
AC 2012-3985: PROCESS SAFETY MANAGEMENT COURSE DEVELOPMENT

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Deborah Grubbe is Owner and Principal of Operations and Safety Solutions, LLC, a consultancy that specializes in safety and operations troubleshooting and support. Deborah is the former Vice President of Group Safety for BP PLC, which had its two safest years ever during her tenure. She was trained in the characteristics of safe operations during her 27-year career at DuPont, where she held corporate director positions in engineering, operations and safety. Grubbe is a member of the NASA Aerospace Safety Advisory Panel and served as a consultant on safety culture to the Columbia Shuttle Accident Investigation Board. Grubbe currently serves on the Purdue University College of Engineering Dean's Advisory Council, and is an Emeritus member of the Center for Chemical Process Safety. She has worked with the National Academies on the Demilitarization of the U.S. Chemical Weapons Stockpile and is a currently a trustee of the National Safety Council. She is Chair of the Institute for Sustainability, and is a retired Board Member of the American Institute of Chemical Engineers. Grubbe obtained a bachelor's of science in chemical engineering with highest distinction from Purdue University and received a Winston Churchill Fellowship to study chemical engineering at Cambridge University in England. A native of Chicago, Ill., she received the Purdue Distinguished Engineering Alumni Award in 2002, and, in that same year, was named Engineer of the Year in the state of Delaware. In 2010, Grubbe received an honorary Ph.D. in engineering from Purdue University.

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Michael "Mike" Harris, the Associate Dean of Undergraduate Education and a professor of chemical engineering in the College of Engineering at Purdue University, West Lafayette, was named a Fellow of AIChE and won the AIChE Minority Affairs Distinguished Service Award in 2009. He is also a Test Bed Leader and member of the Leadership Team of the NSF supported Engineering Research Center (ERC), "The Center for Structured Organic Particulates," which won the 2010 Research Team Award in the College of Engineering at Purdue University. He is the author of 75 peer-reviewed publications and 10 patents. He received his B.S. in chemical engineering in 1981 from Mississippi State University, and both his M.S. (1987) and Ph.D. (1992) degrees in chemical engineering from the University of Tennessee while working full-time at the Oak Ridge National Laboratory. Harris's research is in the areas of nano-materials, colloids and interfacial phenomena, transport phenomena, particle science and technology, and electrodispersion precipitation processes. He has collaborated on multidisciplinary and multi-institution efforts requiring a range of powerful direct probing methodologies including dynamic light scattering, x-ray scattering, high resolution electron microscopy, and NMR spectroscopy. He is recognized as an outstanding researcher, teacher, and citizen. He also excels at mentoring undergraduates, many (more than 100) of whom have benefited by conducting research in his laboratory. Harris brings a broad perspective in many areas important to Purdue's College of Engineering's strategic plan, especially through his commitment to diversity and the creation of a climate which results in a the improved education and better community for students.

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Process Safety Management Course Development

Abstract

A pilot process safety management course (CHE 49700 – Process Safety Management) was developed in collaboration with industrial consultants as a 3-credit hour elective in the School of Chemical Engineering. The course was enhanced and expanded so that applicability was extended beyond chemical engineering to other engineering disciplines, i.e., chemical, civil, electrical, industrial, materials, mechanical and nuclear engineering. The instructors for the course are also working with the faculty in the School of Chemical Engineering to develop a “Dynamic or Living” Process Safety Library. The electronic library is being populated with safety lecture material, homework and exam problems and multi-media resources that can be incorporated in core chemical engineering courses such as thermodynamics, fluid mechanics, heat and mass transfer, reaction engineering and design. The Dynamic Process Safety Library will also be used as resource materials for students taking the Process Safety Management Course. Additionally, the process safety efforts in the College of Engineering are utilizing the existing resources and materials that are provided by the professional societies of the various engineering disciplines. The chemical engineering safety library will be accessible to the College of Engineering (COE) and beyond S2012, with input and support from other disciplines, is envisioned to become a college-wide resource. This presentation will focus on the philosophy behind the development of the course; the essential elements of the course, the benefit of the collaboration between guest lecturers from the process industries, oil and gas, academia, NGOs and government regulatory authorities in the development of the course; and the results from the assessment of student learning outcomes.

Introduction

The Deepwater Horizon off-shore oil platform explosion and the associated human, economic and environmental impacts vividly illustrate what can happen when process safety management goes wrong. Process safety management is a culture within an organization and a state of mind for every employee from the CEO to the engineer to the operator.

The long term objective of this work is to develop undergraduate process safety management courses for the College of Engineering (COE) so that our graduates have a fundamental safety platform and understanding when they enter industry, government or graduate school.

Global examples of the failure of process safety management are abundant in the last 50 years. Catastrophic incidents including Flixborough, England (1974), Seveso, Italy (1976), Mexico City (1984), North Sea (1988), Pasadena, Texas (1989), and the worst, Bhopal, India (1984) compelled U.S. industry and OSHA to enact 29 CFR 1910.119, “Process Safety Management (PSM) of Highly Hazardous Chemicals” in May 1992. This legislation is intended to prevent or minimize the consequences of catastrophic release of toxic, reactive, flammable or explosive chemicals that would endanger employees or the public and may lead to illnesses, injuries and deaths¹. Since the enactment of CFR 1910.119, process safety management has improved in the U.S. but gaps in adherence and understanding still exist. In 2005, an explosion in the isomerization unit at BP Texas City resulted in 15 deaths and ~180 injured. In 2010, an

explosion in a Massey Energy mine in West Virginia killed 29 workers in the worst mine incident in four decades. Also, in 2010, an explosion on the Deep Water off-shore oil platform in the Gulf Coast left 11 dead and caused yet to be understood damage to the environment and economy. The fines and lawsuits associated with these three incidents have been and will continue to be horrendous². Process safety management must continue to improve and be adhered to if employees, communities and the environment are to be protected.

A revision to the ABET program criteria for chemical engineering programs in January 2012 requires that the curriculum “enable graduates to design, analyze, and control physical, chemical and/or biological processes, and address the hazards associated with these processes.”³ This revision (underlined) requires that we educate chemical engineering students in process safety management. We can no longer rely on our students learning process safety fundamentals as part of Co-Op and internship experiences. Process safety management knowledge extends beyond chemical engineering, and engineers from all disciplines need to be educated in this area.

Course Development

A pilot process safety management course (CHE 49700 – Process Safety Management) is being developed and was first taught in SP2011 as a 3-credit hour elective course in the School of Chemical Engineering. Twenty seven chemical engineering students in their junior and senior year took the course. An enhanced and expanded version of the course is being taught in SP2012 so that applicability of the course is extended beyond chemical engineering. It is envisioned that students in chemical, civil, electrical, industrial, materials, mechanical and nuclear engineering will benefit from the course. Three mechanical engineering students are taking the course in SP2012.

In addition to teaching the Process Safety Management course in SP2011 and SP2012, a “Dynamic or Living” process safety library is being developed. The electronic library is being populated with safety lecture material, homework and exam problems and multi-media resources that can be incorporated in core chemical engineering courses such as thermodynamics, fluid mechanics, heat and mass transfer, reaction engineering and design. The chemical engineering safety library will be accessible to other disciplines in the College of Engineering in the future, with input and support from the other disciplines. Thus, this safety library will become a college-wide resource.

CHE 49700 is being developed by a team that includes a faculty member with 15 years or more work experience at the Oak Ridge National Laboratory, and four personnel with over 20 years each of experience in the chemical and petrochemical industries. Currently, three of the developers of the course consult in the area of chemical process safety. One of the instructors has over 20 years of industrial safety experience, and is currently a staff member/Instructor in the College of Engineering and is a safety champion in the School of Chemical Engineering who promotes laboratory and facility safety to our faculty and students. The course is taught primarily by a faculty member and safety is being developed and taught collaboratively. The faculty sponsor is the primary instructor. The Staff member/Instructor is the course administrator, provides industrial perspective in the class and is one of the instructors. The three

consultants are the content experts and are developing the course material. They also lecture as industry experts during the semester.

The objective of the Process Safety Management course is for students to develop knowledge of process safety management including hazard identification, hazard analysis and risk management. The course is taught three times per week where active learning exercises are incorporated in the class between 10 to 20 minute lecture periods during a 50 minute class. Students are assigned individual and team-based homework and in-class assignments and successful completion of two or three SACHE modules. Two to three exams are also planned during the semester. The final project is a team-based response to a hypothetical chemical disaster. The final project assesses the student's ability to effectively synthesize and apply the semester's learnings. The consultants attend the team presentations and participate in grading the final projects. The expected result is that at the end of the semester, the students enrolled in the Process Safety Management course will have developed a solid foundation in process safety management and will spread the word so the course gains momentum and the interest of additional students. This effect was realized in the second offering of the course in SP2012 where the course is filled to capacity (50 students) and includes as stated above three mechanical engineering students.

The learning outcomes for the course are:

- Be able to design a system, component, or process to meet desired technical, economic, safety, and environmental criteria;
- Be able to utilize the techniques, analytical skills, and modern computational tools necessary for successful chemical engineering practice;
- Understand and appreciate the need for professional integrity and ethical decision making in the professional practice of chemical engineering (6);
- Demonstrate an understanding of contemporary issues encountered in the professional practice of chemical engineering including business practices, environmental, health, and safety issues and other public interests. Our graduate will be aware of the wide-reaching effects that engineering decisions have on society, our global community and our natural environment;
- Demonstrate knowledge and understanding of the elements of process safety management;
- Be able to pro-actively identify and analyze safety hazards;
- Demonstrate knowledge and understanding of risk management tools, programs and processes associated with process safety.

The attached survey was administered the first day of class and will be given again at the end of the class to see if the major learning outcomes have been achieved. Of course, the survey will be modified as the course is further developed to ensure that we are assessing the effectiveness of

the course development in educating our students in the area of process safety management. The timeline for the first two years of course development is given below.

PSM Course Survey

Name: _____ (optional)

(Questions 1-3 will assess your current understanding of PSM. Circle your answers.)

1. Which of the following is **not** an element of OSHA 29 CFR 1910.119 – Process Safety Management?
 - a. Mechanical Integrity
 - b. Management of Change
 - c. Safety Culture
 - d. Employee Participation

2. What is the **most compelling** reason for companies to have a strong PSM process?
 - a. They will lose money if a facility shuts down due to an incident.
 - b. Injuries will be prevented and lives will be saved.
 - c. They will avoid government fines and bad media attention.
 - d. They will protect the surrounding community and environment.

3. Who is responsible for process safety?
 - a. Management
 - b. Operators
 - c. Engineers
 - d. Contractors
 - e. Customers
 - f. b and c
 - g. a, b and c
 - h. a, b, c and d
 - i. b, c, d and e

4. What types of professional experience have you had? (Check all that apply.)
 - a. 5 or 3-session Co-Op _____
 - b. Internship _____
 - c. Research _____
 - d. Other (please describe) _____

5. What are your expectations for ChE 497: Process Safety Management?

Timeline for Course Development

- Develop and teach Process Safety Management (PSM) in chemical engineering SP2011
- Develop process safety library in chemical engineering SP2011/SP2012
- Develop process safety awareness assessment tool SP2011-SP2012
- Share PSM and process safety library with COE faculty and develop plan for broadening applicability to other engineering disciplines SP2011- SP2012
- Revise PSM Course/Implement Process Safety Awareness Assessment Tool SP2012
- Expand process safety library to include other disciplines SP2012
- Offer expanded Process Safety Management course in CoE SP2013

Conclusions

A Process Safety Management course is being developed to better prepare students in developing a process safety culture and the importance of integrating the elements of process safety management into facility safety plans. The course is designed so students work in teams to apply the elements of process safety management to real and simulated industrial and laboratory situations.

Acknowledgement

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Bibliography

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