

Program Name : Diploma in Production Engineering / Production Technology
Program Code : PG / PT
Semester : Fourth
Course Title : Plant Engineering and Safety Management
Course Code : 22451

1. RATIONALE

In any type of industry the employer is responsible for the identification and control of hazards. The risk evaluation coupled with the establishment of an effective safety management system can lead to reduction of losses due to accidental human fatality and damage to property, equipment and the environment. It also allows us to show our commitment and due diligence to a healthy and safe workplace. We must identify hazards and potential hazards in the workplace in order to be able to take action to eliminate or control them. The main intention to study this subject is to know concepts, principles, & procedure of different types of maintenance, maintenance tools, safety devices to avoid accidents. The subject also provides knowledge regarding management of hazard.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Use maintenance procedures and control measures to prevent hazards.

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

- Use relevant maintenance procedure for plant maintenance .
- Select relevant lubricants to reduce wear.
- Use safety measures /control measures to reduce hazards.
- Maintain the implemented control measure.
- Analyse risk associated with hazards.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
L	T	P		Theory						Practical						
				Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
Max	Min	Max	Min		Max	Min	Max	Min	Max	Min	Max	Min	Max	Min		
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P - Practical; C – Credit, ESE - End Semester Examination; PA - Progressive Assessment



5. **COURSE MAP** with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

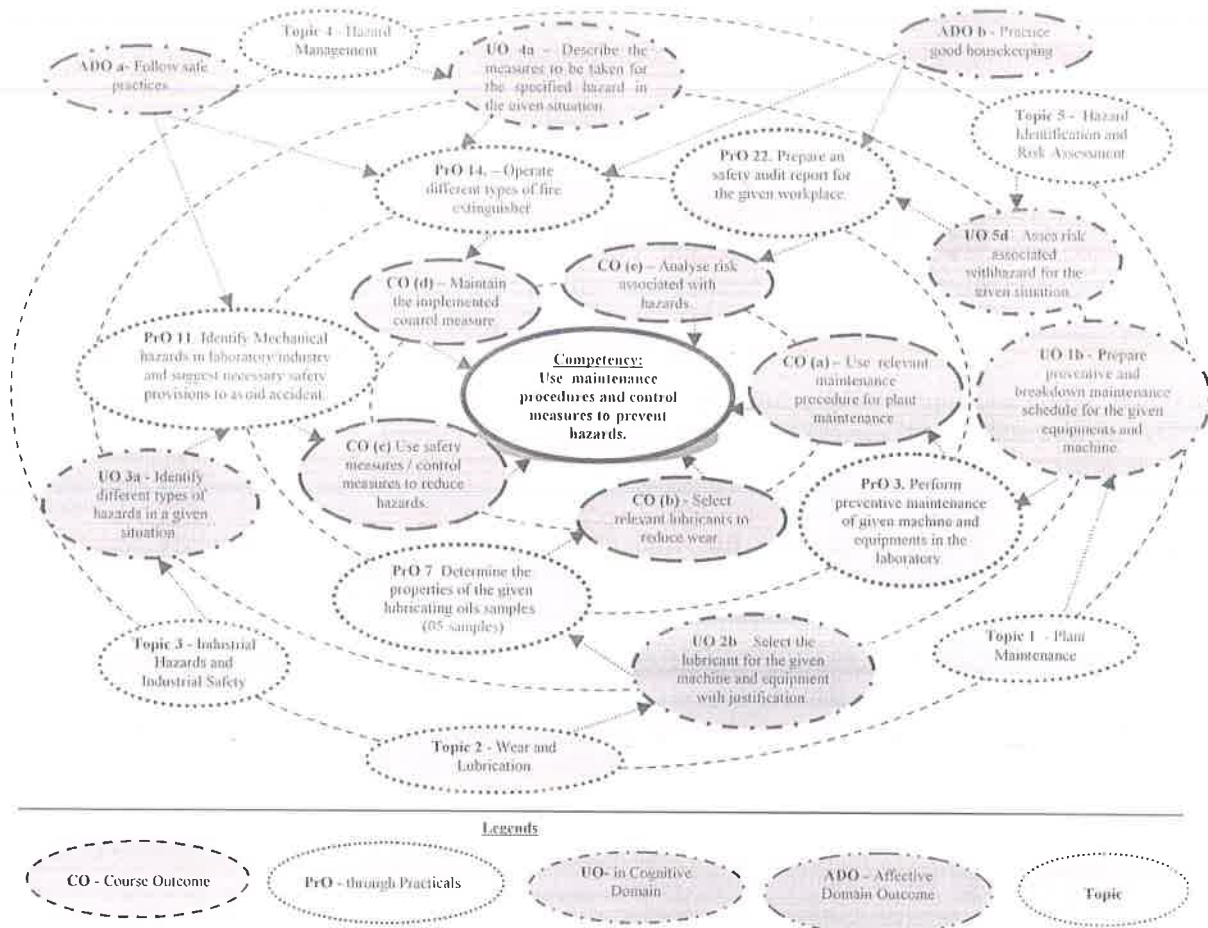


Figure 1 - Course Map

6. **SUGGESTED PRACTICALS / EXERCISES**

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Inspect and overhaul of water pump available in institute.	I	02
2	Clean, degrease and repair any given old equipment/component in workshop/laboratory.	I	02*
3	Perform preventive maintenance of the given machine and equipments in the laboratory.	I	02*
4	Perform safety analysis of the given equipments (02 No.)	I	02
5	Identify safety devices – overload relay, motor type relays, sensors, voltage stabiliser, constant pressure relief valves etc; and make preventive maintenance schedule.	I	02
6	Measure wear of the given components (5 components) and give	II	02

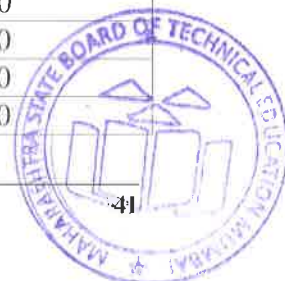


S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	suggestions to reduce wear.		
7	Determine the properties of the given lubricating oil samples. (05 samples)	II	02
8	Determine the viscosity of the given used lubricating oil sample and do the oil analysis.	II	02*
9	Identify the properties of the given lubricant using human senses.	II	02
10	Replace lubricant of the given machine (any one).	II	02
11	Identify Mechanical hazards in laboratory/industry and suggest necessary safety provisions to avoid accident.	III	02
12	Identify Electrical hazards in laboratory/industry and suggest necessary safety provisions to avoid accident.	III	02*
13	Identify Thermal hazards in laboratory/industry and suggest necessary safety provisions to avoid accident.	III	02
14	Operate different types of fire extinguisher.	IV	02*
15	Identify hazardous chemicals available in the given laboratory/industry and prepare Safety Data Sheet of hazardous chemicals. Also suggest storage and handling system.	IV	02
16	Perform periodic air monitoring of various laboratories.	IV	02
17	Identify functional parts and operating phases of a given machine and review each phase for possible malfunctions.	IV	02
18	Conduct Fault Tree analysis (FTA) to determine the cause of failure for the given component.	V	02*
19	Conduct Failure mode and effect analysis (FMEA) for the given component.	V	02
20	Conduct HAZOP study to identify potential hazards and operability problems for the given laboratory/industry.	V	02
21	Design a protection measure for identified potential hazards in PrO no. 18.	V	02
22	Prepare an safety audit report for the given workplace.	V	02
	Total		44

Note

- A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.
- The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	10
2	Setting and operation	10
3	Safety measures	20
4	Observations and recording	10
5	Interpretation of result and conclusion	20
6	Answer to sample questions	20
7	Submission of report in time	10



Total**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

- a. Follow safety practices.
- b. Practice good housekeeping.
- c. Practice energy conservation.
- d. Demonstrate working as a leader/a team member.
- e. Maintain tools and equipment.
- f. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year.
- 'Organising Level' in 2nd year.
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO No.
1	Various types of tools. (Fix spanners, box spanners, ring spanners, allen keys, types of pliers, screw drivers, bearing puller etc;)	1-4, 6,7
2	Various types of rotary and reciprocating pumps	1
3	Old components/equipment	2
4	Different types of lubricants	7-10
5	Redwood Viscometer	8
6	Wear measurement device	6
7	Fire extinguishers - a) DCP type - 1, 2, 5 or 10 Kg, operation - upright, ISS-2171, Class B and C fire b) CO2 type, A, B, C type, Dry chemical powder type c) Foam type- 9 litre, operation - inverted, ISS-933, Class B fire	13, 14
8	Air monitoring device	16
9	Safety goggles, face screens, Industrial safety helmets, hairnets and fire fighters helmets, Earplugs, earmuffs, Gloves, Safety boots and shoes with protective toecaps and penetration - resistant, Apron, Chemical suit etc;	All

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit-I Plant Maintenanc	1a. Prepare maintenance plan for the given equipment and machine.	1.1 Primary and secondary functions and responsibility of maintenance department. 1.2 Importance and types of maintenance.



Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
e	1b. Prepare preventive and breakdown maintenance schedule for the given equipment and machine. 1c. Select tools for the mechanical maintenance of the given equipment with justification. 1d. Develop equipment cards, equipment history cards and preventive maintenance records for the given equipment. 1e. Use TPM for the given situation.	1.3 Breakdown, Preventive, Scheduled maintenance, procedure of Preventive maintenance. 1.4 Planning and scheduling of maintenance work, Repair cycle. 1.5 Maintenance manuals, equipment cards and equipment history cards. 1.6 Tools required for mechanical maintenance. 1.7 Introduction, benefits and features of Total Productive Maintenance (TPM). 1.8 Electrical maintenance: equipment needed for electrical maintenance - Multimeter, fuses, overload relays, circuit breakers. 1.9 Maintenance of plant utilities.
Unit- II Wear and Lubrication	2a. Give reason for the occurrence of the given types of wear in the given component. 2b. Select the relevant lubricant for the given machine and equipment with justification. 2c. Select the relevant lubrication system for the given situation with justification. 2d. Determine the viscosity of the given lubricant data.	2.1 Definition of wear, Primary wear processes - Adhesive, abrasive, corrosive reaction, plastic flow, pitting. 2.2 Lubricants - Importance, properties, types and selection of lubricants, 2.3 Lubrication systems - wick, pad, bottle, bath or sump, splash, centralized.
Unit- III Industrial Hazards and Industrial Safety	3a. Identify different types of hazards in a given situation. 3b. Select personal protective equipments as per situation with justification. 3c. Apply safety measure as per Factories act 1948 and Safety and health standards for the given organization. 3d. Identify different control methods to avoid accident for the given situation.	3.1 Industrial Safety 3.2 Types of industrial hazards: (a) Chemical hazard (b) Thermal hazard (c) Electrical hazard (d) Mechanical hazard (e) Radioactive hazard (f) Ergonomic hazard 3.3 Accident - causes, types, effects and control. 3.4 First aid, Personal protective equipments and Safety policies. 3.5 Important provisions in Factories Act 1948 (for health and safety) 3.6 Safety and health standards: Indian standards and codes for safety and health.



Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub topics
Unit- IV Hazard Management	<p>4a. Describe the measures to be taken for the specified hazard in the given situation.</p> <p>4b. Prepare a preventive maintenance plan for the specified fire protection equipment (s).</p> <p>4c. Describe the handling and storage system for the given hazardous chemical.</p> <p>4d. Prepare a preventive maintenance plan for the specified chemical storage and handling system.</p>	<p>4.1 Fire hazards and their causes.</p> <p>4.2 Sources of ignition. fire triangle. active and passive fire protection systems. various classes of fires – A. B. C. D. E. types of fire extinguishers. Construction. principles and working of fire extinguishers. Methods of their applications.</p> <p>4.3 Industrial fire fighting systems - hydrant pipes, hoses. Sprinkler, monitors. fire watchers, lay out of stand pipes. fire alarms and sirens. foam generators, escape from fire, rescue operations.</p> <p>4.4 Special fire suppression systems like deluge and emulsifier. Other suppression systems – CO₂ system, foam system, dry chemical powder (DCP) system.</p> <p>4.5 Classification of Chemical hazards and their control.</p> <p>4.6 Important characteristics and chemical reaction of hazardous chemicals like Chlorine, Nitric Acid, Ammonia, Carbon Monoxide, Caustic Soda, Phosphoric Acid</p> <p>4.7 Storage, handling and transportation of hazardous chemicals.</p> <p>4.8 Safety Data Sheet (SDS)</p> <p>4.9 Prohibited and restricted hazardous chemicals.</p>
Unit- V Hazard Identification and Risk Assessment	<p>5a. Identify the routes of exposure to industrial hazards for the given situation.</p> <p>5b. Select hazard identification methods for the given situation with justification.</p> <p>5c. Select risk assessment methods for the given situation with justification.</p> <p>5d. Assess risk associated with hazard for the given situation.</p>	<p>5.1 Hazard identification methods :</p> <p>a) Hazard Operability study (HAZOP)</p> <p>b) Hazard Analysis (HAZAN)</p> <p>5.2 Risk Assessment methods:</p> <p>a) Failure mode and effect analysis (FMEA)</p> <p>b) Fault Tree analysis (FTA)</p> <p>c) Event Tree analysis (ETA)</p> <p>5.3 Safety audit.</p>

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN



Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Plant Maintenance	12	04	08	10	22
II	Wear and Lubrication	08	02	06	04	12
III	Industrial Hazards and Industrial Safety	08	04	04	04	12
IV	Hazard Management	12	04	04	06	14
V	Hazard Identification and Risk Assessment	08	02	04	04	10
Total		48	16	26	28	70

Legends: R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)

Note: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related *co-curricular* activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

- Prepare journals based on practical performed in laboratory.
- Prepare a report on facilities provided in the institute workshop to follow the safety precautions.
- Report on industrial visit to observe various facilities such as compressed air, water, steam, electric supply, high voltage electric supply, air conditioning, waste disposal and treatment. (Report on different facilities to be prepared by different groups and compiled)
- Prepare a preventive maintenance schedule of any machine in your college machine shop /laboratory and prepare a report.
- Collect samples of corroded components from field and identify the types of corrosion and possible causes and suggest prevention methods.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

- Massive open online courses (*MOOCs*) may be used to teach various topics/sub topics.
- 'L' in item No. 4 does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
- About **15-20% of the topics/sub-topics** which is relatively simpler or descriptive in nature is to be given to the students for *self-directed learning* and assess the development of the COs through classroom presentations (see implementation guideline for details).
- With respect to item No.10, teachers need to ensure to create opportunities and provisions for *co-curricular activities*.
- Guide student(s) in undertaking micro-projects.
- Visit to near by industry (any three) and collect the information regarding maintenance procedure adopted by them to maintain equipment and machine and write a report.



- g. Visit to near by industry (any three) and collect the information regarding hazard management system adopted by them and write a report.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be **individually** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should **not exceed three**.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than **16 (sixteen) student engagement hours** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

- Visit to websites of reputed fire and safety equipment suppliers and study of features of their equipment/instruments/tools.
- Collect a samples of used lubricant oils from various machine from workshops and industries and do the oil analysis and write a report.
- Visit different industries and workshops (at least 3) and study various control measures used to avoid different types of hazards and submit a report.
- Collect failure data of machine components from the industry and perform reliability analysis using various techniques.
- Divide selected plant/laboratory into nodes as for Hazop. Apply previously developed or published checklists for known failure and deviations. Record consequences, safeguards and actions.
- Identify maintenance problems occurring in product type industries, process type industries and Power plants .
- Use Risk Assessment method for Chemistry laboratory of the institute.
- Prepare checklist for maintenance of given equipments and machine.
- Tests for effects of human activities on a machine or plant (Hazardous human error analysis)
- Collect the list of health and safety legislation at work place in Indian factories. Also provide key regulations and year of amendment for awareness.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Maintenance Engineering Handbook	Higgins & Morrow	McGraw Hill Education, New Delhi, ISBN No: 9780070288119
2	Maintenance Engineering	Garg H. P.	S. Chand & Co. Ramnagar, New Delhi. ISBN No: 9788121901680
3	Standerd handbook on Plant Engineering, Third Edition	Rosaler Robert C	McGraw Hill Education, New Delhi ISBN:9780071361927



S. No.	Title of Book	Author	Publication
4	Chemical Process Safety: Fundamentals with application	Crowl Daniel A., Louvar Joshef F.	Prentice Hall, USA, 3rd Edition, 2011, ISBN 0-13-OZ817b-5
5	Industrial safety management, 1st Edition	Deshmukh L. M.	McGraw Hill Education. New Delhi 2006. ISBN: 9780070617681
6	Maintenance Engineering: Principles, Practices and Management	Srivastav Sushilkumar	S. Chand & Co. Ramnagar, New Delhi, ISBN No: 9788121926447

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

- a. www.pmxpert.com
- b. www.nptel.iitm.ac.in
- c. webstore.ansi.org/preventive-maintenance
- d. www.mapcon.com
- e. <https://www.osha.gov>
- f. https://en.wikipedia.org/wiki/Hazard_and_operability_study
- g. <http://firetexprotectivetechologies.in/>
- h. <http://www.maharashtradiirectory.com/Products/SearchResult?ProductName=fire-fighting-equipments>



