66215 - Safety and Risk Analysis in the Chemical Industry

Información del Plan Docente

Academic Year	2016/17
Academic center	110 - Escuela de Ingeniería y Arquitectura
Degree	531 - Master's in Chemical Engineering
ECTS	6.0
Course	1
Period	Second semester
Subject Type	Compulsory
Module	---

1.Basic info

1.1.Recommendations to take this course

1.2.Activities and key dates for the course

2.Initiation

2.1.Learning outcomes that define the subject

2.2.Introduction

3.Context and competences

3.1.Goals

3.2.Context and meaning of the subject in the degree

3.3.Competences

3.4.Importance of learning outcomes

4.Evaluation

5.Activities and resources

5.1.General methodological presentation

The learning process that has been planned for this subject is based on the following criteria:

Several resources will be employed along the course. The primary one will consist in theoretical expositions by using the traditional blackboard and audiovisual media. Side by side with the theoretical concepts, problems arising from them will be planned and solved in class for every theme. Students will be advised to work on them prior to their resolution. Most cases, they will be "open" problems with different possible approaches that consciously can lead to debate and open

discussion.

In every theme different "case studies" coming from reports and analysis provided by institutions and professional associations worldwide will be suggested. This material will consist of worked 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. Some of them (at least one) will be written down by the students and later collected by the lecturer, corrected and marked. This mark will constitute a significant part of the final one as is conveniently described in the corresponding issue.

5.2.Learning activities

The program offered to the student to assist him/her in achieving the foreseen results, implies the following activities:

Lectures (**30 h**) where the theoretical aspects of the different themes will be provided. Also these sessions will be the scenario for proposing "model" problems related to the theoretical aspects shown in class.

Problems and case studies solving sessions (**30 h**). 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 invited 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 previously mentioned lectures.

Tutored projects (**20 h** - *unattended* -) Conceived for personal work or in group. 2 or 3 activities will be proposed along the course that will be supervised by lecturers.

Personal study time (**50** h - *unattended* -). It is strongly recommended that the student follow a personal study schedule from the very beginning and that it extends up to the end of the course.

Tutored following up (**10 h**).

Evaluation (**10** h). 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.

5.3.Program

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Syllabus:

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.

BLOCK A.- RISK ASSESSMENT AND HAZARD IDENTIFICATION

A.1 Comparative methods for hazard identification. Historical analysis. Codes and standards. Checklists.

A.2 Risk indexes. DOW's Fire & Explosion Index. DOW's chemical exposure index. PROCESO Index. Other risk indexes.

A.3 Structured methods of risk analysis. Hazard and Operability analysis (HazOp). What If analysis.

A.4 Quantitative methods of risk analysis. Fault tree analysis (FTA). Event tree analysis (ETA). Failure mode and event analysis (FMEA).

A.5 Reliability engineering. Introduction. Failure rate. Reliability and availabilyty. Failure density function. Human reliability.

BLOCK B.- CONSEQUENCE ANALYSIS

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. Crow & Louvar's equation for non-stationary liquid flow. Complex vessel geometry (horizontal cylinder and spherical). Two-phase flow. Flash fraction. Pool formation. Evaporation models according to the limiting property (heat or material convention).

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.

B.3 Dust explosions. Introduction. Dust deflagration index K st . Quantification of effects. ATEX Norm. Zone classification. Case study analysis.

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.

B.5 BLEVE Explosions. Introduction. Reid's theory of massive nucleation. Geometry of fireballs. Quantification models. TNT equivalent model for BLEVEs. Case study analysis.

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.

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.

B.8 Chemical reactivity. Reactivity identification. Theoretical methods: CHETAH index. Practical methods: adiabatic calorimetry. Runaway reactions. Semenov's theory. On-set temperature. Maximum adiabatic temperatura. Maximum self-heating rate.

BLOCK C.- NORMATIVE AND LEGISLATION

C.1 Emergency planning.Internal emergency plan (IEP). External emergency plan (EEP). Coordination. Communication of major disasters.

C.2 Normative and Spanish and EU legislation

5.4.Planning and scheduling

Calendar of lectures and Project deadlines

The detailed calendar of activities, as well as the place where they will be celebrated is under the responsibility of the Engineering and Architecture School (EINA), and could be consulted in its web site (*http://eina.unizar.es*) on dates prior to the beginning of the new course. Additionally, every lecturer will inform about his/her availability for personal tutoring and possible modifications that can arise along the course.

5.5.Bibliography and recomended resources

BB	Crowl, Daniel A.. Chemical process safety : fundamentals with applications/ Daniel A. Crowl, Joseph F. Louvar . - 2nd ed. Upper Saddle River, New Jersey : Prentice Hall, cop. 2002
BB	Guidelines for chemical process quantitative risk analysis / [prepared for] Center for Chemical Process Safety of the American Institute of Chemical Engineers . - 2nd ed. New York : The Center, cop. 2000
BB	Mannan, S.. Lees' Loss Prevention in the Process Industries: Hazard Identification, Assessment and Control / S. Mannan Butterworth-Heinemann. 2004
BB	Santamaría Ramiro, J. M.. Análisis y

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	reducción de riesgos en la industria química / J. M. Santamaría Ramiro, P. A. Braña Aísa . - 2ª ed. Madrid : MAPFRE, 1998
BB	TNO YELLOW BOOK. Method for the Calculation of Physical Effects due to Release of Hazardous Materials (Liquids and Gases). CPR14E. Ministerie van Verkeer en Waterstaat. 2005.
BC	Díaz Alonso, Fernando. Explosiones industriales : análisis de consecuencias y distancias de seguridad / Fernando Díaz Alonso Saarbrücken : Editorial Académica Española, cop. 2011
BC	Nolan, D.P.. Safety and Security Review for the Process Industries. Application of HAZOP, PHA, What-If and SVA Reviews / Nolan, D.P. 3rd Edition Gulf Professional Publishing. ELSEVIER. 2012.
BC	Seguridad industrial en atmósferas explosivas / editor, Javier García Torrent [Madrid] : Laboratorio Oficial José María Madariaga, D.L. 2003
BC	Stapelberg, R.D.. Handbook of Reliability, Availability, Maintainability and Safety in Engineering Design / R. D. Stapelberg Springer. 2009
BC	Storch de Gracia y Asensio, José María. Seguridad industrial en plantas químicas y energéticas : fundamentos, evaluación de riesgos y diseño / J. Mª Storch de Gracia y T. García Martín . - 2ª ed. Madrid : Díaz de Santos, D. L. 2008

LISTADO DE URLs:

TNO GREEN BOOK. Method for the Calculation of Physical damage to people and objects resulting from release of hazardous materials. CPR16E. Ministerie van Verkeer en Waterstaat. 1992. TNO YELLOW BOOK. Method for the Calculation of Physical Effects due to Release of Hazardous Materials (Liquids and Gases). CPR14E. Ministerie van Verkeer en Waterstaat. 2005. - [https://www.tno.nl/en/focus-area/urbanisation/environment-sustainability/public-sa