Program Name : **Diploma in Chemical Engineering**

Program Code : **CH**

Semester : **Fourth**

Course Title : **Industrial Safety and Maintenance**

Course Code : **22408**

1. RATIONALE

Diploma chemical engineers have to deal with Plant safety while working in chemical process industries. This course is intended to develop the skills to plan , organize for the safety and prevent accidents and hazards while working in chemical process industry. Information about the management of hazards in various processes and operations may used to control accidents in chemical process plants. Diploma chemical engineers also have to deal with operating different chemical equipments. This course is designed to equip the students with necessary knowledge and skills for using of safe practices, various types of maintenance and their significance.

2. COMPETENCY

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

- **Apply maintenance and safety measures in chemical industry.**

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:

a. Select the relevant safety plan and procedure for industry.
b. Use the different hazard assessment technique in Chemical industry.
c. Prepare accident investigation reports in Chemical Industry.
d. Use hazard control methods for industrial hazards.
e. Use the relevant maintenance procedure in Chemical process plant.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory						Practical						
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					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.

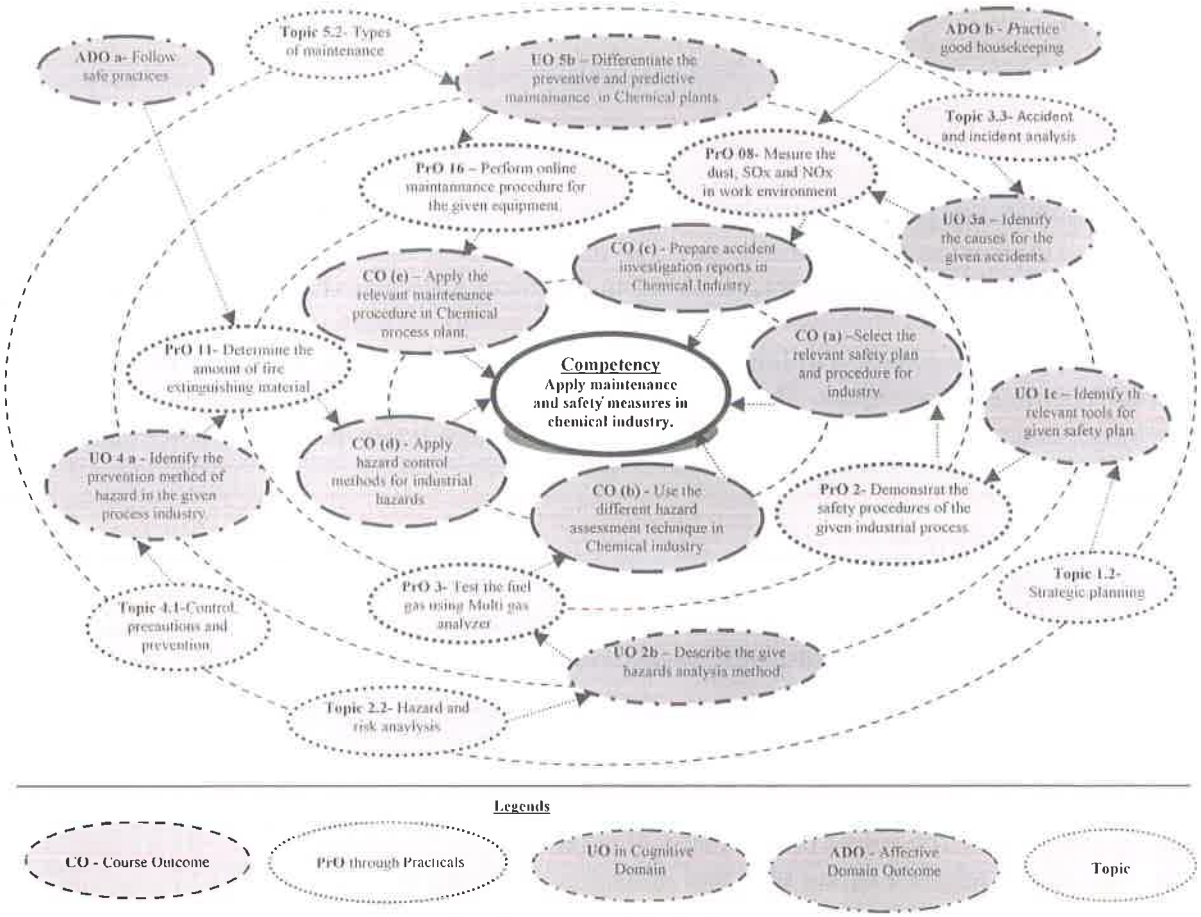

Figure 1 - Course Map

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	Use the personal protective equipment for the given industrial hazard protection plan.	I	02*
2	Perform the safety procedures of the given industrial process.	I	02
3	Use the Multi gas analyzer to test the fuel gas using.	II	02*
4	Use the Hygro meter kata thermometer and global thermometer to measure DBT, WBT, relative humidity .	II	02
5	Use the static charge meter to measure the static charge.	II	02
6	Perform the safety audit in the given chemical engineering laboratory.	II	02
7	Use the colorimetric method to mesure the SOx, NOx, NH_3 and Cl_2 gases in work environment.	III	02*
8	Use the high volume semplar to mesure the dust, SOx and NOx in work environment.	III	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
9	Use the Dragger explosive meter to measure the Oxygen level.	III	02
10	Use the audiometer to test the ear.	III	02
11	Use the step test to test the lung function.	III	02*
12	Use the Lux meter to.measure the illumination level	III	02*
13	Use the classical fire extinguisher in laboratory conditions.	IV	02
14	Determine the amount of fire extinguishing material for given type of fire.	IV	02*
15	Perform the mock drill for evacuation in emergency conditions.	IV	02
16	Perform online maintannance procedure for the given equipment of chemical industry.	V	02*
	Total		**32**

Note

i. *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.*

ii. *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 %
2	Preparation of experimental set up	20
3	Setting and operation	20
4	Safety measures	10
5	Observations and Recording	10
6	Interpretation of result and Conclusion	20
7	Answer to sample questions	10
8	Submission of report in time	10
	Total	**100**

Additionally, the following affective domain LOs (social skills/attitudes), are also important constituents of the competency which can be best developed through the above mentioned laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. 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 and

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- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

S. No.	Equipment Name with Broad Specifications	PrO. S. No.
1.	Multi gas analyzer; Multi-component gas analyzer with up to five components featuring NDIR/UV/VIS photometer, paramagnetic and electrochemical O2 , and thermal conductivity sensors.	3
2.	Hygro meter; Measurement ranges 0 to 100% r.h. -30 to 100°C Resolution 0.01% r.h. 0.01°C Accuracy ±2.0% r.h. at 25°C ±0.5°C at 25°C Display dual LCD with 4.5 positions	4
3.	Kata thermometer; alcohol thermometer with a large bulb A 4 cm. long and 2 cm. In diameter and a stern 20 cm. long.	4
4.	Static charge meter; Measurement Range : /- 10kV At 1 Inch, Measurement Accuracy : /- 10%, Indication : 2 ½ Digit LCD Display	5
5.	Colori meter; I/O 4 lines 3.3V general purpose I/O Trigger input 3.3V compliant , Absolute maximum rating 5.8V.	7
6.	High Volume Sempler; sampling flow rate of 20 to 60 standard cubic feet per minute (SCFM), or 0.57 to 1.71 standard cubic meters per minute (SCMM).	8
7.	Dragger explosive meter; Detected Combustible Gases, O2, CO and H2S. Dimensions 1.85 x 5.08 x 1.22 inch (7 x 129 x 31 mm) Weight 7.8 oz (220 g)	9
8.	Audiometer; Frequency range 0 Hz to 22,000 Hz, Frequency stability +/- 0.0001 Hz (at 1000 Hz), S/N 96 dB (in 16 bit systems), Amplitude (SPL) range -20 dB to 100 dB	10
9.	Lux meter; Weight: 150g(without battery), Size: 185*55*30mm Power supply: 2*AAA(7V) battery, Measuring range: 1lux/2000lux/2	12
10.	Fire extinguisher; 5kg CO_2 fire extinguisher.	13

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs in cognitive domain for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Safety Planning	1a. Identify the relevant safety plan for the given Industry. 1b. Identify the safety procedures of the given industrial process. 1c. Identify the relevant tools for given safety plan. 1d. Describe the safety policy components for the given industry.	1.1 Safty planning : Defination, purpose, scope and procedure, variety of plans 1.2 Strategic planning: tools of implementation, objective and its role in safety, policy formulation and implementation. 1.3 Organising: Defination, need, nature and principles, organizing for safety.
Unit-II Industrial Hazards	2a. Identify the causes of hazards for the given industrial process. 2b. Describe the given hazards	2.1 Hazards: Types, causes, effects 2.2 Hazard and risk anaylysis: Quantitative and qualitative:

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	analysis method. 2c. Identify the relevant analysis method for the given hazard. 2d. Describe the safety audit procedure for the given industry.	failure, mode and effect analysis(FMEA), maximum credible accident analysis (MCAA), Fault tree analysis, Event tree Analysis 2.3 HAZAN, HAZOP, managerial oversight review technique (MORT), incident technique, critical incident review technique safety integrity levels (SIL). 2.4 Safety Audit: Objective and procedure.
Unit– III Accident and Incident Investigation	3a. Identify the causes for the given accidents. 3b. Describe the process for accident investigation for the given situation. 3c. Prepare the report for the given accident. 3d. Explain the safety audit act for given industrial process.	3.1 Accident and incident investigation : Philosophy, purpose, process and types of investigations, factors and the immediate and basic causes, corrective action, accident investigating agencies. 3.2 Accident reporting : Report forms, writing reports, elements of report. 3.3 Accident and Incident Analysis : Standard classification of factors, methods of data collation and tabulating data, record keeping. 3.4 Factories Act 1948(Ammendment) and Rules: Provisions, rules, amendments, case law under the Factories Act.
Unit– IV Hazards in Chemical Process Plants	4a. Identify the prevention method of hazard in the given process industry. 4b. Describe the safety measures for the given process industry. 4c. Identify the various hazards in the given process industries. 4d. Describe the sampling technique for the given industry.	4.1 Control, precautions and prevention. 4.2 Industrial safety measures: fertiliser, insecticide, pesticides-chlor-alkali, explosives, polymer plants. 4.3 Sampling technique: toxic, flammables, pharmaceuticals, petro-chemical. 4.4 Industrial disaster: Case study, Bhopal, Flixborough industrial disaster.
Unit –V Plant Maintainance	5a. Identify the responsibilities of maintenance department for the given industry. 5b. Differentiate the preventive and predictive maintainance for the given Chemical plant. 5c. Describe the online maintainnance procedure for the given equipment in chemical industry. 5d. Descibe the shutdown and startup procedure for the given chemical plant.	5.1 Plant maintenance: Functions & responsibilities 5.2 Types of maintenance: Corrective or breakdown maintenance, Scheduled maintenance, Preventive maintenance, Predictive maintenance 5.3 Online maintenance (eg. Rotameter/ Steam trap), Shut down maintenance, Procedure for shutdown and start up of plant.

***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	Safety Planning	08	02	04	06	12
II	Industrial Hazards	12	02	08	06	16
III	Accident and Incident Investigation	08	04	04	06	14
IV	Hazards in Chemical Process Plants	12	02	04	08	14
VI	Plant Maintainance	08	02	04	08	14
Total		**48**	**12**	**24**	**34**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist students 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:

a. Download the videos related to the industrial hazards& rick analysis in process.
b. Prepare the power point presentation on chemical industrial disaster.
c. Collect information related to picktogram& MSDS.
d. Download the maintanance manuals for different chemical process plants.

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:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'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.
c. 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 LOs/COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Use Flash/Animations to explain various safety aspects of chemical process industries.
f. Guide student(s) in undertaking micro-projects

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:

a. **Preparation of the safty plan:** Prapare a plan for safety in chemical laboratory in the institute.
b. **Prparation of chart:** Prepare the chart for different industrial hazards.
c. **Preparation of report:** Write a accident investigation report.
d. **Visit chemical process plant:** Visit nearest chemical process plants for identification of hazard and prepare the report.
e. **Preparation of chart:** Prepare the safty awareness chart for the domestic unskilled workers, working in relation with chemical process.
f. **Preparation of Flow chart:** prepare flow chart of the procedure for shutdown and startup of distillation unit in the laboratory.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Industrial Safety Management	Deshmukh, L. M.	McGraw Hill Education; New York, 2005, ISBN-13: 978-0070617681
2	Industrial Safety and Health MAnagement	Asfahl, C. Ray Rieske, David W.	Prentice Hall, N. J. USA, 2009, ISBN-13: 978-007132368711
3	Hazard analysis Techniquies for system safety	Ericson, Clifton A.	Wiley Publication, N.J. USA, 2005, ISBN : 9781118940389
4	Safe and Efficient Plant Operation and Maintenance (Chemical Engineering)	Kraus, Milton N.	McGraw-Hill Inc.,New York US, 1980, ISBN: 978-0070107076
5	Chemical Process Safety	Crowl, Daniel A., Louvar, Joseph F.	Prentice hall, NJ, USA, 2002, ISBN 0-13-018176-5

14. SOFTWARE/LEARNING WEBSITES

a. http://www.rockwellautomation.com/icstriplex/overview.page
b. http://iom.invensys.com/EN/Pages/Triconex.aspx
c. https://www.honeywellprocess.com/en-US/explore/ default.aspx
d. http://www.hima.com/Products/HIMax_default.php
e. http://www.siemens.com/process-safety


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