

# **Course Handout (Part-II)**

Date: 14/01/2021

In addition to Part I (General Handout for all courses appended to the Time Table), this portion gives further specific details regarding the course.

Course No. : CHE F413

Course Title : Process Plant Safety

Instructor-in-Charge : P C Sande

## 1. Course Description:

Role of safety in society; Engineering aspects of process plant safety; Chemical hazards and worker safety; Hazardous properties of chemicals; Safety aspects in site selection and plant layout; Design and inspection of pressure vessels; Storage, handling and transportation of hazardous chemicals; Risk assessment methods; Toxic release; Fire and Explosions; Safety audit; Emergency planning and disaster management; Case studies.

## 2. Scope and Objective:

- This course deals with various safety aspects encountered in the chemical process industries.
- The primary objective of this course is teach important technical fundamentals for proper assessment of the risks posed by hazardous chemicals and continuous care during their manufacturing, processing, treatment, packaging, storage, transportation, use and sale.
- We will apply the concepts and principles learned in the course to analyze numerous cases of 'real world' chemical process incidents/accidents.
- This course provides guidance for developing industrial safety procedures and equipment designs.

#### 3. Prescribed Text Book:

T1 Crawl D.A., and J.F. Louvar, "Chemical Process Safety: Fundamentals with Applications", Prentice Hall PTR, Englewood Cliffs, New Jersey, 3<sup>rd</sup> ed., 2012.

### 4. Reference Book:

- R1 Trevor Kletz, "What went wrong? Case Histories of Process Plant Disasters", 4<sup>th</sup> edition, Gulf Professional Publishing, 1999.
- R2 Sanders R.E., "Chemical Process Safety: Learning from case Histories", Butterworth-Heinemann, Boston, 1999.





## 5. Course Plan

Module	Lecture Session	Reference	Learning Outcomes	
1. Introduction to chemical process safety	L1.1 Introduction and discussion of the course content; Recent and historical cases of process accidents; role of safety programs in industry; engineering ethics and professional standards;	1.8 (T1)  Examples from R1, R2 and news articles.  1.1 - 1.2 (T1)	<ul> <li>Understand the importance of safety standards in chemical process industries.</li> <li>Internalize the professional ethics and standards in</li> </ul>	
	L1.2 Accident and loss statistics, acceptable risk; public perceptions about safety; Natural of accident process and inherent safety;	1.3 - 1.7 (T1)	chemical industry.	
2. Toxicology	L2.1 Introduction to Toxicology; Toxicological studies, Dose versus response	2.1-2.4 (T1)	<ul> <li>Understanding the toxicology in biological organisms and</li> </ul>	
	L2.2 Models of does: response curves, relative toxicity; Threshold limit values	2.5- 2.8 (T1)	toxicology studies.  • Understand the dose versus response models for toxicants.	
3. Industrial hygiene and personnel safety	L3.1 Introduction to government regulations for worker safety Industrial Hygiene: anticipation and identification	http://labou r.gov.in/ind ustrial- safety- health 3.1 (T1)	<ul> <li>Recognize         government         regulations.</li> <li>Identify,         anticipation, and         evaluation of         various safety</li> </ul>	
	L3.2 Industrial Hygiene: Evaluation	3.3 (T1)		





	L3.3 Industrial Hygiene: Control	3.4 (T1)	aspects of
			industrial hygiene.
4. Source models	L4.1 Introduction to source models; Flow of liquid through a hole; Flow of liquid through a hole in a tank	4.1-4.3 (T1); Read Cases from: 13.1- 13.2 (R1); Chapter 2 (R2)	<ul> <li>Understand         various aspects of         source models for         cause of         accidents.</li> <li>Understand the</li> </ul>
	L4.2 Flow of liquid through pipes; Pipe failures	4.4 (T1); 9.1 (R1)	safety aspects in flowing liquid, gas/vapor
	L4.3 Flow of gases or vapors through holes	4.5 (T1)	through holes from tanks, and in pipes.
	L4.4 Flow of gases or vapors through pipes; Pipe failures	4.6 (T1); 9.1 (R1)	Identify the causes of pipe and
	L4.5 Flash liquids; liquid pool evaporation or boiling; Realistic and worst-case releases; conservative analysis	4.7-4.10 (T1)	tank failures, and methods to mitigate those failures.
	L4.6 Review and discussion of source models	L4.1-L4.5	
5. Toxic Release and Dispersion Models	L5.1 Introduction to toxic release and dispersion models; Parameters affecting dispersion	5.1-5.2 (case 10) (T1)	<ul> <li>Understanding the release and dispersion of toxic material.</li> <li>Study various</li> </ul>
	L5.2 Pasquill-Gifford Model, (Cases 11-15); dense gas dispersion	5.2 (case 11)-5.4 (T1); 5.3 (T1)	dispersion models and parameters affecting dispersion.





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	L5.3 Dense gas transition to neutrally buoyant gas; Toxic effect criteria; effect of release momentum and buoyancy, release mitigation  L5.4 Review and discussion of	5.5-5.7 (T1) L5.1-L5.3	<ul> <li>Apply the toxic release models to mitigate consequences.</li> </ul>
	Dispersion Models		
6. Fires & Explosions	L6.1 Introduction to fires and explosions; Flammability characteristics;	6.1-6.12 (T1),	<ul> <li>Distinguish         between fires and         explosions</li> <li>Understand the</li> </ul>
	L6.2 LOC and inerting, Flammability diagram, ignition energy, autoignition, adiabatic compression, ignition sources, sprays, and mists	6.5-6.12 (T1)	flammability characteristics of liquids and vapors, gas mixtures and the dependence on
	L6.3 Explosions—Detonation and deflagration, confined explosions, Blast from overpressure, TNT equivalency, TNO Multi-Energy Method	6.13 (T1)	temperature and pressure.  • Understand various factors effecting the fires • Understand the
	L6.4 Explosions –Energy of chemical explosions, Energy of mechanical explosions, missile damage, blast damage to people, Vapor cloud explosions, Boiling-liquid expanding vapor explosions	6.13 (T1)	details of explosions; their causes, methods to measure the resulting damage.
	L6.5 Review and discussion of Fires and Explosions	L6.1-L6.4	
	L7.1 Inerting: Purging	7.1 (T1)	





T.2 Static Electricity		<u> </u>		
prevent fires and explosions  1.7.3 Controlling static electricity and explosions  1.7.4 Explosion-proof equipment and instruments; ventilation; sprinkler systems; other concepts for prevention of fires and explosions.  1.8. L8.1 Background of chemical reactivity; Reactive chemical hazards identification and awareness  1.8.2 Characterization of reactive chemical hazards; controlling reactive hazards  1.8.2 Characterization of reactive chemical hazards; controlling reactive hazards  1.8.2 Characterization of reactive chemical hazards, and study the design principles for controlling these hazards.  1.9. L9.1 Relief concepts and Definitions; Location of reliefs; Relief types and characteristics  1.9.2 Relief scenarios; Data for reliefs sizing; Relief systems  1.9.2 Relief scenarios; Data for reliefs sizing; Relief systems  1.0.1 Hazards Checklists, Hazard  1.1.1-11.2 • Understand the concepts of pressure relief systems and their installation and design criteria to prevent or mitigate hazards  1.1.1-11.2 • Understand the concepts of pressure relief systems and their installation and design criteria to prevent or mitigate hazards		L7.2 Static Electricity	7.2 (T1)	
explosions  and instruments; ventilation; sprinkler systems; other concepts for prevention of fires and explosions.  8. L8.1 Background of chemical reactivity; Reactive chemical hazards identification and awareness  L8.2 Characterization of reactive chemical hazards; controlling reactive hazards  18.2 Characterization of reactive chemical hazards; controlling reactive hazards  18.3-8.4 (T1)  18.3-8.4 (T1)  18.3-8.4 (T1)  18.3-8.4 (T1)  29. L9.1 Relief concepts and Definitions; Location of reliefs; Relief types and characteristics  19.2 Relief scenarios; Data for reliefs sizing; Relief systems  19.5-9.7 (T1)  20.5-9.7 (T1)  21.1-11.2  22.4 Understand the concepts of pressure relief systems and their installation and design criteria to prevent or mitigate hazards  L10.1 Hazards Checklists, Hazard  L10.1 Hazards Checklists, Hazard  L10.1 Hazards Checklists, Hazard  L10.1 Understand the concepts of pressure relief systems and their installation and design criteria to prevent or mitigate hazards	prevent fires	L7.3 Controlling static electricity	7.3 (T1)	
8. L8.1 Background of chemical reactivity; Reactive chemical hazards identification and awareness  L8.2 Characterization of reactive chemical hazards; controlling reactive hazards  18.3 L8.2 Characterization of reactive chemical hazards; controlling reactive hazards  18.3 L8.4 (T1)  18.4 Characterization of reactive chemical hazards; controlling reactive hazards  18.4 Characterization of reactive chemical hazards, and study the design principles for controlling these hazards.  9. L9.1 Relief concepts and Definitions; Location of reliefs; Relief types and characteristics  19.2 Relief scenarios; Data for reliefs sizing; Relief systems  19.5 -9.7 (T1)  10.1 Hazards Checklists, Hazard  11.1-11.2 • Understand the concepts of pressure relief systems and their installation and design criteria to prevent or mitigate hazards	and	L7.4 Explosion-proof equipment	7.4-7.7 (T1)	prevent fires and
for prevention of fires and explosions.  8.	explosions	and instruments; ventilation;		explosions.
8. L8.1 Background of chemical reactivity; Reactive chemical hazards identification and awareness  L8.2 Characterization of reactive chemical hazards; controlling reactive hazards  8.3-8.4 (T1)  18.2 Characterization of reactive chemical hazards; controlling reactive hazards  18.3-8.4 (T1)  18.4 (T1)  18.5 L8.2 Characterization of reactive chemical hazards; controlling reactive hazards  18.4 (T1)  18.5 L8.2 Characterization of reactive chemical hazards  18.3-8.4 (T1)  18.6 L8.2 (T1)  18.6		sprinkler systems; other concepts		
8. Chemical reactivity; Reactive chemical reactivity; Reactive chemical awareness  18.2 Characterization of reactive chemical reactive hazards  18.2 Characterization of reactive chemical hazards; controlling reactive hazards  18.2 Characterization of reactive chemical hazards; controlling reactive hazards  18.3-8.4 (T1)  29. Understand the characterization of reactive chemical hazards, and study the design principles for controlling these hazards.  19. Understand the concepts of pressure relief systems  19.1-9.4 (T1)  19.2 Relief types and characteristics  19.2 Relief scenarios; Data for reliefs sizing; Relief systems  19.5-9.7 (T1)  20.1 Hazards Checklists, Hazard  11.1-11.2  10.1 Hazards Checklists, Hazard  11.1-11.2		for prevention of fires and		
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Chemical reactivity: Reactive chemical hazards identification and awareness  L8.2 Characterization of reactive chemical hazards; controlling reactive hazards  L8.2 Characterization of reactive chemical hazards; controlling reactive hazards  P. L9.1 Relief concepts and Definitions; Location of reliefs; Relief types and characteristics  L9.2 Relief scenarios; Data for reliefs sizing; Relief systems  L10.1 Hazards Checklists, Hazard  L10.1 Hazards Checklists, Hazard  L10.1 Hazards Checklists, Hazard  R3.3-8.4 (T1)  8.3-8.4 (T1)  9.1-9.4 (T1)  9.1-9.4 (T1)  9.1-9.4 (T1)  9.1-9.4 (T1)  9.1-9.5 (T1)  9.1-9.5 (T1)  9.1-9.7 (T1)				
Chemical reactivity: Reactive chemical hazards identification and awareness  L8.2 Characterization of reactive chemical hazards; controlling reactive hazards  L8.2 Characterization of reactive chemical hazards; controlling reactive hazards  P. Introduction to reliefs  L9.1 Relief concepts and Definitions; Location of reliefs; Relief types and characteristics  L9.2 Relief scenarios; Data for reliefs sizing; Relief systems  L10.1 Hazards Checklists, Hazard  L10.1 Hazards Checklists, Hazard  Date of the background and case histories of chemical reactivity hazards  P. Understand the characterization of reactive chemical hazards  P. Understand the concepts of pressure relief systems and their installation and design criteria to prevent or mitigate hazards  L10.1 Hazards Checklists, Hazard  L10.1 Hazards Checklists, Hazard  L10.1 Vicinity hazards  P. Understand the concepts of pressure relief systems and their installation and design criteria to prevent or mitigate hazards				
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awareness  L8.2 Characterization of reactive chemical hazards; controlling reactive hazards  1.8.2 Characterization of reactive chemical hazards; controlling reactive hazards  1.8.3 -8.4 (T1)  1.8.4 (T1)  1.8.3 -8.4 (T1)  1.8.3 -8.4 (T1)  1.8.4 (T1)  1.8.3 -8.4 (T1)  1.8.3 -8.4 (T1)  1.8.4 (T1)  1.8.5 -9.4 (T1)  1.8.5 -9.7 (T1)  1.8.6 (T1)  1.8.7 -9.4 (T1)  1.8	Chemical	reactivity; Reactive chemical		background and
L8.2 Characterization of reactive chemical hazards; controlling reactive hazards  1.8.2 Characterization of reactive chemical hazards; controlling reactive hazards  1.8.3-8.4 (T1)  1.8.3-8.4	reactivity	hazards identification and		case histories of
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of reactive chemical hazards, and study the design principles for controlling these hazards.  9. L9.1 Relief concepts and Definitions; Location of reliefs; Relief types and characteristics  19. L9.2 Relief scenarios; Data for reliefs sizing; Relief systems  19. L9.1 Relief concepts and P.1-9.4 (T1) Understand the concepts of pressure relief systems and their installation and design criteria to prevent or mitigate hazards  11.1-11.2 Understand the		· · · · · · · · · · · · · · · · · · ·		characterization
and study the design principles for controlling these hazards.  9. L9.1 Relief concepts and Definitions; Location of reliefs; Relief types and characteristics  L9.2 Relief scenarios; Data for reliefs sizing; Relief systems  9.5-9.7 (T1) pressure relief systems and their installation and design criteria to prevent or mitigate hazards  L10.1 Hazards Checklists, Hazard  11.1-11.2 • Understand the		Teactive flazards		of reactive
design principles for controlling these hazards.  9. L9.1 Relief concepts and Definitions; Location of reliefs; Relief types and characteristics  L9.2 Relief scenarios; Data for reliefs sizing; Relief systems  Definitions; Location of reliefs; Pressure relief systems and their installation and design criteria to prevent or mitigate hazards  L10.1 Hazards Checklists, Hazard  L11.1-11.2 • Understand the				chemical hazards,
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L9.2 Relief scenarios; Data for reliefs sizing; Relief systems  9.5-9.7 (T1)  systems and their installation and design criteria to prevent or mitigate hazards  L10.1 Hazards Checklists, Hazard  11.1-11.2  • Understand the	Introduction	Definitions; Location of reliefs;		concepts of
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prevent or mitigate hazards  L10.1 Hazards Checklists, Hazard  11.1-11.2  • Understand the		reliefs sizing; Relief systems		
hazards  L10.1 Hazards Checklists, Hazard  11.1-11.2  • Understand the				
L10.1 Hazards Checklists, Hazard 11.1-11.2 • Understand the				_
				Hazarus
Surveys; Fire & Explosion Index, (T1) methods of hazard				
		Surveys; Fire & Explosion Index,	(T1)	methods of hazard





	T	1			
10.	L10.2 Hazard and Operability	11.3-11.5	identification using		
Hazard	(HAZOP) studies; Safety Reviews;	(T1)	checklists and		
Identification	Other methods for hazard		surveys.		
	identification such as Human Error,		<ul> <li>Understand the</li> </ul>		
	FMECA		HAZOP studies,		
			safety reviews in a		
			chemical process		
			Familiarity with		
			concepts of human		
			error and FMECA		
			methods for		
			hazard		
			identification.		
			identification.		
11.	L11.1 Review of Probability Theory	12.1 (T1)	Review the		
Risk	144.25	42.2 (T4)	probability		
assessment	L11.2 Event Trees	12.2 (T1)	mathematics and		
	L11.3 Fault trees: Theory	12.3 (T1)	its use in safety		
	,		Understand two		
	L11.4 Fault trees: case study	12.3 (T1)	probabilistic		
	144.5.004	42.4/74)	methods: event		
	L11.5 QRA and LOPA: Theory	12.4 (T1)	trees and fault		
	L11.6 QRA and LOPA: case study	12.4 (T1)	trees		
	,		Understand the		
	L11.7 Review and discussion of	L11.1-L11.6	concepts of QRA		
	Risk Assessment		and LOPA		
			und LOI A		
12.	Static electricity, Chemical	14.1 -14.4	Study major		
6 16 6: 1	reactivity, System designs,	(T1),	accidents and case		
Self-Study:	procedures, List of Major accidents		histories, apply		
Case	(1970-1998)	cases	knowledge gained		
histories and		studies	from the course to		
Major		from	analyze the cases.		
accidents		reference	, 22 3 222		
		R1			



#### 6. Evaluation Scheme:

EC No.	Component	Duration (Minutes)	Weightage (%)	Date & Time	Remarks
1.	Class activities	TBA	10%	-	In class
2.	Project paper with class presentations	TBA	20%	-	In class and take home
3.	Mid-Semester Test	90	30%	TBA by AUGSD	CB + OB
4.	Comprehensive Exam	120	40%	TBA by AUGSD	СВ

<sup>\*</sup>date will be announced in the class

## **Course Policy:**

- Mid Semester Test and Comprehensive Examination are according to the Evaluation Scheme given in the Course Handout.
- If the student is unable to appear for the Regular Test/Examination due to genuine exigencies, the student must refer to the procedure for applying for Make-up Test/Examination (see Academic Regulations-2015). Final decision rests with IC.

## **Project reports and Presentation:**

- The deadline for the report and date of presentations: to be announced in the class.
- Further guidance will be provided during the lectures.

Pedagogy: mode is adapted for online platform and might include film or video clips/ role play or dialogue/ case studies/ breakout sessions etc.

Instructor-in-charge CHE F413



