacted at all times.

b Information on ingredients (composition)

The information should allow employers to identify clearly the risks associated with a particular chemical so that they may conduct a risk assessment, as outlined in section 6.2 (Procedures for assessment) of this code. Full details of the composition should normally be given but may not be necessary if the risks can be properly assessed. The following should be provided except where the name or concentration of an ingredient in a mixture is confidential information which can be omitted in accordance with section 2.6:

i a description of the main components, including their chemical nature;

ii the identity and concentrations of components which are hazardous to safety and health

iii the identity and maximum concentration to be found of components which are at the concentration or exceed the concentration at which they are classified as hazardous to safety and health in lists approved or recognized by the competent authority, or which are prohibited at higher concentrations by the competent authority.

c Hazard identification

The most important hazards, including the most significant health, physical and environmental hazards, should be stated clearly and briefly, as an emergency overview. The

information should be compatible with that shown on the label.

d First-aid measures

First-aid and self-help measures should be carefully explained. Situations where immediate medical attention is required should be described and the necessary measures indicated. Where appropriate, the need for special arrangements for specific and immediate treatment should be emphasized.

e Firefighting measures

The requirements for fighting a fire involving a chemical should be included; for example:

i Suitable extinguishing agents;

ii Extinguishing agents which must not be used for safety reasons;

iii special protective equipment for fire-fighters.

Information should also be given on the properties of the chemical in the event of fire and on special exposure hazards as a result of combustion products, as well as the precautions to be taken.

f Accidental release measures

Information should be provided on the action to be taken in the event of an accidental release of the chemical. The information should include:

i health and safety precautions: removal of sources of ignition, provision of sufficient ventilation, provision of suitable personal protective equipment;

ii environmental precautions: keeping away from drains, need to alert the emergency services, and possible need to alert the immediate neighbourhood in the event of an imminent risk;

iii methods for making safe and cleaning up: use of suitable absorbent materials, avoiding production of gases/fumes by water or other diluent, use of suitable neutralizing agents;

iv warnings: advise against reasonably foreseeable hazardous actions.

g Handling and storage

Information should be given about conditions recommended by the supplier for safe storage and handling, including:

i design and location of storage rooms or vessels;

ii separation from workplaces and occupied buildings;

iii incompatible materials;

iv conditions of storage (e.g., temperature and humidity, avoidance of sunlight);

v avoidance of sources of ignition, including particular arrangements to avoid static build-up;

vi provision of local and general ventilation;

vii recommended methods of work and those to be avoided.

h Exposure controls and personal protection

Information should be given on the need for personal protective equipment during use of a chemical, and on the type of equipment that provides adequate and suitable protection. Where appropriate, a reminder should be given that the primary controls should be provided by the design and installation of any equipment used and by other engineering measures, and information provided on useful practices to minimize exposure of workers. Specific control parameters such as exposure limits or biological standards should be given, along with recommended monitoring procedures.

i Physical and chemical properties

A brief description should be given of the appearance of the chemical, whether it is a solid, liquid or gas, and its colour and odour. Certain characteristics and properties, if known, should be given, specifying the nature of the test to determine these in each case. The tests used should be in accordance with the national laws and criteria applying at the employer's workplace and, in the absence of national laws or criteria, the test criteria of the exporting country should be used as guidance. The extent of the information provided should be appropriate to the use of the chemical. Examples of other useful data include:

- viscosity
- freezing point/freezing range
- boiling point/boiling range
- melting point/melting range
- flashpoint
- auto-ignition temperature
- explosive properties
- oxidizing properties
- vapour pressure
- molecular weight
- specific gravity or density
- pH
- solubility
- partition coefficient (water/n-octane)
- parameters such as vapour density
- miscibility
- evaporation rate and conductivity

Personal protective equipment

Objectives: At the end of this lesson you shall be able to
- **list the respiratory personal protective equipment for employees,**
- **state the basic knowledge on the selection and usage of PPE**
- **describe the resuscitation & first aid processes available for our immediate safety**.

Importance of Personal Protective Equipments (PPE) (Fig 1)

Fig 1

HSM196711

Respiratory Protective Equipment

Personal protective equipment, commonly referred to as "PPE", is equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses. These injuries and illnesses may result from contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards. Personal protective equipment may include items such as gloves, safety glasses and shoes, earplugs or muffs, hard hats, respirators, or coveralls, vests and full body suits.

Even where engineering controls and safe systems of work have been applied, some hazards might remain. These include injuries to:

- the lungs, eg from breathing in contaminated air
- the head and feet, eg from falling materials
- the eyes, eg from flying particles or splashes of corrosive liquids
- the skin, eg from contact with corrosive materials
- the body, eg from extremes of heat or cold
- PPE is needed in these cases to reduce the risk.

Classifications of Respiratory Personal Protective Devices

A Lungs

Hazards: Oxygen-deficient atmospheres, dusts, gases and vapours

- Some respirators rely on filtering contaminants from workplace air. These include simple filtering face pieces and respirators and power-assisted respirators.
- Make sure it fits properly, eg for tight-fitting respirators (filtering face pieces, half and full masks).
- There are also types of breathing apparatus which give an independent supply of breathable air, eg fresh-air hose, compressed airline and self-contained breathing apparatus.
- The right type of respirator filter must be used as each is effective for only a limited range of substances,
- Filters have only a limited life. Where there is a shortage of oxygen or any danger of losing consciousness due to exposure to high levels of harmful fumes, only use breathing apparatus - never use a filtering cartridge,
- You will need to use breathing apparatus in a confined space or if there is a chance of an oxygen deficiency in the work area,

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. RPE should only be used where adequate control of exposure cannot be achieved by other means, in other words, as a last resort within the hierarchy of control measures: Elimination, Substitution, Engineering Controls, Administrative Controls and PPE.

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.

B Seven Elements of a Respiratory Programme

1 A written plan detailing how the programme is managed.

2 A complete assessment and knowledge of respiratory hazards that will be encountered in the workplace.

3 Procedures and equipment to control respiratory hazards, including the use of engineering controls and work practices designed to limit or reduce employee exposures to such hazards.

4 Guidelines for the proper selection of appropriate respiratory protective equipment.5 An employee training program covering hazard recognition, the dangers associated with respiratory hazards, and proper care and use of respiratory protective equipment.

5 Inspection, maintenance, and repair of respiratory protective equipment.

6 Medical surveillance of employees, where necessary.

5 Respiratory Protection Standards

General industry standard: Protect health of employees from harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors. Applies to all occupational airborne exposures to contaminated air when the employee is: exposed to a hazardous level of an airborne contaminant.

6 Maintenance and Care

There are probably as many different programs for maintaining self-contained breathing apparatus (SCBA) as there are fire departments. They range from the ideal to the feasible. Much depends on the size of the department and its resources. The most advanced fire departments have fully equipped maintenance facilities with trained personnel and precise schedules for the care of breathing apparatus. At the other end of the spectrum are departments and companies which require the users to maintain their own equipment on a day-to-day basis with trained personnel on call.

7 Need of respiratory PPE for employees

When employees must work in environments with insufficient oxygen or where harmful dusts, fogs, smokes, mists, fumes, gases, vapors, or sprays are present, they need respirators. These health hazards may cause cancer, lung impairment, other diseases, or death. Where toxic substances are present in the workplace and engineering controls are inadequate to reduce or eliminate them, respirators are necessary. Some atmosphere-supplying respirators can also be used to protect against oxygen-deficient atmospheres. Increased breathing rates, accelerated heartbeat, and impaired thinking or coordination occur more quickly in an oxygen-deficient or other hazardous atmosphere. Even a momentary loss of coordination can be devastating if it occurs while a worker is performing a potentially dangerous activity such as climbing a ladder.

8 Instruction & Training in the Use

Employees must use respirators while effective engineering controls, if they are feasible, are being installed. If engineering controls are not feasible, employers must provide respirators and employees must wear them when necessary to protect their health. The employee's equipment must be properly selected, used, and maintained for a particular work environment and contaminant. In addition, employers must train employees in all aspects of the respiratory protection program.

9 Resuscitation & first aid

First aid sometimes referred to as EMERGENCY AID is the first skilled [acceptable] assistance given to a victim (sick or injured) on the occurrence of accident or sudden illness in order to preserve life, prevent further injury and relive suffering until qualified medical care is available. To be effective at any form of true first aid you need to obtain some training or instruction. The following basic first aid instructions are designed to assist you in learning the skill. First aid is an application of skills and techniques, in a logical and prioritized sequence. The scope of first aid is to apply a consistent set of standards, and treatment, in a logical order. Victim assessment by a first aider is to identify injuries, treat, and transport victims

C Artificial respiration (Fig 2)

Fig 2

It is a procedure for using air to flow in to and out of persons. Lungs when natural breathing is inadequate or stops.

D Common causes of respiratory failure (problems)

- Obstruction of the air way by tongue is dropping back
- Inhalation of a small amount of food, smoke, irritation, foreign objects, carbon monoxide, etc.
- Compression of the neck *ƒ* Respiratory disease
- Drowning Strangulation
- Combustible gases Signs and symptoms.

General consideration, types of storage, layout of storages with specific reference to LPG, CNG, Chlorine, Ammonia

Objectives: At the end of this lesson you shall be able to
- **describe the general consideration for storage of LPG/CNG**
- **state the types of storage for the LPG/CNG**
- **explain the layout of storages with reference to LPG, CNG, Chlorine and Ammonia.**

1 General Considerations for storage of LPG/CNG

- LPG must be stored in adequate location wherein vessels or cylinders are suitably positioned having regard to the relevant codes of practice
- LPG plant must be designed to appropriate standards and be properly installed and commissioned by competent persons
- Plant must be fitted with adequate safety and monitoring control devices and operated by competent persons
- Occupiers must notify the gas supplier of any structural or other changes which might affect the gas installation
- There must be a suitable programme of maintenance and testing by competent persons
- Plant must be identifiable and accessible for maintenance
- Records of maintenance and tests must be kept
- Precautions must be taken to prevent fire and explosion including appropriate protection of storage vessels
- Installations must have appropriate security measures to prevent deliberate interference
- Incidents involving death or hospitalisation, fire or explosion or a significant release of LPG must be reported to the Authority and records of such incidents must be kept

2 Outline the types of storage for the LPG/CNG

There are two systems for storing natural gas namely buffer and cascade storage systems. In buffer storage, CNG is stored at single high-pressure reservoirs. The cascade storage system is usually divided into three reservoirs, generally termed low, medium and high-pressure reservoirs.

3 Layout of storages with reference to LPG, CNG, Chlorine and Ammonia (Fig 1 Storage Tank)

Fig 1

HSN1970111

Storage Tank

Storage tanks: Storage tanks are containers that hold liquids, compressed gases or mediums used for the short- or long-term storage of heat or cold. The term can be used for reservoirs and for manufactured containers.

Storage tanks are available in many shapes: vertical and horizontal cylindrical; open top and closed top; flat bottom, cone bottom, slope bottom and dish bottom. Large tanks tend to be vertical cylindrical, or to have rounded corners transition from vertical side wall to bottom profile, to easier withstand hydraulic hydrostatically induced pressure of contained liquid. Most container tanks for handling liquids during transportation are designed to handle varying degrees of pressure. A large storage tank is sometimes mounted on a lorry (truck) or on an articulated lorry trailer, which is then called a tanker. (Fig 2 Storage fuel tank).

Fig 2

HSN197012

Storage fuel tank

Since most liquids can spill, evaporate, or seep through even the smallest opening, special consideration must be made for their safe and secure handling. This usually involves building a bunding, or containment dike, around the tank, so that any leakage may be safely contained. Some storage tanks need a floating roof in addition to or in lieu of the fixed roof and structure. This floating roof rises and falls with the liquid level inside the tank, thereby decreasing the vapour space above the liquid level. Floating roofs are considered a safety requirement as well as a pollution prevention measure for many industries including petroleum refining. (Fig 3 Cylindrical fuel tank).

Fig 3

HSN197013

Cylindrical fuel tank

Storage of LPG,CNG and dangerous chemicals to ensure workers safety

Objectives: At the end of this lesson you shall be able to

- **state the need for personal protective equipment, selection and use of PPE**
- **describe the care and maintenance of respiratory protective equipment**
- **explain the non-respiratory protective devices, selection and use**
- **state the care & maintenance of non-respiratory Personal Protective Equipment.**

1 Need for personal protective equipment

PPE, Personal Protective Equipment, are the tools that ensure the basic health protection and safety of users. PPE is any device or appliance designed to be worn by an individual when exposed to one or more health and safety hazards. To reduce the possibility of failure, equipment must be properly fitted and maintained in a clean and serviceable condition.

Employers are required to assess the workplace to determine if hazards that require the use of head, eye, face, hand, or foot protection are present or are likely to be present. Employees must be trained to know when PPE is necessary, what type is necessary, how it is to be worn, and what its limitations are, as well as its proper care, maintenance, useful life, and disposal.

2 Head Protection

Protective hats for head protection against impact blows must be able to withstand penetration and absorb the shock of a blow.

Each type and class of head protector is intended to provide protection against specific hazardous conditions. Protective hats are made in the following types and classes:

- Type 1 - helmets with full brim, not less than 1 and 1/4 inches wide;
- Type 2 - brimless helmets with a peak extending forward from the crown.

Safety shoes should be sturdy and have an impact-resistant toe. Safety shoes come in a variety of styles and materials, such as leather and rubber boots, oxfords, and even tennis shoe models.

Safety footwear is classified according to its ability to meet minimum requirements for both compression and impact tests.

3 Eye and Face Protection

Suitable eye protectors must be provided where there is a potential for injury to the eyes or face from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, potentially injurious light radiation, or a combination of these. Every protector shall be distinctly marked to facilitate identification of the manufacturer and must meet the following minimum requirements:

- Provide adequate protection against the particular hazards for which they are designed
- Be reasonably comfortable when worn under the designated conditions
- Fit snugly without interfering with the movements or vision of the wearer
- Be durable
- Be capable of being disinfected
- Be easily cleanable
- Be kept clean and in good repair.

4 Ear Protection

Exposure to high noise levels can cause hearing loss or impairment. It can create physical and psychological stress. There is no cure for noise-induced hearing loss, so the prevention of excessive noise exposure is the only way to avoid hearing damage. Specifically designed protection is required, depending on the type of noise encountered and the auditory condition of employee.

Disposable earplugs should be used once and thrown away; non-disposable ones should be cleaned after each use for proper maintenance. Earmuffs need to make a perfect seal around the ear to be effective. Glasses, long sideburns, long hair, and facial movements, such as chewing, can reduce protection. Special equipment is available for use with glasses or beards.

2 Arm and Hand Protection

Burns, cuts, electrical shock, amputation and absorption of chemicals are examples of hazards associated with arm and hand injuries. A wide assortment of gloves, hand pads, sleeves, and wristlets for protection from these hazards is available.

The devices should be selected to fit the specific task. Rubber is considered one of the best materials for insulating gloves and sleeves, Each material is thoroughly tested and rated against specific chemical compounds. It is need to know what hazard you are protecting against to choose the correct material.

a Respiratory Personal Protective Equipment's

Solid and liquid particles, including nanoparticles, i.e. dusts, fumes, mists, fibers, radioactive particulates as well as vapours, gases and micro-organisms encountered in workplace's atmospheres can cause significant hazards to health or, in extreme cases, can lead to death. Moreover, work activities may be carried out in confined spaces or areas where the workers breathing the atmosphere, in some cases even momentarily, with oxygen deficiency (less than 19% by volume), or when concentration of toxic substances are at dangerous levels, or with combination of both.

Health and occupational safety rules requires prevention against exposure of employees and others to hazardous substances at work in order to protect their health, safety and wellbeing. Employers must carry out risk assessments and act on them by taking appropriate action. When prevention activities such as collective protection, e.g. elimination or substitution of hazardous material or a change in the process, engineering controls are not available or is not practicable, relevant control measures should be provided in order to prevent hazardous substances from entering the atmosphere.

Direct control measures at the source of contamination should always be preferred in order to protect everyone in the workplace, whereas respiratory protection equipment (RPE) only prevents exposure to a single person. However, if applied control measures at the source are not efficient or are inadequate or not possible, then suitable respiratory protection equipment may/will be needed.

An example of such a dangerous situation are maintenance activities (e.g. tank cleaning, sludge removal, freezer room repairs), due to the possibility of a sudden release of highly concentrated chemical substances (e.g. organic solvent vapours, trapped process inorganic gases, refrigerant vapours).

Respiratory Protective Equipment (RPE) are included in Personal Protective Equipment (PPE), which are dedicated to protect against life threatening situations or hazards that may cause serious and irreversible health damage, the results of which a worker is unable to foresee quickly enough. The employers ought to implicitly apply the principle that RPE should be treated as a last resort.

b Basic rules of RPE use

RPEs are used in situations described as conditions of direct life threat, the result of which may be a worker's death. Probable cases occur in such situations as:

- confined spaces where it is possible to foresee serious wounds or death due to oxygen deficiency or harmful chemical substances,
- oxygen deficiency resulting from:
- cleaning limited spaces with chemically indifferent gas so as to remove flammable or toxic substances,
- natural biological processes connected with oxygen consumption which may take place in sewage systems, storage tanks, storm tanks, sewage pits, sealed silos where crops have been stored, fermentation tanks, beer breweries or in holds, as a result of wood or wooden product transport, steel shavings or filings, vegetable products, grain, coal, etc.,
- leaving a tank tightly sealed for some time (steel ones in particular) while the process of rusting on the external layer of the tank consumes oxygen, e.g. heat exchangers, separators, filters, etc.,
- risk of carbon dioxide increase from hewn limestone in connection with the process of dehydration while it is still wet,
- burning activities and such works as welding and sanding, which consume oxygen,
- oxygen displacement during the freezing process, e.g. with liquid nitrogen,
- gradual oxygen depletion while the workers breathe in confided spaces and where air exchange is inefficient,
- breakdowns caused by chemical substances.

In general RPEs can be used in the following situations:

- where an inhalation exposure risk remains after reasonable controls have been put in place (residual risk),
- short-term or infrequent exposures where the employer decides that other controls at the source are not reasonably practicable,

- while other control measures (interim measures) are being put in place or being maintained / repaired,
- emergency escape - it is necessary to provide RPEs for a safe exit from an area where hazardous substances may be released suddenly in the event of a control system failure,
- emergency work or temporary failure of controls where other means of controls are not reasonably practicable,
- emergency rescue by trained personnel is necessary.

Respiratory protection equipment should be considered as the last option for preventing and/or controlling inhalation exposure to hazardous substances to health which exists in the air.

c Classification

There are two general types of respiratory protective equipment (RPE), based on the principle by which protection is provided to the user. The two types are the following:

1 Respirators (filtering equipment) i.e.: filter, gas filter, combined filter, filtering half-mask.

2 Breathing apparatus (isolating equipment) i.e.: self-contained breathing apparatus (open-circuit and closed circuit), compressed line breathing apparatus.

Respirators are designed to filter out or clean contaminated air from the workplace atmosphere before it is inhaled by the respirator wearer. Respirators are not designed to be used in atmospheres with oxygen deficiency (concentration of oxygen is below 19%) or where the concentration of unknown contaminants has not been evaluated.

Breathing apparatuses deliver breathable air from an independent source (compressed air vessels, compressed line) to the user. Breathing apparatuses are designed to use in atmosphere with oxygen deficiency (concentration of oxygen is below 19%).

It is of key importance that any RPE that is provided to the workers meet the basic requirements. Equipment (PPE) and that they are CE marked. Moreover, there is a specific group of RPEs, the so-called rescue equipment, with a limited time of protective performance which allows the user to leave the contaminated area in a very short time.

Both types of RPEs are available with a range of different face pieces, i.e.:

- Tight-fitting face pieces (filtering face pieces, half and full-face masks) that rely on a good fit - seal between the mask and the wearer's face.
- Loose-fitting face pieces (hoods, helmets) rely on enough air being provided to prevent the contaminant leaking into the face piece as the wearer breathes and moves about. They are used only with powered respirators or with suitable breathing apparatuses.

General classification of the Respiratory Protective Equipment is as follows:

1 Respirators - filter out contamination from the air in the workplace before it is inhaled by the user:

a Filtering respirators:

- Filtering face pieces
- Half mask with filter(s)
- Full-face mask with filter(s)

b Powered/assisted respirators

- Powered hoods and helmets with filter(s)
- Powered-assisted half mask with filter(s)
- Powered assisted full-face mask with filter(s)

2 Breathing apparatuses - provide uncontaminated breathable air from independent source:

a Compressed airline breathing apparatuses:

- Constant flow with any type of face piece
- Negative demand half or full-face mask
- Positive demand half or full-face mask

b Indented line Self-contained breathing apparatuses:

- Open-circuit negative demand full-face mask
- Open circuit positive demand full-face mask
- Closed-circuit full-face mask demand

d Filtering devices

Filtering face pieces: these face pieces are often called "disposable respirators". The respirators may incorporate inhalation and exhalation valves or exhalation valve(s) only, or have no valves. Where the filtering face piece has no valves, both inhaled and exhaled dangerous substances can pass through the filter material. An example of the filtering face piece is shown in the picture.(Fig 1 Filtering facepiece).

Fig 1

There are also valved filtering half masks to protect against gases or vapours and particles. These devices are "disposable" respirators essentially for use against gases and vapours, but with optional protection against particles. Any gas/vapour filters form an inseparable part of the device; any particle filters maybe integral or separable. There are also two types of these respirators i.e. intended to be used for a maximum of a single shift (marked with the letters NR - not reusable), and intended to be used for more than a single shift (marked with the letter R - reusable).

Filters either entirely or substantially consist of filter material. There are particle filters, gas filters and combined filters. The particle filters should conform to the EN 149:2001 standard and are classified as P1, P2 and P3 in order of increasing filtration efficiency. There are two types of these respirators i.e. intended to be used for a maximum of a single shift (marked with the letters NR - not reusable), and intended to be used for more than a single shift (marked with the letter R - reusable).

The gas filters should conform to the EN 14387:2004+A1:2008 standard and are classified as:

- A - for use against certain organic gases and vapours with a boiling point > 65 °C as specified by the manufacturer,
- B - for use against certain inorganic gases and vapours as specified by the manufacturer.,
- E - for use against sulphur dioxide and other acidic gases and vapours as specified by the manufacturer
- K - for use against ammonia and organic ammonia derivatives as specified by the manufacturer,
- AX - for use against certain organic gases and vapours with a boiling point £ 65 °C as specified by the manufacturer. For single use only,
- SX - for use against specific named gases and vapours as specified by the manufacturer.

Multi-type gas filters - filters which are a combination of two or more of the above listed types, excluding SX, and which meet the requirements of each type separately.

Combined filters - gas or multi-type gas filters incorporating a particle filter according to EN 143:2001.

Special filters are:

- Type NOP3 - for use against nitrogen oxides, e.g. NO, NO2, NOX.
- Type HgP3- for use against mercury.

There are 3 classes of gas filters for types A, B, E and K that are classified in terms of capacity as follows:

- Class 1- low capacity filters;
- Class 2 - medium capacity filters;
- Class 3 - high capacity filters.

The protection provided by a class 2 or class 3 filter includes protection provided by the corresponding filter of lower class or classes.

The classification of combined filter(s) includes that of particle filter(s) according to EN 143:2000.

Type AX and type SX gas filters and special filters are not classified.

f Face-pieces

Half masks: usually reusable moulded face pieces, of rubber or plastic, covers the nose and mouth of the wearer and is held in place with adjustable straps. Air passes through the relevant filter(s) by the wearer's lung force, or may be supplied by a powered unit or suitable breathing apparatus attached to the mask. The exhaled air passes through an exhalation valve(s). Half mask completed with particle filter (Fig 2).

Fig 2

Full-face masks: reusable devices which cover the eyes, nose, mouth and chin, and seals against the face of the wearer. It is held in place (on the head) with adjustable straps. Air is drawn into the mask either through a relevant filter(s) by the wearer's lung force, or may be supplied by a powered unit or suitable breathing apparatus attached to the mask. The exhaled air passes through an exhalation valve(s). Most masks have an inner half mask.

There are 3 classes of masks: Class 1 - light duty design intended for use with a filter(s) and light duty compressed airline breathing apparatus, Class 2 - more robust and offers greater resistance to flammability Class 3 - for protection against flame and radiant heat. This type is suitable for fire fighting. The mask should conform to the EN 136:1998 standard. An example of a full-face mask in shown in the picture. (Fig 3 Full-face mask completed with combined filters).

Fig 3

g Isolating apparatus

Compressed airline breathing apparatus are intended to be used in heavily industrial applications. The devices rely on a source of clean breathable compressed air at a maximum pressure of 10 bar. The air is supplied to the wearer via a tube(s). When the compressed air reaches the wearer, there is a basic subdivision of types of equipment which depends on how the air is used.

Constant flow equipment - the usual arrangement for this type of equipment is to connect the compressed air supply tube to a belt-mounted flow control valve or regulator. This supplies air at a constant flow to the face piece via a breathing hose.

An example of constant flow equipment integrated with different types of face pieces is shown in the picture. (Fig 4 Constant flow equipment).

Fig 4

HSN197024

In the demand valve equipment the compressed air is supplied to a demand valve mounted on the mask. This opens as the wearer breathes in, and closes when breathing out. Demand valves can deliver, with certain limits, enough air for a wearer. The valves come in two versions: - Negative demand - this operates as the wearer's breathing makes the pressure in the mask fall below that outside - Positive demand - where the face mask stays at a pressure slightly above normal. Both types of demand-type compressed air equipment are normally used with a full-face mask, but it is possible to use half masks. The relevant standards for compressed air devices are EN (to be completed). An example of the device is shown in the picture. (Fig 5 Demand valve equipment)

Fig 5

HSN197025

Self-contained breathing apparatus consist of a full-face mask fitted with a demand valve and supplied with clean air from vessels of compressed breathable air. Both negative and positive demand types are available. These devices are the most complex, requiring a high degree of training for both wearing and maintenance. The devices are only likely to be used in potentially very dangerous situations. Duration of use is dependent on the size and number of compressed air vessels. Open-circuit compressed-air devices (exhaled air is discharged to the atmosphere) typically lasts about 60 minutes, and is widely used by industry and emergency staff. Closed-circuit compressed-oxygen devices (carbon dioxide in the exhaled air is removed by an adsorbent and the cleaned air is topped up with oxygen and recirculated) can last for more than two hours. The relevant standards for these types of devices are (to be completed). An example of the self-contained breathing apparatus is shown in the picture. (Fig 6 Self-contained breathing apparatus).

Fig 6

HSN197026

Self-contained breathing apparatuses for escape purposes are available in compressed-air, compressed oxygen and chemical oxygen types and are intended to be used for a short-duration in case of an emergency escape from hazardous areas. Escape devices should be used for escape purposes only, and should not be used for normal working or entry to hazardous areas.

Table 1 - Requirements related to protection, safety and usability factors are defined in normative documents (EN series standards). The list of EN standards appropriate for each type of respiratory protective devices are as follows:

h Selection of PPE

If the risk is evaluated as high and applied collective measures are not sufficient or if conditions do not allow for other alternative protective measures, in order to ensure the safety of a worker, appropriate RPEs ought to be applied.

i Maintenance of the RPE

Effective maintenance of the RPE is required in order to ensure that the equipment continues to provide the degree of protection for which it was designed. Maintenance includes cleaning, disinfection, examination, repair, testing, and safe storage. Maintenance details are usually provided by the manufacturer. The RPE should be examined before each use, with particular attention being paid to all rubber parts such as face pieces, exhalation valves, breathing tubes, and head harnesses. The RPE should not be stored together with toxic substances or substances that may negatively influence materials from which it is produced, or such materials that give off unpleasant smells. The RPE should be transported in conditions ensuring protection from damage and atmospheric influences. After each use, face pieces that are reusable ought to be washed in warm water with soap then thoroughly dried by leaving it to dry in a non-contaminated area. It is recommended to carry out frequent disinfections of face pieces (according to the producer's instruction) and after each change of user.

EN 136:1998	Respiratory protective devices. Full face masks. Requirements, testing, marking
EN 137:2006	Respiratory protective devices. Self-contained open-circuit compressed air breathing app ratus with full face mask. Requirements, testing, marking
EN 138:1994	Respiratory protective devices. Specification for fresh air hose breathing apparatus for use with full face mask, half mask or mouthpiece assembly
EN 140:1998	Respiratory protective devices - Half masks and quarter masks - Requirements, testing, marking
EN 142:2002	Respiratory protective devices - Mouthpiece assemblies - Requirements, testing, marking
EN 143:2000	Respiratory protective devices - Particle filters - Requirements, testing, marking
EN 145:1997	Respiratory protective devices - Self-contained closed-circuit breathing apparatus com pressed oxygen or compressed oxygen-nitrogen type - Requirements, testing, marking
EN 149:2001 +A1:2009	Respiratory protective devices - Filtering half masks to protect against particles - Require ments, testing, marking
EN 269:1994	Respiratory protective devices - Powered fresh air hose breathing apparatus incorporating a hood - Requirements, testing, marking
EN 402:2003 R	espiratory protective devices - Lung governed demand self-contained open-circuit com pressed air breathing apparatus with full face mask or mouthpiece assembly for escape - Requirements, testing, marking
EN 403:2004	Respiratory protective devices for self-rescue - Filtering devices with hood for escape from fire - Requirements, testing, marking
EN 404:2005	Respiratory protective devices for self-rescue - Filter self-rescuer from carbon monoxide with mouthpiece assembly
EN 405:2001 + A1:2009	Respiratory protective devices - Valved filtering half masks to protect against gases or gases and particles - Requirements, testing, marking
EN 1146:2005	Respiratory protective devices - Self-contained open-circuit compressed air breath ing apparatus incorporating a hood for escape - Requirements, testing, marking
EN 1827:1999 + A1:2009	Respiratory protective devices - Half masks without inhalation valves and with sepa rable filters to protect against gases or gases and particles or particles only - Require ments, testing, marking
EN 12083: 1998	Respiratory protective devices - Filters with breathing hoses, (Non-mask mounted filters) - Particle filters, gas filters, and combined filters - Requirements, testing, marking
EN 12941: 1998	Respiratory protective devices - Powered filtering devices incorporating a helmet or a hood - Requirements, testing, marking
EN 12942: 1998	Respiratory protective devices - Power assisted filtering devices incorporating full face masks, half masks or quarter masks - Requirements, testing, marking
EN 13794: 2002	Respiratory protective devices - Self-contained closed-circuit breathing apparatus for es cape - Requirements, testing, marking
EN 14387: 2004+ A1:2008	Respiratory protective devices - Gas filter(s) and combined filter(s) - Requirements, testing, marking
EN 14435: 2004	Respiratory protective devices - Self-contained open-circuit compressed air breathing appa ratus with half mask designed to be used with positive pressure only - Requirements, test ing, marking
EN 14593-1: 2005	Respiratory protective devices - Compressed air line breathing apparatus with demand valve - Part 1: Apparatus with a full face mask - Requirements, testing, marking
EN 14593-2: 2005	Respiratory protective devices - Compressed air line breathing apparatus with demand valve - Part 2: Apparatus with a half mask at positive pressure - Requirements, testing, marking
EN14594: 2005	Respiratory protective devices - Continuous flow compressed air line breathing apparatus - Requirements, testing, marking

Occupational Hazards & Dangerous Chemicals

Objectives: At the end of this lesson you shall be able to
- **classify the air-borne contaminants and dangerous properties of various hazards**
- **describe the concepts of threshold limit values and hazard types**
- **state the major industrial disasters and its symptoms.**

1 Classification of Air borne Contaminants

When chemicals are disseminated in air and contaminate it, they are called air-borne contaminants. They are classified according to their physical state as under:

A Gases and Vapors

a Gases:- Normally formless fluid which occupy the space of enclosure and which can be changed to the liquid or solid state only by the combined effect of increased pressure and temperature gases diffuse. The particle size varies from 0.0005 to 0.01 micron.

Example are chlorine, ammonia, sulfur dioxide, Hydrogen sulfide (H2s), Hydrogen cyanide, carbon monoxide, etc. Main pollution are oxides of carbon, sulfur and nitrogen.

b Vapors:- The gaseous form of substance which are normally in the solid or liquid state and which can be changed to these states by either increasing the pressure or decreasing the temperature alone. Vapors diffuse. The particle size varies from 0.005 to 0.01 micron.

Examples are vapours of lead oxide, benzene, xylene, trichloroethylene, and other solvents.

Gases and vapors are also classified as under

- Organic solvent vapors e.g. alcohol acetone, CS_2, CC_{l4}, benzene, xylene.
- Pulmonary irritant gases e.g. CL_2, NO2 and phosgene.
- Upper respiratory irritant gases NH3, SO_2, formaldehyde, acetic acid.
- Chemical asphyxiant gases CO, CHN.
- Simple asphyxiant gases H_2. CO_2, methane, its homologues and acetylene.
- Other inorganic and organic gases H_2S, arsine and pesticides vapors.

B Particulate Matters:

These are solid tiny particles produced by blasting, crushing, drilling, grinding, mixing etc. and suspended in air. Examples are as under:

a Dust : Solid particles generated by handling, crushing, grinding, rapid impact, detonation and decrepitating of organic or inorganic materials such as rocks, metal, coal, wood, grain etc.Dusts do not tend to flocculate except under electrostatic forces. They do not diffuse in air but settle under the influence of gravity. The particle size varies from 0.1 to 1000 microns. Fly ash from chimneys varies from 3 to 80 microns.

b Fumes: Solid particles generated by condensation from the gaseous state, generally after volatilisation from molten metals etc. and often accompanied by a chemical reaction such as oxidation. Fumes flocculate and sometimes coalesce. The particle size varies from 0.001 to 100 microns. Examples: lead, zinc. or nitrous fumes.

c Mists: Suspended liquid droplets generated by condensation from the gaseous to the liquid state, such as by splashing, foaming and atomising. The particle size varies from 50 to 100 microns. Example: sulphuric acid mist.

d Smokes: Small gas-borne particles resulting from incomplete combustion and consisting predominantly of carbon gaseous material are grouped in this category. The particle size varies from 0.1 to 1 micron.

e Smog and Fog: The air contaminants may be present in the forms of smog and fog which are not usually encountered in an industrial environment. The particle size varies from 1 to 50 micron.

f Aerosols: It is a colloidal system in which the dispersion medium is a gas and the dispersed phase is solid or liquid. The term aerosol is applicable till the solids or liquids remain suspended in the gaseous media. The particle size varies from 0.01 to 100 micron. Dust, smoke or mist are examples. Aerosols affect weather, damage materials and impair health. Atmospheric aerosol like hydrocarbons, lead, arsenic, sulfuric acid etc. may injury human health because of their toxic nature.

2 Permissible exposure Limit:

- Set by OSHA, 29 CFR, 1910.1000, and 1910.1001 through 1910.1450.
- Specify the maximum amount of concentration of a chemical to which a worker may lie exposed.
- Generally define in three different way (Salary limit, Short term expose limit & time weighted average).

3 Concepts of Threshold Limit Values (TLVs):

- Prepared by ACGIH volunteer scientists.
- Denotes the level of expositive that nearly all workers can experience with out and unreasonable risk of disease or injury.
- An advisor limit not enforceable by law.
- Generally can be define as selling limit, short term exposure limit and time weighted averages.
- Usually equivalent to PELs.

4 Excursion Limit (ACGIH)

- Excursion in worker exposure levels exceed 3 times the TLV-TWA for no more than a total thirty minutes during a work day.

5 Recommended Exposure Limits (RELs)

- Recommended by NIOSH
- Indicates the concentration of substances to which a worker can be exposure up to a 10 hours work day during a 40 hour work week without adverse effect.
- Based on the animal and human studies.
- Generally expressed as a selling limit, short term exposure limit, or a time weighted average often more conservative then PELs and TLVs.

6 Workplace Environmental Exposure Limits (WEELs)

- Developed by AIHA volunteers
- Advisor limit not enforceable by law

7 Company Developed Limits

- Developed by company scientists
- Advisor limit not enforceable by law
- Usually based on only short-term studies of animals.

8 Immediately dangerous to Life & Health (IDLH)

Concentration immediately dangerous to life or health from which a worker could escape without any escape imparing symptom or any irreversible health effect (NIOSH/OSHA)

9 Tentative Biological Expose Limits & Health weights Limits:

In fact the human organism itself may be regarded as a kind of sampling service. A workers body represent his own individual collector, resistor and monitor of his personal exposure. To arrive at an accurate evaluation of toxic exposure effect limit. The biological exposure (biological monitoring) has been gaining increasing attention recently. The tentative biological exposure limits for the most important toxic substances present in industry have been developed.

The most modern approach is to consider the integral exposure resulting from all modes of entry. (Inhalation, Ingesiton, Skin absorption) Including exposure in the living environment. Adopting this approch WHO (World Health Organisation) study group recently published 'health based limits' for occuptional exposure to some common heavy metals.

10 Classification of hazards:

Hazards can be classified as different types in several ways. One of these ways is by specifying the origin of the hazard. One key concept in identifying a hazard is the presence of stored energy that, when released, can cause damage. Stored energy can occur in many forms: chemical, mechanical, thermal, radioactive, electrical, etc.

Another class of hazard does not involve release of stored energy, rather it involves the presence of hazardous situations. Examples include confined or limited egress spaces, oxygen-depleted atmospheres, awkward positions, repetitive motions, low-hanging or protruding objects, etc.

Hazards may also be classified as natural, anthropogenic, or technological. They may also be classified as health or safety hazards and by the populations that may be affected, and the severity of the associated risk. In most cases a hazard may affect a range of targets, and have little or no effect on others. Identification of hazards assumes that the potential targets are defined.

a Biological hazard

Biological hazards, also known as biohazards, originate in biological processes of living organisms, and refer to agents that pose a threat to the health of living organisms, the security of property, or the health of the environment.

b Chemical hazard

A chemical can be considered a hazard if by virtue of its intrinsic properties it can cause harm or danger to humans, property, or the environment. Health hazards associated with chemicals are dependent on the dose or amount of the chemical. Some chemicals have a cumulative biological effect, while others are metabolically eliminated over time. Other chemical hazards may depend on concentration or total quantity for their effects.

The potential hazards of these chemicals can be identified by performing a variety of tests prior to the authorization of usage. The number of tests required and the extent to which the chemicals are tested varies, depending on the desired usage of the chemical. Chemicals designed as new drugs must undergo more rigorous tests that those used as pesticides.

Some harmful chemicals occur naturally in certain geological formations, such as radon gas or arsenic. Other chemicals include products with commercial uses, such as agricultural and industrial chemicals, as well as products developed for home use. Pesticides, which are normally used to control unwanted insects and plants, may cause a variety of negative effects on non-target organisms. DDT can build up, or bioaccumulate, in birds, resulting in thinner-than-normal egg shells which can break in the nest.

c Ergonomic hazard

Ergonomic hazards are physical conditions that may pose risk of injury to the musculoskeletal system, such as the muscles or ligaments of the lower back, tendons or nerves of the hands/wrists, or bones surrounding the knees. Ergonomic hazards include things such as awkward or extreme postures, whole-body or hand/arm vibration, poorly designed tools, equipment, or workstations, repetitive motion, and poor lighting. Ergonomic hazards occur in both occupational and non-occupational settings such as in workshops, building sites, offices, home, school, or public spaces and facilities.

d Mechanical hazard

A mechanical hazard is any hazard involving a machine or industrial process. Motor vehicles, aircraft, and air bags pose mechanical hazards. Compressed gases or liquids can also be considered a mechanical hazard. Hazard identification of new machines and/or industrial processes occurs at various stages in the design of the new machine or process.

e Physical hazard

A physical hazard is a naturally occurring process that has the potential to create loss or damage. Physical hazards include earthquakes, floods, fires, and tornadoes. Physical hazards often have both human and natural elements. Flood problems can be affected by the natural elements of climate fluctuations and storm frequency, and by land drainage and building in a flood plain, human elements. Another physical hazard, X-rays, naturally occur from solar radiation, but have also been utilized by humans for medical purposes; however, overexposure can lead to cancer, skin burns, and tissue damage.

f Psychosocial hazard

Psychological or psychosocial hazards are hazards that affect the psychological well-being of people, including their ability to participate in a work environment among other people. Psychosocial hazards are related to the way work is designed, organized and managed, as well as the economic and social contexts of work and are associated with psychiatric, psychological and/or physical injury or illness. Linked to psychosocial risks are issues such as occupational stress and workplace violence which are recognized internationally as major challenges to occupational health and safety.

11 Bhopal Gas Tragedy

The Bhopal disaster, also referred to as the Bhopal gas tragedy, was a gas leak incident on the night of 2-3 December 1984 at the Union Carbide India Limited (UCIL) pesticide plant in Bhopal, Madhya Pradesh, India. It is considered to be the world's worst industrial disaster. Over 500,000 people were exposed to methyl isocyanate (MIC) gas. The highly toxic substance made its way into and around the small towns located near the plant.

Estimates vary on the death toll. The official immediate death toll was 2,259. In 2008, the government of Madhya Pradesh had paid compensation to the family members of 3,787 victims killed in the gas release, and to 574,366 injured victims. A government affidavit in 2006 stated that the leak caused 558,125 injuries, including 38,478 temporary partial injuries and approximately 3,900 severely and permanently disabling injuries. Others estimate that 8,000 died within two weeks, and another 8,000 or more have since died from gas-related diseases. The cause of the disaster remains under debate. The Indian government and local activists argue that slack management and deferred maintenance created a situation where routine pipe maintenance caused a backflow of water into a MIC tank, triggering the disaster. Union Carbide Corporation (UCC) argues water entered the tank through an act of sabotage.

The owner of the factory, UCIL, was majority owned by UCC, with Indian Government-controlled banks and the Indian public holding a 49.1 percent stake. In 1989, UCC paid $470 million (equivalent to $845 million in 2018) to settle litigation stemming from the disaster. In 1994, UCC sold its stake in UCIL to Eveready Industries India Limited (EIIL), which subsequently merged with McLeod Russel (India) Ltd. Eveready ended clean-up on the site in 1998, when it terminated its 99-year lease and turned over control of the site to the state government of Madhya Pradesh. Dow Chemical Company purchased UCC in 2001, seventeen years after the disaster.

Civil and criminal cases filed in the United States against UCC and Warren Anderson, UCC CEO at the time of the disaster, were dismissed and redirected to Indian courts on multiple occasions between 1986 and 2012, as the US courts focused on UCIL being a standalone entity of India. Civil and criminal cases were also filed in the District Court of Bhopal, India, involving UCC, UCIL and UCC CEO Anderson. In June 2010, seven Indian nationals who were UCIL employees in 1984, including the former UCIL chairman, were convicted in Bhopal of causing death by negligence and sentenced to two years imprisonment and a fine of about $2,000 each, the maximum punishment allowed by Indian law. All were released on bail shortly after the verdict. An eighth former employee was also convicted, but died before the judgement was passed. (Fig 1 -Bhopal Gas Tragedy).

12 Emergency Planning

An emergency plan specifies procedures for handling sudden or unexpected situations. The objective is to be prepared to:

- Prevent fatalities and injuries.
- Reduce damage to buildings, stock, and equipment.
- Protect the environment and the community.

Fig 1

HSN197111

Bhopal Gas Tragedy

- Accelerate the resumption of normal operations.

Development of the plan begins with a vulnerability assessment. The results of the study will show:

- How likely a situation is to occur?

- What means are available to stop or prevent the situation?
- What is necessary for a given situation?

From this analysis, appropriate emergency procedures can be established.

At the planning stage, it is important that the relevant individuals or groups be asked to participate. Members of the team can include:

- employees with knowledge of the work
- supervisor of the area or work
- safety officer
- health and safety committee
- union representative, if applicable
- employees with experience in investigations
- "outside" experts
- representative from local government, police, fire, or ambulance

Where appropriate other organizations should also be consulted, especially when your organization's plan involves using outside resources, such as fire, police or ambulance. In some situations, one organization may develop shared response teams with neighbouring organizations.

In all situations, communication, training and periodic drills will help make sure the plan is executed well.

13 Types of Major Industrial Disasters

- March 11, 1864: The Great Sheffield Flood. The Dale Dyke Dam, at Bradfield, South Yorkshire, collapsed when its reservoir was being filled for the first time. At least 240 people died, and 5000 properties were flooded. Historian Peter Machan said: "In terms of Victorian England it was the greatest disaster in terms of loss of life, apart from maritime disasters.
- January 20, 1909: Chicago Crib Disaster. During the construction of a water intake tunnel for the city of Chicago, a fire broke out on a temporary water crib used to access an intermediate point along the tunnel. The fire began in the dynamite magazine and burned the wooden dormitory that housed the tunnel workers. 46 workers survived the fire by jumping into the lake and climbing onto ice floes or the spoil heap near the crib. 29 men were burned beyond recognition, and approximately 60 men died. Most of the remainder drowned or froze to death in the lake and were not recovered.
- September 21, 1921: Oppau explosion, Germany. Occurred when a tower silo storing 4,500 tonnes of a mixture of ammonium sulfate and ammonium nitrate fertilizer exploded at a BASF plant in Oppau, now part of Ludwigshafen, Germany, killing 500-600 people and injuring about 2,000 more.
- 1927-1932: Hawks Nest Tunnel Disaster, near Gauley Bridge, West Virginia, United States. Over several years, 476 workers died from silicosis.
- 1932-1968: The Minamata disaster was caused by the dumping of mercury compounds in Minamata Bay, Japan. The Chisso Corporation, a fertilizer and later petrochemical company, was found responsible for polluting the bay for 37 years. It is estimated that over 3,000 people suffered various deformities, severe mercury poisoning symptoms or death from what became known as Minamata disease.
- April 16, 1947: Texas City disaster, Texas. At 9:15 am an explosion occurred aboard a docked ship named the Grandcamp. The explosion, and subsequent fires and explosions, is referred to as the worst industrial disaster in America. A minimum of 578 people lost their lives and another 3,500 were injured as the blast shattered windows from as far away as 25 mi (40 km). Large steel pieces were thrown more than a mile from the dock. The origin of the explosion was fire in the cargo on board the ship. Detonation of 3,200 tons of ammonium nitrate fertilizer aboard the Grandcamp led to further explosions and fires. The fertilizer shipment was to aid the struggling farmers of Europe recovering from World War II.
- July 28, 1948: A chemical tank wagon explosion within the BASF's Ludwigshafen, Germany site caused 207 fatalities. 3,818 were injured, and 3,122 buildings were significantly affected.
- January 9, 1959: In the midst of heavy rains, a failure of the small Vega de Tera dam at about 01:00 a.m. killed 144 of 532 inhabitants in downriver Ribadelago (Zamora, Spain) some minutes later. The dam was new (1956) but poorly built as usual in that period, when the Francoist regime was prioritizing economic development over construction quality. The town was partially destroyed and never recovered; afterwards, the survivors were moved out of the floodable area to a newly built nearby town (Ribadelago Nuevo, "New Ribadelago.") See Catástrofe de Ribadelago (in Spanish.)
- February 3, 1971: The Thiokol-Woodbine Explosion at a Thiokol chemical plant in Georgia (United States) killed 29 people and seriously injured 50.
- June 1, 1974: Flixborough disaster, England. An explosion at a chemical plant near the village of Flixborough killed 28 people and seriously injured another 36.
- 1972-1976: Dioxin spills at Times Beach, Missouri, causing the evacuation and disincorporation of the 2,000-strong town starting 1983. It was the largest civilian exposure to dioxin in the United States' history.
- July 10, 1976: Seveso disaster, in Seveso, Italy, in a small chemical manufacturing plant of ICMESA. Due to the release of dioxins into the atmosphere and throughout a large section of the Lombard Plain, 3,000 pets and farm animals died and, later, 70,000 animals were slaughtered to prevent dioxins from entering the food chain. In addition, 193 people in the affected areas suffered from chloracne and other symptoms. The disaster lead to the Seveso Directive, which was issued by the European Community and imposed much harsher industrial regulations.
- April 27, 1978: Willow Island disaster. A cooling tower for a power plant under construction in Willow Island,

West Virginia collapsed, killing 51 construction workers. The cause was attributed to placing loads on recently poured concrete before it had cured sufficiently to withstand the loads. It is thought to be the largest construction accident in United States history.

- October 12, 1978: Spyros disaster. The Greek tanker Spyros exploded at Jurong Shipyard in Singapore on October 12, 1978. It killed 76 people, and remains the worst accident, in terms of lives lost, in Singapore's post-war history. It is also Singapore's worst industrial accident
- February 24, 1984: Occurred on the night in Cubatao, Brazil around 23:30 a gasoline pipeline exploded in the favela of Vila Sao Jose killing more than 100 people, the tragedy turned the eyes of the world to Cubatao and laid bare another problem: industrial pollution, since the 70s, gave the city the nickname "Death Valley".
- December 3, 1984: The Bhopal disaster in India is one of the largest industrial disasters on record. A runaway reaction in a tank containing poisonous methyl isocyanate caused the pressure relief system to vent large amounts to the atmosphere at a Union Carbide India Limited plant. Estimates of the death toll range from 3700 to 16,000. The disaster caused the region's human and animal populations severe health problems to the present.
- November 1, 1986: The Sandoz disaster in Schweizerhalle, Switzerland released tons of toxic agrochemicals into the Rhine.
- June 28, 1988: Auburn, Indiana. Improper mixing of chemicals at Bastian Plating Company killed four workers in the worst confined-space industrial accident in U.S. history; a fifth victim died two days later.[42]
- October 23, 1989: Phillips Disaster. An explosion and fire killed 23 and injured 314 in Pasadena, Texas and registered 3.5 on the Richter magnitude scale.
- July 5, 1990: An explosion and fire occurred at the Arco Chemical Company complex in Channelview, Texas. 17 people were killed. Five were permanent employees and the remaining 12 were contract labor employees. An area approximately the size of a city block was completely destroyed; no one in the area survived the explosion.[43]
- May 1, 1991: Sterlington, Louisiana. An explosion at the IMC-operated Angus Chemical nitro-paraffin plant in Sterlington, Louisiana killed eight workers and injured 120 other people. There was severe damage to the surrounding community. The blasts were heard more than eight miles away.
- August 21, 2000: Pingxiang steel plant explosion. An oxygen generator exploded in a steel plant in Pingxiang, Jiangxi, China. At least 19 steel workers were killed.
- September 21, 2001: Toulouse, France. An explosion at the AZF fertilizer factory killed 29, injured 2,500, and caused extensive structural damage to nearby neighbourhoods.
- October 19, 2009: Ottawa, Canada. A boiler explosion at the Cliff Central Heating and Cooling Plant killed one person, and three others suffered injuries.
- October 4, 2010: Alumina plant accident. Ajka, Kolontár, Devecser and several other settlements, Hungary. The dam of Magyar Aluminium's red mud reservoir broke and the escaping highly toxic and alkaline (~pH 13) sludge flooded several settlements. There were nine victims, including a young girl, and hundreds of injuries (mostly chemical burns).
- January 20, 2012: Burns Lake, British Columbia, Canada. At a wood mill two workers were killed and 20 others injured in a fire and explosion. A combustible dust environment led to the explosion and fire.
- November 8, 2012: Sherbrooke, Quebec, Canada. Two people died and 19 were injured in an industrial processing plant belonging to Neptune Technologies & Bioressources, a manufacturer of health care products.
- April 17, 2013: Fertilizer plant explosion in West, Texas. An explosion occurred at the West Fertilizer Company storage and distribution facility in West, Texas, 18 miles (29 km) north of Waco, while emergency services personnel were responding to a fire at the facility. At least 14 people were killed, more than 160 were injured and more than 150 buildings damaged or destroyed.
- June 20, 2013: Coteau-du-Lac, Quebec, Canada. Two women were killed in a fireworks warehouse explosion.
- July 31-August 1, 2014: 2014 Kaohsiung gas explosions. From the underground-installed gas pipelines of a petrochemical factory, a large-scale leakage (which had been occurring for more than three hours) led to a series of gas explosions in the streets of Kaohsiung, Taiwan at the midnight between the two days. Thirty-two people were killed and 321 others were injured.
- August 12, 2015: Binhai, Tianjin, China. Two explosions within 30 seconds of each other occurred at a container storage station at the Port of Tianjin in the Binhai New Area of Tianjin, China[51] 173 people died as a result.
- August 23, 2016: Chittagong, Bangladesh. An incident of gas leakage happened at a fertilizer company in port city of Chittagong. The fertilizer company belongs to Chittagong Urea Fertiliser Limited (CUFL) located near the shore of Karnaphuli River. No deaths were reported but 25 people had fallen ill due to toxic ammonia inhalation.[53] The investigation team found that tank was maintained by unskilled workers instead of skilled engineers which resulted in leakage.
- September 10, 2016: Gazipur, Bangladesh. A boiler explosion in a packaging industry in the town of Tongi, Gazipur, led to the death of 23 workers. The explosion was so powerful that it made part of the four story building collapse. The explosion also triggered a fire which spread to surrounding areas.
- May 9, 2018: Patel Milmet Dam failure. An embankment dam in Nakuru County, Kenya, burst during heavy rains, killing at least 48 people

Bio-medical waste and management

Objectives: At the end of this lesson you shall be able to
- **explain the significance of bio-medical waste and e-waste management**
- **state various factors influencing bio-medical and e-waste.**

a Introduction to Biomedical-waste: Biomedical waste or hospital waste is any kind of waste containing infectious (or potentially infectious) materials. It may also include waste associated with the generation of biomedical waste that visually appears to be of medical or laboratory origin (e.g. packaging, unused bandages, infusion kits etc.), as well research laboratory waste containing biomolecules or organisms that are mainly restricted from environmental release. As detailed below, discarded sharps are considered biomedical waste whether they are contaminated or not, due to the possibility of being contaminated with blood and their propensity to cause injury when not properly contained and disposed.

b Sources, composition and characteristic of hazardous waste: Biomedical waste may be solid or liquid. Examples of infectious waste include discarded blood, sharps, unwanted microbiological cultures and stocks, identifiable body parts (including those as a result of amputation), other human or animal tissue, used bandages and dressings, discarded gloves, other medical supplies and laboratory waste that exhibits the characteristics described above. Waste sharps include potentially contaminated used (and unused discarded) needles, scalpels, lancets and other devices capable of penetrating skin.

Biomedical waste is generated from biological and medical sources and activities, such as the diagnosis, prevention, or treatment of diseases. Common generators (or producers) of biomedical waste include hospitals, health clinics, nursing homes, emergency medical services, medical research laboratories, offices of physicians, dentists, veterinarians, home health care and morgues or funeral homes.

Medical facilities generate waste hazardous chemicals and radioactive materials. While such wastes are normally not infectious, they require proper disposal. Some wastes are considered multihazardous, such as tissue samples preserved in formalin.

Characteristics of Bio-medical waste: Disposal of this waste is an environmental concern, as many medical wastes are classified as infectious or biohazardous and could potentially lead to the spread of infectious disease. The most common danger for humans is the infection which also affects other living organisms in the region. Daily exposure to the wastes (landfills) leads to accumulation of harmful substances or microbes in the person's body. Biomedical waste those settings may pose an injury and exposure risks via occupational contact with medical waste for doctors, nurses, and janitorial, laundry and refuse workers. Further, there are opportunities for the general public to come into contact medical waste, such as needles used illicitly outside healthcare settings, or biomedical waste generated via home health care.

c Techniques of bio-medical waste management: Biomedical waste must be properly managed and disposed of to protect the environment, general public and workers, especially healthcare and sanitation workers who are at risk of exposure to biomedical waste as an occupational hazard. Steps in the management of biomedical waste include generation, accumulation, handling, storage, treatment, transport and disposal. The development and implementation of a national waste management policy can improve biomedical waste management in health facilities in a country.

Generation, accumulation and collection of biomedical waste: Biomedical waste should be collected in containers that are leak-proof and sufficiently strong to prevent breakage during handling. Containers of biomedical waste are marked with a biohazard symbol. The container, marking, and labels are often red. Discarded sharps are usually collected in specialized boxes, often called needle boxes.

Storage & Handling of biomedical waste: Storage refers to keeping the waste until it is treated on-site or transported off-site for treatment or disposal. There are many options and containers for storage. Regulatory agencies may limit the time for which waste can remain in storage. Handling is the act of moving biomedical waste between the point of generation, accumulation areas, storage locations and on-site treatment facilities. Workers who handle biomedical waste must observe standard precautions.

d Treatment of bio-medical waste: The goals of biomedical waste treatment are to reduce or eliminate the waste's hazards, and usually to make the waste unrecognizable. Treatment should render the waste safe for subsequent handling and disposal. There are several treatment methods that can accomplish these goals. It include segregating the bio waste.

Biomedical waste is often incinerated. An efficient incinerator will destroy pathogens and sharps. Source materials are not recognizable in the resulting ash. Alternative thermal treatment can also include technologies

such as gasification and pyrolysis including energy recovery with similar waste volume reductions and pathogen destruction.

An autoclave may also be used to treat biomedical waste. An autoclave uses steam and pressure to sterilize the waste or reduce its microbiological load to a level at which it may be safely disposed of. Many healthcare facilities routinely use an autoclave to sterilize medical supplies. If the same autoclave is used to sterilize supplies and treat biomedical waste, administrative controls must be used to prevent the waste operations from contaminating the supplies. Effective administrative controls include operator training, strict procedures, and separate times and space for processing biomedical waste.

Autoclave (Fig 1)

Fig 1

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Autoclave

Microwave disinfection can also be employed for treatment of biomedical wastes. Microwave irradiation is a type of non-contact heating technologies for disinfection. Microwave chemistry is based on efficient heating of materials by microwave dielectric heating effects. When exposed to microwave frequencies, the dipoles of the water molecules present in cells re-align with the applied electric field. As the field oscillates, the dipoles attempts to realign itself with the alternating electric field and in this process, energy is lost in the form of heat through molecular friction and dielectric loss. Microwave disinfection is a recently developed technology which provides advantage over old existing technologies of autoclaves as microwave based disinfection has less cycle time, power consumption and it requires minimal usage of water and consumables as compared to autoclaves.

Microwave (Fig 2)

For liquids and small quantities, a 1-10% solution of bleach can be used to disinfect biomedical waste. Solutions of sodium hydroxide and other chemical disinfectants may also be used, depending on the waste's characteristics.

Chemical disinfection plant (Fig 3)

Other treatment methods include heat, alkaline digesters and the use of microwaves. For autoclaves and microwave systems, a shredder may be used as a final treatment step to render the waste unrecognizable. Some autoclaves have built in shredders.

Fig 2

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Microwave

Fig 3

HSN1107213

Chemical disinfection plant

Hydroclave (Fig 4)

Fig 4

HSN1107214

Hydro clave

Bio-medical Waste (Management and Handling) Rules & Amendments

The Bio-medical Waste (Management and Handling) Rules, 1998 and further amendments were passed for the regulation of bio-medical waste management. On 28 th Mar 2016 Biomedical Waste Management Rules 2016 were also notified by Central Govt. Each state's Pollution Control Board or Pollution control Committee will be responsible for implementing the new legislation. New regulations affect the distribution of medical waste by medical professionals into their proper receptacles.

In India, though there are a number of different disposal methods, the situation is desultory and most are harmful rather than helpful. If body fluids are present, the material needs to be incinerated or put into an autoclave. Although this is the proper method, most medical facilities fail to follow the regulations. It is often found that biomedical waste is dumped into the ocean, where it eventually washes up on shore, or in landfills due to improper sorting or negligence when in the medical facility. Improper disposal can lead to many diseases in animals as well as humans. For example, animals, such as cows in Pondicherry, India, are consuming the infected waste and eventually, these infections can be transported to humans who consume their meat or milk. Large number of unregistered clinics and institutions also generate bio-medical waste which is not controlled.

Due to the competition to improve quality and so as to get accreditation from agencies like ISO, NABH, JCI, many private organizations have initiated proper bio-medical waste disposal but still the gap is huge.

Many studies took place in Gujarat, India regarding the knowledge of workers in facilities such as hospitals, nursing homes, or home health. It was found that 26% of doctors and 43% of paramedical staff were unaware of the risks related to biomedical wastes. After extensively looking at the different facilities, many were undeveloped in the area regarding biomedical waste. The rules and regulations in India work with The Bio-medical Waste (Management and Handling) Rules from 1998, yet a large number of health care facilities were found to be sorting the waste incorrectly.

The latest guidelines for segregation of bio-medical waste recommend the following color coding:

- **Red Bag -** Syringes (without needles), soiled gloves, catheters, IV tubes etc. should be all disposed of in a red colored bag, which will later be incinerated.
- **Yellow Bag -** All dressings, bandages and cotton swabs with body fluids, blood bags, human anatomical waste, body parts are to be discarded in yellow bags.
- **Cardboard box with blue marking -** Glass vials, ampules, other glass ware is to be discarded in a cardboard box with a blue marking/sticker.
- **White Puncture Proof Container (PPC) -** Needles, sharps, blades are disposed of in a white translucent puncture proof container.
- **Black Bags -** These are to be used for non-bio-medical waste. In a hospital setup, this includes stationary, vegetable and fruit peels, leftovers, packaging including that from medicines, disposable caps, disposable masks, disposable shoe-covers, disposable tea cups, cartons, sweeping dust, kitchen waste etc.

The syringe tide environmental disaster

The syringe tide environmental disaster of 1987-1988 raised awareness about medical waste as medical syringes washed ashore in Connecticut, New Jersey, and New York. A similar situation occurred in 2013 at Island Beach State Park in New Jersey, and brought about the Floatables Action Plan. The syringes endangered marine species and posed a threat to humans who visited the beach. The crises spurred scientists and lawmakers to create mechanisms, policies, and laws so that health care providers would process their bio-waste in an environmentally friendly way.

Improper management of health care waste can have both direct and indirect health consequences for health personnel, community members and on the environment. Indirect consequences in the form of toxic emissions from inadequate burning of medical waste, or the production of millions of used syringes in a period of three to four weeks from an insufficiently well planned mass immunization campaign.

Biomedical waste is not limited to medical instruments; it includes medicine, waste stored in red biohazard bags, and materials used for patient care, such as cotton and bandaids.

The high volume of plastic use in the medical field also poses a dangerous threat to the environment. According to North and Halden, 85% of disposable plastic materials make up all medical equipment. Our current reliance on plastic materials is rooted in their unique capabilities to be lightweight, cost-effective, and durable while preserving the sterility of medical equipment. In addition to the serious health implications of releasing harmful toxins in the environment from medical waste deposits, introducing this volume of single-use plastics can catalyze the compounding health detriments caused by macro and micro plastics.

Methods of biomedical waste incineration: The three type of medical waste incinerators are controlled air, excess air, and rotary kiln. Controlled air is also known as starved-air incineration, two-stage incineration, or modular combustion. This is the process of which waste is fed to a combustion chamber and combustion air begins to dry and facilitates volatilization of the waste. As a result, carbon dioxide and other excess gases are released into the atmosphere.

The second type of incineration is the excess air process. This is similar to the controlled air process, such as the waste being dried, ignited, and combusted by heat provided by the primary chamber burner. However, the main difference is that moisture and volatile components in the waste are vaporized.

In a rotary kiln, the process is similar to the two mention above, however, it is more versatile in terms of being able to mix wet and dry waste components and viewed by many waste engineers as being the most environmentally friendly.

Impact on the environment: Post incineration process, toxic ash residue is produced and is often disposed at landfills. These landfills are not protected by any barrier and the residue has the potential of reaching underground water that is often exposed to human use. The combustion of plastic material releases toxic gases that escapes and joins breathable air. Human and animal exposure to such gases can cause long term breathing and health issues. Air pollution caused by the incinerators depletes the ozone layer, causes crop and forest damage, and increases

climate change. Constant exposure to such toxins and chemicals in the air could be deemed detrimental to trees and plants and could eventually lead to extinction of certain plants in specific areas. Pollution and chemical leaks also affect the fruits of trees and would cause them to be poisonous and therefore, inedible.

Environmentally friendly alternatives: Reusable RMW or sharps containers reduce the amount of plastic sent to landfills and CO 2 emissions. Non-incineration treatment includes four basic processes: thermal, chemical, irradiative, and biological. The main purpose of the treatment technology is to decontaminate waste by destroying pathogens. Modern technology invented mechanics that would allow medical professionals and hospitals to dispose medical waste in an environmentally friendly way; such as: autoclaving, plasma pyrolysis, gasification, chemical methods, and microwave irradiation. These alternatives are also highly versatile and can be used for all different types of waste.

Other possible solutions: Initiative from corporations and hospitals is essential to creating a healthier environment, Consequences could be implemented where individuals would be required to pay a fine, or face unpaid suspension from work.

Companies and governmental organization should also initiate non-routine check-ups and searches, this would place pressure on hospitals to ensure that waste is properly disposed all year round.

Voluntary clean-ups would involve hospital staff in assuring that medical waste is not littered around the hospital or thrown into regular garbage bins.

e E-waste

Electronic waste or e-waste: describes discarded electrical or electronic devices. Used electronics which are destined for refurbishment, reuse, resale, salvage recycling through material recovery, or disposal are also considered e-waste. Informal processing of e-waste in developing countries can lead to adverse human health effects and environmental pollution. Electronic scrap components, such as CPUs, contain potentially harmful materials such as lead, cadmium, beryllium, or brominated flame retardants. Recycling and disposal of e-waste may involve significant risk to health of workers and their communities.

Significance of e-waste: E-waste or electronic waste is created when an electronic product is discarded after the end of its useful life. The rapid expansion of technology and the consumption driven society results in the creation of a very large amount of e-waste. The term "waste" is reserved for residue or material which is dumped by the buyer rather than recycled, including residue from reuse and recycling operations, because loads of surplus electronics are frequently commingled (good, recyclable, and non-recyclable). Several public policy advocates apply the term "e-waste" and "e-scrap" broadly to all surplus electronics. Cathode ray tubes (CRTs) are considered one of the hardest types to recycle.

On the other hand, the Partnership on Measuring ICT for Development defines e-waste into six categories, namely : (1) Temperature exchange equipment (e.g., air conditioners, freezers), (2) Screens, monitors (e.g., TV, laptop), (3) Lamps(e.g., LED lamps), (4) Large equipment (e.g., washing machines, electric stoves), (5) Small equipment (e.g., microwave, electric shaver), and (6) Small IT and telecommunication equipment (e.g., mobile phones, printers). Products in each category vary in longevity profile, impact, and collection methods, among other differences.

CRTs have a relatively high concentration of lead and phosphors (not to be confused with phosphorus), both of which are necessary for the display. These CRT devices are often confused between the DLP Rear Projection TV, both of which have a different recycling process due to the materials of which they are composed.

The high value of the computer recycling subset of electronic waste (working and reusable laptops, desktops, and components like RAM) can help pay the cost of transportation for a larger number of worthless pieces than what can be achieved with display devices, which have less (or negative) scrap value. In A 2011 report, "Ghana E-Waste Country Assessment found that of 215,000 tons of electronics imported to Ghana, 30% were brand new and 70% were used. Of the used product, the study concluded that 15% was not reused and was scrapped or discarded. This contrasts with published but uncredited claims that 80% of the imports into Ghana were being burned in primitive conditions.

E-waste is considered the "fastest-growing waste stream in the world with 44.7 million tonnes generated in 2016- equivalent to 4500 Eiffel towers. In 2018, an estimated 50 million tonnes of e-waste was reported, thus the name 'tsunami of e-waste' given by the UN. Its value is at least $62.5 billion annually. Rapid changes in technology, changes in media (tapes, software, MP3), falling prices, and planned obsolescence have resulted in a fast-growing surplus of electronic waste around the globe. Technical solutions are available, but in most cases, a legal framework, a collection, logistics, and other services need to be implemented before a technical solution can be applied.

Display units (CRT, LCD, LED monitors), processors (CPU, GPU, or APU chips), memory (DRAM or SRAM), and audio components have different useful lives. Processors are most frequently out-dated (by software no longer being optimized) and are more likely to become "e-waste" while display units are most often replaced while working without repair attempts, due to changes in wealthy nation appetites for new display technology. This problem could potentially be solved with modular smartphones (such as the Phonebloks concept). These types of phones are more durable and have the technology to change certain parts of the phone making them more environmentally friendly. Being able to simply replace the part of the phone that is broken will reduce e-waste.

In 2006, the United Nations estimated the amount of worldwide electronic waste discarded each year to be 50 million metric tons. According to a report by UNEP titled,

"Recycling - from E-Waste to Resources," the amount of e-waste being produced - including mobile phones and computers - could rise by as much as 500 percent over the next decade in some countries, such as India. The United States is the world leader in producing electronic waste, tossing away about 3 million tons each year. China already produces about 2.3 million tons (2010 estimate) domestically, second only to the United States. And, despite having banned e-waste imports. China remains a major e-waste dumping ground for developed countries.

Since the invention of the iPhone, cell phones have become the top source of e-waste products because they are not made to last more than two years. Electrical waste contains hazardous but also valuable and scarce materials. Up to 60 elements can be found in complex electronics.

While there is agreement that the number of discarded electronic devices is increasing, there is considerable disagreement about the relative risk (compared to automobile scrap, for example), and strong disagreement whether curtailing trade in used electronics will improve conditions, or make them worse.

Benefits of recycling: Recycling raw materials from end-of-life electronics is the most effective solution to the growing e-waste problem. Most electronic devices contain a variety of materials, including metals that can be recovered for future uses. By dismantling and providing reuse possibilities, intact natural resources are conserved and air and water pollution caused by hazardous disposal is avoided.

Additionally, recycling reduces the amount of greenhouse gas emissions caused by the manufacturing of new products. Another benefit of recycling e-waste is that many of the materials can be recycled and re-used again.

Materials that can be recycled include "ferrous (iron-based) and non-ferrous metals, glass, and various types of plastic." "Non-ferrous metals, mainly aluminium and copper can all be re-smelted and re-manufactured. Ferrous metals such as steel and iron also can be re-used.

Due to the recent surge in popularity in 3D printing, certain 3D printers have been designed (FDM variety) to produce waste that can be easily recycled which decreases the amount of harmful pollutants in the atmosphere.

The excess plastic from these printers that comes out as a by-product can also be reused to create new 3D printed creations.

Health hazards of e-waste: Children are especially sensitive to e-waste exposure because of several reasons, such as their smaller size, higher metabolism rate, larger surface area in relation to their weight, and multiple exposure pathways (for example, dermal, hand-to-mouth, and take-home exposure). Studies have found significant higher blood lead levels (BLL) and blood cadmium levels (BCL) of children living in e-waste recycling area compared to those living in control area. For example, one study found that the average BLL in Guiyu was nearly 1.5 times compared to that in the control site (15.3 ug/dL compared to 9.9 ug/dL), while the CDC of the United States has set a reference level for blood lead at 5 ug/dL. The highest concentrations of lead were found in the children of parents whose workshop dealt with circuit boards and the lowest was among those who recycled plastics.

Exposure to e-waste can cause serious health problems to children. Children's exposure to developmental neurotoxins containing in e-waste such as lead, mercury, cadmium, chromium and PBDEs can lead to a higher risk of lower IQ, impaired cognitive function, and other adverse effects. In certain age groups, a decreased lung function of children in e-waste recycling sites has been found. Some studies also found associations between children's e-waste exposure and impaired coagulation, hearing loss, and decreased vaccine antibody tilters in e-waste recycling area.

E-waste recycling workers

The complex composition and improper handling of e-waste adversely affect human health. A growing body of epidemiological and clinical evidence has led to increased concern about the potential threat of e-waste to human health, especially in developing countries such as India and China.

For instance, in terms of health hazards, open burning of printed wiring boards increases the concentration of dioxins in the surrounding areas. These toxins cause an increased risk of cancer if inhaled by workers and local residents.

Toxic metals and poison can also enter the bloodstream during the manual extraction and collection of tiny quantities of precious metals, and workers are continuously exposed to poisonous chemicals and fumes of highly concentrated acids.

Recovering resalable copper by burning insulated wires causes neurological disorders, and acute exposure to cadmium, found in semiconductors and chip resistors, can damage the kidneys and liver and cause bone loss. Long-term exposure to lead on printed circuit boards and computer and television screens can damage the central and peripheral nervous system and kidneys, and children are more susceptible to these harmful effects.

Table 1 - Environmental impact of e-waste

E-Waste Component	Electric Appliances in which they are found	Adverse Health Effects
Americium	The radioactive source in smoke alarms.	It is known to be carcinogenic.
Lead	Solder, CRT monitor glass, lead-acid batteries, some formulations of PVC. A typical 15-inch cathode ray tube may contain 1.5 pounds of lead,[4] but other CRTs have been estimated as having up to 8 pounds of lead.	Adverse effects of lead exposure include impaired cognitive function, behavioural disturbances, attention deficits, hyperactivity, conduct problems, and lower IQ. These effects are most damaging to children whose developing nervous systems are very susceptible to damage caused by lead, cadmium, and mercury.
Mercury	Found in fluorescent tubes (numerous applications), tilt switches (mechanical doorbells, thermostats) and ccfl backlights in flat screen monitors.	Health effects include sensory impairment, dermatitis, memory loss, and muscle weakness. Exposure in-utero causes fetal deficits in motor function, attention, and verbal domains. Environmental effects in animals include death, reduced fertility, and slower growth and development.
Cadmium	Found in light-sensitive resistors, corrosion-resistant alloys for marine and aviation environments, and nickel-cadmium batteries. The most common form of cadmium is found in Nickel-cadmium rechargeable batteries. These batteries tend to contain between 6 and 18% cadmium. The sale of Nickel-Cadmium batteries has been banned in the European Union except for medical use. When not properly recycled it can leach into the soil, harming microorganisms and disrupting the soil ecosystem. Exposure is caused by proximity to hazardous waste sites and factories and workers in the metal refining industry.	The inhalation of cadmium can severe cause damage to the lungs and is also known to cause kidney damage. [112] Cadmium is also associated with deficits in cognition, learning, behavior, and neuromotor skills in children.
Hexavalent	Used in metal coatings to protect from corrosion.	A known carcinogen after occupational chromiuminhalation exposure. There is also evidence of cytotoxic and genotoxic effects of some chemicals, which have been shown to inhibit cell proliferation, cause cell membrane lesion, cause DNA single-strand breaks, and elevate Reactive Oxygen Species (ROS) levels.
Sulfur	Found in lead-acid batteries.	Health effects include liver damage, kidney damage, heart damage, eye and throat irritation. When released into the environment, it can create sulfuric acid through sulfur dioxide.
Brominated Flame Retardants (BFRs)	Used as flame retardants in plastics in most electronics. Includes PBBs, PBDE, DecaBDE, OctaBDE, PentaBDE.	Health effects include impaired development of the nervous system, thyroid problems, liver problems. Environmental effects: similar effects as in animals as humans. PBBs were banned from 1973 to 1977 on. PCBs were banned during the 1980s.

Perfluoroocta noic acid (PFOA)	Used as an antistatic additive in industrial applications and found in electronics, also found in non-stick cookware (PTFE). PFOAs are formed synthetically through environmental degradation.	Studies in mice have found the following health effects: Hepatotoxicity, developmental toxicity, immunotoxicity, hormonal effects and carcinogenic effects. Studies have found increased maternal PFOA levels to be associated with an increased risk of spontaneous abortion (miscarriage) and stillbirth. Increased maternal levels of PFOA are also associated with decreases in mean gestational age (preterm birth), mean birth weight (low birth weight), mean birth length (small for gestational age), and mean APGAR score.
Beryllium oxide	Filler in some thermal interface materials such as thermal grease used on heatsinks for CPUs and power transistors,[116] magnetrons, X-ray-transparent ceramic windows, heat transfer fins in vacuum tubes, and gas lasers.	Occupational exposures associated with lung cancer, other common adverse health effects are beryllium sensitization, chronic beryllium disease, and acute beryllium disease.
Polyvinyl chloride (PVC)	Commonly found in electronics and is typically used as insulation for electrical cables.[118]	In the manufacturing phase, toxic and hazardous raw material, including dioxins are released. PVC such as chlorine tend to bioaccumulate. Over time, the compounds that contain chlorine can become pollutants in the air, water, and soil. This poses a problem as human and animals can ingest them. Additionally, exposure to toxins can result in reproductive and developmental health effects

Table 2 - Components of e-waste

E-Waste Component	Process Used
Aluminium	nearly all electronic goods using more than a few watts of power (heatsinks), ICs, electrolytic capacitors.
Copper	copper wire, printed circuit board tracks, ICs, component leads.
Germanium[107]	1950s-1960s transistorized electronics (bipolar junction transistors).
Gold	connector plating, primarily in computer equipment.
Lithium	lithium-ion batteries.
Nickel	nickel-cadmium batteries.
Silicon	glass, transistors, ICs, printed circuit boards.
Tin	solder, coatings on component leads.
Zinc	plating for steel parts.

Table 3 - Hazards applicable to recycling

Hazards	Details
Slips, trips, and falls	They can happen during collecting and transporting e-wastes.
Crushing hazards	Workers can be stuck or crushed by the machine or the e-waste. There can be traffic accidents when transporting e-waste. Using machines that have moving parts, such as conveyors and rolling machines can also cause crush accidents, leading to amputations, crushed fingers or hands.
Hazardous energy released	Unexpected machine startup can cause death or injury to workers. This can happen during the installation, maintenance, or repair of machines, equipment, processes, or systems.
Cuts and lacerations	Hands or body injuries and eye injuries can occur when dismantling e-wastes that have sharp edges.
Noise	Working overtime near loud noises from drilling, hammering, and other tools that can make a great noise lead to hearing loss.
Toxic chemicals (dusts)	Burning e-waste to extract metals emits toxic chemicals (e.g. PAHs, lead) from e-waste to the air, which can be inhaled or ingested by workers at recycling sites. This can lead to illness from toxic chemicals.

Table 4 –Hazard prevention of e-waste

Hazards	What must employers do	What should workers do
General	Actions include: 1 determine the hazards in the workplace and take actions to control them 2 check and make correction to the work place condition regularly 3 supply safe tools and PPE to workers 4 provide workers with training about hazards and safe work practice 5 written document about injury and illness prevention.	Suggestions include: 1 wear PPE when working; 2 talk with employers about ways to to improve working conditions 3 report anything unsafe in the workplace to employers 4 share experience of how to work safely with new workers
Dust	Actions include: 1 offer a clean eating area, cleaning area and supplies, uniforms and shoes, and lockers for clean clothes to the workers 2 provide tools to dismantle the e-waste	Protective measures include: 1 clean the workplace regularly, and do not eat or smoke when dealing with e-waste 2 don't use brooms to clean the workplace since brooms can raise dust

	If the dust contains lead or cadmium:	3 before going home, shower, change into clean clothes, and separate the dirty work clothes and clean clothes
	1 measure the dust, lead and cadmium level in the air 2 provide cleaning facilities such as wet mops and vacuums 3 provide exhaust ventilation. If it is still not sufficient to reduce the dust, provide workers with respirators 4 provide workers with blood lead testing when lead level is not less than 30 mg/m3	4 test the blood lead, even if the employers don't provide it. 5 use respirator, check for leaks every time before use always keep it on your face in the respirator use area and clean it properly after use.
Cuts and lacerations	Protective equipment such as gloves, masks and eye protection equipments should be provided to workers	When dealing with glass or shredding materials, protect the hands and arms using special gloves and oversleeves
Noise	Actions include: 1 measure the noise in the workplace, and use engineering controls when levels exceed the exposure limit 2 reduce the vibration of the working desk by rubber matting 3 provide workers with earmuffs when necessary	Wear the hearing protection all the time when working. Ask for the employer about the noise monitoring results. Test the hearing ability.
Lifting injuries	Provide facilities to lift or move the e-waste and adjustable work tables	When handling e-waste, try to decrease the load per time. Try to get help from other workers when lifting heavy or big things.

Storage and occupational hazards

Objectives: At the end of this lesson you shall be able to
- **describe the significance of noise pollution**
- **explain the types, causes and sources of noise pollution**
- **describe knowledge on the effects of noise pollution on human health and measures to prevent the same.**

Noise Pollution

The word noise is derived from a Latin word 'Nausea' which means sickness in which one feels the need to vomit. Noise is the unpleasant and undesirable sound which leads to discomfort in human beings. The intensity of sound is measured in decibels (dB). The faintest sound which can be heard by the Human ear is 1 Db. Due to increasing noise around the civilizations, noise pollution has become a matter of concern. Some of its major causes are vehicles, aircraft, industrial machines, loudspeakers, crackers, etc.

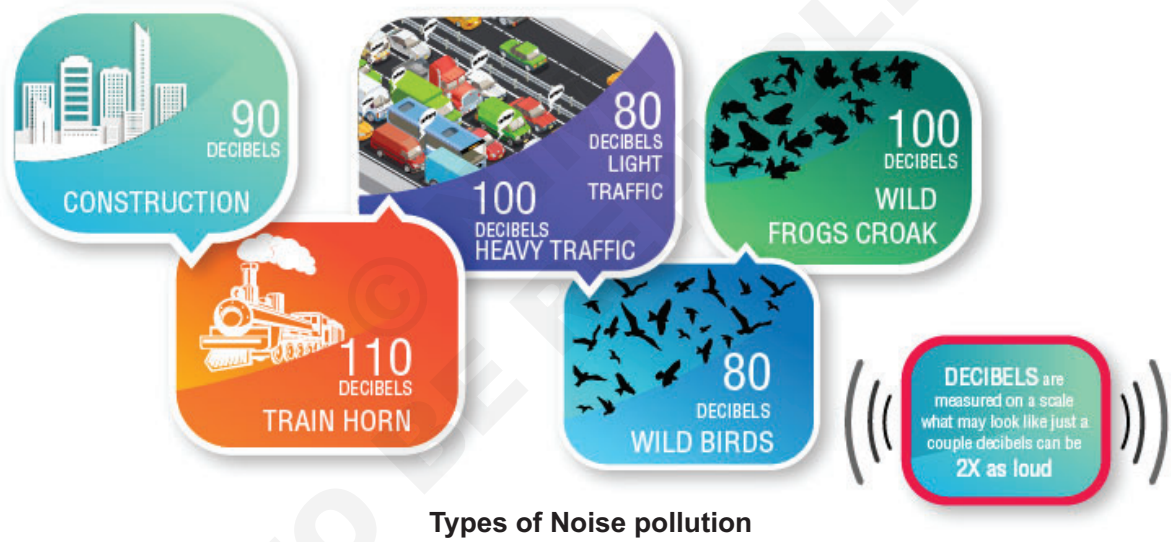
Some other appliances also contribute to noise pollution like television, transistor, radio, etc. when used at high volume.

1 Types of Noise Pollution (Fig 1)

Following are the three types of pollution:

- Transport Noise
- Neighbourhood Noise
- Industrial Noise

Fig 1



Types of Noise pollution

a Transport Noise

It mainly consists of traffic noise which has increased in recent years with the increase in the number of vehicles. The increase in noise pollution leads to deafening of older people, headache, hypertension, etc.

b Neighbourhood Noise

The noise from gadgets, household utensils etc. Some of the main sources are musical instruments, transistors, loudspeakers, etc.

c Industrial Noise

It is the high-intensity sound which is caused by heavy industrial machines. According to many researches, industrial noise pollution damages the hearing ability to around 20%.

2 Causes and Sources of Noise Pollution

Following are the causes and sources of noise pollution:

- **Industrialisation:** Industrialisation has led to an increase in noise pollution as the use of heavy machinery such as generators, mills, huge exhaust fans are used, resulting in the production of unwanted noise.
- **Vehicles:** Increased number of vehicles on the roads are the second reason for noise pollution.
- **Events:** Weddings, public gatherings involve loudspeakers to play music resulting in the production of unwanted noise in the neighbourhood.
- **Construction sites:** Mining, construction of buildings, etc add to the noise pollution.

3 Noise Pollution Examples

Following are the examples of noise pollution:

- Unnecessary usage of horns
- Using loudspeakers either for religious functions or for political purposes
- Unnecessary usage of fireworks
- Industrial noise
- Construction noise
- Noise from transportation such as railway and aircraft

4 Effects of Noise Pollution on Human Health

Noise pollution can be hazardous to human health in the following ways:

- **Hypertension:** It is a direct result of noise pollution which is caused due to elevated blood levels for a longer duration.
- **Hearing loss:** Constant exposure of human ears to loud noise that are beyond the range of sound that human ears can withstand damages the eardrums, resulting in loss of hearing.
- **Sleeping disorders:** Lack of sleep might result in fatigue and low energy level throughout the day affecting everyday activities. Noise pollution hampers the sleep cycles leading to irritation and an uncomfortable state of mind.
- **Cardiovascular issues:** Heart-related problems such as blood pressure level, stress and cardiovascular diseases might come up in a normal person and a person suffering from any of these diseases might feel a sudden shoot up in the level.

5 Prevention of Noise Pollution

Some noise pollution preventive measures are provided in the points below.

- Honking in public places like teaching institutes, hospital, etc. should be banned.
- In commercial, hospital, and industrial buildings, adequate soundproof systems should be installed.
- Musical instruments sound should be controlled to desirable limits.
- Dense tree cover is useful in noise pollution prevention.
- Explosives should be not used in forest, mountainous and mining areas