
Ms. Susan Wang, Vice Chairman of the Board of Formosa Plastics Group, presented the Frank P. Lees Memorial Lecture “Our Continuing Journey to Process Safety Excellence”.

Mr. John DeLeeuw, pilot at American Airlines, presented the keynote address entitled “The Aviation Safety Action Program—A Game Changer in US Commercial Aviation” on the second day.

On the final day of the symposium, the keynote speaker was Ms. Chris Elfring, Director of the NAS Gulf Research Program. Her talk was titled “The NAS Gulf Research Program: Where our Interests Intersect.” In addition, a panel on safety culture was led by Mr. Mark Griffon, retired CSB board member.

Continued on page 3
“There is no free lunch,” - we all understand that saying very well. Someone, somewhere, must pay for that lunch. This phenomenon is easy to understand and everyone accepts it without much argument. We also learn early in the chemical engineering curriculum that we cannot violate the laws of thermodynamics, no matter the circumstances. In that respect, the second law of thermodynamics states that it is impossible to convert heat energy to mechanical energy with 100 percent efficiency. After the process of heating a gas to increase its pressure to drive a piston, there is always some leftover energy in the gas that cannot do any additional work. This waste heat must be discarded by transferring it to a heat sink. For example, a car engine exhausts its spent fuel and air mixture into the atmosphere. Additionally, any device with movable parts produces friction that transfers unusable mechanical energy as heat from the system to a heat sink. This is why the U.S. Patent Office summarily rejects claims of perpetual motion machines. In a closed system, any change or activity leads to a more disordered (higher entropy) state. In other words, the entropy of the universe always increases. The best we can do is slow this increase to the limiting case in which the increase in entropy approaches, but never really reaches, zero.

So, why am I talking about thermodynamics, the second law, and entropy, and what does all this have to do with process safety? Well, translated to applications with regard to process safety issues, the analogy is both stark and appropriate. That is, every activity in the chemical processing industry involves a hazard and an associated amount of risk. Risk can be analogous to an increase in disorderliness or an increase in entropy. We have no choice most of the time with regard to accepting a hazard (once we have exhausted inherent safety discussions) because of the associated benefit it brings. For example, we use a car (knowing that it represents a hazard) because of the associated benefits. We must manage risk, but, just like entropy, we know that risk in a limiting case approaches, but never really reaches, zero. Risk for any activity plotted against the resources spent to reduce the risk represents a classic asymptotic curve that never touches the independent axis. Also, it quickly becomes apparent that, after a certain point, we reach and go beyond the point of diminishing return on investment. Some would call that point as the acceptable level of risk. Where is that point, how is it determined, and does it change with time? Those are complex and complicated questions that require significant thought and analysis to find answers.

In general, society through complicated socio-legal policy-making approach determines the answers. However, various factors directly or indirectly affect those determinations (e.g., affluence of the society, risk understanding, maturity of infrastructures, and many others). Once determined, the acceptable risk level does not remain constant. It changes with time, usually towards lower and lower risk tolerance. So, as we engage in our quest for risk reduction and risk management, we must remember some simple realities. Just as there is no free lunch, there is also always some risk involved in any activity.

M. Sam Mannan
Fall 2016
As highlighted on page 1, we had three excellent keynote speakers this year. In addition, 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 15. We are always excited to have a variety of exhibitors showcase their new technology and safety knowledge. This year, 40 companies participated.

The Center was also delighted to have four sponsor companies: Formosa Plastics Group, GexCon US, Siemens, and RiskPoynt.

On Wednesday evening, Formosa Plastics Group sponsored a banquet for guests at the Traditions Club. Entertainment for the evening was provided by four Aggie Student organizations, Maroon Steel, TAMU String Quartet, Xuan Zhou, and Akh Mastani Dance.

A highlight of the symposium is always 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 within the central theme of the Center: Making Safety Second Nature. In establishing the Merit Award, the Steering Committee underscored the importance of promoting and recognizing significant contributions and accomplishments of practitioners and researchers worldwide. The 2016 Trevor Kletz Merit Award was presented to Kelly Keim. Kelly Keim is the Chief Process Safety Engineer for ExxonMobil Research and Engineering, having worked more than 33 years in the industry. He holds a B.S. in Chemical Engineering from the Pennsylvania State University and an M.B.A. from the University of Houston. After holding positions in research, project engineering, operations and maintenance, Kelly found his passion in Process Safety. He has led HAZOP, LOPA, Inherent Safety, Hazards Analysis for Machinery Safety, Incident Investigations and other Risk Assessments across many parts of ExxonMobil Chemical. Kelly participated in the development of APIs initial Process Safety Metrics document and currently serves as Vice-Chair of the API RP 754 revision committee and continues to serve on the joint API – AFPM working group for the implementation of Process Safety Metrics.

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 the Steering Committee Risk Communication Sub-Committee: Kathy Shell, Kelly Keim, Stewart Behie, William Ralph, Liz McDaniel, Karen Study, and Roy Sanders. This year, the Lamiya Zahin Memorial Safety Scholarship was presented to Syeda Zohra Halim. The honorable mention was presented to Denis Su-Fehrer. 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.”
Absorbing Safety Messages: Risk Communication

How do you raise awareness among people who do not want to hear a lecture about safety? Trying to make the subconscious mind be wary of the risk involved in a task such as hurrying to cross an intersection or running down the stairs can be quite challenging. A browse through the internet would make one come across numerous examples of people taking risk everyday to do something they think are bold, fun or necessary. Yet these people fail to realize the potential hazard associated with what they are doing.

A few days back, I came across an article [1] which stated that people in Indonesia were deliberately sitting on railway tracks in an attempt to cure themselves from health issues (Figure 1). Their belief was that the tracks conveyed low voltages and when they would sit on them for long hours, any illness in their body would somehow be gone. In trying to heal themselves by believing in wrong information (the tracks had no voltages applied), these people were increasing their risk of being hit by a sudden approaching train. Another article [2] shared a story of a group of teenagers in India who would play a deadly game of running along railway tracks with a speeding train behind them, each waiting until the last possible moment to jump off the track on an open bridge into the gushing waters of the river below (Figure 2). When reminded about the risk of their dangerous game, they all claimed nobody had ever been hurt doing this.

With the ongoing ‘selfie’ craze, many people are seen standing next to railway tracks (if not standing on the track itself) snapping away pictures [3] merely being saved from getting hit by the train. Not everyone is lucky enough though [4]. And then there are issues where people in the morning rush, try to board a train at times forget how hazardous it is to push yourself into the train while the doors are closing [5]. As shown in Figures 3 and 4, this lady tried to get on the tube when her scarf got stuck between the doors. Tube doors are designed to reopen if there is an obstruction of 25-30 mm between them. With her scarf being much thinner and the driver failing to check monitors to see if the doors were cleared off before starting the tube, the lady was dragged about 30 feet alongside the moving tube before her scarf released from her neck. The scarf was carried into the tunnel still hanging from the closed doors.

Train incidents like the ones mentioned above are very common all around the world. Platform-train interface (PTI) incidents which include falls from the platform, falls between train and platform, contact between person and train, and people caught in or struck by train doors have gone up from 56 in 2003 to 298 in 2014, a striking 432% rise in 11 years [6]. In Australia, there were 601 road vehicle collision at a level crossing and 92 collisions at a level crossing with a person by a train in between 2002-2012. The statistics are concerning, and something needs to be done to bring this down.

Whether people are in hurry, or whether they are challenging themselves or trying to have fun, they are always thinking the worst will not happen to them. They might have the knowledge that their actions are not safe, but they are unaware of the fact that it can actually happen to them. A possible way to handle situations like these is to constantly make them aware of the dangers involved. However, repetition can appear boring, with people tending to hear but not absorb the warning.
Different research efforts have been made to bring the number of annual train incidents down. Probably the most successful safety innovation in that aspect would be the one taken up by Metro Trains Melbourne. In 2012, Metro Trains Melbourne released an animated video with the song ‘Dumb Ways to Die’ on Youtube.com as a part of a public service announcement campaign to promote rail safety [7, 8]. It was catchy and educating. The song featured twenty characters that appeared cute and innocent, yet were involved in increasingly morbid tasks of killing themselves in silly ways, including being hit by trains because of their careless acts. The song was viewed 2.5 million times within 48 hours of release in Youtube.com. As of last week, the video received over 136 million views. According to John Mescall, Executive Creative Director of McCann Melbourne (the advertising agency that made the video), the aim of the campaign was “to engage an audience that really doesn't want to hear any kind of safety message”. McCann estimated that within two weeks, it had generated at least $50 million worth of global media value for "a fraction of the cost of one TV ad" [9]. According to Metro Trains, the campaign contributed to more than 30% reduction in "near-miss" incidents, from 13.29 near-misses per million kilometres in November 2011 – January 2012, to 9.17 near-misses per million kilometres in November 2012 – January 2013 [9].

With the success of the song, Metro Trains Melbourne next moved on to release a game app from cell phones [10] in May 2013. The game involved trying to avoid dying as the characters that had been featured in the song involved in silly activities including trying to get a toast out with a fork, poking a stick at a grizzly bear, trying to rewire the lighting in the house, running after a balloon on the tracks with a train approaching from behind and driving through a crossing while a train was coming. Three lives were provided in each game and the player earned points for activities done safely. The game would speed up gradually to reflect the increasing urgency people feel when they are late for something and try to take risks to get something done quickly. Along with the activities, the game allowed players to pledge to “not do dumb stuff around trains”. The game, when released, was a major success, climbing to number 1 in 22 countries including US, UK, Canada and Australia. A sequel was later released in 2014 and that too became the number 1 app in 83 countries with 75 million downloads and 1.2 billion unique plays coming from every country in the world. So far 65 million people have pledged to be safe around trains [9].

Apart from the claim by Metro Trains Melbourne that the campaign had reduced the percentage of near-miss incidents around trains, the number of times the song has been viewed and the game played reflects the large number of times safety messages have been delivered to the general public without having to force them to listen. Such attempts appear to be a successful way in which safety awareness can be raised among the general public. Through proper research, it will also be possible to deliver messages that focus on a particular group of people (students working in lab for example) and to make them absorb the information in their mind without boring them down or facing hesitance from them. In designing messages that are catchy, innovative and attractive, it is possible to make people be aware of the danger of the everyday risk they take while trying to get something done.
Future of Process Safety Workshop Collaboration between MKOPSC and ISC

The Mary Kay O'Connor Process Safety Center and the IChemE Safety Centre joined forces to develop a cohesive roadmap for the future of process safety, taking into account both industry, regulatory and academic requirements. By bringing together experts in process safety from across the world, this project will draft the basis for the road map and will then conduct global consultation with a range of stakeholders. It will culminate in the release of an easily readable document in October 2017 at the World Chemical Engineering Congress in Barcelona, Spain. But to be able to plot the future, we need to understand our current challenges. These challenges were considered with respect to a range of bodies, namely industry, regulators, society and academia, as well as thinking about the key focus areas for process safety in the future.

In order to assess these challenges, Trish Kerin ran a Future of Process Safety workshop on the first day of the International Symposium. The audience was asked a series of questions with the answers displaying on the screen in real-time. The topics were risk, systems, assurance, design, and leadership. These were represented in live word clouds, where the font size represented the frequency of the challenge words. This workshop was first introduced at Hazards 26 in Edinburgh, UK on May 24. At Hazards, questions were asked regarding key industrial, regulatory, societal and academic challenges in process safety. The outcomes showed that money and competency appeared to be the most common challenges. When all challenges were combined, competency and risk were in the lead. The workshop was also presented at Hazards Australasia in Melbourne on November 23, where feedback was collected via post-it notes.

All three workshops discussed the current status of process safety activities globally and started to build a future roadmap for process safety.
“Accomplishing Process Safety Excellence through Standardized Programmes” at 2016 Gulf Safety Forum

Under the Patronage of H.E. Sheikh Abdullah Bin Nasser Bin Khalifa Al Thani, Prime Minister and Minister of Interior of the State of Qatar, GSF 2016 – Gulf Safety Forum took place on October 30-31 2016 in Doha, Qatar. The opening ceremony was conducted by H.E. Dr Mohamed bin Saleh Al Sada, Minister of Energy & Industry - State of Qatar. Dr. Mannan presented “Accomplishing Process Safety Excellence through Standardized Programmes” on October 30. Dr. Luc Vechot, Managing Director of MKOPSC-Qatar, presented “Role of Academia in Building Competency in Process Safety: Experience from the MKOPSC in Qatar” the same day.

This conference was jointly organized by the Gulf Organization for Industrial Consulting (GOIC) and Euro Petroleum Consultants (EPC). It brought together key industry players from across the Middle East to discuss strategies for continuous improvement of safety procedures as well as share successful case studies and roadmaps towards achieving the goal of zero incidents. International safety experts and providers of safety tools and technologies presented the latest methodologies which can assist companies to achieve these goals.

It is now widely recognized that as organizations develop on their safety journey, it is necessary to focus on plant safety, reliability and human behavior in order to achieve the target of zero incidents. A focus on safety is the number one priority for companies, and both manufacturers and suppliers are developing innovative and effective solutions in these areas.

Adapted from https://www.europetro.com/en/gsf2016
Steering Committee Chair Liz McDaniel was awarded a Houston Business Journal Women in Energy Innovator Award on November 10. Nearly 400 guests attended the Houston Business Journal’s 2016 Women in Energy Leadership Awards event. The event was held at the Houstonian Hotel, honored 22 women in three categories and a lifetime achievement award winner. Ms. McDaniel currently serves as the vice president of Huntsman Corp. She analyzes injury trends to develop initiatives to ensure the safety of the company’s 2,200 polyurethanes associates at 34 sites across the globe. One of McDaniel’s analyses showed walking injuries in the company increased to 38 percent in 2014. Her “Walking is Working” campaign raised awareness about the issues, and in 2016, analyses revealed the walking injuries were reduced to only 8 percent. Her most recent campaign, “Safety is in Your Hands,” focuses on hand injuries in industry.

On September 26, 2016, the inaugural Texas A&M Conference on Energy began with opening remarks delivered by Dr. Karan L. Watson, Provost of Texas A&M University, Dr. Glen A. Laine, Vice President for Research at Texas A&M University, Dr. Narasimha Reddy, Associate Dean for Research in the Dwight Look College of Engineering at Texas A&M University and Assistant Agency Director for Strategic Initiatives and Centers at the Texas A&M Engineering Experiment Station, as well as Dr. Stratos Pistikopoulos, Interim Co-Director of the Texas A&M Energy Institute and TEES Distinguished Research Professor in the Artie McFerrin Department of Chemical Engineering.

This event also featured poster presentations and oral presentations from industry and government. Poster sessions on Tuesday and Wednesday showcased 89 student posters on an extremely diverse set of topics. Judging teams reviewed the participants in the poster sessions and the oral presentations, and at the closing of the event on Wednesday, five winners were announced from each type of presentation.

MKOPSC students Changwon Son and Susana Caceres won Best Poster Presentation Awards. Susana’s poster was titled “Process Safety Problems Caused by Hydrate Formation in Deepwater Production Operations” and Changwon’s “A Study of Safety Culture Assessment Framework for Chemical Process Industry and its Application to a Bayesian Belief Network Analysis.”

Adapted from: http://energy.tamu.edu/2016-conference-energy/

Graduation — Fall 2016

Logan Hatnaka obtained his PhD after successfully defending his thesis, “Enhanced Thermal Stability and Flame-Retardant Properties of Cross-Linked Polymer Nanocomposites”.

Changwon Son obtained his Master of Science in Safety Engineering after successfully defending his thesis, “A Study of Safety Culture Assessment Framework for Process Industries and its Application to a Bayesian Belief Network Analysis.” He is continuing at Texas A&M and pursuing a PhD in Industrial Engineering.

Pakorn Chaivat obtained his Master of Science in Safety Engineering after successfully defending his thesis, “Probabilistic Risk Assessment of Offshore Production Platform by Bayesian Network Application to HAZOP and Bow-Tie Studies.” He returned to his former employer PTTEP in Thailand.

New Students — Fall 2016

PhD

Hallie Elledge  Chris Gordon  Ahmed Harhara  Jeremy Ikeogu  Guanyang Liu  Yuhe Tian  Lin Zhao

Master of Science in Safety/Chemical Engineering

Zeren Jiao  Nitish Kelekar  Andrew Napaporn  Sankhadeep Sarkar

Interns  Visiting Scholar

Andres Hernandez  Ni Lei  Karen Silgado  Dou Zhan  Tan Liu  Mohidus Samad Khan

Universidad de San Buenaventura  Nanjing Tech University  Universidad de San Buenaventura  Nanjing Tech University  Nanjing University of Science and Technology  Bangladesh University of Engineering Technology
Visitors to the Center

August

Yi Liu, Liqiang Zhang, Haiwen Wang, Haiqing Wang, Peng Ren, Jing Li, Nianyun Shi, Hong Liang, and Juan Wang from China University of Petroleum

Bertrand LeJay and Lucile Barre from TOTAL Petrochemicals

September

Drs. Maria Papadaki, Simon Waldram, Hans Pasman, Luc Vechot, Delphine Laboureur, and Mr. Mark Griffon

November

Graham Bacon, Jill Seward, Angie Murray, and Scott Kellogg from Enterprise Products

Phani Raj and Francisco Gonzalez from the Federal Railroad Administration

Outreach Activities

September 22, 2016
Chemical Processing Webinar
How to Achieve and Maintain Process Safety

October 6, 2016
8th Southwest Process Technology Conference
The Evolution of Process Safety: Current Status and Future Direction
Galveston, TX

November 9-10, 2016
Managing Aging Plants Conference
Process Safety Excellence in Managing Aging Plants
Houston, TX

November 17, 2016
PHMSA Government & Industry R&D Forum
MKOPSC: A Research Organization Perspective
Cleveland, OH

Future Outreach Activities

December 6, 2016
AIChE S&OH Division Meeting Keynote
Mary Kay O’Connor Process Safety Center: Making Safety Second Nature

December 24- January 2, 2017
Lectures at Bangladesh University of Engineering Technology
Dhaka, Bangladesh

January 3-7, 2017
India Conference on Safety 2017
Gandhinagar, India

April 9-13, 2017
Qatar Process Safety Symposium
Doha, Qatar

May 10-12, 2017
Hazards 27
Birmingham, UK

September 26-28, 2017
Hazards Asia Pacific
Kuala Lumpur, Malaysia

October 1-5, 2017
10th World Congress of Chemical Engineering Process Safety Symposium
Barcelona, Spain

October 9-11, 2017
Hazards Africa
Johannesburg, South Africa


15. Vázquez-Román, R., C. Díaz-Ovalle, E. Quiroz-Pérez and M.S. Mannan, “A CFD-Based Approach


On Friday, September 13, 2002 at 9:30 am at the BASF facility in Freeport, TX, there was a catastrophic rupture of a railroad tank car containing 6,500 gallons of hazardous waste. The estimated property damage was close to $9.7 million. Due to the incident, 28 people sustained minor injuries, residents within a 1-mile radius were ordered to shelter-in-place for 5.5 hours, and the site was closed for 10 days due to Oleum leak. The railroad tank car contained 94% cyclohexanone oxime, 4% water, and 2% cyclohexanone. The direct cause of the incident was excessive heating of the chemical that caused an uncontrollable exothermic decomposition reaction. The oxime mixture generally would be consumed in the process, but due to a process upset it was generated as waste. As the mixture is solid at room temperature, it was steam heated and cooled multiple times to transfer. The waste was initially sent to a waste disposal facility in Missouri; however, one-third of the material (~8,000 gallons) came back to the Freeport, TX facility in error. The incident happened as the operators at the Texas site were trying to dispose of the returned waste.

An explosion and subsequent fires occurred on October 6, 2011, at a Co-op Refinery Complex in Regina, Canada. The initial explosion was caused by a 7.5-inch rupture of a corroded pipe which carried partially refined diesel fuel, hydrogen gas and hydrogen sulfide gas. Another four pipe segments ruptured because of exposure to fire. The incident led to 52 injuries, including 3 severe burns. The incident occurred in the process area of the middle distillate unifiner, during a hydrotreating process to remove contaminants from the distillate. The initial rupture was on the corroded reactor effluent line near a weld. Different corrosive materials (e.g., hydrogen sulfide, ammonium bisulfide and hydrochloric acid) damaged the pipe by different corrosion mechanisms. It is important to understand the cumulative effect of their corrosions. In addition, the pipe had non-uniform corrosion because the flow pattern shifted away from annular flow to stratified flow. Operating the process away from the transition area between the two flow patterns could prevent the non-uniform corrosion. Management issues leading to the incident included an insufficient mechanical integrity program, inadequate management of change procedures, and inadequate risk assessments on pipeline layout.
Nilesh Ade, PhD Chemical Engineering Student

The relationship between inherent safety and equipment reliability is studied by developing a methodology wherein inherent safety is quantified using a safety index that takes into account hazards with respect to toxicity, explosiveness, reactivity, and flammability of the chemicals, and operating conditions of temperature, pressure, yield, and heat released for the reactions. Hazards with respect to equipment are also taken into consideration in the safety index. Reliability is quantified using inherent availability taking into account the trade-off between reliability and maintainability while being independent of time period. This methodology is applied to the process selection and conceptual stage. The relationship between inherent availability and inherent safety is complicated and may vary during the different stages of the project. The amount of equipment is a critical factor that impacts inherent safety and inherent availability in the conceptual stage. Using a smaller number of equipment may help in designing an inherently safer process (by the principle of simplicity) and also provide relatively high inherent availability by providing fewer opportunities for failure in equipment. Implementing inherent safety principles can have a significant impact on the process profitability by affecting the maintenance cost by affecting inherent availability. As part of the future work, the methodology will be extended to later stages of design such as the detailed engineering stage, and the well-established Dow F&EI will be used to quantify inherent safety. The relationship between inherent safety and inherent availability for specific equipment, such as a distillation column or a reactor, will be studied as well. Finally, the impact of low inherent availability towards greater risk in a chemical process will be analyzed.

Effect of Dust Dispersion on Particle Integrity and Explosion Hazards

Pranav Bagaria, PhD Chemical Engineering Student

The hazards associated with dust explosions are quantified with the help of parameters such as MIE, Kst (rate of pressure rise), and MEC, Pmax. The particle size distribution is known to affect these explosion parameters. A standard 20-L dust explosion apparatus used to quantify explosion parameters was shown to cause particle breakage during the dispersion process due to the action from the outlet valve. It leads to the misleading association of explosion parameters to the dust particle size. This work uses a novel dispersion mechanism which eliminates the outlet valve. Hence, the dust is expected not to break as much as with the 20-L apparatus. It also allows for the examination of the effect of the nozzle and dispersion cloud on particle breakage. A comparison between the performance of this novel dispersion mechanism and that of a standard 20-L apparatus was made. Also, the dependence of breakage on dust concentration will be examined. Anthraquinone, acetaminophen and ascorbic acid were used for the study. In addition, dispersion behavior of nanomaterials will be studied using Carbon Nanofibers (CNFs). Anthraquinone, acetaminophen and ascorbic acid show that particle breakage is occurring even without the outlet valve and the breakage is comparable to that of a standard 20-L apparatus. It is also seen that dust breaks more when it is dispersed passing through the nozzle than by spreading it over the nozzle. This highlights that the nozzle has a significant role to play in particle breakage and also the fact that dispersion cloud turbulence can break the particles. Further analysis of the obtained data will be done and experiments continued to find the role of concentration on particle breakage and nanomaterial behavior on dispersion. Also, the plan to investigate the effect of morphology on dust explosion parameters will be developed.
Joey Cranston presented Normalizing Deviance: 30 Years After the Challenger Explosion. Normalization of Deviance (NoD) is a concept developed by Dr. Diane Vaughan following the 1986 Space Shuttle Challenger disaster. While the concept has been frequently discussed over the last 30 years, the author questions whether industry has addressed the issue on all fronts. A significant NoD incident within Albemarle Corporation was motivation to fully explore the original concept. The intent of this paper is to highlight the potential gaps in understanding of Normalization of Deviance, to suggest possible avenues to close the gaps, and to solicit industry-wide efforts to develop meaningful programs.

Vanessa Allen Sutherland presented CSB Investigation of the West (Texas) Fertilizer Fire and Explosion. On April 17, 2013, a fire and explosion occurred at the West Fertilizer Company (WFC), a fertilizer blending, retail, and distribution facility in West, Texas. The violent detonation fatally injured 12 emergency responders and three members of the public. Local hospitals treated more than 260 injured victims, many of whom required hospital admission. The blast completely destroyed the WFC facility and caused widespread damage to more than 150 offsite buildings. The WFC explosion is one of the most destructive incidents ever investigated by the U.S. Chemical Safety and Hazard Investigation Board (CSB) as measured by the loss of life among emergency responders and civilians; the many injuries sustained by people both inside and outside the facility fenceline; and the extensive damage to residences, schools, and other structures.

Mary Beth Mulcahy presented Macondo Incident.

Troy Bennett presented Expanded Technique to Determine Ignition Probability. Risk estimation and assessment involves two components; the probability of the event to occur and the consequence if the event occurs. It is evident from literature that various methodologies and models have been developed and are available to determine and evaluate the consequence related to an unexpected event. Determination of probability is less well developed and approaches are still evolving. For scenarios involving flammable releases an important part of probability which has a major influence on risk relates to ignition probability of the released flammable mass. Within industry, there are wide differences on determination of ignition probabilities of a given release. This methodology was developed to provide a simple, yet more comprehensive method to determine ignition probability.

Scott Davis presented Large Scale Detonation Testing: New Findings in the prediction of DDTs at large scales. A large vapor cloud explosion (VCE) followed by a fire is one of the most dangerous and high-consequence events that can occur at petrochemical facilities. As the size and complexity of facilities increase, 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. While the likelihood of DDTs is lower than deflagrations, they have been identified in some of the most recent large-scale explosion incidents including: 2005 Buncefield explosion, 2009 San Juan explosion, and 2009 Jaipur event. The consequences of DDTs can be orders of magnitude larger than deflagration because they have the ability to self-propagate outside the region of high congestion/confinement. Hence, it is critical to understand how a facility’s geometry or equipment layout...
can affect explosion consequences and assist in their mitigation and/or prevention.

**Bin Zhang** presented *LNG Safety Excellence: A Decade of Efforts by the Mary Kay O’Connor Process Safety Center.*

**James McNay** presented *Evaluation of Computational Fluid Dynamics (CFD) vs. Target Gas Cloud for Indoor Gas Detection Design.* After Piper Alpha in 1988, the oil and gas industry was given an abrupt wake up call to its shortcomings in terms of safety. With particular attention to the behaviour of Hydrocarbon gas and the potential for explosions, it was highlighted that while there was a great deal of academic knowledge behind this issue, very little was available to those designing the fire and gas systems for the industry, and even less of this information had been validated through full-scale testing.

**Peter Diakow** presented *Large-Scale Vented Deflagration Tests.* This paper presents results from a test program carried out to determine the peak deflagration pressure achieved within a congested enclosure vented through one wall of the enclosure. The industry standard in the United States for predicting the peak pressure developed in a vented deflagration is the National Fire Protection Association’s Standard on Explosion Protection by Deflagration Venting (NFPA 68). The NFPA 68 (2013 edition) vent area correlation accounts for varying degrees of congestion if the ratio of the obstacle surface area ($A_{obs}$) to that of the enclosure ($A_{s}$) is greater than 0.4 (i.e., $A_{r} = A_{obs}/A_{s} > 0.4$). The tests described in this paper were performed using an obstacle array with an $A_{r}$ ratio of less than 0.4.

**Charline Fouchier** presented *Experimental Investigation of Blast Wave Propagation in an Urban Environment.* As long as explosives represent a threat, understanding the explosion mechanism and its consequences in cities will remain an important issue. Examples of tragedies caused by explosions are numerous. The Oklahoma terrorist attack, United States, 1995, is one of them. A truck filled with handmade explosive exploded, heavily damaging the Alfred P. Murrah Federal Building. The effect of the blast created was equivalent to an explosion of more than 2300 kg of TNT and caused 168 deaths and more than 500 injured [1]. A more recent example is the accident of the west fertilizer company explosion, West Texas, 2013. A charge of more than 28 tons of ammonium nitrate detonated in a storage, causing 15 deaths, more than 200 injured and around 100 MUSD of damages.

**Greg Fletcher** presented *Improving Contractor Safety Experience and Engagement.* Contractor safety management comprises a vital component for managing an outsourced workforce, particularly as owners and operators are faced with additional process and personnel safety regulations and standards – both internal and external. Contractual requirements, industry standards, regulations and risks make it particularly important for employees and contractors to diligently remain informed, engaged, and even change behaviors when it comes to safety. Effective safety programs help employees and contractors understand expectations within the workplace or job site, help them understand how to respond appropriately, and enable them to become better brand stewards who contribute to promoting a safer environment.

**Tomasz Olewski** presented *Challenges in Applying Process Safety Management at University Laboratories.* Risks associated with academic research are often
perceived as being much lower than risks within large-scale process industry operations. While the inventories of hazardous materials are generally lower within an academic environment and the number of other hazards may be lower, factors such as materials of construction typically used in laboratories, and the proximity of researchers to their equipment push risks to the individual disproportionately higher. The number of reported lab incidents worldwide that have resulted in fatalities, severe personnel injury, and financial loss demonstrates that there is a need for better risk management practices within academic teaching and experimental research labs. This need was very strongly emphasized by the US Chemical Safety Board following their investigation of major fatal laboratory incidents in the previous years.

Nafiz Tamim presented Roles of Contractors in Process Safety. Process safety starts at the conceptual phase and continues throughout the entire life cycle of an asset. From process selection to decommissioning, various process safety elements govern the safety and reliability of the total system. Contractors play a crucial role in project execution including detailed design, technology selection, plant layout, commissioning, start-up, and further expansion, modification and maintenance activities. The interface/interaction of the contractor with the operator/owner often defines the importance of process safety throughout this life cycle. Undoubtedly, these are the most critical phases of a plant life cycle which could trigger an unexpected or uncontrolled situation leading to a catastrophic incident. This paper discusses the impact of the contractors’ role during major process safety events including the Phillips explosion in Pasadena (1989), Sonat vessel failure (1998), Texas City Refinery explosion (2005), T2 Laboratories explosion (2007) and a few others. Lessons from past incidents are highlighted and an in-depth analysis is conducted to identify essential process safety components for different groups of contractors and for the different phases of projects.

Different aspects of process safety functional elements are presented and discussed for both greenfield and brownfield projects. A comprehensive understanding of process safety and risk management is required by all levels of contractors to ensure risk-based decision making and hazard mitigation. Besides the process safety expertise needed by the contractors, the necessity of having a consistent and harmonized interaction between the operators/owners and the contractors is also emphasized.

Mike Mangan presented Brain-Centered Hazards: Risks & Remedies. This paper outlines some of the brain-centered hazards identified by applying recent neuroscience research to our modern workplaces. Specifically, three key lessons from neuroscience are explored in detail so leaders can be alerted to the types of risks lurking in every one of their worksites. Then, this paper introduces a hazard mitigation approach that enables leaders to reduce exposures to these newly-understood hazards. What is most crucial for leaders to understand is that, left unattended, brain-centered hazards can create high-consequence exposures as serious as toxic chemicals or loss of controls. In fact, some of our most serious organizational incidents have involved brain-centered hazards typically identified as “human errors.”

Camille Peres presented Advanced Next Generation Procedure Research Study. Today’s procedures are almost exclusively paper based with severe limitations and potential consequences. Research has found that minimum compliance with current PSM regulations is insufficient for companies desiring to maximize human reliability, worker safety and overall operations excellence. Texas A&M is leading a groundbreaking Advanced Next Generation Procedure Research Study with leading oil & gas and chemical companies
to focus on improving procedure quality and usability combining technology with critical human factors methods and research.

Ranjana Mehta presented *Fatigue Monitoring in Offshore Energy Operations: Research to Practice Gaps*. The oil and gas extraction (OGE) industry continues to experience an elevated fatality rate; from 2010-2014 fatality the rate in this industry was nearly seven times higher than that for all U.S. workers. OGE workers are exposed to intensive shift patterns and long work durations inherent in the OGE environment, which can lead to fatigue, thereby increasing risks of incidents and injuries. Fatigue, often defined as a physiological state of reduced mental or physical performance capability resulting from sleep loss, circadian phase, and workload, has been implicated as a critical risk in both offshore and onshore OGE operations. The aims of this study were to explore the effect of offshore shiftwork on physiological and subjective fatigue outcomes. 10 male workers (age: 31.3 (6.1) years; stature: 1.72 (0.1) m; weight: 85.24 (9.8) kg) were monitored throughout their daily shifts for six days using intrinsically safer physiological sensors (EQ02 LifeMonitor, Equivital™, Cambridge, UK) that recorded various physiological parameters at 250Hz and subjective fatigue scales were employed to obtain perceptions of fatigue. Results indicate that overall average ambulatory heart rate (an indicator of fatigue) were elevated for all participants and was highest and raised the most for those who started and ended their hitch on the day shift. The same measure was lowest and did not change for those who started on the day shift and swung to the night shift. The ambulation rates (a measure of movement) were higher later in the participants’ hitch and this effect was seen primarily for those who started their hitch in the day shift. Participants’ reports of fatigue were relatively high for acute fatigue and intershift recovery as well as for lack of effort and sleepiness; however, the physiological measures were not consistently or predictably correlated with the self-report measures of fatigue or activity. The study outcomes identified a critical gap in fatigue assessment in OGE operations; existing fatigue surveys for the general (or other) working populations are not comprehensive of OGE operations and are thus not applicable for OGE workers, nor are they validated against physiological fatigue outcomes in OGE workers.

James Wesevich presented *Accounting for Channeling and Shielding Effects for Vapor Cloud Explosions*. Vapor cloud explosions (VCEs) can cause significant damage to nearby buildings, facilities and infrastructure with potential loss of life and significant business interruption, so the accuracy of predicting blast loads on facility buildings is critical in estimating these losses. Closely spaced buildings and process equipment outside of the congested region of a VCE provide a complicated flow field for an expanding blast wave. Their presence can channel and shield the blast flow field, resulting in significant effects on the blast load magnitude and wave form shape. Currently, the most common way to estimate applied blast pressures resulting from VCE’s is to use simplified methods that account for the total energy from the stoichiometric portion of the vapor cloud, fuel reactivity, and level of congestion and confinement, such as the TNO Multi-energy, equivalent TNT, CAM, and BST methods.

Graham Atkinson presented *A Review of Very Large Vapor Cloud Explosions*. The UK Health and Safety Executive in collaboration with the Pipeline and Hazardous Materials Safety Administration (US Department of Transportation) have carried out a detailed review of very large vapor cloud explosions (VCEs) associated with pipeline failures and losses of containment at refineries as well as LPG, LNG and gasoline storage sites. In the first instance this work is intended to inform assessment of the potential
for escalation at LNG sites, in the case of an explosion following a significant leak of refrigerant gases (e.g., propane and iso-butane), but the findings are relevant to a wide range of petrochemical sites.

Henk Witlox presented Modelling and Validation of Atmospheric expansion and Near-Field Dispersion for Pressurised Vapour or two Phase Releases. The consequence modelling package PHAST includes steady-state and time-varying discharge models for vessel orifice releases of toxic or flammable materials. These models first calculate the depressurisation between the stagnation and orifice conditions and subsequently impose the ‘ATmospheric EXpansion model’ ATEX for modelling the expansion from orifice conditions to the final conditions at atmospheric pressure. The latter post-expansion conditions are used as the source term for the PHAST ‘Unified Dispersion Model’ UDM.

Carl Laird presented A Global Stochastic Programming Approach for the Optimal Placement of Gas Detectors with Nonuniform Unavailabilities. Optimal design of gas detection systems is challenging because of the numerous sources of uncertainty, including weather and environmental conditions, leak location and characteristics, and process conditions. Rigorous CFD simulations of dispersion scenarios combined with stochastic programming techniques have been successfully applied to the problem of optimal gas detector placement; however, rigorous treatment of sensor failure and nonuniform unavailability has received less attention. To improve reliability of the design, this paper proposes a problem formulation that explicitly considers nonuniform unavailabilities and all backup detection levels. The resulting sensor placement problem is a large-scale mixed-integer nonlinear programming (MINLP) problem that requires a tailored solution approach for efficient solution. We have developed a multitree method which depends on iteratively solving a sequence of upper-bounding master problems and lower-bounding subproblems. The tailored global solution strategy is tested on a real data problem and the encouraging numerical results indicate that our solution framework is promising in solving sensor placement problems.

Jiun-Yin Jian presented Reducing Human Error in Crane and Hoist Operations. Between 1971 and 1985, crane incidents resulted in 37 fatalities and 26 injuries in the Gulf of Mexico, and occurred approximately once every year in the North Sea. Over the last decade, major crane incidents in offshore environments resulted in multiple fatalities and incidents. For this reason, crane incidents continue to be a major focus and of industry concern. Despite the large progress made with crane technology and regulation (API 2C and 2D), operators and workers remain exposed to risks due to inadequate consideration of human factors in design. This desk-based evaluation was conducted to address the human factors related to crane operations with a detailed focus on cabin display and control arrangements, identification of blind spots, safe lifting practices, and compliance with regulatory requirements. It was found that the one configuration of the two-lever controls recommended by API 2C was conducive to causing human error, and that a rearrangement of the labeling and color-coding could increase readability and legibility to the operator. A modification to this arrangement is recommended in order to further prevent incidents stemming from human error. In addition, the operator’s field of view (FOV) or line of sight (LOS) was simulated using schematics, 3D models, and anthropometric data in order to identify blind spots during lifting and lowering activities. This strategy can be implemented in the preparation of lift plans.
which will subsequently facilitate adequate communication between the operator and flagman during blind lifts.

Robert Brown presented The Challenges Achieving Compliance to RAGAGEP in Process Safety Management Enforcement and the Impact of Non-Compliance to Budget and Schedule. Every 5 to 8 years’ large waves of capital spending occur known as MEGA Projects. These projects are effectively 1 or more Billion US dollars in Total Installed costs (TIC). When these projects are part of a global race to fill a void in the current marketplace, a serious race to be first to market or otherwise known as “Prime Mover” becomes the main driver and rapid deployment of resources. The reward for being the first to market is a higher (shorter) ROI (return on investment) cycle than other competitors and the ability to capture more customers than other competitors. This paper will explore the challenges of being first to market and how that can affect meeting PHA/LOPA and ultimately achieving required SIL Targets and the impacts to costs and schedule.

Cheryl Grounds presented CCPS’s Vision 20/20: Improving YOUR vision so WE ALL can see better. 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. BP reflects how selected corporate activities may be seen as supporting the industry tenets and societal themes.

Hiroshi Koseki presented Effects of Floating Beads on the Flash/Fire Temperatures and Occurrence of Boilover. Effects of floating beads on the flash/fire temperatures and occurrence of boilover were studied. To avoid crisis such as huge crude oil fires and boilover in oil and chemical complexes after great earthquakes, floating beads have been developed. Therefore, in order to know effects of beads, experimental study was conducted in small scale pan (Diameter: up to 0.3m). Addition of beads into pan increased the fire/flash points, and delayed and minimized boilover. So addition of small beads into oil tank is one of countermeasure against incidents after great earthquake.

Kumar Israni presented HAZOPs in a Cash Constrained Environment. Year 2015 has been another difficult year for the oil and gas (O&G) industry. For the upstream industry, low prices of oil have resulted in operating companies making drastic changes to their economic canvas due to shrinking budgets. Irrespective of the type of industry, changes in the economic environment dominate the operations. To add to this, there are challenges with budgetary cuts on practices and personnel. This results in a common tendency to overlook required process safety needs, which in turn cause more challenges to maintaining safe work environments. In order to meet these moral and obligatory requirements, with dwindling finances, existing traditional PHA techniques require trimming, but without compromising on the objectives of protecting human lives, environment and businesses. Based on recent experiences, and successful outcomes, the author provides modified approaches to PHAs including HAZOPs, HAZIDs and What-ifs.

Dennis Taylor presented CFD Explosion Sensitivity Analysis. This paper describes the various activities involved in conducting a number of Quantitative Risk Assessments (QRA) to identify possible risk reduction measures for an offshore platform being located in an Arctic environment. The program consisted of a number of studies, briefly described in part one, that basically surveyed different options to provide a quantitative basis for narrowing the focus to an option that could then be subjected to a sensitivity analysis. One of the valuable characteristics of a QRA study is the ability to compare various options in a sensitivity analysis.
to determine the advantages/disadvantages of changes in design. Part two of this paper then presents the actual outputs from the QRA to demonstrate the information available to the design engineers on the project. All activities described occurred during the Front End Engineering Design (FEED) phase of the project, starting as soon as the information necessary to start the study was available. It should be emphasized that this particular study was undertaken for an offshore platform, but the principles apply to any type of process where significant hazards are present. In fact, the author is currently involved in the extensive use of a QRA to optimize the FEED portion of an Ethylene Oxide (EO) project.

Mary Ann Lane presented *Control Room Design: Best Practices and Lessons Learned From a Multi-Disciplinary Perspective.* Control room design directly affects the safety of the operations, whether it’s a new build or a renovation. Regardless of the type of project, there is a unique opportunity to optimize the human performance within the system. By using a best practice approach and hiring the right multi-disciplinary team early in the design process, the road to a state-of-the-art control building is paved with technical and financial efficiencies. A one-stop shop/one team approach that includes the client, architects, human factors engineers (HFE) and interior designers with control room experience can make the design process much more streamlined rather than a struggle. Best practices and lessons learned are automatically interwoven into the design process to make for a seamless approach. This paper describes a best practice approach to control room design, the importance of using an experienced and integrated multi-disciplinary team and some key issues that need to be considered.

William Brokaw presented *Applying Predictive Analytics to Process Safety Leading Indicators.* Leading indicators can be defined as safety-related variables that proactively measure organizational characteristics with the intention of predicting, and subsequently avoiding, process safety incidents. Leading indicators become especially powerful when combined with advanced statistical methods, including predictive analytics. Predictive analytics is a broad field encompassing aspects of various disciplines, including machine learning, artificial intelligence, statistics, and data mining.

Laura Bellman presented *Mentoring New Plant and Process Safety Engineers.* Within a matter of months, I was the PHA leader and most experienced of five process safety engineers in our chemical park. Of the other five, 4 had limited process safety experience. The new engineers were of varying backgrounds and cultures. Since I myself have been an HSE professional for 30 years, and grew up with process safety from the beginning, I had limited experience with how to grow process safety competence in someone else. I looked forward to the challenge. This paper is a discussion of the ideas, processes and experiences I had along the way to developing competence in others. It is a case study and includes lessons learned.

William Peplinski presented *Multi-Community Risk Assessment Framework for Drinking Water.* Drinking water supply involves a complex network of natural and man-made infrastructure necessary to capture, store, convey, treat, and discharge this necessary resource. Each component in this “cloud to tap” supply chain faces a host of threats such as systemic decay, population change, natural disaster, cyber and physical attacks, and/or contamination incidents.
Evaluating and quantifying the near- and long-term implications of these stressors on the risk and resilience of the current water infrastructure system has historically been implemented at the local utility level. The Drinking Water Resilience Project (DWRP), a collaboration between the Department of Homeland Security, Oak Ridge National Laboratory (ORNL), Sandia National Laboratories, the University of Colorado, Colorado Springs (UCCS), and the University of Tennessee (UT) is aimed at providing a more comprehensive view of water utility risk and resilience. Specifically, Sandia’s effort will develop an infrastructure risk assessment tool to support self-assessment by the asset owner/operator using an interactive, data-rich, web-based application that guides the user through the analysis. The associated analysis is intended to be simple, consistent and comparable. This facilitates the sharing of results, in a secure environment, across multiple levels of government as the need requires. This sharing helps place individual utility results in the broader context of risk borne by similar utilities across the U.S. Shared analysis also helps identify and address issues with assets and resources shared across multiple utilities. Most importantly, risks and mitigating measures can be prioritized across different geographic scales to aid funding decisions made at levels beyond the capacity of a single utility. A demonstration of the framework will be given along with demonstration results from several public utilities.

Yaneira Saud presented Assessing Risk in the Supply Chain Using the Bowtie Method. After a number of recent incidents involving the transportation and storage of hazardous materials, many industry end-users wish to understand their level of risk exposure during the supply chain. This exposure can either be via actual ownership or when the product can be associated with the concerned party. Ultimately, this may mean that an end-user’s procurement group will want to see that their suppliers of products and services are performing as needed in the control of these risks. A qualitative risk assessment is a technique by which these risks can be identified, understood, and evaluated. This paper will describe the application of one such method, where the bowtie barrier analysis is central to the means by which this assessment is completed. The barriers identified are those necessary to prevent and mitigate undesired events that could result in a fatality or a catastrophic incident to the environment, public, or a company’s reputation.

Joep Winters presented Mind The Gap – Improving Process Safety with an Integrated Approach Using Risk Assessments, Incident Analyses and Audits. Although most organizations have risk critical information available, it is not always integrated. In this paper, a bowtie perspective is proposed that enables an integration of three risk data sources. Issues with these three risk data sources are discussed and ideas for improvement are proposed. The integration of bowtie risk assessments, incident analyses and audit data complements each other and provides an interesting perspective on the status of the process safety management system. The integrated approach can be a useful addition to existing process safety management approaches.

Richart Vazquez Roman presented A Resilience Index for Process Safety Analysis. Qualitative risk analysis is focused on applying methods to prevent accidents in diverse process plants. The numerical number resulting in the QRA tells nothing about the ability for systems’ recovery if an upset related to safety occurs in the process. Hence a resilience study is required to produce this additional information related to process safety. The resilience index is defined as the proportion of success in recovering the system compared to
a number of safety-related upsets. The failure in recovering depends on type and quality of safety barriers, i.e., technology, but also on organizational principles. In this work, Monte Carlo simulation is carried out to estimate the resilience resulting in quantitative resilience estimations. These results provide means to compare processes from a more general safety point of view.

Vic Edwards presented *The Safest Facilities Are Created During Concept, Siting, and Engineering Design*. The best time to create a safer process plant is during the concept, siting, conceptual engineering, front end engineering, and detailed design phases of a project. Inherently safer feedstocks, products, process technologies and facility designs are best chosen early on in an Engineering, Procurement, and Construction (EPC) project. At that critical stage in the life cycle of a process plant, choices are made that will affect the safety and operability of the plant for the rest of its life cycle. Siting and layout choices affect the offsite consequences of any major incident and can decrease or eliminate risk to and from any adjoining hazardous facilities.


Seungho Jung presented *A Study of Effective Mitigation System for Accidental Hydrogen Fluoride Releases*. Hydrogen fluoride (HF) is a strong, pervasive gas that is a stimulus on the body, respiratory system, and skin. HF is widely used in electronics manufacturing as a polisher and disinfectant. Interest in HF increased after the HF release accident in Gumi, S. Korea (2012), emphasizing the special attention and management needs with respect to this gas. In this study, ANSYS FLUENT, a Computational Fluid Dynamics (CFD) program, is used to identify the effect of a physical barrier as a mitigation system against HF and Chlorine leaked from industrial facilities. In a typical industrial facility, there is a barrier that distinguishes the inside and outside of a workplace, but it is not sufficient to prevent hazardous substances from being released outside. However, we assumed various physical barrier heights (3 m, 6 m and 9 m) for mitigating toxic release and used simulations to analyze them to determine how effectively they decreased concentrations offsite. Goldfish experimental data from 1986 were compared to verify the results for HF and Jack Rabbit I test data in 2010 for Chlorine. The results show that HF and Chlorine concentrations can be further decreased with higher barrier heights and their mitigation effectiveness factors were derived. Thus, we can reduce the possibility of offsite exposure to toxic gas release using the mitigation system and make the better and more effective emergency plan with proper mitigation systems.

Robert Siml presented *Static Head An Overlooked Issue in Relief System Design*. Allowable accumulation of pressure over the Maximum Allowable Working Pressure (MAWP) in relief system design is established in ASME Boiler and Pressure Vessel Code (BPVC) Section VIII, Division 1 and followed in API STD 520. This requirement is
frequently simplified to a required relief rate at allowable relieving conditions and the effect of liquid static head is often overlooked. Overfilling scenarios and overpressure scenarios for equipment operating liquid full can result in vessel pressure exceeding code allowable accumulation if relief valves are not set appropriately. This paper will highlight a variety of static head concerns from actual experience and mitigation options.

**Boyd George** presented *Make Inlet Piping and PSV One-System*. For pressure safety valves and associated inlet piping, the API recommends the non-recoverable pressure loss should not exceed 3% of the set pressure at rated capacity flow, with some exceptions, e.g., for remote sensing pilot operated pressure safety valves. The API further notes pressure losses above 3% are allowable if an engineering analysis shows valve performance is not impacted during relief. The API provides little guidance on the recommended engineering analysis. Calculations show the inlet piping and pressure safety valve (PSV) should be considered one system. Analysis of the system improves the basis for judging pressure safety valve performance, especially when compared with treating inlet piping separately from the PSV and then somewhat arbitrarily judging performance adequacy. With increasing inlet piping pressure loss, the energy in the velocity head at the inlet to the PSV grows in significance. Analyzing the inlet piping pressure loss separate from the PSV neglects this energy and makes the experience and knowledge of the judging engineer paramount. Given current computational capability and today’s litigious regulatory environment, an analytical and consistent basis for judging PSV performance may be of interest.

**Jody Olsen** presented *Align PHA Scenarios with PSV Calculation Cases*. It is not uncommon to find that Process Hazard Analysis (PHA) scenarios and Process Safety Valve (PSV) calculation cases do not align. The intent of PHA studies, typically performed using the Hazard and Operability (HAZOP) method, is to identify all plausible hazard scenarios and the risk of those events occurring by assessing potential causes, consequences, safeguards, and independent protection layers. The intent of the PSV protection layer is to provide relief capacity for all plausible overpressure scenarios. Therefore, HAZOP scenarios related to overpressure and PSV calculation cases should align. Lack of alignment between the HAZOP and the PSV calculation file creates problems in completeness, quality, and clarity. Lack of alignment also creates engineering rework and "churn" as inconsistencies are discovered and resolution is needed. A simple solution is proposed. Each PSV calculation case that is considered plausible should contain a direct reference to the related HAZOP scenario, preferably in the summary matrix. Likewise, each HAZOP scenario should reference the related PSV case. New or modified PSV calculations and new or modified HAZOP summary sheets associated with plant modifications or engineering document corrections should include this cross-referencing. Where broader changes are introduced, such as changes to engineering assumptions for PSV calculations or changes to HAZOP scenario protocol, the Discipline Subject Matter Experts (SMEs) responsible for approving those changes must consider the impacts to the related documents and define the expectations for updating those documents in order to assure alignment.

**Philip Hodge** presented *A Method to Utilize Facility Sitting Techniques in the Early Phases of Capital Projects to Reduce Risks and Safety Spending*. A common complaint when undertaking capital projects is the cost of engineered designs that must be added late in the project in
order to mitigate hazards or risks. Due to the typical phasing of these project activities, the facility siting study (FSS) or other consequence or risk modeling is not completed until the layout of the facility has been established. When a site layout is already in a mature state; however, it can be extremely difficult to move hazards or populations to safer locations due to the substantial amount of rework that would be required. With mitigation through relocation thus limited or even unavailable, increasing the safety systems within the unit or adding layers of protection at the buildings of interest becomes the only option. Costs could be reduced and designs made safer if FSS or similar studies could be conducted earlier in the design process.

Zohra Halim presented Probabilistic Methods of Quantitative Risk Analysis: A Case Study with Bayesian Networks and Petri Nets Approach. Conventional risk assessment methods such as Bow Ties have been incapable of capturing the dynamic nature of a system and hence have failed to properly predict the time dependent failure of barriers. Modifications made to incorporate time dependencies in such methods have not found wide application yet. Rapidly changing physical parameters necessitate techniques capable of considering the dynamic aspects of a system throughout its lifetime. The present work is aimed at demonstrating the applicability of Bayesian Networks and Petri Nets to capture the time dependencies of systems to carry out a quantitative risk analysis. A case study is to be carried out using both Bayesian Network and Petri Nets to provide an insight into the pros and cons of using each method to model the system. This insight is to provide a starting point for the development of a model that will enable us to conduct a quantitative risk analysis considering all factors that can lead to an incident.

James Pettigrew presented Equipment Reliability Data Collection: A Journey to Operational Excellence in the Offshore Industry. The offshore industry has witnessed catastrophic incidents, which continue to occur. There is a need to learn from various best practices and incidents and continue to move towards safer operations. Data in different forms on equipment reliability, near misses, key performance indicators and more exists within organizations and agencies in this industry. Most of these databases, if collected and connected could be used to prevent and/or assess the consequences of an event. Near-miss databases can help to assess the barriers that would prevent an event from escalating to consequences, and the reliability databases can be used to assess the barriers that can prevent an event.

Keith Lapeyrouse presented Learnings from Mary Kay O’Connor Process Safety Center (MKOPSC) Instrument Reliability Network’s Project on Pressure Transmitter Maintenance Data Collection. This paper presents the results of the first phase of the pressure transmitter reliability data project executed by the Mary Kay O’Connor Process Safety Center’s (MKOPSC) Instrument Reliability Network (IRN). The quality of the data provided by the six participating companies was checked using self-reporting criteria submitted with each dataset. Out of sixteen reported datasets, only one was excluded due to no devices included in the dataset. The remaining fifteen datasets were used for this analysis. The mean time between corrective maintenance (MTBCM) of the pressure transmitters for the six contributing companies were compared to each other. Even with the limited taxonomy used for this first project phase, it could be concluded that there was a significant difference in corrective maintenance performance between the participating companies and that the company
performance seemed to fall into two distinct groups. In addition, it was observed that there could be significant MTBCM variability between multiple datasets submitted by a company, potentially associated to taxonomy details not included in this study.

**Angela Summers** presented *Measuring the Reliability of Safety Controls, Alarms, and Interlocks*. In order for the risk analysis to not be overly optimistic or pessimistic, the data assumptions need to agree with the actual capability of the installed systems. This paper covers the essential elements of an instrument reliability program that can be applied to both process control and SCAI equipment. It will discuss the critical activities needed to identify and track failures, so negative trends in performance can be responded to prior to a loss event occurrence. A successful instrument reliability program leverages existing work processes to collect quality data that drives improvement in safety and reliability.

**Tom Spicer** presented *Transient Large-Scale Chlorine Releases in the Jack Rabbit II Field Tests: Rainout Source Data Analysis*. Sponsored by the Chemical Security Analysis Center (CSAC) of the U.S. Department of Homeland Security, the Defense Threat Reduction Agency (DTRA) of the U.S. Department of Defense, and Transport Canada, the Jack Rabbit II tests were designed to release liquid chlorine at ambient temperature in quantities of 5 to 20 T for the purpose of quantifying the behavior and hazards of catastrophic chlorine releases at scales represented by rail and truck transport vessels. Phase 1 of the two-year testing campaign was conducted at Dugway Proving Ground, Utah, in August and September of 2015. Five successful field trials were conducted in which chlorine was released in quantities of 5 to 10 tons through a 6-inch circular breach in the tank and directed vertically downward at 1 m elevation over a concrete pad. In 2016, four trials were conducted with three releases of nominally 10 T at different orientations and a single release of 20 T vertically downward. Data from the 2015 tests are available. This paper summarizes preliminary analysis of the available data from the concrete pad including analysis of the temperature measurements below and grade in the concrete pad.

**Hans Pasman** presented *What Value has Risk Assessment? What Factors Do We Have To Reckon With In Explaining Its Results?* Risk assessment results often fail to provide confidence due to overlooking important scenarios, to lack of suitable and reliable failure data, to uncertainties not analyzed or included, to the unpredictability of human action and response, and to the lack of detail in the physical models of consequence analysis. The ultimate in risk assessment is its quantified version: Quantitative Risk Analysis, QRA. However, its results are notoriously inaccurate: one or two orders of magnitude of uncertainty in the results are rather common, and three orders may occur. Yet, risk assessment is crucial for preparing and supporting decision making under uncertainty in many situations. Many problems require comparison of the cost versus the benefit of measures to reduce risk and to select a sufficiently safe solution. Unsupported engineering judgment may be subjective and limited in the aspects considered. Also, in complex and important cases risks must be explained to the public at large to inform, to partner, and to enable decision making in licensing or otherwise. It is therefore that this paper will elucidate the fundamentals of the risk concept, its relativeness and subjectivity, and it will show the distinction of risk perception by the more rational left versus the emotional right brain halves. As Nobel Prize winner Daniel Kahneman
states, even the rational part of our brain must struggle to master probabilistic thinking. However, in view of the many uncertainties to manage a socio-technical system effectively, consistent employment of probabilistic modeling methods is essential. The paper will further touch upon how complexity and ambiguity can result in confused issues, on the necessity of a system approach, on the difficulties of expert knowledge elicitation, and finishes with a brief outlook to the future.

Rym Kanes presented Developing a Framework for Dynamic Risk Assessment Using Bayesian Networks and Reliability Data. Process Safety in the oil and gas industry is managed through a robust Process Safety Management (PSM) system that involves the assessment of the risks associated with a facility in all steps of its life cycle. Risk levels tend to fluctuate throughout the life cycle of many processes due to several time varying risk factors (performances of the safety barriers, equipment conditions, staff competence, incidents history, etc.). While current practices for quantitative risk assessments (e.g., Bow-tie analysis, LOPA, etc.) have brought significant improvements in the management of major hazards, they are static in nature and do not fully take into account the dynamic nature of risk and how it improves risk-based decision making.

Tom Pfitzer presented An Update to the Universal Risk Scales—A Tool Developing Risk Criteria by Consensus: How safe is safe enough. In 1999, the Risk-Based Explosives Safety Criteria Team (RBESCT) developed the Universal Risk Scales (URS) to assist in the job of selecting appropriate criteria for defining “How safe is safe enough?” To answer this question, the URS provides two types of numerical data plotted alongside a logarithmic scale. On the left side, the URS summarizes legal precedents and standards that contain criteria for risk acceptance and compares those standard criteria to numerous data on the right side representing actual risk statistics derived from historical accident data. The URS was the foundation for selection of the risk criteria currently used by Department of Defense Explosive Safety Board (DDES) to evaluate risk-based explosives safety siting assessments. In 2014, A-P-T Research (APT), with guidance from the RBESCT, was tasked to update the URS to reflect changes in the safety culture since the initial study. More current data were collected to update risk values from the previously used activities, and new activities were researched in an attempt to better represent risks similar to the explosives industry. In addition, all standards mentioned in the initial study were compared to see if any updates were made, and new standards were included in the comparison. This research will be evaluated and assessed by the RBESCT and DDES to determine if current Department of Defense (DoD) site planning criteria need revision. This paper provides the details of this update along with additional perspectives and comparisons with the updated and new data. This updated URS data also has many other potential uses within government and industry for decision makers who face the challenging question of “how safe is safe enough?”

Holly Dollinger presented Zero Based Maintenance Program.

Trish Kerin presented Process Safety for OHS Professionals. Process safety is a field dominated by engineers and OHS professionals coming from a range of different disciplines. In addition to this process safety is often managed by engineers outside of the traditional safety function. This has led to a divide where OHS professionals don't always understand the purpose of process safety professionals and vice versa. This paper will explore what OHS professionals need to know about process
safety and how they can work together to get better safety outcomes for all.

Prashanthi Bhupathi presented Journey Towards Risk Based Process Safety. Group wide requirements and supporting ground rules have been defined to effectively utilize these methodologies in a consistent manner across various locations. Customisation also means applying more rigour in the analyses with less subjectivity, pre-defining criteria for choosing scope for quantitative analyses or the way risks are estimated. These ground rules were developed for both qualitative and quantitative techniques like What-if/ Hazop, Consequence analysis, LOPA, MAR/ QRA. However these ground rules are aligned to current group strategy and can potentially undergo review in future and any required changes made. The paper discusses the evolution process in the area of Risk Assessment, challenges faced in realizing the actual benefits out of the assessments and how certain alterations in assessment methodology have helped in continual improvement of process safety and risk management.

Savio Vianna presented Evaluation Beyond a Consequence-Only Approach: When is it Really Needed? The basic consequence analysis is the initial step for any facility siting analysis. It turns out, however, that many studies quickly demonstrate that the impact to buildings can be more significant than what have been defined as acceptable. For such cases, the analysis unfolds a set of more sophisticated approaches that should be considered; explosion exceedance curve, quantitative risk analysis, likelihood of building failure, among others. The current paper addresses a comprehensive methodology that comprises computational fluid dynamics (CFD) technique in the early stage of the analysis without compromising the time schedule and the budget. The more accurate results obtained with CFD modelling lead to cloud sizes which are mainly less conservative than traditional methods. The benefit of the analysis lies on the fact that it may be sufficient to show an acceptably low level of risk right at the initial stage. Therefore, it may avoid extra costs associated with a more detailed quantitative analysis.

Delphine Laboureur presented Migration of Industrial Hazards by Water Spray Curtains. Nowadays, the water spray curtain is recognized as a useful technique to mitigate major industrial hazards. It combines attractive features such as simplicity of use, efficiency and adaptability to different types of risks. In case of accidental toxic gas releases, the spray curtain may be used as a direct-contact reactor exchanging momentum, heat and mass with the gas phase. The cloud is diluted, warmed, and if toxic, some of its toxic content can be absorbed by the droplets to which chemical reactants can be added. In case of fire, water sprays can provide thermal shielding to maintain the integrity of storage tanks. The curtain behaves as a filter and can produce significant attenuation of the incident radiation that impinges on crucial structures such as petro-chemical storage tanks.

Neil Prophet presented An Overview of Worldwide Risk Tolerability Criteria for Chemical Process Industries. Quantitative risk assessment is accepted as a process safety management tool in many countries throughout the world. Risk-based legislation is implemented by national governmental bodies. These organizations are often under public scrutiny, which indicates a high degree of societal endorsement of the values. There are at least three themes that are commonly used in the development of many generally accepted and recognized risk criteria: (1) a comprehensive risk
management program must address both individual and societal risk; (2) risk criteria for the public must be lower, i.e., more conservative, than those for the workforce since the workforce risk is considered to be voluntary; and (3) with respect to individual risk, new facilities should be held to a higher level of risk performance than existing facilities. For new facilities many opportunities exist to apply new/advanced risk reduction technologies. In contrast, societal risk criteria are universally identical for new and existing situations; i.e., where a potential exists for major accident events affecting large numbers of people, most regulators have judged that older facilities must meet the same standards as newer facilities.

Brian Dickson presented Process Safety–Equations of State. By convention, chemical engineering requires us to develop a set of empirical equations that predict the transformation of one state into another. Process Safety generally lacks that discipline and as a consequence is sometimes suggested as having a lack of academic rigour. (Apologies here to the hard working risk, fires & explosions modellers). In the tradition of empirical chemical engineering, this paper takes a philosophical approach to "equations of state" as a way of demonstrating the transitions that have taken place in the approaches to Process Safety, consider the rise and fall of the importance of key components and present a “hypothesis” for discussion, that there is a “need to move away from the Engineering model and its linear solutions, to an Organizational Model where responsibility lies with the Individual rather than the System which is still the current trend.”

Mostafa Saadi presented So What is a “Facility Level” Hazard Analysis Anyway. How can a "facility level" hazard analysis be conducted to ensure hazards of the operation are understood and managed, while at the same time optimizing the use of company resources to complete the analysis? Anadarko has framed these issues into a Facility Level Hazard Analysis (FLHA) Program for our Gulf of Mexico (GoM) facility operations. This FLHA program follows Anadarko’s Risk Management program guidelines and also meets the requirements of the BSEE Safety and Environmental Management System (SEMS) regulation and is consistent with American Petroleum Institute (API) guidance. Anadarko’s GoM FLHA program also provides flexibility to address the initial design, pre-startup, and post-startup hazard analysis needs of the organization.

Drew Botwinick presented Maximizing the Benefit of Early-Stage CFD Ventilation Analyses to Reduce Fire and Explosion Hazards. A carefully constructed ventilation study that accounts for the nature of facility hazards can provide relatively fast and inexpensive insight into potential safety-oriented optimizations during early stages of facility design. By providing this insight early in design, facilities can be rigorously designed for safety—minimizing the risk (and therefore cost) of late-stage design changes. This paper will present guidance on some of the requirements for and benefits of early-stage ventilation studies. The paper will use specific examples derived from recent work in prioritizing safety in early-stages of design to demonstrate the value of such studies and why the industry needs to move beyond focusing on just the 95th percentile ACH.

Edwin Merrick presented The Future of Risk Management/RBI in a Lean Environment – Facing Regulatory Uncertainty. The purpose of this paper is to present a perspective on the human factor and the value of using risk tools to help provide management focus during times of severe economic
pressure. We will highlight an approach to help overcome human obstacles (e.g., ego silos) along with some of the management systems available to chart the unknown problems ahead, help enhance profitability, ensure compliance, and prevent disasters. A culture built around emphasizing risk management will provide focus on what to do and when to take the action; ensuring we focus on doing the next right thing; whatever it is.

Alan Mahoney presented The Role of Process History in Reducing False Alarms. Process history is essential when reviewing operator alarm limits in the context of alarm stewardship and formal rationalization. Far too often limits are implemented on a ‘try-it-and-see’ approach that leads to higher operator load weakening the operators’ trust in the alarm system, potentially leading to delays in acting, and adding extra work later in re-reviewing the limits. Reasons for not making full use of the process history currently in review may include the complexity of the data and perceived overhead of including it in the review. In this paper we demonstrate techniques of data analysis based on the parallel coordinate plot that streamline and improve this, enabling the inclusion and reference to process operating envelopes in all alarm reviews.

Randy Freeman presented General Method for Uncertainty Evaluation of Safety Integrity Level (SIL) Calculations. The IEC 61511 standard requires a verification calculation that a proposed design for a safety instrumented function (SIF) achieves the desired safety integrity level (SIL). The evaluation of the safety integrity level of a new or existing safety instrumented system requires detailed calculations based on the failure rates of the devices are often taken from standard failure rate tabulations of equipment. The maintenance and testing plans are developed based on plant experience. All of the data used in the SIL calculations are uncertain. This paper develops a general method for uncertainty analysis of the SIL calculations. The general method is based on the application of probability theory - variance contribution analysis (VCA) – to the equations presented in ISA TR 84.00.02-2115. An example is worked to demonstrate the methodology.

Manuel Hernandez presented Pros and Cons of Electronic Marshalling for a Safety System. Electronic Marshalling represents a new technology for connecting hard wired inputs and outputs to a control system. In lieu of using a twisted pair of shielded wires. There are specific and obvious advantages to using electronic marshalling in a safety system, but are there specific disadvantages? This would include the risk incurred in moving from a system that brings specific field inputs to the safety system processor, and instead multiplexes a number of inputs/outputs in a set of fiber optic strands. Electronic marshalling also depends on redundant power being supplied from a local equipment room. The loss of power from the redundant source would mean that a whole junction box worth of safety system inputs/outputs would be lost. This paper will review the advantages and potential disadvantages to the use of electronic marshalling in safety system applications.

Elaine Kleiner presented Probabilistic Approach to Deriving Oil Spill Size. Oil spill is one of the most significant consequences of a drilling process failure such as Loss of Well Control. Catastrophic oil spills are very rare events, but the damages inflicted by them may last for generations. In this presentation we describe a probabilistic approach towards estimating the size of a potential catastrophic oil...
spill resulting from loss of well control (LOWC) on the OCS. In building the probabilistic model, we have taken into consideration the conclusion that the factors determining a catastrophic oil spill differ from the factors for smaller spills. There is no deterministic method that can be used to predict what the potential is for having an oil spill from an offshore drilling operation. More frequently, the cases of loss of well control end up with gas release rather than oil. In order for a significant oil spill to happen, evidently the loss of well control must happen very close to, or at an oil reservoir. The superposition of precursory failures has to take place in order to have a blowout resulting in large oil spill.

Kemal Arsava presented A Novel Oil-Water Emulsion Burner Concept for Offshore Oil Spill Clean Up. In-situ burning has been considered as a primary spill response option for oil spills since offshore drilling began in the Beaufort Sea (1970s). Since then, many studies and tests have been performed but researchers are still looking for a more efficient, simple and low cost way to burn the oil faster and as completely as possible. In this study, a new burner concept capable of enhanced combustion of oil-water emulsions and requiring no atomizing nozzles, moving parts and compressed gas for operation is discussed. The operating principle is based on use of immersed noncombustible objects of suitable geometry to transfer the heat generated by the combustion back to the fuel to create a feedback loop thereby sustain an increased burning rate. A 0.5 meter diameter prototype burner showing the viability of the design concept is discussed. Tests show that the submersed lower part of the conductive object can get hot enough to sustain nucleate boiling, significantly increasing the burning rate, when compared to the baseline pool fire, where vaporization is achieved solely by evaporation at the pool surface.

Keija Wu presented The Impact of Subsea Gas Releases and Resulting Gas Plumes Using Computational Fluid Dynamics. A Computational Fluid Dynamics (CFD) model was developed to describe the behavior of a subsea gas release and the subsequent rising gas plume. Four numerical approaches were assessed for their suitability to capture the characteristic behaviors in a rising gas plume by comparing the CFD results with experimental data obtained from an underwater gas release experiment carried out in a 10 m depth towing tank basin. The k-ε turbulence model was found to be unsatisfactory in capturing random wandering behavior of the subsea gas plume due to the inherent Reynolds-Averaged Navier-Stokes (RANS) nature of the approach. The result is an over-prediction of the plume central line velocity and an under-prediction of the plume width as there was no mechanism to distribute and dissipate the high momentum gained during the initial gas release phase. The results obtained using the Large Eddy Simulation (LES) approach show the inherently random wandering behavior of the plume is successfully captured and both the centerline velocity and the velocity profile are in much better agreement with the experimental data.

Kumud Chaurasia presented Case Study of Relief Analysis of Compressor Stations. A compressor station is a facility which helps the transportation process of natural gas from one location to another. Compressor stations include several key component parts, the primary being the actual compressor unit, either centrifugal or reciprocating. They also typically include scrubbers, strainers or filter separators which remove liquids, dirt, particles, and other impurities from the natural gas. This study will give an overview of the relief analysis conducted for multiple compressor stations. The relief analysis was system based as opposed to relief device based so as to identify any unprotected systems that may need overpressure protection. It will discuss the overpressure scenarios identified for these systems. It will provide some
general statistics on the total number of applicable overpressure scenarios. It will give a detailed breakdown of the various concerns found including, but not limited to, undersized devices, unprotected systems, installation concerns, data needs, and documentation discrepancies. The study will discuss possible mitigation solutions for these concerns.

**Syeda Sultana Razia** presented *Challenges in Fire Risk Assessment and Mitigation of Readymade Garments (RMG) Industry: Bangladesh Perspective.*

**Steve Arendt** presented *Lessons from Recent U.S Onshore and Offshore Accident Investigation.* The U.S. oil and gas industry continues to experience major incidents, in spite of many regulatory, industry and company investigations, responses and improvement initiatives. These incidents have involved all segments of the oil and gas value chain – upstream, midstream and downstream – with root causes reaching throughout the project/asset life cycle. This paper will summarize information from a handful of major incidents that have occurred in the U.S. – both onshore and offshore – that have significant learning value. Causal factors, root causes and other common characteristics have been analyzed along with lessons learned. Similarities between these incidents will be highlighted. Organizational factors such as safety culture weaknesses as evident contributors will be discussed. Approaches for eliminating technical, management system, and cultural causal factors will be described so companies can better equip themselves to prevent recurrence of these costly and tragic events in the future for Mexican operations.

**William Nelson** presented *A Framework for Identification of Lessons Learned from Offshore Operational Data Using Barriers and Success Paths.* One of the most pressing challenges facing the offshore industry today is the effective interpretation, decision making, and action identification using the large volumes of operational data that are being collected and stored. Offshore operators, drilling contractors, and third party suppliers have developed real time operations centers designed to support offshore operations. The Bureau of Safety and Environmental Enforcement (BSEE) has proposed requirements for the collection of offshore real time monitoring data, but how such data will be used to support regulatory decision making is not yet clear. Operating companies and original equipment manufacturers are designing and implementing new equipment with a very high degree of instrumentation and advanced diagnostics capabilities, leading to new sources of operational data that could be analyzed to further enhance reliability, reduce downtime, and increase safety.

**Henrique Paula** presented *Data Analytics and Data Management (DA&DM) Solutions to Manage Pipeline Integrity and Comply with new PHMSA Regulations.* The potential of Data Analytics (DA) has become apparent because of the 'Big Data' phenomenon. Business analytics is becoming commonplace where companies use historical business performance data and predictive modeling to gain new insight to drive their business planning. DA for the more technical applications (e.g., engineering, operations, and maintenance) in oil & gas sectors are less mature and are, often by necessity, more customized. However, forward-leaning companies are recognizing that applying incisive analytics has the potential to deliver significant performance improvements. Data Management (DM) is a key enabler of not only DA, but also of critical decisions made every day in a wide array of work processes. This paper addresses the regulatory and industrial context of DA&DM, the evolution of DA&DM solutions, the solutions frameworks for DA&DM, with focus on...
midstream. It also presents suggestions on how midstream companies can get started in achieving efficiency and effectiveness in DA&DM.

Arafat Aloqaily presented Development of new Pipeline Integrity and Failure Assessment Tool. Not all pipelines are created equal. Pipelines have different characteristics, and would therefore show different levels of integrity and fail differently. The failure mode and cause of a given pipeline depends on several factors including the design, operating and environmental parameters. A new tool was developed to evaluate pipeline integrity and assess its potential failure mode, patterns, and rate based on the critical pipeline parameters. These parameters include the pipeline material of construction, wall thickness, operating pressure, service material, backfill medium/material, age, coating, pipeline size and other relevant parameters.

Jeffrey Marx presented Report on the PHMSA LNG Regulation Workshop. In May 2016, the Department of Transportation’s (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA) held a two day public workshop to solicit input and obtain background information for the formulation of a future regulatory change to 49 CFR part 193, Liquefied Natural Gas Facilities: Federal Safety Standards. Representatives from the public, industry, and governmental agencies were offered an opportunity to participate in a future rule making by providing their desired changes to Part 193. Part 193 was promulgated in 1980 and the last major revision was in 2000 when requirements were removed from Part 193 and replaced by incorporating additional requirements from National Fire Protection Association (NFPA) 59A, Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG). This paper serves to report the major outcomes of the workshop and outline some of the challenges that are present in updating the regulation. This paper in no way represents a definitive path forward for Part 193 and is not an advance notice of proposed rulemaking. The discussion contained in this paper is intended for information purposes only.

Alfred Ward presented Using Data to Building a Picture of Safety. Process Safety Management (PSM) involves a number of key elements from a technical prospective ‘Plant’, operational management ‘Processes’ and the human element ‘People’. All major incidents can be traced back to the failure in the management of these elements and can be attributed to these elements being managed in silos. PSM plays an integral role in delivering efficient, reliable, cost effective and safer facilities. While PSM has been recognised by many in the Oil &Gas sector, PSM has evolved significantly over the past three decades. Citing key incidents such as Piper Alpha, Longford, Texas City and Macondo have lead regulators such as BSEE 250, EU Offshore Safety Directive 2013/30/ue, UK HSE Safety Case Regulations 2015 and COMAH 2015 to work with operators, industry bodies such as API, UKOOA, IOGP etc. and technology providers to find solutions that demonstrate an asset’s integrity and safe operating status. These various stakeholders are driving the need for standardisation in PSM yet are met with the challenge of data proliferation and growing complexity of relating data elements’ impact on overall safety status. Emerging as a standard method of conveying asset integrity health is the use of barrier models as a solid approach to improving PSM, resulting in more favourable safety outcomes. The following article is a case study that addresses the next generation of PSM leveraging, complex data, visualisation and the barrier model.

Horng-Jang Liaw presented Lesson in Process Safety Management Learned in an Explosion Accident in Taiwan. A substantial explosion attributed to thermal decomposition of
o, o-dimethyl phosphoramidothioate (DMPAT) resulted in 1 fatalities and 1 injury in Taichung, Taiwan, in 2016. An analysis of this explosion indicated that such an accident could have been prevented, or the consequences might not have been as severe if certain elements of process safety management (PSM) had been applied. Proper execution of process safety management, including process safety information, operating procedures, pre-startup safety review, and process hazard analysis, can prevent the occurrence of such explosion incidents. The impact of this explosion could have been reduced had these process safety management elements, particularly management of change, been executed.

Rosalynn MacGregor presented 
*Results Matter: Three Case Studies Comparing and Contrasting PFFM and HazOp PHA Reviews*Complete, thorough, and correct process safety management depends to a large extent on complete, thorough, and correct process hazard identification, both before and during the process hazards analysis (PHA) review. Findings from the examination of incidents and disasters in industry indicate that PHA reviews fail to identify a significant number of process hazards. This is unacceptable: we cannot manage a hazard if we don’t know that it exists, and incidents will continue to occur if PHA reviews continue to overlook process hazards. HAZOP is widely recognized as the standard for conducting thorough PHA reviews, but it is not the only technique available. In this paper, outcomes of three actual HAZOP reviews in the oil & gas industry are compared and contrasted with the results for the same facilities using Process Flow Failure Modes (PFFM). PFFM is a unique method, best described as a highly efficient, highly effective cross between FMEA and HAZOP, enhanced by a customized visual tool. Differences in the success rate of the two methodologies to identify process hazards are quantified and discussed with the aim of improving the industry success rate in identifying process hazards during PHA reviews in a cost-effective, straightforward manner.

Mingguang Zhang presented 
*System Dynamical Simulation of Risk Perception for Enterprise Decision-Maker in Communication of Chemical Incident Risks.* Risk communication is an effective way to understand, assess and manage risk of chemical industrial parks, a process which requires the involvement of stakeholders. However, different risk perceptions may cause sorts of barriers formed in risk communication, sometimes resulting in mass confrontation incidents. Enterprise decision-makers play a key role in this process and further risk management. In this paper, a system dynamical model is established to interpret the feedback of this subjective process and analyze the mechanism of the barrier formation. To study the changes of risk perception of enterprise decision-maker in the face of incidents in chemical industry park, the sequence of “risk perception – risk perspective – risk response – risk communication – risk perception” was used to form causality feedback loops based on the theory and methods of system dynamics. Comparing and analyzing the simulation results, qualitative relationships among state variables of risk perception, risk perspective, risk communication and risk response are obtained. The results show that the diversification of psychological activities can be reflected by the simulated data and images roughly, which has practical significance to strengthen joint safety management.

John Craik presented 
*Utilizing Scenario-based Risk Assessment Methodology to Support Operations Teams during Abnormal Events.* In today's world, organizations are constantly being challenged by the fast changing economic environment in which the need to remain competitive is the key to ultimate survival. In the downstream oil sector, these challenges are real, on-going and refineries are constantly adapting and evolving to ensure that they continue to operate responsibly, effectively,
efficiently and minimize loss to avoid those economic realities such as closure. To remain in business, the downstream oil sector is looking toward and relying more on the use of improved technology and the support of the individual organization’s internal management systems.

Julia Nielsen presented A Modern Control Room-Human Factors and their Impact on Plant Safety and Optimization. Modern history is full of breakthroughs in technology, all striving to increase productivity and efficiency. What are the elements that should be taken into consideration in the design and implementation of modern automation systems in a control room? Both industry and international standards are now demanding that Human Factors be considered as part of the design of control rooms, to maximize efficiency and minimize the potential of human error, which can lead to downtime, and a loss of profit as a result of interruptions in production. We will examine how these new standards are helping to address these challenges that are facing the Process industry today – combined with an increased focus on operator health, and how an intelligent and ergonomic workspace can both mitigate risk and optimize production. Optimization is money. We will discuss examples of how to apply technology and innovative control room planning to maximize production and minimize risks that can impact overall production and profit.

David Wilbur presented A principal mindset among organizational leaders and managers is the belief that the end goal of attaining human reliability is to achieve flawless performance of job tasking. Despite persistent efforts to enforce compliance, nearly 90% of incidents are still being attributed to human influences at their source. A contemporary perspective sees error as product of the operational system. Human error is accepted as ubiquitous and cannot be categorically eliminated through engineering, automation or process controls. Error is embraced as a system product rather than an obstacle; sources of error are minimized and programs focus on recognition of error in order to disturb its pathway to becoming failure. Achieving safe, reliable and resilient operations begins with a mindset shift in the way leaders view their operation, particularly the human agent within a dynamic, multi-dimensional concurrence where choices are made and actions are taken that lead to outcomes both desired and undesired.

Vijay Raghunathan presented Risk Benchmarking for Onshore and Offshore LNG Developments. With the continuing growth in the global LNG trade and an increased activity of liquefaction projects proposed within North America, safety risk management is gaining more focus both from regulators and public. Multiple stakeholders, new technologies, tighter deadlines, cost efficiency and an increased focus on safety are some of the key factors driving these projects. As the industry is moving towards adopting principles of inherent safety, earlier in the projects, complex design decisions are being made with relatively less design data or input. This poses an endless challenge to both the project management making investment decisions and the design team making design decisions. Hence, the aim of this paper is to draw examples from previous LNG projects worldwide and provide best practice guidance on risk assessment processes.

Jesse Brumbaugh presented Improving Prevention and Mitigation Efforts Related to Accidental Releases of LNG. Liquefied Natural Gas (LNG) is a rapidly growing industry, both in terms of the increase in export terminals, as well as the growing number of regasification plants required to put natural gas back into pipelines. In the selection of a location or design of new facilities, the potential impact of an accidental release must be evaluated. Some
of the protective and mitigative measures required by onshore storage and handling facilities for reducing impacts due to accidental releases are dictated by 49 CFR 193, with design requirements based on accidental leakage calculations following NFPA 59A. In the United States, these measures are reviewed by the US Pipeline and Hazardous Materials Safety Administration (PHMSA). Siting and construction of onshore and nearshore LNG facilities are authorized by the Federal Energy Regulatory Commission (FERC). While various specific regulations and codes require some measures, a detailed evaluation of the potential consequences may indicate that additional mitigative actions are needed.

Sunny Choi presented High Pressure Relief Systems in LNG Receiving Terminals— A Safety Case for HP Flare. Worldwide demand for liquefied natural gas (LNG) has been steadily increasing, leading to the design and construction of larger receiving terminals in recent years. While the safety record of the LNG industry has been good, it may be beneficial to review some of the standard design safety features, with regard to their adequacy given the increased scale of the new facilities. In particular, unlike other industries where hydrocarbon vents are connected to flare system, it is common practice to route pressure safety valve (PSV) discharges on vaporizers to the atmosphere directly. The relief loads from one single vaporizer PSV has increased from 50t/hr in the past to the latest 300t/hr. As a result, it has become challenging to dispose of such a large quantity of flammable gas through atmospheric vents in a safe manner. Furthermore, during events such as blockage of the send-out pipeline, simultaneous relief of PSVs from multiple vaporizers may increase the total combined discharge rate to more than 1,000t/hr. High thermal radiation arising from the ignition of such a release may lead to damage of nearby equipment, piping and structures as well as personnel injury or fatality. To account for such effects, some designers have transformed the PSV discharge from simple tailpipes to multiple vent stacks with elevations of more than 20m.

Wasana Kowhakul presented Thermal Decomposition Mechanisms of 1H-1,2,4-Triazole Derivatives: Theoretical Study. In the present work, T_DSC of 1Htri, 1Htri-CH_3 and 1Htri-NH_2 were determined by using SC-DSC and Molecular orbital calculations (MO) was used to clarify thermal decomposition mechanism and stability criteria of pathway of 1Htri, 1Htri-CH_3 and 1Htri-NH_2 were determined from the lower ΔEa of thermal decomposition pathway model as proton transfer combine with cleavage bond. The determined T_DSC were 297 ºC of 1Htri, 114 ºC of 1Htri-CH_3 and 289 ºC of 1Htri-NH_2. There results corresponded with the measured T_DSC as were 338 ºC of 1Htri, 172 ºC of 1Htri-CH_3 and 293 ºC of 1Htri-NH_2, respectively. The results reveal that our approach thermal decomposition pathway model as combination of proton transfer and cleavage bonds of 1Htri, 1Htri-CH_3 and 1Htri-NH_2 cab be possible to expand and control the application of these compounds.

Maria Papadaki presented Isoperibolic Study of Hydroxylamine in Aqueous Solutions in the Presence of Selected Inorganic Salts. The thermal decomposition of
hydroxylamine aqueous solutions in two different concentrations and two temperatures was studied in the presence of KCl, NaCl and Na₂SO₄ using isoperibolic calorimetry. It was found that Na₂SO₄ was substantially reducing its decomposition rate, while the other two compounds had a rather insignificant influence on hydroxylamine decomposition rate. The results are compared with the effect that the same salts have on ammonium nitrate decomposition rate and similarities and differences are discussed.

Emmanuel Addai presented Ignition Sensitivity of Hybrid Mixtures. This paper reports on experimental and theoretical investigations into the ignition sensitivity of four gas-dust hybrid mixtures consisting of either methane or propane combined with either starch or polyethylene. The experimental work was done using a Hartmann tube to determine minimum ignition energy (MIE) and a Godbert-Greenwald furnace to determine minimum ignition temperature (MIT). The test procedures were based on European standards EN 13821 and EN 50281 for dust-air mixtures for MIE and MIT, respectively, with minor modifications to accommodate testing of hybrid mixtures. The experimental results show a significant decrease in the MIE and MIT of hybrid mixtures compared to corresponding values for single-components. The increase in ignition sensitivity was apparent even with gas concentrations below the lower flammability limit, or with dust concentrations below the minimum exploisable concentration. For example, the MIE of polyethylene dust decreased from 40 mJ to 5 mJ when only 1 vol% of propane was added. Mathematical models were also used to predict the MIE and MIT of hybrid mixtures. The predicted values were compared to experimental results, which showed very good agreement. The models allow more accurate estimates for MIE and MIT of a hybrid mixture than using corresponding data for either the dust or gas component.

Lubna Ahmed presented Flame-Retardant Polymer Nanocomposites Synthesis and Characterization. Polymers are widely used in our day-to-day lives and we often are unaware of the fire hazard imposed by these materials made up of hydrocarbon. This article introduces the application of fire retardant additives, namely, nano-fillers for enhanced flame retardancy and a potential remedy for flame spread. In fact, polymer nanocomposites have the potential to lead the way for satisfying material performance with enhanced flame retardancy in terms of char production. This article describes the in-situ polymerization method for synthesizing polymer nanocomposites, namely polystyrene-silica nanocomposites and application of subsequent characterization techniques for thermal and kinetic studies. Thermogravimetric analysis equipment has been used for the purpose of thermal studies. The effect of addition of silica nanoparticles on thermal stability of the polymer and potential flame-retardant mechanism has been discussed.

Yan-Ru Lin presented Analysis of Enhanced Flame Speed in the Transition Droplet Sizes for n-Alkane Aerosols Generated by Electrospray. Fire and explosion incidents related to aerosol occur occasionally throughout the industries. However, its hazards are relatively overlooked due to the misconception of that liquids are safe below their flash point. Scarcity of data stems from the difficulty of aerosol generation by a well-controlled manner. In this research, n-alkane aerosols were produced from an improved electrospray device, and their flame speeds were measured to verify the transition range. When droplet sizes fell into this range, the flame speed would be enhanced and pose greater threats to people and surroundings. Theoretical simulation and empirical equation were performed to predict the trend of flame propagation. Application of
convective droplet evaporation improved the theoretical simulation but still failed to recognize the transition range. On the other hand, the empirical equation provided a good fitting and explained possible reason for the trend. It should be noted that the transition droplet size range is not a fixed range for aerosols. Therefore, process design and operation should consider the potential generation of aerosol size and location of transition range to reduce the hazards. By understanding the flammability of aerosol, the associated risk can be managed to an acceptable level.

Monir Ahammad presented *A Medium-Scale Cryogenic Spill Study to Estimate Vapor Formation on Concrete Substrate*. This paper presents the findings of medium-scale (5 - 15 kg) cryogenic liquid experiments on a concrete substrate which may represent an industrial grade diking material. The temperature varying thermal characteristics, i.e. the conductivity ($k$) and heat capacity ($C_p$) of the concrete substrate were measured in the range of -160°C to 50°C using guarded hot plate and DSC, respectively. Vaporization rate of liquid nitrogen (LN$_2$), liquid oxygen (LO$_2$) and a mixture of 80% LN$_2$ and 20% LO$_2$, (i.e., liquid air) were studied on the same concrete substrate. It was found that conductive heat transfer from the concrete substrate has the greatest contribution in the vaporization of cryogenic liquids. The evidence of phase change from film boiling to nucleate boiling was observed during the pool vaporization of LO$_2$. The effect of preferential boiling on the temperature and heat flux profiles inside the concrete substrate was also observed. The change of heat fluxes due to the preferential boiling after each refill of mixture liquids were found to vary from 3% to 15%. Finally, the recorded heat flux during the early and later stages of pool vaporization were 12.4 kW/m$^2$ and 3.7 kW/m$^2$ for LN$_2$ and 12.9 kW/m$^2$ and 2.96 kW/m$^2$ for LO$_2$.

Wen Zhu presented *Thermokinetic Investigation of o-Nitrotoluene Using Reaction Calorimetry*. O-nitrotoluene (2-NT) is an important chemical widely used in the chemical industry. However, in the past 25 years, severe incidents have killed 10 people and injured more than 200 due to its thermal decomposition. This research focuses on the thermal behavior of 2-NT decomposition. Advanced Reactive Systems Screening Tool (ARSST) and the Automatic Pressure Tracking Adiabatic Calorimeter (APTAC) have been used to better understand the mechanisms that result in the explosion hazard of 2-NT. Key parameters such as observed onset temperature, onset pressure, self-heat rate, and pressure rate have been reported. Furthermore, the APTAC data is used in the calculation of Arrhenius data, reaction order, and self accelerating decomposition temperature (SADT). The results show that the 2-NT decomposition reaction has potentially severe consequences and is sensitive to the conditions like sample size and initial pressure. Also, there are two peaks in self-heat rate profile in the ARSST tests which indicate a minimum of two different reactions that may be occurring during the decomposition. This study also focuses on the kinetics of the decomposition reaction which is nearly zero-order reaction and SADT prediction of the 2-NT of UN 25 kg package storage.

Matthias Braedel presented *Benefits of Simple Consequence Modeling for Burner Management Systems*. The current approach used to analyze fired heaters during a Process Hazard Analysis (PHA) is inefficient and outdated. Fired heaters can be one of the more complex systems evaluated in a PHA; however, they certainly are not anything new. In fact, they are one of the most common pieces of process equipment throughout industry, and have been for quite some time. Why then is such a large amount of PHA team time still needed to analyze them? Why, when using the same Process Safety Information (PSI), methodology, and risk criteria, can the results still be inconsistent? The obvious answer is the PHA team; different teams
yield different results. Since the results of a PHA can impact several facets of a facility and its operation, including driving the Safety Integrity Level (SIL) for the heater’s Burner Management System (BMS), inconsistencies between analyses can have significant safety and financial impacts. If the consequence estimation is over conservative the selected SIL may be too high, which will result in an over designed and a very costly Safety Instrumented System (SIS). Conversely, if the consequence estimation is too low, the facility’s risks may not be adequately reduced by the selected SIS. Therefore a means to efficiently and consistently determine the consequence is critical. This paper will describe how simple consequence modeling can solve this problem, its inherent benefits, and the cost savings it provides.

Max Kolbe presented *Are We Missing any Detonations?*. The common rift between academia and industry has existed in all fields of engineering. However, ultimately the rift can be seen as more of a lag; it is not so much a question of “academia is not the real world” but rather “academia is research which ends up finding its way into the practical world of industry years if not decades later”. On the topic of detonations or vapor cloud explosions (VCE), this is indeed a true statement. A little more than a decade ago the common belief in the chemical process industry was that detonations were not really possible unless you had some very reactive process materials such as hydrogen or acetylene. When some industry and consulting experts began to challenge this view they soon found out that a more common and less reactive process material such as ethylene could in fact be made to detonate as well. The key was that the environment had to be just right in order for an ignited flame to accelerate and transition to a detonation. In fact, academia had known this since the early 1960s and so the question remains, what else can we learn? Industry has retuned itself and made use of a several common explosion modeling tools which for some can be made to predict detonations. In others, they must be inferred and only very knowledgeable users can determine detonations. This paper will review the basics of detonations, the academic perspective and the industrial applications. Additionally several of the various and commonly used models for explosion prediction will be reviewed.
2017 INTERNATIONAL SYMPOSIUM
Beyond Regulatory Compliance, Making Safety Second Nature
In Association with IChemE
October 24-26, 2017
Hilton Conference Center • College Station, Texas

CALL FOR PAPERS
Abstracts due March 10, 2017

Topics:

• Offshore Energy and Safety - Deep Water and Arctic
• Hazard Assessment
• Case Studies – Histories, Lessons Learned, Databases
• Safety Instrumented Systems
• Inherently Safer Processes – New Processes, Existing Plants, Man – Machine Interface
• Human Factors – Engineering, Behavioral Safety, Human Error
• Process Management for Safety – PS Engineering, PSM components, PSM with limited resources, innovative strategies for improvement
• Fire Protection Engineering
• Safety Culture – Relationship to High Consequence/Low Probability Events
• Facility Siting – Personnel Siting
• Consequence Analysis
• LNG – Design, Experiment Evaluation, Consequence Analysis, Mitigation, Research Needs, Regulations
• Control Systems – Unusual Situation Mgmt., Safety Instrumented Systems, Integrity Levels, Reliability analysis, Reliance on SIS, Alarm Mgmt.
• Resilience/Sustainability
• Risk Assessment, Analysis and Management
• Reactive Chemistry – Predicting Reactivity, Role of Contaminants, Catalysts and Inhibitors, Case Histories, Experimental Methods
• Equipment Integrity – Design for Maintenance, Maintenance Hazard Analysis, Monitoring


psc.tamu.edu/symposia/2017-sym
The Instrumentation and Automation Symposium for the Process Industries, now in its 72nd year, continues to educate professionals and students in the Instrumentation industry. At the Symposium, practical technical papers as well as vendor exhibits are presented with a focus on education. Over the years, the Symposium has grown in both stature and attendance with over 460 attendees at the 2016 Symposium.

SPECIAL SAVINGS OPPORTUNITY

Don’t miss out on this opportunity to save 20% on your full attendee registration! If you are a past participant of the annual Instrumentation Symposium and you bring a first-time attendee, both you and your guest’s registration will be discounted by 20%!

Symposium Attractions

- Earn 17 Professional Development Hours
- An Ethics course for Professional Engineer License
- 5th Annual Instrument Reliability Network
- Back to Basics Workshop
- Quality Assurance and HIPPS Topics
- Emerging Technology and Cyber Security Topics

For more information and to register online, visit: http://instrumensymp.wpengine.com/2017-symp/2017-registration
Classes start January 17

Online Registration

http://psc.tamu.edu/education/schedule-of-classes-registration

SENG 455/655: Process Safety Engineering

*Required for PSPC/42 PDHs*

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

SENG 460/660: Quantitative Risk Analysis in Safety Engineering

*Required for PSPC/42 PDHs*

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

SENG 312/674: System Safety Engineering

*42 PDHs*

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

SENG 422/677: Fire Protection Engineering

*42 PDHs*

Fire Protection design concepts and considerations for chemical, petrochemical, and hydrocarbon processing facilities. Special attention given to fire hazard analysis, fire risk assessment, fire protection features, and emergency response. Specific Fire Protection design considerations are studied for the various types of facilities and processes.

**Process Safety Practice Certificate**

The Process Safety Practice Certificate (PSPC) created for industry engineers who want a more in-depth study of process safety in chemical engineering. This certification requires completion of 125 Professional Development Hours (PDHs) within a three year timeframe. The program has two required courses totaling 84 PDHs. The remaining hours may be obtained through courses offered at training facilities in Houston, other distance learning course offerings, and through the Center’s Annual International Symposium in College Station, Texas.

The application and list of classes are available on our website. Upon completion of the program requirements, participants will be issued a certificate of completion.

**For questions, contact**

Azucena White
Phone: 979-458-1863 or E-mail: azucwhite@tamu.edu
2017 INTERNATIONAL SYMPOSIUM

Become a Sponsor!

Elite

★ SYMPOSIUM PARTNER - $100,000
★ Sponsor’s logo on large screen in every session
★ Four complimentary banquet tickets at reserved table
★ Sponsor receives all benefits afforded to Platinum Sponsor

Distinguished

★ PLATINUM Sponsor - $50,000
★ A booth in the exhibit area will be provided to the sponsoring organization
★ Sponsor receives all benefits afforded to Gold Sponsor plus one additional Symposium registration

★ GOLD Sponsor - $35,000
★ Recognized as an official sponsor at the Symposium with visible signage
★ Company logo on the Symposium website and program
★ Two complimentary banquet tickets
★ Full-page premium ad in the official Symposium Proceedings
★ One Symposium registration

★ SILVER Sponsor - $25,000
★ Recognized as an official sponsor at the Symposium with visible signage
★ One complimentary banquet ticket
★ Company logo on the Symposium website and program
★ Half-page premium ad in the official Symposium Proceedings

★ Symposium Banquet Sponsor - $15,000
★ Recognized as an official sponsor at the Banquet with visible signage
★ Company name and logo on Banquet promotional material
★ Company logo on the Symposium website, program and Proceedings
★ Present Welcome Address at banquet
★ Two complimentary banquet tickets

Select

★ Lanyard Sponsor – $7,500
★ Reception Sponsor – $7,500
★ Hotel Key Sponsor – $7,500

★ Proceedings Sponsor – $7,500
★ Bag Sponsor – $7,500
★ Lunch Sponsor – $7,500

★ Recognized as an official sponsor at the Symposium with visible signage in designated areas
★ Company logo on the Symposium website, program and Proceedings
★ Lanyards Sponsor – Company name and logo on lanyards
★ Bag Sponsor – Company name and logo on official Symposium bags
★ Proceedings Sponsor – Company logo on one side of Symposium proceedings flash drives

★ Exhibit Sponsor - $5,000
★ Break Sponsor - $5,000
★ Pen Sponsor - $3,000

★ Hospitality Sponsor - $3,500
★ Keynote Sponsor - $3,500
★ Window Cling Sponsor - $3,500

★ Recognized as an official sponsor at the Symposium with visible signage in designated areas
★ Company logo on the Symposium website, program and Proceedings

Valerie Green, Associate Director
Mary Kay O’Connor Process Safety Center  •  Phone: 979-845-6884  •  Email: val-green@tamu.edu
Hazards 27

Europe's leading process safety conference

Risk will never be eliminated, but it can be better managed and reduced.

Our Hazards conference series brings the process safety community together to share best practice, latest developments and lessons learned.

First staged in 1960, Hazards is now widely recognised as Europe's leading process safety event. The Hazards brand is growing internationally too, with sister conferences now held regularly in Australasia and Asia.

Aimed at anyone who is active in process safety and risk management, Hazards provides essential technical insight into how to improve process safety performance, and excellent networking opportunities.

Hazards is held annually in the UK and next takes place on 10–12 May 2017 at the International Convention Centre (ICC) in Birmingham.

Key features

• invited keynote speakers providing their own strategic views on the process safety challenge
• approximately 70 oral presentations from industry, academia, and regulators running in parallel sessions across two days
• poster presentations
• trade exhibition of process safety related products and services
• optional pre-conference workshops
• excellent networking with the international process safety community

Key dates

• call for abstracts closes: 3 October 2016
• registration opens: early December 2016
• full papers due: 3 January 2017
• conference programme published: early February 2017
• early-bird registration ends: 28 February 2017
• conference dates: 10–12 May 2017
Process Safety Symposium (JE-PSS) - 
A WCCE10 Joint Event

CCPS, EPSC, ISC, MNOPCS, and WPLP organize a joint Process Safety Symposium as part of WCCE10. This will be a 2-day single track joint event. Why do incidents keep happening despite efforts on regulations, best practices and management systems? What are the trends for process safety performance as a whole? What are the causes behind our failure to learn?

The scope of this joint process safety symposium is to have a dialogue on this call for action, and raise awareness and understanding on the importance of process safety amongst all stakeholders.

The focus will be to foster discussion among scientists, professors, engineers, industrial professionals by sharing process safety lessons learned, process safety leadership and management best practices, and highlight the critical need to improve process safety education and competence.

Presentations and posters will exemplify recent development in these areas to raise the bar on process safety performance globally.

Coordinators
Shakeel H Kadri, Center of Chemical Process Safety, (USA)
Piet Knijff, European Process Safety Centre, DSM, (NL)
Trish Kerin, iChemE Safety Center, (AU)
Sam Mannan, Mary Kay O’Connor Process Safety Centre, (USA)
Bruno Fabiana, Working Party of Loss Prevention-EFCE, (IT)
Rose Nomen, IQS, (ES)

Call for Abstracts now open
Calendar of Events

Short Courses

2052 – Process Hazard Analysis Leadership Training
Date: March 7-8, 2017
Time: 8:30am – 4:30pm
Credit: 1.4 CEUs/14 PDHs
Instructor: Mr. Watson Dupont

1082 - Process Safety Management-Fundamentals
Date: April 4-5, 2017
Time: 8:30am – 4:30pm
Credit: 1.4 CEUs/14 PDHs
Instructor: Mr. John Lockwood

1041 - Management of Change
Date: April 25, 2017
Time: 8:30am – 4:30pm
Credit: 0.7 CEUs/7 PDHs
Instructor: Dr. Jack Chosnek

2073 – SIS Implementation
Date: March 21 – 23, 2017
Time: 8:30am – 4:30pm
Credit: 2.1 CEUs/21 PDHs
Instructor: Mr. Bill Hearn

2042 - Layer of Protection Analysis
Date: April 11-12, 2017
Time: 8:30am – 4:30pm
Credit: 1.4 CEUs/14 PDHs
Instructor: Mr. Bill Hearn

2082-Safety Integrity Level Verification
Date: May 2-3 2016
Time: 8:30am – 4:30pm
Credit: 1.4 CEUs/14 PDHs
Instructor: Mr. Bill Hearn

For more info: [http://psc.tamu.edu/education/continuing-education](http://psc.tamu.edu/education/continuing-education)

Symposia

January 24-26, 2017
72nd Annual Instrumentation and Automation Symposium for the Process Industries
Memorial Student Center
Texas A&M University
College Station, Texas

October 24-26, 2017
Mary Kay O’Connor Process Safety Center
20th Annual International Symposium
Beyond Regulatory Compliance, Making Safety Second Nature
In Association with IChemE
Hilton Conference Center
College Station, Texas

Contact

Mary Kay O’Connor Process Safety Center
3122 TAMU
College Station, TX 77843-3122
Phone: 979-845-3489
Fax: 979-458-1493
[http://psc.tamu.edu](http://psc.tamu.edu)

© Copyright 2016. Mary Kay O’Connor Process Safety Center. All rights reserved.
College Station, Texas, USA. November 2016