COURSE MATERIAL

IV YEAR B.TECH II SEMESTER

MECHANICAL ENGINEERING

A. Y : 2022-23

MAINTENANCE & SAFETY ENGINEERING

R18A0333

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MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

(Autonomous Institution-UGC, Govt. of India) Secunderabad-500100, Telangana State, India.

www.mrcet.ac.in

CONTENTS

MALLA REDDY COLLEGE OF ENGINEERING&TECHNOLOGY

(Autonomous Institution – UGC, Govt. of India)

VISION

- To establish a pedestal for the integral innovation, team spirit, originality and competence in the students, expose them to face the global challenges and become technology leaders of Indian vision of modern society.

MISSION

- To become a model institution in the fields of Engineering, Technology and Management.
- To impart holistic education to the students to render them as industry ready engineers.
- To ensure synchronization of MRCET ideologies with challenging demands of International Pioneering Organizations.

QUALITY POLICY

- To implement best practices in Teaching and Learning process for both UG and PGcourses meticulously.
- To provide state of art infrastructure and expertise to impart quality education.
- To groom the students to become intellectually creative and professionally competitive.
- To channelize the activities and tune them in heights of commitment and sincerity, the requisites to claim the never - ending ladder of **SUCCESS** year after year.

For more information: www.mrcet.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

To become an innovative knowledge center in mechanical engineering through state-of- the-art teaching-learning and research practices, promoting creative thinking professionals.

MISSION

The Department of Mechanical Engineering is dedicated for transforming the students into highly competent Mechanical engineers to meet the needs of the industry, in a changing and challenging technical environment, by strongly focusing in the fundamentals of engineering sciences for achieving excellent results in their professional pursuits.

Quality Policy

- ✓ To pursuit global Standards of excellence in all our endeavors namely teaching, research and continuing education and to remain accountable in our core and support functions, through processes of self-evaluation and continuous improvement.
- ✓ To create a midst of excellence for imparting state of art education, industry- oriented training research in the field of technical education.

PROGRAM OUTCOMES(PO'S)

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and teamwork**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective

11. reports and design documentation, make effective presentations, and give and receive clear instructions.

12. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a memberand leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1 Ability to analyze, design and develop Mechanical systems to solve the Engineering problems by integrating thermal, design and manufacturing Domains.

PSO2 Ability to succeed in competitive examinations or to pursue higher studies or research.

PSO3 Ability to apply the learned Mechanical Engineering knowledge for the Development of society and self.

Program Educational Objectives (PEOs)

The Program Educational Objectives of the program offered by the department are broadly listed below:

PEO1: PREPARATION

To provide sound foundation in mathematical, scientific and engineering fundamentals necessary to analyze, formulate and solve engineering problems.

PEO2: CORE COMPETANCE

To provide thorough knowledge in Mechanical Engineering subjects including theoretical knowledge and practical training for preparing physical models pertaining to Thermodynamics, Hydraulics, Heat and

Mass Transfer, Dynamics of Machinery, Jet Propulsion, Automobile Engineering, Element Analysis, Production Technology, Mechatronics etc.

PEO3: INVENTION, INNOVATION AND CREATIVITY

To make the students to design, experiment, analyze, interpret in the core field with the help of other inter disciplinary concepts wherever applicable.

PEO4: CAREER DEVELOPMENT

To inculcate the habit of lifelong learning for career development through successful completion of advanced degrees, professional development courses, industrial training etc.

PEO5: PROFESSIONALISM

To impart technical knowledge, ethical values for professional development of the student to solve complex problems and to work in multi-disciplinary ambience, whose solutions lead to significant societal benefits.

Blooms Taxonomy

Bloom's Taxonomy is a classification of the different objectives and skills that educators set for their students (learning objectives). The terminology has been updated to include the following six levels of learning. These 6 levels can be used to structure the learning objectives, lessons, and assessments of a course.

1. **Remembering**: Retrieving, recognizing, and recalling relevant knowledge from long- term memory.
2. **Understanding**: Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.
3. **Applying**: Carrying out or using a procedure for executing or implementing.
4. **Analyzing**: Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, andattributing.
5. **Evaluating**: Making judgments based on criteria and standard through checking and critiquing.
6. **Creating**: Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.

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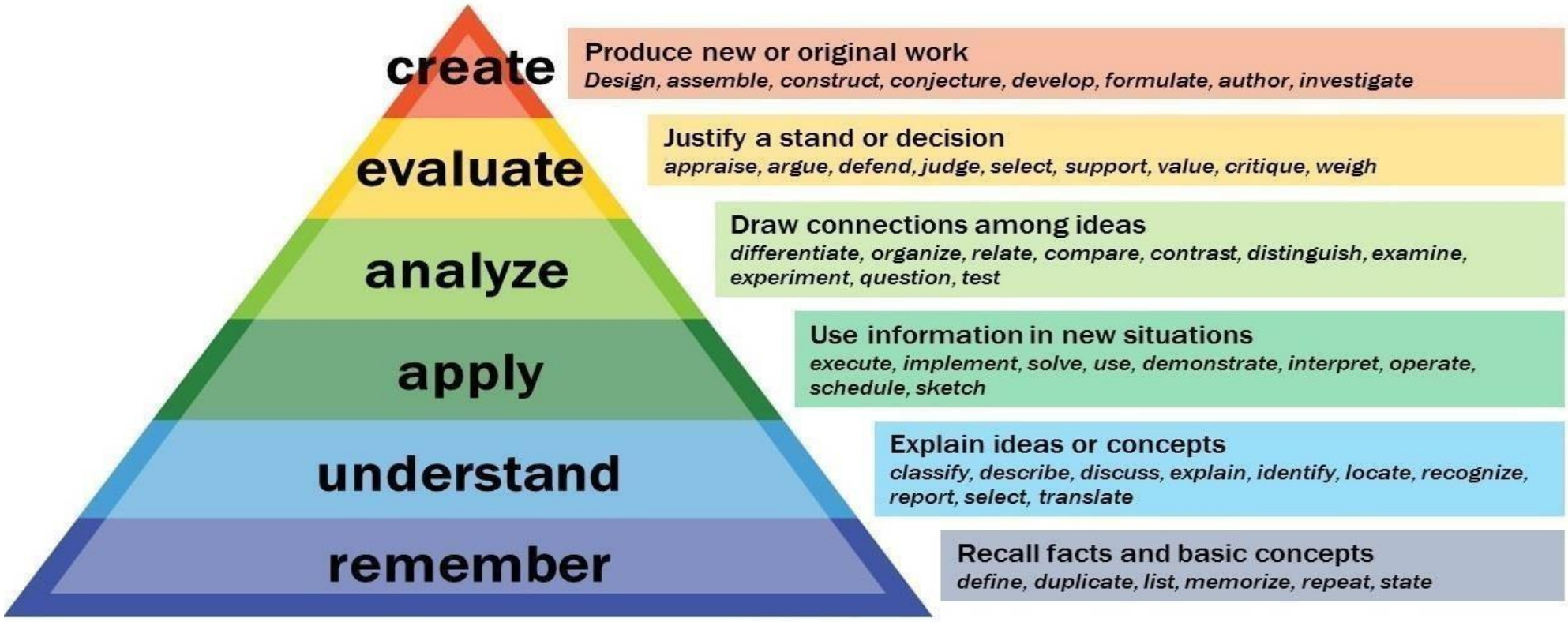
Department of Mechanical Engineering



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Department of Mechanical Engineering

MAINTENANCE AND SAFETY ENGINEERING(R18A0333)

COURSE OBJECTIVES

UNIT - 1	CO1: To ensure the desired plant availability at an optimum cost within the safety prescription.
UNIT - 2	CO2: Student able to know about the objectives of maintenance.
UNIT - 3	CO3: To minimize the total cost of unavailability and resources.
UNIT - 4	CO4: Explain the repair methods of beds and slide ways.
UNIT - 5	CO5: Discuss various condition monitoring techniques.

Bloom's Taxonomy - Cognitive

1 Remember

Behavior: To recall, recognize, or identify concepts

2 Understand

Behavior: To comprehend meaning, explain data in own words

3 Apply

Behavior: Use or apply knowledge, in practice or real life situations

4 Analyze

Behavior: Interpret elements, structure relationships between individual components

5 Evaluate

Behavior: Assess effectiveness of whole concepts in relation to other variables

6 Create

Behavior: Display creative thinking, develop new concepts or approaches

COURSE OUTLINE

UNIT – 1

NO OF LECTURE HOURS: 12

LECTURE	LECTURE TOPIC	KEY ELEMENTS	LEARNING OBJECTIVES (2 to 3 objectives)
1.	Introduction to Maintenance and safety Engineering	Maintenance and Safety	Understand the basics Maintenance and Safety.(B1)
2.	History and development of Industrial safety	Industrial safety	Understand the various Industrial safety precautions (B2)
3.	Implementation of factories act	factories acts	Understand the various Industrial factories act(B2)
4.	Safety and productivity	Safety and productivity	Understand the various Industrial Safety andproductivity(B1)
5.	Safety organizations Safety committees and structure	Safety committees and structure	Understand the various Industrial Safety committees and structure(B2)
6.	Role of management and role of Govt. in industrialsafety.	Management role in safety	Understand the Role of management androle of Govt. in industrial safety.

COURSE OUTLINE

UNIT – 2

NO OF LECTURE HOURS: 11

LECTURE	LECTURE TOPIC	KEY ELEMENTS	LEARNING OBJECTIVES (2 to 3 objectives)
1.	Personal protective equipment	About protective equipments	Classification of protective equipments.(B4)
2.	Survey the plant for locations, Part of body to be protected	Survey the plant locations, body protected	To Know the Survey the plant for locations, Partof body to be protected (B2)
3.	Education and training in safety, Prevention causes and cost of accident	Education and training in safety, Prevention causes and cost of accident	To understand Education and training in safety, Prevention causes and cost of accident (B2)
4.	Housekeeping, First aid, Firefighting equipment, Accident reporting, Investigations	First aid, Firefighting equipment	To understand the Housekeeping, First aid, Firefighting equipment, Accident reporting, Investigations (B2)
5.	Industrial psychology in accident prevention, Safety trials.	Industrial psychology, Safety trials.	To understand the Industrial psychology in accident prevention (B2) To Know about Safety Trails (B4)

COURSE OUTLINE

UNIT – 3

NO OF LECTURE HOURS: 11

LECTURE	LECTURE TOPIC	KEY ELEMENTS	LEARNING OBJECTIVES (2 to 3 objectives)
1.	**Safety Acts:** Features of Factory Act	Safety Acts	Types of Safety Acts (B2)
2.	Industrial hygiene, Occupational safety	Hygiene, Occupational safety	Know about Hygiene and OccupationalSafety.(B4)
3.	Diseases prevention, Ergonomics, Occupational diseases, stress, fatigue, health	Occupational diseases, stress, fatigue, health	To be active about health (B2)
4.	safety and the physical environment, Engineeringmethods of controlling chemical hazards	physical environment , controllingchemical hazards methods	To know about physical environment , controlling chemical hazards methods (B4)
5.	Control of industrial noise and protection against it,Code and regulations for worker safety and health.	industrial noise, Code and regulations	To understand industrial noise, Code andregulations (B2)

COURSE OUTLINE

UNIT – 4

NO OF LECTURE HOURS: 10

LECTURE	LECTURE TOPIC	KEY ELEMENTS	LEARNING OBJECTIVES (2 to 3 objectives)
1.	Basic Principles of maintenance planning – Objectives and principles of planned maintenance activity	principles of planned maintenance activity	Understand the principles of planned maintenance activity (B2)
2.	Sound Maintenance systems – Reliability andmachine availability,	Sound Maintenance systems	Know about Sound Maintenance systems.(B4)
3.	Measures for Maintenance Performance	Maintenance Performance	To understand Equipments breakdowns, Mean Time Between Failures and Repair (B2)
4.	Factors of availability	Factors of availability	To analyse Factors of availability (B4)
5.	Maintenance organization and economics	Maintenance organization and economics	To be familiar with Maintenance organization and economics (B2)

COURSE OUTLINE

UNIT – 5

NO OF LECTURE HOURS: 12

LECTURE	LECTURE TOPIC	KEY ELEMENTS	LEARNING OBJECTIVES (2 to 3 objectives)
1.	Maintenance Policies and Preventive Maintenance	Policies and Preventive Maintenance	To Know Policies and Preventive Maintenance(B2)
2.	Merits of each category – Preventive maintenance	Preventive maintenance	Merits of Preventive maintenance.(B4)
3.	Repair cycle, Principles and methods of lubrication	Principles and methods oflubrication	To understand Principles and methods oflubrication (B2)
4.	Fault Tree Analysis	Fault Tree Analysis	To know about Fault Tree Analysis (B4)
5.	Total Productive Maintenance	Total Productive Maintenance(TPM)	To be familiar with TPM(B2)

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DEPARTMENT OF MECHANICAL ENGINEERING

Mapping of COs and POs:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C337.1	X	X	X	X	X	X	X	X	X	-	-	X	X	X	X
C337.2	X	X	X	X	-	X	X	X	-	-	-	X	X	X	X
C337.3	X	X	X	X	-	X	X	X	-	-	-	X	X	X	X
C337.4	X	X	X	-	-	X	X	X	-	-	-	X	X	X	X
C337.5	X	X	X	-	-	X	X	X	X	-	-	X	X	X	X

Course Outcomes	**PO 1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
C337.1	3	3	2	1	1	3	3	3	1	-	-	3	3	3	2
C337.2	2	3	2	1	-	2	2	2	-	-	-	2	3	2	3
C337.3	2	3	2	1	-	2	3	2	-	-	-	2	3	2	3
C337.4	2	2	3	-	-	2	2	3	-	-	-	3	2	2	2
C337.5	3	2	3	-	-	2	2	3	2	-	-	3	2	2	2

Mode of Evaluation: X

- 70% of marks for External Evaluation.
- 24% of marks for Internal Evaluation.
- 6% of marks for Continuous Evaluation assignments.

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	L	T/P/D	C
IV Year B. Tech, ME-II SEM	**3**	**0**	**3**

(R18A0333) MAINTENANCE AND SAFETY ENGINEERING
(PROFESSIONAL ELECTIVE 4)

Course Objectives:

1. To ensure the desired plant availability at an optimum cost within the safety prescription.
2. Student able to know about the objectives of maintenance.
3. To minimize the total cost of unavailability and resources.
4. Explain the repair methods of beds and slide ways.
5. Discuss various condition monitoring techniques.

UNIT-I

Introduction to the Development of Industrial Safety and Management: History and development of Industrial safety: Implementation of factories act, Safety and productivity, Safety organizations. Safety committees and structure, Role of management and role of Govt. in Industrial safety.

UNIT-II

Accident Preventions, Protective Equipments and the Acts: Personal protective equipment, Survey the plant for locations, Part of body to be protected, Education and training in safety, Prevention causes and cost of accident, Housekeeping, First aid, Firefighting equipment, Accident reporting, Investigations, Industrial psychology in accident prevention, Safety trials.

UNIT-III

Safety Acts: Features of Factory Act, Introduction of Explosive Act, Boiler Act, ESI Act, Workman's compensation Act, Industrial hygiene, Diseases prevention, Ergonomics, Occupational diseases, stress, fatigue, health, safety and the physical environment, methods of controlling chemical hazards, safety and the physical environment, Control of industrial noise and protection against it, Code and regulations for worker safety.

UNIT-IV

Principles and Practices of Maintenance Planning: Basic Principles of maintenance planning

– Objectives, Sound Maintenance systems – Reliability and machine availability, Equipment Life cycle, Measures for Maintenance Performance: Equipments breakdowns, Mean Time Between Failures and Repair, Factors of availability, Maintenance organization and economics.

UNIT-V

Maintenance Policies and Preventive Maintenance:

Maintenance categories –Merits of each category – Preventive maintenance, Maintenance schedules: Repair cycle, Principles and methods of lubrication, Fault Tree Analysis, Total Productive Maintenance: Methodology and Implementation.

TEXT BOOKS:

1) Industrial Maintenance Management -Srivastava, S.K. - S. Chand and Co.
2) Occupational Safety Management and Engineering Willie Hammer - Prentice Hall
3) Installation, Servicing and Maintenance Bhattacharya, S.N. - S. Chand and Co.

REFERENCE BOOKS:

1) Occupational Safety Management and Engineering Willie Hammer - Prentice Hall
2) Reliability, Maintenance and Safety Engineering by Dr. A. K. Gupta
3) A Textbook of Reliability and Maintenance Engineering by Alakesh Manna.

Course Outcomes:

1. Describe the various categories of maintenance.
2. Assemble, dismantle and align mechanisms in sequential order.
3. Carry out plant maintenance using tribology, corrosion and preventive maintenance.
4. Student gets the exposure of Maintenance Policies and Preventive Maintenance.
5. Explain the repair methods of material handling equipments.

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

IV Year B. Tech, ME-II Sem
(R18A0333) MAINTENANCE AND SAFETY ENGINEERING

UNIT-I

Introduction to the Development of Industrial Safety and Management: History anddevelopment of Industrial safety: Implementation of factories act, Safety and productivity,Safety organizations. Safety committees and structure, Role of management and role of Govt. inindustrial safety.

UNIT-II

Accident Preventions, Protective Equipment's and the Acts: Personal protective equipment,Survey the plant for locations, Part of body to be protected, Education and training in safety,Prevention causes and cost of accident, Housekeeping, First aid, Fire fighting equipment,Accident reporting, Investigations, Industrial psychology in accident prevention, Safety trials.

UNIT-III

Safety Acts: Features of Factory Act, Introduction of Explosive Act, Boiler Act, ESI Act,Workman's compensation Act, Industrial hygiene, Occupational safety, Diseases prevention,Ergonomics,Occupational diseases, stress, fatigue, health, safety and the physical environment,Engineering methods of controlling chemical hazards, safety and the physical environment,Control of industrial noise and protection against it, Code and regulations for worker safety andhealth.

UNIT-IV

Principles and Practices of Maintenance Planning: Basic Principles of maintenance planning –Objectives and principles of planned maintenance activity, Sound Maintenance systems –Reliability and machine availability, Equipment Life cycle, Measures for MaintenancePerformance: Equipment's breakdowns, Mean Time Between Failures and Repair, Factors ofavailability, Maintenance organization and economics.

UNIT-V

Maintenance Policies and Preventive Maintenance: Maintenance categories –Merits of each category – Preventive maintenance, Maintenanceschedules: Repair cycle, Principles and methods of lubrication, Fault Tree Analysis, TotalProductive Maintenance: Methodology and Implementation.

TEXT BOOKS:

1) Industrial Maintenance Management Srivastava, S.K. - S. Chand andCo.

2) Occupational Safety Management and Engineering Willie Hammer - PrenticeHall

3) Installation, Servicing and Maintenance Bhattacharya, S.N. - S. Chand andCo.

REFERENCE BOOKS:

1) Occupational Safety Management and Engineering Willie Hammer - PrenticeHall

2) Reliability, Maintenance and Safety Engineering by Dr.A.K.Guptha

3) A Textbook of Reliability and Maintenance Engineering byAlakeshManna

UNIT-I

INTRODUCTION TO THE DEVELOPMENT OF INDUSTRIAL SAFETY AND MANAGEMENT

History and development of Industrial safety:

Industrial safety in the United States as we know it today did not begin to take shape until the early 20th century. Before that, many risked their lives daily going to work in industrial settings that included mines, construction, mills and manufacturing. In today's world, work safety statistics are usually measured by the number of injuries or deaths that take place yearly. Prior to 1900 these type of statistics are hard to come by, in part because it appeared that no one cared enough to make tracking on-the-job injuries and deaths a priority.

19th Century Bleakness:

There is little doubt that workers faced new and unprecedented dangers when the industrial revolution arrived on U.S. shores. American entrepreneurs developed labor-saving devices and machinery that, albeit profitable and highly productive, were often very dangerous. Workplace accidents did not impact the bottom line, since the only legal recourse for victims was suing the company. Those that went to court rarely won their case, and thus made work safety an unprofitable venture for many industrialists of the timeMining, train transportation and manufacturing were probably the most hazardous occupations of the time, and workers responded by taking out insurance policies to cover themselves in the case of a death or an accident, or by leaving a job altogether. This resulted in companies paying higher wages for jobs that were deemed more dangerous.

Public Efforts Lead to Improvements:

Federal safety regulation traces its birth to the creation of the Food and Drug Administration (FDA), and the Bureau of Mines, both which occurred prior to the United States' entry into World War I. Thanks in part to news coverage, the efforts of labor unions and some more progressive business men, the issue of work safety came to the forefront.

Unions representing trainmen campaigned for equipment improvements to ensure train and freight cart safety, and in 1910 the Bureau of Mines was established to identify new ways to make mines safer after a series of dangerous mine explosions.

Workman's Compensation is Born:

Congress passed a federal employers' liability law in 1908 that made it more expensive for companies to have an accident on their books. The law applied to railroad workers in interstate commerce, and made it harder for companies to claim that the employee was partially responsible for an injury. Thanks to the new law, worker injuries that once cost companies $200 to resolve now cost almost $2,000.

In 1910, the state of New York created a workmen's compensation law that forced companies to automatically compensate for workplace injuries (eliminating the need for families to take corporations to court). By 1921, 43 more states had followed New York's lead and established their own compensation laws.

Employers Take Action:

Compensation laws and other liability costs suddenly made workplace injuries an expensive proposition for many employers. What followed was a slow but steady increase in workplace safety. Large firms in railroading, mining and manufacturing suddenly became interested in safety. Manufacturing companies began to work to create safer equipment, and managers in many industries began getting tasked with identifying workplace dangers. In mining and construction, for instance, workers began to wear safety glasses and hard hats.

In 1913 the National Safety Council was formed by a group of business owners to pool shared knowledge, and to apply the information gathered through national agencies like the Bureau of Mines.

Between World Wars I and II accidents in the workplace declined at an uneven rate, and it should be noted that during times of economic boom safety law enforcement tended to take a back seat.

Post World War II to the Present:

The Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration were established in 1970. In addition worker's unions became more powerful than ever after World War II, and made work safety a priority.

Safety in the workplace remains a top concern for most U.S. industries---which must follow OSHA rules as well as rules and regulations established by other safety councils within specific industries. Workplace injury has steadily declined since World War I, and today meticulous records are kept of every injury, illness or fatality that occurs in a workplace.

IMPLEMENTATION OF FACTORIES ACT:

The Factories Act, 1948 (Act No. 63 of 1948), as amended by the Factories (Amendment) Act, 1987 (Act 20 of 1987), served to assist in formulating national policies in India with respect to occupational safety and health in factories and docks in India. It dealt with various problems concerning safety, health, efficiency and well-being of the persons at work places. It was replaced by the Occupational Safety, Health and Working Conditions Code, 2020.

The Act is administered by the Ministry of Labour and Employment in India through its Directorate General Factory Advice Service & Labour Institutes (DGFASLI) and by the State Governments through their factory inspectorates. DGFASLI advises the Central and State

Governments on administration of the Factories Act and coordinating the factory inspection services in the States.

The Act is applicable to any factory using power & employing 10 or more workers and if not using power, employing 20 or more workers on any day of the preceding twelve months, and in any part of which a manufacturing process is being carried on with the aid of power, or is ordinarily so carried on, or whereon twenty or more workers are working, or were working on any day of the preceding twelve months, and in any part of which a manufacturing process is being carried on without the aid of power, or is ordinarily so carried on; but this does not include a mine, or a mobile unit belonging to the armed forces of the union, a railway running shed or a hotel, restaurant or eating place.

SAFETY AND PRODUCTIVITY:

In the world of manufacturing and construction, safety, quality, and productivity are inextricably linked. It's impossible to sacrifice one without sacrificing the others. When organizations put better care into maintaining their safety, quality, and productivity, they are also better able to serve their customers and protect their employees. Let's explore the relationship between these three important pillars of a strong, sustainable business.

The Three Pillars: Safety, Quality, and Productivity

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

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

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

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

As you can see, all three of these pillars really rely upon each other to improve upon the organization's outcomes. When one pillar falls, the others follow. But when one pillar is strong, it strengthens the entire business. Companies need to take a look at their safety, quality, and productivity, so they can explore where they may be falling short, and where their business may be destabilized.

Traditional Barriers to Safety, Quality, and Productivity

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

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

Finally, productivity must never be seen to be at odds with safety or quality. Organizations may feel that safety and productivity are mutually exclusive, and that it's difficult to maintain a productive office with increased regulation and safety processes. However, the opposite is true; it's impossible for employees to remain productive in a dangerous environment.

Creating a Solid Foundation for Your Organization

How can businesses create a solid foundation for safety, quality, and productivity? It begins with company culture. Employers need to foster a company culture that values all these things, and it all begins with safety. Safety is essential to a business. A business can always improve upon the quality of its products and the productivity of its employees. But a business that is dangerous and unsafe can establish a negative reputation that will follow it forever.

In addition to company culture, employers should embrace new business processes and business technology. Safety management software can be used to improve upon incident reporting and provide better real-time visibility, making it easier for companies to ensure that their employees are following enhanced safety protocols, and that any safety issues are being properly and expediently addressed.It isn't always easy for an employer to improve their organization from the ground up, especially if it requires sweeping or structural changes. But when it comes to safety, it's critical. Learn how Anvl can help you gain real-time visibility and ensure process compliance to identify defects early and gain valuable data insights to drive continuous improvement.

SAFETY ORGANIZATIONS:

World Safety Organization National Office for India established since 2016. Our operational principles are fully aligned with the World Safety Organization Management Center in USA. WSO Management Center has dedicated Representatives in the United Nations in New York, Geneva and Vienna.

We are operating this office under the rules, regulation and bylaws of the WSO Management Center in the US.

Our goals are to make awareness each and every individual in the field of Occupational Health, Safety & Environmental

Our aim is to provide enhanced health and safety information together with a pragmatic approach in developing solutions, which enables employers and organizations to maintain the health, safety and welfare of all employees and members of the public, who may be at risk from their activities or undertakings.

WSO National Office for India has a team of national and international occupational safety health and environment professionals who have academic knowledge and many years of practical experience in risk management and loss prevention controls fields.

The World Safety Organization (WSO) was founded in 1975 as a result of an international conference, organized by the Safety Organization of the Philippines Inc. (SOPI), in Manila, Philippines. There were over 1,ooo delegates from over 20 countries represented at that conference (Thailand, USA, Japan, Australia, China, Iran, Singapore, Spain, Nigeria, Sweden, Iraq, Turkey, Yugoslavia, Papua New Quinea, Philippines, Hong Kong, and others). On that occasion the conference delegates agreed on the need for an international exchange of information, programs, new research methods, and data, in the areas of safety, environment, and all associated fields.

Dr. Emiliano Camarillo, one of the SOPI's board members, was the Chairman of the above conference and later was confirmed as the first WSO President-Director General. The charter members of the WSO Board of Directors were representatives from all continents.

1975

In 1975 the WSO was incorporated as a not-for-profit, non-governmental, non-religious, civic entity in the Philippines, and started to work with safety professionals around the world on the promotion of the organization, development of programs, etc. Conferences, seminars, congresses, and small classes/courses were given through the years in the Pacific Rim Countries. The purpose of the organization was to protect people, property, resources, and the environment; to promote safety; and, of course, to work toward the goal to "Make Safety a Way of Life."

During the first 10 years of the operation, approximately 7,000 WSO individual memberships were awarded. There were no services/benefits provided at that time for the WSO members. A single issue of the World Safety Journal was published in 1984 for attendees of the conference held in Manila, Philippines. Based on the information provided by Dr. Camarillo, there were no "renewals of membership" requested from the WSO members. Funds for the office operation were provided from the successful conferences and seminars.

1985

In 1985 Dr. Glenn E. Hudson, at that time a private consultant (loss control) and a retiree from the U.S. military service after 28 plus years, participated at the Asian Safety Educational Conference organized in Manila, Philippines. During that visit the WSO Board of Directors nominated Dr. Hudson, and later confirmed him, as a Chairman of the WSO Certification Board.

The first WSO Certification Board was established in 1975, but only the general program outline was completed under the pro-term chairmanship of Dr. Frederic Baldwin.

In 1985 the WSO Certification Board was fully established under the leadership of Dr. Hudson as the Chairman of the WSO Certification Board, incorporated as the Missouri not-for-profit corporation.

When the WSO certification program was transferred to the U.S.A., the complete operation of the WSO had to be brought up to standards of other professional organizations as they exist in industrialized countries. Membership brochures were designed and published, members of the certification board were appointed and confirmed, certification standards and requirements were designed, and the certification program was completed and presented to the professionals and practitioners in the fields of safety, environment, security, public health, transportation, construction, and all of the allied disciplines which the WSO brings together. The WSO Certification programs are being periodically reviewed and updated to incorporate all of the changing needs of the safety, environmental, and occupational community.

To further increase promotion of the WSO program and to achieve better contact with the new members, the WSO began to publish the WSO News-Letter, WSO Tech-Letter, and the World Safety Journal.

1986

During the 1986 conference in Manila, Philippines, Dr. Camarillo, who wished to retire, nominated Dr. Hudson to the position of the Vice President-Deputy Director General. Dr. Hudson would take over the leadership of the organization in 1987 during the 4th World Safety and Accident Prevention Congress, which was held in Anaheim, California.

WSO World Management Center was established in the U.S.A. to assist with the administrative management of the organization under the leadership of the Chief Executive Officer.

1987

In 1987 the WSO received the Consultative Status, Category II (non-governmental), with the Economic and Social Council of the United Nations. At that time, 157 Missions of the United Nations were awarded Honorary Membership in the WSO for their support of the WSO programs.

In 1987 the first WSO Division was established in the transportation safety field, comprised of the Maritime, Highway, Rail, and Aviation Committees. At present, there are three WSO Divisions, several committees, numerous chapters, and national offices throughout the world.

1988

To insure the undisturbed continuity of programs and unified leadership, the complete administration of the organization was moved to the U.S.A., first to Doniphan, Missouri, and then in 1988 to Warrensburg, Missouri. As there was not enough support for the international administration in the rural area of Southeast Missouri, Warrensburg, with its proximity to Kansas City, was selected.

Programs developed in the following years, including member networking, promotion of new programs, support in establishment of new safety groups, international and national conferences, chapters and divisions/committees, and national offices.

1989

In 1989 the new WSO Board of Directors was confirmed and the Board's first meeting was in Warrensburg, Missouri, during the WSO Regional Conference for Americas. At that time Dr. Hudson accepted another term of the presidency of the WSO, but a change was included in the WSO By-Laws and Constitution to limit the re-appointment of the WSO President-Director General to three consecutive terms. Some other changes were confirmed as well. Possibly the most important change was the change of operation in the Philippines to the WSO Philippine Islands Chapter. There was no apparent benefit to keep the operation in the Philippines as part of the administrative body, as the economical, political, and staffing problems would be eliminated by changing the operation into the operation of the Chapter. More recently, the WSO Philippine Island Chapter was re-assigned as the WSO International Office for the Philippines.

1990 to present

There are now several thousands of national and international companies, corporations, and other entities, which have received the WSO Honorary Membership for the support they provide for their employees by paying their WSO dues. There are also several organizations holding the "WSO Organizational Membership" in the WSO, which, together with the "WSO Institutional Membership," brings to the WSO universities and research institutes, national

and international associations, societies, organizations, and covers additional scores of members.

WSO-sponsored programs are the International Accrediting Commission for Safety and Environmental Education and Training, Inc., and the World Institute for Safety Education and Research.

The WSO has set up offices, recruited personnel, and provides facilities to pool technological and methodological knowledge in the health, safety, environmental, and accident prevention fields worldwide in order to share this wealth of information.

The WSO is undergoing a strong growth period. With individual referrals and recommendations from the WSO members, there is a continuous growth of the membership and a pool of professionals seeking the WSO certifications. One of the latest WSO programs is directed toward professionals seeking the WSO certifications, and toward the new generations of the professionals and practitioners of safety and accident prevention: the students of the safety and environmental programs of various universities in the U.S.A and other countries.

The WSO's purpose is to internationalize all safety fields including occupational and environmental safety & health, accident prevention movement, etc., and to disseminate throughout the world the practices, skills, arts, and technologies of the safety and accident prevention fields.

CODE OF ETHICS

Members of the WSO, by virtue of their acceptance of membership in the WSO, are bound to the following Code of Ethics regarding their activities associated with the WSO:

Members must be responsible for ethical and professional conduct in relationships with clients, employers, associates, and the public.

Members must be responsible for professional competence in performance of all their professional activities.

Members must be responsible for the protection of professional interest, reputation, and good name of any deserving WSO member or member of other professional organization involved in safety or associated disciplines.

Members must be dedicated to professional development of new members in the safety profession and associated disciplines.

Members must be responsible for their complete sincerity in professional service to the world.

Members must be responsible for continuing improvement and development of professional competencies in safety and associated disciplines.

Members must be responsible for their professional efforts to support the WSO motto, "Making Safety a Way of Life…Worldwide."

Any individual, member, officer, employee, or representative of any outside agency/organization may file a complaint against any member, officer, or employee of the WSO. Once a complaint has been filed, a thorough and confidential investigation will be completed by the Ethics Committee Chairman. If the charges are found to be true, the punishment shall range from:

- Informal counseling by a member of the WSO Executive Action Committee;
- Formal counseling by a member of the WSO Executive Action Committee;
- Written letter of Admonition placed in the member's file for one year;
- Written letter of Counseling placed in the member's file for one year;
- Written letter of Reprimand placed in the member's file for one year;
- Written letter of Reprimand placed permanently in the member's file;
- Individual being placed on a formal probation that could result in removal from the WSO and suspension and/or revocation of membership and credential privileges;
- Permanent disbarment from the roles of WSO and revocation of credentials.

SAFETY COMMITTEES AND STRUCTURE:

Safety committees range in size and structure based on the organization's number of employees, worksites and hazards present, but certain arrangements have been found to be more effective. According to a 2008 study published in the journal New Solutions (Vol. 18, No. 4), organizations that had safety committees made up of more hourly workers than managers had lower injury and illness rates. Researchers also found that organizations with a higher percentage of their workforce on safety committees had better rates.

The Maine Department of Labor states that ideal safety committees have representation from all departments and shifts, as well as from both management and the labor force.

Ben Bloom is safety consultant principal for Minnesota OSHA. Bloom said many organizations that participate in the Minnesota STAR (MNSTAR) program – which recognizes organizations with safety and health systems that go above and beyond OSHA requirements – have multiple safety committees. Some organizations assign a committee to each area in the facility, such as the warehouse, production area and offices. Having multiple committees is a great way to involve more workers in an organization's safety and health efforts, but clear guidelines or a centralized committee must be established to help prevent potential overlap, Bloom said.

Effective task delegation by a centralized committee allows a subcommittee to allocate more time and effort to a specific workplace problem. Dave Ferkul, workplace safety consultation supervisor for Minnesota OSHA, spoke of a nursing home that established multiple subcommittees to address specific issues related to staff and resident safety. One subcommittee focused on safe patient-handling equipment, and for fresh ideas they visited

other nursing homes to seek out examples of alternative equipment. The subcommittee reported its findings to the central safety committee, with upper management present, and a resulting investment in new equipment reduced workplace injuries, Ferkul said.

Committee leaders and member participation

An effective committee leader can facilitate a meeting without dominating it or allowing someone else to do so, Ferkul said. Instead of dictating how a discussion should proceed – which is not conducive to member participation and feedback – committee chairs should focus on encouraging participation among all members, he added.

Effective committee heads also should establish basic ground rules and ensure meetings do not get out of control. Rick Long, safety lead of the Dillard, OR-based Roseburg Forest Products' Dillard Plywood Division, described how his company used detailed agendas and time limits to turn around its approach to committee meetings.

In the late 1990s, safety committee meetings at the company usually became shouting matches between labor and management representatives, and would sometimes last four or more hours, Long said. In 1999, the company's approach to safety committees evolved: Overly lengthy, unstructured meetings were replaced by streamlined meetings lasting one hour or less. Safety committee chairs were voted in by hourly employees and given control over each meeting's agenda. Committee members also began voting on a written charter and flow-chart featuring each member and their responsibilities.

"Basically, we learned how to use agendas, how to stay on track and stay on time," Long said. "If there was an outstanding issue we couldn't agree on, we learned to 'put them in the parking lot' and revisit [at] the next meeting."

As a result, he said, employees and management feel they have equal say when it comes to safety, he said. "Everyone has a voice and is allowed to speak it, as long as they do it respectfully."

Enthusiasm:

Safety committees may struggle with maintaining member enthusiasm over time. Tim Morse, professor emeritus for the University of Connecticut Health Center in Farmington, recommends the following techniques to prevent or address committee member burnout:

- Rotate the committee's focus among a variety of topics, such as ergonomics for a period of time, followed by chemical hazard reduction, and so on.
- Bring in new committee members when the committee becomes stale. Also, periodically invite non-committee front-line workers to participate in a meeting and discuss any day-to-day hazards they encounter.
- Invite safety committees from similar organizations to visit and help identify hazards.

Management support:

Tim Morse, professor emeritus for the University of Connecticut Health Center in Farmington, co-authored a report published in 2013 in the American Journal of Industrial Medicine (Vol. 56, No. 2) that looked at common characteristics of effective safety committees. Researchers found that committees that made a meaningful impact on workplace safety had clear and visible upper management support. This allowed committees to secure funding or support to quickly address a safety hazard, another key trait of effective committees, Morse said. In addition, "larger committees are generally beneficial for both detecting problems and getting reality-based solutions," he said.

Management participation in meetings is important for the committee to make realistic decisions and recommendations, Ferkul said. Committee members need to see that their recommendations have an effect on workplace safety, and if too many are too costly or are never used, committee members' enthusiasm may decrease, he said.

Uncommunicative or unsupportive management reduces the effectiveness of committees, Bloom said. He remembers one worksite with a safety committee that did not receive updates from management on whether an identified safety hazard was being addressed. Management actually was making changes based on the recommendations, but lack of communication made the safety committee members feel as though their efforts were not valued, he said.

When employees see that safety is important to management, this can have a positive effect on their own safety values, said Ryan Nosan, state program administrative director for Minnesota OSHA. Management also can help stagnant safety committees make a turnaround.

"Effective support from upper management goes a long way," Nosan said. "Seeing management in attendance and active participants in the safety committee's activities is a powerful tool."

Committees and safety culture:

Safety professionals can benefit in many ways from the information generated from a committee containing front-line employees. However, Hurliman advised against safety professionals taking too active of a role. "[That] takes away the creativity of the group," he said. "You really want to let [employees] step forward." Instead, he said, safety professionals should behave more as a coach and resource to the group.

Nosan recalled a worksite that initiated a committee-led behavior-based safety program. A safety supervisor attended the meetings to help coordinate management support, but otherwise the committee was entirely employee-led. The enthusiasm of the group led to significant ergonomics-related changes throughout the facility, he said.

For safety professionals struggling to establish a safety culture at their organization, safety committees can help, Hurliman said.

"Employee involvement is how employers can get their safety cultures to be bought into. How they really make a lasting impact in safety and health is by getting people involved," he said. "Some of the things I have seen safety committees do have been just incredible, because the employer is allowing the employees to start driving aspects of the safety programs. Once that happens, I tell employers, 'Hang on, you're going for a ride. They're going to take you to places you didn't believe you could get to.'"

Selection of state safety committee requirements:

The table below is a selection of states that, at press time, require some type of safety committee, and a summary of the state's requirements. Please view the associated links for more detailed information on a state's requirements.

In addition to this list, states not included may have mandatory safety committee requirements for certain industries, sectors or organizations using specific work processes. These states also may offer incentives such as reduced workers' compensation premiums or reduced violation penalties.

To ensure your organization is compliant with your state's safety committee requirements, contact your Department of Labor, local OSHA office, workers' compensation board or other applicable agency.

ROLE OF GOVT. IN INDUSTRIAL SAFETY:

There are plenty of good reasons why any business would want to maintain a safe workplace. Other than the basic human desire to avoid pain and suffering, workplace accidents can destroy your business!

Thousands of Americans are killed each year in on-the-job accidents, and many more suffer work-related disabilities or contract occupational illnesses. Some of the high monetary costs attached to workplace accidents include:

- the inability to meet your obligations to customers
- wages paid to sick and disabled workers
- wages paid to substitute employees
- damaged equipment repair costs
- insurance claims
- workers' compensation claims
- administrative and recordkeeping costs

In addition, while both humanitarian desires and economic good sense have encouraged employers to create and maintain safer and healthier working conditions, employees, unions, and government agencies have applied pressure for greater efforts.

Federal Occupational Safety and Health Administration (OSHA) regulations govern workplace safety and no matter what business you are in, you should know and comply with the rules that apply to that business. General rules apply to just about any business and fines and penalties for violations can be severe!

Once you understand the government's role in regulating workplace safety, familiarize yourself with major workplace safety issues, including newer types of risks, such as workplace automation hazards, AIDS and biohazards, that your business may have to deal with.

With the necessary knowledge of your responsibilities and the safety issues involved, you can then access available resources to develop and document a safety program and train your employees to avoid workplace accidents.

The Occupational Safety and Health Act (OSHA)

Your legal obligations to provide a safe work environment for your employees arise primarily from a federal law known as the Occupational Safety and Health Act (OSH Act). OSHA was enacted in 1970 to address the uneven patchwork of state laws regarding workplace safety, and to respond to the growing number of serious injuries and deaths occurring in the workplace. OSHA is administered by the Department of Labor under the direction of the Assistant Secretary of Labor for Occupational Safety and Health.

Absent an accident, a small business owner isn't likely to be visited by federal health and safety inspectors very often, if at all. Unfortunately, if an accident does occur and you're found to be in violation of applicable safety rules, the consequences of the accident can be compounded. Not only must you bear the consequences of the accident (such as being unable to meet your obligations to customers), you may also have to pay government fines and other costs. So, it's worthwhile to have a general understanding of the legal underpinning of the safety standards that apply to almost every employer:

- **All** businesses have a duty to comply with some general rules under what's called a general duty clause.
- **All** businesses must also comply with industry-specific requirements and guidelines, known collectively as OSHA standards.

State safety regulation: Although your safety obligations originate directly at the federal level, states have the right to develop their own standards under a federally approved state plan. The standards under a state plan may differ from federal OSHA regulations, but must be at least as effective as the federal standards. Some states have established and administer their own state plans for workplace safety. If your business is in a state that has a state plan, you must comply with it. If your state does not have a state plan, you must comply with federal OSHA laws. For more information about these plans, contact your particular state labor department.

Are You an Employer Subject to OSHA?

The Occupational Safety and Health Act is a comprehensive law — it covers most employers. Unless you are **sure** your business is exempt, you should assume that the law applies to you.

Generally, if you have employees, you are probably covered by OSHA. If you have none, you usually aren't covered, although in some cases businesses who use workers such as independent contractors are still subject to OSHA.

Specifically an employer under the Act is a person engaged in a business affecting commerce who has employees, but does not include the United States or any state or political subdivision of a State. You are probably subject to OSHA requirements if you:

- are in control of the actions of your employee
- have power over the employee
- are able to fire the employee

Some of the usual indications of an employment relationship, such as who pays the employee, are **not** part of the definition of an employer under OSHA. There are special circumstances if you are one of multiple employers or if you have workers other than employees.

Employers Exempt From the Act

There are some very specific exemptions to employers covered by the Act. The following employers are **not covered** by the OSH Act:

- self-employed persons
- farms at which only immediate members of the farmer's family are employed
- those whose working conditions are regulated by other federal agencies under other federal statutes (This includes most employment in mining, nuclear energy and nuclear weapons manufacture, and many segments of the transportation industries.)
- persons who employ others in their own homes to perform domestic services such as housecleaning and child care
- churches and nonsecular church activities
- states and political subdivisions (although some state plans cover public employees)
- employers not engaged in interstate commerce

UNIT II

Accident Preventions and Protective Equipment's

Accident Preventions, Protective Equipment's and the Acts:

Personal protective equipment, Survey the plant for locations, Part of body to be protected, Education and training in safety, Prevention causes and cost of accident, Housekeeping, First aid, Fire fighting equipment, Accident reporting, Investigations, Industrial psychology in accident prevention, Safety trials.

PERSONAL PROTECTIVE EQUIPMENT:

This section explains your obligations for providing personal protective equipment (PPE) to employees and different types of PPE available.

Personal Protective Equipment (PPE) is equipment that will protect the user against health or safety risks at work, this can include items such as

- safety helmets
- ear protection
- high visibility clothing
- safety footwear and safety harnesses
- thermal, weather and waterproof clothing
- respiratory protective equipment (RPE).

As an employer, it is important that you understand your responsibilities and take steps to keep your workers and members of the public safe.

You will need to know what PPE you need to provide and what training you need to provide to employeesto ensure that they use it correctly.

As an employee, you will need to understand your responsibilities for the use, storage and maintenance ofyour own PPE.

1. PPE legislation
2. When do I need to provide PPE
3. Training, maintenance and storage of PPE
4. Types of PPE
5. PPE and corona virus (COVID-19)

1.PPE legislation

The Personal Protective Equipment at Work Regulations 1992 seeks to ensure that where risks cannot becontrolled by other means PPE should be correctly identified and put into use.

Under the requirements of The Health and Safety at Work Act 1974 (external site), Employees will not be charged with or contribute to the provision and maintenance of PPE. If there is a need for PPE items they must be provided free of charge by the employer. The regulations do not apply where requirements are detailed in other regulations such as respirators in The Control of Substances Hazardous to Health Regulations 2002 (COSHH). Many other regulations have specific requirements for the

provision,maintenance and the use of PPE. Such as the regulations dealing with asbestos, noise or ionising radiation. This ensures that specific hazardsand their controls are dealt with by specific regulations.

Duties of employees regarding PPE

The Personal Protective Equipment at Work Regulations 1992 place duties on employees to takereasonable steps to ensure that the PPE provided is properly used.

The Regulations also place the following duties on employees.

- PPE must be worn and used in accordance with the instructions provided to them
- Employees must make sure that PPE is returned to the provided accommodation after use(unless the employee takes the PPE away from the workplace e.g. footwear or clothing).
- PPE should be returned to the appropriate storage unit (if applicable) after use, unless theemployee takes their PPE home, for example footwear or clothing.
- PPE must be visually examined before use.
- Any loss or obvious defect must be immediately reported to their line manager.
- Employees must take reasonable care of any PPE provided to them and not carry out anymaintenance unless trained and authorized.

2.When do I need to provide PPE

PPE should always be your last resort to manage workplace risks. This is a legal requirement.

While risk assessing work activities you need to think of different control measures before moving to ask employees to wear PPE. When deciding what precaution that you are going to introduce in the workplace you can work through the 'hierarchy of controls'. It aims to minimize or prevent workplace hazards.

2.1.Hierarchy of controls

The controls in the hierarchy are in order of decreasing effectiveness, you should always follow this order.

1. Elimination - Physically remove the hazard, for example use a mechanical aid instead of manual handling.
2. Substitution - Replace the hazard with something less dangerous, for example by using aless hazardous chemical.
3. Engineering Controls - Isolate the employees from the hazard, such as noise zones or barriers.
4. Administrative Controls - Change or train the way people work, for example by reducing the exposure to vibration by rotating employees.
5. PPE - Protect the worker with personal protective equipment.

These are some of the reasons why PPE must be considered as a last resort.

- PPE only protects the person wearing it, whereas measures controlling the risk at source

protectseveryone in the workplace.

- It is hard to assess the level of protection provided by PPE because it depends on how it fits theindividual and if it is maintained and used correctly.
- PPE may restrict the user to some extent by limiting mobility or visibility, or by requiringadditional weight to be carried. Thus creating additional hazards.

2.2.Assessing and choosing PPE

The need for PPE must be identified through Risk Assessment; it should not be a one size fits all approach. The protective equipment should be personal to the individual user and be suitable and fit for purpose.

All personal protective equipment must be 'C E' Marked (external site). The C E mark signifies that the PPE satisfies certain basic/minimum safety requirements. To establish if your employees need to wear PPE you can carry out a risk assessment. Training, maintenance and storage of PPE

3.Information, Instruction and Training (IIT) on PPE usage

When PPE is provided it's required that all employees receive the correct information, instructions and training on its use and show how the equipment should be maintained,cleaned and disposed of.

The extent of the information, instruction and training will vary with the complexity and the performance of the kit, for example a full breathing apparatus will require more training to useproperly than a disposable face mask.

In addition to initial training, refresher training may be required from time to time.

Supervisor checks on the use of the PPE may help determine when refresher training is needed.

You can use this form to create a record of the induction and training programme for staff whoare new to their job.

3.1.What should PPE information and instruction cover?

1. The risks present and why PPE is needed.
2. The operation (including a demonstration), performance and limitations of the equipment.
3. Use and storage (including how to put it on, how to adjust it and remove it).
4. Any testing requirements before use.
5. Any user maintenance that can be carried out (e.g. hygiene, cleaning, procedures).
6. Factors that can affect the performance of the equipment (e.g. working conditions personal factors,defects and damage).
7. How to recognise defects in PPE and arrangements for reporting them.
8. Where to get replacement PPE.

3.2.Maintaining PPE

An effective system of maintenance of PPE is essential to make sure the equipment continues to provide the degree of protection for which it is designed for. Therefore the manufacturer's maintenance schedule (including recommended replacement periods and shelve life) must alwaysbe followed.

Maintenance may include, cleaning, examination, replacement, repair and testing. The user may be able to carry out simple maintenance but more intricate repairs must be carried out by a competent person.

3.3.Storage of PPE

You need to ensure that adequate storage facilities are provided when PPE is not in use unless the employee can take the PPE away from the workplace (e.g. footwear or clothing).

The storage should be adequate to protect the PPE from contamination, loss, damage, or sunlight. Where PPE may become contaminated during use you will need to provide storage that is separated from any other storage provided for ordinary clothing.

4.TYPES OF PPE:

Respiratory Protective Equipment (RPE)

RPE is designed to protect the individual wearer from various hazardous substances in their workplace. There are two types of respiratory equipment.

1. Filters contaminated air or cleans it before it is breathed in.
2. Supplies clean air from an independent source.

RPE may be required for working with large amounts of

- gases, vapours
- dusts, powders
- welding
- grinders, cutter and saw use.

Face masks rely on a good seal against the face, if there are gaps in the face mask then contaminated air, dust, gases and vapors may be breathed into the lungs. For this reason it is very important your mask fits properly and is used correctly every time you use it.

Facial hair, stubble and beards make it impossible to get a good seal on the face.

For this reason you need to be clean shaven to allow a good seal around the face and prevent any leaks of contaminated air into the lungs.

There are reasons that employees may have a beard for example, religious reasons. If that is the case there are alternative options that could be introduced, such as a full hood covering the head and the face.

4.1.Face fit testing of RPE

The RPE should have a tight-fitting face piece, you need to ensure the user has the correct device. For this reason the initial selection of RPE should include fit-testing. A competent face fit tester should carry out these assessments.

You will need to repeat the face fit testing if there are changes. For example if the model or size of the face piece changes or if there are significant changes to the user's facial characteristics. There are two forms of face fit testing.

- Qualitative fit testing is suitable for disposable filter face pieces and half masks. This can be done as a simple pass/fail based on the user's subjective assessment of the fit and leakage and this method is not suitable for full face masks.
- Quantitative fit testing provides a numerical measure of the fit known as a fit factor. This test requires special equipment and it is more complicated to carry out. This method is recommended for full face masks. Quantitative risk assessment is a more in-depth assessment of the risk.

4.2.Hearing protection

There are three types of hearing protection.

- Earmuffs/defenders that completely cover the ear.
- Ear plugs that are inserted into the ear canal.
- Semi inserts (also called canal caps) which cover the entrance of the ear canal.

Hearing protection must be worn by anyone who is likely to be exposed to noise at or above the Exposure Action Level set by The Control of Noise at Work Regulations 2005.

4.3.Head protection

There are three widely used types of head protection.

- Industrial safety helmets (hard hats) which are designed to protect against materials falling from a height or swinging objects.
- Industrial scalp protectors (bump caps) which are designed to protect from knocking against stationary objects.
- Caps/hair nets which protect against entanglement.
- Tasks where head protection may be required include
- construction
- building repair
- work in excavations or tunnels
- work with bolt driving tools
- driving motorcycles.

Turban-wearing Sikhs are exempt from wearing head protection on construction sites by virtue of The Employment Act 1989 as amended by Section 6 of the Deregulation Act 2015 (external site).

4.4.Eye protection

There are several types of eye protection.

- Safety spectacles: these are similar to regular glasses but have a tougher lens, they can include side shields for additional protection.
- Eye shield: a frame-less one piece molded lens often worn over prescription glasses.
- Safety goggles: these are made of flexible plastic frames and an elastic headband.
- Face shields: heavier and bulkier than other types of eye protection, face shields protect the face, but do not fully enclose the eye so do not protect against dust, gases, fumes and mists.

Tasks where eye protection may be used include

- handling hazardous substances where there is a risk of splashes
- working with power driven tools where materials are likely to be propelled
- welding operations
- working with lasers
- using gas or vapour under pressure.

4.5.Foot protection

There are a number of types of safety footwear.

- Safety boots or shoes, normally have steel toe caps but can have other safety features (e.g. steel mid soles, slip resistant soles, insulation against the heat and cold.

- Wellington boot can also have steel toe caps.
- Anti-static and conductive footwear, these protect against static electricity.
- Tasks where foot protection may be required include
- construction
- demolition
- building repair
- manual handling where the risk of heavy objects falling on the feet
- working in extremely hot or cold environments
- working with chemicals and forestry.

Where there is a risk of slipping that cannot be avoided or controlled by other measures, attention must be given to slip resistant soles and replaced before the tread pattern is worn.

4.6.Hand and arm protection

Hand and arm protection comes in a variety of forms.

- Gloves or gauntlets (leather, latex, nitrile, plastic coated, chain mail, etc).
- Wrist cuff armlets (e.g. used in glass cutting and handling).
- Tasks where hand and arm protection may be required include
- manual handling of abrasive, sharp or pointed objects
- working with vibrating equipment such as pneumatic drills and chainsaws
- construction and outdoor work
- working with chemicals and hazardous substances such as body fluids
- working in hot or cold materials or temperatures.

In order to eliminate the risk of ill health through exposure to latex a number of organisations have phased out the use of latex gloves and replaced them with nitrile.

4.7.Body protection

Types of body protection include

- overalls, aprons and coveralls (protection against hazardous substances)
- clothing for hot, cold or bad weather
- clothing to protect against machinery
- high visibility (jackets, trousers and vests)
- harnesses
- life jackets.

Tasks where body protection may be required include

- working with hazardous substances
- working next to the highway or areas with moving transport and vehicles (e.g. construction sites)
- outdoor, forestry and ground maintenance work.

5.PPE and coronavirus (COVID-19)

There are few workplaces outside of health and social care that will require extra PPE to protect against COVID-19 but it is important to remember that work tasks that required PPE before COVID-19, will still require that same level of use and protection for workers. Your risk assessments should reflect this and include any extra protection required to protect workers from the risk of transmission of COVID-19.

Guidance on use of PPE in health and social care settings can be found on the HPS website. The HPS website also gives Guidance on protection in non-health care setting.

Face coverings

Face coverings are not PPE as they do not protect the wearer. They are intended to protect others. Further information can be found on the Scottish Government's Coronavirus (COVID-19): general guidance for safer workplaces.

Preventing the spread of infection

Coronavirus will live for some time on surfaces, including on PPE, so you need to be aware of how to use and dispose of it correctly.

You can use these resources to remind employees how to

- put on and take off PPE correctly (for non-aerosol generating procedures) posters and videos from GOV.UK
- use disposable respirators correctly video and poster from the Health and Safety Executive.

Handwashing

Good hand hygiene is essential to help stop the spread of COVID-19. Watch this video on how to wash your hands.

Survey the Plants for Location

Plant location refers to the choice of the region where men, materials, money, machinery and equipment are brought together for setting up a business or factory. A plant is a place where the cost of the product is kept to low in order to maximize gains. Identifying an ideal location is very crucial, it should always maximize the net advantage, must minimize the unit cost of production and distribution. Plant location decisions are very important because once the plant is located at a particular site then the organization has to face the pros and cons of that initial decision.

Factors affecting the plant location:

Decisions regarding selecting a location need a balance of several factors. These are divided into primary factors and secondary factors; here both the factors can influence the business inthe long run.

Primary factors:

Availability of raw materials

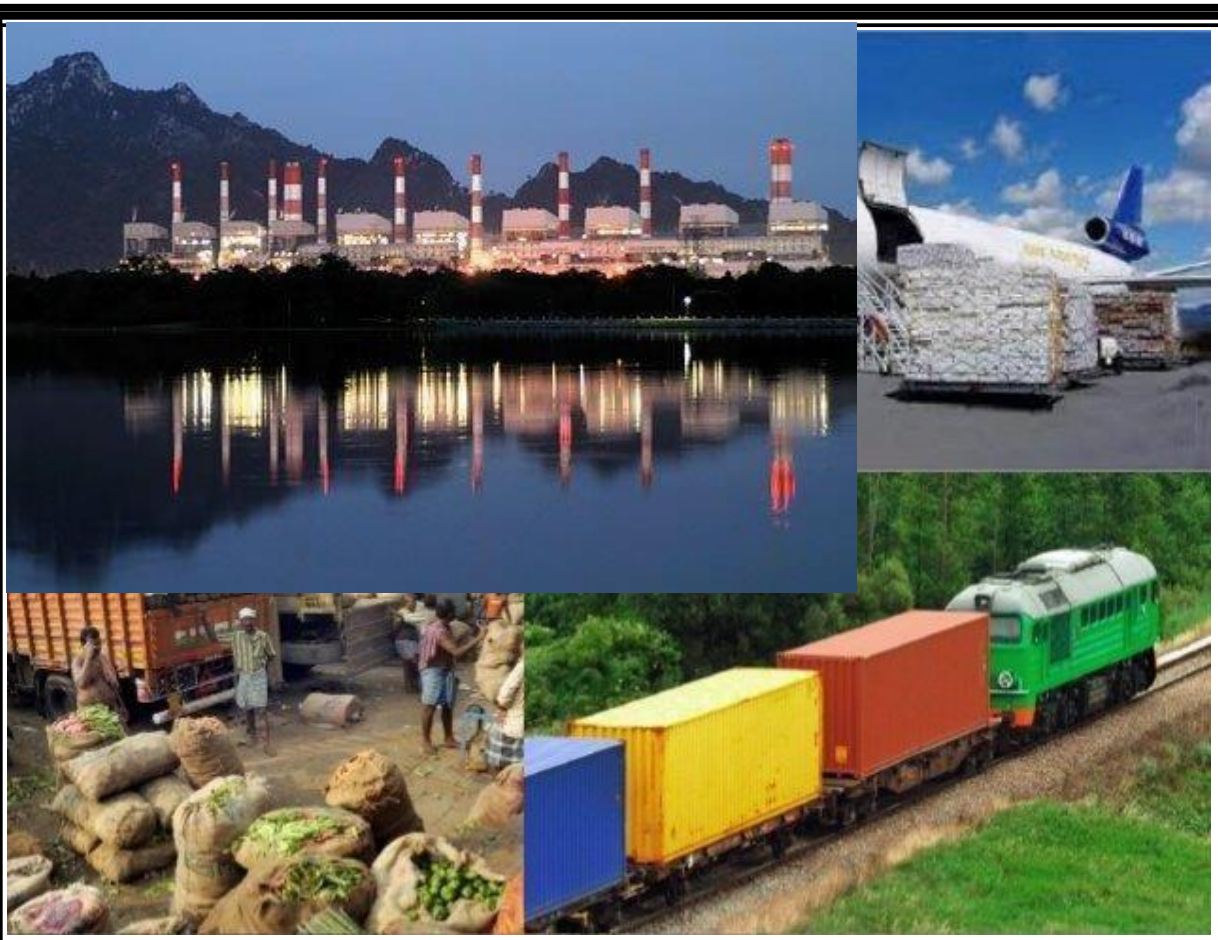
Availability of raw materials is the most important factor in plant location decisions. Usually, manufacturing units where there is the conversion of raw materials into finished goods is the maintask then such organizations should be located in a place where the raw materials availability is maximum and cheap.

Nearness to the market

Nearness of market for the finished goods not only reduces the transportation costs, but it can render quick services to the customers. If the plant is located far away from the markets then thechances of spoiling and breakage become high during transport. If the industry is nearer to the market then it can grasp the market share by offering quick services.

Availability of labor

Another most important factor which influences the plant location decisions is the availability of labor. The combination of the adequate number of labor with suitable skills and reasonable labor wages can highly benefit the firm. However, labor-intensive firms should select the plant location which is nearer to the source of manpower.



Transport facilities

In order to bring the raw materials to the firm or to carrying the finished goods to the market, transport facilities are very important. Depending on the size of the finished goods or raw materials a suitable transportation is necessary such as roads, water, rail, and air. Here the transportation costs highly increase the cost of production, such organizations can not completewith the rival firms. Here the point considered is transportation costs must be kept low.

Availability of fuel and power

Unavailability of fuel and power is the major drawback in selecting a location for firms. Fuel and power are necessary for all most all the manufacturing units, so locating firms nearer to the coal beds and power industries can highly reduce the wastage of efforts, money and time due to the unavailability of fuel and power.

Availability of water

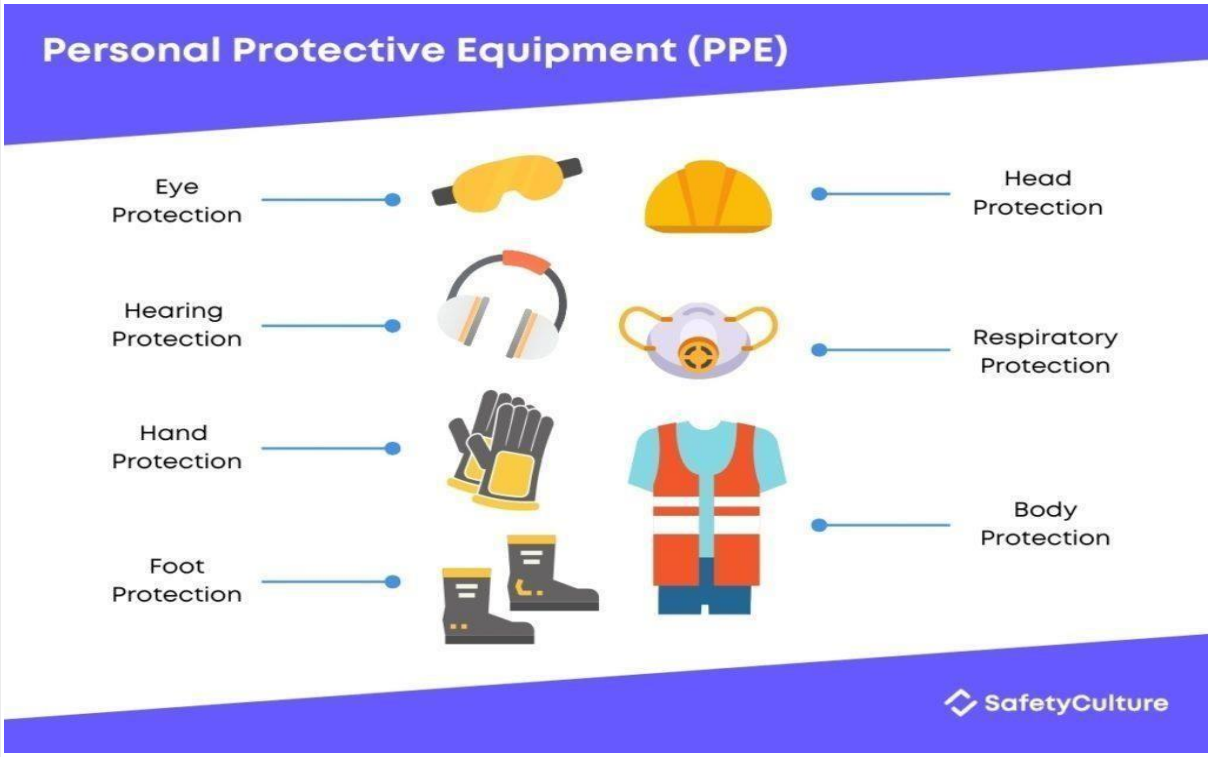
Depending on the nature of the plant firms should give importance to the locations where water isavailable.

For example, power plants where use water to produce power should be located near the water bodies.

Secondary factors:

Suitability of climate:

Climate is really an influencing factor for industries such as agriculture, leather, and textile, etc. For such industries extreme humid or dry conditions are not suitable for plant location. Climate can affect the labor efficiency and productivity.



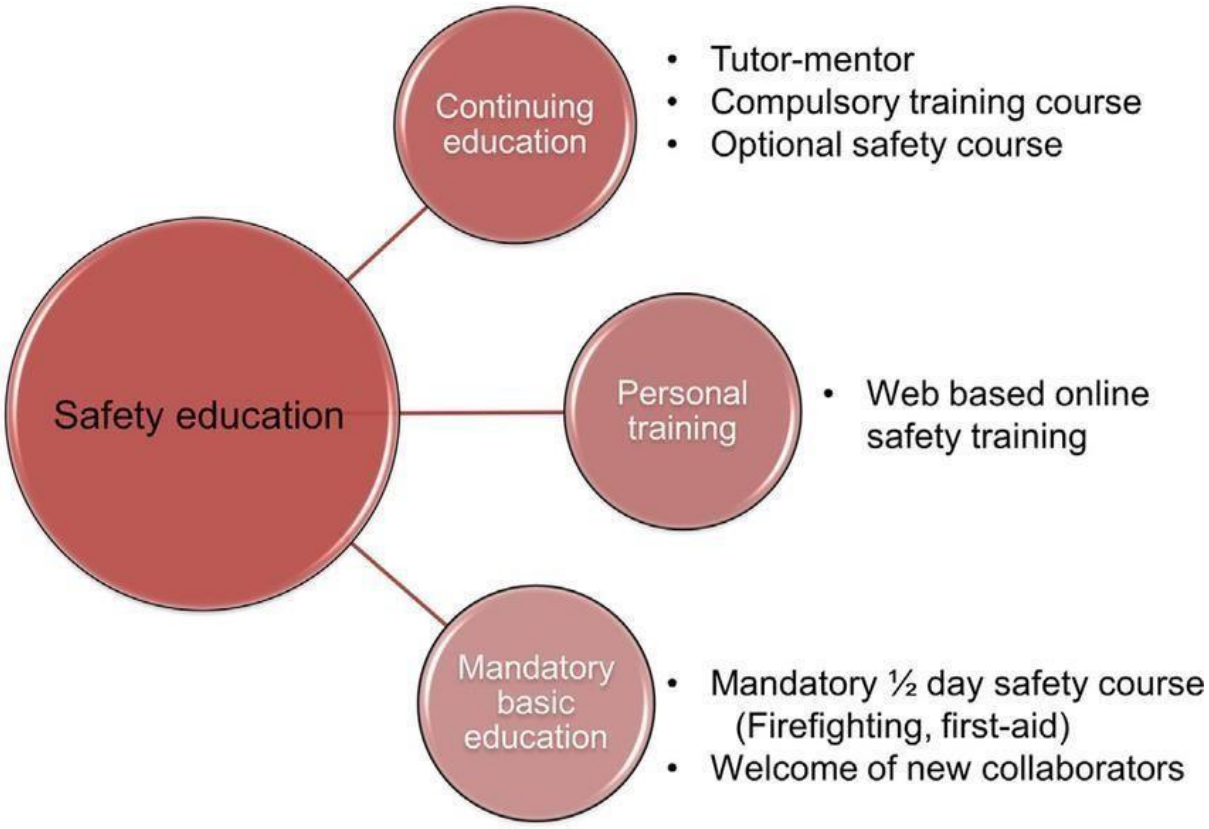
Government policies

While selecting a location for the plant, it is very important to know the local existed Government policies such as licensing policies, institutional finance, Government subsidies, Government benefits associated with establishing a unit in the urban areas or rural areas, etc.

Availability of finance

Finance is the most important factor for the smooth running of any business; it should not be far away from the plant location. However, in the case of decisions regarding plant location, it is the secondary important factor because financial needs can be fulfilled easily if the firm is running

smoothly. But it should be located nearer to the areas to get the working capital and other financial needs easily.



Competition between states

In order to attract the investment and large scale industries various states offer subsidies, benefits, and sales tax exemptions to the new units. However, the incentives may not be big but it can help the firms during its startup stages.

Availability of facilities:

Availability of basic facilities such as schools, hospitals, housing and recreation clubs, etc can motivate the workers to stick to the jobs. On the other hand, these facilities must be provided by the organization, but here most of the employees give preference to work in the locations where all these benefits/facilities are available outside also. So while selecting plant location,

organizations must give preference to the location where it is suitable for providing other facilitiesalso.

Disposal of waste

Disposal of waste is a major problem particularly for industries such as chemical, sugar, and leather, etc. So that the selected plant location should have provision for the disposal of waste.

Education and training in safety:

Safety training and education creates consciousness and develops alertness to safety. Safety education develops safety –mindedness while training helps apply acquired safety knowledge to the specific job or task or procedure.

Just as safety engineering is the most effective way of preventing environmental causes, safety education is the most effective tool in the preventive of human causes of accidents. Through adequate safety instructions, personnel gain useful knowledge and develop safe attitudes.

Education and Training

Education and training are important tools for informing workers and managers about workplacehazards and controls so they can work more safely and be more productive. Another role of education and training, however, is to provide workers and managers with a greater understanding of the safety and health program itself, so that they can contribute to its development and implementation.

Education and training provides employers, managers, supervisors, and workers with:

- Knowledge and skills needed to do their work safely and avoid creating hazards that could place themselves or others at risk.
- Awareness and understanding of workplace hazards and how to identify, report, and control them.
- Specialized training, when their work involves unique hazards.

Additional training may be needed depending on the roles assigned to employers or individual managers, supervisors, and workers. For example, employers, managers, and supervisors may need specific training to ensure that they can fulfill their roles in providing leadership, direction, and resources for the safety and health program. Workers assigned specific roles in the program (e.g., incident investigation team members) may need training to ensure their full participation inthose functions.

Effective training and education can be provided outside a formal classroom setting. Peer-to-peer training, on-the-job training, and worksite demonstrations can be effective in conveyingsafety concepts, ensuring understanding of hazards and their controls, and promoting good work practices.

Action item 1: Provide program awareness training

Action Item 2: Train employers, managers and supervisors on their roles in the program Action item 3: Train workers on their specific roles in the safety and health program Action item 4: Train workers on hazard identification and controls

Action item 1: Provide program awareness training

Managers, supervisors, and workers all need to understand the program's structure, plans, and procedures. Having this knowledge ensures that everyone can fully participate in developing,implementing, and improving the program.

How to accomplish it

- Provide training to all managers, supervisors, workers, and contractor, subcontractor, and temporaryagency workers on:
  - Safety and health policies, goals, and procedures
  - Functions of the safety and health program
  - Whom to contact with questions or concerns about the program (including contact information)
  - How to report hazards, injuries, illnesses, and close calls/near misses
  - What to do in an emergency
  - The employer's responsibilities under the program
  - Workers' rights under the Occupational Safety and Health Act
- Provide information on the safety and health hazards of the workplace and the controls for those hazards.
- Ensure that training is provided in the language(s) and at a literacy level that all workers can understand.
- Emphasize that the program can only work when everyone is involved and feels comfortable discussingconcerns; making suggestions; and reporting injuries, incidents, and hazards.
- Confirm, as part of the training, that all workers have the right to report injuries, incidents, hazards, and concerns and to fully participate in the program without fear of retaliation.

Action item 2: Train employers, managers, and supervisors on their roles in the program

Employers, managers, and supervisors are responsible for workers' safety, yet sometimes have little training on safety-related concepts and techniques. They may benefit from specific trainingthat allows them to fulfill their leadership roles in the program.

How to accomplish it

- Reinforce employers, managers, and supervisors' knowledge of their responsibilities under the Occupational Safety and Health Act and the workers' rights guaranteed by the Act.
- Train employers, managers, and supervisors on procedures for responding to workers' reports

of injuries, illnesses, and incidents, including ways to avoid discouraging reporting.

- Instruct employers, managers, and supervisors on fundamental concepts and techniques for recognizing hazards and methods of controlling them, including the hierarchy of controls (see "Hazard Prevention andControl").Instruct employers, managers, and supervisors on incident investigation techniques, including root cause analysis.

Action item 3: Train workers on their specific roles in the safety and healthprogram

Additional training may be needed to ensure that workers can incorporate any assigned safety andhealth responsibilities into their daily routines and activities.

How to accomplish it

- Instruct workers on how to report injuries, illnesses, incidents, and concerns. If a computerized reporting systemis used, ensure that all employees have the basic computer skills and computer access sufficient to submit an effective report.
- Instruct workers assigned specific roles within the safety and health program on how they should carryout those responsibilities, including:
  - Hazard recognition and controls (see action item 4)
  - Participation in incident investigations
  - Program evaluation and improvement
- Provide opportunities for workers to ask questions and provide feedback during and after the training.
- As the program evolves, institute a more formal process for determining the training needs of workers responsible for developing, implementing, and maintaining the program.

Action item 4: Train workers on hazard identification and controls

Providing workers with an understanding of hazard recognition and control and actively involving them in the process can help to eliminate hazards before an incident occurs.

How to accomplish it

- Train workers on techniques for identifying hazards, such as job hazard analysis.
- Train workers so they understand and can recognize the hazards they may encounter in their own jobs, as well as more general work-related hazards.
- Instruct workers on concepts and techniques for controlling hazards, including the hierarchy of controls and its importance.
- Train workers on the proper use of work practice and administrative controls.
- Train workers on when and how to wear required personal protective equipment.
- Provide additional training, as necessary, when a change in facilities, equipment, processes, materials, or work organization could increase hazards, and whenever a worker is assigned a new task.

Prevention causes and cost of accident:

The domino effect theory: in a sequential combination of five factors (social environment, human error, unsafe acts, **accident**, **injury**), each of the factors alone will not **cause** an **accident** so that removing any one would be effective in **accident prevention**; however, each of the factors can be depicted as a "domino"

Accidents in Industries: Causes, Prevention and Proneness:

Economic Aspects (Cost) of Accidents:

An accident can be very costly to the injured employee as well as to the employer of the concern.There are definite costs associated with the accident, e.g., direct and measurable costs and indirect, i.e., somewhat intangible but nevertheless real costs.

(i) Compensation insurance, including Payment, and Overhead costs.

(ii) Uncompensated wage losses of the injured employee,

(iii) Cost of medical care and hospitalization.

Indirect costs of an accident they associate:

(i) Costs of damage to equipment, materials and plant.
(ii) Costs of wages paid for time lost by workers not injured.
(iii) Costs of wages paid to the injured worker.
(iv) Costs of safety engineers, supervisors and staff in investigating, recording and reporting ofaccidents and its causes.

(v) Costs of replacing the injured employee.
(vi) Cost of lowered production by the substitute worker.
(vii) Cost of delays in production due to accident.
(viii) Cost of reduction in efficiency of the injured worker when he joins the concern after getting recovered.

Causes of Accidents:

An accident is an unplanned incident and for each such incident there is usually a specific cause or causes if one could but discover them.

Accident may be caused due to:

Technical causes or unsafe conditions reflect deficiencies in plant, equipment, tools, materials handling system, general work environment, etc. Human causes or unsafe acts by the person concerned are due to his ignorance or forgetfulness, carelessness, day-dreaming, etc. It has beenestimated that there are four accidents caused by human causes to everyone that is caused by technical causes.

Mechanical Causes or Factors:

Unsafe mechanical design or construction.

2. Hazardous arrangement (piling, over-loading etc.)

3. Improper machine guarding.

4. Unsafe apparel.

5. Defective agencies or devices.

6. Improper material handling.
7. Broken safety guards.

8. Protruding nails.

9. Leaking acid valve.

10. Untested boilers or pressure vessels.

Environmental Factors:

Environmental factors indicate improper physical and atmospheric surrounding conditions of workwhich indirectly promote the occurrence of accidents.

Environmental factors include:

1. Too low a temperature to cause shivering.

2. Too high a temperature to cause headache and sweating.

3. Too high a humidity (in textile industry) to cause uncomforted, fatigue and drowsiness (especially when the atmosphere is also hot).

4. Defective and inadequate illumination causing eyestrain, glares, shadows, etc.

5. Presence of dust, fumes and smokes (e.g., in foundary or welding shop) and lack of proper ventilation.

6. High speed of work because of huge work load.

7. More number of working hours and over and above them the tendency of the employer to insist for over-time work.

8. Inadequate rest pauses or breaks between the working hours.

9. Noise, bad odour and flash coming from the nearby machinery, equipment or processes.

10. Poor housekeeping.

Personal Factors:

1.Age.2. Health3. Number of dependents.4. Financial position.5. Home environment.6. Lack of knowledge and skill.7. Improper attitude towards work.8. Incorrect machine habits.9. Carelessness and recklessness.10. Day-dreaming and un-attentiveness.11. Fatigue.12. Emotional un-stability, e.g., jealousy, revengefulness, etc.13. High anxiety level.14. Mental wordiness.15. Unnecessary exposures to risk.16. Non-use of safety devices.17. Working at unsafe speeds.18. Improper use of tools.

ACCIDENT PREVENTION:

Accident prevention is highly essential in an industry, in order to:

(i) Prevent injury to and premature death of employees.

(ii) Reduce operating and production costs.

(iii) Have good employer-employee relations.

(iv) High up the morale of employees.

Above all, prevention of accidents is a true humanitarian concern.

Housekeeping:

The Housekeeping department takes pride in keeping the hotel clean and comfortable, so as to create a 'Home away from home'. The aim of all accommodation establishment is to provide their customers with clean, attractive, comfortable and welcoming surrounding that offer value for money. Nothing sends a stronger message than cleanliness in a hospitality operation. No level of service, friendliness or glamour can equal the sensation a guest has upon entering a spotless, tidy and conveniently arranged room. Both management and guest consider the keeping of the place clean and in a good order a necessity for a hotel to command a fair price and get repeat business.

ROLE OF HOUSEKEEPING DEPARTMENT

Housekeeping plays a very important role in hospitality industry such as:-

- To achieve the maximum possible efficiency in ensuring the care and comfort of guests and in thesmooth running of the department.
- To establish a welcoming atmosphere and ensure courteous, reliable service from all staff of the department.
- To ensure a high standards of cleanliness and general upkeep in all areas for which the department is responsible.
- To provide linen in rooms, restaurants, banquet hall, conference venues, health clubs, and so on, as well as maintain an inventory for the same.

FIRST AID:

It is impossible to predict when will an accident happen in the workplace. However, it is the employer's duty to do everything in their power to prevent accidents and provide access to first aid to their employees and everybody who frequents their workplace.

The **5 main aims of first aid** are:

1. preserve life
2. prevent the escalation of the illness or injury
3. promote recovery
4. pain relief
5. protect the unconscious.

1. **Preserve life** – while the first aider is the person who has the certificate for the first aid, they are not medical professionals. They can do their best to make sure the patient is given the basic care and they can help treat minor injuries like cuts and scrapes that don't need routine or emergency attention.

However, in case of severe situations that are a threat to the patient's life, they do not focus on providing care but on preserving life long enough until the ambulance arrives

2. **Prevent the escalation** – again, the efforts of the first aiders are directed toward prolonging the time the patient has until the ambulance arrives. If the patient is bleeding profusely, the first aider will not stitch the wound, but they will do their best to stop the bleeding until the ambulance arrives. In that way, they will prevent further complications and health deterioration.

3. **Pain relief** – this is done only if it is in any way possible and it doesn't present a risk to the patient. Some pain relief medications can be dangerous in case a person is bleeding. Therefore, if not sure if the pain medication is appropriate, it is better to ask the medical experts first.

4. **Protect the unconscious** – one of the important factors in administering first aid is protection and safety for both the patient and the first aider. Moreover, this extends to the people who are nearby, as well. Protecting the unconscious can mean removing them from a dangerous situation, like fire, flooded space or road with traffic.

5. **Promote recovery** – every action that a first aider takes should be in the direction of helping the person who has suffered an injury or sudden illness get better.

Promoting the recovery usually means using the first aid kit. It is packed with supplies that are necessary for the first aider to be able to help the person in need. You can understand that the time of providing the first aid is crucial. If your first aid is not well-stocked or it is not there at all – thatis a big problem.

Firefighting equipments:

- Fire Extinguishers.
- Smoke Detectors.
- Fire Alarm Systems.
- Fire Suit.
- Fire Extinguisher Cylinders.
- Fire Sprinklers.
- Fire Hydrants.
- Fire Safety Service.

Accident Reporting:

Purpose

An accident reporting and investigation plan prescribes methods and practices for reporting and investigating accidents that can be read and understood by all managers, supervisors, and employees. No matter how conscientious the safety efforts are, accidents are going to happen sometimes due to human or system error.

This written Accident Reporting and Investigation Plan is intended to demonstrate The University of Mary Washington's compliance with the requirements in 29 CFR 1904 by:

- prescribing methods and practices for reporting and investigating accidents, and providing a means to deal with workplace accidents in a standardized way.

In addition it is the policy of the University to comply with all workers' compensation laws and regulations. The requirements of this plan apply to all operations and departments at the University.

AdministrativeDuties

The University of Mary Washington's Workman's Compensation Coordinator, is responsible for developing and maintaining and reporting First Records of Injury to Virginia State Department of Risk

Management.

This function is shared by the Human Resource office and the PublicSafety Department, Office of Occupational Health and Safety. They are both responsible for the OSHA 300A report as well as compensatory reports for the employee and have full authority to make necessary decisions to ensure the success of this plan. They are also qualified, by appropriate training and experience to commensurate with the complexity of the plan, to administer or oversee our accident reporting and investigation program and conduct the required investigations and incident evaluations.

All employee accidents are reviewed by a committee of university representatives from all trades, skills and professions for adequate recommendations and remediations.This written Accident Reporting and Investigation Plan is kept at the following locations Fairfax House and the Public Safety office at Brent Hall.

Accident Reporting Procedures:

Employees injured on the job are to report the injury to their supervisor as soon as possible after the incident/accident. Near miss accidents or incidents (when an employee nearly has an accident but is able to avoid it) should be reported as well. All accidents and incidents should be reported for prevention purposes.

The supervisor must immediately notify Human Resources Department and the Public Safety Department when an incident/accident occurs.

If they are not available a report should be forwarded for there review and the supervisor shall conduct an investigation and interview

Accident Investigation Procedures

Thorough investigation of all accidents will lead to identification of accident causes and help:

- reduce economic losses from injuries and lost productive time;
- determine why accidents occur, where they happen, and any trends that might be developing;
- employees develop an awareness of workplace problems and hazards;
- identify areas for process improvement to increase safety and productivity;
- note areas where training information or methods need to be improved; and
- suggest a focus for safety program development.

For all accident investigations, the Safety Department or designate will perform the following duties:

- Conduct the accident investigation at the scene of the injury as soon after the injury as safely possible.
- Ask the employee involved in the accident and any witnesses, in separate interviews, to tell in their own words exactly what happened.
- Repeat the employee's version of the event back to him/her and allow the employee to make any correctionsor additions.
- After the employee has given his/her description of the event, ask appropriate questions that focus on causes.
- When finished, remind the employee the investigation was to determine the cause and possible corrective action that can eliminate the cause (s) of the accident.
- Complete an accident investigation report with the employee and review data with employee for accuracy. This will provide information to put into database format.

The accident investigation report is used to:

- track and report injuries on a monthly basis;
- group injuries by type, cause, body part affected, time of day, and process involved;
- determine if any trends in injury occurrence exist and graph those trends if possible;
- identify any equipment, materials, or environmental factors that seem to be commonly involved ininjury incidents;
- discuss the possible solutions to the problems identified with the safety team and superiors; and
- proceed with improvements to reduce the likelihood of future injuries.

Injury/MedicalIssues

If a workplace accident results in injury or illness requiring hospitalization of three or more employees or a fatality of one or more employee, the University's Workman's Compensation Coordinator will report the incident within eight hours by phone or in person to the nearest VOSH office.

If an injured person is taken to a doctor, a statement from the doctor will be attached to the Accident Report form.

Record-keeping

The University of Mary Washington's Workmen Compensation Coordinator is responsible for maintaining the following records and documentation:

- OSHA 300A log of injuries and illnesses
- Accident investigation reports
- *Employer's Accident Report*

The University of Mary Washington Safety Department is responsible for maintaining the following records and documentation:

- Training records
- Investigation and Interviews

Training

This plan is an internal document guiding the action and behaviors of employees, so they need to know about it. To communicate the new accident reporting and investigation plan, all employees are given a thorough explanation as to why the new plan was prepared and how individuals may be affected by it.

The information and requirements of this written plan are presented to employees during new hire orientation or as the plan is reviewed and modified but at least annually.

Program Evaluation

The accident reporting and investigation program is evaluated and updated by The University of Mary Washington's Workmen's Compensation Coordinators and the Safety Department annually to determine whether the plan is being followed and if further training may be necessary.

Investigations:

Finding the cause of safety incidents is the first step in preventing similar incidents in the future. Safety Management Group's safety professionals have extensive experience at investigating workplaceaccidents, fatalities, and other incidents involving injuries or near misses.

When a serious workplace accident occurs, it's imperative that companies conduct a prompt and thorough accident investigation. An incomplete, inaccurate or biased investigation can aggravate the problem and increase your potential liability. Our safety professionals understand OSHA and know how to properly conduct the workplace investigation and perform interviews, even in high-profile cases receiving media attention.

In addition to preventing future incidents, a thorough investigation will allow your company to fulfill any legal requirements, determine the cost of an accident, determine compliance with applicable OSHA safety regulations, and process workers' compensation claims. Incidents that involve no injury or property damage should still be investigated to determine the hazards that should be corrected.

Industrial psychology in accident prevention:

Many efforts are being made to reduce accidents in the manufacturing plants and great stress is being placed on safety. Efforts are being made in two directions.

i) Reducing the liability of the situation

ii) Minimising the possible influence of any relevant personal factors.

The most common type of safety training is to make employees safety conscious and safety-wise. Many psychological principles are used to safeguard the workers. The measures taken by the safety engineers cover a spectrum of techniques, procedures and guidelines directed toward reducing situational liability.

These include the installation of protective guards on machines, changes of method, arrangement of material and equipment, use of protective clothing and gear, improvements in the environment and other techniques aimed at minimising the specific types of hazards.

It has been increasingly recognised that the design of equipment and the nature of the physical environment can effect the accident liability. There is more focus on the design of equipment and work stations to suit the individual physical aspects (like height, weight etc.) that contribute to safety. Let us consider atleast a few of the possible approaches to reduce accidents from the human liability rather than from situational side.

Safety Trails:

A safety outcomes trial (SOT) is a prospective, randomized, controlled trial that is specifically designed and adequately powered to test a safety hypothesis using a clinical outcome (single or composite) such as

irreversible morbidity or mortality as the primary trial endpoint.

UNIT III

SAFETY ACTS

UNIT-III

SAFETY ACTS

Features of Factories Act

Objective of Factories Act :

The main objectives of the Indian Factories Act, 1948are to regulate the working conditions in factories, to regulate health, safety welfare, and annual leave and enact special provision in respect of young persons, women and children who work in the factories.

1. Working Hours:

According to the provision of working hours of adults, no adult worker shall be required or allowed to work in a factory for more than 48 hours in a week. There should be a weekly holiday.

2. Health:

For protecting the health of workers, the Act lays down that every factory shall be kept clean and all necessary precautions shall be taken in this regard. The factories should have proper drainage system, adequate lighting, ventilation, temperature etc.

Adequate arrangements for drinking water should be made. Sufficient latrine and urinals should be provided at convenient places. These should be easily accessible to workers and must be kept cleaned.

3. Safety:

In order to provide safety to the workers, the Act provides that the machinery should be fenced, no young person shall work at any dangerous machine, in confined spaces, there should be provision for manholes of adequate size so that in case of emergency the workers can escape.

4. Welfare:

For the welfare of the workers, the Act provides that in every factory adequate and suitable facilities for washing should be provided and maintained for the use of workers.

Facilities for storing and drying clothing, facilities for sitting, first-aid appliances, shelters, rest rooms' and lunch rooms, crèches, should be there.

5. Penalties:

The provisions of The Factories Act, 1948, or any rules made under the Act, or any order given in writing under the Act is violated, it is treated as an offence. The following penalties can be imposed:-

(a) Imprisonment for a term which may extend to one year;

(b) Fine which may extend to one lakh rupees; or

(c) Both fine and imprisonment.

If a worker misuses an appliance related to welfare, safety and health of workers, or in relation todischarge of his duties, he can be imposed a penalty of Rs. 500/-.

Introduction of Explosive Act:

Power for Central Government to prohibit the manufacture, possession or importation of specially dangerousexplosives.

This Act shall come into force on such day1 as the Central Government,
by notification in the OfficialGazette, appoints.

(1) This Act shall come into force on such day5 as the Central Government, bynotification in theOfficial Gazette, appoints.

Central Government may, for any part of 1[India] 2 [***] make rules3 consistent with this Act to regulate or prohibit, except under and in accordance with the conditions of a licence granted as provided by those rules, the manufacture, possession, use, sale, 4[transport, import and export] of explosives, or any specifiedclass of explosives."

(2) Rules under this section may provide for all or any of the following, among other matters, that is to say:—

(a) the authority by which licences may be granted;

(b) the fees to be charged for licences, and the other sums (if any) to be paid for expenses by applicants forlicences;

(c) the manner in which applications for licenses must be made, and the matters to be specified in suchapplications;

(d) the form in which, and the conditions on and subject to which, licences must be granted;

(e) the period for which licences are to remain in force; the authority to which appeals may be preferred under section 6F, the procedure to be followed by such authority and the period within which appeals shall be preferred, the fees to be paid in respect of such appeals and the circumstances under which such fees may be refunded; 6[(ee) the authority to which appeals may be preferred under section 6F, the procedure to be followed by such authority and the period within which appeals shall be preferred, the fees to be paid in respect of such appeals and the circumstances under which such fees may be refunded;"

(eea) the total quantity of explosives that a licensee can purchase in a given period of time;

(eeb) the fees to be charged by the Chief Controller of Explosives or any officer authorised by him in this behalf, for services rendered in connection with the manufacture, transport, import or export of explosives;]

(f) the exemption absolutely or subject to conditions of any explosives 6[or any person or class of persons] from the operation of the rules.6[or any person or class of persons] from the operation of the rules

Boiler Act: The Indian Boilers Act-1923 was enacted with the objective to provide mainly for the safety oflife and Property of persons from the danger of explosions of steam boilers and for achieving uniformity in registration and inspection during operation and maintenance of boilers in India.

"Steam Boiler" means any closed vessel exceeding 22.75 litres which is used exclusively for generating steam under pressure and includes any mountings and other fittings attached to suchvessel which is wholly or partly under pressure when steam is shut off.

Every boiler owner is required to make an application to the Chief Inspector of Boilers for the inspection of the boiler along with the treasury challan of the requisite fees as per requirements of Indian Boilers Act- 1923. The requisite fee for the inspection of the boiler has been prescribed under Delhi Boilers Rules-1927.

Under Indian Boilers Act-1923 Indian Boilers Regulation-1950 has been framed. This Regulation deals with the materials, procedure & inspection techniques to be adopted for the manufacture of boilers & boiler mountings & fittings. The boiler is inspected by the Inspectorate as per the procedure laid under IBR -1950 and if found satisfactory, a Certificate is issued for operation for amaximum period of 12 months.

The boilers which are not found satisfactory during the inspection are repaired as per the procedure laid under Indian Boilers Regulation-1950 & are re-inspected as explained above. The Boilers which are transferred to NCT of Delhi are also inspected in the similar fashion after their records are obtained from the parent state.

The Boilers are also casually visited by the Inspectorate from time to time to check the validity of their certificates, safe and efficient operation. The show cause notice is issued to the boiler owner whose boiler is found working without a valid certificate and given a specified time to comply with. If the complianceis not made during the stipulated period, then necessary action as deemed fit under the Act is taken against the erring boiler owner.

REGISTRATION OF THE BOILER :

Every boiler owner who purchases a new boiler submits an application to the Chief Inspector of Boilers along with the inspection fees as per regulation 385 of IBR-1950 and the certificates of the manufacture in form of II, III & IV issued by the Chief Inspector of Boilers of the manufacturing state, for the registration of the boiler.

The Boiler is inspected and its M.B along with (Memorandum of Inspection Book) is prepared. All calculations for the pressure parts of the boiler are made as per IBR-1950 and a P.O. (Provisional Order) is issued for a maximum period of six months to operate the boiler at the maximum working pressure as calculated.

The boiler is offered for the STEAM TEST by the boiler owner within the validity of PO and if found satisfactory, a certificate for a period of 12 months is issued.

INSPECTION OF STEAM PIPE LINE:

The Steam-Pipe-Line is used to carry the Steam from the boiler to the user's equipment and it hasbeen defined as:

"Steam Pipe" means any pipe through which steam passes from a boiler to prime mover or otheruser or both if:-

(i) The pressure at which steam passes through such pipe exceeds 3.5 kilograms per square centimeters above atmospheric pressure: or
(ii) Such pipe exceeds 254 millimetres in internal diameter; and includes in either case, anyconnected fitting of a steam pipe.
The boiler owner submits the layout of the SPL in duplicate alongwith the requisite fees. The layouts of the SPL are checked for the safe working pressure and flexibility as per IBR-1950. The steam pipe line is later on subjected to Hydraulic Test Pressure and allowed to be used at requisite pressure if found satisfactory.

INSPECTION UNDER CONSTRUCTION :

New Boilers, Valves, Mountings and other components are required to be inspected at different stages of the fabrication to comply with the Indian Boiler Regulation-1950 or other renowned standards of the world with the motive of maintaining quality, interchangeability, efficient operation and as well as the safety of workers, and property.

EXAMINATION OF THE BOILER ATTENDANTS

Each boiler is required to be worked by qualified Boiler Attendant. As such the examinations are conducted by the department from time to time to enable the personnel's to qualify to operate the boilers as per the guidelines of "Delhi Boiler Attendant Rules, 1953."

EXAMINATION OF WELDER

As per Indian Boiler Regulation-1950 all welding work in the boilers, Steam Pipe Lines and its related components etc. is required to be carried out by the qualified High Pressure Welders. To enable the personnel's to qualify as High Pressure Welders, examinations are conducted by this section from time to time.

ESI Act: The promulgation of Employees' State Insurance **Act**, 1948 envisaged an integrated need based social insurance scheme that would protect the interest of workers in contingencies such as sickness, maternity, temporary or permanent physical disablement, death due to employment injury resulting in loss of wages or earning capacity. the Act also guarantees reasonably good medical care to workers and their immediate dependants.

Following the promulgation of the ESI Act the Central Govt. set up the ESI Corporation to administer the Scheme. The Scheme, thereafter was first implemented at Kanpur and Delhi on 24th February 1952. The Act further absolved the employers of their obligations under the Maternity Benefit Act, 1961 and Workmen's Compensation Act 1923. The benefit provided to theemployees under the Act are also in conformity with ILO conventions.

Workman's compensation Act:

An Act to provide for the payment by certain classes of employers to their workmen of compensation for injury by accident. Whereas it is expedient to provide for the payment by certainclasses of employers to their workmen of compensation for injury by accident

The Workmen's Compensation Act, 1923 provides for payment of compensation to workmen (or their dependants) in case of personal injury caused by accident or certain occupational diseases arising out of and in the course of employment and resulting in disablement or death. The Act was last amended in 1976.

The laws provide employees with monetary awards to cover loss of wages directly related to the accident as well as to compensate for permanent physical impairments and medical expenses. The laws also provide benefits for dependents of those workers who are killed in work-related accidents or illnesses.

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INTRODUCTION

The growing complexity of industry in this country, with the increasing use of machinery and consequent danger to workmen, along with the comparative poverty of the workmen themselves, rendered it advisable that they should be protected, as far as possible from

hardship arising from accidents. After a detailed examination of the question by the Government of India, Local Governments were addressed in July 1921, and provisional views of the Government of

India were published for general information. The advisability of legislation had been accepted by the great majority of Local Governments and of employers' and workers' associations and the Government of India believed that public opinion generally is in favour of legislation. In June,

1922 a committee was convened to consider the question. After considering the numerous replies and opinions received by the Government of India, the committee was unanimously in favour of legislation, and drew up detailed recommendations. On the recommendations of the committee theWorkmen's Compensation Bill was introduced in the Legislature.

STATEMENT OF OBJECTS AND REASONS

The general principles of workmen's compensation command almost universal acceptance and India is now nearly alone among civilised countries in being without legislation embodying those principles. For a number of years the more generous employers have been in the habit of giving compensation voluntarily, but this practice is by no means general.

The growing complexity of industry in this country, with the increasing use of machinery and consequent danger to workmen, along with the comparative poverty of the workmen themselves, renders it advisable that they should be protected, as far as possible from hardship arising from accidents. An additional advantage of legislation of this type is that by increasing the importance for the employer of adequate safety devices, it reduces the number of accidents to workmen in a manner that cannot be achieved by official inspection. Further, the encouragement given to employers to provide adequate medical treatment for their workmen should mitigate the effects of such accidents as do occur.

The benefits so conferred on the workman added to the increased sense 16(3) The Workmen's Compensation Occupational Diseases (Punjab) Rules, 1964 of security which he will enjoy, should render industrial life more attractive and thus increase the available supply of labour. At the same time, a corresponding increase in the efficiency of the average workman may be expected.

A system of insurance would prevent time burden from pressing too heavily on any particular employer. After a detailed examination of the question by the Government of India, Local Governments were addressed in July 1921, and provisional views of the Government of India were published for general information. The advisability of legislation has been accepted by the great majority of Local Governments and 'at employers' and workers' association and the Government of India believe that public opinion generally is in favour of legislation. In June 1922,a committee was convened to consider the question.

This committee was composed, for the most part of members of the Imperial Legislature. After considering the numerous replies and opinions received by the Government of India, the committee was unanimously in favour of legislation and drew up detailed

recommendations regarding the lines which in its opinion such legislation should follow. The Bill now presented follows these recommendations closely. A number of supplementary provisions have been added where necessary, but practically no variations of importance have been made. The Bill contains two distinct proposals. In Chapter II modifications are made in the ordinary civil law affecting the liability of employers for the damages in respect of injuries sustained by their workmen; these clauses will operate only in actions before the ordinary civil courts.

The main part of the Bill makes provisions for workmen's compensation and sets up special machinery to deal with claims falling under this category. Both parts of the Bill, however, apply to the same classes of workmen. If the scope of the employers' liability clauses was made wider than the scope of the workmen's compensation provisions, there would be considerable danger of a great increase in litigation.

The classes included are those whose inclusion was recommended by the committee, and are specified in Schedule II. Two criteria have been followed in the determination of the classes to be included— (1) that the Bill should be confined to industries which are more or less organised;

(2) that only workmen whose occupation is hazardous should be included. The general principle is that the compensation should ordinarily be given to workmen who sustained personal injuries by accidents arising out of and in the 16(3) The Workmen's Compensation Occupational Diseases (Punjab) Rules, 1964 course of their employment. Compensation will also be given in certain limited circumstances for disease. The actual rates of compensation payable are based on the unanimous recommendation of the committee. They are in every case subject to fixed maxima, in accordance with the committee's recommendations. It should be remembered, however, that the more highly paid workmen will be enabled in cases to which the employers' liability clauses will apply, to obtain damages on a scale considerably in excess of the maximum fixed for workmen's compensation. A consistent endeavour has been made to give as little opportunity for disputes as possible. Throughout the Bill in the definitions adopted the scales selected, and the exceptions permitted the great aim has been precision in order that in as few cases as possible should the validity of a claim for compensation or the amount of that claim be open to doubt. At the same time, on the unanimous recommendation of the committee provision has been made for special Tribunal to deal cheaply and expeditiously with any disputes that may arise, and generally to assist the parties in a manner which is not possible for the ordinary civil courts. ACT 8 OF 1923 The Workmen's Compensation Bill having been passed by the Legislature received its assent on the 5th March, 1923. It came into force on 1st day of July, 1924 as THE WORKMEN'S COMPENSATION ACT, 1923 (8 of 1923).

LIST OF AMENDING ACTS AND ADAPTATION ORDERS

1. The Repealing and Amending Act, 1924 (7 of 1924).
2. The Repealing and Amending Act, 1925 (37 of 1925).
3. The Workmen's Compensation (Amendment) Act, 1926 (29 of 1926).
4. The Workmen's Compensation (Amendment) Act, 1929 (5 of 1929).
5. The Workmen's Compensation (Amendment) Act, 1933 (15 of 1933).
6. The Government of India (Adaptation of Indian Laws) Order, 1937.
7. The Workmen's Compensation (Amendment) Act, 1937 (7 of 1937).

8. The Workmen's Compensation (Amendment) Act, 1938 (9 of 1938).
9. The Workmen's Compensation (Amendment) Act, 1939 (13 of 1939).
10. The Workmen's Compensation (Second Amendment) Act, 1939 (42 of 1939).
11. The Workmen's Compensation (Amendment) Act, 1942 (1 of 1942).
12. The Workmen's Compensation (Amendment) Act, 1946 (1 of 1946). 16(3) The Workmen'sCompensation Occupational Diseases (Punjab) Rules, 1964
13. The Indian Independence (Adaptation of Central Acts and Ordinances) Order, 1948.
14. The Adaptation of Laws Order, 1950.
15. The Part B States (Laws) Act, 1951 (3 of 1951).
16. The Adaptation of Laws (No. 3} Order, 1956.
17. The Repealing and Amending Act, 1957 (36 of 1957).
18. The Workmen's Compensation (Amendment) Act, 1959 (8 of 1959).
19. The Repealing and Amending Act, 1960 (58 of 1960).
20. The Workmen's Compensation (Amendment) Act, 1962 {64 of 1962).
21. The Central Labour Laws {Extension to Jammu and Kashmir) Act, 1970 (51 of 1970). 22. TheWorkmen's Compensation (Amendment) Act, 1976 (65 of 1976).
23. The Workmen's Compensation (Amendment) Act, 1984 (22 of 1984).
24. The Delegated Legislation Provisions (Amendment) Act, 1985 (4 of 1986).
25. The Workmen's Compensation (Amendment) Act, 1995 (30 of 1995).
26. The Workmen's Compensation (Amendment) Act, 2000 (46 of 2000).

Industrial Hygiene: Industrial Hygiene has also been defined as the practice of identifying of hazardous agents; chemical, physical and biological; in the workplace that could cause disease or discomfort, evaluating the extent of the risk due to exposure to these hazardous agents, and the control of those risks to prevent ill-health in .

Industrial hygiene has been a profession since the 1940s, working with science and technology to protect the health and safety of workers and the community. Our industrial hygiene team helps clients meet and maintain regulatory compliance in all industrial health and safety areas.

Our knowledgeable team of Certified Industrial Hygienists are experienced in a variety of settings including manufacturing, public works, heavy industrial, remediation, commercial, warehousing, healthcare, laboratories and office environments. Our dynamic team of Certified Industrial Hygienists, Certified Safety Professionals, indoor environmental scientists, engineers, and business professionals brings a holistic and practical approach to solving workplace hazards.

Employer responsibilities:

To protect the health of employees, exposure measurements must be unbiased, representativesamples of employee exposure. Employers must:

- Devise sampling plans to evaluate occupational exposures to airborne concentrations of chemicalsubstances as well as ingestion and dermal absorption
- Determine the need for exposure measurement
- Evaluate exposure measurement data
- Make decisions concerning what action is required by federal regulations.

Occupational safety:

Occupational safety deals with all aspects of physical, mental and social health and safety in a workplace. It is the umbrella for company's efforts to prevent injuries and hazards in all workenvironments.

Every industry presents various kinds of safety hazards to its employees. The spectrum of possible occupational safety risks ranges from severe and immediate physical dangers to milder hazards. The more immediate cases can be fires, explosions, chemical hazards or other such dangers that present an immediate threat to an employee's life. Milder hazards include challenges in ergonomics, workloads, mental capacity and general well-being of employees. The latter kinds of risks often take place in an office environment. However, whatever business you are in, there is always the possibility of an accident happening to someone.

Well-maintained occupational safety saves money

The biggest and non-measurable cost of a safety failure might be of the personal kind. A lost limb or years of mental rehabilitation can force an individual to adopt a completely new lifestyle and even self-identity. It's hard to define how to put a price tag on those types of incidents. Fatal injuries, where people actually get killed at completing their tasks, are also unquestionably beyond what we can economically quantify. Besides the one being killed, there are several other direct stakeholders such as family and friends, coworkers and other parties that suffer from it.

These accidents also directly impact the company's bottom line. An injured employee easily means countless lost man hours and quickly adds up to not only billions but trillions of euros in company's expenses. Only in the US the costs of non-fatal injuries and occupational diseases account for more than estimated $450B. Similarly, fatal injuries in 2013 accounted for the estimated $214B in the US. From a company's perspective, the expenses do not add up only because of lost in productivity, but also because of the increasing insurance costs.

Another big loss to a company comes from decreased work morale and increased employee retention. People want to feel safe. It comes as no surprise if employees' work morale decreases after seeing, for instance, a coworker fall of a lifting track because of inadequate safety measures. And the best people tend to leave first.

Occupational safety creates new opportunities

Instead of just seeing occupational safety as hazards and costs which should be controlled and limited, another viewpoint is to embrace it as an untapped opportunity. One example of doing this is the story of Alcoa. The aluminum products manufacturer is famous for understanding the importance of occupational safety and showing how investment in it can positively affect company profits. When Paul O'Neill started as the CEO of Alcoa, he announced that he wanted to make the company the safest one in the US. Instead of only wanting to hear reports of already occurred injuries and fatalities, he wanted employees to give out suggestions and ideas how to improve safety. And that eventually changed the whole company culture and employees started to also share their other improvement ideas. Alcoa ended up notably increasing its profits based on ideas that came from their employees. Not only that, butthey also learned how to adapt and learn from failure and make better processes.

Occupational safety affects company reputation and productivity

Companies of all forms and from all fields should really take a look at their occupational safety. Adapting and learning from failure is crucial if a company is looking to improve processes in the VUCA world.

All the previously mentioned reasons are enough to drive a possible change needed at a workplace. We are also living in an era when anyone can update their social media profiles of bad management experiences orpost a review of the company to Glassdoor.com. No company should want a possible future recruit to read online that the workplace is not investing in occupational safety. It might soon lead to a situation where the HR department receives less and fewer applications from good candidates.

It is evident that even the smallest acts of not taking care of employees' health and safety are a huge concern for companies both big and small. But the concern should not initially come from complaints in social media. Willingness and interest to invest in occupational safety should strive from a sincere interest in employees' safety and health and therefore also company's productivity and growth. This again can be turned into a huge asset in improving employee retention and hiringthe best people.

Diseases Prevention: The Epidemic Diseases Act, 1897 is a law which was first enacted to tackle bubonic plague in Mumbai (formerly Bombay) in former British India. The law is meant for containment of epidemics by providing special powers that are required for the implementation of containment measures to control the spread of the disease.

The Act has been routinely used to contain various diseases in India such as swine flu, cholera, malaria and dengue.In 2018, the Act was enforced as cholera began to spread in a region of Gujarat. In 2015, it was used to deal with dengue and malaria in Chandigarh and in 2009 it was invoked in Pune to combat swine flu. Starting in March 2020, the act is being enforced across India in order to limit the spread of coronavirus disease 2019 during the COVID-19 pandemic in India.

Ergonomics: Ergonomics (or human factors) is the scientific discipline concerned with the understanding of the interactions among human and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.

When evaluating a job, looking for three main characteristics known as Ergonomic Stressors: the force required to complete a task, any awkward or static working postures adopted in completing a task, and the repetitiveness of a task. Any of these factors, or any combination of these factors, may place someone at greater risk for discomfort.

Purpose

The Department of Environment, Health and Safety's (EHS) purpose is to help all UNC employees create and maintain a healthy and safe working environment.

Goal:

EHS wants to provide information and education to allow any employee to avoid injury. EHS wants to educate people on the basics of ergonomics. Not only will they be able to help themselves at work, but these principles can be applied to home, hobbies or help friends and coworkers who may have similar issues. Remember, knowledge is contagious.

Services

Services EHS offer include:

- Providing information about ergonomics
- Providing consultation regarding workstation setup
- Giving on-campus training on ergonomics (as requested)
- Providing product evaluations
- Providing an online self-assessment tool. This tool will walk the individual through a self

evaluation and provide the user with recommendations to modify their workstation.

Occupational Disease : An "occupational disease" is any disease contracted primarily as a result of an exposure to risk factors arising from work activity. "Work-related diseases" have multiple causes, where factors in the work environment may play a role, together with other risk factors, in the development of such diseases.The WHO Global Plan of Action on Workers' Health called for improving the diagnosis, reporting and registration of occupational diseases and building capacities for estimating the occupational burden of diseases

WHO's activities regarding occupational and work-related diseases include:

- Carrying our estimates of the global burden of disease from major occupational risks, such as injuries, airborne exposures, carcinogens, ergonomic stressors, noise and other specific risks.
- Incorporating occupational diseases and their causes in the 11th revision of the International Statistical Classification of Diseases and Related Health Problems.
- Working with ILO to develop diagnostic and exposure criteria for occupational diseases and to enable primary and secondary health care providers to detect and report such diseases.

STRESS:

Some of the factors that commonly cause work-related stress include:

- Long hours.
- Heavy workload.
- Changes within the organization.
- Tight deadlines.
- Changes to duties.
- Job insecurity.
- Lack of autonomy.
- Boring work.

FATIGUE:

Workers' fatigue is a significant problem in modern industry, largely because of high demand jobs, long duty periods, disruption of circadian rhythms, and accumulative sleep debt that are common in many industries.

Fatigue is the end result of integration of multiple factors such as time awake, time of day, and workload. Then, the full understanding of circadian biologic clock, dynamics of transient and cumulative sleep loss, and recovery is required for effective management of workplace fatigue. It can be more investigated in a new field of sleep medicine called occupational sleep medicine. Occupational sleep medicine is concerned with maintaining best productivity and safety in the industrial settings. The fatigue risk management system (FRMS) is a comprehensive approach that is based on applying scientific evidence of sleep knowledge to manage workers fatigue. It is developing rapidly in the highly safety demand jobs; especially truck drivers, pilots, and power plant workers. The objective of this review is to explain about fatigue in the workplace with emphasis on its association work performance and errors/accidents. Also, we discussed about different methods of fatigue measurement and management.

Safety And The Physical Environment

: Ensuring a clean, safe, and healthy environment can help to promote physical, social, and emotional health throughout a community. Physical environment refers to the level of upkeep, ambient noise, lighting, indoor air quality and/or thermal comfort of the school's physical building and its location within the community**.**

HSE management is responsible for planning, implementing, monitoring and optimising operational processes in the areas of environmental management, health protection and occupational safety.

General categories

- **Environmental**. 1.1 Air emissions and ambient air quality. 1.2 Energy conservation.
- Occupational **health and safety**. 2.1 General facility design and operation. 2.2 Communication
- and training. ...

- Community **health and safety**. 3.1 Water quality and availability. ...
- Construction and decommissioning.

Engineering methods of controlling chemical hazards:

Hazardous chemicals present a number of risks upon the people in the workplace. To help mitigate theserisks, the hazards associated with dangerous substances must be controlled in a professional

Controlling the risk associated with hazardous chemicals is one part of the four phases of the methodology that is used to manage the risks of hazardous chemicals in the workplace.

STOREMASTA methodology for managing risk:

The way that this methodology can be used to manage hazardous chemicals in the workplace is that you must first identify and assess their potential risks. This must be done before any controls are implemented to mitigate the risks associated with hazardous chemicals.

Identifying risk is a process that involves identifying situations involving hazardous chemicals that could potentially harm people.

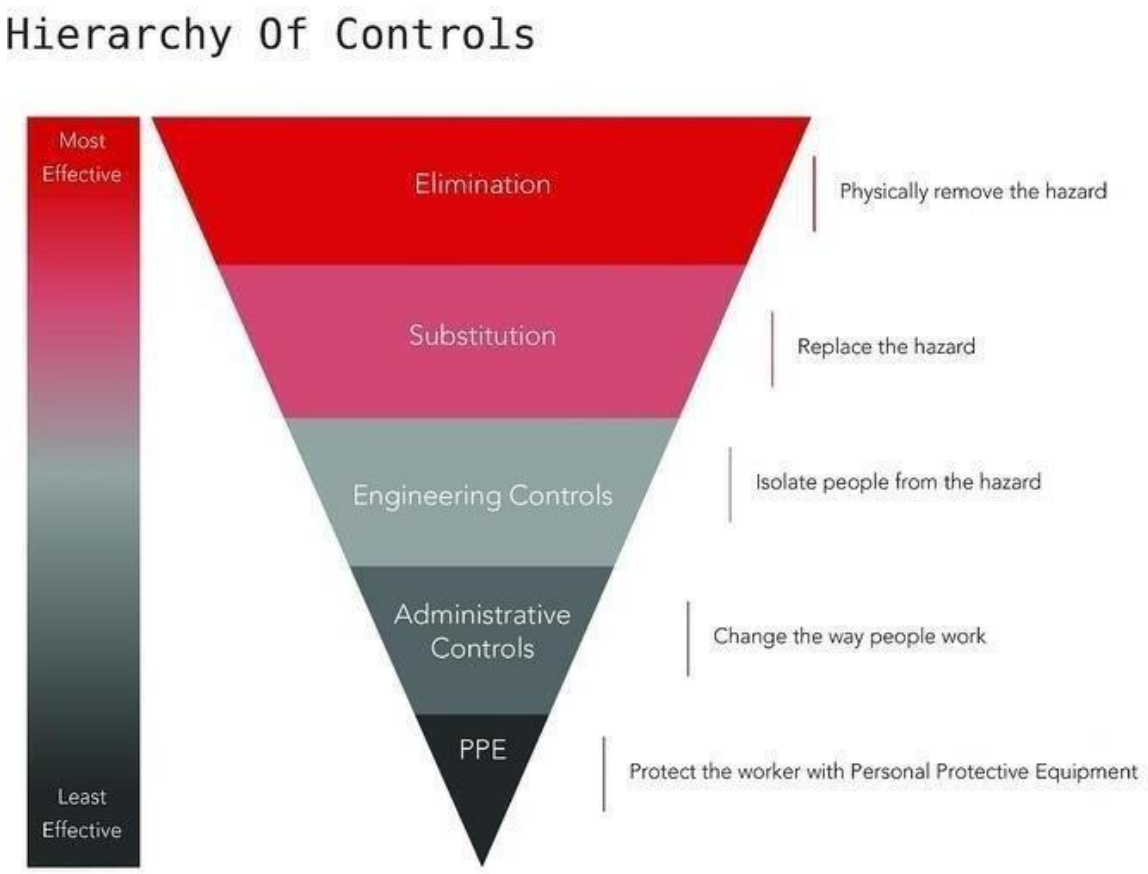
Once the potential risks associated with hazardous chemicals have been identified, the risk must be assessed. Assessing risk allows you to evaluate what would happen if someone was exposed to hazardous chemicals. A risk assessment will allow you to calculate the magnitude of the risk by determining the severity and likelihood of an incident occurring.

Once you have identified and assessed the severity of the risks, you will have valuable data that will allow you to determine the best methods that should be used to control the risk.

We will now go into more detail on how to control the risk associated with hazardous chemicals. Controlling the risks associated with hazardous chemicals must be done by following the hierarchy of controls.

How to control the risk of hazardous chemicals

As outlined above, managing the risks associated with hazardous chemicals has four distinct phases. The third phase of this process is to implement controls to reduce the risks associated with hazardous chemicals. When you are considering what controls to use to reduce the risk associated with hazardous chemicals, you must follow the hierarchy of controls.



Elimination

The risk control measure that has the greatest level of effectiveness is elimination. Before any other control measures are considered, elimination must be applied first. Elimination is the method of totally removing a hazard or hazardous practice from the workplace. Some examples of eliminating the use ofa hazardous chemical in the workplace include:

- Eliminating the use of chemical adhesive by using fasteners such as screws or nails.
- Eliminating the use of flammable forklift gas by using electric power forklifts instead of LPG powered forklifts.

Isolation

If it's not possible to substitute the use of a hazardous chemical with another chemical that is less hazardous, you must then isolate the hazardous chemical from people and other incompatible substances. This can be done in a number of ways. For example; if one part of a manufacturing process involves the use of a hazardous chemical, you could build a ventilated enclosure over this part of the manufacturing process. This enclosure would stop the airborne contaminants from this area moving into other areas of the manufacturing facility where people are present. The airborne contaminants that are generated inside this enclosure should be vented to the outside atmosphere in a safe location where people don't congregate.

If large quantities of hazardous chemicals are stored in the workplace, you could isolate these hazardous chemicals from people by storing them outdoors in a compliant chemical storage container. Isolating hazardous chemicals from people by storing them outdoors reduces the risk of harm to people in the event of a workplace fire or chemical spill.

Hazardous substances must also be isolated from other incompatible substances. If incompatible substances mix, it can result in violent chemical reactions that can harm people and property. Incompatible hazardous substances can be isolated by storing them in separate chemical storage cabinets and dangerous goods storage containers.

Engineering Controls

If isolation cannot be achieved, you can implement a number of engineering controls to reduce the risk associated with hazardous chemicals. Engineering controls are physical in nature and are devices or processes that eliminate exposure to hazardous chemicals. Engineering controls can be used to:

- Minimise the generation of hazardous chemicals
- Suppress or contain chemicals
- Limit the area of contamination in the event of spills

Engineering controls can include devices such as mechanical ventilation systems, compliant chemicalstorage containers or the automation of processes involving the use of hazardous chemicals.

Methods for Industrial Noise Control:

Noise attenuation is achieved by decreasing the intensity or volume of sound in a controlled environment. There are many noise reduction strategies that can be employed in industrial settings. One of the most effective and logical approaches to noise attenuation is to install systems that minimize noise from the start, using control techniques such as:

- Damping – A method of reducing noise levels from chutes, hoppers, machine guards, conveyors,panels and more
- Selecting efficient equipment – Selecting fans, compressors, PD blowers and engines that operateefficiently contribute significantly to noise attenuation
- Adjusting Fan Speed – Fan noise is in direct correlation with fan speed, so simple adjustments canproduce significant results
- Controlling high-pressure steam, natural gas, and other vent noises
- Attenuating noise from process exhausts with stack silencers
- Acoustically treating fans, blowers, and ventilating equipment
- Closing openings in enclosures and barrier walls required for utilities

Industrial Noise Control Products and Systems:

The environmental impact caused by industrial processes such as vent blow-offs, rooftop fans and

HVAC equipment, chillers, cooling towers, oil and gas building ventilation systems, power gen engines, and other noise generating processes can be addressed by installing various types of noise abatement equipment. We partner with the leading manufacturers of industrial noise control products and systems to offer a broad range of reliable industrial noise control solutions.

Industrial Fan Silencers :Fans are found in almost all industrial applications and can be large contributors to the problem of industrial noise. Exhaust and supply fan silencers can significantly reduce noise in both indoor and outdoor environments.

Acoustic Louvers :Where ventilation air is required, addressing noise concerns from a processing area within a building or machinery noise mitigation from a facility, acoustic louvers are a provenmeans of attenuation.

Industrial Exhaust Silencers :In addition to selecting the right noise control equipment, SysTech will access the entire noise attenuation application and reduce the overall sound level. Process silencers are applied to PD blower and compressor exhausts, stack discharges, and the venting or blow-off of high-pressure gases.

Noise Control Enclosures: Engineered acoustically for superior noise control, sound enclosures are an extremely effective means for containing industrial equipment noise.

Duct Silencer – Where a noise sound radiates from a ducted system or enclosure, duct silencers are typically applied with success.

Acoustic Building Ventilation Systems: When very high equipment noise levels are present in a building caused by large compressors, engines, generators, and motors, and heat removal ventilation systems are required, SysTech offers customized acoustic ventilation systems to meet both ventilation and noise reduction requirements.

Duct Lining : Ventilation systems using acoustic absorbent material such as foam or fiberglass will effectively decrease airborne noise.

Vibration Isolation Pads – Vibration control, employing anti-vibration machine mounts such as springs or neoprene will reduce transmission of noise created by vibration.

Acoustic Flexible Connectors:They serve a dual purpose in containing noise generated by the fan blade rotation and that induced by vibration.

Code and regulations for worker safety and health:

The Occupational Safety, Health and Working Conditions Code, 2019 was introduced in Lok Sabha by the Minister of Labour and Employment, Mr. Santosh Kumar Gangwar, on July 23, 2019. Following this, it was referred to the Standing Committee on Labour and Employment, on October 9, 2019. The Code seeks to regulate health and safety conditions of workers in establishments with 10 or more workers, and in all mines and docks. It subsumes and replaces 13 existing labour laws relating to safety, health and working conditions.

The Occupational Safety, Health And Working Conditions Code, 2020 is a code to consolidate and amend the laws regulating the Occupational safety and health and working conditions of the persons employed in an establishment. The Act replaces 13 old central labour laws.

The bill was passed by the Lok Sabha on 22 September 2020, and the Rajya Sabha on 23 September 2020.The bill received the presidential assent on 28 September 2020, but the date of coming into force is yet to be notified in the official gazette.

The bill was formulated according to the Report and Recommendations of the Second National Commission on Labour.

It amalgamated The Factories Act, 1948, The Plantations Labour Act, 1951, The Mines Act, 1952, The Working Journalists and other Newspaper Employees (Conditions of Service and Miscellaneous Provisions) Act, 1955, The Working Journalists (Fixation of Rates of Wages) Act, 1958, The Motor Transport Workers Act, 1961, The Beedi and Cigar Workers (Conditions of Employment) Act, 1966, The Contract Labour (Regulation and Abolition) Act, 1970, The Sales Promotion Employees (Condition of Service) Act, 1976, The Inter-State Migrant workmen (Regulation of Employment and Conditions of Service) Act, 1979, The Cine Workers and Cinema Theatre Workers Act, 1981, The Dock Workers (Safety, Health and Welfare) Act, 1986 and The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996.

UNIT IV

PRINCIPLES AND PRACTICEES OF MAINTENANCE PLANNING

Maintenance Engineering:

Introduction

Maintenance Engineering is the discipline and profession of applying engineering concepts to the optimization of equipment, procedures, and departmental budgets to achieve better maintainability, reliability, and availability of equipment.Maintenance engineering is the occupation that uses engineering theories and practices to plan and implement routine maintenance of equipment and machinery.

This must be done in conjunction with optimizing operating procedures and budgets to attain and sustain the highest levels of reliability and profit.Maintenance engineers are often required to have knowledge of many types of equipment and machinery.A person working in the field of maintenance engineering must have in-depth knowledge of or experience in basic equipment operation, logistics, probability, and statistics.

Experience in the operation and maintenance of machinery specific to a company's particular business is also frequently required.Since the position normally requires oral and written communications with various levels of personnel, excellent interpersonal communication and participatory management skills are also desirable.Maintenance engineering positions require planning and implementing routine and preventive maintenance programs.

In addition, regular monitoring of equipment is required to visually detect faults and impending equipment or production failures before they occur.These positions may also require observing and overseeing repairs and maintenance performed by outside vendors and contractors.

In a production or manufacturing environment, good maintenance engineering is necessary for smooth and safe daily plant operations.Maintenance engineers not only monitor the existing systems and equipment, they also recommend improved systems and help decide when systems are outdated and in need of replacement.

Such a position often involves exchanging ideas and information with other maintenance engineers, production managers, and manufacturing systems engineers.Maintenance engineering not only requires engineers to monitor large production machine operations and heavy duty equipment, but also often requires involvement with computer operations.

Maintenance engineers may have to deal with everything from PCs, routers, servers, and software to more complex issues like local and off-site networks, configuration systems, end user support, and scheduled upgrades. Supervision of technical personnel may also be required.

Good maintenance engineering is vital to the success of any manufacturing or processing operation, regardless of size.The maintenance engineer is responsible for the efficiency of daily operations and for discovering and solving any operational problems in the plant.

A company's success may depend on a **quality maintenance engineering department** that can be depended upon to discover systematic flaws and recommend solid, practical solutions.

MAINTENANCE MANAGER

If you choose to take an entry-level position in order to become a facilities **maintenancemanager**, you can expect to spend several years working **maintenance** positions as you learn the skills necessary to become a **manager**.

Larger employers with greater **maintenance** needs generally look for a facilities **maintenancemanager** who can perform these tasks when needed, but is more focused on managing an in-house staff responsible for the majority of the actual work.

MAINTENANCE ENGINEERING JOBS

- Typically, **maintenance** engineers need to possess knowledge of the principles of building or mechanical **engineering**. **Maintenance** engineer **jobs** generally require the person to maintain the plant or manage a crew who maintains it.

- They also set schedules, hand out paychecks, assign **job** duties, and monitor daily progress. Most construction **engineeringjobs** require at least a bachelor's degree in civil **engineering** or project management.

DEFINITION OF MAINTENANCE

Maintenance is the routine and recurring process of keeping a particular machine or asset in its normal operating conditions.So that it can deliver the expected performance or service without any loss or damage. Or

Maintenance is defined as

- All actions necessary for retaining an item, or restoring to it, a serviceable condition, include servicing, repair, modification, overhaul, inspection and condition verification
- Increase availability of a system
- Keep system's equipment in working order

Purpose of Maintenance

- Attempt to maximize performance of production equipment efficiently and regularly
- Prevent breakdown or failures
- Minimize production loss from failures
- Increase reliability of the operating systems

Principle Objectives in Maintenance

- To achieve product quality and customer satisfaction through adjusted and serviced equipment
- Maximize useful life of equipment
- Keep equipment safe and prevent safety hazards
- Minimize frequency and severity of interruptions
- Maximize production capacity – through high utilization of facility

Problems in Maintenance

- Lack of management attention to maintenance
- Little participation by accounting in analyzing and reporting costs
- Difficulties in applying quantitative analysis
- Difficulties in obtaining time and cost estimates for maintenance works

Problems Exist Due To:

- Failure to develop written objectives and policy
- Inadequate budgetary control
- Inadequate control procedures for work order, service requests etc.
- Infrequent use of standards
- To control maintenance work
- Absence of cost reports to aid maintenance planning and control system

Maintenance Costs

- Cost to replace or repair
- Losses of output
- Delayed shipment
- Scrap and rework

Basic Principles of maintenance planning

Effective planning and scheduling contribute significantly to the following:

- Reduced maintenance cost.
- Improved utilization of the maintenance workforce by reducing delays and interruptions.
- Improved quality of maintenance work by adopting the best methods and procedures and assigning the most qualified workers for the job.

Planning Objectives

- Minimizing the idle time of maintenance workers.
- Maximizing the efficient use of work time, material, and equipment.
- Maintaining the operating equipment at a responsive level to the need of production in terms of delivery schedule and quality.

Classification of Maintenance Work According to Planning Purposes

- Routine maintenance: are maintenance operations of a periodic nature. They are planned and scheduled and in advance. They are covered by blanket orders.
- Emergency or breakdown maintenance: interrupt maintenance schedules in order to be performed. They are planned and scheduled as they happened.

- Design modifications: are planned and scheduled and they depend on eliminating the cause of repeated breakdowns.
- Scheduled overhaul and shutdowns of the plant: planned and scheduled in advanced.
- Overhaul, general repairs, and replacement: planned and scheduled in advanced.
- Preventive maintenance: planned and scheduled in advanced.
- An essential part of planning and scheduling is to forecast future work and to balance the workload between these categories.
- The maintenance management system should aim to have over 90% of the maintenance work planned and scheduled.

Planning Procedures

- Determine the job content.
- Develop work plan. This entails the sequence of the activities in the job and establishing the best methods and procedures to accomplish the job.
    - Establish crew size for the job.
    - Plan and order parts and material.
    - Check if special tools and equipment are needed and obtain them.
    - Assign workers with appropriate skills.
    - Review safety procedures.
    - Set priorities for all maintenance work.
    - Assign cost accounts.
    - Complete the work order.
    - Review the backlog and develop plans for controlling it.
    - Predict the maintenance load using effective forecasting technique.

Basic Levels of Planning Process (Depend on The Planning Horizon)

1. Long-rang planning: it covers a period of 3 to 5 years and sets plans for future activities and long-range improvement.
2. Medium-range planning: it covers a period of 1 month to 1 year.
3. Short-rang planning: it covers a period of 1 day to 1 week. It focuses on the determination of all the elements required to perform maintenance tasks in advance.

Long Range Planning

Needs to utilize the following:

1. Sound forecasting techniques to estimate the maintenance load.
2. Reliable job standards times to estimate staffing requirements.
3. Aggregate planning tools such as linear programming to determine resource requirement.

Medium-Range Planning

- Specify how the maintenance workers will operate.
- Provide details of major overhauls, construction jobs, preventive maintenance plans, and plant shutdowns.
- Balances the need for staffing over the period covered.
- Estimates required spare parts and material acquisition.

Assessing required maintenance tools and skills required for efficient maintenance of

Short-Range

It focuses on the determination of all the elements required to perform maintenance tasks in advance.

Objectives and Principles of Planned Maintenance Activity

Analysis of repetitive equipment failures.
Estimation of maintenance costs and evaluation of alternatives. Forecasting of spare parts.
Assessing the needs for equipment replacements and establish replacement programs when due application of scheduling and project management principles to replacement programs, equipment.
Assessing required skills required for maintenance personnel.

Reviewing personnel transfers to and from maintenance organizations assessing and reporting safety hazards associated with maintenance of equipment.

Importance and benefits of sound Maintenance systems

Minimization of down time Life of equipment Safety and smooth operation Backup Supply Reliability Working environment profit

Maintenance organization

- Organizing is the process of arranging resources (people, materials, technology etc.) together to achieve the organization's strategies and goals.

- The way in which the various parts of an organization are formally arranged is referred to as the organization structure.

- It is a system involving the interaction of inputs and outputs.

- However, there is no universally accepted methodology for designing maintenance systems, *i.e.,* no fully structured approach leading to an optimal maintenance system (*i.e.,* organizational structure with a defined hierarchy of authority and span of control; defined maintenance procedures and policies, *etc.*).Identical product organizations, but different in technology advancement and production size, may apply different maintenance systems and the different systems may run successfully.

- So, maintenance systems are designed using experience and judgment supported by a number of formal decision tools and techniques.

- Maintenance managers must have the capabilities to create a division of labor for maintenance tasks to be performed and then coordinate results to achieve a common purpose.
- Solving performance problems and capitalizing on opportunities could be attained through selection of the right persons, with the appropriate capabilities, supported by continuous training and good incentive schemes, in order to achieve organization success in terms of performance effectiveness and efficiency
-

Maintenance Organization Objectives and Responsibility

A maintenance organization and its position in the plant/whole organization is heavily impacted by thefollowing elements or factors:

- Type of business, *e.g.,* whether it is high tech, labor intensive, production or service;
- Objectives: may include profit maximization, increasing market share and other social objectives;
- Size and structure of the organization;
- Culture of the organization; and
- Range of responsibility assigned to maintenance.

Organizations seek one or several of the following objectives: profit maximization, specific quality level of service or products, minimizing costs, safe and clean environment, or human resource development

1. Keeping assets and equipment in good condition, well configured and safe to perform their intended functions;
2. Perform all maintenance activities including preventive, predictive;
   ` corrective, overhauls, design modification and emergency maintenance in an efficient and effective manner;
3. Conserve and control the use of spare parts and material;
4. Commission new plants and plant expansions; and
5. Operate utilities and conserve energy.

The above responsibilities and objectives impact the organization structure for maintenance as will be shown in the coming sections.

Determinants of a Maintenance Organization

The maintenance organization's structure is determined after planning the maintenance capacity. The maintenance capacity is heavily influenced by the level of centralization or decentralization adopted. In this section the main issues that must be addressed when forming the maintenance organization's structure are presented. The issues are: capacity planning, centralization *vs* decentralization and in-house *vs* outsourcing.

Maintenance Capacity Planning

Maintenance capacity planning determines the required resources for maintenance including the required crafts, administration, equipment, tools and space to execute the maintenance load efficiently and meet the objectives of the maintenance department. Critical aspects of maintenance capacity are the numbers and skills of craftsmen required to execute the maintenance load. It is difficult to determine the exact number of various types of craftsmen, since the maintenance load is uncertain. Therefore accurate forecasts for the future maintenance work demand are essential for determining the maintenance capacity. In order to have better utilization of manpower, organizations tend to reduce the number of available craftsmen below their expected need. This is likely to result in a backlog of uncompleted maintenance work. Maintenance Organization 7

Centralization vs *Decentralization*

The decision to organize maintenance in a centralized, decentralized or a hybrid form depends to a greater extent on the organization is philosophy, maintenance load, size of the plant and skills of craftsmen. The advantages of centralization are:

1. Provides more flexibility and improves utilization of resources such highly skilled.

and special equipment and therefore results in more efficiency;

2. Allows more efficient line supervision;
3. Allows more effective on the job training; and
4. Permits the purchasing of modern equipment.

Disadvantages:

1. Less utilization of crafts since more time is required for getting to and from jobs;
2. Supervision of crafts becomes more difficult and as such less maintenance control is achieved;
3. Less specialization on complex hardware is achieved since different persons work on the same hardware; and
4. More costs of transportation are incurred due to remoteness of some of the maintenance work.

In a decentralized maintenance organization, departments are assigned to specific areas or units. This tends to reduce the flexibility of the maintenance system as a whole. The range of skills available becomes reduced and manpower utilization is usually less efficient than in a centralized maintenance. In some cases a compromise solution that combines centralization and decentralization is better. This type of hybrid is called a cascade system. The cascade system organizes maintenance in areas and whatever exceeds the capacity of each area is challenged to a centralized unit. In this fashion the advantages of both systems may be reaped.

In-house vs *Outsourcing*

At this level management considers the sources for building the maintenance capacity. The main sources or options available are in-house by direct hiring, outsourcing, or a combination of in-house and outsourcing. The criteria for selecting sources for building and maintaining maintenance capacity include strategic considerations, technological and economic factors. The following are criteria that can be employed to select among sources for maintenance capacity:

1. Availability and dependability of the source on a long term basis;
2. Capability of the source to achieve the objectives set for maintenance by the organization and its ability to carry out the maintenance tasks;
3. Short term and long term costs;
4. Organizational secrecy in some cases may be subjected to leakage;
5. Long term impact on maintenance personnel expertise; and
6. Special agreement by manufacturer or regulatory bodies that set certain specifications for maintenance and environmental emissions.

Examples of maintenance tasks which could be outsourced are:

Work for which the skill of specialists is required on a routine basis and which is readilyavailable in the market on a competitive basis, *e.g.,*:

Installation and periodic inspection and repair of automatic fire sprinkler systems;

Inspection and repair of air conditioning systems;

Inspection and repair of heating systems; and

Inspection and repair of main frame computers *etc.*

When it is cheaper than recruiting your own staff and accessible at a short notice of time.

The issues and criteria presented in the above section may help organizations in designing or re- designing their maintenance organization.

Design of the Maintenance Organization

A maintenance organization is subjected to frequent changes due to uncertainty and desire for excellence in maintenance. Maintenance and plant managers are always swinging from supporters of centralized maintenance to decentralized ones, and back again. The result of this frequent change is the creation of responsibility channels and direction of the new organization's accomplishments *vs* the accomplishments of the former structure. So, the craftsmen have to adjust to the new roles. To establish a maintenance organization an objective method that caters for factors that influence the effectiveness of the organization is needed. Competencies and continuous improvement should be the driving considerations behind an organization's design and re-design.

Criteria to Assess Organizational Effectiveness

Rather than designing the organization to solve a specific problem, it is more important to establish a set of criteria to identify an effective organization. The following could be considered as the most importantcriteria:

1. Roles and responsibilities are clearly defined and assigned;
2. The organization puts maintenance in the right place in the organization;
3. Flow of information is both from top-down and bottom-up;
4. Span of control is effective and supported with well trained personal;
5. Maintenance work is effectively controlled;
6. Continuous improvement is built in the structure;
7. Maintenance costs are minimized; and
8. Motivation and organization culture.

Basic Types of Organizational Models

To provide consistently the capabilities listed above we have to consider three types of organizational designs.

- Entralized maintenance. All crafts and related maintenance functions report to a central maintenance manager as depicted in Figure 1.2. The strengths of this structure are: allows economies of scale; enables in-depth skill development; and enables departments (*i.e.,* a maintenance department) to accomplish their functional goals (not the overall organizational goals). This structure is best suited for small to

  medium- size organizations. The weaknesses of this structure are: it has slow response time to environmental changes; may cause delays in decision making and hence longer response time; leads to poor horizontal coordination among departments and involves a restricted view of organizational goals.

  Decentralized maintenance. All crafts and maintenance craft support staff report to operations or area maintenance as described in Figure 1.3. The strengths of this structure are that it allows the organization to achieve adaptability and coordination in production units and efficiency.The production units or area maintenance and to a central maintenance function that supports the whole plant or organization. The strengths of this matrix structure are: it allows the organization to achieve coordination necessary to meet dual demands from the environment and flexible sharing of human resources. The weaknesses of this structure are: it causes maintenance employees to experience dual authority which can be frustrating and confusing; it is time consuming and requires frequent meetings and conflict resolution sessions. To remedy the weaknesses of this structure a management with good interpersonal skills and extensive training is required.

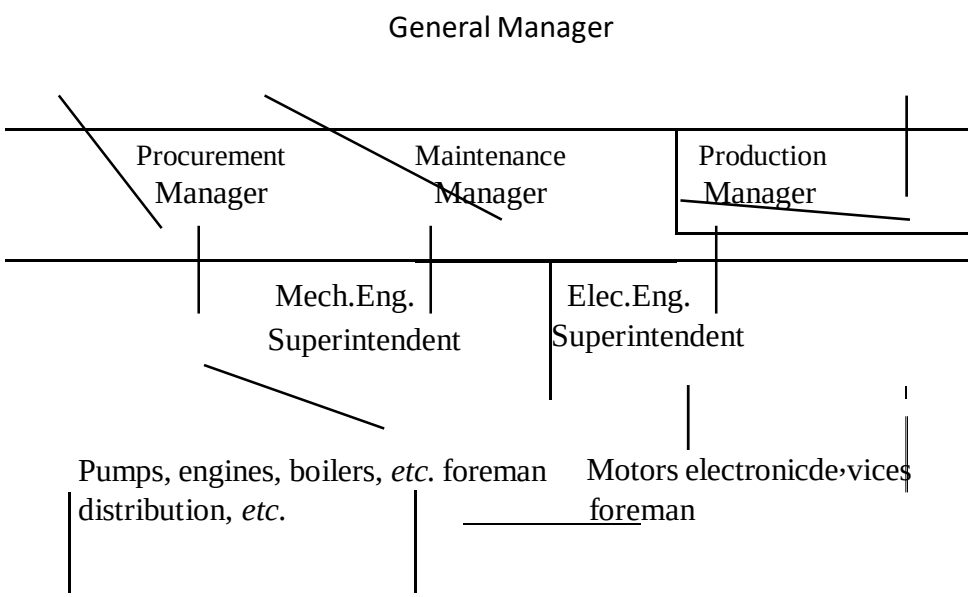


Figure 1.2. Centralized (functional) organizational structure

Material and Spare Parts Management

The responsibility of this unit is to ensure the availability of material and spare parts in the right qualityand quantity at the right time at the minimum cost. In large or medium size organizations this unit may be independent of the maintenance organization; however in many circumstances it is part of maintenance. It is a service that supports the maintenance programs. Its effectiveness depends to a largeextent on the standards maintained within the stores system. The duties of a material and spare parts unit include:

1. Develop in coordination with maintenance effective stocking polices to minimize ordering, holding and shortages costs;
2. Coordinate effectively with suppliers to maximize organization benefits;
3. Keep good inward, receiving, and safe keeping of all supplies;
4. Issue materials and supplies;
5. Maintain and update records; and

Establishment of Authority and Reporting

Overall administrative control usually rests with the maintenance department, with its head reporting to top management. This responsibility may be delegated within the maintenance establishment. The relationships and responsibility of each maintenance division/section must be clearly specified together with the reporting channels. Each job title must have a job description prescribing the qualifications and the experience needed for the job, in addition to the reporting channels for the job.

Quality of Leadership and Supervision

The organization, procedures, and practices instituted to regulate the maintenance activities and demands in an industrial undertaking are not in themselves a guarantee of satisfactory results. The senior executive and his staff must influence the whole functional activity. Maintenance performance can never rise above the quality of its leadership and supervision. From good leadership stems the team- work which is the essence of success in any enterprise. Talent and ability must be recognized and fostered; good work must be noticed and commended; and carelessness must be exposed and addressed.

Incentives

The varied nature of the maintenance tasks, and differing needs and conditions arising, together with theinfluence of production activity, are not attuned to the adoption of incentive systems of payment. There are, however, some directions in which incentives applications can be usefully considered. One obviouscase is that of repetitive work.

The forward planning of maintenance work can sometimes lead to an incentive payment arrangement, based on the completion of known tasks in a given period, but care must be taken to ensure that the required standards of work are not compromised. In some case, maintenance incentives can be includedin output bonus schemes, by arranging that continuity of production, and attainment of targets, providesrewards to both production and maintenance personnel.

Education and Training

Nowadays it is also recognized that the employers should not only select and place personnel, but should promote schemes and provide facilities for their further education and training, so as to increase individual proficiency, and provide recruits for the supervisory and senior grades. For senior staff, refresher courses comprise lectures on specific aspects of their work; they also encourage the interchange of ideas and discussion.

The further education of technical grades, craft workers, and apprentices is usually achieved through joint schemes, sponsored by employers in conjunction with the local education authority. Employees should be encouraged to take advantage of these schemes, to improve proficiency and promotion prospects.

A normal trade background is often inadequate to cope with the continuing developments in technology.The increasing complexity and importance of maintenance engineering warrants a marked increase in training of machine operators and maintenance craftsmen through formal school courses, reinforced by informed instruction by experienced supervisors.

The organization must have a well defined training program for each employee. The following provides guidelinesfor developing and assessing the effectiveness of the training program:

- Evaluate current personnel performance;
- Assess training need analysis;
- Design the training program;
- Implement the program; and
- Evaluate the program effectiveness.

The evaluation is done either through a certification program or by assessing the ability to achieve desired performance by persons who have taken a particular training program.
The implementation of the above five steps provides the organization with a framework to motivatepersonnel and improve performance.

Management and Labor Relations

The success of an undertaking depends significantly on the care taken to form a community of well-informed, keen, and lively people working harmoniously together. Participation creates satisfaction and the necessary team spirit. In modern industry, quality of work life (QWL) programs have been applied with considerable success, in the form of management conferences, work councils, quality circles, and joint conferences identified with the activities. The joint activities help the organization more fully achieve its purposes.

Summary

This chapter considered organizing as one of the four functions of management. It is the process of arranging resources (people, materials, technology, *etc.*) together to achieve the organization's strategies and goals. Maintenance organization structure is the way various part of the maintenance organization is formed including defining responsibilities and roles of units and individuals. A set of criteria are provided to assess and design organization structures and the main issues to be addressed are outlined. The issues include centralization, decentralization and outsourcing. The chapter describes three types of organization structures. In addition, several functions that could support maintenance organization such as material and spare management, training and the management of labor relations are presented.

Maintenance economics.

Life cycle cost analysis

Life-cycle cost analysis (LCCA) is a tool to determine the most cost-effective option among different competing alternatives to purchase, own, operate, maintain and, finally, dispose of an object or process, when each is equally appropriate to be implemented on technical grounds. For example, for a highway pavement, in addition to the initial construction cost, LCCA takes into account all the user costs, (e.g., reduced capacity at work zones), and agency costs related to future activities, including future periodic maintenance and rehabilitation. All the costs are usually discounted and total to a present day value known as net present value (NPV). This example can be generalized on any type of material, product, or system. In order to perform a LCCA scoping is critical - what aspects are to be included and what not? If the scopebecomes too large the tool may become impractical to use and of limited ability to help in decision-makingand consideration of alternatives; if the scope is too small then the results may be skewed by the choice offactors considered such that the output becomes unreliable or partisan. Usually the LCCA term implies that energy and environmental costs are included, whereas the similar Whole Life Costing generally has areduced scope.

Estimation of economic life of equipment

Consider an investment in a machine with an initial purchase price of $1000. The yearly operating costs and salvage value of the machine depend on its age as shown in the table below. We anticipate requiring the use of the machine far into the future. Given that the salvage value is decreasing and operating costs are increasing, there must be some optimal time to replace it. The optimal replacement time is called the economic life of the machine.

Investment analysis recognizes that money spent or earned in the future has less value when viewed from the present. This is called the time value of money principle. We compute the present value of an amount cn received n years from now as

$P = cn/(1 + i)n$ The quantity i is a percentage expressed as a decimal, and is variously called the interest rate, discount rate, or minimum acceptable rate of return. The term $1/(1 + i)n$, is the discount factor. When i is a positive quantity the discount factor is less than 1.

"Maintenance costs"

One universal measurement of maintenance performance, and perhaps the measure that matters most in the end, is the cost of maintenance. Unfortunately maintenance costs are often used to compare maintenance performance between companies or between plants within the same company. Equally unfortunately, there is no standard for measuring maintenance costs. Each company, usually each plant within a company and often each department within a plant develop their own definition of "maintenance costs."

For this reason, maintenance cost comparisons should always be accompanied by a clear definition of what is included and excluded for each plant included in the comparison.
If you are in the process of defining maintenance costs, or believe that your definition needs updating, the following table may be of help.

Reliability Program Plan may also be used to evaluate and improve Availabilityof a system by the strategy on focusing on increasing testability & maintainability and not on reliability.

Improving maintainability is generally easier than reliability. Maintainability estimates

(Repair rates) are also generally more accurate. However, because the uncertainties

in thereliability estimates are in most cases very large, it is likely to dominate the

availability (prediction uncertainty) problem; even in the case maintainability

levels are very high.When reliability is not under control more complicated issues

may arise, like manpower (maintainers / customer service capability) shortage,

spare part availability, logistic delays, lack of repair facilities, extensive retro-fit

and complex configuration management costs and others.

The problem of unreliability may be increased also due to the "**Domino effect**" of maintenance

induced failures after repairs.Only focusing on maintainability is therefore not enough.

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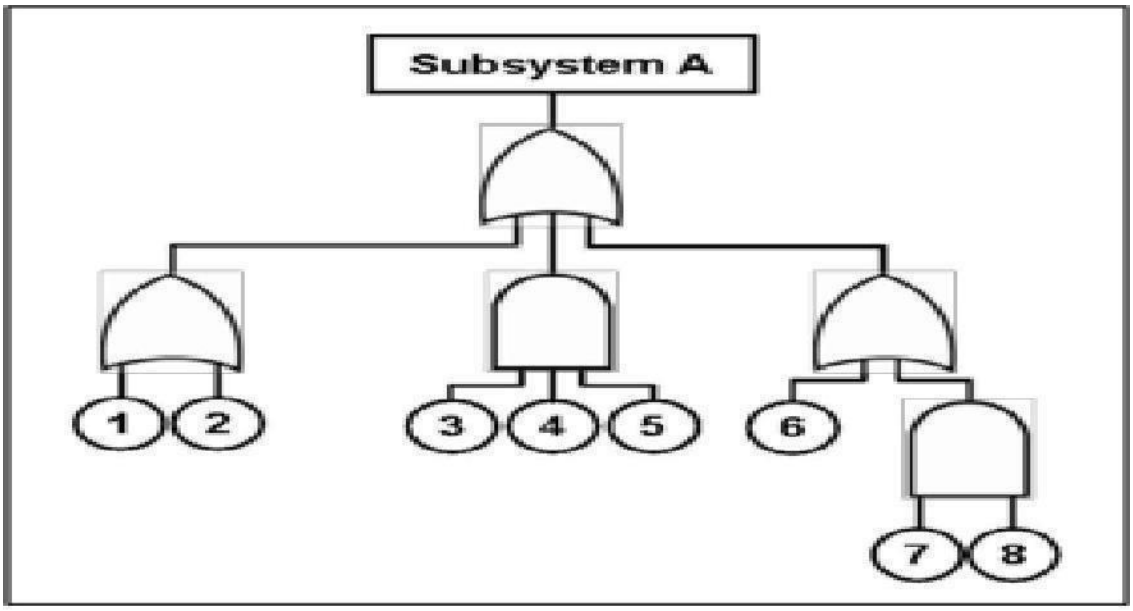


A Fault Tree Diagram

One of the most important design techniques is redundancy.

RELIABILITY THEORY

Reliability is defined as the probability that a device will perform its intended function during a specified period of time under stated conditions. Mathematically, this may be expressed as,

ACCELERATED TESTING:

The purpose of accelerated life testing is to induce field failure in the laboratory at a much faster rate by providing a harsher, but nonetheless representative, environment.In such a test, the product is expected to fail in the lab just as it would have failed in the field—but in much less time.The main objective of an accelerated test is either of the following:

To discover failure modes.

To predict the normal field life from the high stress lab life

An Accelerated testing program can be broken down into the following steps:

Software reliability is a special aspect of reliability engineering. System reliability, by definition, includes all parts of the system, including hardware, software, supporting infrastructure (including critical external interfaces), operators and procedures. Traditionally, reliability engineering focuses on critical hardware parts of the system. Since the widespread use of digital integrated circuit technology, software has become

an increasingly critical part of most electronics and, hence, nearly all present day systems.

Despite this difference in the source of failure between software and hardware, several software reliability models based on statistics have been proposed to quantify what we experience with software: the longer software is run, the higher the probability that it will eventually be used in an untested manner and exhibit a latent defect that results in a failure (Shooman 1987), (Musa 2005), (Denney 2005).

As with hardware, software reliability depends on good requirements, design and implementation. Software reliability engineering relies heavily on a disciplined software engineering process to anticipate and design against unintended consequences. There is more overlap between software quality engineering and software reliability engineering than between hardware quality and reliability. A good software development plan is a key aspect of the software reliability program. The software development plan describes the design and coding standards, peer reviews, unit tests, configuration management, software metrics and software models to be used during softwaredevelopment.

Define objective and scope of the test Collect required information about the product Identify the stress(es) Determinelevel of stress(es)

Conduct the accelerated test and analyze the collected data.

MEAN TIME BETWEEN FAILURES

Mean time between failures (MTBF) is the predicted elapsed time between inherent failures of a system during operation. [1] MTBF can be calculated as the arithmeticmean

(average) time between failures of a system.

FORMAL DEFINITION OF MTBF

By referring to the figure above, the MTBF is the sum of the operational periods dividedby the number of observed failures.

If the "Down time" (with space) refers to the start of "downtime" (without space) and "up time" (with space) refers to the start of "uptime" (without spMean time betMean time between failuresween failuresace), the formula will be:

$$\text{Mean time between failures} = \text{MTBF} = \frac{\sum(\text{start of downtime} - \text{start of uptime})}{\text{number of failures}}.$$

The MTBF is often denoted by the Greek letter θ, or

$$\text{MTBF} = \theta.$$

The MTBF can be defined in terms of the expected value of the density function *f*(t)

$$\text{MTBF} = \int_0^\infty t f(t)\, dt$$

where *f* is the density function of time until failure – satisfying the standard requirement ofdensity functions –

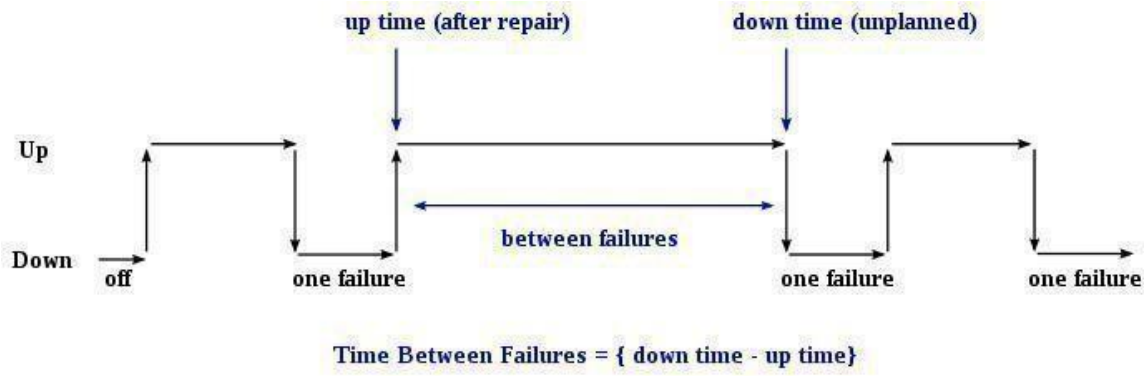
$$\int_0^\infty f(t)\, dt = 1.$$

The OverviewFor each observation, downtime is the instantaneous time it went down, which is after (i.e. greater than) the moment it went up, uptime. The difference (downtime minusuptime) is the amount of time it was operating between these two events.

MTBF value prediction is an important element in the development of products. Reliability engineers / design engineers, often utilize Reliability Software to

calculate products' MTBF according to various methods/standards (MIL-HDBK-217F, Telcordia SR332, Siemens Norm, FIDES,UTE 80-810 (RDF2000), etc.).

However, these "prediction" methods are not intended to reflect fielded MTBF as is commonly believed. The intent of these tools is to focus design efforts on the weak linksin the design



MTTR

MTTR is an abbreviation that has several different expansions, with greatly differing meanings.

It is wise to spell out exactly what is meant by the use of this abbreviation, rather than assuming the reader will know which is being assumed. The M can stand for any of minimum, mean or maximum, and the R can stand for any of recovery, repair, respond, or restore. The most common, mean, is also subject to interpretation, as there are many different ways in which a mean can be calculated.

Mean time to repair

Mean time to recovery/Mean time to restore Mean time to respond

Mean time to replace

In an engineering context with no explicit definition, the engineering figure of merit, mean time to repair would be the most probable intent by virtue of seniority of usage.It is also similar in meaning to the others above (more in the case of recovery, less in the case of respond, the latter being more properly styled mean "response

UNIT V

MAINTENANCE POLICIES AND PREVENTIVE MAINTENANCE

Maintenance categories:

What is maintenance?

Maintenance, in general, can be defined as efforts taken to keep the condition and performance of a machine always like the condition and performance of the machine when it is still new.

Maintenance activities can basically be divided into two parts: planned maintenance activities and unplanned maintenance activities.

Planned maintenance is maintenance that is organized and carried out with thought to the future, control and recording in accordance with the plans that have been determined previously.

The type of maintenance cannot be equated for each equipment, which depends on the method, cost and critical level. The following types of maintenance methods are commonly used in several industries.

1. Preventive Maintenance
2. Predictive Maintenance
3. Corrective Maintenance
4. Breakdown Maintenance

Preventive Maintenance:

It is a method for preventing damage to equipment by periodically replacing parts based on time of use and carrying out minor maintenance and inspections to find out the current state of the equipment / machinery.

Example: Cleaning, checking, lubricating, bolt tightening Periodic inspection Periodic and small over haul restorations

Predictive Maintenance:

Predictive maintenance is a method for doing maintenance by replacing parts based on predictions using a tool. The point is if the preventive method is only based on the schedule, then the predictive method is based on the results of the measurement.

This method can also use the five senses, for example in bearing inspection can be distinguished from the sound produced. Or checking temperature, by touching it we can feel the difference or abnormality of the equipment.

Examples: Tachometer, to measure the rotation of the Thermometer, to measure the temperature of the Ampermeter, to measure amperage

Corrective Maintenance:

It is a method intended to improve the reliability of equipment/machines by improvising. In addition to equipment, it is also intended for parts that have a short life cycle (reduce the frequency of damage) and speed up repair time.

In other words, this method is to extend MTBF (Mean Time Between Failure) and accelerate MTTR (Mean Time To Repair) because of its reliability (activity to prevent recurrence of damage) and maintenability (activity to speed up repair time).

Example: The operator has difficulty checking the oil volume of the generator engine, so improvisation is done by making a measuring cup equipped with a scale.

Breakdown Maintenance

It is a method where inspection and replacement of parts are not carried out, so with this method we leave the equipment damaged and then we fix it or replace it

Usually this method is applied to equipment / machines with consideration:

- Equipment is only optional (additional) so that if it is damaged it does not interfere with production
- The cost of repairing / replacing cheap parts
- Insignificant damage
- Easy and fast repair

Predictive Maintenance (PDM)

Up until recently when people spoke about Predictive Maintenance (PDM) this was essentially as a synonym for Condition Based Maintenance. But in my view with the advent of Artificial Intelligence, much lower costs of equipment sensors (IIoT) and machine learning there is clearly a difference appearing between Predictive Maintenance (PDM) and Condition Based Maintenance (CBM), at least in my view.

I see Predictive Maintenance as an extension, a more advanced approach to CBM where we use potentially many process parameters gained from online sensors to determine if our equipment is moving away from stable operating conditions and is heading towards failure.

There are a lot of (very large) companies actively moving into this space and it is certainly a fast-moving and exciting part of our discipline as Maintenance & Reliability professionals. However, I do still believe that even the most advanced Predictive Maintenance approaches need to be underpinned by sound reliability principles and understanding.

Corrective Maintenance (CM)

A Run to Failure or Corrective Maintenance strategy only restores the function of an item after it has been allowed to fail. It is based on the assumption that the failure is acceptable (i.e. no significant impact on safety or the environment) and preventing failure is either not economical or not possible.

Apart from being the outcome of a deliberate Run to Failure strategy Corrective Maintenance is also the result of unplanned failures which were not avoided through preventive maintenance.

A run to failure strategy can effectively be used for general area lighting, smart process instrumentation (without trip functionality) etc. where the consequence of failure is limited and would not necessitate a need for an urgent repair. When opting for corrective maintenance as a strategy it is essential to ensure that the failure modes under consideration do not have the potential to become Emergency Maintenance.

You see, if you adopt run-to-failure for equipment that once it has failed must be restored immediately to have doomed your organisation to a reactive maintenance environment. A reactive maintenance environment is not where you want to be. It is more expensive, less efficient, and less safe.

Preventive Maintenance

- Time Based Maintenance (TBM)
- Failure Finding Maintenance (FFM)
- Risk Based Maintenance (RBM)
- Condition Based Maintenance (CBM)
- Predictive

Maintenance (PDM)

Corrective Maintenance

(CM)

- Deferred Corrective Maintenance
- Emergency Maintenance (EM)

Preventive Maintenance

Preventive maintenance can be defined as *"an equipment maintenance strategy based on replacing, or restoring, an asset at a fixed interval regardless of its condition.* Scheduled restoration tasks and replacement tasks are examples of preventive maintenance tasks." 1

Preventive maintenance (or preventative maintenance) is basically a type of maintenance that is done at a regular interval while the equipment is still functioning with the objective of preventing failure or reducing the likelihood of failure.

Preventive maintenance can be time based i.e. every week, every month or every three months. But preventive maintenance can also be based on usage e.g. every 150 cycles, every 10,000hrs or like your car: service every 10,000km.

Apart from the regular interval approach (time based maintenance) there are also other types of maintenance that fall within the category of preventive maintenance:

- Time Based Maintenance (TBM)
- Failure Finding Maintenance (FFM)
- Risk Based Maintenance (RBM)
- Condition Based Maintenance (CBM)
- Predictive Maintenance (PDM)

Time-Based Maintenance (TBM)

Time-Based Maintenance refers to replacing or renewing an item to restore its reliability at a fixed time, interval or usage regardless of its condition. This is what Moubray calls Scheduled Restoration or Scheduled Discard tasks in his RCMII book.

I limit the use of that phrase as for some reason people then jump to the conclusion that another maintenance is not scheduled. When in fact, of course, all maintenance should be scheduled through our Weekly Schedule. The only exception would be Emergency Maintenance, which due to its very nature of requiring immediate attention cannot be scheduled.

The purpose of Time Based Maintenance is to protect yourself against the failure of known wearing

parts which have predictable Mean Time Between Failure (MTBF) i.e. Time Based Maintenance assumes that the failure is age related and a clear service life can be determined. Or, that it's simply not worth the effort to assess the condition and a time based replacement is more economical and still (reasonably) effective.

Time Based Maintenance can never effectively manage non-age related failure modes and therefore should only form a small part of your overall maintenance program as >70% of the failure modes in your plant are not age related (refer to the article 9 Principles of Modern Maintenance).

It is important to realise that in many industries companies do have to complete certain tasks to meet regulatory compliance requirements and these would typically be executed on a fixed time interval i.e. Time Based Maintenance. But even with compliance related maintenance, there are often opportunities to engage a regulator and look at moving to for example risk-based approaches. A good example of this would be adopting Risk-Based Inspection (RBI) for vessel inspections instead of e.g. 4-yearly internal vessel inspections.

Failure Finding Maintenance (FFM)

Failure Finding Maintenance tasks are aimed at detecting hidden failures typically associated with protective functions. Think pressure safety valves, trip transmitters and the like.

This type of equipment won't be required to function until something else has failed. That means that under normal operating conditions you will not know whether this equipment is still functional i.e. the failure modes are hidden.

And since these failures are hidden, you'll need to find them before you are relying on that equipment to protect you. Simple really.It's important to realise that failure finding maintenance tasks do not prevent failure but simply detect it. And once detected you'll have to repair the failure you found. Failure Finding Maintenance is conducted at fixed time intervals typically derived from legislation or risk based approaches.

Risk Based Maintenance (RBM)

Risk Based Maintenance (RBM) is when you use a risk assessment methodology to assign your scarce maintenance resources to those assets that carry the most risk in case of a failure (remembering that risk = likelihood x consequence).

As a result, equipment that has a higher risk and a very high conseauence of failure would be subject to more frequent maintenance and inspection. Low risk equipment may be maintained at a much lower frequency and possibly with a much smaller scope of work.

When you implement a Risk Based Maintenance process effectively you should have reduced the total risk of failure across your plant in the most economical way.

Risk-Based Maintenance is essentially preventive maintenance where the frequency and scope of the maintenance activities is continuously optimised based on the findings from testing or inspection and a thorough risk assessment. Examples of Risk-Based Maintenance would be Risk-Based Inspection as applied to static equipment like vessels and piping or even pressure relief valves.

Condition Based Maintenance (CBM)

Most failure modes are not age related. However, most failure modes do give some sort of warning that they are in the process of occurring or are about to occur.

If evidence can be found that something is in the early stages of failure, it may be possible to take action to prevent it from failing completely and/or to avoid the consequences of failure. Condition Based Maintenance as a strategy therefore looks for physical evidence that a failure is occurring or is about to occur. Thinking of CBM in this way shows its broader applications outside condition monitoring techniques often only associated with rotating equipment.

Deferred Corrective Maintenance

In the chart of maintenance types I broke 'corrective maintenance' into two sub-types:

- Deferred Corrective Maintenance
- Emergency Maintenance (EM)

And that was very deliberate because it is so essential that we absolutely minimize the amount of Emergency Maintenance we allow into our organisations. As I already pointed out above Emergency Maintenance is expensive, various sources have suggested that Emergency Maintenance is 3 to 5 times as expensive as 'normal' preventive maintenance. Emergency Maintenance typically leads to longer equipment outages and more production impact. And it is less safe. So when a corrective maintenance work request is raised it is essential that you prioritise it properly to make sure that where possible you defer the work request and give your team the time to properly plan and schedule the work.

If you want to read more about prioritisation of corrective maintenance have a look at the article You Will Fail Without Planning & Scheduling.

Emergency Maintenance

Emergency Maintenance is corrective maintenance that is so urgent that it breaks into your Frozen Weekly Schedule (you do have one don't you?).It upsets your plans and schedules and typically throws everything into disarray.Some people thrive in this type of environment and often get heralded as heroes when they've worked 16hrs non-stop to get production back online. But when it comes to the Road to Reliability it is a dead end. So Emergency Maintenance is the one and only maintenance type that we really want to avoid as much as possible. In fact, World Class organisations ensure that less than 2% of their total maintenance is Emergency Maintenance. How much Emergency Maintenance do you have?

Advantages of preventive maintenance

- Less equipment downtime.
- Fewer interruptions to critical operations.
- Longer asset life.

- Improved efficiency (assets in good **repair** tend to operate better)
- Increased workplace safety and improved compliance with OSHA.

Maintenance Planning and Scheduling:

Proper maintenance and scheduling, when done right, can greatly increase productivity. Below we discuss how to implement maintenance planning and scheduling and more.

Breaking Down Maintenance Planning and Scheduling

The 34th president of the United States and an American army general, Dwight D. Eisenhower is famous for making the paradoxical statement, "In preparing for battle, I have always found that plans are useless, but planning is indispensable." He essentially was saying that plans often don't work out the way you lay them out once an actual emergency arises; however, the planning process makes you thoroughly explore all possible options and possibilities. The knowledge you gain from planning is vital when it comes to choosing appropriate actions.

In the modern world of manufacturing, higher productivity that produces quality products at the lowest cost possible is what companies strive for to stay ahead of the competition. Maintenance planning and scheduling are two different functions that, when used together, form a maintenance program.

Maintenance planning can be defined as an end-to-end process that identifies and addresses any possible issues ahead of time. This involves identifying the parts and tools necessary for jobs and making sure they're available and laid out in the appropriate areas, having a planner write out instructions on how to complete a job, and even determining and gathering the necessary parts and/or tools before a job is assigned. Maintenance planning also includes tasks related to parts like:

- Handling reserve parts
- Ordering nonstock parts
- Staging parts
- Illustrating parts
- Managing breakdowns and vendor lists
- Quality assurance (QA) and quality control (QC)

Maintenance planning should define the "what," "why" and "how." This means specifying what work needs to be done with what materials, tools and equipment; why a particular action was chosen (why a valve is being replaced instead of a seat); and how the work should be completed.

Maintenance scheduling refers to the timing of planned work, when the work should be done and who should perform it. It offers details of "when" and "who." Scheduling is meant to:

- Schedule the maximum amount of work with the available resources
- Schedule according to the highest priority work orders
- Schedule the maximum number of preventive maintenance jobs when necessary
- Minimize the use of contract and outside resources by effectively using internal labor

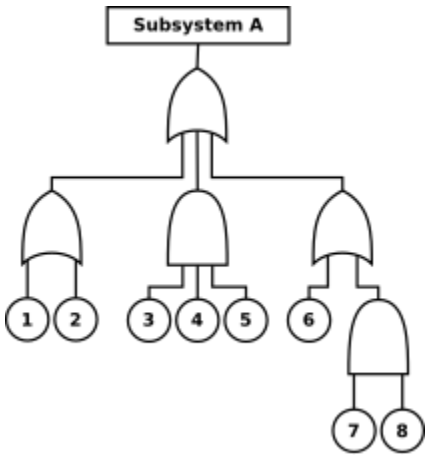
When implemented together, maintenance planning and scheduling should have a significant benefit in multiple areas of your organization. These can include:

- Help with budgeting by controlling resources associated with maintenance
- A reduction in equipment downtime
- A reduction in spare parts
- Improved workflow
- Improved efficiency by minimizing the movement of resources between areas

Fault tree analysis (FTA):

Fault tree analysis (**FTA**) is a top-down, deductive failure analysis in which an undesired state of a system is analyzed using Boolean logic to combine a series of lower-level events. This analysis method is mainly used in safety engineering and reliability engineering to understand how systems can fail, to identify the best ways to reduce risk and to determine (or get a feeling for) event rates of a safety accident or a particular system level (functional) failure. FTA is used in the aerospace,[1] nuclear power, chemical and process,[2][3][4] pharmaceutical,[5] petrochemical and other high- hazard industries; but is also used in fields as diverse as risk factor identification relating to social service system failure.[6] FTA is also used in software engineering for debugging purposes and is closely related to cause-elimination technique used to detect bugs.

In aerospace, the more general term "system failure condition" is used for the "undesired state" / top event of the fault tree. These conditions are classified by the severity of their effects. The most severe conditions require the most extensive fault tree analysis. These system failure conditions and their classification are often previously determined in the functional hazard analysis.



Total Productive Maintenance:

Total productive maintenance (TPM) is the process of using machines, equipment, employees and supporting processes to maintain and improve the integrity of production and the quality of systems.

What Is Total Productive Maintenance (TPM)?

According to Aberdeen Research, the average hourly cost of downtime across all businesses is $260,000, and it seems to be rising. This figure is up from the 2014 data of $164,000. This is especially concerning since nearly all industrial and manufacturing production is accomplished using machines, making it largely dependent on those machines operating continuously.

So, how can you help remedy this issue? Total productive maintenance (TPM) is the process of using machines, equipment, employees and supporting processes to maintain and improve the integrity of production and the quality of systems. Put simply, it's the process of getting employees involved in maintaining their own equipment while emphasizing proactive and preventive maintenance techniques. Total productive maintenance strives for perfect production. That is:

- No breakdowns
- No stops or running slowly
- No defects
- No accidents

Since the goal of total productive maintenance is to improve productivity by reducing downtime, implementing a TPM program can greatly impact your overall equipment effectiveness (OEE) over time. To do this, preventive maintenance should always be at the forefront of everyone's mind. For example, running machines with the mindset of "we'll fix it when it breaks" is not an option with total productive maintenance. A TPM program helps get rid of this mindset and turns it into one of putting machinery at the core focus of an operation and maximizing its availability.

Improving OEE through TPM is often done by forming small, multidisciplinary teams to address core areas such as preventive and autonomous maintenance, training employees who operate machinery, and the security and standardization of work processes. Total productive maintenance focuses on the efficient and effective use of the means of production, meaning all departments should be involved. These small teams work together to increase productivity and decrease downtime through equipment reliability.

Benefits of Total Productive Maintenance (TPM)

Going from reactive to predictive maintenance is one of the biggest advantages of implementing a TPM program. Reactive maintenance or "firefighting" is costly, as you're not only footing the bill for machinery repairs but also dealing with the cost of unplanned downtime. Let's take a look at some of the direct and indirect benefits that result from total productive maintenance.

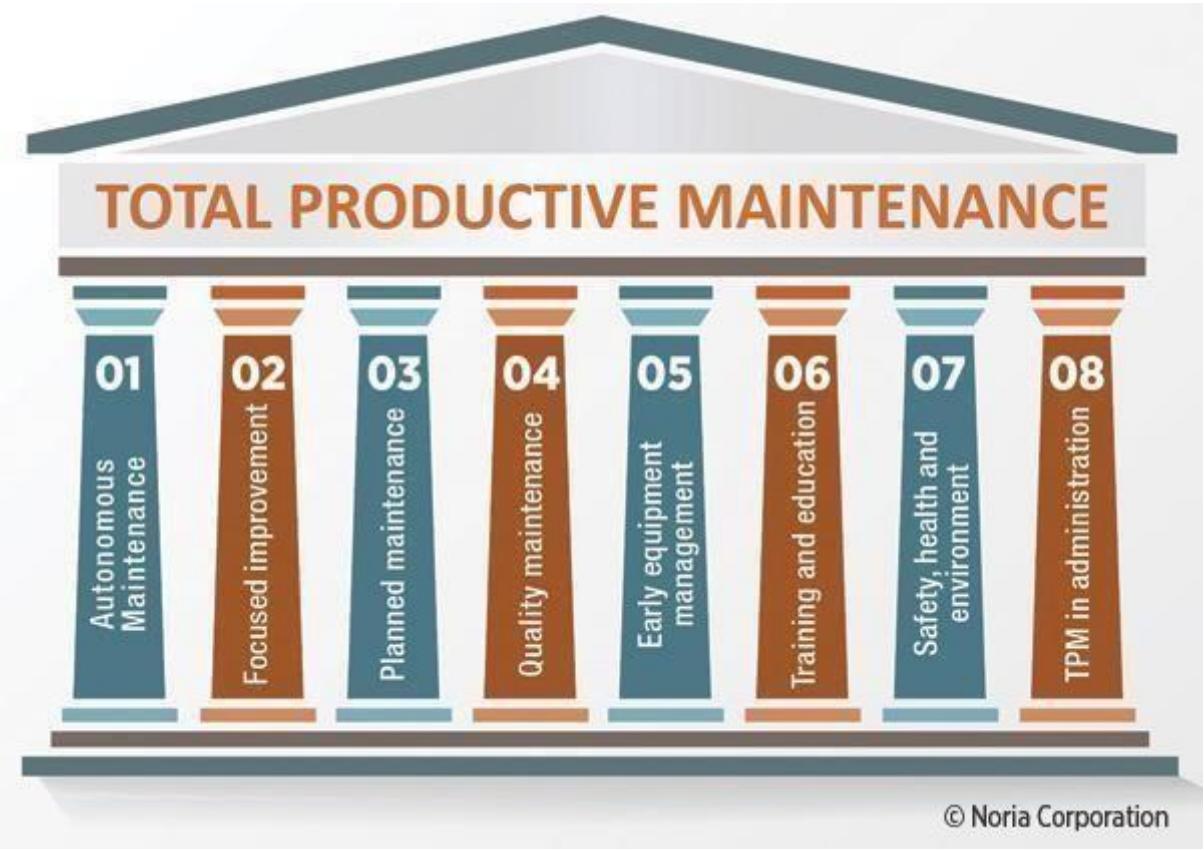
Benefits of Total Productive Maintenance

Direct Benefits	Indirect Benefits
Less unplanned downtime resulting in an increase in OEE	Increase in employee confidence levels
Reduction in customer complaints	Produces a clean, orderly workplace
Reduction in workplace accidents	Increase in positive attitudes among employees through a sense of ownership

Reduction in manufacturing costs	Pollution control measures are followed
Increase in product quality	Cross-departmental shared knowledge and experience

The 8 Pillars of Total Productive Maintenance (TPM)

Traditional total productive maintenance was developed by Seiichi Nakajima of Japan. The results of his work on the subject led to the TPM process in the late 1960s and early 1970s. Nippon Denso (now Denso), a company that created parts for Toyota, was one of the first organizations to implement a TPM program. This resulted in an internationally accepted benchmark for how to implement TPM. Incorporating lean manufacturing techniques, TPM is built on eight pillars based on the 5-S system. The 5-S system is an organizational method based around five Japanese words and their meaning:



- *Seiri (organize):* eliminating clutter from the workspace
- *Seiton (orderliness):* ensure order by following "a place for everything and everything in its place"
- *Seiso (cleanliness):* clean the workspace and keep it that way
- *Seiketsu (standardize):* standardize all work processes, making them consistent
- *Shitsuke (sustain):* constantly reinforcing the first four steps

The eight pillars of total productive maintenance focus on proactive and preventive techniques to help improve equipment reliability. The eight pillars are: autonomous maintenance; focused improvement (kaizen); planned maintenance; quality management; early equipment management; training and education; safety, health and environment; and TPM in administration. Let's break down each pillar below.

1. **Autonomous maintenance:** Autonomous maintenance means ensuring your operators are fully trained on routine maintenance like cleaning, lubricating and inspecting, as well as placing that responsibility solely in their hands. This gives machine operators a feeling of ownership of their equipment and increases their knowledge of the particular piece of equipment. It also guarantees the machinery is always clean and lubricated, helps identify issues before they become failures, and frees up maintenance staff for higher-level tasks.

   Implementing autonomous maintenance involves cleaning the machine to a "baseline" standard that the operator must maintain. This includes training the operator on technical skills for conducting a routine inspection based on the machine's manual. Once trained, the operator sets his or her own autonomous inspection schedule. Standardization ensures everyone follows the same procedures and processes.
2. **Focused improvement:** Focused improvement is based around the Japanese term "kaizen," meaning "improvement." In manufacturing, kaizen requires improving functions and processes continually. Focused improvement looks at the process as a whole and brainstorms ideas for how to improve it. Getting small teams in the mindset of proactively working together to implement regular, incremental improvements to processes pertaining to equipment operation is key for TPM. Diversifying team members allows for the identification of recurring problems through cross-functional brainstorming. It also combines input from across the company so teams can see how processes affect different departments.

   In addition, focused improvement increases efficiency by reducing product defects and the number of processes while enhancing safety by analyzing the risks of each individual action. Finally, focused improvement ensures improvements are standardized, making them repeatable and sustainable.
3. **Planned maintenance:** Planned maintenance involves studying metrics like failure rates and historical downtime and then scheduling maintenance tasks based around these predicted or measured failure rates or downtime periods. In other words, since there is a specific time to perform maintenance on equipment, you can schedule maintenance around the time when equipment is idle or producing at low capacity, rarely interrupting production.

   Additionally, planned maintenance allows for inventory buildup for when scheduled maintenance occurs. Since you'll know when each piece of equipment is scheduled for maintenance activities, having this inventory buildup ensures any decrease in production due to maintenance is mitigated.

   Taking this proactive approach greatly reduces the amount of unplanned downtime by allowing for most maintenance to be planned for times when machinery is not scheduled for production. It

also lets you plan inventory more thoroughly by giving you the ability to better control parts that are prone to wear and failure. Other benefits include a gradual decrease in breakdowns leading to uptime and a reduction in capital investments in equipment since it is being used to its maximum potential.

4. **Quality maintenance:** All the maintenance planning and strategizing in the world is all for naught if the quality of the maintenance being performed is inadequate. The quality maintenance pillar focuses on working design error detection and prevention into the production process. It does this by using root cause analysis (specifically the "5 Whys") to identify and eliminate recurring sources of defects. By proactively detecting the source of errors or defects, processes become more reliable, producing products with the right specifications the first time.

   Possibly the biggest benefit of quality maintenance is it prevents defected products from moving down the line, which could lead to a lot of rework. With targeted quality maintenance, quality issues are addressed, and permanent countermeasures are put in place, minimizing or completely eliminating defects and downtime related to defected products.
5. **Early equipment management:** The TPM pillar of early equipment management takes the practical knowledge and overall understanding of manufacturing equipment acquired through total productive maintenance and uses it to improve the design of new equipment. Designing equipment with the input of people who use it most allows suppliers to improve maintainability and the way in which the machine operates in future designs.

   When discussing the design of equipment, it's important to talk about things like the ease of cleaning and lubrication, accessibility of parts, ergonomically placing controls in a way that is comfortable for the operator, how changeovers occur and safety features. Taking this approach increases efficiency even more because new equipment already meets the desired specifications and has fewer startup issues, therefore reaching planned performance levels quicker.
6. **Training and education:** Lack of knowledge about equipment can derail a TPM program. Training and education applies to operators, managers and maintenance personnel. They are intended to ensure everyone is on the same page with the TPM process and to address any knowledge gaps so TPM goals are achievable. This is where operators learn skills to proactively maintain equipment and identify emerging problems. The maintenance team learns how to implement a proactive and preventive maintenance schedule, and managers become well-versed in TPM principles, employee development and coaching. Using tools like single-point lessons posted on or near equipment can further help train operators on operating procedures.
7. **Safety, health and environment:** Maintaining a safe working environment means employees can perform their tasks in a safe place without health risks. It's important to produce an environment that makes production more efficient, but it should not be at the risk of an employee's safety and health. To achieve this, any solutions introduced in the TPM process should always consider safety, health and the environment.

   Aside from the obvious benefits, when employees come to work in a safe environment each day, their attitude tends to be better, since they don't have to worry about this significant aspect. This can increase productivity in a noticeable manner. Considering safety should be especially

prevalent during the early equipment management stage of the TPM process.

8. **TPM in administration:** A good TPM program is only as good as the sum of its parts. Total productive maintenance should look beyond the plant floor by addressing and eliminating areas of waste in administrative functions. This means supporting production by improving things like order processing, procurement and scheduling. Administrative functions are often the first step in the entire manufacturing process, so it's important they are streamlined and waste-free. For example, if order-processing procedures become more streamlined, then material gets to the plant floor quicker and with fewer errors, eliminating potential downtime while missing parts are tracked down.

How to Implement Total Productive Maintenance (TPM)

Now that you have an understanding of the foundation (5-S system) and pillars on which the TPM process is built, let's take a look at how to implement a TPM program. This is generally done in five steps: identifying a pilot area, restoring equipment to prime operating condition, measuring OEE, addressing and reducing major losses, and implementing planned maintenance.

Step 1: Identify a Pilot Area

Using a pilot area to begin implementation helps gain more acceptance from staff when they see the benefits that come out of the process. When choosing equipment for a pilot area, consider these three questions:

- *What's the easiest to improve?* Selecting equipment that is easiest to improve gives you the chance for immediate and positive results; however, it doesn't test the TPM process as strongly as the other two options.

- *Where's the bottleneck?* Choosing equipment based on where production is clearly being held up gives you an immediate increase in total output and provides quick payback. The downside is that employing this equipment as a pilot means you're using a critical asset as an example and risk the chance of it being offline longer than you would like.
- *What's the most problematic?* Fixing equipment that gives operators the most trouble will be well-received, strengthening support for the TPM program. However, this doesn't give you as much immediate payback as the previous approach, and it may be challenging to obtain a quick result from figuring out an unsolved problem, leading to disinterest.

If this is your first time implementing a TPM program, your best choice is typically the first approach – the easiest equipment to improve. If you have some or extensive experience with total productive maintenance, you may choose to correct the bottleneck. This is because you can build temporary stock or inventory, making sure downtime can be tolerated, which minimizes risk.

Include employees across all aspects of your business (operators, maintenance personnel, managers and administration) in the pilot selection process. It's a good idea to use a visual like a project board where you can post progress for all to see.

Step 2: Restore Equipment to Prime Operating Condition

The concept of restoring equipment to prime operating condition revolves around the 5-S system and

autonomous maintenance. First, TPM participants should learn to continuously keep equipment to its original condition using the 5-S system: organize, cleanliness, orderliness, standardize and sustain. This might include:

- Photographing the area and current state of the equipment and then posting them to your project board.
- Clearing the area by removing unused tools, debris and anything that can be considered waste.
- Organizing the tools and components you use regularly (a shadow board with tool outlines is apopular option).
- Cleaning the equipment and the surrounding area thoroughly.
- Photographing the improvements of the equipment and surrounding area and then posting to the projectboard.
- Creating a standardized 5-S work process to maintain the continuity of this process.
- Auditing the process with lessening frequency (first daily, then weekly, etc.) to ensure the 5-S process is being followed (update the process to keep it current and relevant).

Once you've established a baseline state of the equipment, you can implement the autonomous maintenance program by training operators on how to clean equipment while inspecting it for wear and abnormalities. Creating an autonomous maintenance program also means developing a standardized way to clean, inspect and lubricate equipment correctly. Items to address during the planning period for the autonomous maintenance program include:

- Identifying and documenting inspection points, including parts that endure wear.
- Increasing visibility where possible to help with inspection while the machine is running (replacing opaque guarding with transparent guarding).

Identifying and clearly labeling set points with their corresponding settings (most people put labels with settings directly on the equipment).

- Identifying all lubrication points and scheduling maintenance during changeovers or planned downtime (consider placing difficult-to-access lubrication points that require stopping the machine on the outside of the equipment).
- Training operators to make them aware of any emerging or potential issues so they can report them to the line supervisor.
- Creating an autonomous maintenance checklist for all operator-controlled tasks.
- Auditing the process with lessening frequency to ensure the checklist is beingfollowed.

Step 3: Measure OEE

Step three requires you to track OEE for the target equipment, either manually or using automated software (as long as it includes code tracking for unplanned stoppage time). For details on how to calculate OEE manually, reference Reliable Plant's article on OEE. Regularly measuring OEE gives you a data-driven confirmation on whether your TPM program is working and lets you track progress over time.

Since the biggest losses in regard to equipment are the result of unplanned downtime, it's important to categorize every unplanned stoppage event. This gives you a more accurate look at where a stoppage is occurring. Include an "unknown" or "unallocated" stoppage time category for unknown causes.

It's recommended that you gather data for a minimum of two weeks to get an accurate representation of the unplanned stoppage time and a clear picture of how small stops and slow cycles impact production. Below is a simplified example of a top 5 loss chart. Each loss is categorized and is in descending order from the loss that causes the most downtime to the loss that causes the least.

Loss Chart

Loss Rank	**Loss Category**	**Lost Time (minutes)**
1	Equipment Failure: *Filler Jam*	400
2	Equipment Failure: *Bottle Labeler Down*	250

3	Setup/Adjustments: *Bottle Change*	170
4	Setup/Adjustments: *Label Change*	165
5	Equipment failure: Bottle	10

Total Lost Time = 995 minutes (16.5 hours)

Step 4: Address/Reduce Major Losses

Once you've got a data-driven snapshot of where your top losses are, it's time to address them. This step uses the previously discussed pillar of focused improvement or kaizen. To do this, put together a cross- functional team of operators, maintenance personnel and supervisors that can dissect the OEE data using root cause analysis and identify the main cause(s) of the losses. Your team's process might look something like this:

- Select a loss based on OEE and stoppage time data. This should be the biggest source of unplanned stoppage time.
- Look into the symptoms of the problem(s). Collect detailed information on symptoms like observations, physical evidence and photographic evidence. Using a fishbone diagram to track symptoms and record information while you're at the equipment is strongly recommended.
- With your team, discuss and identify potential causes of the problem(s), check the possible causes against the evidence you've gathered, and brainstorm the most effective ways to solve theissue.
- Schedule planned downtime to implement the agreed-upon fixes.
- Once the fix has been implemented, restart production and observe how effective the fix is over time. If it resolves the issue, make a note to implement the change and move onto the next cause of stoppage time. If not, gather more information and hold another brainstorming session.

Step 5: Implement Planned Maintenance

The last step of the TPM implementation process is the integration of proactive maintenance techniques into your program. This involves working off the third pillar of planned maintenance. Choose which components should receive proactive maintenance by looking at three factors: wear components, components that fail and stress points. Identifying stress points is often done by using infrared thermography and vibration analysis.

Next, use proactive maintenance intervals. These intervals are not set in stone and can be updated as needed. For wear and predicted failure-based components, establish the current wear level and then a baseline replacement interval. Once these have been determined, you can create a proactive replacement schedule of all wear- and failure-prone components. When doing this, use "run time" as opposed to "calendar time." Finally, develop a standardized process for creating work orders based on the planned maintenance schedule.

You can optimize maintenance intervals by designing a feedback system. Things like log sheets for each wear- and failure-prone component where operators can record replacement information and component condition at the time of replacement will be key. Additionally, conduct monthly planned maintenance audits to verify the maintenance schedule is being followed and the component logs are being kept up to date. Review the logs' information to see if adjustments to the maintenance schedule need to be made.