AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

CENTER FOR CHEMICAL PROCESS SAFETY

SACHE News

Safety and Chemical Engineering Education - Fall 2000

Status of SACHE

J. F. Louvar, Chair
CCPS Undergraduate Education Committee

SACHE already has 75 university members in 2000, and the membership is increasing. For those who have not yet joined, please recall that you will receive products worth $1000 for a membership fee of $300. A great return on your investment!

The real return, however, is the ability to add an element of safety to your courses. This is a real service to your students and out future engineers.

The most recent SACHE highlight is the 2000 Workshop for faculty. It was a great success. See the article by Crowl and Wehman on Page 3.

2000 Workshop Sponsors

A special "thank you" is extended to the sponsors of this workshop. Their financial contributions and commitments of personnel and resources were essential to the success of the SACHE 2000 Workshop.

BASF Corporation
Center for Chemical Process Safety
The Dow Chemical Company
Merck & Company, Inc.
Rohm and Haas Company
Shell Oil Company
U.S. Chemical Safety and Hazard Investigation Board

2000 Products

The products for 2000 have been shipped and included the following:

Free CCPS book
Safety Course (AIChE) for half price
Video - Explosions (Welker)
Problem Set on Mass Transfer (Willey)
NIOSH Pocket Guide to Hazardous Chemicals (CD-ROM)
Design for Overpressure and Underpressure Protection (Grossel and Louvar)
Case History - Batch Polystyrene Reactor Runaway (Willey)
Faculty Workshop (Crowl and Wehman)

SACHE Essay Award

Winners of the SACHE Essay for 2000 are Darcey LaClair, Northeastern University, and Corey Kriegermeier, University of Iowa. Stephanie Keemer, Texas A&M University, and Debbie Steinke, Michigan Technical University, received honorable mention. There were over 300 papers submitted for the essay contest.

Students have an opportunity to write an essay on safety and win $500. We will have two $500 awards and two honorable mention awards every year. Details are summarized on Page 3 of this edition of SACHE News.

SACHE Breakfast at AIChE National Meeting

Each department chair (or SACHE interface) should plan to send one or two of your faculty to our SACHE Breakfast on Tuesday, November 14, during the Los Angeles Annual AIChE Meeting (7:00 a.m. to 8:30 a.m.). At this meeting, we will discuss the status of CCPS and SACHE, and acquire your ideas and suggestions concerning SACHE and our products.

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Volume 10, No. 1 – October 2000

SACHE, or Safety and Chemical Engineering Education, is a project under the auspices of AIChE's Center for Chemical Process Safety (CCPS). SACHE's charter is to enhance the presentation of process safety in undergraduate education.

SACHE News is published two times annually by the Undergraduate Education Committee of the AIChE Center for Chemical Process Safety.

The opinions expressed in the articles contained in the *SACHE News* are not necessarily the opinions of the Center for Chemical Process Safety or the American Institute of Chemical Engineers.

Articles related to any aspects of safety in the academic community are solicited from both the academic and industrial community for publication in *SACHE News*. Material should be sent directly to the editor for consideration.

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SACHE Workshop 2000

Daniel A. Crowl, Michigan Technical University
Jack Wehman, BASF

The 2000 SACHE Faculty workshop was held at BASF in Wyandotte, Michigan, on September 17 through 20. Twenty-four faculty attended representing 22 universities.

This year, we selected a completely different format. In the past, the workshops were delivered primarily in a lecture format, interspersed with plant and laboratory tours. This year, we decided to demonstrate how safety is integrated into the entire life cycle of a particular process, including business objectives, process conceptualization, detailed design, plant construction, operation and maintenance. The faculty participants also worked in teams, assisted by industrial moderators, to review various issues and presented their conclusions to the assembled workshop.

We focused on a single process, in this case the poly-ether process, which uses ethylene oxide and propylene oxide in a semi-batch reactor to produce water soluble polymers. The polyether product in combination with isocyanate compounds is used to produce urethane polymers for a variety of end-uses, including foams for insulation, automobile dashboards, shoe soles, and so forth. The dominant safety issues included toxicity, reactivity and flammability. *Continued next column*

The workshop structure included, in addition to business considerations presentations by experts on various technical and regulatory areas, process and laboratory tours, team discussions on designated issues, and team presentations on selected topics.

The social highlight of the workshop was the picnic Tuesday night at BASF's conference facility on Fighting Island in the Detroit River. A short boat ride up the Detroit River delivered us to this magnificent facility and our steak dinners. The forecast rain never arrived and the weather remained warm and balmy. The end of the picnic was announced by the swarms of mosquitoes that arrived at the appointed time!

We were amazed at the level of participation by the faculty, the concern for understanding the safety requirements of the process, and the enthusiasm for integrating this material into chemical engineering instruction.

The evaluations by the faculty were excellent - confirming that this workshop format is a very viable approach to present this material.

We are hopeful that we will be able to offer a similar workshop next year.

Student Essay Award

The SACHE essay contest for undergraduate chemical engineering students will continue. Students should prepare a 1500 word essay on one of the following or closely related topics:

- Safety in the unit operations laboratory
- Integration of safety into undergraduate education
- Safety relevance in undergraduate education
- Most important safety concepts taught in the university
- How industry can help universities add safety to their courses

Entries should be sent to

Dr. J. F. Louvar
Department of Chemical Engineering
and Materials Science
Wayne State University
Detroit, MI 48202

Deadline for entries is June 1, 2001. The two authors of the winning essays will each recieve $500.

SACHE BREAKFAST
2000 AIChE ANNUAL MEETING
Tuesday, November 14, 2000
7:00 AM to 8:30 AM
Check meetings listing for location.

You are invited to join us at this reception to learn what SACHE has been doing and has on tap for 2001.

This is your opportunity to tell us how you are using our materials, what new products you would like to see, and what formats you would like us to use in the future.

This is also an opportunity to network with other SACHE users.

SACHE member university representatives and universities interested in learning more about SACHE are welcome to join us.

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Agency for Toxic Substances and Disease Registry

The Agency for Toxic Substances and Disease Registry (ATSDR) is an agency of the U.S. Department of Health and Human Services. The mission of the ATSDR is to prevent exposure and adverse human health effects and diminished quality of life associated with exposure to hazardous substances from waste sites, unplanned releases, and other sources of pollution present in the environment.

Several resources are available on the ATSDR web page (http://www.atsdr.cdc.gov/). These include national health alerts and advisories, the ATSDR Hazardous Substance Release and Health Effects Database, Minimal Risk Levels (MRLs) for Hazardous Substances, and public health assessments for sites on the EPA National Priorities List. Two newsletters are also available: *Hazardous Substances & Public Health*, ATSDR's quarterly newsletter, and *Health Risk Communicator*, a newsletter published three times each year by the Subcommittee on Risk Communication and Education.

One particularly useful publication is *A Primer on Health Risk Communication Principles and Practices* (http://www.atsdr.cdc.gov/HEC/primer.html). Although this document was developed to provide a framework of principles and approaches for the communication of health risk information to diverse audiences, it can also serve as a primer for classroom and professional presentations.

Inherently Safer Design

Professor J. P. Gupta of the Indian Institute of Technology, Kampur, has developed a course covering inherently safer design in chemical engineering. The course is designed for 36 to 40 one-hour lectures per semester. At least one visit to a safety conscious company about 2/3rds of the way through the course is recommended. The course can be adapted to a continuing education course of 3 to 4 days in length.

Subject matter includes such approaches as process simplification, minimization (intensification) of hazardous materials, substitution of less hazardous materials, and moderation of process conditions. A review of the causes of major reported accidents is included.

Professor Gupta can be contacted for further information by email at jpg@iitk.ac.in.

Bhopal

Instructors using the SACHE slide package *The Bhopal Disaster* by Ronald J. Willey, and others, may be interested in the incident from another perspective. The article "Bhopal Disaster Spurs U.S. Industry, Legislative Action" (http://www.csb.gov/lib/bhopal01.htm) looks at the implications of the incident on U.S. based multi-national corporations.

Positive reactions, such as the development of industry standards such as Responsible Care® under the Chemical Manufacturers Association (http://www.cmahq.com/), are cited. Legislation resulting from the incident included the 1986 Emergency Planning and Community Right to Know Act. The 1990 Clean Air Act Amendments required EPA to promulgate the Risk Management Program Rule (40 CFR 68) and OSHA to promulgate the Process Safety Management Standard (29 CFR 1910.119). The Amendments also established the independent U.S. Chemical Safety and Hazard Investigation Board (http://www.csb.gov).

Process Safety Progress Database Update

Dennis Hendershot

The database of articles in Plant/Operations Progress - Process Safety Progress has been updated to include 1999, Volume 18. The database is available for download from the Safety and Health Division web site at:

http://www.chem.mtu.edu/org/aiches&h/psp.html.

The database is in the following formats:

- ProCite (Version 3.4)
- Microsoft Access (Version 7)
- Tab delimited text
- Microsoft Excel 95 (note that some entries are truncated due to limited number of characters in an Excel cell)

A complete table of contents for Volumes 1-18 (1982-1999) is also available in Adobe Acrobat format.

SACHE Web Page

SACHE has a page on the AIChE web site (www.aiche.org). Look for announcemts and information at www.aiche.org/sache/.

EDITORS NOTE: The following essay is the first of two winning entries in the 2000 SACHE Student Essay Contest. The second essay by Darcy LaClair, Northeastern University, will be published in the Spring, 2001, issue of *SACHE News*. Each student will receive a $500 award and a certificate at the AIChE Annual Meeting in Los Angeles .

Importance of Process Safety Instruction in Undergraduate Chemical Engineering Curriculum

Corey Kriegermeier
University of Iowa

Throughout the chemical process industry, many aspects of an engineer's daily life are considered common knowledge. Things such as how to approach a new project, creating an accurate estimate for a bid package, managing contractor personnel, and the concept of process safety are all situations that engineers face on a daily basis. For a seasoned engineer, these skills are considered basic knowledge and have been acquired over the years through hands-on experience. Of these basic skills, process safety is the most important. However, this is usually not incorporated into most chemical engineering programs at the undergraduate level with the rest of the core classes such as thermodynamics and material and energy balances. Not having process safety incorporated into course work presents a problem once a new engineer is in the "real world."

As an engineer moves from the academic to the working world, many new concepts are faced that most likely had not been covered in school. Learning the extensive safety procedures and practices that are required to work safely in a chemical processing environment is one of the largest barriers. The introduction to these safety topics should be dealt with prior to an engineer entering the workforce. By introducing process safety at the undergraduate level, the engineer would have a beginning knowledge of such topics as toxicology, flammability limits, fire and explosion characteristics, process safety management systems, relief systems, electrostatics, loss prevention, and hazard identification. All of these safety related topics are dealt with on a daily basis by engineers who are working with or designing processes in a chemical plant. The processes must be in compliance with Occupational Safety and Health Administration and Environmental Protection Agency standards. Without prior exposure to or experience with these standards, it would be easy for a fresh engineer to overlook the concepts covered by these standards. With the instruction of process safety in the undergraduate program, this can be avoided since these issues would be covered making engineers aware of such concerns.

The responsibility of engineers is to ensure safe practices to protect capital investments of companies, prevent chemical releases that pollute the environment, and most of all protect the employees within the work environment and people in nearby communities. By following safe design and work practices taught in a safety course, this loss prevention can be effectively carried out. When dealing with personnel protection, many concepts can be related to process safety instruction; industrial hygiene deals with the identification, evaluation, and control of potential hazards to employees. By identifying potential hazards, certain methods can be used to determine the hazardous effects and efficient ways to reduce these effects. By teaching these concepts early on in an engineer's career, potential risks can be avoided due to the existing knowledge when faced with such situations in the workplace. One other important concept that is discussed in process safety that is very important in the workplace is the concept of runaway reactions.

Runaway reactions can be catastrophic but preventable with the correct knowledge and background of such a phenomenon. By introducing the causes and prevention methods of runaway reactions while still in the academic world, incidents such as Bhopal can be avoided, saving lives as well as money. Being able to determine the conditions for an upset reaction is an invaluable tool to possess when dealing with deadly chemicals. Going hand in hand with runaway reactions is relief design, another tool discussed in process safety. The ability to determine adequate relief capacities prior to entering the workforce could prevent inadequate designs, which in turn would prevent vessel ruptures and save lives and money.

Process hazard assessments and safety reviews are a critical part of any project that takes place in a chemical manufacturing environment. These methods incorporate the ideas covered in a process safety course. The ability to identify potential risks by looking at a proposed system is a key concept used throughout an engineer's career. By having process safety as a fundamental part of the thinking process, the chance of overlooking a potential danger greatly reduces. The only way to ingrain process safety into the thought process is to repetitively use the

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New SACHE Modules

Case History: A Batch Polystyrene Reactor Runaway

Ronald J. Willey

This module is based on a runaway reaction that occurred at the Monsanto Canada, Ltd. plant at LaSalle, a village near Montreal, Canada, on October 13, 1966. At the time the plant was one of the largest producers of polystyrene in Canada.

Although current industrial processes have improved the control of styrene polymerization reactions, the message here is plain and universal. Without careful consideration and control, exothermic reactions can runaway. When they do, the consequences can be very significant, from large fires to an uncontrolled release of a flammable material to large reactor explosions. In this case, a runaway reaction generated enough pressure to burst the rupture disk in the pressure relief system on the reactor. Attached to the relief system was a site glass. This failed when the reactor started to relieve the pressure buildup and contents.

A styrene fog entered the reactor building and ignited. The resulting pressure wave killed 11 men and destroyed the building. This case history examines the events leading up to the incident, the consequences of the uncontrolled release of styrene vapor, possible root causes of the incident, and lessons learned.

Design for Overpressure and Underpressure Protection

S. S. Grossel and J. F. Louvar

This product will help professors, students, and professionals to add the concepts of "overpressure and underpressure protection" to their process designs. This package will help you to:

- Understand the technology, special engineering devices, and methods that are used for the protection against overpressure and underpressure (vacuum) incidents,
- Understand the root causes of overpressure and underpressure incidents, and
- Design plants with the appropriate features to protect against overpressure and underpressure incidents.

This product is deliberately designed to be only an introduction to these topics. Using this "introductory" concept, we were able to design the product for three half-hour lectures or a two hour self-study exercise.

This product is divided into six sections 1) introduction, 2) causes of overpressure and underpressure, 3) reliefs, 4) effluent handling systems for reliefs, 5) runaway reactions, and 6) overpressure protection for internal fires and explosions.

This design package includes an appendix with detailed information for each of the sections of this presentation. The appendix also includes an extensive list of relevant references.

This product is a CD-ROM lecture. The CD-ROM has several icons to allow the presenter to conveniently fast forward and rewind. This product can be used as lectures in a design course, in a seminar, or as a self-directed study exercise.

Chemical Safety and Hazard Investigation Board

The Chemical Safety and Hazard Investigation Board (CSB) is an independent federal agency whose mission is to ensure the safety of workers and the public by preventing or minimizing the effects of chemical incidents at industrial facilities. The CSB has no enforcement or regulatory authority; it is a scientific investigation organization. Established by the Clean Air Act Amendments of 1990, the CSB is responsible for determining the probable causes of incidents, issuing safety recommendations, studying chemical safety issues, and evaluating the effectiveness of other government agencies involved with industrial chemical safety. The Clean Air Act explicitly prohibits the use of any conclusions, findings, or recommendations of the CSB relating to any chemical incident from being admitted as evidence or used in lawsuits. The CSB publishes its actions and decisions through investigation reports, summary reports, safety studies, safety recommendations, special technical publications, and statistical reviews. Summary reports address incidents that are within the CSB's jurisdiction, but because of the limited nature of the issues involved, do not require a more comprehensive investigation and report. Information about investigations, news, and publications may be obtained at http://www.csb.gov.

Process Safety Instruction

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concepts over and over, whether in a classroom setting or in an industrial setting. By utilizing the classroom setting, young engineers would be able to apply the thought process early on in their career making them more useful to their employer as well as the community that they are working in. This would greatly reduce the time required in the workplace before such tasks could be carried out. The thought process gained in the classroom environment could also be applied to the determination of fire and explosion risks in the workplace.

Several key concepts covered in process safety can be used in the analysis of potential fire and explosion scenarios. By utilizing the knowledge of flammability limits, flash points, fire points, MOC, autoignition temperatures, and the fire triangle, appropriate actions may be taken to turn potential hazards into safe operating conditions. The knowledge of these concepts allows the engineer to determine the conditions when a system has the potential for an unsafe operating condition as well as offering methods to reduce this risk. Concepts such as inerting taught in process safety allow for this potentially unsafe condition to be brought into the realm of safeness. Without the knowledge gained in such a process safety course, a potentially dangerous hazard would go unnoticed as a result of the minimal knowledge on the subject of explosions.

An important topic that deals with explosions in the industrial setting that is not covered in process safety, but which should be, is the practice of electrical classification. Electrical classifications are of the utmost importance in an industrial setting where flammable vapors are present. Currently this training is received while in the workplace; however, companies should push for its addition to process safety courses offered at the academic level. The National Electric Code and electrical classifications are fundamental principles that any project or process engineer would face while dealing with any electrical device in an area where flammable vapors are present. These fundamentals are common for anything ranging from a motor on a pump to a control panel for a control system. It is important to be able to identify the type of flammable atmosphere and select the correct equipment as to not have an exposed spark ignite the surrounding atmosphere. Such knowledge that could be gained prior to the entry into the industrial setting would result in fewer incidents dealing with incorrect equipment selection.

Integrating process safety courses into the undergraduate curriculum of chemical engineering is required to fully prepare young engineers for the move from the academic world to the industrial setting. Several key concepts are covered which allow engineers to work with and design processes that are safe for the environment and the personnel of the employer. With the background knowledge gained from such a course, the concept of process safety would be fundamental part of the thought process rather than secondary thought after a process is designed or modified. A significant decrease in catastrophic failures and lost time injuries would be noticed if all young engineers were required to take this most fundamental engineering course. With help from the industrial side, this could be possible, making the chemical processing industry a much safer environment than it currently is.

Louvar and Willey Participate in 2000 Annual Student Conference

The Annual Student Conference will be held at the Westin Bonaventure Hotel, Los Angeles, on November 11-13, the weekend before the AIChE Annual Meeting. The schedule of events can be found at http://www.aiche.org/students/annualconference/program.htm

Joe Louvar, Director of Chemical Engineering, BASF Corporation, and Ron Willey, Chemical Engineering Professor at Northeastern University, will host the Explosions and Control Technology Session of the Frontiers in Chemical Technology Program. They will give talks entitled "Explosions and More Explosions" and "Explosion Control Techniques," respectively.

These presentations will describe the types of accidental explosions that are periodically encountered within the chemical industry and the special process technology and techniques that need to be used to prevent these major accidents. The students and attendees of this session will recognize that accidents of this type must be prevented by the appropriate application of process safety technology. This is particularly important to our engineers in this new millennium. This is an era of larger and more complex production facilities. Even minor errors in the beginning of projects may lead to grave consequences. The engineers in this new millennium have a significant responsibility to design, construct and operate new, better, and safer plants, even as they become larger and more complex.

SACHE Committee Members Make Presentations at AIChE Annual Meeting

Three members of the SACHE Committee will be making presentations under Topical Group T3 - Chemical Engineering in the New Millennium at the AIChE Annual Meeting in Los Angeles. These presentations address issues of chemical process safety in the undergraduate curriculum. The abstracts of the presentations are reproduced below together with the times and locations of the sessions.

[53] - Innovations in Chemical Reaction Engineering Education
8:30 a.m., Monday, November 13, 2000
Movie Theater 1 - Marriott

[53b] - Use of SACHE Products in the Class Room - a Polystyrene Reactor Runaway

Ronald J. Willey, Northeastern University

This paper focuses on a SACHE case history, available from your departmental SACHE representative or AIChE-CCPS, about a runaway reaction that occurred with a batch reactor used in the manufacturing of polystyrene from styrene. This case history provides practical information to students and professors about potential disaster from poorly designed reactors or relief systems. Styrene to polystyrene is extremely exothermic. Although today's industrial processes have improved the control of this reaction significantly by stepwise addition of reactants, the message here is plain and universal: without careful consideration and control, exothermic reactions can runaway. When they do, the consequences can be quite significant, from large fires due to an uncontrolled release of a flammable (as was this case) to reactor explosions. Students studying chemical engineering need to be made aware of situations dealing with exothermic reactions. The photographs and background information such as the Arrhenius, kinetic, and heat transfer equations, help students understand the nature of a runaway reaction. Further, the root cause is discussed, and in this case is partially related to instrumentation that students may encounter in plant environments. By making students more aware of accidents like this one, they will be more conscious of engineering decisions that they will be involved in professionally.

[54] - Chemical Engineering Issues of the New Millenium: Beyond Vision 2020
2:00 p.m., Monday, November 13, 2000
Movie Theater 1 - Marriott

[54f] - Safety Elective Versus Integration into Existing Courses

Joseph F. Louvar , BASF

This talk will first emphasize the importance of adding chemical process safety to the curriculum. Issues will be covered including the viewpoints of industry, professors, and students. The advantages of a safety elective and the advantages of the integration within existing courses will be described. Safety and Chemical Engineering Education(SACHE) resourses will also be described. This information will help professors to give their students an appropriate safety culture and ultimately help them improve their performance.

[65] - Is Unit Operations Necessary in the Era of Simulation?
2:00 p.m., Thursday, November 16, 2000
San Gabriel A - Westin

[65a] - A Unit Operations Laboratory Experiment for Runaway Reactions

Ron Darby, Texas A&M University

Determination of the reactivity of chemicals and compounds is a key element of process safety. In principle, if sufficient information is available for the thermodynamics, kinetics, reaction mechanisms, yields, by-products, thermal properties, mixing, etc. the dynamics of a runaway reaction can be calculated. However, since this information is rarely available, it must be obtained in the laboratory. This presentation describes a relatively simple laboratory experiment using an adiabatic calorimeter (RSST) to characterize a runaway reaction and illustrates how this data can be used to size the relief vent required for the reactor. The experiment can easily be incorprated into the Unit Operations Laboratory to provide students with valuable experience in an important area of process safety as well as very practical experience in engineering design.