**2009 International Symposium Achieves Record Turnout**

The 2009 Mary Kay O’Connor Process Safety Center International Symposium, Beyond Regulatory Compliance, Making Safety Second Nature was a great success with a record attendance of 450+ attendees, traveling from across the globe.

The two day symposium featured presentations containing relevant information, including the keynote address presented by Dr. Andrew Hopkins, Professor of Sociology, at the Australian National University. He presented “Why BP Failed to Learn the Lessons: The Texas City Refinery Explosion”

Also during the symposium, the annual Merit and Service Awards were presented. The Service Award was established by the Steering Committee to honor and recognize individuals who have contributed directly to the success of the Center and have played a significant role in advancing the mission of the Center. The 2009 Service Award was presented to Mr. Don Kimbril, Chief Safety Engineer of ExxonMobil Chemical Company in Baytown Texas, and chair of the Mary Kay O’Connor Process Safety Center Steering Committee.

The Merit Award recognizes an individual who has made significant contributions to the advancement of education, research, or service activities related to process safety concepts and/or technologies. The contributions or accomplishments leading to the annual Merit Award need not be associated with the Center but must fit within the central theme of the Center, i.e., Making Safety Second Nature. The 2009 Merit Award was given posthumously to Ms. Carolyn Merritt, former chairman and chief executive officer of the U.S. Chemical Safety Board. The award was accepted by Carolyn’s daughter Shannon Ross.

Seventy papers were presented during the two days of the symposium. Summaries of the papers are included here, beginning on page 11 of this newsletter.

Next year’s Mary Kay O’Connor Process Safety Center International Symposium will be held on October 26-27, 2010 at the College Station Hilton.
At the 2009 Annual International Symposium of the Mary Kay O’Connor Process Safety Center, Ms. Carolyn Merritt was honored posthumously with the Center’s Merit Award. Carolyn Merritt was chairman of the US Chemical Safety Board (CSB) from August 2002 until August 2007, died in on August 29, 2008, after a long and characteristically tough fight against cancer. I chose the words “characteristically tough” intentionally because that is what she was. If she believed in it, no fight was unwinnable and you could rest assured that she would put everything in the fight. When she was nominated to the CSB, she had already completed a career that spanned 30 years working as a high school teacher, as a general foreman, environmental manager and corporate officer. But her signature assignment would be her last as the chairman of the CSB in government service. In my opinion, Carolyn Merritt left her indelible mark on the mission and role of the CSB in process safety issues in the chemical industry. The second day of the 2009 Symposium, the opening session was a tribute to Carolyn Merritt and her accomplishments. It was also an opportunity to talk about the direction and the role CSB has been playing in the process safety arena since Carolyn righted the ship.

Carolyn Merritt went to school at Radford University obtaining a degree in Analytical Chemistry. In addition to being passionate about her job and family, Carolyn’s interests were traveling, gardening, teaching Reformation Theology and “yes, can you believe it, motorcycling.” From the 1980s to 1994, Carolyn had several jobs with increasing responsibilities at Champion International Corporation and Tennessee Chemical Company. From 1994 to 1995, she worked for RMT, Inc. I also was working for RMT at that time and had the privilege to work with her at that time. I could you tell you numerous anecdotes about my interaction with her at that time, but let me summarize them all by saying that as I look back at those two years, I am not surprised by what Carolyn went on to later on and her accomplishments at the CSB. Soon Carolyn moved on to her next assignment and two years later in 1997 I moved to my next assignment, i.e., to my current job at the Mary Kay O’Connor Process Safety Center. From 1994 to 2001, Carolyn served as Senior Vice President for Environment, Health, and Safety for The Vigoro Corporation and then IMC Global, a billion dollar agricultural chemicals company with as many as 12,000 employees.

During our work at RMT, Inc. we happened to work together on several projects. Even at that time, I was impressed by the strong conviction and commitment Carolyn showed towards environmental, health and safety issues. Carolyn insisted on a quality job, was willing to call it like it was, even if that meant losing a project. After she left RMT, she joined The Vigoro Corporation which later on became IMC Global. Within two weeks of her joining the new company, she called back and said she needed help. She wanted to mould the Environmental, Safety and Health programs within the company in her own vision and she knew that she needed expertise and help from outside and she was not afraid or threatened by either admitting it or asking for help.

In July 2002 when President George W. Bush nominated her as the Chairman of the Chemical Safety Board, Carolyn Merritt was prepared for the challenge. A career of working in facilities that manufactured chemicals, fertilizers, pharmaceuticals, munitions, minerals, and pulp and paper had prepared her for the challenges she faced in a fledgling new agency with questionable reputation and numerous critiques. She had experience in research, quality control, process engineering, plant operations, wastewater treatment, environmental compliance, worker safety and executive management. She wanted to bring her experiences in working with communities, industrial managers and workers to reduce the risk at facilities and prepare for emergency response in the event such an event were to occur. She eagerly wanted to continue her work as part of the Chemical Safety Board.
Through my personal interactions with Carolyn as well as a thorough reading of her public comments and speeches, I have tried to summarize Carolyn’s core beliefs:

- OSHA’s 1993 Process Safety Management standard was an important milestone in improving plant safety and protecting workers, residents, and the environment
- Management must set the pace and driving force for process safety programs
- Management and operating staff should work in concert in the implementation of process safety programs
- Process safety regulations and programs save lives and prevent substantial environmental damage
- The chemical industry is an important contributor to our economy and quality of life
- Government has a significant role to play in verifying the safety and compliance of chemical manufacturing facilities and facilities that use hazardous chemicals in their processes
- The Chemical Safety Board should work in partnership with enforcement agencies, the regulated community and Congress to determine how best to use lessons learned from incident investigations to prevent their recurrence
- Prevention has to be the ultimate reason for regulation
- The CSB can be an important vehicle to achieve effective prevention
- The combination of academic, industrial, and agency experience is needed for progress in process safety performance

With these beliefs Carolyn Merritt came to the CSB and set about charting a new course. I am sure that even her worst critics would agree that she brought her executive and organizational skills to move the agency forward; improve morale and effectiveness; and achieve the support and respect of this Committee, sister government agencies, and industry. Those who knew about her work knew about her untiring work towards improving workplace safety as well as environmental performance. During her 5-year term at the CSB, she committed the fledgling agency to build on a new legacy. She brought great vision and energy to the CSB. When the agency was struggling to find its own image and identity, she provided great leadership in righting the ship and establishing the CSB as a respected federal agency producing quality incident investigations and disseminating lessons learned. There is no question that she has left an indelible mark and her legacy at the CSB.

Carolyn was ideally suited to the role of CSB Chairman when she was appointed by President George W. Bush in 2002. As I said earlier, prior to becoming the chairman, Carolyn had served for many years in executive roles in major corporations with responsibility for health, safety, and environmental issues. But she brought more than her experience and expertise to the agency. Carolyn believed passionately in the CSB’s mission. She worked tirelessly to save lives of workers and the public through chemical accident prevention, insisting on thorough investigations and meaningful safety recommendations. Carolyn led a great renewal of the agency, establishing it as a highly respected institution in the field of chemical process safety. She greatly increased the CSB’s productivity and its impact on safety. She worked hard to recruit new staff and build bridges with colleagues worldwide. Words cannot begin to express the extent of everything she accomplished. The safety community has lost a remarkable woman and a trailblazer.

M. Sam Mannan
Fall, 2009


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Information on Consortium membership can be found at:

http://psc.tamu.edu/membership

or by contacting Valerie Green at val-green@tamu.edu or Donna Startz at donnas@tamu.edu or 979/845-3489.
Visitors to the Center

The Center was host to many visitors this Fall, including several renowned guest lecturers who presented seminars, which were open to all department faculty, graduate students and staff.

On October 9, 2009, Dr. Maria Molnarne, visiting from the BAM company in Germany, presented “Explosion Protection Using the Database CHEMSAFE”. Molnarne also presented the lecture entitled, “Gas and Dust Explosion Behavior,” on October 13, 2009.

Dr. Hans Pasman a research professor with the center, “Sustainability of This World Forces Us to Alternative Fuels. New Fuels, New Risks to Cope With!” on October 19, 2009.

Dr. Adam Markowski, professor at the Technical University of Lodz in Poland presented, “Process Safety Education and Research at the Technical University of Lodz, Poland” on November 2, 2009. Dr. Markowski also guest lectured to students in Process Safety and Safety Engineering academic courses.

Also visiting the center was Dr. Maria Papadaki, professor at the University of Ioannina in Greece presented the seminar entitled “The Photolytic/Photocatalytic Destruction and Genotoxicity of Clorinated Pyridines,” on November 6, 2009.

Mr. Roy Sanders spent a week at the Center in October. He presented guest lectures to students in Process Safety and Safety Engineering academic courses, and spent time with many of the MKOPSC graduate students.

Dr. Tomasz Olewski, postdoctoral research associate at Texas A&M University at Qatar, is visiting the center to conduct LNG research. Dr. Olewski is also a faculty member at the Technical University of Lodz in Poland.

Dr. Zhenlin Li, from the Mechanical & Electronic Engineering Department at China University of Petroleum-Beijing, will be at the center for six months, conducting research and visiting with students.

The center is hosting many international graduate students, who will be attending classes and conducting research at the center during a six month stay. They include Christian Ovalle from the Technical Institute of Celaya, Mexico, and Bibian Amaya, Alberto Benavides, Olga Reyes, and Carlos Espindola from the Industrial University of Santander in Bucaramanga, Santander, Colombia.

Iowa Governor’s Safety & Health Conference

Dr. Sam Mannan recently gave a keynote speech at the Iowa Governor’s Safety & Health Conference held on November 4th & 5th, 2009 in Cedar Rapids, IA. The 38th Annual conference was entitled, “Safety at Risk: Choice and Influence.”

Mannan presented “Making the right Decision: What we Learn From History” on Wednesday, November 4 at the Cedar Rapids Marriott Hotel.

In addition to Mannan’s address, the conference featured keynote presentations from John S. Bresland, chairman/chief executive officer of the U.S. Chemical Safety Board, and John Henshaw, former assistant secretary of labor for the Occupational Safety and Health Administration.
Qingsheng Wang, graduate student in the Mary Kay O’Connor Process Safety Center and Artie McFerrin Department of Chemical Engineering, has been awarded a Graduate Student Research and Presentation Grant funded by the Association of Former Students and the Office of Graduate Studies. The grant is in the amount of up to $400 to cover travel expenses to attend the 2009 American Institute of Chemical Engineers Annual Meeting, which was held on November 8-13, 2009 in Nashville, TN.

The center would like to recognize and thank Shell International Exploration and Production Inc. for their sponsorship of the 2009 MKOPSC Alumni Reunion. Through Shell’s generosity the center held a day of festivities honoring past and upcoming graduates of the center.

Through a generous donation, Chevron has awarded two annual Chevron Safety Certificate Scholarships in the amount of $3000. Recipients of these scholarships are Amanda Roberts and Cody Osgood, both undergraduate students in the Artie McFerrin Department of Chemical Engineering. Said department head Dr. Michael Pishko, “We applaud Chevron for their generous donation and continued support of our academic programs, particularly those in process safety.”

Victor Carreto-Vazquez, a graduate student in the Artie McFerrin Department of Chemical Engineering at Texas A&M University, has been selected as the recipient of the 2009 Lamiya Zahin Memorial Safety Scholarship. Carreto-Vazquez, who is conducting his graduate studies under the auspices of the Mary Kay O’Connor Process Safety Center (MKOPSC), received the scholarship for his essay “Expanding MKOPSC Dust Explosion Research Capabilities by including MIE and Electrostatics Charge Accumulation/Discharge Research.” He was presented the scholarship at the center’s annual international symposium.

The scholarship was established by MKOPSC and the department of chemical engineering to honor the memory of Lamiya Zahin, the daughter of chemical engineering graduate student Saquib Ejaz. Zahin died from injuries sustained in an explosion and fire in a university apartment on the Texas A&M campus in 2004. Ejaz’s mother also died from injuries sustained in the accident.

Each year Texas A&M graduate students are encouraged to apply for the scholarship by writing an essay on “Safety Innovations in Research Projects.”

Three groups of students from Texas A&M University’s Artie McFerrin Department of Chemical Engineering have been recognized by the Mary Kay O’Connor Process Safety Center and BP for their work focusing on improving safety in the process industries.

Participating in a process safety management course offered through Texas A&M’s chemical engineering department, Samuel A. Swasey, Aurea S. Tandazo, Daniel A. Thierry, Lynda Tran and Jared A. Walker were awarded top honors by BP, the competition sponsor, for their paper titled “Detonation: Myth or Reality.”

The team of Adam A. Spriggs, William A. Stephens, Steven, Andrew T. Stitt and Bryan Holekamp was awarded second place for their paper titled “A Programmatic Approach to Reducing the Number of Fire-related Deaths in the U.S.”

Kimberly K. Salinas, Jaynesh J. Shah, Stephan P. Smith and John E. Sorrells received third-place recognition for their paper titled “Characteristics of Facilities with CSB Investigations.”

As part of their recognition, each team received a monetary prize from BP. Founded in 1909, BP is one of the world’s largest energy companies, providing its customers with fuel for transportation, energy for heat and light, retail services and petrochemicals products for everyday items. Active in 100 countries, BP employs more than 96,000 people worldwide.
The Mary Kay O’Connor Process Safety Center (MKOPSC) is offering the following safety education and process safety engineering courses in Fall 2009, via the Petroleum Engineering Department’s Distance Learning Program.

These distance learning courses are eligible for academic credit or Continuing Education Units (CEUs). To receive academic credit for the courses, you must be a currently enrolled student at Texas A&M University. The courses also apply towards the Safety Engineering Certificate.

### Spring 2010 Offerings

**SENG 312 – SENG 674: System Safety Engineering**

Instructor: Dr. Dedy Ng

Application of system safety analytical techniques to the design process; emphasis on the management of a system safety or product safety program; relationship with other disciplines such as reliability, maintainability, human factors and product liability applications. Prerequisite: Junior classification.

**CHEN 455 – SENG 455: Process Safety Engineering**

Instructor: Ray Mentzer

Applications of engineering principles to process safety and hazards analysis, mitigation, and prevention, with special emphasis on the chemical process industries; includes source modeling for leakage rates, dispersion, analysis, relief valve sizing, fire and explosion damage analysis, hazards identification, risk analysis, accident investigations.

**CHEN 460/660 – SENG 460/660: Quantitative Risk Analysis in Safety Engineering**

Instructor: Dr. William J. Rogers

Following the growth in complexity of engineering systems, demands are increasing for health, safety, and environmental quality with more stringent requirements for reliability and increased engineering performance. This course presents the fundamentals of quantitative risk analysis for cost-effective engineering applications, risk criteria, and risk decisions.

To register for a course, contact:

**Mary Cass**

Mary Kay O’Connor Process Safety Center
3122 TAMU - 244 Jack E. Brown Building
College Station, TX 77843-3122
Phone: (979) 458-1863
E-mail: mary-cass@tamu.edu

*CEUs will be issued through the Mary Kay O’Connor Process Safety Center upon successful completion of the course.*

### Distance Learning Objectives

In the future, the Center plans to offer all courses online for the Safety Engineering Program and the Safety Engineering Certificate Program, to teach the knowledge and skills required for safety, health, and environmental engineering.

Also in future plans is the ability to offer the Masters of Engineering in Process Safety and Masters in Safety Engineering programs as distance education programs. The objective of the non-thesis Masters of Engineering in Process Safety (ME-PS) program is to teach the principles and practices of process safety engineering for leadership careers in the process safety. For more information on requirements and prerequisites, please see website at:

http://psc.tamu.edu/education/safety-engineering-program
Case History Presented by MKOPSC Graduate Student at October 26 Steering Committee Meeting

Ethylene Oxide Explosion at Sterigenics International Facility
Presented by Mahdiyati Syukri

On August 19, 2004, an explosion occurred at ethylene oxide (EO) sterilization facility owned by Sterigenics International. The explosion resulted from EO-laden air that got ignited in the catalytic oxidizer. As consequence, four workers were injured and the 66,000 square-foot Ontario, California facility was extensively damaged. The Sterigenics plant and neighboring facilities were evacuated, and the plant’s operation was disrupted for nine months.

Sterigenics International, Inc. is a contract medical sterilization service company and its facility in Ontario performs sterilization for products such as disposable syringes, urinary catheters and cardiovascular stints and valves. Prior to the incident, the facility’s control system alerted of an EO injection failure in one of the sterilization chambers. The operators then decided to abort the sterilization process, emptied the chamber and performed maintenance to identify the gas injection problem. There was no problem found and then a calibration cycle was utilized using 125 lbs of EO to put the chamber back on immediate operation. At this point, the final gas wash of the cycle was bypassed because of the misbelief that the single cycle had removed the explosive concentration of EO. The EO-laden air from the chamber moved to the ventilation system and was ignited by the catalytic oxidizer and created a powerful explosion.

The CSB investigation found several contributing causes that led to this incident. The facility did not equip engineering control of gas monitoring system that could identify the presence of explosive EO mixture in the chamber and the employees did not fully understand the hazards associated with the process. Several recommendations were given to Sterigenics International such as to evaluate and improve the current process control by installing multiple layers of protection, review and revise PHA of the facility, and to validate training for the workers.

Georgia Pacific Hydrogen Sulfide gas Release
Presented by Katherine Prem

On January 16, 2002, highly toxic hydrogen sulfide (H₂S) gas leaked from a sewer manhole at the Georgia-Pacific Naheola mill in Pennington, Alabama. Two contractors were killed and eight others were injured in this incident. On the day of the incident, sulfuric acid was being added to the acid sewer to control pH downstream in the effluent area. Sodium hydrosulfide (NaSH) from the oil pit and the collection drain was draining to the sewer and reacted with the sulfuric acid to form toxic H₂S gas. Within 5 minutes, an invisible cloud of H₂S gas leaked through a gap in the seal of a manhole in the area of the Burkes Construction workers.

An investigation lead by the CSB revealed that good engineering and process safety practices were not followed when joining the drain from the truck unloading station and the oil pit to the acid sewer. There were no management systems to incorporate hazard warnings about mixing NaSH with acid. The fiberglass manway was not adequately sealed to ensure that the sewer remained closed. H₂S was not identified as a hazard in the immediate area of the mill where the incident occurred. Therefore, there were no monitors, alarms or warning signs in the area. Georgia-Pacific did not require detailed H₂S safety training for those working in this area of the mill. The contractors working on the day of the incident had only basic awareness of H₂S and its hazards. The exposed workers were also not decontaminated.
In the Risk Assessment session, “Screening Atmospheric Relief Devices for Unacceptable Risks,” was presented by D. Eure, Dow Chemical. Eure said that Dow has developed a practical work process for screening relief device effluent streams for flammability and toxicity risks. Its objective is to apply safe and consistent screening criteria for relief streams routed to the atmosphere. The process includes two levels of screening. The first screening tests use simplified spreadsheet calculations that are less rigorous but more conservative. Relief devices that pass this conservative test are compliant with Dow’s risk criteria for atmospheric venting. A re-design is attempted for devices that fail this first test. If the device cannot be re-designed to pass the first-level test, then the user proceeds to the second-level tests which use rigorous dispersion modeling and/or Layers of Protection Analysis (LOPA). He presented the work process and discussed how effluent screening is applied at the Dow Chemical Company.

A. Markowski with the Technical University of Lodz presented “ExSys-LOPA - Simplified Risk Assessment Method for Typical Major Hazards Scenario Encountered in the Process Industry.” Markowski said that experience-based decision frequently may be sufficient to ensure safe work conditions, especially for industry with years of experience in their operation. However, process industries and its complex hazards and uncertainty involved, especially in human activities, can lead to abnormal process conditions that may initiate accident scenarios often developing to major accidents. These were the reasons to introduce the regulatory requirements that are based on risk assessment. Recently, the EU-funded ARAMIS project has developed a comprehensive methodology, called MIMAH and MIRAS, for the identification of major accident hazard through the reference incident scenario in process industry. He said his study, which may be considered also as the combined method, aims to analyze and assess the risk of particular accident scenario and design (or verify) the appropriate safeguards to manage the identified risk. This will go through two steps which are as follows: 1. identification of possible accident scenario using an expert system (ExSys), and 2. application of LOPA.

“Process safety challenges in view of the upcoming hydrogen economy,” was presented by H. Pasman with MKOPSC. Pasman said that Hydrogen is an attractive fuel (energy carrier), which also can be produced by renewable sources and which can be utilized as an alternative to the present day hydrocarbons, certainly when the mass and volume storage efficiency and safety can be further improved by absorption in a solid matrix. From a safety point of view, care has to be taken because of its explosion and fire proneness when mixed with air. Although much is known about its properties, there are still aspects not well explained such as the delayed self-ignition when jet escapes from a high pressure leak. To enable a smooth introduction of the technology, risk studies shall be carried out and adequate codes and standards be formulated so that the distribution system including refueling stations can be built with inherently safer features to cope with hydrogen’s properties. In that respect quite a few knowledge gaps have been defined. Further international coordination with respect to risk acceptance is also desirable.

N. Faulk with Lloyds Register presented “Applying Risk Assessment to Overpressure Protection System Concerns.” Faulk discussed a Risk Assessment System Plan for Relief Systems methodology developed and refined to perform risk assessment and priority ranking of overpressure protection and effluent handling concerns. An experienced Hazard Identification and Risk Analysis facilitator, along with a team, then determines if standard resolution is possible, if a layer of protection analysis (LOPA) can/should be applied, or if some other type of formal Risk Assessment Method should be utilized. The recommendations proposed can range from resolution per work practices (for low-risk issues) up to approval of action items acceptable for short-term or long-term operation (for high or very high severity issues), and are subsequently presented to operations, maintenance, and technical authorities for their consideration. Management should develop a system to ensure a formal resolution, and periodic reviews and revisions to the risk criteria must occur in order to keep the plan current.

“Scenario Identification and Evaluation for Layers of Protection Analysis,” was presented by K. First with Dow Chemical. First said, often the experience of the analyst is a significant factor in determining what scenarios are evaluated and the worst credible consequences. He presented a simplified chemical process risk analysis that is effective in providing a semi-quantitative measure of consequence that may include human harm and is independent of the analyst. This process may be used in evaluation of Management of Change, inherently safer design decisions for capital projects and LOPA revalidation. Conditional and relational logic may be captured with the use of simple spreadsheets to further improve overall efficiency. For example, this method minimizes the overall time required for scenario development and re-validation relative to Hazard and Operability studies (HAZOP).
R. Pitblado with DNV presented the paper entitled “Risk Communications: Websites for Barrier Diagrams and Process Safety.” Pitblado said many companies globally are now using barrier diagrams as a key tool for risk management during operations. The barrier approach focuses on critical activities necessary to prevent or mitigate threats from becoming major accidents. It does this based on the Swiss Cheese model – where each slice is a barrier and the holes represent its effectiveness. Barriers can be hardware, people or systems. These diagrams have threats on the left and document all the prevention controls, a central hazardous event – usually a loss of containment, and all the mitigation and recovery controls on the right side. They are often called bow-tie diagrams as the figure has that classic shape. Bow tie software can generate very useful large scale diagrams, showing all the threats, the barriers, their effectiveness, and color coded for ownership. However these can get complicated and large scale drawings and paper reports are poor tools for ongoing communication and regular updating. He described the development of a web-based solution, using Sharepoint 2007, Microsoft’s standard knowledge management tool that takes the bow tie database and converts this into a format accessible to everyone.

“The Comprehensive Quantitative Assessment of an Offshore Fire Water System,” was presented by R. Gustafson with Atkins. Gustafson said that traditional design of fire protection systems has primarily relied on general industry codes to define appropriate design. General industry codes are established primarily by consensus processes and standards to unusual or novel applications, such as modern deepwater installations or highly hazardous processes provides a limited qualitative basis for their design. Modern hazard and risk assessment practices including the systematic hazard identification and consequence modeling present a structured approach to identifying potentially hazardous scenarios, estimating their impacts and assessing the responses of hazard control and protection systems. He discussed the assessment of a complete hydraulic model of an offshore platform’s fire water system and its response against complete and realistic cross section of major fire hazards scenarios.

N. Kazantzis with the Worcester Polytechnic Institute presented the paper entitled “A Toxicity Risk Assessment Method for Spill Incidents Involving Volatile Liquid Hydrocarbons and Aqueous Solutions in Enclosed Areas.” Kazantzis said the quantification of risk assessment associated with incidents involving the natural, accidental or intentional release of potentially hazardous chemicals into the environment has been recognized as a rather useful methodological paradigm and well-justified research endeavor by the scientific community, provided that its inherent limitations and extent of scope are carefully acknowledged in a complex world where uncertainty reigns. Under these insurmountable conditions, quantitative risk models with varying degrees of sophistication should aim at complementing and skillfully guiding intuition in the presence of complexity, where the latter should be also exercised as models aspire to capture even value-laden facets of complex situations through constant refinement as is very often the case in the field of chemical process safety. He discussed a study that aims at developing a quantitative framework for the assessment of toxicity risk posed by spill incidents involving volatile liquid hydrocarbons and aqueous solutions in an enclosed area or indoor environment.

“Using Quantitative Risk Analysis Tools for Early Project Definition Decision Support,” was presented by I. Shaikh with Lloyds Register. Shaikh said that decisions regarding process facility/equipment layout, directionality, proximity, location, and protection may be driven by regulatory, geological, or logistical concerns, but they have HSE input elements as one of the drivers. Many of us who work in upstream (or downstream) oil & gas projects have come across questions that have to be made early in concept selection stage or they will add a lot more cost when the design moves to a more detailed engineering stage of the project. How do you justify these decisions? Utilizing quantitative tools coupled with established risk analysis techniques is one way forward when there is a lack of time and resources for a detailed study, when engineering details that are not finalized, and when the scope of the project is not completely defined. He discussed the use of HSE element of complex decisions examples by utilizing consequence and probability analysis mixed with risk level /matrix based approach to determine incremental risk.

B. Nalbone presented the paper entitled “Brine Injection Pump Incident.” He discussed the case history of a fatal incident on a brine reinjection pumping unit that was caused by a “blocked in” positive displacement pump being energized. Nalbone said a common pump protective bypass valve and piping arrangement was not installed on this pumping unit. The piping system was solely protected from overpressure by a Pressure Relief Valve designed to fail at a predetermined pressure by the shearing of a retaining pin, commonly referred to as a “nail”. This PRV had been altered to prevent its proper operation. Prior to this incident, an improperly designed vibration dampener was installed on the pump. The design was technically flawed. It employed an air column as the dampening means; however the air pocket collapsed under the blocked pump’s discharge pressure. The collapse of the air pocket resulted in a water hammer shock wave that caused the dampener to explode.

“Beyond-Compliance Uses of HAZOP/LOPA Studies,” was presented by R. Johnson with Unwin. He said recent years have seen a convergence of scenario-based Hazard and Operability (HAZOP) Studies, Layer of Protection Analyses
(LOPAs), and Safety Integrity Level (SIL) determinations. These can all be performed using order-of-magnitude estimates for the initiating cause frequency, the effectiveness of protection layers, the severity of loss event consequences, and the inclusion of other risk-reduction factors. Conducting a HAZOP Study or a HAZOP/LOPA Study in this manner makes it possible to extend the study results to not only determine required SILs, but also to sum scenario risks by process unit and show the quantitative benefit of implementing risk reduction measures. The aggregated risk can be compared to process-wide tolerable risk criteria, in addition to comparing each scenario to a risk matrix or risk magnitude. Johnson discussed how a true risk-based HAZOP Study can be performed with little additional effort over that required for commonly performed cause-by-cause HAZOP Studies, and how facility managers and engineers can then use the results when deciding on and implementing risk-reduction measures.

N. Ryder with Packer Engineering presented the paper entitled “Design Requirements: A Comparison of Vapour Cloud Explosion Models and the Importance of Properly Assessing Potential Incident Impact.” Ryder discussed the various explosion models that are frequently used in support of facility layout and risk assessments and examines the results that each model type will produce for comparative purposes. It is shown that while empirical based models, such as the TNT equivalency and TNO Multi-Energy Method, may be simple in concept, that proper application of the model can be complex.

In the Inherent Safety/Resilience/LOPA session, V. Edwards with Aker Solutions presented the paper entitled “Develop and Design Inherently Safer Processes and Process Plants.” Edwards said many individuals and organizations have made important contributions to the creation of inherently safer (IS) products, processes and process plants. A brief survey of successful case histories shows that most reported applications employed only a few of the core IS principles. He discussed the opportunities presented by often overlooked possibilities for inherently safer processes and how to insure maximum incorporation of inherently safer processes into the creation of a process plant by beginning at the product and process research stages and concluding with the detailed design.

“LOPA Lessons from Past Process Plant Incidents,” was presented by M. Sawyer with ASC. Sawyer said the Layer of Protection Analysis (LOPA) is a semi-quantitative assessment technique used by the process industries as a tool for making risk based decisions. The primary purpose is to determine if there are sufficient layers of protection or defense against high risk scenarios identified during the hazard analysis. LOPA also may be used to analyze incidents in regard to how available protection layers failed, thus adding a new level of lessons that may be learned from incidents. He presented a review of selected process plant incidents and comparison of failed layers of protection or layers of defense for each incident in order to investigate any commonality and/or emerging patterns that may be used to predict future incidents and bolster LOPA techniques.

D. Moore with Acutech presented the paper entitled “Managing Risk - Finding the Optimum Level of Safety.” Moore said that most industrial facilities in the developed world are balancing the need to provide a safe workplace, while maximizing profits to maintain viability. Insufficient spending in safety increases the chance of a major accident, which could possibly put a company out of business. On the other hand, excessive spending on safety would have a diminishing return on the safety investment, resulting in reduced profits, possibly also driving the company out of business. The proper selection of a numerical risk standard is key to optimizing the balance between safety and expenditures. He discussed an approach for establishing an effective onsite numerical risk standard. Once the risk standard is established, the LOPA methodology can be designed to specifically address that standard. This approach is intended to ensure that companies can minimize their process safety costs meeting their corporate responsibilities to provide a safe workplace.

“Process Hazard Analysis: Study Enhancement,” was presented by K. Farrell with Invista. Farrell said that the need to perform a useful Process Hazard Analysis (PHA’s) has been mandated by OSHA’s CFR Title 29 §1910.119 and EPA’s CFR Title 40 Part 68. The levels of information necessary to the PHA’s can only are anticipated to increase. Companies are now strained to accomplish quality PHA’s on minimum resources while preserving the level of analysis. This undertaking would on first appearance seem a contradiction. However, the proper application of training, technology and information management, can achieve your PHA objectives. He discussed how these principles were applied to achieve a prompt and appropriate PHA.

In the Buncefield session, M.S. Mannan with MKOPSC presented “A Technical Analysis of the Buncefield Explosion and Fire.”

“Anatomy of the Failures that led to the Buncefield Explosion and Fire,” was presented by H. Kytomaa with Exponent. Kytomaa said that on December 11, 2005 a vapor cloud explosion occurred at the Buncefield fuel terminal located twenty-five miles northwest of London. Significant overpressure damage occurred to the facility, neighboring businesses, and homes. The resulting post explosion fire continued for almost four days,
consuming fuel from over 20 tanks, and has been described as the largest peacetime fire in Europe. Such significant damage had not been anticipated in risk analyses performed by the facility operator. He described the investigation of the incident and identified contributing causes that allowed the incident to occur and contributed to its magnitude.

C. Schemel with Packer Engineering presented “Analysis of the Buncefield Oil Depot Explosion: Explosion Modeling and Process Safety Perspective.” Schemel said the process failure and resulting explosion and fire at the Buncefield Site in Hemel Hempstead, UK was a landmark incident in process safety and explosion analysis in several ways. The explosion rocked the area early on a Sunday morning, causing damage to the adjacent business and residential communities. The resulting investigation into this incident, which was driven by the legal actions and proceedings, was a test of the available methods and tools available to the engineering community to perform risk assessments, consequence analysis and forensic analysis. He discussed the details of the explosion, the analysis performed, and the perspective of legal experts.

“The Potential for Vapour Cloud Explosions - Lessons from Buncefield,” was presented by M. Johnson with Advantica. Johnson said that as a storage site, the Buncefield terminal had very little pipework congestion and at first sight would not have been considered as having much potential for a vapor cloud explosion. As a consequence, one of the actions of the Buncefield Major Incident Investigation Board (BMIIB) was to initiate a review of the possible causes of the severe explosion on the site. This review was then extended to a Joint Industry Project, Phase 1 of which has offered an explanation of the cause of the explosion. He summarized the conclusions along with reference to relevant experimental studies, illustrating how the elements of the explanation were already known and discussed the implications of the incident for the assessment of vapor cloud explosion hazards, both in terms of understanding worst case consequences and the use of risk based approaches.

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In the Reactive Chemicals/Flammability session, “Azodicarboxylates: Explosive Properties and Thermal Hazards,” was presented by A. Berger with BAM Germany. Berger said, a large number of Azodicarboxylates and their derivatives are produced and used in the chemical industries. The versatile applications of these Azodicarboxylates in research institutes and in the chemical industries for chemical synthesis led to additional hazards. She discussed that the aim of the study was to obtain a predication about the structure-response relationship regarding the explosive properties and the thermal hazards of different versatile used Azodicarboxylates. The substances were examined with the Differential Scanning Calorimetry (DSC). Furthermore, different laboratory test methods, based on the UN Recommendations on the Transport of Dangerous Goods, were applied to determine the explosive properties of the mentioned substances.

“Secondary decompositions in the N-oxidation of low-order alkyl-pyridines,” presented by L. Saenz with MKOPSC. Saenz said during a runaway reaction of N-oxidation of alkylpyridines, hydrogen peroxide, which serves as the reaction oxidant, starts decomposing into oxygen and water at low temperatures. This decomposition can increase the temperature enough to trigger the decomposition of alkylpyridine N-oxide (product of N-oxidation), leading to a subsequent exponential increase in temperature and pressure which can have severe consequences due to the continuous production of non-condensable gases. As hydrogen peroxide decomposition is condition sensitive, the runaway behavior of the N-oxidation depends on the conditions of the system as well. She discussed the study conducted to identify the runaway behavior of the N-oxidation of low-order alkylpyridines under different scenarios which allow for the development of appropriate safety and control measures.

“Experimental Investigations on Flammability Characteristics of Acetone Aqueous Solution at 150°C and 1 atm,” presented by C-M. Shu with the National Yunlin University of Science and Technology. Shu said that the history of the chemical process industries is replete with major accidents. To cope with stringent process safety requirements in the 21st century, a thorough and comprehensive knowledge of safety properties of loading materials is crucial for safe handling during operations. Ensuring the fire and explosion safety of flammable substances is unlikely without detailed investigations of their flammability characteristics and corresponding potential hazards. He discussed a study investigating the flammability characteristics of four acetone aqueous solutions and discussed the effect of inert steam on loading fuel concentration by systematic experimental investigations on a 20 liter spherical explosion vessel.
presented the paper entitled, "High Temperature Effects on Vessel Integrity." 

"Reactive Chemical Hazard Evaluation using CFD Simulation,” was presented by D. Ng with MKOPSC. Ng said that a recent report from US Chemical Safety and Hazard Investigation Board highlighted concerns associated with reactive chemical hazard management. Thermal runaway may occur in the storage process of reactive chemicals due to energy accumulation of exothermic decomposition reactions in the absence of sufficient heat dissipation. The common method used to study the critical behavior of reactive chemicals is to determine inflection points on temperature versus concentration/time data. He discussed current research that investigates the critical behavior of a large quantity reactive chemical under the influence of natural convection and a proposed approach that can be used to guide the development of safer storage/operation condition for large quantity reactive chemical storage.

M. Malow with BAM Germany presented “Evaluative Comparison of Two methods for SADT determination (UN H.1 and H.4).” He presented results on the comparison of two methods for the SADT determination. Both methods, UN test H.1 and UN test H.4 are recommended by the international transport regulations from the UN. But during the last years the applicability of the UN test H.4 has been questioned for solid substances. Therefore, three organic peroxides and one self-reactive substance have been investigated in 5 kg and 20 kg packages as well as in the UN test H.4 in a 500 mL dewar vessel. The SADT values determined with the different methods match. The UN test H.4 seems to be well suited also for solid substances at least for 20 kg or 60 L.

“Safely Handling Guideline for Organic Peroxides and Inorganic Peroxides by Calorimetric Approaches,” was presented by C-H. Su with the Wu Feng Institute of Technology, Taiwan. Su said that Organic peroxides (OPs) and inorganic peroxides (IPs) are usually employed as an initiator for polymerization, a source of free radicals, a hardener, and a linking agent in low density polyethylene (LDPE), polyvinyl chloride (PVC), controlled rheology polypropylene (CR-PP), and styrene industries. Due to their unstably reactive natures, OPs and IPs have caused many thermal explosions and runaway reaction incidents. He discussed a study that was conducted to elucidate its essentially hazardous characteristics.

M. Levin with Shell Global Solutions presented the paper entitled, “High Temperature Effects on Vessel Integrity.”

H. Kytomaa with Exponent presented the paper entitled “Transient Spreading of LNG on Water.” Kytomaa discussed the implementation and development of a ‘protective devices register’ on a large multi-unit, multi-EPC, refinery project. He said the Protective Devices Register is intended to function as a single source repository for information on plant equipment related to plant safety. If a device or system meets the criteria for inclusion in the register it is mandatory to include it. Device or System Testing, Preventive Maintenance, and Inspection frequency are essential elements of the Register. Constant attention must be focused on the Register to ensure that it is maintained in a up to date state.

In the LNG session, F. Licari with DOT presented the paper entitled “Performance Metrics for Evaluating LNG Vapor Dispersion Models.” Licari said new performance metrics are necessary to quantify the inherent margins of safety in vapor dispersion models for liquefied natural gas (LNG) spills. Currently, vapor dispersion model calculations in the 49 Code of Federal Regulations, Part 193 as well as Standard 59A of the National Fire Protection Association (2001 edition) reduce the lower flammability limit (LFL) of methane in air by a safety factor of two (to 50% LFL) to ensure that flammable vapors do not extend beyond a LNG facility’s property line during a LNG spill. He proposed an improved performance metric to evaluate the validity of vapor dispersion models and a statistical methodology to determine the confidence level and the inherent margin of safety in calculating vapor dispersion exclusion zones and discussed descriptions of the new metric and methodology for the DEGADIS vapor dispersion model, together with example calculations.

H. Hernandez with Fluor presented the paper entitled “Project Wide Development of a Protective Devices Register.” Hernandez discussed the implementation and development of a ‘protective devices register’ on a large multi-unit, multi-EPC, refinery project. He said the Protective Devices Register is intended to function as a single source repository for information on plant equipment related to plant safety. If a device or system meets the criteria for inclusion in the register it is mandatory to include it. Device or System Testing, Preventive Maintenance, and Inspection frequency are essential elements of the Register. Constant attention must be focused on the Register to ensure that it is maintained in a up to date state.

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This scenario has not been given the same level of scientific attention in the literature compared to surface releases and assessment of consequences therefrom. He discussed questions like, (1) does an LNG spill underwater form a pool on the water surface and subsequently evaporate like an LNG spill “on the surface” has been shown to behave producing cold vapors?, and (2) what is the range of expected temperatures of the vapor generated by LNG release and heat transfer within the water column when the vapor emanates from the water surface.

C. Herrera, MKOPSC presented the paper entitled “Absorption Characteristic of LNG as a Function of IR Wavelength.” Herrera said predictions of thermal hazard distances arising from pool fires have been generated with both semi-empirical and field or computational fluid dynamic-based (CFD) models. However, these models have as a major constraint a limited range in which they were validated with the additional uncertainty introduced by unstudied phenomenon observed in large scale experiments. Previous works have reported an overestimation of the mass evaporation rate when using calorimeters on the pool surface to measure the heat feedback from the fire with radiant heat as the driving force for LNG evaporation. This heat was assumed to be absorbed entirely by the liquid pool and used as latent heat. She discussed the current research being conducted to determine the absorption characteristics of natural gas in liquid state at cryogenic temperatures by the variation of IR wavelength.

“LNG Trench Dispersion Modeling Using Computational Fluid Dynamics,” T. Melton, Quest. Melton said quantifying the size of flammable vapor cloud hazards associated with an accidental release of Liquefied Natural Gas (LNG) into a spill containment system supported by narrow drainage trenches has posed a modeling challenge since the inception of the LNG industry. Early attempts to treat the vapors evolving from the trenches included using line-source Gaussian models, and the use of the DEGADIS model by modeling “segmented” trench elements and adding the contributions from each trench segment at a specified downwind distance. These approaches often are only reasonable for a select set of conditions (e.g., winds perpendicular to the trench) and have no ability to simulate many of the conditions that might result in a larger potential impact (e.g., winds blowing parallel to the trench). He discussed the parallel development of computational fluid dynamics (CFD) models and desktop computer power that now allows for the evaluation of the dispersion of natural gas vapor clouds produced by LNG spills following accidental releases into drainage channels or trenches. CFD models have the ability to simulate a full range of trench layouts and drainage paths.

M. Rana with MKOPSC presented the paper entitled “Forced Dispersion of LNG Vapor with Water Curtain.” Rana said that there has been, and will continue to be, tremendous growth in the use and distribution of LNG. LNG poses the hazard of flammable vapor cloud formation from a release, which may result in a massive fire and so increased public concerns have been expressed regarding the safety of this fuel. To ensure public safety, regulations and standards require LNG facilities to have a “dispersion exclusion zone” so that LNG vapor cloud from an accidental release will not propagate beyond the plant boundaries. That is why installation of effective safety measures to prevent and mitigate an accidental LNG release is critical. Water curtain which is usually inexpensive, simple and reliable is currently recognized as an efficient technique to control and mitigate various hazards in the process industries. He discussed data from medium scale out-door experiments at the Brayton Fire Training School (BFTF), Texas to understand the relative importance of induced mechanical mixing effects, dilution with air, and heat transfer between water droplets and the LNG.

“The Effect of Substrate on Vapor Dispersion from an LNG Spill into an Impoundment,” was presented by F. Gavelli with Exponent. Gavelli said that ambient air vaporizers (AAVs) are widely used to regasify liquefied industrial gases, which are liquefied for transport and storage. Depending on the conditions (temperature and relative humidity) of ambient air and AAV effluent, the potential exists for the formation of fog as the two fluids mix with each other. This has raised some regulatory and environmental concerns that the fog cloud may impact human activities in the vicinity of the AAV arrays. He discussed a method to quantitatively predict the formation, advection and dissipation of AAV-induced fog clouds, using a commercial computational fluid dynamics (CFD) model.

R. Qi with MKOPSC presented the paper entitled “LNG Vapor Dispersion Consequence Modeling with CFX.” Qi said that consequence modeling for LNG vapor dispersion plays a vital role in the risk assessment of LNG operations to determine potential hazardous areas in an LNG accidental spill. Due to the rapid advancement of computational capabilities, Computational Fluid Dynamics (CFD) has been widely proposed in safety applications considering its comprehensive description of fluid physics. He discussed the use of ANSYS CFX, a general-purpose CFD code, to simulate LNG vapor dispersion in scenarios involving vapor fences. Fundamental input parameters to set up domain and boundary conditions are discussed. Simulation results are validated against
In the Case Histories session, “Common Operations Failure Modes in the Process Industries,” was presented by P. Bullemer with ASM. Bullemer said the Abnormal Situation Management® (ASM®) Consortium funded a study to investigate common failure modes and root causes associated with operations practices. The study team analyzed 20 public and 12 private incident reports using the TapRoot® methodology to identify root causes. These root causes were mapped to operations practice failures. He presented the top ten operations failure modes identified in the analysis. Specific recommendations included how to analyze plant incident reports to better understand the sources of systemic failures and improve plant operating practices.

B. Singh with IONIK presented the paper entitled “20 Years On—Lessons learned from Piper Alpha the Evolution of Concurrent and Inherently Safer Design.” Singh said it has now been well over 20 years since the North Sea Piper Alpha disaster in 1988. There have been many lessons learned; some documented others just etched in memory. The event chronicled many significant changes in the offshore industry across many world offshore regions. The emanating point for most sweeping changes has been the Cullen Report and the UK North Sea industry. He reviewed some of the critical lessons and identified many ‘secondary’ finer points that also constitute important learnings many of which still need to be addressed, if pragmatic life cycle safety and performance are to be assured. He discussed major changes instigated by step changes in safety criticality regarding offshore assets. It is argued that the ‘second tier’ modes of failure such as corrosion, materials degradation, environmental cracking, erosion, plant ergonomics, etc need to be better examined.

T. Kletz presented the paper entitled “ICI’s Contribution to Process Safety.” Kletz said that substantial contribution to process safety was made by the United Kingdom company, Imperial Chemical Industries (ICI). He discussed an accident, that is an event that had unforeseen and unexpected results: it led to the end of an independent company, Imperial Chemical Industries (ICI), which had made major changes in process safety, most of which were widely copied.

In the process management for safety session, “One Company’s Experience with Process Safety Metrics,” was presented by B. Saab with BP. Saab explained that following publication of the findings of the Independent Panel safety review of BP’s U.S. Refineries, the executive leadership reviewed the company’s approach to process safety and operational excellence. This evaluation led to significant changes designed to promote safe and reliable operations, not just at the U.S. refineries, but across the BP group worldwide. He said these changes go beyond adoption of the Independent Panel’s recommendations, and discussed the application of Process Safety Performance Indicators as part of an integrated and comprehensive process safety management system. BP’s thinking on the selection and use of leading and lagging process safety metrics at corporate and operating site levels within the company, and their contribution to verifying the robustness of key barriers designed to prevent, control and mitigate process safety incidents, are discussed.

R. Sanders presented the paper entitled “Our People are our Most Important Asset: Making Money between the Safety Limits.” Sanders said that companies in the process industries in high-wage, developed nations face a challenge. Much of the normal, routine manufacturing business has moved to offshore nations where labor costs are much lower. Similarly, engineering companies have moved much of their work to lower cost nations. Many of the normal operations that used to be controlled by operators and supervisors are now managed by sophisticated instrumentation systems. Given these circumstances, management of facilities in developed nations must address what competitive advantages they possess, and more specifically how they can use the skills and knowledge of their high-wage personnel in order to justify the high wages. Therefore, an opportunity that presents itself to PSM professionals is to develop and adapt their current PSM programs so as to use the existing high-skill, high-wage workforce to achieve new financial and safety goals.

“Prescriptive Safety Requirements in a Goal Setting Environment?,” was presented by M. Zerafa with Shell. Zerafa said since the Cullen Enquiry was completed in the United Kingdom in the wake of the Piper Alpha disaster, the offshore oil and gas industry has moved from prescriptive safety requirement codes to a goal setting based regime. Operating companies and engineering contractors have often struggled to incorporate effective goal setting in the design process. There are several examples where the analytical processes and subjective acceptance criteria have resulted in excessive costs, project schedule delays, or inadequate levels of design safety.

Track 3 was chaired by Skip Early with Early Consulting, Kiran Krishna with Atkins, and Ray Mentzer with MKOPSC. This track includes the Process Management for Safety sessions and the Human Factors/Safety Culture session.
He discussed proposing a set of minimum safety criteria that could be adopted for the primary safety critical systems for large-scale offshore E&P facilities.

**M. Serpas** with TAMU Chemical Engineering presented the paper entitled “Investigation of Different Extended Kalman Filter Implementations.” He said many comparative studies, often based upon simulation results, between extended Kalman filters (EKF) and other estimation methodologies such as moving horizon estimation, unscented Kalman filter, or particle filtering have been published over the last few years. However, the results returned by the extended Kalman filter are affected by the algorithm used for its implementation and some implementations of EKF may lead to inaccurate results. He discussed several different algorithms for implementing extended Kalman filters and explained the advantages and drawbacks of different EKF implementations illustrated in a comparative simulation study.

“Using Leading Indicators to Continuously Improve QHSE Performance,” was presented by **Kip Carter** with Syntex. On an enterprise-wide scale, worldwide operations from major “operators” and “service” companies are applying a common approach to collect and analyze data from a myriad of “risk reduction” activities. With such a vast dataset from both “outcomes” and “work practice behaviors”, these companies have created a unique opportunity to find the “real” leading indicators of performance. Many companies track and analyze Leading Indicators in isolated areas of their businesses but few are applying Leading Indicators to rival the age-old “incident rate” as the primary Key Performance Indicator (KPI) for judging an operation’s QHSE performance. To overcome the obstacles, the most effective Leading Indicators must 1) minimize “additional” resources required for execution and 2) provide sufficient proof that executing Leading Indicators will improve QHSE performance. This can be done by implementing an integrated enterprise-wide tool to consolidate data from business practices that fit a common risk reduction cycle “pattern” and utilizing the existing field-level activities to leverage and minimize the effort of gathering leading indicator data.

**K. Shell**, RMT and **K. Budd** with Huntsman presented the paper entitled, “Driving Process Safety Performance.” They discussed the Huntsman organization, which has taken shape largely through acquisitions and divestitures. There are five divisions with seventy plus manufacturing facilities operating across five continents. With emphasis on regulatory compliance and loss prevention, Huntsman implemented a global performance based Environmental, Health and Safety (EHS) Management System. Metrics were established and a governance process implemented to monitor and control EHS performance. Facilities were given flexibility on their approach to compliance with the Global EHS Standards, and monitoring achieved through the internal audit program. They described the journey Huntsman has undertaken to make a stepwise improvement in process safety effectiveness and culture globally.

“Effective Process Safety Auditing Techniques,” was presented by **L. Morrison** with BP International Limited. Morrison discussed some of the effective auditing techniques operating companies and consultants have used to identify process safety issues and drive improvements in process safety. From the development of the second edition of the CCPS Guidelines for Auditing Process Safety Management Systems, the subcommittee has identified a number of methods and example questions that can be used to audit specific process safety topics.

**S. Waldram** with TAMU-Qatar presented the paper entitled “Teaching process safety: a stand-alone course or a continuous integrating thread throughout a chemical engineering degree?” Waldram said that process safety is an absent, or neglected, subject in many US, undergraduate, chemical engineering, course programs. He discussed how the broad topic of process safety can be infused, or embedded, into many aspects of conventional chemical engineering courses and presented a unifying, or integrating, theme that can then be focused in the core process safety course which must be taken by all students in their Senior year. He showed examples of how process safety related applications can be introduced into core chemical engineering subjects.

“Dynamic SIL Analysis,” was presented by **P. Goteti** with Honeywell. Goteti said by determining the SIL based on the most hazardous process, the designed Safety Instrumented System (SIS) may be over instrumented for the rest of the applications! This may not be the best option in terms of capital costs to buy the system and revenue costs to maintain the system. He explained that the intent of “Dynamic SIL analysis” is to modify the SIFs based on the External and Operating Process parameters without compromising on Process Safety, and gave examples and scenarios indicating why the present SIL determination techniques do not adequately address the issues of over instrumentation which indirectly increase costs for the operating company for some applications.
A. Summers with SIS-Tech presented the paper entitled, “Overfill Protective Systems - Complex Problem, Simple Solution.” Summers said overfills have resulted in significant process safety incidents. Longford (Australia, 1998), Texas City (United States, 2005), and Buncefield (United Kingdom, 2005) can be traced to loss of level control leading to high level and ultimately to loss of containment. A tower at Longford and a fractionating column at Texas City were overfilled, allowing liquid to pass to downstream equipment that was not designed to receive it. The Buncefield incident occurred when a terminal tank was overfilled releasing hydrocarbons through its conservation vents. The causes of overfill are easy to identify; however, the risk analysis is complicated by the combination of manual and automated actions often necessary to control level and to respond to abnormal level events. She provided a summary of the Longford, Texas City, and Buncefield incidents from an overfill perspective and highlighted five common factors that contributed to making these incidents possible. Fortunately, while overfill can be a complex problem, the risk reduction strategy is surprisingly simple.

“Integrating Medium Voltage Switchgear Breakers into a Safety Instrumented Function,” was presented by D. Grattan with S&B Engineers & Constructors. He said that for some incident outcome scenarios, a risk assessment study has determined the need to include the shutdown of a large electric motor, as part of a safety instrumented function (SIF). He discussed the design considerations for integrating medium voltage switchgear used for shutdown of an electric motor, into a safety instrumented function.

J. Chosnek with KnowledgeOne presented the paper entitled, “Maintaining the Corporate Memory.” Chosnek said that it is a well known fact that corporations don’t have memories. This is because the majority of the knowledge is maintained in the employees’ heads and when they leave that knowledge walks out with them. This continues to be the bane of process safety as errors get perpetuated and incidents repeated. A system can be created, though, to form and keep corporate memory by accumulating the knowledge as it is developed and saving it in an organized manner, to be easily found and used by others as needed. He discussed that knowledge is best shared by example (for instance, we would like to design our plant based on the best applicable designs available), and how it can be continually collected with little effort once a proper work flow has been adopted.

In the Human Factors/Safety Culture session, W. Mostia with SIS-Tech presented the paper entitled “Why Bad Things Happen to Good People.” Mostia said that accidents in the process industries are extensively investigated to determine root causes, for lessons learned, and many times in search of the “guilty.” Accidents are seldom simple and most accidents have human elements that led to or facilitated the accident. Many times the people involved in these accidents, when considered individually on their merit, would be considered “good” people yet “bad things” (accidents) still occur. He discussed why accidents happen in environments of seemingly competent people with apparent procedures and practices in place to prevent accidents. Why seemingly competent people acting in concert in a group do not always reduce the likelihood that an accident would occur but just the opposite. And, why do a number of events, conditions, and factors seem to come together and line up at the exact time and place to cause an accident.

S. Payne with TAMU Industrial Psychology presented the paper entitled, “Leading and lagging: The safety climate-unsafe events relationship.” Payne said, in order to compare the leading and lagging effects of safety climate, we examined the relative timing of the measurement of organizational safety records and survey data as a moderator of the safety climate-injury relationship. We obtained data from a large, multinational organization with manufacturing operations involving a number of complex processes, chemicals, and hazardous substances. Over 4500 employees from 46 manufacturing plants responded to a safety climate survey in 2007. Individual responses were aggregated to the plant-level and matched to plant-level organizational records of injuries 1 year before and 1 year after survey administration. Employees’ perceptions of quantitative workload, communication of change, safety training, and employee empowerment were all significantly related to injuries retrospectively and prospectively. Across all eight safety climate components examined, predictive and postdictive correlations were very similar in magnitude, suggesting safety climate is an equally strong leading and lagging indicator of injuries. She discussed Implications for safety climate research, study design, and climate change.

C. MacKenzie with the Chemical Safety Board presented the paper entitled, “CSB’s Perspective on Safety Culture and Human Factors as Accident Causation.”

R. Hartley with Pantex presented the paper entitled “Causal Factors Analysis to Investigate Information-Rich Events Before Accidents Occur.” Hartley said that Pantex, because of its mission, has no choice but to be a High Reliability Organization (HRO). In addition to using Human Performance Improvements (HPI) as a way of proactively enhancing the attributes of its HRO, B&W Pantex is currently undertaking a plant-wide initiative to implement a new Causal Factor Analysis.
(CFA) process that will provide a clear glimpse of “operational reality” during event investigations. By correlating this “operational reality” with Pantex HRO indicators, Pantex evaluates workers’ response as a way of evaluating the effectiveness of the Pantex HRO.

Track 4 was chaired by Scott Ostrowski with ExxonMobil, Michela Gentile with BP and Sara Saxena also with BP. This track included the Facility Siting, Gas Detection/Dispersion, and Explosion sessions.

In the Facility Siting session, “Land-Use Planning Regulations in France Following the Tolouse Disaster,” was presented by J. Taveau with the Institute for Radiological Protection and Nuclear Safety. Taveau said, after the disaster of AZF plant in Toulouse on 21 September 2001, France adopted a new law relative to safety reports and land-use planning on 30 July 2003. He presented the new approach of risk analysis established by the French Ministry of the Environment, and in particular, the benefits and limits of the French semi-quantitative probabilistic assessment method; the benefits and difficulties to use a quantitative probabilistic assessment method; some learning from the risk analysis approaches carried out in the nuclear industry; and, some discussion about the national matrix to appreciate the gravity of human consequences from an accident outside facilities.

D. Ng with MKOPSC presented the paper entitled, “A New Approach for Facility Siting by Mapping Risks on a Plant Grid Area and Optimization.” Ng said that facility siting is well known to help identifying hazard scenarios that could have significant effects on occupied buildings, identifying vulnerable locations of control rooms or other occupied buildings, spacing of process units, and spacing between equipment and employees in occupied buildings. Usually, facility siting is conducted for evaluating the location of process plant buildings which already exist. However, this problem can be approached at an earlier stage deciding on locations of facilities in the initial design step, which can help saving money to avoid changing locations later. He discussed research being conducted that is focused on achievement of optimal locations of hazardous facilities and other process plant buildings with optimization theory and mapping risks on the given land in order to calculate risk in financial terms.

“New API RP 752 Facility Siting Requirements and How They Affect Your Company,” was presented by J. Alderman with RRS Engineering. Alderman said that many companies have conducted facility siting studies of their facilities. API, at the request of the CSB and OSHA, has updated API RP 752, Management of Hazards Associated with Location of Process Plant Buildings. There are several keys changes involving occupancy criteria, occupant vulnerability, risk assessment approach, and structural analysis that will have a significant impact on facility siting studies previously conducted. He discussed the key changes to be introduced in the 3rd Edition of API RP 752 and provided several approaches for companies on how to update or revise their facility siting studies.

In the Gas Detection / Dispersion session, H. Witlox with DNV presented, “Flashing liquid jets and two-phase droplet dispersion - I. Overview and model implementation/validation.” Witlox said many accidents involve two-phase releases of hazardous chemicals into the atmosphere. He described the results of a third phase of a Joint Industry Project (JIP) on liquid jets and two-phase droplet dispersion. The aim of the project is to increase the understanding of the behaviour of sub-cooled non-flashing and superheated flashing liquid jets, and to improve the prediction of droplet atomisation, droplet dispersion and rainout.

In the presentation entitled “Flashing liquid jets and two-phase droplet dispersion - II. Scaled experiments for derivation of droplet atomisation correlations,” H. Witlox with DNV described the results of the first stage of Phase III of a Joint Industry Project (JIP) on liquid jets and two-phase droplet dispersion. He said this stage included scaled experiments for water, gasoline, cyclohexane, butane and propane for a range of superheats and nozzles with different aspect ratios. Moreover it provided recommendations for atomisation correlations in the regimes of mechanical break-up, transition to flashing, and fully flashing.

R. Deshotels with Fluor presented the paper entitled “Reliability Considerations in Locating Gas Detectors.” Deshotels said, to produce a tolerable risk for processes that have a high severity of consequence, high system reliability is required. For a typical chemical or hydrocarbons processing plant, the detector control logic and mitigation system (isolation valves, control interlocks, alarms, etc.) are designed to a high reliability standard, and the individual detectors are frequently tested and maintained to meet an availability that is consistent with the SIL rating. The methods and procedures for establishing the reliability and availability requirements for every connected to the detectors are thoroughly described and supported by extensive reliability data. However, how do we know whether the individual detectors are placed to detect the required percentage of releases? Deshotels discussed identifying the causes of difficulty and presented recommendations for new approaches.
“Using CFD to Optimize Gas Detector Systems in Process Facilities,” was presented by S. Davis with Gexcon. Davis said that explosions will, in most cases, generate blast waves. While simple models (e.g., Multi Energy Method) are useful for simple explosion geometries, most practical explosions are far from trivial and require detailed analyses. For a reliable estimate of the blast from a gas explosion it is necessary to know the explosion strength. He discussed the use of computational fluid dynamics (CFD) explosion models for near and far field blast wave predictions.

In the Explosion sessions, A. Qiao with DNV presented the paper entitled, “Application of Advanced CFD Modeling on VCE and Vapor Dispersion.” Qiao said, the Vapor Cloud Explosion (VCE) occurring in the onshore or offshore facilities could potentially damage nearby buildings and jeopardize personnel. The most important aspects to determine a gas explosion in a complex geometry are the development of turbulence and the corresponding increase in the combustion rate during the explosion. To be able to model this process it is necessary to use a Computation Fluid Dynamics (CFD) code, provided with suitable models for turbulence, combustion and representation of the geometry. The ignitable and explosive transient gas cloud sizes, at probable wind and leak conditions, can be determined at first through the dispersion analysis using CFD. She discussed the DNV study to quantify the potential overpressures due to VCE and the potential gas buildup by using CFD for onshore or offshore oil and gas production facilities, as well as its application in Design Accidental Load (DAL) analysis.

“A Study on the Effect of Trees on Gas Explosions,” was presented by K. van Wingerden with Gexcon. Van Wingerden said the downstream as well as the upstream oil and gas industry has for a number of years been aware of the potential for flame acceleration and overpressure generation due to obstacles in gas clouds caused by leaks of flammable substances. To a large extent the obstacles were mainly considered to be equipment, piping, structure etc. typically found in many installations. For landbased installations there may however also be a potential for flame acceleration in regions of vegetation, like trees and bushes. He discussed the case for the Buncefield explosion.

M. Molnarne with BAM Germany presented the paper entitled “Explosion protection - using the DATABASE CHEMSAFE.” Molnarne said prevention of and protection from explosions is one of the most important tasks of safety management systems in dealing with flammable substances. Plant management needs to implement safety requirements, such as prevention of the formation of explosive atmospheres, avoiding ignition sources where explosive atmospheres cannot be excluded, or protection from explosion by using constructive solutions in order to mitigate the detrimental effects of an explosion so as to ensure health and safety of workers. In addition, one has to prepare an explosion protection document and carry out risk assessment. The database CHEMSAFE has over 300 recommended LOC-values for 170 different mixtures measured at different temperatures and pressures. She discussed applications of the database for use in practical explosion protection problems.

“Dust Explosion Risks of Common Food Products,” was presented by D. Castellanos with MKOPSC. Castellanos said recent dust explosion and subsequent fire at the Imperial Sugar refinery in Port Wentworth, Georgia and numerous other industrial dust explosion incidents over the past 25 years have raised serious concerns about combustible dust hazards in the workplace. Suppression of explosion in its early stages is a common approach used to reduce explosion consequences. Currently, there are two types of suppressants used to combat dust fires: solid suppressants such as mono-ammonium phosphate (MAP), NaHCO₃ and gaseous suppressants such as nitrogen and CO₂. She discussed the advantages and disadvantages of these two types of suppressants in order to identify characteristics that influence each of the effectiveness measures that could be integrated into a new binary solid-gas suppressant. In addition, some experimental studies to explore the suppressant effectiveness are proposed for future in-house tests.

G. Mohan with Atkins presented the paper entitled “A Risk Based Approach to Blast Modeling for the Design of Offshore Installations.” Mohan said, offshore installations are characterized by a limited area for the location of adequate processing facilities. The resulting congested regions generate turbulence, which can accelerate the flame front through the gas cloud, generating higher overpressures. These overpressures have the potential to cause damage leading to adverse consequences for the personnel onboard. In designing offshore installations, a key consideration is the blast assessment which estimates the design overpressures to be applied. The methodology used in the blast assessment depends on the information available and the specificity of results required. He discussed a risk based approach to arriving at blast overpressures which evolves along with the facility design. The methodology uses a variety of tools from simple phenomenological models to sophisticated computational fluid dynamics to arrive at the most appropriate design overpressures aligned with the state of the overall facility design.

“OSHA Combustible Dust NEP Inadequacies,” was presented by J. Astad with the Combustible Dust Policy Institute. Astad said that combustible dust related fires and
explosions continue to occur throughout the manufacturing, non-manufacturing and utility sectors on a global basis. In the United States the February 7, 2008 Imperial Sugar Refinery dust explosion at Port Wentworth, Georgia resulted in 14 fatalities and dozens of injuries. OSHA responded to this tragic event with the reissuance of the OSHA Combustible Dust National Emphasis Program (NEP). At the conclusion of 2008, according to media accounts, over 150 combustible dust related fires and explosions occurred in the manufacturing, non-manufacturing and utility sectors. Over 50% of these incidents occurred in national industries, and are not referenced in the Combustible Dust National Emphasis Program (NEP) as having frequent, high consequence, or potential for combustible dust related fires and explosions. He discussed the Utilization of the OSHA Combustible Dust National Emphasis Program (NEP) as the foundation for the current combustible dust rulemaking process.

O. Hansen with Gexcon presented the paper entitled “Validation of FLACS for Vapor Dispersion from LNG Spills: Model Evaluation Protocol.” Hansen said, since LNG spills are complex phenomena and may occur on scales much larger than are assasable to experiment, models have been utilized to help evaluate hazards associated with LNG releases. This has led to the development of a Model Evaluation Protocol (MEP) that can be used to assess the suitability of dispersion models for predicting hazard ranges associated with large spills of LNG. The hazards associated with LNG releases are usually analyzed in three phases: the source term or the development of the evaporating LNG pool, atmospheric dispersion or the transport of the natural gas vapors, and effects (whether thermal radiation or explosion consequences). Traditionally the source term is analyzed separately from the dispersion model, where the output from the source model is used as input in the dispersion model. FLACS is one of the few CFD models with integrated source and dispersion models. He discussed the use of FLACS, widely used for consequence modeling in the oil and gas industry, against all of the benchmarks outlined in the MEP. FLACS predictions were compared with specific datasets and FLACS successfully met the quantitative assessment criteria for the validation stage of the MEP.

“Dust Explosion Hazard Assessment, Including OSHA Combustible Dust National Emphasis Program,” was presented by V. Ebadat with Chilworth Technology, Inc. Ebadat said the majority of powders that are used in the processing industries are combustible (also referred to as flammable, exploisible). An explosion will occur if the concentration of the combustible dust that is suspended in air is sufficient to propagate flame when ignited by a sufficiently energetic ignition source. He discussed the conditions that are required for dust cloud explosions to occur and presented a well-tried approach to identify, assess, and eliminate/control dust explosion hazards in facilities.

The 2009 symposium also featured a poster display. The following posters were presented at the symposium:

- “Data Mining Application on Chemical Incident Database Analysis,” M. Syukri, MKOPSC
- “Experimental Investigation on Combustion Behavior of Aerosols from Heat Transfer Fluids,” P. Lian, MKOPSC
- “Experimental Measurement and Calculated Flame Temperature (CFT) Modeling of Binary Hydrocarbon Mixture Flammability Limits,” F. Zhao, MKOPSC
- “New fire Fighting Materials,” C. Osorio, MKOPSC
- “Numerical simulations of LNG vapor dispersion in Brayton Fire Training Field tests,” R. Qi, MKOPSC
- “Design of a chip-scale calorimeter for thermal screening of highly energetic materials,” V. Carreto, MKOPSC
- “Thermokinetics study for dicumyl peroxide,” F-M. Chen, China
- “Thermal Runaway Hazards of Base-Catalyzed Cleavage of Cumene Hydroperoxide,” H-Y Hou, Taiwan
- “Integrating safety issues in optimizing solvent selection,” S. Patel, MKOPSC
- “Analysis of Visualization of LNG Vapor using Infrared Imaging Systems,” A. Safitri, MKOPSC
- “Safety performance in petrochemical industries,” T-C Wu, Taiwan
- “Uncertainty delimitation & reduction for improved overall mishap probability prediction: application to level control of distillation unit,” X. Yang, MKOPSC
- “Determination of Key Parameters of Expansion Foam during LNG Vapor Dispersion Control and Pool Fire Suppression by Medium Scale outdoor Experiment,” G. Yun, MKOPSC
- “Electroencephalographic assessment of human reliability on visual response task,” S-Y Cheng, Taiwan
- “Integrating of Resilience and Optimization in Chemical Process Design,” L. Dinh, MKOPSC
- “Active, Knowledge-based Process Safety Incident Retrieval System,” S. Khan, MKOPSC
- “The Influence of Molecular Structure on reactivity of Organic Peroxides,” Y. Lu, MKOPSC
- “Evaluation of Thermal Runaway Hazards and Process Safety of Tert-butyl hydroperoxide from Calorimetry,” Y-W Wang, Taiwan
- “Integration Tool for HAZOP and LOPA,” J. Zhao, China
CALL FOR PAPERS
Beyond Regulatory Compliance, Making Safety Second Nature
INTERNATIONAL SYMPOSIUM

October 26-27, 2010
Hilton Conference Center
College Station, Texas

Topics:
• **Metrics for Safety Performance** – Leading and Lagging Indicators, Industry vs. Organization
• **LOPA** - Techniques, Case Studies, Multiple Failures Leading to Incidents
• **Explosivity and Flammability** - Dusts, Aerosols, Experimental, Modelling
• **Process Safety Career Development and Education**
• **Engineering for Resilience and Sustainability**
• **Incident Histories** – Case Studies, Lessons Learned, Databases, Investigations
• **Inherently Safer Processes** – New Processes, Existing Plants, Man – Machine Interface
• **Human Factors** – Engineering, Behavioral Safety, Human Error
• **Management for Process Safety** – PS Engineering, PSM components, PSM with limited resources, Innovative strategies for improvement
• **Safety Culture** – Relationship to high consequence/low probability events
• **Facility Siting** – Personnel Siting, Tents
• **LNG** – Design, Experiment Evaluation, Consequence Analysis, Mitigation, Research needs, Regulations, CFD
• **Control Systems** – Unusual Situation Mgmt., Safety Instrumented Systems, Integrity Levels, Reliability analysis, Reliance on SIS, Alarm Mgmt.
• **Risk Assessment, Analysis and Management**
• **Reactive Chemistry** – Predicting Reactivity, Role of Contaminants, Catalysts and Inhibitors, Case Histories, Experimental Methods
• **Equipment Integrity** – Design for Maintenance, Maintenance Hazard Analysis, Failure Data
• **Transportation**
• **Process Safety in Related Industries** - Pharmaceutical, Nuclear, Paper, Semi-Conductors, Food Processing, Metal Processing, Water Treatment

Abstracts are due no later than **March 1, 2010**
Send abstracts to Dr. Sam Mannan, e-mail: mannan@tamu.edu

Additional information is available on-line at [http://process-safety.tamu.edu](http://process-safety.tamu.edu)
# 2010 Continuing Education Schedule

http://psc.tamu.edu/events/2010-schedule-of-classes

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<td>Fundamentals of Process Safety Management</td>
<td>Sepeda</td>
<td>Phoenix Contact</td>
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<td>2/4</td>
<td>Management of Change</td>
<td>Sepeda</td>
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<tr>
<td>2/9 – 2/10</td>
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<td>9/21 – 9/23</td>
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<td>Summers</td>
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<td>10/5 – 10/6</td>
<td>SIL Verification</td>
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<tr>
<td>11/2 – 11/3</td>
<td>Layer of Protection Analysis</td>
<td>Summers</td>
<td>SIS-TECH</td>
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**Will be offered in 2010**

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<td>Best Practices – Fluid Transfer Solutions</td>
<td>Thurman/Lingo</td>
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**Available upon request**

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<td>Implementing or Optimizing Your SHE Management Systems</td>
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<td>Auditing your SHE Management System</td>
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<td>Fundamentals of Loss Prevention</td>
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<td>What Went Wrong?</td>
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OSHA PSM and NEP Training

Course Overview

Since the promulgation of the OSHA PSM standard (29 CFR 1910.119) in 1992, refineries and chemical plants have reduced the number of process-related incidents and near-misses that occur at their facilities. However, fatal accidents are still happening even in facilities where PSM is practiced and well-established.

Based on the belief that chemical facilities may have an extensive written PSM program, but insufficient program implementation, OSHA expanded its 2007 refinery NEP to include chemical plants CPL 2 - 09-06) in July 2009. OSHA estimates 7,000 chemical facilities will be impacted by this NEP. These plants will not have the opportunity to review the static questions to prepare for the NEP inspections as they are not published on the OSHA website.

Join Siemens Energy and their leading PSM consultants in their “OSHA PSM NEP” training course to learn how to prepare your facility for an NEP inspection. In the course, you will:

• Learn about the OSHA PSM standard
• Get answers and interpretations about the OSHA PSM standard
• Gain insight about the Refinery NEP and Chemical Plant NEP directives
• Get answers and interpretations about the IPI static questions (Refinery NEP)
• Learn how to prepare for the OSHA NEP inspections
• Gain insight on what OSHA NEP teams may look for in chemical plants
• Gain insight about the top violations and penalties issued by the Refinery NEP
• Get answers to all your general questions about MOC, MI, PHA, PSI or PSM from Siemens’ leading experts, including a former OSHA PSM manager
• Gain insight about Risk Based Inspection of process equipment
• Get answers to all your questions about OSHA enforcements
• Gain insight on how to develop a PSI framework for PSI Management
• Gain insight on how to build smart KPI models for each PSM element
• Have opportunities to network

January 14 - 15, 2010
OSHA PSM and NEP Training Course Agenda

*Subject to change

Thursday, January 14
8 AM - 4:30 PM

- Learning Objectives
- Incidents that led to the initiation of the OSHA PSM standard
- Overview of the PSM standard, 29 CFR 1910.119
- Management of Change (MOC) - Mandate & Implementation Strategy
- Process Safety Information (PSI) - Mandate & Implementation Strategy
  - Mechanical Integrity
  - Relief System Design
- Employee Participation
  - PSM Culture
  - PSM Foundation
- Contractor Management
- Process Hazard Analysis (PHA) - Mandate & Implementation Strategy
- Mechanical Integrity (MI) - Mandate & Implementation Strategy
  - Deficiencies/Fitness for Service
  - PV Evaluation and Re-rating
  - IDMS
  - Procedures & Standards
- Incident Investigation - Mandate & Implementation Strategy
  - Root Cause Analysis
  - Failure Analysis
- Operating Procedures and Operator Training - Mandate & Implementation Strategy
- Work Permits - Mandate & Implementation Strategy
- Emergency Planning and Response - Mandate & Implementation Strategy
- Trade Secrets - Mandate & Implementation Strategy
- Compliance Audits - Mandate & Implementation Strategy

Friday, January 15
8 AM - 4:30 PM

- Overview of OSHA Refinery NEP
- Overview of the OSHA Chemical Plant NEP
- OSHA NEP Inspection Process
  - OSHA NEP Team
  - NEP Inspection Protocol
  - Overview of OSHA Litigation Process
- Overview of the IPI Static Questions from the Refinery NEP
- OSHA Inspection and Citation Process
CALENDAR

January 13, 2010
Steering Committee Meeting
Mary Kay O’Connor Process Safety Center
Siemens Facility,
4615 Southwest Frwy, Suite 900

March 4, 2010
Steering Committee Meeting
Mary Kay O’Connor Process Safety Center

April 29, 2010
Steering Committee Meeting
Mary Kay O’Connor Process Safety Center

April 30, 2010
Technical Advisory Committee Meeting
Mary Kay O’Connor Process Safety Center

October 26-27, 2010
2010 SYMPOSIUM
Mary Kay O’Connor Process Safety Center
College Station Hilton Conference Center