UNIT 5 CONCEPT OF SAFETY ENGINEERING (ERGONOMICS, PROCESS SAFETY)

Structure

5.1 INTRODUCTION

For Safety Engineering to succeed in any industry, a safety culture has to be built first. Safety engineering concepts provide the structure for Safety and Industrial design engineers to develop intrinsically safe equipment, systems, processes and facilities. When employed early in a design process, safety engineers provide insight into how people will interface with the equipment and facilitate safe design accordingly. Implementation of safety aspects at design stage will ensure not only safe design for people, but also, a safe operational concept that will reduce equipment/plant downtime and minimize the cause-effect of accidents. Engineered safety includes fail safe process equipment, fault-tolerant equipment, fire safety features and enclosed

hazardous systems that prevent exposure to both workmen and the environment.

Safety engineering is the engineering discipline which train students to build and maintain engineered systems that operate free of risk or with minimum risk to the people and environment. It is an integral part of industrial engineering/systems engineering, and the subset, system safety engineering.

Rapid advances in technology have led to increased use of more and more dangerous operations and use of hazardous materials in the industry today. It becomes imperative on the part of engineers and managers to adopt systems / processes and design / operate / maintain devices that will reduce / eliminate the risks of injury to the physical body and long term health of the workmen.

Objectives

After studying of this unit, you should be able to:

- appreciate the importance of safety in industrial practices,
- describe workmen's viewpoint towards safety and accidents,
- explain how safety is organized in large industries, and
- identify safety functions and processes in workplace operations and industries.

5.2 SAFETY ENGINEERING : SCOPE

Indian industry is yet to fully come out of the age old habits of unsafe working practices. The first and foremost job of the Safety Engineer would be to build a Safety Consciousness/Safety Culture in the organization where it is absent or to tone up the standards, where it already exists.

The approach has to be top-down and involvement of the highest level of management is necessary for safety practices to succeed. Building a Safety Cell with a dedicated team and allocation of funds is the responsibility of the higher management. The management will have to spell out a safety policy, generate consciousness towards safety and protection and generally oversee that engineering functions help to build safety consciousness in workmen and train them on various safety aspects. The cost effectiveness of all protective methods and equipment will have to be kept in mind too.

The managerial and supervisory functions become very important in seeing that the workmen follow the rules for safety, use personal protective devices and that the protective equipment are available at proper places.

The engineers must design devices and processes that will reduce or eliminate any risk during operation. Example: employing safety guards for moving machinery parts, interlocking machine movements liable to cause injury etc. Engineers should also try to avoid use of hazardous materials or ensure safe handling of hazardous materials.

It is worthwhile to mention at this point that safety from accidents alone should not be the target of Safety Engineering. Health of workmen is also

associated with safety. Inhaling welding fumes may not cause an accident but can be very detrimental to health in long term. The situations in workplace do not only cause physical injury or stress but also psychological stress. A workman who is mentally stressed may forget to follow a safety precaution and subject himself to accident. This understanding broadens the field of Safety Engineering and requires help of specialists like safety engineers, industrial hygienists, health physicists, occupational therapists and risk managers.

SAQ 1

a) Why is Safety important in industry?

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b) What is the first and foremost job of a Safety Engineer?

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5.3 EVALUATION OF SAFETY

5.3.1 Historical Background

Large-scale industrial expansion started in the beginning of nineteenth century but at that time little or no importance was attached to safety in the industries. With expansion of industrial activities, the sizes of industries multiplied and so did the number of workmen in individual industries. The productivity of workmen increased tremendously with the aid of newer machineries and product quality too was visibly controlled and improved. However, all these developments did not bring about any concern to human lives, safety and general well being of factory workmen. By the beginning of twentieth century lack of safety concern and consciousness began to speak upon the health of the industry. Adverse health effects began to run rampant in workplaces. With the advent of newer and more complex technologies the number of serious industrial accidents began to rise. It was then that a few enlightened and progressive factory managers started feeling the necessity of abating the causes of rising number of accidents, serious injuries to workmen and poor health conditions in workplaces that were affecting productivity.

The early thrust started with taking care of cuts and bruises and broken bones of factory workmen. The responsibility was largely entrusted upon personnel managers, maintenance foremen or plant engineers. These people tried to

evolve methods of safe working by providing guards on machines, shields on implements or by making workmen use gloves and wear glasses during some specific activities. Soon these persons were replaced by safety engineers or supervisors and safety managers. Such need was felt greatly by two industry giants, viz, steel industry and railroad establishment. Yet the personnel made responsible to prevent accidents were not specifically trained for the job but were chosen from available force based upon their wide experience in an industry.

The situation continued until 1912 when in USA the Cooperative Safety Congress was organized. The Electrical Engineers from steel industry took lead in organizing this conference. The congress resulted in establishment of National Safety Council (NSC) in USA. This body was given charter to take responsibility to look after prevention of accidents and development of safety programs. In post 1920 period several safety codes were formulated by American Standards Association. The onset of second World War caused a setback in safety movement both in Europe and America. This period was marked by workmen's demand for higher wages, their insistence on forming unions to demand their rights. There was a perceptible change in government attitude towards sacrificing safety considerations in favour of desire to win the war. The industry managers too developed a false notion that safety was a nonproductive activity. This set back was short lived and soon the attitudes of governments and managements changed and they started paying more attention to safety aspects of industrial workmen.

5.3.2 Safety Concerns : New Areas

The industries started including newer aspects in safety concerns. The noise, dust, fumes, heat, mists and radiation etc. got included in the growing lists of hazards in industry. This became necessary because the industrial activities widened and scope of industrial activities expanded. This renewal of interest was followed by governments paying more attention to safety programs and large industries began to organize special trainings to their engineers.

These steps helped increase the number of suitably trained personnel in the area of industrial safety. New disciplines were added to safety practices in industry. These were industrial hygiene, health physics, ergonomics, design engineering, illumination engineering, audiology and workmen's compensation claim administration. Each of these fields had twin targets of safeguarding workmen's health and life and improving productivity. Tremendous amount of research work and enunciation of safety theories propelled safety practices into academic body of knowledge and information.

In 1949 the Government of India passed the Factories Act (1948) which provided the guiding principles of safety in Indian industries. The Act through the years has undergone many amendments and is constantly updated depending on the demands of the industry. A list of the guiding Standards is provided for reference at the end of the unit (Section____) as Annexure-1 to this unit.

It has now become possible for engineers and managers to specialize in safety engineering and safety management through formal education. That a chief executive of an industry needs to be equally conscious about safety and quality is of crucial importance now. Safety, health and environmental controls have become essential staff functions. In most industries today, safety finds place as one of the important industrial activities along with manufacturing, research, design and development, purchase, sales, service and profits.

Along with the University curriculum you should also apprise yourself with the existing Government regulations on safety.

5.4 SAFETY CELL

Every industry must have a Safety Cell with a Standard Operating Procedure that clearly defines the objectives and functions of the Cell. It has been experienced that safety policies often fail if safety functions are distributed or made part of activities of several departments. Under the system of distributed responsibilities, the safety functions have often been reported to corporate managers through personnel and human resource department, operational office or legal office. Such practices have mostly failed in successful implementation of safety programs.

Safety policies can be properly implemented and safety practices succeed if they are controlled by a single department with safety personnel interacting with other activities functionally.

Structure of the Safety Cell in an organization will largely depend on the size of its workforce and type of industry. Certain industries need to have different Safety Cell structure with qualified experts at the right positions like steel producing industry, light engineering industry and industries producing or handling hazardous chemicals.

5.4.1 Safety Cell structure of a large industry

In a large industry, a top level corporate manager must supervise the Safety Cell. Safety director or manager at industry level may report to the corporate manager heading the Safety Cell. There may be several managers reporting to safety director who would each be responsible for special safety functions such as fire, environment, occupational health, claim for compensation etc. These managers will necessarily interact with all other departments wherever workmen are involved. A safety person should not be a specialist with compartmentalized view but a broad-based expert with clear idea of workmen's safety and health being as the objective. Teamwork and cooperation with others are other attributes required for being successful and responsible safety personnel. Organizantionl chart for large, safety concious industry has been shown in Figure5.1.

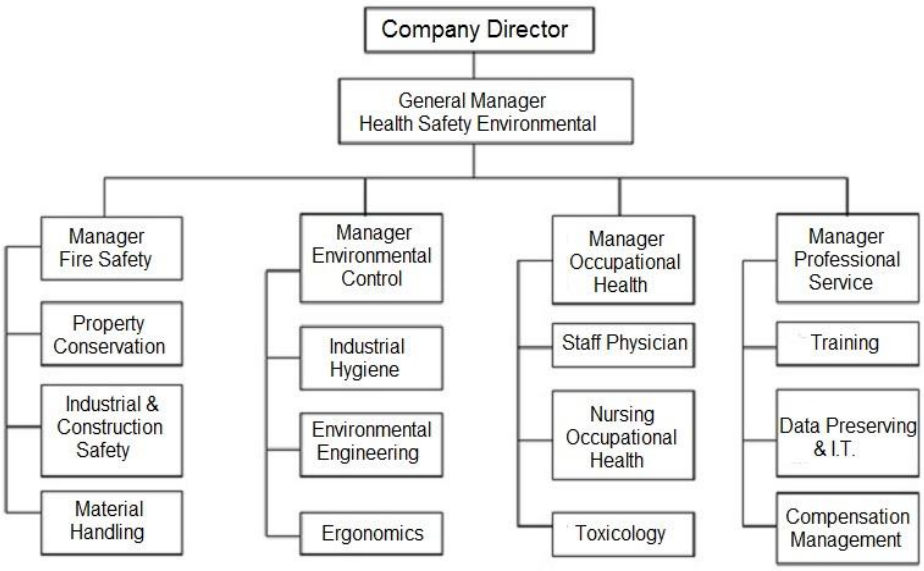

Figure 5.1: Organizational Chart for Large, Safety Conscious Industry

Various levels of responsibility are identified and described below:

i) Level 1

This is the corporate level and there should be a company director who will be engaged in formulating safety policies at this level. These policies will be continuously monitored and upgraded as required. The company director will have to see that safety audits are made regularly. She must be readily available for advising and guiding the safety personnel. The company director must appoint a general manager safety at company level.

ii) Level 2

This is at company level and the general manager, safety directly reports to the corporate director. He has to continuously monitor safety policies of the company and bring about necessary improvement in the light of directives issued from time to time by the higher management and experiences gained from the field. She must also see that the directives and policies are in accordance with governmental regulatory standards. She should provide guidance and assistance for training of safety personnel at various levels and must conduct seminars / workshops on Introduction to Safety Engineering and arrange internal and external industrial Safety audits. He must see that safety records are properly maintained and data and information regarding safety status of the company are available.

iii) Level 3

This level works at plant level and would directly report to general manager safety. There must be four plant safety managers, one each for fire safety, environmental control, occupational health and professional service. Specific conditions and size of plant may dictate combining two or three of these functions under a single plant level manager but in all

cases the functions should remain separate and, identifiable. The main responsibilities at this level include : (1) development of procedures for implementing safety measures on equipment / processes and outlining safe working practices for workmen in consultation with the shop floor safety supervisors and taking into account their feedback on existing systems. (2) Readiness and preparedness to deal with emergency situations, (3) coordination and providing feedback to other managers in the areas of design, manufacture, purchase, sale, research & development, etc. to have a comprehensive safety policy in place. (4) A plant manager will also have the full responsibility to investigate the injuries to a workman on job site and report the matter to higher officials.

iv) Level 4

This level comprises representatives of safety departments working at shop floor level or with workmen. They are the first line of defense against any mishap in the workplace and need to be on a strict vigil all the time. The personnel will actually

1. implementing the main responsibilities of such personnel include safety procedures,
2. training workmen on procedures,
3. guiding them in adopting the procedure.
4. They also monitor and analyse how workmen follow safety procedures and take preventive action where necessary.
5. They provide all support for maintenance of environment and its preservation.

   The Plant Safety manager has to put due importance to their feedback and suggestions for continuous improvement on the safety aspect.
6. Most importantly the personnel at level 4 will conduct safety drills at regular intervals.

5.5 SAFETY FUNCTIONS

In the statement about safety cell various functions have been mentioned. The same are explained in detail here:

- **Industrial safety Compensation:**

  There are two kinds of compensation. One is against injury or long term occupational health hazards covered by the Workmen's Compensation Act, 1923 and other is against longer working hours covered by Sec. 59 of Factories Act, 1948.

- **Property conservation:**

  Under this segment the role of the Safety Engineer is to ensure that apart from ensuring safety of the workmen, property of the organization is also safeguarded from all possible hazards, mainly fire.

- **Safety in material handling:**

  The Indian Government has several IS specifications for guidance on safe material handling procedures to be followed. Eg. IS 8324-1988 applies to Lifting chain & chain slings.

  Employers, supervisors, owners and constructors, among others, are required to know and comply with the regulations that apply to their workplaces. For the specifics on the regulations that cover one's workplace, one will need to look up the applicable IS specification/s.

- **Industrial hygiene:**

  Complying with occupational health and safety regulations is not just about providing helmets and protective clothing. A work place could be a source of risk through exposure to gases and radiation, as well as hazards relating to temperature control, noise and micro pollutant contamination. As a Safety Engineer to maintain the hygiene of your workmen, mainly you will have to reduce or eliminate the ill effects of acidic gases, Ammonia and sulphuric acid, asbestos and irrespirable dust, heat stress, harmful organic gases and vapours, illumination problems (light intensity) and noise pollution.

- **Environmental control:**

  To exercise proper environmental control in a factory you will have to monitor and take action on the following:

  I. **Air quality:** This requires checking of parameters like VOC (Volatile Organic Compounds), Benzene, NOx, H_2S, SO_2, SPM (Suspended Particulate Matter) and RSPM (Respirable Suspended Particulate Matter) and keeping within acceptable limits.

  II. **Stack Monitoring:** This involves stack emission testing from Boiler, DG set stack, Chimney, scrubber etc. for parameters like sulphur dioxide (SO_2), Total Productive Management (TPM), Dichloride (Cl_2) etc..

  III. **Noise level monitoring:** This involves monitoring and impact assessment of problem areas which may impact human health and employing measures to contain them.

  IV. **Waste water management:** This includes effluent treatment or sewage treatment to bring it to acceptable levels before releasing to outside drainage.

  Another aspect is to take effective steps for conservation of water.

- **Occupational health:**

  The major occupational diseases of concern in India are accidents, silicosis, musculo-skeletal injuries, coal workers' pneumoconiosis, chronic obstructive lung diseases, asbestosis, byssinosis, skin related disorders, pesticide poisoning, noise induced hearing loss and workplace

stress. As a Safety Engineer one has to ensure that the workmen do not suffer from the above problems.

- **Health and safety information system:**

  Maintaining proper records at all stages of the safety programme is of utmost importance. Record of safety training and drills will allow you to maintain repeatability and keep the programme alive in people's mind. Record of accidents, their analysis, record of hazardous waste disposal and such other activities are declared mandatory by the Government.

SAQ 2

a) As a Safety Engineer in an industry what are the aspects you need to look into?

b) Under what circumstances do Safety Policies of an organization fail?

c) Briefly describe the various levels of responsibility in the Safety Cell of a large organization.

d) What are the different safety functions?

e) What type of occupational health hazards are usually found in Indian industries?

5.6 GENERAL AWARENESS OF ERGONOMICS

Ergonomics, also called human factors is the application of psychological and physiological principles of human body to engineering and designing of products, processes and systems. It combines the knowledge of multiple disciplines like psychology, physiology, sociology, engineering, biomechanics, visual design, user interface design and others. Through these disciplines, human behaviour in studied so that the findings are applied to the primary objectives of reducing human error, increasing productively safety and comfort and promoting interaction.

Using Ergonomics in workplace reduces costs, improves productivity and quality, improves employee engagement and creates a better safety culture. Simply put, ergonomics is an applied science of designing and arranging things people use in order to increase efficient and safe interaction of people with those things. For example, studying how office goers who sit in offices get work related back injuries or those working for long hours on computers weaken their eye sight.

The first international ergonomics standard developed (based on a German DIN national standard) is ISO 6385, 'Ergonomic principles in the design of work systems which was published in 1981. It is the basic standard of the ergonomics standards series and set the stage for the standards which followed by defining the basic concepts and stating the general principles of the ergonomic design of work systems, including tasks, tools, machinery, workstations, work space, work environment and work organization.

This international standard is a guideline standard, and provided guidelines to be followed. It does not, however, provide technical or physical specifications which have to be met. These can be found in a different type of standard called specification standards. For example, those on anthropometry or thermal conditions.

Both types of standards fulfil different functions. While guideline standards intend to show their users, "what to do and how to do it" and indicate those principles that must or should be observed, for example, with respect to mental workload; specification standards provide users with detailed information about safety distances or measurement procedures for example, that have to be met and where compliance with these prescriptions can be tested by specified procedures.

This is not always possible with guideline standards, although despite their relative lack of specificity, it can usually be demonstrated when and where guidelines have been violated. A subset of specification standards are "database" standards, which provide the user with relevant ergonomics data, for example, body dimensions.

CEN (European) standards are classified as 'A', 'B' and 'C' type standards, depending on their scope and field of application. 'A' type standards are general, basic standards which apply to all kinds of applications, 'B' type standards are specific for an area of application (which means that most of the ergonomics standards within the CEN will be of this type), and 'C' type standards are specific for a certain kind of machinery, for example, hand-held drilling machines.

To reduce the chance of injury, work tasks should be designed to limit exposure to ergonomic risk factors. Engineering controls are the most desirable, where possible. Administrative or work practice controls may be appropriate in some cases where engineering controls cannot be implemented or when different procedures are needed after implementation of the new engineering controls. Personal protection solutions have only limited effectiveness when dealing with ergonomic hazards. For example if a workman has to continuously bend or twist his body as a requirement to execute the job, in the long run, he may damage his spine. PPE (Personal Protective Equipment) would not be of much help in such cases. Your job as a safety engineer would be to review the work process and equipment and provide an ergonomic solution.

5.7 WORKPLACE OPERATIONS REQUIRING SAFETY

The operations performed by workmen in their workplace are of different nature, but they involve some machine, equipment and material. The safety precautions are adopted for machines and operations performed on them. Many operations require hazardous material or handling of materials in hazardous state.

Here are some operations which are either machine or equipment or material specific and need safety practices.

i) Electrical assembly and fabrication
ii) Electronic assembly and cleaning
iii) Use of electrical tools
iv) Use of chemical agents and chemical treatments
v) Use of biological materials and treatments
vi) Use of acidic and alkaline materials
vii) Toxic vapour applications
viii) Use and production of mists, dust
ix) Use of boiler and use of compressed air and gas
xi) Use of combustible and toxic gases and liquids
xii) Processing of radioactive sources and treatments
xiii) Painting and mixing of paints
xiv) Spraying of paints and liquid metals
xv) Welding gas and electric, brazing and soldering
xvi) Wood cutting and working
xvii) Sawing metal and wood
xviii) Sanding, sand blasting and shot peening
xix) Burning and furnace application
xx) Casting and foundry practice
xxi) Digging
xxii) Climbing
xxiii) Masonry work particularly at lofty heights
xxiv) Hoisting and lifting
xxv) Machining on lathes and mills
xxvi) Shearing
xxvii) Cutting
xxviii) Drilling
xxix) Jointing

5.8 SAFETY BENEFITS

An industry or a company that follows safety programs is benefitted in several ways. The benefits are shared between employer and employees directly and consumers are indirectly benefitted. A sound safety policy will eliminate or reduce greatly the accidents where by the employer will save cost of lost man-hours and machine down-time. The employer will also save on paying compensation and replacement or repair of equipment. The employees feeling safe to work will show better productivity. Also since a sound safety policy will guarantee an adequate compensation, the employees will work without apprehension and psychological pressure. The latter factor often causes accidents.

The increased productivity and quality consciousness will produce goods which will be to the liking of the customer.

5.9 SAFETY IN DESIGN

Amec Foster Wheeler was a British multinational consultancy which is now owned by the Wood Group. It give a systematic approach to engineering safety into the design. It is a five-step approach to engineering design which results in the ability to demonstrate that hazards to people, the environment, assets, and reputation have been systematically and comprehensively identified, and eliminated or controlled during the design phase of the facility/system or equipment. These five steps are:

1) Defining safety goals: Goals are necessary to maintain focus in the safety by design process. They should reflect regulatory requirements, legislation of risk and sustainability strategies on safety and environment.
2) Understanding hazards: If hazards are not known they cannot be controlled. Project specific health and safety hazards and environmental impacts should be understood well in advance.
3) Implementing inherent safer design principles: Inherently safer design can be achieved by adopting a strategy based on the following principles:
    a) Eliminate: removal of dangerous material, processes and activities.
    b) Minimise: using smaller quantities of hazardous substances and minimizing the number of hazardous activities.
    c) Substitute: Replacement of hazardous or expensive material or activity with a lesser one.
    d) Moderate: minimizing the potential impact of release of substances or energy and the number of people exposed to it.
    e) Simplify: eliminating complexity to minimise the possibility of human error.
4) Managing residual risks and environmental impacts: If inherent control cannot be fully achieved or is inadequate, residual risks and environmental impacts will remain and need to be managed. This may require additional engineered or procedural controls.
5) Consolidating and communicating: Once the safety by Design process has been completed as required and the goals identified in the first step have been met, the process may be closed. The findings are consolidated and communicated to the external and internal stakeholders.

As a result of the safety by design process, the overall risks of operation of the designed equipment / plant are minimized by eliminating hazards or applying the right hazard controls to minimize the identified hazards. Further more, the design elements to control or eliminate the hazards are identified and designed early in the design process when the implementation cost is at a minimum.

5.9.1 Life Cycle Phases of Safe Design

The life cycle phase of safe design is shown in Figure5.2

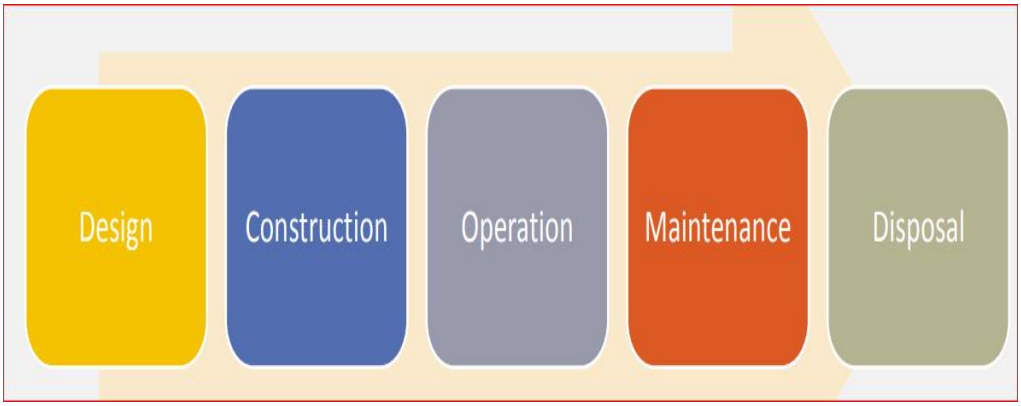

Figure 5.2: Life Cycle Phases of Safe Design

5.9.2 Benefits of Safety

The benifits of life cycle phase in work place health and safety benefits and its benefit on project is given below:

Life cycle Phase	Workplace Health and Safety (WHS) Benefits	Project Benefits
Design	• Risks Identified • Risks reduced/ controlled	• Reduced re-design or retrofitting • Reduced life cycle OHS costs
Construction	• Communication of residual risks to contractor • Reduced likelihood of accidents	• Informed contractor reduces risk contingency • Decreased time and no over-running cost
Operation	• Occupant Health & Safety • Public Health & Safety	• Reduced costs (absence & claims) • Company image - Reduced civil claims
Maintenance & Repair	• Safe access for maintenance and repair strategies • Reduced likelihood of accident	• Informed contractor reduces risk contingency • Reduction in maintenance costs • Reduction in repair costs
Demolition/ Refurbishment	• Communication of residual risks to the contractor • Reduced likelihood of unplanned events	• Informed contractor reduces risk contingency • Decreased time and no over-running cost

5.9.3 Opportunity to Influence Safety Outcomes

Various **o**pportunity to Influence Safety Outcomes has been shown in Figure 5.3

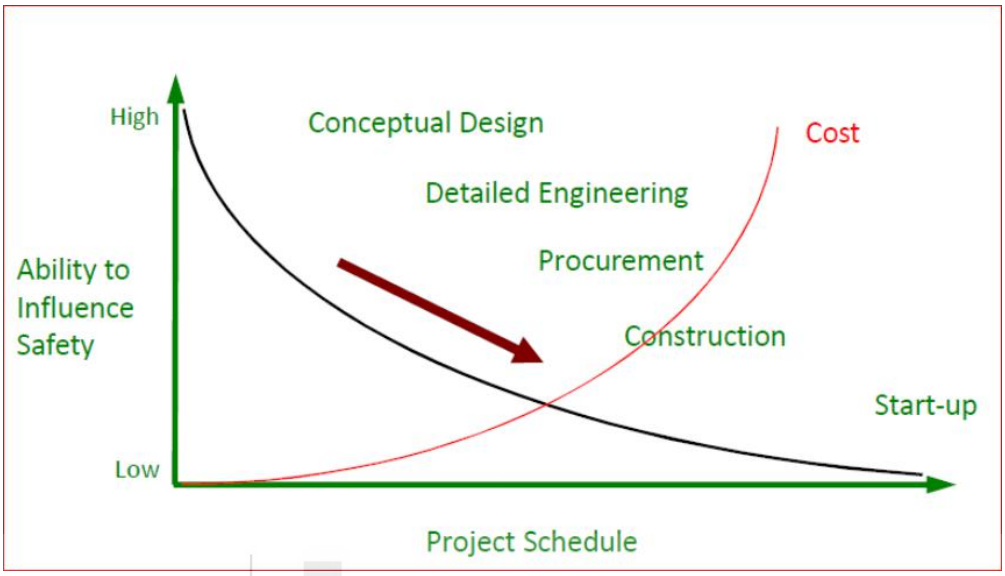

Figure 5.3: Opportunity to Influence Safety Outcomes

SAQ 3

a) What are the benefits of using ergonomics in the industry?

b) Name five common operations in the factories which need safety practices to be implemented.

c) What are the benefits of following safety practices?

d) What are the benefits of incorporating safety at the design stage of an equipment / plant?

5.10 LET US SUM UP

Safety and health of a workman in the workplace is important for industrial practices to benefit all. Today safety concerns are widely regarded essential in industry and governments make regulations to see that employers implement safety practices. However, this concern started to be felt first in 1912 in USA. Before it could mature, the onset of Second World War diminished the importance of safety. The industrial nations of that time sacrificed safety for victory in war. But soon the professionals were convinced that safety could not be overlooked. It not only established itself as an essential practice but also developed into an academic subject in its own right requiring specialized knowledge and research. Thus, trained and educated safety engineers become available.

Now the industries follow safety directives and policies made at corporate levels. At company or factory level their implementation is guided, reported and audited by trained personnel. Such policies also keep government regulations in mind and their compliance is necessary. Regular safety drills and training of workmen, availability and upkeep of protection gears along

with written instructions have become common safety management functions. Each industry must identify its safety functions and operations that will attract safety considerations. Sound safety policies keep all three of employees, employers and customer satisfied.

5.11 KEYWORDS

Safety: Workmen are not hurt, injured physically or psychologically and maintain good health.

Workplace: The place where industrial and construction works are carried out.

Health: The state of well being of workmen so that capacity of working is not adversely affected.

Safety manager and supervisor: The personnel who initiate and monitor the safety policies of the organization are safety managers. The personnel who supervise implementation of Engineering safety policies are supervisors

Industrial hygiene: The conditions leading to keeping of good health in the industrial atmosphere, mainly related to cleanliness.

Health physics: The conditions related to physical facilities and conditions that help workmen to maintain good health.

Safety functions: Establishing of policies and execution in respect of safety.

Safety Cell: The designated department or unit in an organisation responsible for maintaining safety.

Safety Benefits: Advantages accrued from safety policies.

Operations: The physical actions for production, repair and services.

5.12 ANSWER TO SAQs

SAQ 1

a) Rapid advances in technology have led to increased use of more and more dangerous operations and use of hazardous materials in the industry today.

   Safety in industry have become important so that risks of injury to the physical body and long term health of the workmen, as also machineries can be reduced or eliminated. This in turn helps to boost employee morale, increase throughput and quality of product that finally improves the organization's bottom line.

b) The first and foremost job of the Safety Engineer would be to build a Safety Consciousness / safety Culture in the organization where it is absent or to tone up the standards, where it already has the roots. The approach has to be top-down and involvement of the highest level of management is necessary for Safety practices to succeed. Building a Safety Cell with a dedicated team and allocation of funds

is the responsibility of the Higher Management which will have to be initiated by the Safety Engineer.

SAQ 2

a) A Safety Engineer should cover the aspects of industrial hygiene, health physics, ergonomics, design engineering, illumination engineering, audiology and workmen's compensation claim administration. Each of these fields had twin targets of safeguarding workmen's health and life and improving productivity.

b) It has been experienced that safety policies often fail if safety functions are distributed or made part of activities of several departments. Under the system of distributed responsibilities, the safety functions have often been reported to corporate managers through personnel and human resource department, operational office or legal office. Such practices have mostly failed in successful implementation of safety programs.

c) Various levels of responsibilities in the Safety Cell of a large organization are briefly described below.

i) Level 1

This is a corporate level and there should be a company director who will be engaged in formulating safety policies at corporate level. These policies will be continuously monitored and upgraded as required with the help of personnel at the lower levels.

ii) Level 2

This is at company level and the general manager will directly report to the corporate director. He has to continuously monitor safety policies of the company and bring about necessary improvement in the light of directives issued from time to time by the higher management and experiences gained from the plant level. He must also see that the directives and policies are in accordance with governmental regulatory standards.

iii) Level 3

This level works at plant level and would directly report to general manager safety. There must be four plant safety managers as identified by four plant safety functions, namely fire safety, environmental control, occupational health and professional service.

iv) Level 4

This level comprises representatives of safety departments working at shop floor level or with workmen. The personnel will actually implement safety procedures, train workmen on procedures, guide them to adoption of procedure. They will monitor and analyse on how workmen are following safety procedures and take preventive action where necessary.

d) The different Safety functions are as listed below:
   - Industrial safety Compensation
   - Property conservation
   - Safety in material handling
   - Industrial hygiene
   - Environmental control
   - Occupational health.
   - Health and safety information system.

e) The major occupational diseases/morbidity of concern in India are accidents, silicosis, musculo-skeletal injuries, coal workers' pneumoconiosis, chronic obstructive lung diseases, asbestosis, byssinosis, skin related disorders, pesticide poisoning, noise induced hearing loss and workplace stress.

SAQ 3

a) Using Ergonomics in a workplace reduces costs, improves productivity and quality, improves employee engagement and creates a better safety culture. It reduces the fatigue of workmen resulting their better health and reduction in handling time increases productivity.

b) Some common operations in factories that require safety practices to be implemented are,
   - Use of electrical tools
   - Use of chemical agents and chemical treatments
   - Toxic vapour applications
   - Casting and foundry practice
   - Masonry work particularly at lofty heights

c) A sound safety policy will eliminate or reduce greatly the accidents whereby the employer will save cost of lost man-hours and machine down-time. The employer will also save on paying compensation and replacement or repair of equipment. The employees feeling safe to work will show better productivity. Also since a sound safety policy will guarantee an adequate compensation, the employees will work without apprehension and psychological pressure.

d) By incorporating safety at the design stage the overall risks of operation of the designed equipment / plant are minimized by eliminating hazards or applying the right hazards controls to minimize the identified hazards. By eliminating the hazards in the design process, the implementation cost is also minimum. Future machine down-time compensation to employees can be avoided.

5.13 REFERENCES AND FURTHER READINGS

[01] ELECTRICAL SAFETY HAZARDS HANDBOOK: https://www.lanl.gov/safety/electrical/docs/arc_flash_safety. pdf

[02] Occupational Safety and Health Simplified for the Industrial Workplace

Frank R. Spellman.

[03] Safety and Environmental Management, Frank R. Spellman, 3, Publisher Bernan Press, 2015, ISBN 159888770X, 9781598887709.

[04] https://www.bristol.ac.uk/civilengineering/bridges/Pages/Engineering%20Safety%20By%20David%20Blockley.pdf