66215 - Safety and Risk Analysis in the Chemical Industry

Información del Plan Docente

Academic Year	2018/19
Subject	66215 - Safety and Risk Analysis in the Chemical Industry
Faculty / School	110 - Escuela de Ingeniería y Arquitectura
Degree	531 - Master's in Chemical Engineering
ECTS	6.0
Year	1
Semester	Second semester
Subject Type	Compulsory
Module	---

1.General information

1.1.Aims of the course

1.2.Context and importance of this course in the degree

1.3.Recommendations to take this course

2.Learning goals

2.1.Competences

2.2.Learning goals

2.3.Importance of learning goals

3.Assessment (1st and 2nd call)

3.1.Assessment tasks (description of tasks, marking system and assessment criteria)

4.Methodology, learning tasks, syllabus and resources

4.1.Methodological overview

The methodology followed in this course is oriented towards achievement of the learning objectives. A wide range of teaching and learning tasks are implemented, such as

- Theory sessions using the traditional blackboard and audiovisual media.
- Side by side with the theoretical concepts, problems arising from them will be proposed and solved in class for each topic. Students will be advised to work on them prior to their solving. Most cases will be "open" problems with different possible approaches that consciously can lead to discussion.
- In every topic, different "case studies" coming from reports and analysis provided by institutions and professional associations worldwide will be suggested. This material will consist of cases involving real accidents in which hazardous substances have played a primary role. Case studies will be suggested by the lecturer, worked by the

students on their own (individually or in small groups) and commented in class.
- At least one of the case studies will be written down by the students and later handed in to the lecturer, corrected and marked. This mark will constitute a significant part of the final one as is conveniently described in the corresponding issue.

4.2.Learning tasks

The course includes the following learning tasks:

- Lectures (**30 hours**). The theoretical aspects of the different topics will be provided. Besides, these sessions will be the scenario for proposing "model" problems related to the theoretical aspects shown in class.
- Practice sessions (**30 hours**). In these sessions the lecturer will solve problems and case studies previously offered to the students to be worked on their own. Likewise, students will be encouraged to take part in the solving process, proposing alternatives and/or doubts that have arisen along the autonomous solving process. These problems or case studies will be related to the theoretical aspects exposed in the lectures.
- Guided projects (**20 hours**). In groups or individually, students will do 2 or 3 activities proposed along the course that will be supervised by lecturers.
- Autonomous work and study (**50 hours**). It is strongly recommended that students follow a personal study schedule from the very beginning until the end of the course.
- Tutorials (**10 hours**).
- Assessment (**10 hours**). A final global exam will be carried out at the end of the course where it will be evaluated the achievements of the student as much in theory as in practice.

4.3.Syllabus

The course will address the following topics:

1. **0.** Safety and risk analysis. Introduction to safety and risk analysis. Concepts: Risk, danger and accident. Individual risk and societal risk. Individual risk maps. Risk in human activity: risk indexes. Risk acceptability. Loss prevention. Mathematical losses expectation.

SECTION A. RISK ASSESSMENT AND HAZARD IDENTIFICATION

1. **A.1** Comparative methods for hazard identification. Historical analysis. Codes and standards. Checklists.
2. **A.2** Risk indexes. DOW's Fire & Explosion Index. DOW's chemical exposure index. PROCESO Index. Other risk indexes.
3. **A.3** Structured methods of risk analysis. Hazard and Operability analysis (HazOp). What If analysis.
4. **A.4** Quantitative methods of risk analysis. Fault tree analysis (FTA). Event tree analysis (ETA). Failure mode and event analysis (FMEA).
5. **A.5** Reliability engineering. Introduction. Failure rate. Reliability and availability. Failure density function. Human reliability.

SECTION B. CONSEQUENCE ANALYSIS

1. **B.1** Loss of containment. Introduction. Classifications. Factors involved. Characterization of outcoming flow from a vessel. Vapours and gases: flow through orifice. Vapours and gases: flow through pipe + orifice. Liquids: flow through orifice. Liquids: flow through orifice + accessories. Bernouilli's theorem. Crowl & Louvar's equation for non-stationary liquid flow. Complex vessel geometries (horizontal cylinder and sphere). Two-phase flow. Flash fraction. Pool formation. Evaporation models according to the limiting property (heat or material convention).
2. **B.2** Explosions (Gas and Vapours). Introduction. Fire and explosion triangle. Explosion and flammability limits. Flammability diagrams. Autoignition temperature. Minimum ignition energy. Characteristic effects of explosions. Deflagration and Detonation. Differences between fire and explosion. Quantification of the effects of explosions. Pilling effect. Confined cloud explosions (CCE). Bursting of vessels (physical rupture). Emergency release devices: rupture discs and release valves. Unconfined Vapour Cloud Explosions (UVCE). Overpressure graphs. Characteristic parameters of an explosion: side pressure, dynamic pressure, positive and negative phase, arrival time. TNT equivalent model. TNO Multienergy model. TNT equivalent model applied to bursting of vessels.
3. **B.3** Dust explosions. Introduction. Dust deflagration index Kst. Quantification of effects. ATEX Norm. Zone

classification. Case study analysis.

4. **B.4** Fires. Introduction. Classification. Poolfire model. Geometry of the fire: Thomas models. Emissive intensity. Atmospherical transmissivity. Geometric visión factor. Jetfire model. Flashfire model. Case studies.
5. **B.5** BLEVE Explosions. Introduction. Reid's theory of massive nucleation. Geometry of fireballs. Quantification models. TNT equivalent model for BLEVEs. Case study analysis.
6. **B.6** Toxic clouds. Introduction. Convective movement in the atmosphere. Characteristics and atmospheric stability. Adiabatic Lapsus Rate. Wind direction, velocity and persistence: Wind rose, Pasquill-Guifford stability classes. Gaussian dispersion models. Continuous source. Instantenous source. Gaussian model limitations. Model corrections: size of the source, rugosity of the terrain, duration of the exposition. Case studies.
7. **B.7** Vulnerability Analysis.Introduction. Access to human organism. Toxicologic indexes. Population heterogeneity. PROBIT methodology. Vulnerability to persons and materials. Equations for predicting damage by overpressure. Equations for predicting damage by thermal radiation. Equations for predicting damage by toxic exposition. Refuge and evasive actions.
8. **B.8** Chemical reactivity. Reactivity identification. Theoretical methods: CHETAH index. Practical methods: adiabatic calorimetry. Runaway reactions. Semenov's theory. On-set temperature. Maximum adiabatic temperature. Maximum self-heating rate.

SECTION C. NORMATIVE AND LEGISLATION

1. **C.1** Emergency planning. Internal emergency plan (IEP). External emergency plan (EEP). Coordination. Communication of major disasters.
2. **C.2** Normative and Spanish and EU legislation.

4.4.Course planning and calendar

Further information concerning the timetable, classroom, office hours, assessment dates and other details regarding this course, will be provided on the first day of class or please refer to the EINA website (*http://eina.unizar.es*).

4.5.Bibliography and recommended resources