SACHE News

CENTER FOR CHEMICAL PROCESS SAFETY
An AIChE Industry Technology Alliance

Safety and Chemical Engineering Education - Spring 2006

Report from the SACHE Committee Chair

DENNIS HENDERSHOT

This will be my last report on the status of SACHE to the SACHE membership. I will not be going away, and intend to remain actively involved with the SACHE Committee, but will no longer serve as the SACHE Committee Chair. Traditionally, the Chair of all CCPS committees, including SACHE, is a representative of a CCPS member company. As many of you know, I retired from Rohm and Haas Company last July, but have continued to chair the SACHE Committee since then. However, the time has come for me to turn over the chairmanship to an industrial representative from a CCPS member company. CCPS is currently looking for somebody to take over the SACHE Committee. If anybody has any suggestions, please pass them on to me (dchendershot@comcast.net), Joe Louvar (josephlouvar@yahoo.com), or Scott Berger (scotb@aiche.org). I want to take this opportunity to thank all of the SACHE Committee members and other supporters of SACHE, including SACHE module authors and SACHE Workshop participants, for their support and hard work for this important effort to bring safety to chemical engineering students.

As you may know, the AIChE Board of Directors suspended the ChemE Car competition this year because of a number of safety incidents, both at the finals at last year's competition at the AIChE National Meeting in Cincinnati, and during the preparation for this year's competition. Following the suspension, the Board asked a group of SACHE members, headed by Dr. Ron Willey of Northeastern University, to develop a protocol and set of requirements to improve safety in the ChemE Car competition. This protocol was developed and, in early June, the AIChE Board reinstated the competition for this year. Some of the enhanced safety requirements for participation in the ChemE Car competition include:

- A required safety workshop for team captains and faculty advisors
- Safety inspections by designated people with appropriate safety experience at both regional and national competitions
- A safety design, construction, and operation plan approved by the faculty advisor
- A Job Safety Analysis (JSA) form must be provided
- The car must be safely tested and run at least 3 weeks before the competition

The four known ChemE Car near misses will be written up as case studies and posted on the ChemE Car web site to demonstrate the consequences of unsafe operation. Additional detailed information on the new requirements for the ChemE Car competition will be posted on the web site as a part of the updated competition rules over the summer. There are also special provisions for this year's competition, because the regional competitions have already been run. The ChemE Car competition group can be contacted through the web site (http://www.aiche.org/Students/Awards/ChemeCar.aspx) for more information.

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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 communities for publication in *SACHE News*. Material should be sent directly to the editor for consideration.

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Report from the Chair

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Inherently safer design of chemical plants continues to receive attention from activist groups, the media, state and local government, and the United States Congress. Contra Costa County, California has required covered facilities to consider inherently safer design options for several years under its industrial safety ordinance. In November 2005, New Jersey also began requiring the consideration of inherently safer design for covered facilities as a provision of new state requirements for chemical plant security. The issue continues to be debated in Congress, and several chemical facility security bills have been introduced, some of which include requirements for consideration of inherently safer design. SACHE has an existing 35mm slide module on inherently safer design, and, this summer, we will be providing a new and updated PowerPoint module on this timely topic.

Thank you again for the opportunity to work with all of you for the past several years as the SACHE Committee Chair, and I look forward to continuing to work with SACHE in the future with the new committee chair.

Process Safety in U.S. Chemical Engineering Curriculums

The Mary Kay O'Connor Process Safety Center at Texas A & M University recently completed a survey of 180 universities to determine the status of process safety in chemical engineering curriculums in the United States. Highlights of the study are

- About 20 universities (11 % of the chemical engineering departments) have process safety as part of the core curriculum.

- An additional 24 universities (13 % of the chemical engineering departments offer a process safety course as an elective.

- Five universities have plans to introduce process safety in their curriculum in the near future.

More details of the survey are published in the Spring 2006 *Centerline* Newsletter (http://psc.tamu.edu/publications/news_letter/SPR%202006.pdf).

U.S. Chemical Safety and Hazard Investigation Board Safety Videos

The U.S. Chemical Safety and Hazard Investigation Board, or CSB, has released a DVD of the safety videos issued through March 2006. The videos feature animation, video, photos, and recommendations and safe practices. The titles are

1. *Ethylene Oxide Explosion at Sterigenics, Ontario California*
2. *Dangers of Flammable Gas Accumulation: Acetylene Explosion at ASCO, Perth Amboy, New Jersey.*
3. *Explosion at BP Refinery, Texas City, Texas*
4. *Preventing Harm from Sodium Hydrosulfide (NaHS)*
5. *Excerpts from CSB Public Hearing on Hazards of Combustible Dust*
6. *Excerpts from CSB Public Hearing On New York City Building Explosion and Need for Fire Code Reform*
7. *About the CSB*

Each of the videos can be viewed or downloaded from the Video Room at http://www.csb.gov/. Alternatively, a request can be submitted to receive a DVD containing all the current videos.

New SACHE Products for 2006

These SACHE products are available to member universities. Faculty and students should contact their SACHE representative for access to these and other SACHE products, including slide and PowerPoint presentations, videos, problem sets, NIOSH publications, and CCPS books. Recent SACHE deliverables are posted at http://www.sache.org.

Dust Explosion Prevention and Control

J. F. Louvar and R. Schoeff
Wayne State University

This SACHE product covers the fundamentals and guidelines for preventing dust explosions. This product includes three sections:

Section 1: A PowerPoint presentation describes the basic concepts for understanding dust explosions (deflagrations, detonations, necessary conditions for causing dust explosions, and the consequences of dust explosions).

Section 2: This includes two DVDs call Deadly Dust II and III. Deadly Dust II was developed in the 1980s and it emphasizes the technology to prevent dust explosions. Deadly Dust III was developed in the early 2000s and emphasizes the injuries caused by dust explosions. Both DVDs include case histories. Although the DVDs were specifically developed for the grain industry, everything in this product is relevant to the prevention of any dust explosion. The DVDs are available through streaming video links in one of the product files.

Section 3: This section covers the fundamentals for eliminating dust ignitions from the build-up of static electricity. The topics which are described in this PowerPoint presentation include: a) conditions for the accumulation of static charges, b) specific types of static electricity discharges, c) calculation methods for estimating the potential for ignitions, d) case histories, and e) design methods for eliminating ignitions.

This product supports the U.S. Chemical Safety Board's emphasis concerning the hazards of handling dusts. This emphasis is due to the continued accidents and injuries that are the result of dust explosions.

Design for Overpressure and Underpressure Protection

S. S. Grossel
Process Safety and Design, Inc.

J. F. Louvar
Wayne State University

This product will help faculty, students, and professionals incorporate proper overpressure and underpressure protection in their process designs. This package helps students:

- Understand the technology, special engineering devices, and methods that are used for 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 SACHE product contains two PowerPoint presentations that can be copied and modified to fit specific teaching/learning objectives. It includes detailed instructions covering a) reliefs, b) runaway reactions, and c) safeguards to prevent accidents. This product can be used in design, fluid flow, or control courses. Some background information is included in this package (see Abstract - References) to assist the student in understanding these general concepts. The package is deliberately designed to be only an introduction to these topics. Using this introductory approach, the package can be used for three half-hour lectures or two hours of self-study exercises.

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SACHE Products

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Student AIChE Student Design Problem Solution (2002 Problem)

S. Horsch and J. F. Louvar
Wayne State University

J. Wehman
BASF Corporation (Retired)

This product includes a solution to the 2002 AIChE Design Problem that was developed by a student (S. Horsch) with significant assistance from very knowledgeable design professionals; these are the professionals who developed this design problem, and they have worked on this design in an industrial environment.

This product includes concepts, calculations, and drawings that can be used in future AIChE design solutions, for example:

- Relief valve calculations for gases, liquids, and two phase flows;
- Safety review including hazards and resulting safety measures to prevent accidents and inherent safety concepts and features;
- The process flow diagram (PFD) and process and instrument diagram (P&ID); and
- MathCad programs for making the design calculations.

All of the MathCad programs and Visio drawings can be copied for use in future design problem solutions. Additionally, the safety review and inherent safety discussions will be an excellent aid in the development of safety and inherent design concepts for all future AIChE design problems. The AIChE Student Chapters Committee that administers the annual AIChE Design competition approved posting of this example problem.

Safety in the Chemical Process Industries

D. A. Crowl
Michigan Technological University

This video series entitled "Safety in the Chemical Process Industries" presents a strong introduction to the application of chemical process safety technology in an actual chemical facility. All video material was taped at the Chemical Engineering Research Department at BASF Corporation in Wyandotte, Michigan. Most of the demonstrations are given using actual process equipment in the BASF Process Development facility.

This series is designed as instructional material for undergraduate students in chemical or mechanical engineering as well as industrial engineers or chemists who are being introduced to industrial safety for the first time. This series provides significant supplementary material for an existing undergraduate chemical engineering course on chemical process safety. This series was funded by the National Science Foundation and by BASF Corporation.

Hyperlinks to streaming video sources are included in a word processing file. A Study Guide and Instructor's Guide were written to accompany the video, and both guides are included with this product.

OECD Program on Chemical Accidents

The Environment Directorate of the Organization for Economic Cooperation and Development (OECD) provides governments with the technical basis to develope effective and economically efficient policies. In particular, the Program on Chemical Accidents helps public authorities, industry, labor and other interested parties prevent chemical accidents and respond appropriately if one occurs. The home page of their website is http://www.oecd.org. This is an excellent resource for safety and environmental information.

State Fire Marshal's Alert

February 22, 2006

University Campus Liquid Nitrogen Cylinder Explosion

Recently, a compressed gas cylinder exploded in a state university campus laboratory. The explosion was attributed to dangerous alterations that had been made to the cylinder. To help prevent similar gas cylinder-related incidents, universities shall, at a minimum:

- Repair, replace or remove from service leaking, damaged, or corroded compressed gas cylinders or systems.
- Implement and sustain a preventative maintenance program for all compressed gas cylinders and systems. A preventative maintenance program shall include periodic inspection of all cryogenic fluid storage systems and replacement of pressure relief valves every five years, ensuring the valve is set as required by the tank design. A record of the inspection should be prepared and provided to the user or the authority having jurisdiction upon request.
- Ensure that an individual trained in tank usage be in attendance at all times cryogenic fluid is transferred from one container to another.
- All service, repair, modification, or removal of valves, pressure-relief devices, or other container appurtenances shall be performed in accordance with National Fire Protection Association (NFPA) Standard 55 and the Compressed Gas Association (CGA) guidelines (http://www.cganet.com/Publication.asp?mode=c).

Figure 1 -Effect of Explosion on Dewar Cylinder Compared to unaffected cylinder

Incident Specifics

Figure 2 - Hallway Outside Laboratory Showing Explosion Damage

At approximately 3:00 a.m. on Thursday, January 12, 2006, an explosion occurred in a state university chemistry building laboratory, causing substantial building damage. The explosion resulted from a rupture in a liquid nitrogen (Dewar) cylinder. The cylinder was originally constructed and tested in December 1980.

The State Fire Marshal's Office, in cooperation with the university's environmental health & safety office, conducted an investigation that included an assessment of the building damage and reconstruction of the events leading to the explosion. The resulting examination revealed catastrophic failure of the cylinder. The failure permitted rapid expansion of the nitrogen gas, blowing out the bottom of the tank and propelling the cylinder upwards.

Figure 3 - Inside the Laboratory after Explosion

The examination revealed that the cylinder's pressure release valve and rupture disc had been replaced by two brass plugs. Without these two features in place, the cylinder's rupture-prevention function became compromised. During the investigation, lab students related that the bottom portion of the cylinder had been frosting for approximately twelve to eighteen months, suggesting to them that the cylinder was "leaking". It is speculated that the tank was relieving normal excessive pressure through an old leaking gasket on the top of the tank (the actual pressure-relief function had been plugged). Approximately twelve hours prior to the explosion, one of the students replaced the leaking gasket and refilled the cylinder. As the old gasket that helped relieve internal pressure had been replaced, the now full cylinder was completely sealed. The cylinder ruptured when its internal pressure rose above 1,000 psi.

The catastrophic failure of the nitrogen cylinder was a direct result of the removal and subsequent plugging of the internal tank pressure relief devices. The cylinder was modified by inexperienced and unidentified person(s) resulting in the eventual failure of the cylinder. It could not be determined when the modifications took place.