2015 International Symposium Reaches New Heights


The Honorable Vanessa Allen Sutherland, Chairperson of the US Chemical Safety Board, presented the Frank P. Lees Memorial Lecture. Dr. Ian Cameron, professor at the University of Queensland, presented the keynote address entitled “In Pursuit of Improving Process Safety Performance” on the second day.

In addition to the highlighted keynote addresses, nearly 100 presentations were given on various safety-related topics, including safety culture/operational discipline, risk analysis, process management for safety, and inherent safety. Summaries of the papers are featured beginning on page 10. Exhibits from 40 companies displayed products, technology and software related to process safety.

On Wednesday evening, the Center sponsored a banquet for guests at the Traditions Club. Entertainment for the evening was provided by two Aggie Student organizations, the Aggienizors and Wreckin’ Raas, and also featured the professional jazz band Big Apple Trio.

A highlight of the symposium was the presentation of the Merit and Service Awards. The annual Trevor Kletz Merit Award recognizes individuals who have 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...
Director’s Corner

Hazard and risk, what do they mean, and are they interchangeable terms? The answer is, “not just no, but absolutely not.” The definition, understanding, and interpretation of these two words are completely different. The Merriam-Webster online dictionary defines hazard and risk as follows:

**Hazard**: a source of danger.
Source: http://www.merriam-webster.com/dictionary/hazard

**Risk**: the possibility that something bad or unpleasant (such as an injury or a loss) will happen.
Source: http://www.merriam-webster.com/dictionary/risk

On the other hand, when speaking about process safety, it is common to use the following definitions given by the Center for Chemical Process Safety, American Institute of Chemical Engineers:

**Hazard**: An inherent chemical or physical characteristic that has the potential for causing damage to people, property, or the environment.
Source: http://www.aiche.org/ccps/resources/glossary/process-safety-glossary/hazard

**Risk**: A measure of human injury, environmental damage, or economic loss in terms of both the incident likelihood and the magnitude of the loss or injury. A simplified version of this relationship expresses risk as the product of the likelihood and the consequences (i.e., Risk = Consequence x Likelihood) of an incident.
Source: http://www.aiche.org/ccps/resources/glossary/process-safety-glossary/risk

Given the above definitions, it should be very clear that hazard and risk are not interchangeable terms. Once the basic definition of these two terms is accepted, we can then talk about what and how people understand different aspects of hazard and risk in day-to-day activities. What is common is that not only do we use these terms interchangeably, but the actions we take and what is acceptable in a given situation is based on the confused understanding of these two terms. To keep matters simple, let us take the example of a kitchen knife with a six-inch blade common in day-to-day use in the kitchen. This knife is a useful article for cooking and other applications but could also be used to injure people or commit other undesirable activities. The knife is a hazard because it is a source of danger, but the risk from it may vary from minimal to extensive depending on how it is handled. The hazard from the knife could only be eliminated if we decide to forgo the benefits of having a knife completely. Given that we do not want to do that, our only reasonable action is to manage and reduce the risk, which could include proper storage and access to the knife, use of a sheath to cover the sharp edge, safety handle/lock, and other features and procedures. Inherently safer concepts call for elimination or reduction of the hazard and in so far as we do need a knife to get some useful things done, let us agree that at least in this example we cannot eliminate the hazard. Furthermore, reduction of the hazard is probably limited only to certain options, e.g., we can only go below a certain size or sharpness for it to be a useful knife. Thus, a major part of preventing undesirable outcomes, such as injury or loss of property falls on risk management techniques.

Transposing the above discussion on knife to chemicals or hazardous materials yields some interesting observations. Any substance (e.g., hydrocarbons, chemicals, materials) represents a certain hazard because of its inherent properties (think about the knife example). For example, chlorine is toxic and gasoline is flammable, and we cannot do anything about these inherent properties of chlo-
Dr. Mannan Recognized as Professional Process Safety Engineer and IChemE Certifies Masters in Safety Engineering Program

Since 2014, the Mary Kay O'Connor Process Safety Center (MKOPSC), has held events and engaged in collaborative projects with the Institution of Chemical Engineers (IChemE), the lead professional engineering organization in Europe. The relationship between IChemE and MKOPSC has led to collaboration in process safety education, CPD products, and strategic leadership and direction.

IChemE recently introduced the Professional Process Safety Engineer registration to provide public recognition of peer reviewed process safety practitioners. The registration is globally recognized and positioned at the same professional level as Chartered Engineer or Professional Engineer. The goal of this program is to distinguish those with a strong process safety competence and be a mark of professional excellence for practitioners worldwide. At MKOPSC’s 2015 International Symposium, IChemE conferred the Professional Process Safety Engineer certification on Dr. Mannan. Dr. Mannan, also a Fellow of IChemE, joins fewer than 100 engineers worldwide who have achieved this qualification.

At the 2015 International Symposium, IChemE recognized the Master of Science in Safety Engineering (MS SENG) as a preferred pathway to obtaining the Professional Process Safety Engineer qualification. IChemE benchmarked the MS SENG curriculum and certified it as satisfying the academic requirements for registration as PPSE.

M. Sam Mannan
Fall 2015
within the central theme of the Center: Making Safety Second Nature. In
establishing the Merit Award, the Steering (continued on page 4) Committee underscored the importance of promoting and recognizing
significant contributions and accomplishments of practitioners and
researchers worldwide. The 2015 Trevor Kletz Merit Award was presented
to Valerio Cozzani. Dr. Cozzani is a Professor at the University of
Bologna Department of Chemical Engineering, Mining and Environmental
Technologies. He was the coordinator of educational projects for
international education at the University of Bologna. For over ten years he
carried out research in the field of chemical plant safety, environmental
technologies and innovative chemical processes. He is a member of the
Editorial Board of the Journal of Hazardous Materials and scientific reviewer
for 25 international scientific journals.

The Harry H. West 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 Service Award was presented to Michael L.
Marshall. Mike Marshall is the OSHA Directorate of Enforcement Programs
in the Office of General Industry Enforcement. He serves on the MKOPSC
Symposium Planning Committee and has been a Symposium Track Chair
since 2004.

This year, the Lamiya Zahin Memorial Safety Scholarship was presented to Pranav Kannan. In fond
and living memory of Lamiya Zahin, the Artie McFerrin Department of Chemical Engineering and the
Mary Kay O’Connor Process Safety Center have established the Lamiya Zahin Memorial Safety
Scholarship. On July 31, 2004, an explosion and fire occurred in a university apartment on the Texas
A&M University campus. Four members of the family of Saquib Ejaz, a chemical engineering graduate
student, were critically injured and hospitalized. Saquib’s mother and his four-year old daughter, Lamiya
Zahin subsequently passed away a few days later in the intensive care burn unit at Galveston Hospital
from injuries sustained in the fire. Graduate students in the Chemical Engineering department are
encouraged to apply for the scholarship by writing a 1,000-word essay on “Safety
Innovations in Research Projects.”
"As we look ahead into the next century, leaders will be those who empower others", this was Bill Gates thoughts on leadership in the 21st century, which when carried over to Process Safety forms the fundamentals of exemplary process safety performance in industries. Leadership by technical safety professionals who empower employees with the tools to operationalize that improvement more often than not bridges the translation of all the effort to improve safety performance to actual improvement. Hence, given the criticality of leadership, it is important to establish methods to interpret leadership in the context of process safety and research in process safety should provide the tools to professionals in order to empower organization employees to contribute and assimilate the safety culture in the organization.

The exponential advancement in microprocessor technology and the rapid fall in the cost of sensors of every type, shape and size is a tremendous opportunity which research in safety can be capitalized. The research into sensors for safety needs to be broadly in two critical paradigms both of which have important implication on overall integrity of the process. The first is the development of sensors, which can be used, in safety critical processes. This may seem redundant, since the general implication is, we can have a temperature sensor in a reactor, which may have a runaway reaction and shut it down. But the issue with this approach it is after the fact. We need sensors which can be placed in the system, and monitor multiple parameters with a single probe, thus reducing issues such as spatial and temporal specificity issues. There have been accidents where sensor malfunctions have often lead to erroneous actions and hence sensors need to be designed with a keen focus on process safety, hence it is not only how accurate measurements are, but can this accuracy be maintained in stressed conditions providing data at critical moments. The development of these sensors provides a powerful tool to the safety professional to empower their operators and concerned professionals with the confidence to trust their training when it is time to put it in practice.

The second aspect of sensors is the data collected. There is an age-old adage, which is appropriate for any kind of data analysis. It reads “Garbage In – Garbage out”. Both unacceptable in the modern world of process safety. There is more need now than ever for robust techniques to both analyze and present the data in a Usable, Accessible and Robust format to the safety professional. This implies that research needs to focus on methods to identify the appropriate indicators, outliers, and means of data which can often quickly accumulate, especially in the modern chemical process where hundred’s variables interact and create a data mine. The methods may include research into data filters, data processing, in-situ risk modeling, online updating of Bayesian networks, data informed event and fault trees and many others, thus extending traditionally static concepts into dynamic and more useful forms. An important extension is visualization of this process safety data; hence this research needs to be augmented by interdisciplinary forays into human factors engineering, human machine interface and cognitive research. The safety professional can only function and lead the team when the information they process satisfies the best practices in the aforementioned research areas, hence it is important that, we establish the best practices by a science-informed, hypothesis driven research.

The first lecture in any undergraduate class would generally resonate with the words “Understand the fundamentals”. There is a reason for imbining this value, it is important to have a strong understanding of the physics of phenomena, before we can implement the principle in a technology. Process safety needs and also will be the biggest beneficiary of fundamental research into several core subjects, which influence technologies. Case in point is research into flammability and dust explosions, which form the fundamentals of prevention and mitigation technologies. We need to understand the behavior of materials in a variety of environments, to understand if we can use them as materials of construction and the understanding comes from how the physics of the environment interacts with the chemistry of the materials. In today’s world, where there are enough mathematical models than one can apply, it is even more important that experimental schemes are setup to validate the models, before process design philosophies are developed. This is an area where thought leadership is of utmost necessity, since the research needs to be focused on effect of applied process variables to fundamental parameters. Hence when this research is performed, we need to ensure that the design of experiments, the setup and the data obtained is relevant to the one of the pillars of process safety, inherently safer design. We cannot be inherently safer, unless we understand phenomena inherently. Hence for a safety professional to provide leadership, accurately and confidently advise design, the fundamentals need to be solid.

The introduction of process safety into chemical engineering curriculum has been a giant step towards empowering the
next generation towards safety sensitized design and operations. However, one of the key lessons from many process safety incidents seems to be the poor management and lack of decisiveness by leadership. Better management systems definitely do help alleviating the problem, however this is often a result of expensive reviews and audits, and in spite of these, many soft issues may slip through the cracks. Hence, solution is in having professionals who enter the field with an understanding of tools for leadership and management. The key here is to focus on the aspects of leadership and management, which is of relevance to the safety professional. This includes communication in a hierarchical organization, tools to influence safety culture and behavior, management of audits and structure amongst others. This is an area of process safety research where academia needs to collaborate with professionals in practice to design appropriate and critical curriculum to equip the next generation safety professional.

In conclusion, it is important to state the importance of leadership, and in the words of former President of United States of America John F. Kennedy, “Leadership and learning are indispensable to each other.”

Bridging the Information Gap: Instrument Reliability Network

In the process safety industry, where having reliable data can mean the difference between an accident and a normal day at the plant, an abundance of information sounds like a good thing, but just like your email inbox, if the data is not organized and sent where it needs to go, it is useless. A cornucopia of information is recorded during industrial processes, but how much of it is really used to its fullest potential? How are lessons learned from data at the facility level communicated to the industry level? In reality, recorded data is underutilized and lessons learned from data at facilities often are not communicated further.

The Instrument Reliability Network (IRN), a collaboration between industry and the Mary Kay O’Connor Process Safety Center, focuses on bridging this information gap. The IRN confidentially collects already existing process data from industry, provides educational opportunities to improve data collection practices and analyzes the data to develop global lessons learned and wider trends that the entire process industry can benefit from. IRN serves as a data repository and provides the statistical analysis necessary for metrics and benchmarking.

Currently, IRN has three projects in its various project phases:

- Pressure Transmitter Project
- Input Device Project
- Final Element Project

Please contact the IRN for additional information on these projects.

Additionally, the IRN will have three panel discussions at the 71st Annual Instrumentation and Automation Symposium. These panel discussions are:

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>Topic</th>
<th>Topic Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuesday, afternoon</td>
<td>Competency through Quality Assurance</td>
<td>Discussion about qualification program for technicians and contractors, how they verify work and documentation quality, how they ensure good reporting and failure escalation.</td>
</tr>
<tr>
<td>Tuesday, afternoon</td>
<td>Data Analysis and Results</td>
<td>Discussion about challenges to collecting data, IRN progress in overcoming the challenge, and why we think that we are unique within the worldwide efforts.</td>
</tr>
<tr>
<td>Wednesday, workshop</td>
<td>Inspections, Preventive Maintenance, and Proof Testing</td>
<td>3 users to talk about their ITPM program. How are they incorporating reliability tracking into these programs?</td>
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Please come to the Instrumentation and Automation Symposium and participate in the panel discussion as panel chair or audience participant. Contact Keith Lapeyrouse or Angela Summers for additional details.
Dr. M. Sam Mannan and researchers in the Artie McFerrin Department of Chemical Engineering at Texas A&M University were featured on the cover of the American Institute of Chemical Engineers (AIChE) Journal.

Mannan, director of the Texas A&M Engineering Experiment Station’s Mary Kay O’Connor Process Safety Center and regents professor, was assisted by Olga Reyes-Valdes, a graduate student in the department, and Drs. Sonny Sachdeva, Hao Chen, Yi Liu and Delphine Laboureur, all former postdoctoral researchers with the center.

The research article, titled “Trends and Challenges in Process Safety,” was featured in the November issue of the peer-reviewed AIChE Journal. In addition to the publication of the article and being chosen as the cover story, their research was highlighted in a summary article in the November 2015 issue of the Chemical Engineering Progress, which highlights the importance of this article.

“Chemicals play a key role in today's high-tech world,” Mannan wrote. “The chemical industry is linked to every technologically advanced industry; only a handful of the goods and services we enjoy on a daily basis would exist without essential chemical products.

The focus of the research, process safety, is a concept that is applicable across various industries. It introduces base knowledge of chemical interactions into everyday engineering procedures. This understanding assists experts working with complex and dynamic chemical interactions. The research brings together the science of material characteristics and behaviors, human-machine interfaces and management systems to assist with equipment design, sustainability, reliability engineering and organizational science.

The researchers suggest a systematic approach to process safety is needed to ensure safety of the public, researchers and the environment. Such an approach would ensure safety not only during normal production, but also during abnormal and disaster situations.

“An engineer must function as a member of the global community,” Mannan wrote. “This means not only competing in a global marketplace, but also acting as a professional who shares global responsibilities.”
Student News

Jiaojun Jiang obtained his PhD after successfully defending his thesis, “Study of Dust-Gas Hybrid Mixture Explosions”. He started employment at Evonik in August.

Josh Richardson obtained his PhD after successfully defending his thesis, “Facility Siting and Layout Optimization for Risk Reduction of Offshore Operations”. He started employment with ExxonMobil in August.

William Pittman obtained his PhD after successfully defending his thesis, “Study of the Phase Behavior of Mono-Nitrated Poly-Substituted Aromatic Nitrocompounds.” He will start working at Smith & Burgess in January.

Amira Chowdhury obtained her PhD after successfully defending her thesis, “Shock Interaction with Dust Layers.” She started employment with Shell in August.

Bin Zhang obtained his PhD after successfully defending his thesis, “Liquefied Natural Gas Hazards Mitigation with High Expansion Foam.”


Bilkis Islam obtained her Master of Science in Safety Engineering after successfully defending her thesis, “Risk Management Strategy for Road Transportation of LNG.” She accepted employment with PSRG.


Rendra Haristyawan obtained his Master of Science in Chemical Engineering and started working at Pertamina in Indonesia.

New Students — Fall 2015

PhD

Joshiba AV, Pritishma Lakhe, Bharatvaaj Ravi, Yueqi Shen, Denis Su, Shuai Yuan, Jingyao Wang

Master of Science in Safety/Chemical Engineering

Nilesh Ade, Faisal Alshethry, Susana Caceres, Shiqi Chen, Haitian Han, Jake Marek, Sunhwa Park, Ankita Taneja, Lihan Zeng
Visitors to the Center

October

Dr. Daniel Hartmann from Ben-Gurion University

Drs. Maria Papadaki, Simon Waldrum, Hans Pasman, and Luc Vechot

Dr. Daniel Crowl from Michigan Tech University

Dr. Benjamin Seligmann from Curtin University

November

Dr. Valerio Cozzani from University of Bologna

Dr. Viatcheslav Kafarov from University of Santander in Bucaramanga, Colombia

Dr. Leopoldo Villadiego from Universidad de San Buenaventura, Cartagena, Colombia

Interns

Laura Angarita
Universidad Industrial de Santander

Emelyn Barrios
Universidad de San Buenaventura

Juan Gamarra
Universidad de San Buenaventura

Chunyu Jiang
China University of Petroleum

Anqi Li
China University of Petroleum

Jeimy Martinez
Universidad Industrial de Santander

Cesar Rojas
Universidad de Los Andes

Haoyi Wang
China University of Petroleum

Scholars

Byung Chul Jung
Director General
Daegu Regional Environmental Office
Ministry of Environment
Republic of Korea

Juliana Puello Mendez
Professor
Group of Research in Engineering Sciences
Universidad de San Buenaventura

Li Shi
Associate Professor
Department of Environmental and Safety Engineering
China University of Petroleum
Amarette Renieri has joined the Center as a Program Assistant. She will be working with the Center’s continuing education and distance learning programs, the Instrumentation and Automation Symposium as well as many other important activities. Amarette studied Communication and German at St. Edward’s University in Austin, Texas. After receiving her bachelor’s degree, she was a Fulbright English Teaching Assistant in Ingelheim, Germany, where she grew to love traveling and experiencing other cultures. She recently relocated from Alpine, TX to College Station.

Yogesh Koirala has joined the center as a Postdoctoral Research Associate. He is a recent graduate from Colorado School of Mines, and graduated from TAMU in 2010. His PhD work focuses on the pyrolysis process of converting biomass to biofuel.

Dr. Paul J. Tikalsky, dean of College of Engineering, Architecture and Technology at Oklahoma State University, has appointed Dr. Qingsheng Wang holder of the Dale F. Janes Endowed Professorship in Fire Protection & Safety.

Wang is an associate professor in Fire Protection & Safety and a graduate faculty in Chemical Engineering at Oklahoma State University and is also a faculty fellow of MKOPSC. Wang earned his bachelor’s degree from Zhejiang University and his Ph.D. from TAMU.

The Dale F. Janes Endowed Professorship in Fire Protection and Safety was created in 2007. In 2008, FPST stakeholders donated over $400,000 for the creation of a $1.6 million endowed professorship, for the university’s “40 Days and 40 Nights” fundraising campaign, in which donations of over $250,000 were quadrupled.

Outreach Activities

September 10
Chemical Processing Webinar
Why Do Catastrophic Incidents Keep on Happening?

September 15-22
Nanjing University of Science and Technology
Cultivation Model of American Safety Professionals
Inherent Safety Research
Reactive Chemicals
Nanjing and Chengdu China

September 22-24
3rd CCPS China Conference on Process Safety
Role of Safety Programs for the Continued Development of Industry—A Chinese Perspective
Ningbo, China

October 1
7th Southwest Process Technology Conference
Integration and Fire Protection Engineering for Better Safety Performance
Galveston, TX

October 16
TAMU Industrial and Systems Engineering Seminar Series
Systems Engineering and Risk Control of Complex Systems
College Station, TX

October 21
SOCMA’s ChemStewards National Safety Symposium
Accountability and Competence for Improved Process Safety Performance
Houston, TX

November 3
Fall Seminar Series
MKOPSC: A Catalyst for Enhanced Process Safety Competency and Knowledge
Lamar University
Beaumont, TX

Staff and Alumni News

Amarette Renieri Joins the Center
Amarette Renieri has joined the Center as a Program Assistant. She will be working with the Center’s continuing education and distance learning programs, the Instrumentation and Automation Symposium as well as many other important activities. Amarette studied Communication and German at St. Edward’s University in Austin, Texas. After receiving her bachelor’s degree, she was a Fulbright English Teaching Assistant in Ingelheim, Germany, where she grew to love traveling and experiencing other cultures. She recently relocated from Alpine, TX to College Station.

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Recent Publications


Upcoming Speaking Events — Dr. Sam Mannan

December 22, 2015
Opportunities for Engineering Graduates
Bangladesh University of Engineering Technology

December 27-28, 2015
Inherently Safer Design
Bangladesh University of Engineering Technology

December 23, 2015-January 6, 2016
Industrial Safety Course
Bangladesh University of Engineering Technology

December 31, 2015
Chemical Safety and Security
Bangladesh University of Engineering Technology

January 3-4, 2016
Recent Developments in Process Safety
Bangladesh University of Engineering Technology

January 5, 2016
Curriculum Development to Address the Changing Nature of the Engineering Profession
Safety Programs for Garment Industry
Bangladesh University of Engineering Technology

TBD 2016
A Serendipitous Journey for a Chemical Engineer
University of Oklahoma
Norman, OK

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Case History— 2015 Tianjin Explosions
Presented by Yue Sun at the October 26 Steering Committee Meeting

The presentation was about the series of explosions that happened in Ruihai International Logistics, Port of Tianjin, China, on August 12, 2015. The student described the incident, as well as the sequence of events and the consequences. There was also information about related chemical hazards, typically sodium cyanide and ammonium nitrate. The siting issues and similar chemical industrial incidents in China were discussed, which called for more concern about process safety and industrial safety in China. The recommendations given were regarding regulations on land use planning and process safety, implementation of regulations, reshuffling of industrial layout, emergency response, and training and communication.

Case History— Caribbean Petroleum Refining Tank Explosion and Fire
Presented by Pakorn Chaiwat at the October 26 Steering Committee Meeting

The incident occurred on October 22, 2009 at a refinery site in Bayamon, Puerto Rico during the transfer operation of 11.5 million gallons of unleaded gasoline. The immediate cause of the incident was a faulty level transmitter and inadequate tank supervision which lead to overfill of 200,000 gallons of unleaded gasoline. The gasoline flowed through the open dike valve into the waste water treatment area where the gas cloud ignited. The ensuing explosion was equivalent to 2.9 on the Richter scale and damaged over 300 homes and businesses, while the subsequent fire took more than 60 hours to extinguish. The explosion calculation confirmed the overpressure radius for which the safe distance (equivalent to 0.3 psi) of more than 1.5 miles was required. Qualitative barrier analysis was performed and found that the company's Asset Integrity Management System, Safety Management System, Incident Investigation and root cause analysis, Training and Competency Development System, and Knowledge Management System were inadequate and inefficient. Statistics show that overfilling contributed to almost 20% of aboveground storage tank incidents and more than 16 of these incidents happened between 1972 and 2014. The company also had 15 overfill incidents during refinery operations (1992-1999) and 3 during tank farm operations (2005-2009) which indicates failure to learn from past incidents to prevent future mistakes. The two main recommendations from this incident are to develop and implement a Knowledge Management System that incorporates lessons learned from the past and to use reliable equipment for tank level measurement such as a radar tank gauge connected to a computer system.
“Application of Computational Fluid Dynamics (CFD) for LNG pool spreading and vaporization on water” Nirupama Gopalaswami, PhD Chemical Engineering Student

The presentation discussed the growth of the LNG industry in the US. The potential causes for spills on water and hazards that can occur due to an LNG release were presented using a bow-tie structure. The different phases of the research were discussed with key conclusions. The presentation then gave details on the LNG experiments that were performed last year at the Brayton Fire Training School. The CFD model details were provided. The results were discussed with respect to pool spreading parameters and vaporization rate. The presentation was concluded with future work.

“Flammability Characteristics of Light Hydrocarbon and its Mixtures at Elevated Condition” Ning Gan, PhD Chemical Engineering Student

The flammability characteristics of combustible gases like hydrogen, methane, and propane is related to the temperature and pressure of the gas and air mixture when it is ignited. Large amounts of reaction energy will be released in a short duration of time which can cause deflagration or even detonation, also the extremely high temperature of the reaction will become a threat to the facility and people. The research objective is to study the flammability characteristics of combustible gases at elevated conditions (high temperature and high pressure) and propose the corresponding methods to handling them safely. By using both experimental data and theoretical calculations, an improved Le Chatelier’s Law will be proposed and tested to better predict the flammability limits of combustible mixtures.
Ryan Wong with ExxonMobil presented “Risk Assessment Tool for Liquid Overfill of Process and Storage Vessels.” The presentation describes the process that a large company uses to analyze the risk associated with liquid overfill from pressure vessels and atmospheric storage in both petrochemical and refining operations. Due to learnings from recent overfill events, a tool was developed to assess the risk of liquid overfill. This presentation covers methodology and industry learnings that were used to develop a tool that is able to consistently assess liquid overfill risks across various operation types. The hope is that in sharing this information other companies may incorporate parts of the methodology or develop similar tools to identify overfill risks.

Syeda Sultana Razia with Bangladesh University of Engineering and Technology presented “Facility Siting of an Ammonia Urea Complex Based on Risk Analysis.” The major accident in the history of chemical industry of Bangladesh occurred on June 20, 1991 with the CO\textsubscript{2} stripper of Urea Fertilizer Factory Limited (UFFL), located in Ghorashal, Bangladesh. About 50 people in and near the control room were affected and 7 of total 11 died on spot. The accident was caused by the faulty welding of stripper. However, the location and safety features of control room were the key factors that lead to the fatality. In this study a number of critical process units of an existing ammonia-urea plant were selected as the sources of overpressure and toxic release. Locations of control room and two operator’s shelters were considered with respect to the critical units. The consequences due to toxic release and blast overpressure were modeled for various worst case scenarios of the critical units. Both structural damage and human mortality/injury were converted into risk factors and locations with minimum risk factors were determined for the probable siting of the control room and operator’s shelters. The result is compared with the existing layout of the ammonia-urea complex considered.

Ravi Sharma with Indian Institute of Technology Roorkee presented “Lessons Learned from Industrial Chemical Accidents: A Case Study of Indian Oil Corporation Terminal, Jaipur, India.” Indian Oil Corporation (IOC) storage terminal accident in Jaipur, India, is a recent example of Vapor Cloud Explosion (VCE) and fire accidents preceded by Buncefield (2005) and Puerto-Rico (2009). On 29th October 2009, a leak of gasoline occurred in the IOC storage terminal. Long delay of 80 minutes in ignition led to a huge vapor cloud covering an area of 180,000 m\textsuperscript{2} over the entire installation and subsequent ignition triggered strong VCE with intensity more than 200 kPa. Eleven people lost their lives, more than 150 people were injured and a property loss of approximately U.S. $60 million was reported. The Individual and Societal Risk has been quantified and found that risk does not lie in the unacceptable region, but in the As Low As Reasonably Practicable (ALARP) region where substantial measures for a risk reduction were needed. The incident has left many safety issues behind which must be repeatedly addressed. It reveals that adequate safety measures were either underestimated or not accounted seriously. This presentation highlights the aftermaths of IOC incident and addresses challenges put forward by it. Furthermore, a comparative study is performed between such incidents to analyze the similarities and how they could have been avoided. Therefore, electronic-Incident Command System (e-ICS) based emergency response planning is an integral and essential part of the safety and loss prevention strategy and comprises of the actions taken to manage, control and mitigate the immediate effects of an incident.

James Thompson with ABS Group presented “Implementing New Elements into an Existing PSM Group.” This presentation discusses an approach for successfully implementing a new element(s) into a site or company’s existing process safety management (PSM) system. This approach includes steps for:

- developing a new element
- integrating new element activities into existing elements
- implementing new Risk Based Process Safety (RBPS) elements, and
- monitoring new elements or activities.

Specific examples for implementing RBPS elements...
such as Process Safety Culture, Compliance with Standards, Process Safety Competency, Stakeholder Outreach, Conduct of Operations, Measurement and Metrics, and/or Management Review and Continuous Improvement was provided.

William Nelson with DNV GL presented “Dynamic Barrier Management — Managing a Dynamic Reality.” Bow tie risk management has grown in application significantly since early demonstration studies 15-20 years ago. This method builds on the Swiss cheese model for accident causation and converts this into practical risk management strategies. The number and quality of barriers needs to match the risk potential of the threat and the consequence magnitude. The bow tie method is easy to understand and it can be communicated well to staff and contractors. Each barrier can be assigned to an owner who tracks the barrier performance. More recently, DNV GL has worked with several companies to address dynamic barrier issues. This recognizes that barriers are not static in their performance, but they tend to degrade over time if not actively managed. Degraded barriers affect the risk equation as well, as assumptions that various threat or consequence arms match company risk criteria can be defeated when barriers perform below their assumed performance standard. The Dynamic Barriers approach described in this presentation includes several means by which barrier status can be monitored and improvements implemented where required. At the basic level, this includes routine inspections, audits and required regulatory reviews, but it adds deeper audit functions. Performance standard monitoring can also be integrated into barrier status. An interesting extension is the use of incidents and near misses as a means to update dynamic barriers. The BSCAT tool recognizes that every incident means several barriers failed or were degraded. Thus investigation in a barrier model format can also be used for dynamic barrier assessment. It is often the case that incident information appears at a higher rate than audits and planned inspections. Integrating all these techniques allows a better estimation of current barrier performance and whether any operational modifications are required to achieve the company risk criteria.

Peter Veloo with Exponent presented “A Numerical Approach to Determining Flammability Limits of Hydrocarbon Process Fluids.” Intrinsic to the computer modeling of explosions and fires is the concept of flammability limits. Conventionally, the term “flammability limit” is defined loosely as the concentration limits beyond which flame propagation is no longer possible. More formally, a fundamental flammability limit is defined as the mixture concentration at which a steady, laminar, one-dimensional, planar, and adiabatic flame fails to propagate. Fundamental flammability limits are reached when the heat release from chemical reactions becomes comparable to the radiative heat loss from the flame. The difficulty in predicting these fundamental limits, a priori, for a given combustible mixture is the dependence of the flammability limit on chemical kinetics. In this study we present a computational methodology for the determination of a mixture’s fuel lean and fuel rich flammability limits. Numerical calculations were performed using a modified version of the CHEMKIN PREMIX flame code. This code has been modified to allow for the capturing of the singular behavior around the turning point and allowing, thus, the accurate determination of a mixture’s flammability limits. The present methodology has been extensively validated to determine the flammability limits of single component and binary fuel mixtures. These validations are presented. Real hydrocarbon process fluids are complex mixtures that consist of hundreds of species spanning a wide range of molecular weights and chemical classes. The surrogate fuel approach, whereby the kinetics of the complex mixture is modeled using a few individual components, is now applied to determine the flammability limits of real hydrocarbons.

Simon Leyland with Process Systems Enterprise presented “Ensuring Safe Facility Blowdown and Lessons Learnt from Incident Investigation. A facility blowdown in the oil and gas industry is a safety critical operation; required to ensure the safe shutdown of processing facilities during a plant emergency. In a blowdown operation, the entire plant is isolated into a number of segments and then depressurized into the facility’s flare system. The outcome of a blowdown event is dependent on the performance of a number of safety critical elements in the plant; these are designed to ensure the safe and successful depressurization of the plant without any conspicuous incidents. Blowdown events are inherently fast transient processes, reliant on a large
number of valve opening and closing operations with rapid reduction in pressure and temperature. It is critical to ensure that the process is depressurized quickly enough (cf API 521) but whilst respecting constraints such as minimum design metal temperatures, AIV/FIV limits in flare tailpipes and pressure constraints throughout the flare system. Blowdown incident investigations typically involve a critical review of the plant historian data and require dynamic simulation studies to adequately assess the event so as to determine whether the blowdown operation proceeded as planned, that no constraints were violated and to glean any process safety lessons that can be learnt. In this talk, with reference to a number of recent events on oil and gas facilities, we explain how to carry out a comprehensive blowdown investigation. We will discuss a number of case studies from facilities in different parts of the world, including those that have shown operational deviations such as non-closure/partial closure ESD valves, delays in opening or non-opening of BDVs, non-operational check valves. Some of these deviations caused flare capacity issues in the plant, minimum design metal temperature (MDMT) violation risks to process drums, unexpected pressurization of process drums, flow reversal into low pressure segments causing near miss events, and other violations of recommended practice. We will explain how these studies have helped understand the current state of the plant’s safety barrier and have been used by operating companies to identify design and operational changes critical for safe plant operation. Finally we will discuss how these studies provided input to plant maintenance personnel in order to help prioritize maintenance activities and to make prudent maintenance investment.

**David Moore** with AcuTech Consulting presented “Creating a PSM Environment.”

**Valerio Cozzani** with University of Bologna presented “Quantitative Assessment of Safety Barrier Performance in the Prevention of Cascading Events.” The prevention of high-impact low-probability (HILP) events in industrial clusters or complex industrial areas where critical infrastructures are present critically depends on the presence and the performance of safety barriers that may have the potential to prevent escalation. In recent years a set of tools and models were developed for the quantitative assessment of risk due to cascading events and domino scenarios. The aim of the present study is the integration of tools for risk assessment with a specific approach allowing a detailed assessment of safety barrier performance. A LOPA (layer of protection analysis) based methodology, aimed at the definition and quantification of safety barrier performance in the prevention of escalation was developed. The method allowed the quantitative characterization of alternative mitigated and unmitigated escalation scenarios. Data were collected on the more common types of safety barriers aimed at the prevention of fire escalation. An example of application was developed, allowing the quantitative assessment of risk mitigation of cascading events triggered by fire escalation based on the assessment of safety barrier performance.

**Richard Prugh** with Chilworth Technology presented “Life-Safety Concerns in Chemical Plants.” The safety and health standards of the Occupational Safety and Health Act [OSHA] do not specifically address life safety in chemical plants, other than requiring owners and operators to “provide a safe place to work” and to ensure that “employees may evacuate the workplace safely”. NFPA 101 would classify chemical plants as high-hazard industrial occupancies, and a primary concern is to ensure “minimal danger to occupants in case of fire or other emergency before they have time to use exits to escape”. NFPA 1 also requires that the design and operation of buildings and facilities “provide an environment for the occupants that is reasonably safe from fire and similar emergencies, for the amount of time needed to evacuate”. Thus, most life-safety requirements are concerned with safe exit. There are, however, other life-safety hazards that should be of concern to chemical plant owners and operators. They include many single-exit locations, such as the upper levels on distillation/fractionation columns, scrubbers, and other tall equipment; elevated work platforms as atop multi-story buildings and smokestacks; platforms above tank cars, tank trucks, and hopper cars; at the head of bucket elevators; work spaces above false ceilings; and ladder-access roofs over operating areas. Also, chemical-plant life-safety hazards include flash fire [flammable vapors and combustible dusts]; releases of toxic gases and vapors; and vessel rupture from runaway reaction or other causes of overpressure. This presentation included practical countermeasures for these life-safety
Facility Siting such as adaption of data for local conditions, to two orders of magnitude are recorded. Challenges in estimating risk due to process hazards, while excluding explosion hazards resulting from combustion, explosives, and unstable chemicals. The safety and health standards of the Occupational Safety and Health Act [OSHA] do not specifically address life safety in chemical plants, other than requiring owners and operators to “provide a safe place to work” and to ensure that “employees may evacuate the workplace safely”. Similarly, the concern of NFPA 101 and NFPA 1 is to “provide an environment for the occupants that is reasonably safe from fire and similar emergencies, for the amount of time needed to evacuate”. There are, however, other life-safety hazards that should be of concern to chemical plant owners and operators. They include many single-exit locations, such as the upper levels on distillation/fractionation columns, scrubbers, and other tall equipment; elevated work platforms; platforms above tank cars, tank trucks, and hopper cars; ladder access to other areas. Also, chemical-plant life-safety hazards include flash fire [flammable vapors and combustible dusts]; releases of toxic gases and vapors; and vessel rupture from runaway reaction or other causes of overpressure.

Mahesh Murthy with Maersk Oil and Nellya Serikova with DNV GL presented “Selection of Failure Frequency and its impact on risk assessment—a case study from plot plan optimization.” Facility Siting is an important phase of project development. A critical stage is plot plan optimisation, where significant potential hazards are eliminated due to equipment spacing. In addition to ensuring appropriate compliance with minimum spacing requirements, occupied building studies to achieve compliance with the requirements of API 752 and API 753 could also be undertaken to optimise safety outcomes. The studies are done in three stages, where the first stage is hazard identification, second stage is consequence assessment and the third stage is risk assessment. Third stage assessments are only carried, if the consequence based siting recommendations are not practical to implement. This presentation included the challenges in estimating risk due to process hazards with a focus on selecting right event likelihood data. A comparison is presented on the variation in predicted risk levels based on equipment failure rates and leak frequencies. Case study of a plot plan optimisation study is undertaken with DNVGL Phast Risk and the variation in risk levels up to two orders of magnitude are recorded. Challenges such as adaption of data for local conditions, consistent definitions of failure, sample size of data, applicability of data play a significant role in identifying and correctly quantifying the risk levels. Such challenges and its impact on risk quantification are presented as well as its impact on facility siting.

Hocine Ait Mohamed with Saudi Aramco presented “Process Safety Management to Manage Risk in Occupancies Other than Chemical Process Facilities.” Process Safety Management (PSM), as a loss prevention management system, has been used for many years to limit and control risks in the chemical process industries (CPI). Losses at chemical and petrochemical facilities are characterized by high energy fire and explosions which in many cases have received large press coverage. Most CPI fires and explosions happened in organic hydrocarbon processes originating from mechanical integrity failures. Mineral, metallurgical refining and pulp and paper processes, on the other hand, feature seemingly benign and often non combustible chemicals. Corrosion in acid plants, physical explosions of digesters, autoclaves, and black liquor recovery boilers have been more common than fires or combustion explosions. This presentation included case studies of incidents in several non-chemical occupancies and efforts made by some companies in eastern Canada to incorporate elements of PSM as a tool for loss prevention and risk management.

Pei-Chen Lu with National Changhua University of Education presented “The Interpersonal Relationships Dealt by Safety Professionals in Universities: The Impacts of Safety Department.” Safety professionals may establish good interpersonal relationships to achieve outstanding performances when providing safety and health management services. The objectives of this study are to develop an interpersonal relationship scale (IRS) and investigate the factors that influence interpersonal relationships among safety professionals facing complex internal and external environments by surveying people or departments that frequently interact with safety professionals. This study selected 200 university safety professionals throughout Taiwan as participants. A questionnaire was mailed to each of the selected safety professionals, and 114 valid questionnaires were returned. The overall
recovery rate was 72%. The results of exploratory factor analysis and reliability and validity tests indicate that the IRS developed in this study possesses good reliability and validity. Additionally, we found that staff in general affairs offices, laboratories or the people responsible for laboratories, and faculty and staff had the most frequent contact with university safety professionals. Furthermore, the result of multivariate analysis of variance (MANOVA) indicates that the presence or absence of safety departments at universities has a statistically significant influence on interpersonal relationships among safety professionals. Therefore, we recommend that universities and colleges without safety departments establish these departments in accordance with OSHA to strengthen the structure of occupational safety and health. Occupational safety departments can enable safety professionals to establish good interpersonal relationships and promote occupational safety and health management services.

Jason Leacox with Atkins presented “Fire Protection Integrity and Optimization.” The greatest challenge to fire protection engineering is the gap between codes and optimized facility design. Fire code and industrial practices provide prescriptive guidelines to mitigate the risk and control hazards. However, within the past decade new processes or methods of construction have been used and their associated hazards have not been foreseen in the current guidelines or standards. Atkins Consulting Canada Ltd. has developed a method to link process safety methods (PHA, Consequence Modeling, QRA, Facility Siting etc.) and the deterministic approach to optimize the design while also maintaining integrity of fire protection elements. This methodology focuses on risked based (probabilistic) and performance based (deterministic) assessment to select the most appropriate active and passive fire protection system and optimize the design. This presentation demonstrates a practical application of process safety to assess fire hazard scenarios and implementing the results in design to meet both the prescriptive legislative requirement as well as the goal of optimal safety in design.

Michael Stern with Exponent presented “Quantification of the Thermal Hazard from Metallic and Organic Dust Flash Fires.” The presence of combustible dusts at manufacturing facilities poses flash fire and dust explosion hazards, which have received significant attention over the past decade. The hazard analysis and mitigation strategies for combustible dust explosions are relatively well understood, but standardized experimental methods for the assessment of flash fire hazards are currently lacking. Exponent previously developed an unconfined dust cloud testing technique that incorporates the injection system of a standard 20-L combustion chamber. Initial testing demonstrated that dusts with similar deflagration indexes ($K_{St}$) and maximum pressures ($P_{max}$) as measured in a standard 20-L combustion chamber can exhibit significantly different qualitative flash fire behaviors. In this presentation, the system is further refined to provide quantitative measurements of temperatures and heat fluxes generated by the unconfined dust deflagrations. Through these experiments we compare the thermal hazard of metal and organic combustible dusts to results with pre-mixed propane cloud.

Seungho Jung with Ajou University presented “QRA Considering Multi-Vessel Failure Scenarios Due to a Natural Disaster—Lessons from Fukushima.” Quantitative risk analysis (QRA) estimates the number of fatalities that can be expected in outdoor and indoor personnel due to explosions. The aim of this presentation is to provide a way to calculate the fatality rate specifically for outdoor personnel, for all types of explosions including vapor cloud explosions (VCE), pressure vessel bursts (PVB), and boiling liquid expanding vapor explosions (BLEVE). The key to reasonable calculation of the fatality rate is to start by properly obtaining the overpressure as well as the impulse for different types of explosions and then integrating the damage to humans. The damage can be calculated by separating damage causes from blast waves, blast winds, thermal radiation (when fires exist), and fragment impacts. The human damage by fragments is initially defined as a Probit equation for injury rate and converted into a fatality rate to be used in QRAs. Results are compared to limited data on outdoor fatalities from real accidents and the model shows a good agreement.

Elizabeth Schlee with Bluefield Process Safety...
presented “Increasing Near-Miss Reporting Through a Culture of Mutual Understanding and Self-Disclosure.” Considering the known benefits of near-miss reporting, why are workers on the front lines of the process industries – operators and maintenance technicians – still so reluctant to communicate their daily experiences? Many have recommended increased operator training or incentive programs as solutions, but those mechanisms can only work when leaders already see improved safety as a priority. More common are leaders who openly prioritize performance, leaving their operators and maintenance workers to make a personal choice between safety and productivity. Although safety can always be deferred, disappointing productivity is guaranteed to have immediate, negative consequences – one can hardly blame them for cowering to the whip that hurts the most. It stands to reason that near-miss reporting mechanisms are only as effective as the safety culture in which they’re implemented. Using research in process safety, psychology, and human resources, this presentation suggests methods for developing a culture of mutual disclosure, understanding, and respect between leaders and workers, resulting in an environment in which near-miss reporting is frequent, voluntary, and effective in creating safer conditions and behaviors.


Masatoshi Todaka from Fukuoka University presented “Thermal Behavior and Dust Explosion Characteristics of Spent Coffee Grounds and Jatropha as Biodiesel Feedstock.” We have investigated the properties of biodiesel fuels derived from spent coffee ground (SCG) and jatropha kernels combined with various alcohols. This work included an evaluation of the thermal and oxidation stabilities of these fuels, based on analysis of their combustion and storage behaviors. As the result, biodiesel derived from SCG oil was shown high oxidation stability. However, these materials are processed as the powder form then they have significant potential on fire and dust explosion accident. In this study, the risk assessment of dust explosion and fire accident of oily biomass and oil-extracted biomass were evaluated by thermal analysis and dust explosion test. Thermal gravimetric and differential thermal analysis (TG-DTA) simultaneous measurement in air atmosphere was applied to estimate decomposition temperature (T_d) of SCG and jatropha. T_d of oil-extracted biomasses were lower by 20 °C than oily biomasses. It shows that ignition temperatures of biomasses were depended on the amount of oil content. Minimum explosion limit (MEL) and minimum ignition energy (MIE) were evaluated by Hartmann apparatus. MEL of oily SCG was 35 g/m³, oil-extracted SCG was 120 g/m³ and oil-extracted jatropha was 45 g/m³, respectively. On the other hand, we could not obtained MEL of Jatropha even at 1000 g/m³ of the test. However, MIE of all samples were over 1000mJ then it can conclude that although SCG and Jatropha are the combustible biomass, but they can be resistant to the low-energy ignition sources such as static electricity spark. Characteristics of static electricity were evaluated by using plastic cylinder devised in our laboratory and surface potential measurement equipment. The results shows that electrical charge value of oily biomasses were over 3kV then it can be considered that these biomass significantly on the dangers of static electricity. Additionally, in case of under moisture condition, fermentation heat of oily biomasses were conducted by Calvet calorimeter (C80). Fermentation heat of oily biomass or oil-extracted biomass included 20wt% water were not observed during 72 hours. Thus fire accident caused by fermentation heat is low-potential. It is concluded that ignition temperature of oily biomass was higher than oil-extracted biomass, but MEL concentration of oily biomass was lower than oil-extracted biomass. Also it is observed that biomass, including oil over 60 wt%, like jatropha was unexploded at Hartmann test because of the cohesive, but the burning of jatropha is high-intensity.

Mike Marshall with OSHA and William Bridges with Process Improvement Institute presented “Necessity of Performing Hazard Evaluations (PHAs) of Non-Normal Modes of Operation (Startup, Shut-down, and Online Maintenance).” Chapter 9 of “Guidelines for Hazard Evaluation”, 3rd Ed, 2008, requires analysis of all modes of operation, as does OSHA enforcement actions for PSM. The commonly used approaches for PHA of continuous mode of operation only find about 5 - 10% of the
accident scenarios that occur during startup, shutdown, and online maintenance. Yet, 70-80% of major accidents occur during these non-continuous modes of operation. This presentation provides examples of what PHA of procedures for non-routine modes of operation find, that were missed by competent PHA teams that performed HAZOP of continuous modes of operation.

**Ning Gan and Monir Ahammad** with MKOPSC presented “Building Process Safety Culture at Texas A&M University at Qatar: A Case Study on Experimental Research.” Over the last few years, the importance of establishing and maintaining a positive safety culture in the process industry and its impact on the safety performances of a company have strongly been emphasized by regulatory institutions, academia and very importantly by the process industry itself. A strong safety culture, when everyone in a company feels responsible for safety and acts accordingly, is not achieved overnight as it requires changing behaviours and instilling safety values to individuals. The challenge is there for existing employees of a company but also for new recruits. In the particular case of freshly graduated engineers, it is often only when joining a company that the individual discovers the concept of safety culture and has to buy into it. Academia could play a much better role in training engineers who, not only understand the process safety challenges faced by the industry, but genuinely join the industry with a pre-established positive safety culture developed during the years of their education. Instilling a process safety culture to future engineers is an area that still requires major efforts from academia. Experimental research at university or college often involves the handling of hazardous substances and processes, with an associated level of risk that need to be minimized. Incidents (major and minor) do happen in university laboratories. It is very common that only major incidents are reported and investigated. Operational deviations, minor incidents, near misses almost never see the light of discussion, although they are opportunities to instil a process safety culture to students, as they are in the process industry. The objective of this presentation is to provide a case study on building process safety culture in a research environment by applying different key aspects of process safety principles. In this study, a series of experiments were analysed to show how process safety principles starting from inherently safer design and management program can be learnt while performing experimental research. The authors have found that investigating the root causes of near misses have multiple benefits. During the actual experiments no injuries have occurred and even the potential of having injuries was relatively low. However, in the context of this study, selected issues were investigated as accidents, which referred to not being able to successfully perform the experiments or near miss referred to delay of a planned / scheduled experiment. As the matter of fact, all these issues may be treated as time and financial losses. Different aspects of failures such as human factor, process design or inherently safer design and standard operating procedures were discussed via case studies. It was found that having students discussing and presenting the investigation results to other students has greatly improved not only the safety aspects of research but also the productivity and safety culture of the involved researchers.

**Greg Robinson** with DEKRA Insight presented “Organizational Process Safety: Taking Process Safety to the Next Level.” Process safety management relies on multiple models for the safe manufacture, storage, use and transportation of highly hazardous chemicals. For the most part these models are little more than a checklist of activities that, at best, create a fractured strategy for preventing catastrophic incidents. To manage process safety at a world-class level, organizations need to develop their culture and capabilities around process safety. These two elements help integrate the overall system and move process safety to the next level.

**H. Greg Johnston** with Texas A&M University presented “Effect of Moisture Content on Dust-Layer Dispersion Behind a Moving Shock Wave.” Secondary dust explosion events in coal mines or industry settings are known to cause greater catastrophic hazards than the initiating explosions themselves. The shock waves produced during the initiating explosions lift surrounding coal particles, and if added to create an inert mixture, limestone as well. This study works with limestone as the primary element, as its density is close to that of coal particles and its presence in the environment. The work presented herein involves drying the limestone...
samples to see the effect of moisture-reduced particles on the dispersion of the dust. The influence of drying limestone samples may prove to reduce agglomeration and/or density, and lead to higher dust growth rates. The quantification of weight loss and weight differences of samples between dried and undried samples were compared. A shock tube provided the mechanism to lift the dust, to characterize the shock-wave/dust-layer interaction. Based on the two Mach number regimes, namely Mach 1.23-1.24 and 1.37-1.4, the trending data show an increase in lifting height for the dried samples, as compared to the undried samples. If the drying of samples had no affect, then the dried samples in the two regimes should have lower dispersion heights than measured; the trend for increasing Mach number yields larger dust-lifting heights. The dried samples clearly rise much faster than is to be expected, therefore more experiments are needed to prove this preliminary result. Further work presented in the full paper involves drying the limestone samples, recording weight differences, and testing additional shock Mach numbers to see resulting trends.

Scott Davis with GexCon US presented “Use of FLACS During the TWA-800 Accident Investigation.” The TWA flight 800 accident occurred on July 17, 1996 just outside New York City shortly after take-off. The airplane disintegrated as a result of an “explosion” and 230 people were killed. The investigation concentrated on the possibility of a gas explosion in the Centre Wing Fuel Tank (CWT). The hypothesis was that the heating of fuel in the tank by the air conditioning system was the cause of the flammable vapor concentration (temperature above flash-point). The explosion investigation used laboratory experiments, scale-model tests, and numerical simulations to examine the explosion of Jet-A (aviation kerosene) mixtures with air under conditions simulating the center wing tank environment at the time of the accident. Work was carried out over a period of four years to determine the chemical and physical properties of Jet A, particularly the flammability limits, combustion behavior, and the propagation of flames through the compartmentalized structure of the center wing tank. The CFD tool FLACS was adapted and validated against scale-model experiments. The problem of quenching or flame extinction was identified as an issue and addressed through experiments and modeling. FLACS was then used in full-scale simulations to explore the effects of various parameters and assumptions, especially ignition locations within the tank. All of this information was integrated through a rule-based system to attempt to narrow down the number of plausible ignition locations that would be consistent with the observed damage as deduced from the recovered wreckage.

Ali Sari with Genesis Oil and Gas presented “Inherently Safer Design for Process Plant Piping and Equipment Exposed for Accidental Explosion Loads.” Recent statistics have indicate that it is not uncommon to have an accidental explosion on an offshore platform. The design and assessment of process piping systems against blast events are of importance and require advanced analysis capabilities. They are important because during an explosion rupture of a piping and vessel system leads to the leakage or release of hydrocarbons which will likely cause another explosion, and eventually leads to a disastrous event. On an offshore platform where availability of escape, shelter, and evacuation is limited, the consequences are worse because explosion escalation into severe scenarios can have more detrimental effects in addition to direct damages such as injuries, fatalities and asset losses. A safe design should be driven by the ultimate goal of no accidents, no harm to people, and no damage to the environment. In order to have such design for process piping systems, advanced nonlinear analysis is required in order to properly capture the dynamic response of the piping and vessels subjected to blast loadings. This type of analysis, in general, should take into account (1) Blast drag load and blast overpressure; (2) Nonlinear material properties, i.e. thermal and strain-rate dependence; (3) Effects of non-structural masses and adjacent piping systems; (4) Pipe supports; (5) Failure of flanges and piping detail; (6) Effects of operating temperature on material properties; (7) Blast direction/ignition location/attenuation sensitivity; (8) Shielding effect, e.g. pipes behind large objects such as vessels; and (9) Effects of pipe insulation, i.e. increased pipe diameters. This presentation first discusses the methodology/techniques to account for such effects in nonlinear advanced analysis for a safe design. The presentation then uses case studies to demonstrate the methodology we develop to show how advanced simulation techniques are applied as tools for piping blast response to minimize the risk of failure. These
case studies involve a process piping system that is simulated from global to detail modeling. The goal of the presentation is to discuss how to achieve a safe design for process piping systems by using advanced analysis.

Stewart Behie with Occidental Oil and Gas presented “Critical Mitigation Element Methodology: An Approach to Achieving Consistent Risk Evaluation Results.” This presentation introduces Critical Mitigation Element (CME) Methodology, an Oxy internal Process Hazard Analysis (PHA) methodology developed for the purpose of achieving consistent results when conducting risk evaluation throughout the company’s worldwide upstream oil and gas operations. The methodology was developed in-house as an efficient means of utilizing a simplified Layer of Protection Analysis, LOPA. A CME is defined as a robust mitigation that reduces the probability by one level on the company’s risk matrix. In the past, Oxy relied heavily on the industry historical approach to estimate event probability which resulted in very inconsistent estimation of event probability since the accuracy was based solely on the knowledge and experience of PHA team members. In order to address this issue, Oxy developed its CME Methodology which is similar to a LOPA approach but much more structured in terms of determining what credit can be taken to reduce event scenario probability. The Oxy CME methodology limits the layer of protection credit to those provided in a list of approved CMEs. CMEs are independent layers of protection that must be highly reliable upon demand. CMEs must be supported by verifiable field and test programs that are required to ensure overall CME integrity. These support elements are termed Key Mitigation Element (KME).

By using this CME methodology, Oxy has demonstrated much greater consistency across their corporate-wide risk profile. Since mitigation prioritization is based on risk levels, consistency allows for an effective basis for resource allocation. Oxy’s implementation of the CME methodology has resulted in significantly improved PHA accuracy and consistency and, ultimately, a more efficient and effective risk management program.

Quentin Baker with Baker Risk presented “A Study of the Blast Wave Shape from Elongated VCEs.” Elongated congestion patterns are common at chemical processing and petroleum refining facilities due to the arrangement of processing units. The accidental vapor cloud explosion (VCE) which occurred at the Buncefield, UK facility involved an elongated congested volume formed by the trees and undergrowth along the site boundary. Although elongated congested volumes are common, there have been few evaluations reported for the blast loads produced by elongated VCEs. Standard VCE blast load prediction techniques do not directly consider the impact of this congested volume geometry versus a more compact geometry. This presentation discusses an evaluation performed to characterize the blast loads from elongated VCEs and identified some significant differences in the resulting blast wave shape versus those predicted by well-known VCE blast load methodologies (e.g., BST and TNO MEM). The standard blast curves are based on an assumption that the portion of the flammable gas cloud participating in the VCE is hemispherical and located at grade level. The results of this evaluation showed that the blast wave shape for a deflagration in an elongated congested volume is similar to that for an acoustic wave in the near-field. An acoustic wave has a very quick transition from the positive phase peak pressure to the negative phase peak pressure, relative to the positive phase duration. The magnitude of the applied negative pressure on a building face depends strongly on the transition time between the positive and negative phase peak pressures, and this applied negative phase can be important to structural response under certain conditions. The main purpose of this evaluation was to examine how far away from the congested volume the acoustic wave pattern persists. The dependence of the acoustic wave pattern on the initial flame acceleration behavior in an elongated VCE was also examined.

Kalisha Bennett with Shell presented “The Human Error Bowtie as an Effective Tool to Assess Critical Processes and Human Based Barriers.” Human Error has been noted as a significant contributor to incidents that occur in the Oil and Gas industry. Regardless of the reliability or integrity of the design, the human interface will always be a factor that needs to be considered when identifying ways to defeat or impair a healthy barrier as a part of the risk management...
program. The Bowtie analysis is a risk assessment methodology that is employed to identify how a Hazard can be released, the potential Consequences and to implement Barriers to prevent and / or mitigate the risk. Human Error is identified as an escalation factor on Bowties for multiple circumstances that can degrade or impair a Barrier and may lead to the partial of full failure of that Barrier. The Human Performance Bowtie has been developed to examine the aspects that may impede human action and subsequently degrade barriers where they rely on human action (including via Safety Critical Tasks). This Bowtie is intended to remove Human Error as an escalation factor across multiple bowties for one site / facility and instead analyze all aspects of the Human Performance as it relates to the release of the Hazard. The Human Performance Bowtie also aids as a Gap Assessment tool to assure that a site or facility has incorporated the appropriate procedures and Critical Processes to manage the risks being considered.

Faraz Khan from Siemens presented “Safe Design Consideration for Overpressuring Protection via Depressuring Valves.” Depressuring valves are used in the oil and gas industry to release fluid in a controlled manner in the event of an overpressure, upset, or shutdown of a plant. API 521 provides guidance on how and when to utilize depressuring valves but do not clearly indicate cases where a plant might prefer to configure multiple depressuring valves instead of a single depressuring valve. Refining and offshore oil explorations are two areas where knowing a reasonably optimum configuration of the number and set point of the valves could meet the constraints of operation while meeting the safety requirements and disposal system design limitations. This presentation provides basic guidelines for consideration and highlights the theory behind depressuring through valves, so that practitioners can make preliminary safe design assessments. In addition, the impact of depressuring valves design on disposal system, such as flare header system, is presented.

Scott Davis with GexCon US presented “Large Scale Detonation Testing—RPSEA Project Award.” GexCon was awarded Subcontract 12121-6403-01 under the Research Partnership to Secure Energy for America (RPSEA), whereby the objective of this project is to improve inherently safer offshore facility designs. As the size of Ultra Deep Water (UDW) facilities increases in the Gulf of Mexico (GOM), designs must consider the potential adverse effects associated with vapor cloud explosions in large congested areas and understand the potential for more devastating deflagration-to-detonation transitions (DDTs) on these facilities. However, there is a lack of data at the large scale to validate the necessary design tools used to predict the risk of DDT. One of the main goals of this research project is to provide large scale DDT explosion data and validate the tools necessary to predict vapor cloud explosions in early design phase. The work will also be used to develop guidance documents and recommended practices to facility owners and designers in order to minimize the consequence of explosion incidents. This presentation included the current updates for the large scale testing being conducted in a newly developed test rig of 51,840ft³ (1,459m³) gross volume. These tests will involve evaluation of deflagrations and DDTs involving stoichiometric, lean and rich mixtures ethylene, propane and methane. Further phases of the testing will also evaluate the effectiveness of other mitigation measures (e.g., water deluge, solid inhibitor) on the explosion consequences.

Surendra Singh with ioKinetic presented “Pressure Relief Sizing of Reactive System using DIERS Simplified Methods and Dynamic Simulation Method.” Incidents involving uncontrolled chemical reactions continue to result in fatality, injury and economic loss. The incidents are often the result of inadequate vent size design due to limited knowledge of chemical reactivity hazard involved in storage, mixing and processing operations. A safe process design requires knowledge of chemical reactivity of desired as well as undesired chemical reactions due to upset conditions. The simplified, cost effective methods to relief system sizing are presented by The Design Institute of Emergency Relief Systems (DIERS). They require multiple experiments and sizing is only valid for the system composition and thermal inertia represented by the small scale experiments. Results are often conservative, especially for gassy systems. On the other hand detailed dynamic computer simulation, is highly accurate, can be used for iterative design and what-if. In this study, a low thermal inertia calorimeter (automatic pressure tracking adiabatic calorimeter...
APTAC™) was used to collect chemical reactivity data for the dicumyl peroxide and toluene system. Vent sizing results from the two methodologies are presented and compared.

William Brokaw with Kestrel Management presented “Using a Data-Driven Method of Accident Analysis: A Case Study of the Human Performance Reliability Process.” Companies use a variety of administrative and engineered controls to manage risks associated with employee and contractor behavior. For complex companies, with literally thousands of these individual controls (e.g., procedures, work instructions, SOPs, inspection and maintenance programs, etc.), identifying where to focus safety improvement efforts and resources can be an especially difficult task. In the absence of data, these decisions are often made using intuition or “gut feel”. Through the gathering and analysis of valid data, intuition and gut feel can be removed from safety improvement efforts in favor of data-driven decisions. This presentation will outline an approach that has been employed at a North American refinery to assess human factors and associated controls that are contributing to incidents. As part of the analysis, 36 months of safety and incident data were analyzed using Human Performance Reliability and existing controls were evaluated against PSM requirements and best practices. The results of the analysis yielded a data set that enabled the organization to determine how to most effectively use scarce resources to make the greatest possible safety improvement.

Tom Drake with the Drake Group presented “Process Safety Compliance Does Not Mean You Are Safe?” Providing your facility with effective barriers to process hazards and risk involves more that just compliance with current process safety standards. Understanding specific process hazards and risk will provide a clear assessment that provides the site with the identification of appropriate layers of protection. There are many tools that have been effectively used over the years to protect people, environment and property from process failures. Compliance regulations and standards have addresses some, but not all, of these tools. This presentation will illustrate the use of hazard/risk assessment and best practices to reduce the risk to an acceptable level.

Jean Lewis with Equity Engineering presented “Managing Risk and Capturing Corporate Memory with Internal Best Practices.” Insight will be given as to how an Operator can utilize a set of customizable best practices, while relying on support from subject matter experts, both internal and external, to cost effectively run and maintain a customized best practices program. Recommendations will be provided how to implement a new collection, including what to do with all of the legacy standards and piping classes a site may have accumulated, as well as methods for keeping the collection evergreen to consistently align with industry and company best practices over time. By utilizing the benefits of a time-tested, evergreen, and proven customizable practices collection used by 13 refining, chemical, and pipeline companies throughout the U.S., we hope to show how Operators can manage risk, promote safety and reliability, and train junior staff through maintaining corporate memory in a customized engineering practices collection to efficiently and cost-effectively manage their facilities.

MI Radulescu with the University of Ottawa presented “The Critical Transition Length from Chapman-Jouguet Deflagrations to Detonations.” In the process of deflagration-to-detonation transition (DDT) in reactive gases contained in obstructed tubes, the flame typically accelerates to a Chapman-Jouguet deflagration speed, at which a steady state is usually observed. The present study addresses the subsequent acceleration to detonation. Laboratory-scale experiments were performed where Chapman-Jouguet deflagrations were established following the quenching of an incident detonation after its interaction with a perforated plate. The experiments were performed in methane, ethane, ethylene, acetylene and propane with oxygen as oxidizer. The subsequent acceleration was monitored via large scale time-resolved shadowgraphy. The mechanism of transition was found to be through the amplification of transverse waves and hot spot ignition. The critical distance for acceleration was determined in all mixtures and correlated with characteristic chemical kinetic time scales. These amplification times and length
scales were found in good agreement with previous theoretical estimates for unconfined DDT based on the gradient mechanism for acceleration. The characteristic amplification lengths determined can thus serve to evaluate the propensity of detonation formation in partially obstructed or open geometries by the Dorofeev scaling. Dependencies of the amplification lengths on the kinetic times, as well as non-dimensional heat release, activation energies and induction-to-reaction time scale ratios are discussed based on a proposed model for shock induced ignition.

Elliott Lander with ATR presented “Applying Human Factor Principles to Procedure Presentation and Design.” Well written procedures are an integral part of any industrial operation for safe operation, managing risks and continuous improvement. Although the importance of procedures is recognized by all industries and regulators, significant and costly incidents still occur due to procedural breakdown on several levels. The goals of this study are to develop a more effective procedure framework and identify technology innovations and best practices based on human factored research.

Shubharthi Barua with Chicago Bridge & Iron presented “Comparison of Prescriptive and Performance Based Regulatory Regime in the USA and UK.” Every major industrial accident such as Piper Alpha disaster, Exxon Valdez Oil Spill, BP Texas City Refinery led to development of new regulations. After the BP Deepwater Horizon accident, several investigation committees recommended to reexamine the existing regulatory approaches of the United States to integrate more sophisticated risk assessment and risk management practices. It has been observed that this type of reactive changes to regulation sometimes narrowed down by too much focus on the cause of the accident itself rather than focusing on possible future hazards unrelated to accident. There are primarily two approaches of offshore oil/gas industry’s regulatory regime; while the United States’ regulatory system is the most prescriptive-based, the United Kingdom’s approach is performance-based. The US National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling Accident recommended focusing US regulatory regime to a proactive, risk-based approach which could be similar to the “Safety Case” approach of the North Sea. The “Safety Case” is considered successful in minimizing accidents in North Sea region. The objective of this study is to perform an evaluation and comparison between the United States’ prescriptive-based regulatory approaches and the United Kingdom’s performance-based regulatory approaches to understand their advantages and disadvantages. Then, this study presents an analysis of major accident histories under both regulatory regimes and discusses their effectiveness in reducing accidents to understand whether the cause of occurrence is “regulatory failure” or “implementation failure”. The study recommends that implementing a hybrid regulatory system, combining prescriptive regulations with performance based regulation, would be more effective.

Hans Pasman with MKOPSC presented “HAzOp: Our Primary Guide in the Land of Process Risks: How can we improve it and do more with its results? ”All risk management starts in determining what can happen. Reliable predictive analysis is key. So, we perform process hazard analysis, which should result in scenario identification and definition. Apart from material/ substance properties, thereby, process conditions and possible deviations and mishaps form inputs. Over the years HazOp has been the most important tool to identify potential process risks by considering systematically deviations in observables, by determining possible causes and consequences, and, if necessary, suggesting improvements. Drawbacks of HazOp are known; it is effort intensive while the results are used only once. The exercise has to be repeated at several stages of process build-up, and when the process is operational, it must be re-conducted periodically. There have been many past attempts to semi-automate the HazOp procedure to ease the effort of conducting it, but lately new promising developments have been realized enabling also the use of the results for facilitating operational fault diagnosis. This presentation reviewed the directions in which improved automation of HazOp is going and how the results, besides for risk analysis and design of preventive and protective measures, also can be used during operations for early warning of upcoming
abnormal process situations. The latter will enhance operator's situation awareness, will guide operators more efficiently to causes, and make possible more realistic prediction of system behavior. Thereby, use is made of advanced methods of process simulation and data treatment. Freeing manpower for HazOp- ing of operations may allow HazOps of non-routine activities such as start-ups, shutdowns, and turnarounds in which a relatively large fraction of accidents happen because of greater uncertainty due to wider ranges of potential upset consequences and reduced control as a result of non-routine activities.

Michael Tia with Kazarians and Associates presented “Integration of Damage Mechanism Review with Process Hazard Analyses.” Process Hazard Analysis (PHA) provides a thorough and efficient method for systemically reviewing complex systems for safety concerns. A commonly applied PHA method is the Guide-Word Style Hazard and Operability (HAZOP) approach, which breaks complex systems into focused sections called nodes. This methodology can be augmented to systematically address the effects of various damage mechanisms. Possibility of corrosion and other damage mechanisms can be included in each node through the addition of a new deviation dedicated to these phenomena. The PHA Team with the help of a subject matter expert reviews the various mechanisms unique to a particular node that can cause loss of integrity. PHA discussions of damage mechanisms should address normal and abnormal operating conditions. The timing of progression of damage mechanism effects and established methods for discovering the damage (detection safeguard) should be explicitly noted. It is important to note that such discussions require participation of experts in metallurgy, corrosion mechanisms, inspection techniques, and process chemistry. The proposed method has been applied successfully in identifying potential vulnerabilities and improvements to minimize the risks associated with corrosion. Specific examples are shown from actual studies addressing systematic analysis of damage mechanisms and the lessons learned from those studies.

Dennis Butts with ERM presented “Correlation of Safety Leadership and Safety Culture.” This presentation discusses the influence of safety culture in the management of process safety accidents. The crucial element of this culture is the identification of safety critical tasks that are essential to the maintenance and assurance of technical safety barriers. The presentation highlights the use of bowtie diagrams as an initial planning tool to manage process safety risk. The barrier or control measures displayed in a bowtie diagram are often technical equipment (safety critical equipment) and their reliability depend on certain tasks (safety critical tasks) that people have to perform to ensure proper functioning of the control measure.

Michael Scott with aeSolutions presented “Implementing Safety Instrumented Burner Management Systems: Challenges and Opportunities.” Implementing a Safety Instrumented Burner Management System (SI-BMS) can be challenging, costly, and time consuming. Simply identifying gaps can be costly, and this does not include risk analysis or gap closure. Additionally, when you multiple your costs by the number of heaters, oxidizers, etc., these costs can escalate quickly. However, a template approach to implementing SI-BMSs may offer a solution for clients with multiple units. Creating standard templates for all deliverables associated with a SI-BMS will allow each additional SIS-BMS to be implemented at a fraction of the cost of the first. This is because a template approach minimizes rework associated with creating a new BMS package. The ultimate goal is to standardize the way we implement SI-BMSs in order to reduce engineering effort, create standard products, and reduce cost.

Stan Kaczmarek with BSEE presented “The Challenges and Successes in Safety and Environmental Management System Approaches to Offshore Operations.” Using management systems to improve the quality of products and of operations has been a common practice for 30 years. While management systems started out as industry-led, voluntary efforts, they are now often required by regulators sometimes as a response to significant events. When BSEE's SEMS regulations became effective after the Deepwater Horizon incident, it initiated a change in how regulators and regulated parties actually interact with each other, and that
change is continuing to evolve. This is because in the US, prescriptive regulations have often been the norm, which has led to decades of “Tell me what to do, and I’ll do it” mentality. BSEE still utilizes prescriptive regulations in its oversight responsibilities for offshore safety and environmental protection, especially where there are established and recognized industry standards that define a baseline for operations. But the SEMS regulations represent a hybrid approach to improving safety and environmental performance in OCS activities, one that incorporates both prescriptive and performance-based elements. The performance based elements derive from and are similar to some international regulations in that they require operators to manage their risks in new and self-critical ways. This is true in performance elements, especially as operators risks change, as technology changes, and as their knowledge grows. In this way BSEE is looking for the operator to take primary responsibility to drive performance and adopt a “beyond compliance” mentality. In addition, SEMS has required both BSEE and the regulated parties to recognize the need to think in different ways and modify their approaches to each other. This approach is required in order to make sure that a robust management system and not overly prescriptive regulations becomes the real-time driver for continuous improvement in safe and environmentally protective designs and behaviors. This is especially important in an operating environment with many unknowns and where the process for creating new standards and modifying regulations is slow. In this talk, BSEE will give examples of how a change from prescriptive to performance-based approaches in regulation is changing the regulators job by allowing it to recognize a wider range of enforcement approaches. This approach is beginning to empower operators to do more on their own without waiting for or needing regulators to require more.

William Banick with Genesis Oil and Gas presented “Application of Human Factors Evaluation in Engineering Design and Safe Operation of Dense Phase Ethylene Treaters.” Ethylene dryers are widely used in petrochemical industry to remove impurities such as water and carbon dioxide from ethylene feedstock. The safety concerns of ethylene dryers were well known and studied due to the reactive and highly flammable nature of ethylene. Under certain conditions, ethylene may decompose violently and self-polymerize with heat release. If vented too fast, ethylene may cause potential brittle fracture hazards. This presentation includes a risk assessment method to evaluate the engineering design and safe operation options for ethylene dryers. Totally automated dryer regeneration system will add complexity and instrument maintenance requirements. Manually operated system will rely heavily on operator training and procedures. The proposed risk assessment method integrates human factor analysis into the traditional HAZOP, LOPA and fault tree analysis to allow evaluation of automated, manual and hybrid approaches. The goal is to select and optimize the design options to ensure plant safety.

Cynthia Spitzenberger with DNV GL presented “Comparison of Methods to Determine Exclusion Zones for LNG Terminals.” A Maritime Safety Zone is defined by the U.S. Coast Guard as a water area, shore area, or water and shore area combined to which, for safety or environmental purposes, access is limited to authorized persons, vehicles, or vessels. A Maritime Safety Zone is established to prevent interference with safe navigation and tug maneuvers, to exclude third party access in order to reduce ignition probability, to aid in emergency preparation, and to protect the public from being exposed to potential harm. USCG also defines a Maritime Security Zone for protection against intentional threats, and this is usually larger than the Safety Zone. The USCG requires that a Maritime Safety Zone be defined before a Letter of Recommendation is given. While the Canada Marine Act only suggests that a port authority may establish Traffic Control Zones, the USCG suggests using the Sandia study as guidance for determining Maritime Safety and Security Zones. Though there are guidance documents, no standard method is currently available for determining site specific Maritime Safety Zones applicable to accidental spills that could occur at the waterfront configuration of the terminal. A common methodology would enable Safety Zones to be more properly defined and create safer waterways. Two types of approaches have been proposed by DNV GL to determine the Safety Zones surrounding LNG terminals from accidental spills. A deterministic approach is based on a single maximum credible event among a set of representative scenarios that have been modeled. This approach may conservatively produce a very large hazard distance
depending on the consequence of the maximum credible scenario. A probabilistic approach is a risk based approach which associates the consequence (the thermal radiation intensities and the flammable vapor dispersion distances) with the likelihood of having such a consequence. A probabilistic approach provides a more realistic basis for making informed decisions.

Daniel Poston with LyondellBasell presented “ISA84/IEC61511 SIS Functional Safety Compliance—It’s a Journey Worth Taking.” Achieving full functional safety compliance at a plant will not just happen; it takes a focused effort from dedicated personnel and a supporting management staff. It’s a lot of work, but the potential safety and reliability benefits are well worth the investment. This presentation walked through the steps employed at several sites in Texas and hopes to provide stimulus for others to follow suite. The first ISA 84 (ISA 84.01-1996) functional safety standard initiated the safety lifecycle; the second, internationally adapted version, ISA 84 (ISA 84.00.01-2004) refined the process through the Functional Safety Management (FSM) plan and various other vital additions. Each helped provide a sturdy framework for an expected sustainable process for the remainder of the subject facility’s life and are considered good practices by OSHA for PSM. It is fully believed that if done properly, the end result of applying the ISA84 standard to complete compliance will be a safer and more cost effectively controlled process environment.

Chandra Gulati with Shell presented “Is Your Temporary Refuge Truly Safe?” The increasing complexity and size of offshore facilities are resulting in increasingly larger numbers of people working and residing at these installations. The Temporary Refuge (TR) is a key safety system to keep the personnel staying on board offshore oil & gas facilities safe from hazards of fire and explosion. The UK Health and Safety Executive (HSE) define the TR as: "a place where personnel can muster safely in an emergency, monitor and assess the developing situation, and either take control action or initiate evacuation”. The application of a structured approach for the management of hazards through the lifecycle of an offshore facility is essential to keeping people safe. The presentation outlined lessons learned from Gulf of Mexico (GoM) experience with the decay of the Temporary Refuge System integrity due to aging. Further, the presentation discussed how changes and additions to facilities can impact TR integrity throughout its lifecycle. To ensure the integrity of the Temporary Refuge System throughout the life of the facility, it is essential that programs are in place to periodically identify how changes to facility design and operation can result in new threats to the TR. The process to identify and manage these potential threats was described, along with an outline of the program implementation at Shell in the GoM. In addition the presentation detailed how changes in corporate risk acceptance have driven changes and retroactive upgrades to the TR, along with the associated process used to identify the gaps and implement the identified additional mitigation measures. Additionally the processes used to ensure the performance of maintenance and inspection and to effectively meet the required integrity levels are discussed. In summary this presentation discusses the challenges of sustaining the integrity of TRs and the learning’s gained over the years from the management process in the GoM.

Steven Pereira with Professional Safety Associates presented “Lessons Learned from Third Party Process Safety Management Audits.” OSHA is contemplating revising the Process Safety Management (PSM) Standard, 29 CFR 1910.119, to require third party compliance audits. The author has facilitated over 50 third party PSM compliance audits and participated in numerous PSM-related incident investigations and assisted clients in addressing OSHA citations. The results of third party audits often uncover issues not previously detected in the facilities’ internal audits. This session will address lessons learned and include examples of issues third party auditors identified that had not been detected by internal auditors.

Richart Vazquez Roman with Instituto Tecnologico de Celaya presented “A CFD-Based Approach for Gas Detectors Allocation.” Accidental gas releases are detected by allocating sensors in optimal places to prevent
escalation of the incident. Gas release effects are typically assessed based on calculating the dispersion from releasing points. In this work, a CFD-based approach is proposed to estimate gas dispersion and then to obtain optimal gas sensors allocation. The Ansys-Fluent commercial package is used to estimate concentrations in the open air by solving the governing equations of continuity, momentum, and energy combined with the realizable κ-ε model for turbulence viscosity effects and species convection-diffusion. CFD dynamic simulations are carried out for potential gas leaks, assuming worst-case scenarios with F-stability and 2 m/s wind speed during a 4min releasing period and considering 8 wind directions. The result is a scenario-based methodology to allocate gas sensors supported on fluid dynamics models. The three x-y-z geographical coordinates for the sensor allocation are included in this analysis. To highlight the methodology, a case study considers releases from a large container surrounded by different types of geometric units including sections with high obstacles, low obstacles, and no obstacles. A non-redundant set of perfect sensors are firstly allocated to cover 100% detection for all simulations releases. The benefits of redundant detection via a MooN voting arranging scheme is also discussed. Numerical results demonstrate the capabilities of CFD simulations for this application and highlight the dispersion effects through obstacles with different sizes.

Arvin Creef with HIMA presented “Diversity and Independence with Regard to BPCS and SIS Systems.” Albert Einstein is quoted as saying, “The world is a dangerous place to live; not because of the people who are evil, but because of the people who don’t do anything about it.” As safety professionals, it is our job to do something about it. Yet, in the interest of ease of implementation or due to some belief that communications might be easier or for the more base reason that there might be a cost saving, we find ourselves making too many compromises. This presentation postulates that the Integrated Control and Safety System is one of those compromises. Since the beginning of this industry, separate and diverse systems have been the rule in processing facilities. Such systems provide the ultimate in safety and security. This presentation will make the case for Independent and Interconnected Control and Safety Systems that will provide the ultimate in safety and cyber security.

Megan Weichel with DNV GL presented “Building on the Foundation of Process Safety by Incorporating Barrier Integrity Assurance.” As operating companies continue to strive for improvement in the areas of process safety and integrity management, the need for an integrated approach becomes more evident. Many operators have become adept at conducting inspection, maintenance, and testing activities for equipment and piping, but the program and strategy for ensuring the integrity of controls and barriers can be improved. Barrier Integrity Assurance (BIA) focuses on ensuring process safety fundamentals are appropriately applied to safety critical elements, barriers, and activities to ensure asset integrity in an organization. A comprehensive approach to BIA can provide a means of bringing together the activities already being undertaken, determine improvements that are needed, and provide assurance that assets are protected and Inspection, Testing, and Preventive Maintenance (ITPM) activities are planned, carried out, reported, and acted upon in an effective, efficient manner. It combines a process safety management framework with the identification and evaluation of operational hazards and integrity related threats to ultimately provide assurance that safety critical equipment and barriers in place are healthy. BIA provides a roadmap, or work process, that is applied to provide assurance throughout an asset’s lifecycle from design and development through operation and eventually decommissioning.

John Perez and William Wimberly presented “Double Jeopardy for $1000 Alex—What it is and how to apply it.” Process hazards analyses, such as Hazard and Operability studies (HAZOPs) and Layer of Protection Analyses (LOPAs), are structured, team-based exercises focused on hazard identification, risk assessment, and risk management. In order to manage the complexity associated with these analyses, recognized and generally accepted rules are imposed to manage and limit the review of hazard scenarios involving simultaneous failures. One of these rules has been dubbed “double jeopardy”. Based on the authors experience via direct observation and
Pressure protection for these systems has been forming highly concentrated CO₂ processes often require high environmentally acceptable fuel. These treatment must be treated before it can be used as an significant amounts of carbon dioxide (CO₂) produced from many major reservoirs can contain foreseeable future. However, natural gas, considered the cleanest burning hydrocarbon fuel available, is expected to rise significantly over the foreseeable future. However, natural gas produced from many major reservoirs can contain significant amounts of carbon dioxide (CO₂) and must be treated before it can be used as an environmentally acceptable fuel. These treatment processes often require high-pressure operations forming highly concentrated CO₂-rich streams. Pressure protection for these systems has been challenging to date because of the potential for solids generation upon pressure let down and the consequent potential for plugging that the solids present. ExxonMobil has completed successful field demonstrations relieving dehydrated, CO₂-rich liquid and vapor streams forming up to 40 wt% solids in relief lines. The results of these field demonstration tests as well as learnings from design of CO₂-solid-forming relief systems are discussed in this presentation.

Scott Hardesty with Applied Research Associates presented “Vapor Cloud Explosion Live Test and Data Analysis Development Program.” Vapor Cloud Explosions (VCE), an ever-present threat to the petroleum refining industry, create hazards to employees, equipment and production capabilities. To mitigate the effect of these hazards, effective designs for structural and non-structural components must be developed and confirmed via experimental validation to ensure the safety and performance of the facility and its occupants. Current methodologies for full-scale VCE performance testing involve the use of large quantities of high explosives set at a large standoff distance to achieve the time durations common in VCE events. While effective in achieving the peak pressures involved, these tests do not adequately characterize the full behavior of the time-dependent loading conditions and other effects seen in VCE events, such as enhanced turbulence, degree of confinement and the reactivity of unburned materials. The explosive testing community recognizes that current testing methods do not fully characterize the loading behavior and that only a small number of large-scale VCE tests have been conducted by various commercial and government agencies. Unfortunately, most of the work has been in support of counterterrorism efforts, making the test data unavailable to the petroleum industry.

Trish Kerin with IChemE presented “Lead Process Safety Metrics.” Metrics have existed for many years across the occupational realm. In more recent times, there has been a focus on the use of metrics to monitor process safety. This has traditionally focused on lag metrics, as these are easier to monitor and analyse than their leading relatives. Excellent publications, such as the American Petroleum

Bryant Hendrickson presented “Where to Begin—A Parametric Study for Vapor Barriers at LNG Export Facilities.” Vapor barriers are widely used to contain the release of flammable mixtures in LNG facilities in the United States. The computational fluid dynamics (CFD) modeling tool FLACS has been validated and accepted for detailed consequence modeling of flammable vapor dispersion scenarios and includes capabilities to assess the impact of vapor barriers at varying heights and locations. While every plant design is unique and the optimization of vapor barriers often requires several iterations, guidance on where to begin is often limited. This presentation details a parametric study on vapor barrier height and placement for different release rates to establish a basis for beginning a vapor barrier design.

David Maher with ExxonMobil presented “Successful Demonstration of Relieving CO₂ Solid Forming Streams through a Pressure Relief System.” The demand for natural gas, considered the cleanest burning hydrocarbon fuel available, is expected to rise significantly over the foreseeable future. However, natural gas produced from many major reservoirs can contain significant amounts of carbon dioxide (CO₂) and must be treated before it can be used as an environmentally acceptable fuel. These treatment processes often require high-pressure operations forming highly concentrated CO₂-rich streams. Pressure protection for these systems has been
Institute Recommended Practice 754, Process Safety Performance Indicators for the Refining and Petrochemical Industries, have emerged to provide guidance on how to develop and monitor metrics. Rightly, as defined in the recommended practice, each facility needs to understand what is important for themselves and implement their own leading metrics. This however, has lead to a divergence in what is measure and how it is done. In an effort to enable effective benchmarking, the members of the IChemE Safety Centre initiated a project to develop a suite of common lead metrics. This work, which occurred over a 12 month period, culminated in the release of a guidance document that details lead metrics that can be commonly applied across varied industries. This presentation defines the process used to establish the common metrics and shows some examples of the metrics chosen.

Wasana Kowhakul with Fukuoka University presented “Dust Explosion Characteristics of Cellulose Acetates with Different Degrees of Acetylation.” In this work, the relation between various degrees of acetylation (CAs) of Cellulose acetate (CA) to dust explosion characteristics as minimum explosive concentration (MEC) and minimum ignition energy (MIE) have been studied. Also, we attempt to clarify the relative of moisture content and water adsorption to cellulose, cellulose ester as CA and cellulose ether as Methyl cellulose (MC), Ethyl cellulose (EC), Hydroxyethyl cellulose (HEC), Hydroxypropyl cellulose (HP), and sodium carboxymethyl cellulose (CMC) to MEC and MIE have been studied. We found that the chemical derivatives have significant on thermal behavior of cellulose which $T_d$ of CA shifted to higher temperature because of acetate derivative effect. Meanwhile, $T_d$ of cellulose ethers as MC, EC, HEC, HEC and CMC were shifted to lower temperature. Moreover, CAs was not evident effect to $T_d$ of CA. Moisture content of cellulose powder had not significant on MEC of both air dry and absolute dry powder were 55 g/m$^3$. But, we found MEC was relative to its moisture content of CA which absolute dry was more sensitive on explosion than dry CA powder. However, MEC was consistent with the hydrophilicity index at 75%RH of dry and absolute dry of cellulose, cellulose acetate and cellulose ethers in present work. MIE was not corresponding to moisture content of cellulose ether and cellulose ester but it was relative to cellulose. The results from our experiments, comparing with CAs, chemical derivatives have more significant on moisture adsorption, thermal stability and dust explosion characteristics of cellulose.

Achilles Arnaez with Smith & Burgess presented “Proven MOC Process Workflow to Ensure that Relief Systems PSI is Updated with Changes.” The Process Safety Management (PSM) Standard requires that covered facilities manage change through the Management of Change (MOC) program. A robust MOC program effectively identifies and analyzes changes. Observation has shown that many MOC processes employ checklists and workflows to help MOC facilitators identify when engineering expertise is needed (e.g. Preventative Maintenance updates or changes in engineering documents / Process Safety Information (PSI)). Knowing when to update relief systems documentation as required is critical in ensuring accurate PSI. The typical relief systems documentation process evolves updating or repeating the documentation for the entire facility on a semi-frequent basis. Based on experience at various facilities, the authors have developed the workflow that either eliminates the need for this expensive process or lengthens the time between updates. This detailed workflow is intended to guide plant-level engineers to understand when a change being reviewed in the MOC process requires a review and potential update of the relief device system PSI. This methodology can reduce the error rate in identifying when relief-systems-related PSI updates are required for changes managed through a site’s MOC process, which ensures facilities more effectively manage relief systems documentation as part of an MOC program.

Renjith Ravindran with Cochin University of Science and Technology presented “Risk Assessment of LNG Storages using LOPA and FTA: An Integrated Approach.” Liquefied Natural Gas (LNG), an economically attractive and environmental friendly fuel is the current energy alternative across the globe. Its market potential and high demand is felt currently in the Indian subcontinent as well. Government and private players are seriously getting into this energy option and establishing many LNG facilities on the west and east coast of India. While establishing in this new energy sector it is vital to identify and analyse the safety hazards likely to
LNG being a flammable chemical, loss of its containment manifests to consequences in terms of fire, explosion and other impacts. There are several methods currently available to carry out the risk analysis of such projects. LOPA is a quick and simple technique applied to determine the risk by estimate consequence frequencies. But application of LOPA becomes constrained when failures are compound and safety systems are integrated. Fault Tree Analysis (FTA) was integrated into LOPA to eliminate this draw back. FTA was used to find out the probability of failure on demand (PFD) of integrated protection layers. This FTA-LOPA integrated approach was used as an effective tool in this work to study hazard potentials and estimate the consequences due to such hazards. Based on the technical specifications provided and description of the work, the LOC scenarios are identified in the facility from the HAZOP study.

Mike Neill with Petrotechnics presented “Improving Operational Performance: Connecting the Impact of Process Safety Management to Daily Operations.” Process Safety Management (PSM) needs to be treated as an operational driver rather than just a compliance obligation. Understanding and managing the specific risk impact and the cumulative risk impact of the deviations or non-conformances with the performance standards of your process safety management system in the context of daily operations is the key. Managing these risks is a powerful driver of operational performance. With increased visibility into operations, having all of the risks in one place, plant operators can improve operational decision-making to get more of the right work done safely, efficiently, and sustainably. This presentation will demonstrate how to connect PSM performance to daily operations in a practical and tangible way to help treat PSM as an operations requirement and an enabler of optimized business performance.

Mike Marshall presented “A Flare and Overpressure Management System—Methods, Metrics, KPIs, and Software Solutions.” This presentation identifies the attributes and benefits of a data and metrics-driven management system focused on the process safety design integrity, reliability, and control of process plant flares and pressure relief systems. This management system process focuses on the four key business drivers of risk, regulatory, operations, and profits, and involves several distinct business methods involving people, processes and tools/technology. At the center of the management system is the unique design and implementation of metrics and KPIs created from data lifted and aggregated from an enterprise informational management platform.

Ryan Morton with Anadarko presented “Onshore Facility Hazard Analysis.” Onshore oil and gas operators face challenging cost efficiency targets while pressing for higher production volumes. Within this tension is a need to reduce planned facility foot prints while maintaining primary focus of personnel and environmental protection. This was examined in this presentation.

Olav Hansen with Lloyd’s Register presented “Explosion Loading on Equipment from CFD Simulations.” Explosion studies using computational fluid dynamics (CFD) are performed on daily basis among safety consultants all over the world. The purpose of the explosion studies is usually to give guidance on required design strength of equipment, piping, blast walls or buildings. One key element is to translate the results from an explosion simulation, into actual forces on equipment. Major weaknesses exist in the current approaches for estimation of loads on small and medium sized equipment. Hansen et al. (2014) demonstrated how loads on rectangular equipment could be estimated by combining free field form drag and pressure gradient. In the current work it is discussed how best to estimate loads onto other types of equipment including cylindrical pipes, pipe bundles and other shapes, and some comparisons and validation against large scale experiments are also included. The main findings of this work are the more accurate guidance on how best to extract explosion loads from simulations, including discussions on appropriate drag coefficients.

John Harrison presented “Equipment Data Collection...Simplified.” Lack of Equipment Data is a fundamental barrier to understanding asset performance inside of and outside of ERP solutions.
Defining the solution is highly dependent on the organization's existing IT infrastructure, the effectiveness of implementation of these solutions and continuing support to keep data accurate. The costs of the solution can vary by one or more orders of magnitude depending on the organizational goals and value propositions communicated to management. We will discuss a Multi-generation approach and benefits associated with each generation. We will show a product in each space that can accomplish the above stated objectives.

Qingsheng Wang with Oklahoma State University presented “Evacuation Simulations of Confined Spaces in Petrochemical Facilities.” With the development of petrochemical industry, confined space evacuation has been a major safety issue due to the potential fatalities and injuries caused by inadequate emergency responses. In this work, two existing software, BuildingEXODUS and FDS+Evac, were used to simulate the Required Safe Egress Time (REST) in different evacuation environments. Vertical and horizontal storage tanks were constructed by using these two simulation software. Then, different parameters such as occupant load, with and without internal obstruction, and exit size were studied in different simulation scenarios. The simulation results from the software have shown a good agreement with those from the field experiments. It is found that the REST of vertical storage tank is nearly half of that of horizontal storage tank. The work has demonstrated a concept that the fire safety software could be used to simulate evacuations from confined spaces in petrochemical facilities.

Dominique Hebrault with Mettler Toledo presented “Successfully Scale-up via Simulation of Production Vessels and Lab Conditions using PAT and Thermal Analysis.” Understanding and minimizing the thermal risks of chemical processes is a critical part of sustainable process development and scale-up. Sophisticated and dedicated analytical instrumentation, for instance reaction calorimetry with RC1e, has been used to determine reaction kinetics and thermodynamics. Now, even simpler and more affordable technologies with higher throughput provide chemists and engineers with the required thermodynamic data-rich experiments early-on for state-of-the-art process development. In this example, we discover how 1- The reduction of a nitroaromatic, 2- The production of a heteroatom-rich heterocycle, have been made safer, and more efficient through the use of a combination of reaction calorimetry, computer controlled experiments, and process analytical technologies. In each example, these technologies provided a better kinetic and mechanistic understanding, resulting in enhanced batch or continuous (CSTR or plug flow) processes.

Jeffrey Marx with Quest Consultants presented “A Comprehensive Approach to API RP 752 and 753 Building Siting Studies.” Facility siting studies are an important part of process safety, and are required for facilities that fall under OSHA’s PSM program. Facility siting is frequently interpreted as performing a building siting study which adheres to the guidance given in API RP 752. Facility siting may also consider siting of temporary or portable buildings based on the guidance in API RP 753. While both API RP 752 and API RP 753 provide a framework and some guidance for performing building siting studies, they do not provide detailed methodologies or provide guidance on performing a detailed analysis. As a result many building siting studies are inconsistent in their overall approach, or in the way they address hazards. Due to the recent scrutiny applied to building siting studies, more attention has been given to provide evaluations which correctly describe the range of hazards that may affect an occupied building at a petrochemical facility. This presentation outlines a comprehensive methodology for performing building siting studies at such facilities. The methodology addresses the applicable methodologies and the available tools by which the potential impacts to building occupants can be evaluated.

Melinda Mayes with BSEE presented “Improving Offshore Regulatory Data Reliability for Decision Making.” As the need for quality data increases for both internal and public use for BSEE’s regulatory enforcement activities, a greater emphasis has been placed on improving data reliability. A review of offshore operational event data in 2014, such as loss of well control and injuries, showed significant disparities between data entry and data validation, upwards of 35%. Without this data, BSEE cannot determine improvement to offshore safety and
environmental management systems, or create new initiatives such as the Risk Based Inspections Program. To correct this issue, BSEE is taking a number of approaches; submitting defects to internal change request boards, implementing a data stewardship program and contracting Argonne National Lab to create a validation procedure. With the help of these initiatives, BSEE can replicate quality data sets for decision making and use by external stakeholders.

John Fontecha presented “Pattern Recognition Techniques Implementation on Data from In-Line Inspection.” Onshore pipeline failure caused by corrosion represents about 16% of the overall number of incidents during the period from 2004 to 2011 according to databases such as CONCAWE and PHMSA. In-Line Inspection (ILI) is one of the available inspection techniques used to determine overall pipeline status, highlighted because it establishes a clear perspective of inner and outer condition of the pipe against the failure modes and wall thickness. Furthermore, it supports measures to prevent risk based on standards such as ASMEB31G or API579-1/ASME FFS-1. However, this approximation could represent a conservative assessment of the pipeline status, taking into account the uncertainty associated with ILI inspection tools such as MFL and UT. Several researches have been conducted to analyze available inspection techniques attempting to reduce noise generated by their inspection tools, and determine procedures in order to establish correct metal loss detection, excelling pattern recognition analysis and reliability concepts. Therefore this work seeks to transform a set of data obtained from two ILI runs, into useful information to support decision making in risk analysis based on pattern recognition techniques and reliability concepts, in order to obtain base failure frequencies for prior analysis from individual and grouped flaws. Moreover, growth corrosion and remaining life models supported on the standards mentioned above were evaluated using a pressure failure criteria. As a result it was obtained that the failure probability of the grouped flaws increases 10% in comparison with the corresponding flaws evaluated individually.

Samantha Scruggs presented “CCPS Vision 20/20: Delivering Great Process Safety Performance.” Vision 20/20, developed by the Center for Chemical Process Safety (CCPS), looks into the not-too-distant future to describe how great process safety is delivered when it is collectively and fervently supported by industry, regulators, academia, and the community worldwide. Driven by five industry tenets and enhanced by four global societal themes, Vision 20/20 highlights the principles that will help industry target and drive performance improvement, and serves as a call to action for all of society to be passionate about protecting people and property. This presentation briefly reviews the concepts of Vision 20/20 and highlight the available resources that will help companies achieve this goal. Emphasis will be placed on the Industry Tenet Assessment Tool, as well as the Implementation Guide, which will help companies put their Vision 20/20 efforts into action. Other tools in support of Vision 20/20 which will be discussed include communication tools and a listing of helpful resources available to companies with identified opportunities for improvement.

Benjamin Seligmann with Curtin University presented “Visualizing Process Design, Operation and Failure Impacts through State Space Representations.” Visualization can improve insights into choices made in early stages of design, particularly in relation to the impact of system related failures. Improved decision making can lead to higher commitment to inherently safer designs, more fault tolerant systems and increased operational resilience. This presentation proposes a means to visualize the function of a design in terms of the state space defined by multiple capabilities possessed by the individual components that constitute the system. Capability is related to the abilities of the component to affect the states of the system, primarily the properties of mass and energy streams that flow through the system. A representation that is constructed from these capability vectors maps out the potential space in which the system can normally operate. It also shows the impact on that space when selected capabilities are degraded or lost. The visualization benefits of the proposed methodology will be displayed with an industrial case study. A typical supply line configuration to a fuel storage facility is investigated to show the fundamental concepts and to assess the utility of the ideas within conceptual process design and operations.

William Nelson with DNV GL presented “Decision...
Support for Dynamic Barrier Management for Offshore Operations.

Effective safety barrier management is a fundamental principle for prevention and mitigation of major accidents in offshore drilling and production operations. Barrier management methods such as bow tie diagrams are commonly used for identifying safety barriers in the development of safety case documentation and the performance of major accident risk assessments. In addition to such applications for establishing design baselines for offshore installations, some organizations are taking safety barrier management into the operational regime by establishing measures for assessing barrier health and assigning barrier owners to ensure that barriers are continuously maintained. The next step in effective safety barrier management is to develop and implement methods to continuously monitor barriers in real time and provide decision guidance for operations, maintenance, and management personnel regarding actions to be taken when barriers are degraded or failed. A systematic approach has been developed by DNV GL for identifying information requirements for dynamic barrier management, instrumentation or other sources of data for providing that information, decision criteria for determining when barriers are degraded or failed, and guidance for actions to be taken to restore degraded barriers and to prevent major accidents and mitigate their consequences. The resulting information framework can be used to support communication, consensus, decision making and action across technical disciplines and organizational boundaries. This presentation summarizes the approach for the development of decision support tools for dynamic barrier management, and insights gained from application of the approach to offshore production and drilling operations with multiple industry partners. In addition, the presentation summarizes industry research and development activities that are needed for effective implementation of dynamic barrier management in the offshore oil and gas industry.

Swarup Bade with Lloyd’s Register presented “A Simplified PSM Guidance for Small Facilities Using a Risk Based Approach.” “Safety matters at all levels”, even for small companies that may not be OSHA’s PSM level facilities, as long as they use highly hazardous chemicals which may be toxic, reactive, flammable, or explosive. Incidents aren’t restricted to “large” companies and the fallout from an incident - having to deal with loss of life and property, OSHA/CSB investigations and possible fines and legal ramifications, can actually have a more significant impact on a smaller company. That’s why a robust PSM program (Process Safety Management) is important. It will drive the development of a safety culture among plant personnel to have safer operating facilities free of incidents. Smaller facilities face major challenges in providing financing and resourcing to implement a standard PSM program. This presentation includes a risk based approach towards a simplified PSM program that is not a drain on company resources and is feasible to implement in practice. A combination of CCPS Risk-Based Process Safety approach with an organization’s own risk tolerance for various factors and data from OSHA NEP citations (National Emphasis Program) is used as a basis to suggest a simplified PSM guidance by prioritizing specific elements.

Roy Sanders presented “Case Histories of Chemical Plant Hoses Delivering Grief.”

Ali Sari with Genesis Oil and Gas presented “Improved Methodology on the Safe Design of Offshore Exploration and Production Facilities for Accidental Collisions.” Accidental loads constitute the great majority of potential and actual fatalities in offshore drilling operations. An unplanned HSE (Health, Safety, and Environment) event has a great potential to cause permanent disablement or death to onboard personnel. Therefore, it is highly desirable to minimize or prevent the accidental incidents rather than risking an unexpected event. Among all types of accidental collisions, dropped objects can pose the highest risks to the personnel, equipment, and structures on an offshore platform. Other types of accidental collisions, such as ship impact, helicopter collisions etc., can also endanger the safety of offshore platforms, however, these scenarios are often underreported. In order to prevent human loss and for a safe design of an offshore platform, the risks of these accidental collisions should be quantified, in terms of probability/frequency and consequence aspects. The risk assessment quantifies the risk caused by accidental collisions including dropped objects on potential
Summary of Symposium Presentations—Continued

targets from topsides to seabed, helicopter transport risk for inflight crash and for take-off/landing crash on the platform, and a passing vessel collision based on influence factors for severe structural damage and loss of hydrocarbon. This presentation addresses the human and asset risk assessments against accidental collisions including dropped objects, helicopter collision, and ship impact in offshore operations. A new perspective on safe design of offshore structures for accidental collisions is outlined to estimate the associated risk to potential targets such as human personnel as well as platform decks, helidecks, jacket legs, risers, electrical cables, and pipelines. The frequencies and consequences of each modelled event are estimated to measure the overall risk to life in terms of IRPA (Individual Risk Per Annum), PLL (Potential Loss of Life), and WEV (Weighted Expectation Value). A risk matrix is utilized in mitigation decision as high impact frequency and high consequential events require mitigation strategies. The proposed assessment methodology will contribute towards identifying the mitigation measures and safety-critical procedures and equipment.

Luc Vechot with TAMUQ presented “Reactive Chemicals Projects at MKOPSC-Q.”

Phani Raj with the Federal Railroad Administration presented “A Flammability (risk) Index for Transportation of Flammable Liquids.” Recent accidents involving trains carrying flammable liquids (crude oil, ethanol, etc.) and consequent release of these flammable liquids have resulted in the formation of large fires. These fires have caused significant property damage and, in some cases, fatalities. The focus of reducing such accidents has been on implementing train operational controls, improving tank car puncture resistance, and providing thermal protection systems on tank cars to reduce the rate of heat input from an external fire to the liquid in the tank. In addition, one of the current regulatory approaches for reducing the post-accident fire and explosion risk is to require the reduction in the product vapor pressure at the time of loading of the product into tank cars. This is based on the assumption vapor pressure is the sole metric of volatility and flammability. This presentation demonstrates that vapor pressure alone cannot be a metric to evaluate the hazard potential of a flammable liquid. Other vapor properties, including the flammability range concentrations in air and the minimum ignition energy, must be considered. A Flammability Index (FI) is developed and applied to example flammable liquids. FI for a specific Bakken crude oil sample is 1.25 and for ethanol 11.3, making ethanol a more “flammable risk” material than crude oil, at normal temperatures. This result is completely opposite to what one would conclude based purely on vapor pressure (ethanol vapor pressure at 77 °F is 1.2 psia vs. 8.7 psia for crude oil at the same temperature).

Suresh Yellsety with ERM presented “Are you as safe as you think you are?” This presentation provides a qualitative methodology for estimating the effectiveness of barriers, which can be considered as a screening process that can both focus OPEX and identify areas where barriers may need to be reinforced or added to. The method accounts for a variety of factors such as safety measures being fail-safe, and the possibility of safety system overrides. One of the major benefits of the bowtie technique is to assist in the development of key performance indicator metrics. It gives an insight as to how well protected a facility is against accident events and supports operational managers in making risk based decisions, e.g. making choices on how to focus OPEX spend.

With continued development of new sources for oil and gas production, the risk to surrounding public receptors has been a growing concern in the industry. Questions arise about how to best implement safeguards and position detectors, respond to emergencies, and better protect vulnerable areas, making a thorough understanding of risk key.

Christopher Seifert with Wilson Perumal and Company presented “High Reliability Organizations: Managing Risk in Complex Operating Environments.” Over the past two decades the environment companies operate in has become increasingly complex, and the pace of change continues to accelerate. With increased complexity, comes increased risk for high consequence/low probability events. At the same time, society’s expectations for performance have never been higher. Injuries to personnel, impacts to the environment, and disruptions in production will no longer be tolerated. In other words, achieving excellence in safety and operations is both more
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Summary of Symposium Presentations—Continued

important and more difficult than ever before. Yet there are a select few High-Reliability Organizations (HROs), such as the U.S. Nuclear Navy, that have defied this trend. Their culture and organizational practices allow them to consistently demonstrate extraordinary levels of excellence while operating in complex, high-risk environments. This presentation will examine how these HROs leverage management systems and culture to thwart the impacts of complexity and achieve safety and operational excellence.

Daniel Crowl with Michigan Tech University presented “Why we need process safety education as we move into the 21st Century.”

John Cornwell with Quest Consultants presented “Magnitude of Hazards Associated with the Rail Transport of Crude Oil and LPG.” Over the past several years, the volume of crude oil being transported by rail has dramatically increased. With this increase, the number of train accidents involving crude oil rail cars has also increased. A common perception of the public is that the risk associated with “crude-by-rail” has increased. This may be true due to an increase in rail car shipments but has the magnitude of hazards associated with crude by rail transport changed? Arguments have been made that the compositions of specific crudes make them more hazardous than conventional crude. Is there a basis for this claim? As the volume of crude transported by rail has increased, so has the volume of liquefied petroleum gases (LPGs) transported by rail, albeit with different types of rail cars than those used for crude oil. This presentation includes the magnitude of hazards associated with rail transport of a range of crude oils and LPGs. The release mechanisms will be affected by the type of rail car employed (DOT-112, DOT-111, and the modified DOT-111 called the 1232) and the fluid condition upon release. The result of the overall analysis will be a side-by-side comparison of hazard magnitude as a function of the transported fluid and the rail car employed.

Dave Norton with Hawk Consultants presented “Oversight of Petroleum Systems Integrity in Alaska.” Following pipeline leaks on the Alaskan North Slope in 2006, the state of Alaska, by executive order of the governor, responded by establishing the Petroleum Systems Integrity Office (PSIO) as the lead state agency responsible for oversight of the maintenance of facilities, equipment, and infrastructure for oil and natural gas resources in Alaska. PSIO efforts identified infrastructure components with indeterminate regulatory oversight. In addition, PSIO recommended improvements in state oversight, including establishment of minimum requirements for operators’ integrity management systems and the ability to collect sufficient information to develop leading performance indicators. PSIO was consolidated into another state agency in 2014 and its mission was suspended in 2015. Future efforts to improve policies, systems, and methods of oversight will depend on executive direction, legislative support, and emphasis within state agencies.

Peter Bullemer with Human Centered Solutions presented “Managing Human Reliability: An Abnormal Situation Management Historical Perspective.” In 1993, five companies initiated a project to better understand the problem of managing abnormal situations. A study team was formed to visit several operations facilities to better understand the abnormal situation management challenge and identify the requirements to improve operations team’s ability to prevent and respond to abnormal situations. The 1993 project team’s findings were powerful enough to motivate several industry competitors to form a research and development consortium to work together to develop solutions to plant safety. This presentation summarizes the key findings of this foundational 1993 study that lead to the founding of the Abnormal Situation Management (ASM) Joint Research and Development Consortium, which is commemorating its 20th year working together. More importantly, this presentation examines the progress made over the past 20+ years against the ASM requirements identified in that foundational study in terms of (i) industry’s understanding of the contribution of human reliability to major process safety incidents and (ii) the implications for operations practices to effectively manage human reliability in reducing risks that may contribute to process safety incidents. The ASM historical perspective is intended to show where progress has been made and where there are still gaps in effective solutions to improve human reliability and process safety.

Brian Holland with Trinity Consultants presented
“Large Scale VCE Consequence Modeling for Industrial Facility Siting, Risk Assessment, Hazard Mitigation Design, and Response Planning.” New, fully three dimensional, technologies are now making it possible to more quickly and accurately simulate and predict the consequences of accidental releases leading to vapor cloud explosions (VCE) at a wide variety of industrial facilities. The primary objective of these explosion consequence analysis (ECA) technologies is to assess building damage and occupant injury levels for both ‘individual’ and ‘all possible’ release and explosion scenarios. A typical industrial facility can have hundreds of potential release scenarios and hundreds of potential VCE locations leading to an exponential number of possible explosion scenarios. High speed 3D modeling techniques can provide updateable, ongoing and real-time capabilities for analyzing individual and all possible release and explosion scenarios. These ECA technologies, combined with release probabilities, make possible quantitative risk assessments (QRA) which lead to better risk evaluations, mitigation strategies, risk management, and emergency response planning. In this presentation, the Vapor Cloud Explosion Damage Assessment module in BREEZE ExDAM is used to demonstrate a high speed 3D modeling technique that can quickly 1) generate 3D models of large-scale chemical/petroleum facilities with hundreds of building structures, hundreds of release locations, and hundreds of congestion zones, 2) simulate, display, and document the consequences of individual release scenarios involving a subset of congestion zones within a single plume geometry, and 3) compute, display, and document the maximum consequence levels resulting from explosions at all identified congestion zones.

John Fontecha with Universidad de Los Andes presented “Optimal Sectioning of Hydrocarbon Transport Pipeline by Volume Minimization, and Environmental and Social Vulnerability Assessment.” Sectioning is one of the key mitigation strategies in pipeline transport of liquid hydrocarbons. The valves located along pipelines reduce the maximum volume that may be spilled, decreasing economic, social and environmental losses. Defining the location and number of valves in a specific pipeline section is a challenge due to the countless combinations of these two design components (i.e., where and how many valves). In this work, we tackle the valve location problem (VLP) for sectioning. To solve the problem, we use an optimization approach which assesses the number and location of valves to minimize environmental and social consequences. This problem is modeled as a shortest path problem and it considers the maximum volume that could be spilled as well as environmental and social issues. To estimate and quantify the damages (environmental and social) a new framework is proposed. We present a case study for sectioning in a pipeline of Colombia; the problem is solved using a Bellman-Ford algorithm with CPU times up to 32 s. The results show reductions around 75% of the maximum possible spilled volume. The resulting valve configurations cover areas with high vulnerability, guaranteeing individual risks lower than the acceptable risk on all populated areas.

Savio Vianna with University of Campinas presented “An Alternative CFD Tool for Gas Dispersion Modeling of Heavy Gas.” The numerical simulation of gas dispersion is of great importance in various areas of engineering such as optimisation, synthesis of chemical process, petroleum industry and process safety. The OpenFOAM (Open Field Operation and Manipulation) code is a free and open source computational Fluid Dynamics (CFD) program. The current research is focused on the development of a computational tool for handling gas dispersion of heavy gases, such as LNG and CO₂. The novel CFD tool relies on OpenFOAM framework. The core of the work is based on the OpenFOAM solver rhoReactingBuoyantFoam to handle gas dispersion. A series of CFD simulations has been performed for methane and CO₂. The source term of the former is modelled by HSM (Hybrid Switch Model). The model comprises contribution from HEM (Homogeneous Equilibrium Model) approach, frozen model and non-equilibrium model for CO₂ leak. The novel approach switches between equilibrium and non-equilibrium conditions based on the meta-stable parameter on the grounds of thermodynamics and experimental observations. Good agreement with experimental data is observed. The latter combines the modified vapourisation model, initially proposed by AICHE in order to calculate a new set of boundary conditions implemented in OpenFoam. Comparison with experimental data has
shown that HSM approach led to smaller errors than current source models when compared with the same set of experimental data. Numerical findings for methane leakage from the proposed CFD tool are compared with experimental data and with ANSYS-CFX and FLACS. Good agreement is observed.

Camille Peres with TAMU presented “Development of an effective procedure writer’s guide using a human factors and regulatory compliance approach.” Well-written procedures are an integral part of any industrial organization for safe operation, managing risks, and continuous improvement. Regulatory bodies around the world require industries to have current, accurate, and appropriate procedures for most processes. Although the importance of procedures is recognized by all industries in general, significant incidents have occurred in the past due to procedural breakdowns. Some of the procedural breakdowns come from obvious problems such as the procedure not being available or the procedure being wrong. However, some incidents have occurred when correct procedures were available and the operator used those procedures. In these instances, the reason why operators do not follow procedures correctly may be attributable to many factors, one of them being that the procedure is presented or designed in a manner that does not sufficiently communicate to the operators the information that is needed in a manner that is easily and quickly understood. The work presented here is focused on the latter circumstance and is part of a program of research that will ultimately lead to the development of a writer’s guide for procedures that supports operators’ comprehension and compliance with all types of industrial procedures. The writer’s guide is based on empirical findings from human factors and human performance studies and provides writers with information on how to present procedures in a manner that is clear, thorough, and (if necessary) implementable with short notice. For the first phase of the project, a sample of the regulations and standards from several industries were used to identify procedure writing practices necessary for ensure regulatory compliance. Regulations and industrial standards from around the world were organized to reflect common ideas and the implications in terms of human factors needs were identified with regard to procedure design. Any human factors (HF) that had implications for the writer’s guide that had empirical support, were included in the writer’s guide (with the reference) with an explanation of the HF implication and empirical support. The writer’s guide developed is structured to allow procedure writers access to guidance on various types of procedures they are writing, the type of information they are trying to communicate, and methods for maintaining accurate and current procedures. As mentioned, the current project is the beginning of a program of research and then next phase will include feedback from operators regarding the challenges they face when using procedures.

Irufan Ahmed with DNV GL presented “Validation of Geometry Modeling Approaches for Offshore Gas Dispersion Simulations.” Computational Fluid Dynamics (CFD) codes are widely used for gas dispersion studies on offshore installations. The majority of these codes use single-block Cartesian grids with the porosity/distributed-resistance (PDR) approach to model small geometric details. Computational cost of this approach is low since small-scale obstacles are not resolved on the computational mesh. However, there are some uncertainties regarding this approach, especially in terms of grid dependency and turbulence generated from complex objects. An alternative approach, which can be implemented in general-purpose CFD codes, is to use body-fitted grids for medium to large-scale objects whilst combining multiple small-scale obstacles in close proximity and using porous media models to represent blockage effects. This approach is validated in this study, by comparing numerical predictions with large-scale gas dispersion experiments carried out in DNV GL’s Spadeadam test site. Gas concentrations and gas cloud volumes obtained from simulations are compared with measurements. These simulations are performed using the commercially available ANSYS CFX, which is a general-purpose CFD code. For comparison, further simulations are performed using CFX where small-scale objects are explicitly resolved. The aim of this work is to evaluate the accuracy and efficiency of these different geometry modelling approaches.
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Time: 8:30am – 4:30pm
Credit: 1.4 CEUs/ 14 PDHs
Instructor: Mr. Mike Carter

3102 – Pressure Relief Systems – Best Practices
Date: February 23 – 24, 2016
Time: 8:30am – 4:30pm
Credit: 1.4 CEUs/14 PDHs
Instructor: Dr. Nancy Faulk

3151 – Disposal Systems Analysis – Best Practices
Date: February 25, 2016
Time: 8:30am – 4:30pm
Credit: 0.7 CEUs/7 PDHs
Instructor: Mr. Ben Pratt

2073 – SIS Implementation
Date: March 22 – 24, 2016
Time: 8:30am – 4:30pm
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