2014 International Symposium Reaches New Heights


Brian Salerno, Director of the Bureau of Safety and Environmental Enforcement, presented the Frank P. Lees Memorial Lecture entitled, “Reducing Risk Offshore: A Systematic Approach” the first day of the symposium. Eamonn Naughton, Group Head of Risk, Learning, and HSSE at BP presented the keynote address entitled “BP’s Global Process Safety Journey: What are we learning about learning?” on the second day. Dwight Johnston, Vice President of Safety, Environment, and Social Performance in Shell’s Deep Water Business Unit, delivered the day three keynote lecture, “Process Safety Management”.

In addition to the highlighted keynote addresses, nearly 100 presentations were given on various safety-related topics, including safety culture/operational discipline, risk analysis, process management for safety, and inherent safety. Summaries of the papers are featured beginning on page 10. Exhibits from 39 companies that demonstrated products, technology and software related to process safety were displayed at the symposium.

On Wednesday evening, the Center sponsored a banquet for guests at the Traditions Club. Entertainment for the evening was provided by two Aggie Student organizations, TAMU Bellydance (continued on page 4)
Director’s Corner

In the summer issue, I wrote about the 30th anniversary of the Bhopal (India) methyl isocyanate gas release tragedy. The December edition of the Loss Prevention Bulletin commemorates the tragedy as well. The December Loss Prevention Bulletin was made available to everyone on a complimentary basis as “a timely reminder of where we have been, but also how far we still have to go in implementing the learnings from this event” (Trish Kerin, Director IchemE Safety Center). In early December the International Conference on Safety (ICS 2014) at IIT-Gandhinagar held a special focus Symposium on Process Safety (SPS2014) to bring together national and international thought leaders in Process Safety to answer the question, “Have we really made progress since Bhopal?”

Obviously, there are a lot of people in academia and industry who take these issues very seriously and do not want to see such a tragedy ever occur again—tragedies that can be prevented. Publications, monologues, and books are being devoted to this topic. International, national and regional conferences and symposia are being organized to bring together thought leaders, researchers, practitioners, and regulators to discuss these issues of great importance. However, an important question we still cannot answer with any kind of quantitative certainty is if we are getting better.

Tragedies such as Bhopal are catalysts for change, but that change is not always driven because of legislation. There is no one who goes to work and thinks that it will be okay for him/her not to return home on that day because of an incident. That is why the goal of zero incidents is something that we must all work towards. However, we must recognize that this elusive goal will only be accomplished by the joint collaboration of everyone working in academia, government and industry through education, training and outreach. Facilities processing hazardous materials must also recognize that zero incidents can only be accomplished through the contribution of each and everyone in the organization. And that is why everyone in the organization must have responsibilities with regard to process safety and be held accountable for those responsibilities.

You all have heard me talk about the need for a national repository for chemical incidents. Currently, there are many federal, state and local agencies collecting data. There are also data collection systems for incidents and near-misses within companies. However, there is no national repository that can be used to trend incidents and provide a statistical analysis of incident causation and other factors. There could be many other applications of such a national repository.

One pertinent question, our readers and constituents might and should ask, “What is the Mary Kay O’Connor Process Safety Center doing with regard to these important issues? Obviously, there are the numerous research projects and other activities being conducted by the Center that benefit the industry and government. But the most important and meaningful accomplishment of the Center is increasing the number of highly skilled engineers (ingrained deeply with process safety principles) going into industry, academia and government and increasing the footprint of process safety programs. Our hope is that this new breed of engineers will make a significant impact on improving the process safety performance in the industry. However, we at the Center and Texas A&M University cannot do it alone. Other universities must join in and start their own programs. We at MKOPSC stand ready to provide support and assistance to any university who want to start their own programs. With regard to that, you have my personal com-
MKOPSC Wins Best Paper Honorable Mention Award at AIChE Spring Meeting

The paper entitled “Effects of Expansion Foam on Controlling LNG Vaporization Rate” received the Best Paper Award — Honorable Mention, Fuels and Petrochemicals Division, at the 2014 AIChE Spring Meeting in New Orleans, LA. The first author, Bin Zhang, is a PhD candidate in Chemical Engineering in the Center. The paper’s co-authors are Dr. Yi Liu, Dr. Tomasz Olewski, Dr. Luc Vechot, and Dr. Mannan.

The growing production and consumption of natural gas due to the advancement of technology has accelerated the inter-regional trade. Liquefied Natural Gas (LNG) provides flexibility, however there are associated safety concerns in the form of flammable vapor cloud and fire that can be caused by a potential spill. High expansion foam is recommended as a mitigation measure for LNG incidents by NFPA 11 and NFPA 471, and was proved to be effective for LNG spill emergency response through field tests. The purpose of this research is to mitigate LNG vapor hazards via high expansion foam’s blanketing effect to reduce vaporization rate and warming effect. The blanketing effect was studied through tests conducted in a wind tunnel, in which convection and radiation were provided manually. The reduction of vaporization rate of liquid nitrogen by high expansion foam was determined quantitatively for heat convection and radiation. The warming effect was studied with a test apparatus and a foam generator, which were both newly designed and built with specific features to the study the warming effect and parametric analysis.

The AIChE Spring Meeting is the year’s key technical conference for practicing chemical engineers. A wide range of subjects relevant to the current needs of industry is covered. Plus, the Global Congress on Process Safety covers the critical needs of process safety practitioners more broadly and deeply than any other conference. From its initial meeting in 2005, the Global Congress on Process Safety has grown into the world’s largest gathering practitioners from industry, regulatory bodies and academia. Presented by the Center for Chemical Process Safety (CCPS) and the AIChE Safety & Health Division, this annual event now draws attendees from around the globe.

Wishing everyone a happy and safe holiday season.

M. Sam Mannan
Fall 2014

Certificate of Achievement

This certificate is awarded to:
M. Sam Mannan
Fuels and Petrochemicals Division of AIChE
Best Paper Award – Honorable Mention
Spring 2014 AIChE Annual Meeting

Awarded By
Chair, Fuels & Petrochemicals Division.
Association and Percussion Studio, and also featured the professional classical Indian musicians, Shankar Bhattacharya, Indrajit Banerjee, and Gourisankar Karmakar.

A highlight of the symposium is 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 2014 Trevor Kletz Merit Award was presented to Dr. Paul Amyotte. Since 2011, Dr. Paul Amyotte has held the C.D. Howe Chair in Process Safety at Dalhousie University, and has recently been elected as President-Elect of Engineers Canada. Dr. Amyotte has published or presented approximately 240 research papers, and is the editor of the Journal of Loss Prevention in the Process Industries. He is also a Past-President of the Canadian Society for Chemical Engineering, and of Engineers Nova Scotia.

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 Jack Chosnek. Jack Chosnek has an MS in Chemical Engineering from Technion-Israel Institute of Technology, MBA from Texas A&M at Corpus Christi, and PhD in Chemical Engineering from the University of Missouri-Rolla. He is a licensed Professional Engineer in the State of Texas and a Process Safety Manager with 35 years of experience in the petrochemical industry. He is proficient in all aspects of process safety, process engineering, and maintenance of technology. He currently serves the Center as Chairman of the Technical Advisory Committee.

The Lamiya Zahin Memorial Safety Scholarship was presented to Lubna Ahmed. 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 department are encouraged to apply for the scholarship by writing a 1,000-word essay on “Safety Innovations in Research Projects.” The Honorable Mention recipient was Ravi Chawla.
Recent Publications


News & Events

Noor Al-Quddus Joins the Center
Dr. Noor Al-Quddus has joined the Center as a new Research Associate. Dr. Quddus graduated from the Department of Mechanical Engineering at Bangladesh University of Engineering and Technology (BUET) in 1999. After completing his Master’s degree from the same university, he earned his PhD degree from the Department of Mechanical Engineering at University of Alberta in 2009. His research interests include hindered pore transport, electrophoresis, complex fluids, and thermo-fluid system modeling. We look forward to working with Dr. Quddus.

Dr. Mannan Presents General Session at Huntsman EHS and Manufacturing Excellence Conference
Dr. Mannan presented “The Future of Process Safety Management from an Industry, Government, and Academic Point of View” at Huntsman’s EHS Conference in the Woodlands, TX, on September 18.

Dr. Mannan Spends Four Weeks in China
Dr. Mannan presented a Plenary Lecture, “Process Safety at the Crossroads of Systems Engineering, Complex Systems, and Engineering for Sustainable Development” at the China Process System Engineering Conference. Then, he presented at the 2nd CCPS China Conference on Process Safety and Pipeline at SINOPEC University, and ended the trip with lectures on Fundamentals of Process Safety and Loss Prevention at Nanjing University of Science and Technology. He was also presented with a visiting professor award at China University of Petroleum.
Student News

Tony Rocha obtained his PhD after successfully defending his thesis, “Well Integrity Diagnostics for Sustained Casing Pressure and Faulty Gas-Lift Valves Based on Pressure Transient Modeling”. He will start working at ExxonMobil in January.

Alberto Benavides obtained his PhD after successfully defending his thesis, “Mathematical Programming Formulations for the Optimal Placement of Imperfect Detectors with Applications to Flammable Gas Detection and Mitigation Systems.” He will start working at Shell in January.

Jiaqi Zhang was one of three finalists in the Chemical Engineering category of Science Magazine’s “Dance Your PhD” contest. Her dance is entitled “Carbon Nanofibers’ Flammability and Explosion” and can be viewed here.

Monir Ahammad and Alberto Benavides presented papers at the AIChE Annual Meeting in Atlanta, Georgia on November 16-21.

New Students

Changwon Son, Pakorn Chaiwat, Tatiana Flechas, Cassio Ahumada, Jiayong Zhu, Yashfin Mahid, Yue Sun, Dushyant Chaudhari, Pranav Bagaria, Zohra Halim, Purvali Chaudhari, and Akshay Jain joined the Center.

Visitors to the Center

September

Carl Laird from Purdue University
Steve Bross, Brady Crouch, Dan Mueller, and Dan Smallwood from Conoco Phillips
Dwight Johnston, Natalie Salter, and Tony Paul from Shell
Neil Atkinson from IChemE

October

Several visitors from SINOPEC visited on October 20 to discuss LNG research.

Adam Markowski, John Bresland, Maria Papadaki, Simon Waldram, Hans Pasman, Luc Vechot, and Roy Sanders

November

Dr. Viatcheslav Kafarov from University of Santander in Bucaramanga, Colombia
Frank Broussard and Kate Holzhauser from Chevron Phillips
Professor Han from Seoul University
Upcoming Speaking Events — Dr. Sam Mannan

February 13, 2015  
*The Evolution of Process Safety and the Need for New Competencies*  
ChemStewards  
Houston, TX

May 13, 2015  
*Hazards Trevor Kletz Lecture*  
Hazards 25  
Edinburgh, UK

March 20, 2015  
*West, Texas Fertilizer Plant Incident*  
Environmental and Occupational Health Sciences Seminar  
UT Health, Houston, TX

May 26-27, 2015  
*Hazards Australasia Conference*  
Brisbane, Australia

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**Case History—Sinking of Maintenance Platform in the Gulf of Mexico**  
*Presented by Jehova Arenas at the October 27 Steering Committee Meeting*

On April 12, 2011, a combination of system, physical, and human factors resulted in the sinking of the semi-submersible platform Jupiter I in the Gulf of Mexico. The event did not cause injuries or deaths, but it cost financial losses of around 200 million dollars.

During the execution of a regular and considered low risk activity, the personnel of the platform violated the basic provisions of the safety management system, continuing the activities even when a pontoon water intake valve and the control panel presented a failure. Those actions ended in seawater inlet through the valve, and sunk the platform in less than seven hours. Among the principal causes of the incident were a deficient maintenance program, lack of operational procedures, poor training, and a deficient safety culture.

**Case History—Ignition of Liquid Flammables by Static Charge and Subsequent Fire at Barton Solvents, Des Moines, Iowa**  
*Presented by Logan Hatanaka at the October 27 Steering Committee Meeting*

On October 29, 2007, an incident occurred at a Barton Solvents dispensing facility in Des Moines, Iowa. The incident involved the ignition of a 300 gallon portable tote containing ethyl acetate and the subsequent fires and explosion. The fire was caused primarily due to poor tank filling operations and improper grounding. Several additional recommendations were concluded, including the importance of MOC when replacing flammable service hoses and nozzles, the necessity of fire suppression in the packaging area at the facility, the importance of better hazard communication to first responders, and finally, the importance of including cascading effects when approximating the worst case scenario for a facility.

**Case History—LPG Truck Explosion in Riyadh, Saudi Arabia**  
*Presented by Mohammed Alnashwan at the October 30 Technical Advisory Committee Meeting*

Rollover of a 17-ton LPG truck resulted in the hitting of a bridge pillar, which lead to rupture in the LPG tank and release of LPG to form a vapor cloud that exploded after 5 minutes and resulted in 23 fatalities, 135 injuries and more than $50 million losses including cars, building and the bridge.
“Numerical Simulation of Cryogenic Pool Boiling” Monir Ahammad, PhD Chemical Engineering Student

Film boiling occurs during the early stage of cryogenic spills and also occurs in the front of a spreading pool. Therefore, it is important to model film boiling phenomena, in order to achieve an accurate source term estimation of spills of LNG and other cryogens. This research presents a CFD based approach where R-T instability is used to model film boiling phenomena. Result of CFD simulation is compared with the Berenson and Klimenko correlations. It is found that the time weighted average heat flux for LN2 is greater than Klimenko correlation and less than Berenson. However, for LCH4, the simulation result is well above both correlations. Experimental data will be used to validate the simulation result.

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

The flammability characteristics of combustible gases like hydrogen, methane, and propane is related to the temperature and pressure of the gas and air mixture when it is ignited. Large amounts of reaction energy will be released in a short duration of time which can cause deflagration or even detonation, also the extremely high temperature of the reaction will become a threat to the facility and people. The research objective is to study the flammability characteristics of combustible gases at elevated conditions (high temperature and high pressure) and propose the corresponding methods to handling them safely. By using both experimental data and theoretical calculations, an improved Le Chatelier’s Law will be raised and tested to better predict the flammability limits of combustible mixtures.

“Study of Ammonium Nitrate Thermal Hazards with Additives” presented by Zhe Han, PhD Chemical Engineering Student

Ammonium nitrate (AN) related incidents have occurred throughout the last century, causing property loss and fatalities. This research looks at reducing the explosion hazard associated with AN while maintaining its agricultural benefit, including investigating the mechanisms that drive the reactions, developing predictive models, and creating effective mitigation strategies. The reaction stoichiometry, thermodynamic parameters, and kinetic parameters related to AN explosion were developed. This presentation focuses on studying the decomposition of AN with additives using RSST and APTAC. Inhibitors and promoters have been identified. The future work of this research is to study AN decomposition under various conditions, such as under confinement, various gas atmospheres, heating rates, and thermal history, as well as using Gaussian software to study AN from a fundamental point of view.

“Risk Management Strategy for LNG Road Transportation” Bilkis Islam, MS Safety Engineering Student

Liquefied Natural Gas (LNG) plays an important role in the energy market. In the near future, LNG used as fuel in road transportation will be increased due to some significant advantages. Since LNG has safety hazards, the risk management process is essential to ensure minimum risk during transportation. In this project, a database has been created with all LNG road transportation accidents in order to identify the associated risks and hazards. A HAZID has been done for the identification of risks and hazards associated with LNG truck tankers and heavy duty vehicles using LNG fueling. For a complete overview of major risks and hazards a bow-tie analysis was performed. Based on the identification and assessment of incident scenarios and study of existing codes and standards, recommendations on risk management strategy will be provided in the future.
Michael Schmidt with Bluefield Process Safety presented “Making Sense of Risk Tolerance Criteria.” Risk analysts spend a great deal of effort quantifying risk, both in terms of consequence and likelihood. But until risk is compared against risk tolerance criteria (RTC), it is impossible to know whether that risk is too high or not, and if it is too high, by how much it must be reduced to become tolerable. RTC drive the allocation of finite resources for risk reduction. Rational RTC lead to rational allocation of resources while irrational RTC lead to misallocation of resources and ultimately, poorer safety. Most practitioners acknowledge the need for RTC but do not discuss how they are developed. While a few countries dictate RTC, most governments, including that of the United States, leave it to organizations to establish and justify their own RTC. This presentation reviewed a methodology based on impact equivalency to evaluate whether RTC are structurally sound, and goes on to explore a variety of risk benchmarks and shows how to infer RTC from them. The presentation proposed a methodology for addressing the historically poor equivalency between safety and environmental RTC.

Anandita Sengupta with University of Twente presented “An Evaluation of Industrial Risk Assessment Framework-Indian Perspective.” Except for a few discrete regulations, there is as such no integrated system for assessing and managing the risks arising out of hazardous industries. In particular, there is no common guideline on risk assessment methodology, risk acceptability or tolerability criteria, unavailability of accident database for frequency estimation as well as risk reduction strategy for the areas where risks are already high, etc. Though current regulations have tried to address some of the issues, there is no integration into a complete system. On top of this, there are technical and legislative gaps in the institutional framework to implement any of the above mentioned issues. The objective of this work is to evaluate the effectiveness of a comprehensive risk assessment/management framework for an emerging economy like India, in order to control and/or reduce risk levels. In this context, regulations and policies pertaining to industrial risk management were reviewed.

William Goble with Exida presented “Combining Field Failure Data with New Instrument Design Margins to Predict Failures Rates for SIS Verification.” Performance based functional safety standards like IEC 61511 offer many advantages including the opportunity to optimize and upgrade Safety Instrumented System (SIS) designs. But performance calculation depends upon realistic failure data for instruments used. A predictive analysis technique called Failure Modes Effects and Diagnostic Analysis (FMEDA) has been developed along with a component failure rate database that can predict failure rates of instruments based on their design strength and the expected stress environment. This method has been calibrated with billions of unit operating hours of field failure data over the last 15 years.

Mindy Bergman with Texas A&M University presented “How Often Should I Assess My Organization’s Safety Climate?” Safety climate is usually thought of as a human resources issue and treated as such—measured annually (if not less often) and reported back out to units some number of months after the survey is completed with general recommendations to “improve climate through communication” or “improve climate through training” or “maintain the good climate”. However, this presentation argued that safety climate should be treated like the key performance indicator that it is. The presentation reviewed evidence that safety climate is a key safety performance indicator, and provided recommendations for how to measure and use safety climate as a key performance indicator.

Gregory Robinson with BST presented “Metrics for Safety Performance: Leading and Lagging Indicators Industry vs. Organization.” Safety data provides leaders with valuable information needed to drive process safety improvement in their organization. A balanced dashboard of leading and lagging indicators specifically targeted to the unique profile of the company can reveal exposures and at-risk behaviors with the potential for catastrophe. Safety metrics also help leaders uncover opportunities to improve the company culture, impacting attitudes, behaviors, and long-standing routines that have a powerful influence on process safety outcomes. Leaders can evaluate the current state of their process safety culture by examining several questions that will inform the direction the organization needs to go to gain fluency in catastrophic event prevention. Strong performers are especially adept at the four organizational components of...
Detection Mapping tools. A more traditional approach can be utilised by the modern Fire and Gas Detection Engineering Solutions International presented “Application of Operational Discipline Performance Standard.”

Chandra Gulati with Shell presented “Risk-Based Equipment Spacing for Process Safety in Onshore Shale Development and Production Facilities.” The Technical Safety Engineering team in Shell Exploration & Production Company assisted Shell’s onshore unconventional projects and operations to identify risks in the development and production activities, and developed a series of guidance for equipment spacing. The spacing guidance includes a spacing table with instructions on when and how to apply the tables. The tables cover both well pad facilities and central processing facilities. The guidance divides the table’s applicability according to characteristics of the facilities and potential associated risks to onsite personnel and surrounding properties. The guidance is based on an extensive survey of existing regulatory, industrial and company standards. Development of the guidance also employed a risk-based method with consequence modeling to understand potential physical effects of flammable gas dispersion and heat radiation from jet fires or pool fires. Release scenarios were identified for equipment from which release and ignition of flammable hydrocarbon may occur. Scenarios and minimum spacing distances were selected according to the principle of Managing Risk in Shell’s HSSE & SP Control Framework. The spacing charts will be used at Shell’s unconventional shale gas and oil facilities in the United States. The spacing guidance will be integrated into Shell’s Design and Engineering Practice (DEP) standards. The development process provides an opportunity to check through onsite hydrocarbon release and fire hazards in a systematic way for various operations. The purpose is to create a standard solution and a practical tool to manage the risk of fire hazards in onshore shale assets, create more consistency in operations, and elevate the bar for safety performance in Shell.

Enrico Bononi with Monaco Engineering Solutions International presented “Fire and Gas Detection Mapping Sample Assessment Report.” As outlined in ISA technical report (TR 84.00.07) two approaches can be utilised by the modern Fire and Gas Detection Mapping tools. A more traditional geographic approach can be utilised to estimate detector coverage and determine detector numbers in a three dimensional (3D) environment. This presentation discussed the more sophisticated ‘3D risk based approach’ which can be utilised to incorporate consequence analysis and company risk criteria. Concepts from Fire and Gas Detection Mapping, QRA, Reliability and SIL (IEC 61511) are incorporated to ensure an in-depth risk-based analysis, consistent with site asset integrity and safety studies. This presentation aimed to highlight that through the implementation of a ‘risk based approach’ for the placement and coverage of detectors, the magnitude of the consequence, frequency of occurrence and the relative risk reduction effectiveness can be investigated and utilised in ensuring the risk is as low as reasonably practicable. This presentation utilised a sample study on an existing facility to demonstrate the application of a risk based approach along with its general findings.

Kelly Keim with ExxonMobil presented “Inherently Safer Technology — Making it Second Nature.” The concept of Inherent Safety is often translated to one of four words that symbolize strategies for achieving inherently safer processes: Substitution, Attenuation, Intensification and Moderation. Many add the concept of simplification to this list although others do not consider this to be “true” Inherent Safety. To this list, the concept of Elegant Design will be added as an alternate strategy toward achieving inherently safer processes. Examples of application of inherently safer operations are provided to demonstrate the concept of Elegant Design as applied to process and non-process applications. Ultimately the goal is to achieve safer process operations and the concept of inherently safer operations is one strategy for achieving that goal.

Sharon Tinker with ExxonMobil presented “Using Incident Risk Analysis to Learn from Near Misses.” Ineffective or missing layers of protection or protective barriers can result in incidents with consequences that range from insignificant to catastrophic. Incidents with minor or insignificant consequences are referred to as a near miss. Investigation findings from these near misses can be as valuable to organizational learning and incident prevention as the findings from serious accident investigations. The challenge is to determine which near misses will provide valuable lessons and justify a full investigation. She presented a process to identify which near misses to investigate by analyzing the risk associated
with each near miss.

**Dal Vernon Reising** with Human Centered Solutions presented “Understanding Process Safety Challenges Associated with Heater Operations in the Process Industry.” The Abnormal Situation Management® Consortium (ASMC) funded a study to investigate challenges associated with heater operations. At the 2009 symposium, an ASMC sponsored paper reported on an investigation on common failure modes and root causes associated with operations practices. At the 2010 symposium, a follow-on ASMC paper was presented on the failure modes associated with procedure execution failures during abnormal situations. This presentation provides an update to the previous findings with the additional analysis of incident reports specific to heater operations.

**Taylor Schuler** with aeSolutions presented “Validating Process Safety Assumptions Using Operations Data.” As facilities are assessing risk, making recommendations for gap closure, and designing safety instrumented functions (SIFs), assumptions are made to facilitate calculations in the design phase of protection layers used to reduce the likelihood of hazards occurring. Each of these assumptions are made based on design standards, process safety experience, and data supplied by the manufacturers concerning operability and reliability. The purpose of the presentation was to identify key assumptions and replace the assumptions with real-world operations data to prove that the risk may be greater than perceptions based on design. This case study focused on looking at real functional test intervals verses those applied in the safety integrity level (SIL) calculations. It also compared unsafe bypasses verses probability of failure on demand (PFD) and the count of initiating causes compared to the frequencies documented in the layer of protection analysis (LOPA).

**Manuel Hernandez** with Fluor presented “Time to Make All your Safety System Digitals Line Monitored?” This presentation reviewed the consequences of a Safety System specification change made at the end of a project and how implementation of the change was ultimately accomplished. This presentation reviewed how a safety system specification change related to “line monitoring” impacted the completion of the Instrument Control and Safety System (ICSS), discussed the process that took place in reviewing that specification change and reviewed the ultimate decision in implementing that change.

**Karen Study** with Dow Chemical Company presented “Good Till the Last Drop.” This presentation reviewed a pilot conducted at The Dow Chemical Company to compare using the valve tightness class as a basis for MALR versus a safety based calculated MALR. Economics and safety aspects were evaluated and the general types of safety based calculations used were reviewed. Key questions answered included: 1) what exactly is the requirement for estimating MALR, 2) how is MALR calculated using a safety basis, 3) are there differences in cost when basing MALR on valve tightness class versus a safety based calculation, 4) are time efficiencies realized when basing MALR on the safety case versus on the valve tightness class, and 4) which is usually more conservative, a valve tightness class based MALR or a safety based MALR?

**Zubin Kumana** with Siemens presented “Analysis of Pressure Relief System Deficiencies.” At the completion of a pressure relief system design audit, the findings of the study indicate the problem areas and deficiencies identified using the best practices in place at the time of the study. This presentation discussed the collected findings of a large number of pressure relief system design audits on various refinery/downstream process units, and show typical breakdowns of findings based on the process unit type. Additionally, the findings showed a breakdown of findings over time, showing the performance of the industry as understanding and best practices have evolved.

**Juergen Schmidt** with Karlsruhe Institute of Technology presented “Sizing of Rupture Disks for Two-Phase Gas/Liquid Flow According to HNES-Model.” Industrial rupture disk vent line areas for two-phase flow are currently overestimated. As a consequence, the dischargeable mass flow rate is partially much higher than necessary often leading to malfunctions in downstream retention systems and increased environmental loads. For two-phase gas/liquid flow there is no standardized sizing procedure available. Hence, the homogeneous non-equilibrium model HNE-DS is transferred from sizing safety valves to a procedure for sizing rupture disk vent lines. Thermodynamic non-equilibrium effects like boiling delay were considered.
Identifying fugitive emissions

ExxonMobil presented “IntelliRed System for Autonomous Detection of Hydrocarbon Releases.” Identifying fugitive emissions from large scale LNG and gas processing and handling facilities is a difficult time and resource intensive process. Because of the limitations of hand held gas detection devices, and the sheer size and complexity of these facilities, smaller leaks may go undetected for extended periods of time and unintended releases may occur when plant personnel are not present or the area monitored. Reducing the total emissions from a large plant or a regional industry footprint could very well have an appreciable positive impact on the environment. Furthermore, early detection of hydrocarbon leaks using a continuous monitoring system can reduce the risk of potentially serious safety incidents that can result from ignition of gas plumes. ExxonMobil Research Qatar Ltd. and Providence Photonics LLC have developed the IntelliRed™ Remote Gas Detection system that integrates computer vision algorithms and infrared (IR) optical technology that can autonomously scan for and identify small leaks such as those associated with fugitive emissions. Efficient identification of these emission sources will lead to better control and maintenance activities.

Jonathan Matthys with QTRCO presented “Partial Stroke Testing Devices—Why Users Correctly Distrust their PSTD’s Ability to Prohibit Spurious Over-Travel, and a Logical Solution.” One of the major buzz words among many engineers in the process industry today is Partial Stroke Testing (PST). If implemented correctly PST can greatly reduce the amount of unnecessary downtime due to maintenance and/or required testing of critical emergency shutdown valves (ESDV). However, despite the many benefits of PST, engineers are often times extremely hesitant to utilize it due to the inherent shortcomings that have been associated with the more commonly known PST methods on the market. Currently the most commonly used PST systems include solenoid valve or positioner based pressure regulating systems and mechanical jammers.

Manoj Kamaliya with Reliance Industries presented “Safe & Reliable Manufacturing—MIQA Perspective and Challenges.” A focused approach emphasizing “MIQA – Mechanical Integrity and Quality Assurance” throughout the various stages of a project and then as a part of the operations has been the only way to meet the challenges. A structured approach has been adopted to ensure mechanical integrity of the units. After commissioning of the process units, a different set of MIQA elements are being focused upon to ensure safe and reliable operations. The presentation dwelled upon the various systems, processes, tools that are being followed and engaged to ensure that the vision of safe and reliable manufacturing is achieved uninterrupted.

Hazem Abdelmoati with ExxonMobil presented “IntelliRed System for Autonomous Detection of Hydrocarbon Releases.” Identifying fugitive emissions from large scale LNG and gas processing and handling facilities is a difficult time and resource intensive process. Because of the limitations of hand held gas detection devices, and the sheer size and complexity of these facilities, smaller leaks may go undetected for extended periods of time and unintended releases may occur when plant personnel are not present or the area monitored. Reducing the total emissions from a large plant or a regional industry footprint could very well have an appreciable positive impact on the environment. Furthermore, early detection of hydrocarbon leaks using a continuous monitoring system can reduce the risk of potentially serious safety incidents that can result from ignition of gas plumes. ExxonMobil Research Qatar Ltd. and Providence Photonics LLC have developed the IntelliRed™ Remote Gas Detection system that integrates computer vision algorithms and infrared (IR) optical technology that can autonomously scan for and identify small leaks such as those associated with fugitive emissions. Efficient identification of these emission sources will lead to better control and maintenance activities.
focused on how to leverage current research in fire protection to benefit process safety and hence to reduce/prevent potential losses in the process industries. For example, many industrial processes involve flammable and combustible materials where flammability research on dusts, aerosols and liquid mixtures is essential to maximize process safety design.

James Milke with the University of Maryland presented “Fire Protection as the Underpinning of Good Process Safety Programs.” This presentation concentrated on the involvement of fire protection engineering in the mitigation phase of a process safety program. Fire protection engineers are involved in the assessment of hazards and the selection of fire protection strategies which can reduce the risk to an acceptable level. Fire protection strategies may include the installation of a variety of approaches, such as passive and active fire protection systems, manual intervention and siting. Passive systems include fire rated barriers and protection of openings in those barriers, while active systems include systems such as fire detectors and sprinklers. Manual intervention may include the manual activation of fixed fire protection systems or firefighting activities by facility fire brigades or municipal fire departments. The manual firefighting activities are typically considered to be in the ‘response’ phase. An analysis of the contribution of a particular fire protection system to the achievement of specified objectives should include an assessment of the effectiveness and reliability of the proposed fire protection systems. These objectives may be implicit, being incorporated into the basis of regulatory requirements in prescriptive codes, or may be explicit where performance-based designs are proposed. Because fire protection systems have many variations, with few standard, one-size-fits-all designs, understanding the performance objectives intended for the system is essential in order to identify the correct type of system, as well as to formulate the best design options for the selected system, as was outlined in the presentation.

David Moore with AcuTech Consulting Group presented “Practical Examples of Fire Protection Engineering Practices and Technology.” Process Safety Engineers benefit from a practical understanding and examples of fire protection. The presentation provided an overview of key fire protection principles and direct applications to the elements of process safety management – from hazards and risk analysis to engineering considerations of fixed and portable systems. An understanding of these principles and practices will enable a PSM Engineer to recognize fire protection hazards and to understand traditional and contemporary methods of fire control, suppression and mitigation.

Andrew Fowler with HFL Risk Services presented “Process Safety Management Certification and Credentialing.” The strong growth of the oil and gas industry in many places around the world, coupled with the demographics of the workforce and growing regulation, indicates a need for an effort to certify or credential many younger and new workers in Process Safety Management, or PSM. In the USA and in the UK, the current university efforts are building, but are largely immature at this point in time. Additionally, the movement of experienced technical and engineering personnel indicates that additional competence building could be helpful. The high mobility of the oil and gas workforce suggests that a method is needed to standardize, to track and to ensure a growing level of PSM competency through many employers. The talk introduced an already established, benchmarked and certified PSM curriculum and technique, approved and registered in the UK. The training process is setup so that oil and gas personnel can learn the requirements of US OSHA, UK COMAH, and other Risk Based Process Safety Topics (CCPS) of interest to both US and UK regulators. The curriculum is approved and audited to outcomes by UK training and rating agencies. Portions of the coursework are delivered asynchronously over the web, while other portions can be part of an in-house or open-sourced training effort. With business and regulatory requirements tightening, a Process Safety Management Credential, delivered in module form, makes sense to the many firms that prefer to operate “beyond compliance.”

Laura Bellman with Bayer presented “The Art of Facilitation—Team Building, Bridge Building, and Success Beyond the HAZOP Boxes.” For a successful HAZOP, the facilitator is required to present additional talent beyond technical knowledge of methodology, software and OSHA requirements. Talents required include developing the team into a high performance integrated unit, encouraging creative and feasible solutions which provide the desired risk reduction, and building agreements between the various on-site departments which have varying interests and commitments related to the process being HAZOPed. Using experiences with package refrigeration HAZOPs at
a large chemical facility, facilitation leadership concepts show how new levels of safety measures were implemented given constraints of package units, diverse teams, various business units and plant organizations. Package units can be assessed beyond the black box assumption. The facilitator considers the process of selling new safety measures which requires cooperation of various entities within the plant. Leadership involves networking with various entities within the plant and communicating new risk reduction concepts where a status quo may have traditionally existed. The facilitator provides a value added service and steps through the difficult process of developing new synergies.

**Derek Engel** with GexCon US presented “The Effect of Ignition Modeling on Prediction of Explosion Risk.” This presentation evaluated the concept of “intermittent” ignition sources. Presumably the concept of intermittent ignition sources is motivated by historical data that suggests ignition occurs after an area is exposed to flammable gas and hence this is not consistent with a continuous ignition source, which theoretically would ignite a flammable cloud upon initial exposure. However, it seems unlikely that explosion-proof equipment would “fail” in such an intermittent manner, and a more likely explanation is that the conditions leading to a successful ignition were intermittent. For example, a large release in an enclosed area can quickly “smother” a continuous ignition source by removing the necessary oxygen for ignition; however, when the leak slows or stops (ESD or emptying the inventory) the gas concentration can dilute back within the flammable range and the cloud can ignite. The idea that discrete ignition is due to intermittent ignition conditions, rather than intermittent ignition sources, is also supported by experimental data. This presentation explored alternate mechanisms that can more accurately describe the concept of “intermittent” ignition, and the potential effect of risk level and drivers.

**Calvin Parnell** with Texas A&M University presented “Evaluation of Dust Explosibility Testing Methods.” There are a number of scientists and engineers who equate explosible with combustible. Palmer, (1973) addressed this topic as follows: “All explosible dusts are combustible but not all combustible dusts are explosible.” There is a simple test for determining the mass fraction of a dust that is combustible. Not all dusts are explosible. There were several problems detected in the ASTM process of testing gin dust for explosibility. A potential explosible dust is dispersed into a totally enclosed 20L chamber. A subsequent flame used to ignite the dust cloud is propagated through the dust cloud. (The energy of the flame may be as high as 10 kJ.) If the resulting measured test pressure exceeds 1 bar (14.5 psig) the dust is classified as explosible. The only criterion for classifying a dust as explosible is the resulting pressure in an enclosed chamber. There is a possibility that sufficient pressure will result without a self-propagating flame passing through the dust cloud in the totally enclosed 20L chamber. The result is classifying a dust as explosible when it is not.

**Laura Bishop** with IBM presented “Systems-of-Systems Engineering for Safety-Critical Projects.” The recent changes and ‘black swan’ events in the chemical and petroleum have created a complex puzzle of regulatory guidelines, safety performance metrics, human factors changes, risk assessments, and new off shore exploration techniques, to name a few. These recent changes are creating complexities in maintaining regulatory compliance and strengthening safety cultures while facing the unyielding pressure of costs and time to market. Organizations are finding themselves in dilemma where detailed specifications, changes and relationships among key elements in operational assets are not clear and traceable. Constantly changing opinions, priorities, and perspectives in society can fuel frustration and animosity, impeding success in process safety projects. Critical best practices in process, requirements, engineering, and risk modeling using systems or interdisciplinary engineering practices can enable rapid transformation and improve the likelihood of success.

**Jeff Stemke** with the Marrell Group presented “The MKN Project: Knowledge Retention and Recovery in Chemical Manufacturing R&D.” This presentation introduced the Manufacturing Knowledge Network (MKN) method for improving safety by enabling expert knowledge sharing using an online, process-oriented, visual method. Real-world scenarios were presented in order to highlight how expertise impacts safety in chemical manufacturing R&D; and how safety incidents can be prevented by improving knowledge sharing and the transfer of lessons learned. Domain visualization examples showed how understanding and communication are improved by visual representations that provide contextual information and functional relationships between domain elements. For recovering and accessing external expertise, the MKN method includes how to access knowledge sources outside of the subject department or organization; so that retired or relocated experts, vendors, consultants,
and academic institutions can contribute relevant knowledge to a given domain. The business value of this approach was discussed.

Christy Blanchard with Huntsman presented “PHA’s for Non-Routine Operations.” The majority of major Process Safety accidents occur during non-routine modes of operation. Traditional Process Hazard Analysis (PHA) methodologies focus on normal operations and do not thoroughly analyze the errors that can occur during startup, shutdown and non-routine modes. If a PHA does not identify scenarios that can occur during these non-routine operations, the organization will not know the safeguards needed to protect against these scenarios. This presentation showed a practical methodology for the analyses of operating procedures that can uncover accident scenarios caused by human error and/or process conditions unique to non-routine modes of operation.

Brian Bain with DNV GL presented “Modeling of the Progression of an Offshore Hydrocarbon Release Accident.” The modelling of the chain of events is more difficult than most people, even those working within safety engineering, appreciate. This presentation described a process to analyze the risks in a more detailed way than is normally used. It took into account the consequences of the accident as they develop with time in reaction to the deployment of safety systems and the movement of personnel. This has been done in an attempt to calculate risk levels more accurately and in turn provide the industry with a more powerful tool to understand and ultimately manage the risks on an offshore platform. Much of the methodology presented was utilized in a new software tool which is able to depict the timeline of the development of the accident in a three-dimensional graphical form and with representation of mustering actions which enables insight by a range of stakeholders in a way not possible with conventional approaches.

Sam Mannan with MKOPSC presented “One Company’s Approach on Relative Ranking of Portfolio of Process Safety Risk” for Shakeel Kadri. Air Products has a dual risk management mandate. Recently, to better prioritize the risk management effort, the senior executives requested to see a relative ranking of risks in the portfolio. They evaluated three different approaches, two internally developed, and one available externally. This presentation described these approaches, and reviewed in detail the finalized internally developed approach.

Anh Bui with MMI Engineering presented “Integration of Human Reliability Analysis in Oil & Gas QRA.” In this paper, a pilot QRA study which includes human factor analysis is demonstrated. The work leverages on the experience of coupled PSA/HRA from nuclear industry and, in particular, the SPAR-H (Standardized Plant Analysis Risk-Human Reliability Analysis) model developed at the Idaho National Laboratory. This model is available as a module of the SAPHIRE (System Analysis Program for Hands-On Integrated Reliability Evaluation) software. The current risk and safety analysis conducted by MMI Engineering is based on both QRA and advanced numerical analysis/modeling. Advanced fluid and structural modeling tools, such as FLACS, KFX, OpenFOAM, ABAQUS, are used to determine the possible initiators as well as the consequences of different accident scenarios. This analysis workflow is modified to integrate the results of HRA.

Daniel Denslow with Quest Consultants presented “Comparative Risks Associated with the Transport of LPG by Pipeline, Railcar, and Tanker Truck.” Accidental releases from LPG transport vessels and pipelines can cause devastating damage and loss of life. When a release occurs in equipment that handles LPG, the highly pressurized system can flash into vapor phase, causing a rapidly expanding flammable vapor cloud containing LPG vapor, air, and liquid LPG aerosol droplets. A release from isolated LPG vessels such as railcars and tanker trucks can cause a boiling liquid expanding vapor explosion (BLEVE). Due to the potential hazards associated with transport of LPG and the fuel’s ever-increasing demand, it seems prudent to compare the risk associated with different forms of transportation of LPG. Consequence simulations are performed using CANARY by Quest® in order to model the effects of LPG releases from pipelines, tanker trucks, and railcars. The results of the consequence analysis are combined with accident, failure, and release frequency data for the specific equipment employed for each transportation method. The transportation risk associated with pipelines,
railcars, and tanker trucks was evaluated with a quantitative risk analysis. The result shows that transporting LPG by pipeline has a significantly lower public risk than transporting LPG by railcar or tanker truck.

**Edward Sharpe** with Suncor Energy presented “Case Study: Laser-based Gas Detection Technology and Dispersion Modeling Used to Eliminate False Alarms and Improve Safety Performance on Terra Nova FPSO.” Suncor Energy is the operator of the Terra Nova FPSO, which is located in the Grand Banks, off the East Coast of Canada. In 2010, a multi-disciplinary team was assembled to assess and upgrade the overall gas detection system on the FPSO. The team involved personnel from safety, risk analysis, operations, instrumentation and controls engineering. A detailed analysis of the facility, based on computational fluid dynamics (CFD) modeling, was performed. In aggregate, more than 1,400 gas leak scenarios were simulated and used in the evaluation, detector selection process, optimization and overall design of the upgrade to the gas detection system. Laser-based technology was selected to replace infrared gas detection technology after extensive testing in both onshore and offshore environments. The Terra Nova FPSO is a remote facility with limited egress. Therefore, any hazardous gas release in the facility requires complete production shutdown, blow down of available inventory and isolation of electrical equipment that is not Zone 1 rated. Prior to the upgrade, false alarms from gas detectors were resulting in prolonged outages, damage to process equipment and production deferments of approximately 50,000-100,000 barrels per year. The upgrade was able to address all of these problems. This presentation described the methodology that was applied and provided an overview of the results. Implementation of this retrofit and upgrade approach is expected to benefit numerous industrial facilities where the threat of a toxic or flammable gas leak exists.

**Stephen Shaw** with ERM presented “Black Swans are Red Herrings.” Risk and sustainability management are the two greatest challenges facing our industry. Risk management philosophies and techniques have become more sophisticated with time and the experience of various major accident events. However, there still remains much opportunity to extract better value from risk management activities and investments. This presentation discussed some of the current weaknesses and highlight specific opportunities for improvement. It was intended to provoke change in how we look at existing risk management processes.

**Michael Crosby** with Lloyd’s Register presented “Subsea Blowout Preventers Risk Model.” The BOP Risk Model has been developed to assist in this critical decision making process. Based on technology first applied in the nuclear industry, the model automates risk assessment of the BOP based on available component condition information, with results that are objective, consistent and transparent using a process that has been approved by relevant regulatory authorities. Local regulations, operating procedures, P&IDs, Logic Block Diagrams and Fault Tree Analysis are applied in calculating a risk level for modelled BOP component failure, and expressed by colour-coding for easy reference. The risk level is associated with a general recommendation for course of action. Notification of high risk situations can be sent directly to regulators.

**Jiaqi Zhang** with MKOPSC presented “A Supercritical Pressure BLEVE in Nihon Dempa Kogyo Crystal Inc.” On December 7, 2009, a 50-foot high-pressure vessel ruptured in the Nihon Dempa Kogyo Crystal (NDK), Inc. facility in Belvidere, Illinois. Several projectiles rapidly travelled outward from the facility, killing one truck driver 650 feet away and injuring an employee in another building 435 feet away. This presentation summarizes the lessons learned from this incident both on causal and consequential aspects. Stress corrosion cracking (SCC) was identified as the failure mechanism by the U.S. Chemical Safety and Hazard Investigation Board (CSB). After analyzing the operating conditions and the aftermath, this incident has been identified as a supercritical pressure Boiling Liquid Expanding Vapor Explosion (BLEVE). A consequence analysis of the incident is performed where overpressure and fragment distance are calculated, together with safety distance estimation. Additionally, other safety-related problems, such as poor safety culture, poor management inside the corporation, and poor communication between this facility and the government are also discussed.

**Michael Washington** with BASF presented “Anatomy of Human Error and Reliability in Modern Age Plants.” Human performance has been a key component of incidents and accidents in many industries. Recently, the role of human error was documented in a number of well-studied, high-profile events in the petrochemical and
nuclear power industries. The most recent data within BASF shows that greater than 2/3 of most incidents (whether attributed to Process Safety Incidents involving fires, explosions, and releases or occupational accidents) involve some form of human error or human reliability that was miscounted or flawed, respectively, at various points in the lifecycle process. This presentation detailed the approach taken for 1) Identifying important factors for analyzing Human Error during a Hazard Analysis in Modern plants, 2) Evaluating key probability of failure on demand considerations for assessing risks involving Human Error, 3) Evaluate how Human (PSFs) performance Shaping Factors and system interaction can potentially lead to accidents and 4) Provide insight on how culture and human factors Engineering can play a significant role in reducing human error.

Scott Davis presented “Initial Investigative Facts in the West Fertilizer Explosion.” On April 17, 2013, an explosion occurred at the West Fertilizer Company storage and distribution facility in West, Texas. The explosion at West Fertilizer resulted from an intense fire in the seed and storage area of the facility that led to the detonation of approximately 20-30 tons of ammonium nitrate stored inside a wooden receiving bin. The explosion occurred while emergency services personnel were responding to a fire at the facility and at least fifteen people were killed, more than 200 were injured, and numerous buildings were damaged or destroyed. The cause of the initial fire is still ongoing. This presentation detailed the initial evidence of our investigation into the cause and origin of the explosion event. In addition, the presentation outlined the current local, state and federal regulations regarding the storage and use of reactive chemicals such as ammonium nitrate.

Azmi Mohd Shariff with Universiti Teknologi PETRONAS presented “Application of Inherent Safety Concept in Preliminary Design Stage to Eliminate or Minimize the Potential Accident due to BLEVE.” Many of the worlds’ major process industry accidents are due to BLEVE such as at Feyzin, France, 1966 and San Juan Ixhuatepec, Mexico City, 1984. One of the approaches to eliminate or minimize such accidents is by the implementation of inherently safer design concepts. These concepts are best implemented where the consequence of BLEVE can be evaluated at the preliminary design stage and necessary design improvements can be done as early as possible. Thus, the accident could be avoided or minimized to as low as reasonably practicable (ALARP) without resorting to a costly protective system. However, the inherent safety concept is not easy to implement at the preliminary design stage due to lack of systematic technique for practical application. To overcome these hurdles, this presentation detailed a new approach to assess a process plant for a potential BLEVE at the preliminary design stage and to allow modifications using inherent safety principles in order to avoid or minimize major accidents. A model known as Inherent Fire Consequence Estimation Tool (IFCET) is developed in MS Excel spreadsheet to evaluate BLEVE impacts based on overpressure, radiation heat flux and missile effects. In this study, BLEVE impacts are the criteria used as the decision-making for the acceptability of the design. IFCET is integrated with iCON process design simulator for ease of data transfer and quick assessment of potential BLEVE during the design simulation stage. A case study was conducted to assess of potential BLEVE from propane storage vessel at the design simulation stage using this new approach. The findings show promising results that this approach has a potential to be developed as a practical tool.

Raymond Bennett with Baker Engineering presented “Modeling of Tent Response to Blast Loads to Support Siting in Accordance with API RP 756.” The performance of a pole tent is investigated. An Arbitrary Eulerian Lagrangian (ALE) finite element model and a simplified approach are used to evaluate the suitability of the tent in compliance with the requirements of API RP 756 – Management of the Hazards Associated with Process Plant Tents (due for release in the 2nd quarter, 2014). The ALE calculations are compared to the response predicted by using the simplified approach in the RP when they are applied to the same tent. The presentation addressed the factors influencing the effective blast loading on the tent, and methods for increasing the capability of a pole tent to resist blast loads.

Cecilia Palma with SKE&C presented “Fire Risks Associated with Control Rooms Located in Oil and Gas Facilities, with Analysis of Fire Protection Options inside these Buildings.” Control Rooms are a critical part of any oil and gas facility because they contain all basic control and safety systems required for operation of the plant in a safe and effective manner. These buildings require special fire protection considerations in order to avoid hazards that can cause shutdown of the facility. Several options for fire protection

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will be analyzed, such as fire extinguishers, smoke detection, and suppression systems based on building layout, response time, personnel availability and resources. A case study for the control room installed inside an LNG plant was described.

Gary Fitzgerald with ABSG Consulting presented “Evaluating Emergency Shelters in a Facility Siting Study.” The American Petroleum Institute Recommended Practice 752 (API RP 752) requires designation of every occupied building as either to be evacuated or to be used as an Emergency Shelter* in the event of a fire or toxic release. In general, industry has been addressing consequences for buildings that are evacuated during a fire or toxic release for many years but addressing hazards for buildings used as an Emergency Shelter is a unique problem, different than that for buildings which are evacuated. Unfortunately, it is also an issue without a universally accepted approach. This presentation listed available published guidance documents including those intended for other audiences and presents a best practices approach to address the API RP 752 Emergency Shelter requirements.

Brian Holland with Trinity Consultants presented “Explosion Consequence Modeling: Balancing Model Sophistication with Finite Resources.” This presentation detailed the technological foundations of the BREEZE Explosion Damage Assessment Model (ExDAM), which seeks to fill the “sophistication gap” between purely distance-based simple models and CFD tools. Discussion of the model’s capabilities included the types of situations it is and is not appropriate for, the level of effort required in comparison to other modeling approaches, and the strengths and weaknesses of this approach. Some sample real-world applications of the model were presented, including both a high explosive and vapor cloud explosion case.

Shubharthi Barua with MKOPSC presented “Bayesian Network Based Dynamic Operational Risk Assessment.” The oil/gas, chemical, petrochemical, food, power, papermaking and other process industries consist of numerous equipment and unit operations, thousands of control loops, and exhibit dynamic behavior. It is very important to identify hazards, perform risk assessments, and take proper initiatives to minimize/remove hazards and risks; else a catastrophic accident may result. Dynamic characteristics such as stochastic processes, operator response times, inspection and testing time intervals, aging of equipment/components, season changes, sequential dependencies of equipment/components and timing of safety system operation also have great influence on the dynamic processes. Conventional risk assessment methodologies generally used in oil/gas and petrochemical plants have limited capacity in quantifying these time dependent characteristics. Therefore, it is important to develop a method that can address time-dependent effects in risk calculation and provide precise estimation. This study proposes a risk assessment methodology for dynamic systems based on Bayesian network, that represents the dependencies among variables graphically and capture the changes of variables over time by dynamic Bayesian network. This study proposes to develop dynamic fault tree for a chemical process system/subsystem. The developed dynamic fault tree is then mapped in the Bayesian network and the dynamic Bayesian network is further developed to demonstrate dynamic operational risk assessment. A case study on a level control system was provided to illustrate the methodology’s ability in capturing dynamic operational changes in process due to sequential dependency of one equipment/component on others.

William Lowry with Baker Engineering presented “Effect of Inert Species on the Laminar Burning Velocity of Hydrogen and Ethylene.” The maximum laminar burning velocity (LBV) of a fuel-air mixture is an important input parameter to vapor cloud explosion (VCE) blast load prediction methods. In particular, the LBV value has a significant impact on the predicted blast loads for high reactivity fuels with the propensity to undergo a deflagration-to-detonation transition (DDT). Published data are available for the maximum LBV of many pure fuel-air mixtures. However, little test data are available for mixtures of fuels, particularly for mixtures of fuels and inert species. Such mixtures are common in the petroleum refining and chemical processing industries. It is therefore of interest to be able to calculate the maximum LBV of a fuel/inert mixture based on the mixture composition and maximum LBV of each flammable component. This paper presents measured test data for the maximum LBV of H2/inert and C2H4/inert mixtures, with both nitrogen and carbon dioxide as the inert species. The LBV values were determined using a constant-volume vessel and the pressure rise method. This presentation provided a comparison of the measured LBV values with simplified LBV prediction methods.
Jeffrey Marx with Quest Consultants presented “Review of the Risk Analysis Option in NFPA59A (2013).” In the 2009 version of the National Fire Protection Association (NFPA) Standard 59A, Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG), Annex E was introduced. This Annex, which was not a mandatory part of the standard’s requirements, was presented as an alternative approach to the plant siting exclusion zone provisions. It provided semi-quantitative guidelines for a risk-based approach for evaluating the offsite impacts associated with thermal radiation and flammable vapor dispersion. While well-intentioned, Annex E was not widely applied to LNG projects. With the release of the 2013 version of the standard, the NFPA 59A committee updated the information previously presented in Annex E and replaced it with Chapter 15, expanding what was a semi-quantitative risk assessment into a quantitative risk analysis (QRA). Chapter 15 describes a risk-based alternative to the exclusion zone portions of the plant siting requirements in Chapter 5, and provides guidance on selection of event probabilities and the choice of consequence models. It also presents a set of risk acceptability/tolerability criteria by which the risks to the public can be assessed. This presentation provided a review of the Chapter 15 provisions from a risk analyst’s point of view. The review and associated commentary highlighted the strengths of these new provisions, and also outlined some recommended improvements to the methodology.

Simon Waldrum with MKOPSC presented “Runaway Reaction and Catastrophic Reactor Failure During the Production of an Azo Dye.” It was a normal Sunday morning about 20 years ago in the UK: a regular semi-batch process, run hundreds of times before without any major incident, was being carried out. But a violent runaway reaction occurred in the 2.3 m³ reactor. At the time of the accident a diazonium ion was being produced for subsequent decomposition to form a phenol. Under excessive overpressure the reactor ruptured and the damage to equipment and buildings was very significant: by good fortune nobody was hurt. A single chart recording of the reactor temperature was all that survived from the control room. This presentation explained how this chart, modelling and a combination of isothermal and adiabatic calorimetry were used to support the accident investigation and provided insight into the violent decomposition that occurred. In due course the plant was rebuilt and production resumed. Some of the strategies to reduce both the hazards, and the risks associated with them, were discussed. A brief summary of the impact that this accident had on the company involved was presented.

Robin Pitblado with DNV GL presented “The Potential Value of a Safety Case Regime in the USA.” There have been discussions in the USA for a more risk-based approach in regulation. Both the National Commission and the Chemical Safety Board (CSB) have recommended a safety case regime in their respective reports on the Deepwater Horizon accident and the Chevron fire. This presentation explored the background to safety case, why it was developed, the types of facilities covered, and how it has evolved from its initial formulation to the current formats in several countries. Onshore process facilities, offshore oil and gas installations, and mobile drilling units all have a different format for safety case and the nature of these differences is explained. A key feature of all these is that the safety case underpins a risk-based approach to the management of process safety. Since there are fewer prescriptive requirements, the safety case creates facility specific prescriptions that in theory lead to a safer installation. The offshore installations safety case requires defining key safety barriers and establishing for all of these reliability, testing and competence requirements to ensure their continuous effectiveness. Some statistics were presented which provide some indication as to the success of the safety case approach. The issue of implementing safety case in the USA was discussed in terms of specialized competence requirements, and whether the potential risk reduction benefits merit the extra burdens associated with the safety case approach. It is likely that not all facilities would need a safety case approach, but higher risk facilities – such as deepwater installations, deepwater drilling units, and high potential consequence onshore plants (e.g. large refineries, major toxic plants, and ammonium nitrate facilities) would all benefit.

Adam Markowski with Lodz University of Technology presented “Selection of Representative Accident Scenarios (RAS) for Major Accident Industry.” Safety analysis of each major hazard industry, extremely important for the safety report and emergency planning required by an appropriate SEVESO Directive, is based on the analysis of several selected potential accident scenarios connected with loss of containment incidents. In fact, each point of the plant may be a potential source of a failure leading to the releases of...
the substance. Can we take all of such release sources into account or should we select those which may be considered representative accident scenarios (RAS)? This subject used to be the most debated for process risk management as well as for emergency planning. The presentation discussed the problem of the selection of representative accident scenarios, understood as maximum credible accidents for major accident industry. The selection process is based on the risk ranking scheme applicable to all potential accident scenarios identified during PHA analysis for a major hazard plant. Unfortunately, the process, due to incomplete and vague information concerning the assessment of the frequency and severity categories required for risk ranking matrix as well as to the lack of data reflecting the impact of the layer of protection on those categories, implies a substantial level of uncertainty. In most cases it is caused by insufficient knowledge and experience of the PHA team. It usually effects the credibility of accident scenario identification process and, by the same token, underestimates or overestimates process risk level. In order to deal with all knowledge-based uncertainties, the new approach for the identification of the representative accident scenarios is proposed. It consists in the inclusion of a semi-quantitative assessment of the safety performance of protection layers combined with a fuzzy logic approach into risk ranking assessment. Fuzzy logic deals with uncertainty and imprecision, and is an efficient tool for solving problems where knowledge-based uncertainty may occur. Such situations frequently arise in different aspects of process safety analysis. The proposed methodology may be successfully used for any major hazard industry and the case study for fictional model of the LNG storage facilities is presented. Preliminary tests confirmed that final results of the risk index were determined in a more precise and realistic manner.

Sahil Shah with Atkins presented “Using Multiphysics CFD to Model Water Spray Curtain Effects on Dense Gas Dispersion.” Accidental release of dense gases such as heavy hydrocarbons and LNG pose a safety hazard as observed during the Buncefield vapour cloud explosion. Difficulties arise in risk mitigation as these releases sink and spread along the ground, and are therefore less conducive to natural dispersion by wind. Water spray curtains are an effective means in overcoming this issue as forced dilution through air entrainment and mixing can push the concentration limits below LEL. While a range of open-field spill tests and scaled wind tunnel experiments have been performed to study this effect, a lesser focus has been placed on numerical simulation using Computational Fluid Dynamics (CFD). In this investigation, multiphysics CFD simulation will be performed using the general purpose software STAR CCM+. RANS turbulence models coupled with Lagrangian sprays will be used to capture water spray curtain effects on atmospheric heavy gas dispersion. The proposed model will be validated against experimental data by comparing spray and no-spray concentration ratios at points both upstream and downstream of the water curtain. Sensitivity to mesh resolution will also be examined. The validated model will then be used to determine the dilution performance for varying release densities and source-to-spray separation distances. CFD modeling poses an effective yet inexpensive platform for designing water spray curtains for hydrocarbon processing and handling facilities. This approach will also provide a framework upon which thermal and smoke shielding effects of water curtains can also be investigated.

Jerome Taveau with Fike presented “Combustible Metal Dusts: A Particular Class.” Dust explosions have been a hazard for as long as man has been processing, storing and transporting powders and bulk materials. The first recorded dust explosion occurred in an Italian flour mill in 1785. Most of the reported dust explosions have involved organic products, mainly because most of the materials in commerce are organic. Nevertheless, due to their increased use in the process industries (automotive, aeronautics, electronics), metal dusts have been involved in several devastating explosions in recent years. According to a review carried out by the Chemical Safety Board (CSB) in 2006, metallic dusts were involved in 20% of the 281 dust explosions that occurred between 1980 and 2005. Metal dust deflagrations have also been regularly reported in Europe and Asia. The term “metal dusts” encompasses a large family of materials with diverse ignitability and explosibility properties. While copper and lead are considered non-ignitable, fine particles of aluminum and magnesium can have ignition energies as low as 1 mJ. The latter dusts also exhibit much higher flame temperature than organic materials: this results into high values of maximum explosion pressure (Pmax) and rate of pressure rise (dP/dt)max, making explosion protection particularly challenging. The presentation reviewed the unique combustion characteristics of metal dusts. It also summarized the corresponding challenges for explosion protection systems.
Decision makers need reproducible, believable results to support investment decisions. A wide variety of hazard identification and risk analysis methods are available to support process safety decisions. All methods require knowledge in the fundamentals of process design and experience in the process operation under consideration. Every method has uncertainty and no method yields any better reflection of the risk than the level of engagement that the analyst or team has in the assessment. Traditional approaches work well on processes with a long history of operation, but are difficult to apply in the rapidly evolving environment of modern manufacturing. This presentation discussed the challenges that the risk analysis process is facing in today’s work environment. These challenges include understanding that the calculations are only a model for process safety events that harm people, events with low calculated likelihood can still occur, and management systems with metrics are critical to sustain the performance of the identified protection layers. These challenges are met by adapting current tools and work processes for recording process data to also collect data on abnormal operation and protection layer failure.

Praveen Lawrence with Process Systems Enterprise presented “Process Modeling Requirements for the Safe Design of Blowdown Systems—Changes to Industry Guidelines and How This Impacts Current Practice.” Safe design of pressure relief and blowdown systems requires that safety valves, relief orifices, flare piping and knockout (KO) drums are all sufficiently sized, to ensure that the process is protected from over-pressurization and that emergency depressurization can be executed rapidly and effectively. An essential design step is to ensure that temperatures resulting from auto-refrigeration are sufficient to avoid the risk of brittle fracture in both the process equipment and flare system. However conventional calculation methods rely on a number of assumptions and approximations. In particular, calculations of safe design temperatures and relieving rates for complex blowdown segments are typically based on analysis of a single pseudo-vessel with simplified representations of the fluid’s thermodynamics and heat transfer. Best-practice in engineering and operating companies when assessing risks in pressure relief and blowdown systems now increasingly involves the application of high-fidelity dynamic simulation techniques. Evolving industry guidelines necessitate a change in the way all oil and gas companies approach process safety, in particular the design and analysis of pressure relief and blowdown systems. This presentation discussed how industry practice, and the tools and methods that support it, are beginning to evolve due to recent guideline changes.

Bing Wang with Tsinghua University presented “An Integrated Prediction Method for Real-Time Accidental Toxic Gas Release in Industrial Plants.” Toxic or flammable gas release accidents will possibly form dangerous vapor clouds, which is of significant concern to industrial safety and social security. In the current stage, several models are available for simulating and predicting the dispersion of hazardous gases to the surrounding environment, but these models all require information about the release source, for example, the release rate or release velocity, which is difficult to acquire in an emergency situation. There is a need to find an effective method to predict the real-time gas dispersion for a toxic/flammable gas release accident. An integrated method combining a gas detection system, numerical simulations using the PHAST and an artificial neural network (ANN), was developed to aid decision making involved in an emergency situation. The purpose of implementation of the integrated method is to find a way to predict the dispersion of released gases while bypassing the requirement of source information, thus saving time for emergency response. The integrated method is an extension to the existing consequence analysis tools and is specialized in real-time gas dispersion prediction.

Delphine Laboureur with MKOPSC presented “Experimental Study on Propane Jet Fire Hazards: 1. Assessment of the Main Geometrical Features of Horizontal Jet Flames.” Jet fires are among the least severe fires in terms of direct effects, but are very important in terms of risk assessment due to the potential escalation of the incident by impingement or engulfment of the jet fire on the surrounding vessel, pipework or other components. This presentation focused on the determination of the main geometrical features (flame shape, length, and width) of large-scale horizontal jet fires in air. The study is based on the experimental results of LPG jet fire released from a horizontal pipe of 1.9 cm diameter at different flow rates, with either vapor or two-phase flows, reaching a flame size of 1 to 10m
defined systems and procedures, coupled with assurance with inherently safer engineering and design principles, safety requires leadership in knowledge and competence, in itself, need not be complex. The management of process for the purposes of safe design and operation. This concept, calculations are in themselves complex, they are performed back into the reach of all people in an organisation. While engineering design and risk calculations are in themselves complex, they are performed for the purposes of safe design and operation. This concept, in itself, need not be complex. The management of process safety requires leadership in knowledge and competence, with inherently safer engineering and design principles, defined systems and procedures, coupled with assurance processes and incorporating an understanding of human factors to shape safety culture. This presentation showed the redefinition of process safety in simpler terms, and showed how it can be applied to any phase of a facility lifecycle.

Trish Kerin with IChemE presented “Defining Process Safety in Practical Terms.” The term process safety conjures thoughts of complex engineering activities, resulting in people shying away from participating in process safety activities. The principles of process safety need to be restated to bring it back into the reach of all people in an organisation. While engineering design and risk calculations are in themselves complex, they are performed for the purposes of safe design and operation. This concept, in itself, need not be complex. The management of process safety requires leadership in knowledge and competence, with inherently safer engineering and design principles, defined systems and procedures, coupled with assurance processes and incorporating an understanding of human factors to shape safety culture. This presentation showed the redefinition of process safety in simpler terms, and showed how it can be applied to any phase of a facility lifecycle.

Keith Lapeyrouse with Dow Chemical Company presented “Implementing SIS Metrics for Life Cycle Management.” This presentation overviewed the key elements of implementing SIF Metrics for Life Cycle Management. Each of these elements are essential to an effective SIS Metric Implementation whether for one or for many metrics. These elements can be aggregated into the categories: 1) Business Justification, 2) System Implementation and 3) Action Execution. Implementation of SIS Metrics aligns to the CCPS Vision 20/20 (American Institute for Chemical Engineers 2014) initiative by supporting the Industrial Tenant of Disciplined Adherence to Standards and the Societal Themes of Harmonization of Standards and Meticulous Verification.

Xinrui Li with Bureau Veritas presented “Methods for Simulation of Multi-phase and Multi-component Venting.” Understanding multiphase flows behaviors of the oil-water-gas system is critical for many processes from upstream to downstream such as oil and gas recovery from shale, transport along pipelines and distillation or cracking in a refinery. The hydrodynamics determines the multiphase flow or the local flow conditions such as pressure and temperature and the geometrical characteristics of the relieved flow and venting lines connected, hence affects the thermodynamic behavior of the mixture components. The additional complexity is that the state where phase change occurs strongly depends on the mole/mass fraction of each component in the mixture. This paper attempts to develop a CFD model using ANSYS Fluent to support the study of the development of a thermodynamic coupled CFD model addressing the above complexity under the multiple phase flow modeling framework. Relief scenarios under cooling water or external fire failures from an extractive pentane-hexane distillation plant in the flare header result in pressure relieved gases or liquids from difference header/relief branches. The CFD meshes are generated on a 3-D model. k-ε turbulence model is applied for the turbulent flows, meanwhile multiple phase - volume of fraction model is coupled to solve the multiphase problem. As a result, reliefs at an elevated temperature show how the phase distribution of gas release, in terms of turbulence intensity, velocity and pressure present in the branch, flare main header pipe and the intersection. While reliefs at a dew point of pentane and hexane shows how multiphase flow present in the relief pipe. The potential application of this modeling approach in process simulations was highlighted.

Bernd Schroers with Bayer AG presented “Life-cycle Management of Safety Instrumented Systems.” Process and plant safety requires the implementation of a safety management system. IEC 61511 and ANSI ISA 84 define rules for safety management. Every company in the process industry shall incorporate safety management into its corporate goals. A number of integrated management systems already exist, which simplifies the integration of an additional management component. The policy and strategy for achieving safety shall be described together with the methods for evaluating their achievement and shall be communicated throughout the organization. All persons, departments, organizations or other units responsible for carrying out and reviewing each of the necessary activities involved in the implementation of safety measures (Safety Instrumented Functions, SIFs) in the form of a Safety Instrumented System (SIS) shall be identified and informed of the tasks for which they are responsible. The core of safety management is the SIS safety life-cycle. The activities that shall be carried out must be defined in a
safety planning process. This planning shall be updated as necessary throughout the SIS safety life-cycle and implemented on a detailed level of activity commensurate with the role of the individual or organization in the SIS safety life-cycle. As part of safety planning, the safety life-cycle shall be documented in the form of an SIS safety life-cycle plan. Generally, the above requirements can be met by companywide regulations describing how and by whom (functional) safety assessments (FSA), design and engineering, maintenance, change etc. of SISs must be carried out, and which internal and external standards apply.

**Jack Chosnek** with KnowledgeOne presented “Becoming a World-Class HSE Organization.” In order for an organization to be recognized as a world-class Health, Safety and Environmental (HSE) organization certain elements and resources need to be in place. This applies whether the organization is an engineering or an operating company. The most important element is qualified personnel in the areas where HSE needs to be developed and maintained. It may not be necessary to have experts in all the areas where excellence is desired, but an in-house person that fully understands and has had hands-on experience in these areas is required. That person will hire, permanently or temporarily, the experts that will execute the pertinent part of the job. As such, he/she should be able to define the needs, the scope and the extent of the work, plan and execute the plan and assess the quality of the HSE work as it is being implemented. Knowledge and understanding of all applicable regulations, codes and standards is essential. These should serve as a basis and starting point and should be interpreted to enhance the company’s HSE and not narrowly to satisfy minimum requirements. The areas that are under the scope of HSE are the health, safety and risk, and environmental domains. For matters related to health and understanding of the impact of chemicals on people is needed and knowledge of the available resources to assess this impact (for example, Safety Data Sheets). The safety and risk domain (in which process safety resides) may be the most extensive in terms of the analyses and information required. These include hazard identification (HAZID), consequence analyses, facility siting, fire protection design, process hazards analyses (PHAs), and operating knowhow. Processes to maintain the safety long-term such as management of change (MOC) and development of operating procedures, among others, are required. In the environmental domain familiarity with the effects of the process on the air, water, and noise, and how to minimize them, is essential. This presentation addressed in detail the HSE needs of the organization, for both engineering and operating companies, and the levels of expertise and experience that are necessary to reach in order to stand out.

**Ed Gibson** with Metapower presented “Risk Management at the Source.” For a “Safety Case” approach to regulation, this information is documented in a “safety case report” and submitted to the regulator, who then passes judgment on its adequacy to maintain the plant as “safe”. When it is deemed adequate, permission to operate is granted. He then uses auditing and other techniques to monitor the facility operation to ensure that the mitigations maintain the acceptable risk level. The Risk Management approach requires techniques to determine and quantify risk. For much of the industry the use of Quantitative Risk Analysis (QRA) to evaluate the safety of occupied structures has provided these techniques. The “Safety Case” documentation appears to be a similar approach to that used for Nuclear Power Plants in the US. In that industry, A Preliminary Safety Analysis Report is developed and submitted to document the facility’s engineering, construction and operating plans. The regulator uses this to justify issuing a Construction Permit. The Safety Analysis is updated to reflect the actual facility and a Final Safety Analysis Report issued. Following the incident at Three Mile Island, the use of Probability Risk Assessment became part of the regulatory information. When the facility is deemed safe, an operating license is issued.

**Michael Bearrow** with Controls and Data Services presented “Heard, Understood, Acknowledged and Action (HUAA) When Learning and Sharing are Not Enough!” Learning from mistakes as well as from the experience of others makes us better placed to deal with future experiences; Organizations are no different. Successful organizations learn from any and every experience. We learn from the changes in the business, regulatory and legal landscape. There is a Latin proverb that says, “A smart man learns from his mistakes, a wise man learns from the mistakes of others.” Fortunately, we can learn from mistakes as well as from success. In industry we call mistakes incidents, accidents, undesirable event, disasters, calamity, mishaps, anomalous activity, etc. When we learn from success we call the learnings best practices, good practice or good catch. When we have an unwanted event, we always wonder why. Could we have done anything to prevent that
event? What will we do differently in the future to make sure we don’t have to relearn what we should already know? That is a good process. However with large organizations, multiple sites, differing regulations and laws governing operations, the picture becomes more complex. Being able to focus on identifying those lessons you really must learn, regardless of their source, and putting into action a process to address the learning within your Organization is what every smart Organization should be aiming to do. Continuous improvement makes your Organization safer, smarter and sustainable. This presentation discussed how to take learnings from your experience and the experience of others and use them to your best advantage.

Steve Marwitz and Jaime Tseng with Formosa presented “Growing Your PSM Program.”

Alec Harley with Lockheed Martin presented “The Use of Bowtie Theory to Develop and Deliver Process Safety Indicators.” A programme initially supported by Lockheed Martin has been adopted and developed in to a multi-strand approach for Oil & Gas and Generation businesses focusing on the development of an integrated Process Safety Management system. Based originally on UK HSE guidance on developing process safety indicators (HSG 254) and supported by numerous other international standards including ISO55000:2014 (Asset Management) and API Recommended Practice (RP) 754, Process Safety Performance Indicators our programme address the subject at every level in an organization. A critical success factor in the programme was the development by Lockheed Martin of a near real-time KPI monitoring system, which was introduced to enable staff at all levels to see the current status of the risk control barriers across all assets regardless of age, type and level of automation. The programme has been enhanced over the past three years and received numerous “best in class” awards for innovation in process safety from bodies such as Institution of Chemical Engineers and Institute of Risk Management. Today the program is being rolled out in Oil & Gas and Utilities organizations operating in the UK, Europe, Australia, New Zealand and North America, all at differing stages of the life cycle.

Delphine Laboureur with MKOPSC presented “Experimental Study on Propane Jet Fires: 2. Comparison on Geometrical Features between Experiments and Empirical Models.” An experimental study of jet fires using propane was performed at the Brayton Fire Training Field (BFTF), College Station, to understand the flame geometry of jet fires. Horizontal jet fires were simulated by varying the mass flow rate of fuel through a 19 mm nozzle. The exit velocities varied from 25-210 m/s, flame lengths from 1-6 m and Froude Numbers from 4,000 to 2.3×105. The flames generated were visually captured using a normal CCD camera. The frames obtained from CCD camera are reconstructed using image visualization method to obtain the flame lengths and lift-off lengths. The flame lengths and lift-off lengths obtained from the image analysis were compared with empirical models. The flame length showed strong dependence on the Froude number indicating buoyancy-dominated regime. The lift-off length varied linearly with the strain rate.

Derek Engel with GexCon presented “Challenges of Explosion Risk Management in Arctic Environments.” Fully enclosed platforms utilized in arctic climates can present challenges for managing explosion risk. Generally, modules on modern platforms are built with an “open” wall design. These open wall designs provide: (1) increased ventilation, which helps to prevent the accumulation of flammable gases within the module; (2) open pathways for flammable gases to dissipate; and (3) open pathways for the explosion to vent, thus reducing the overpressures. Due to the harsh conditions in arctic environments, the outer walls of the platform are solid and enclosed, which prevents flammable gas from escaping during unintentional releases. Unlike open modules, nearly all mass flow leak rates (including the high frequency of occurrence, low mass flow rate leaks) can fill an entire process area with near stoichiometric gas concentrations at some time during the release. When ignited, these clouds can produce devastating explosion overpressures. Enclosed modules also increase the duration of time for which these clouds are present, which can increase the probability of ignition as mechanical ventilation is the only means of diluting and removing the gas vapor. This study will use FLACS CFD explosion and dispersion modeling to analyze the application of various mitigation techniques to help manage the explosion risk in these enclosed platforms. More specifically, the effectiveness of soft barriers/partitions (to reduce cloud sizes) as well as partially opening the outer enclosing walls (to reduce cloud sizes and the time that gas vapor may remain in the flammable range) will be evaluated. Exceedance curves will be
produced for various geometry changes to analyze the 10-4 and 10-5 per year frequency of occurrence overpressures.

Ranjana Mehta with Texas A&M University presented “Investigating Display-Related Cognitive Fatigue in Oil and Gas Operations.” As part of an industry-academic collaboration, this presentation highlighted ongoing research efforts to isolate and document the extent of operator performance- and safety-related implications of cognitive fatigue, as well as to develop effective countermeasures in mitigating the negative effects of this particular type of fatigue. Examples of how aspects of common display and interface technologies in current upstream operations directly contribute to cognitive fatigue are discussed. Concrete examples of well-known problems in the oil and gas industry, such as alarm fatigue, are described within a developed theoretical paradigm that incorporates physical and cognitive fatigue, sleep-related fatigue, and other mental and physical factors such as motivation and the prevalence of environmental stressors. The presentation also described a planned in situ task analysis, and explored assessment methods for human factors display/interface design guidelines that will ultimately be applied to address the risk factors identified in those efforts.

David Hollaway with ABSG Consulting presented “There Will Be Blood: API 770 and Human Error Prevention in Process Safety.” It is axiomatic that human error is a causal factor in 60 to 80 percent of accidents and catastrophic events in complex, tightly-coupled systems used in the process industry. It is also clear that these events often have large environmental and public consequences. This presentation discussed the perception of consequences in mishap causation and presented a number of tools used to prevent human error. One of these is the SHEL Model, a simple but extremely effective way to analyze error provocative conditions through the interaction of system components with the human operators; the model may also be used as a results-multiplier in the application of human error mitigation strategies presented in API 770. Use of the SHEL Model for routine error trapping tasks such as job safety analyses, permit-to-work systems, or management of change, may significantly reduce the potential for human error as well as decrease near miss and accident events.

Risma Rusli with Universiti Teknologi PETRONAS presented “Selection of Inherently Safer Strategies to Reduce Human Error.” The inherent safety concept has been introduced to overcome the shortcoming of traditional hazard assessments by allowing modification to be made at any stage of life-cycle of a process plant. However, most of the proposed inherent safety modifications were suitable to prevent fire, explosion and toxic hazard assessment but less attention on the human factor. Therefore, this presentation introduced a technique to assess improvement strategies based on human factor using inherent safety approach. Analytic Hierarchy Process model integrated with fuzzy logic and known as FAHP was employed to rank the identified inherently safer strategies. The model was applied to the Piper Alpha offshore disaster with the main intention to prevent similar incidents occurring in the future. The result shows the capability of the proposed methodology in selection of the best inherently safer strategy together with its implementation cost without requiring precise information to transfer experts’ opinion from human performance’s point of view.

Ankur Laroia with ATR presented “Are Your Procedures Designed for Humans?”

Scott Tipler with Dow Chemical Company presented “Practical Examples of Alternate Overpressure Protection Systems An Owner’s Manual.” In 2007, the American Petroleum Institute (API 521/ISO 23251) published guidance on the use of High Integrity Protective Systems (HIPS). In 2009, The Dow Chemical Company (Dow) updated its internal work process to apply Dow’s risk based work processes to HIPS design, application and evaluation. The overall result is an efficient process that links together the existing work processes for conventional relief design, Layers of Protection Analysis (LOPA) and Safety Instrumented Systems (SIS). This produces a risk based method for applying and designing protection layers into HIPS. For additional details, refer to “High Integrity Protection System Design Using a Risk Based Approach” by Robert J. Stack, AIChE 2010 spring meeting 6th Global Congress on Process Safety. A natural extension of HIPS is to use system design and operating discipline to mitigate overpressure scenarios where use of fully instrumented protection layers or conventional relief devices is neither practical nor effective. For example, fire protection systems may be used to mitigate the consequences associated with a fire and reaction scenario where conventional relief devices and instrumentation systems are not possible. In Dow, this approach is referred
A fire occurred at a petroleum refinery when a fractionator overflowed, resulting in the release of a hot flammable liquid. The initiating event of this incident was a failure in the fractionator’s level control transmitter. The control room operator failed to diagnose the level control fault and executed specific actions which worsened the process upset. The fractionator filled with naphtha and overflowed into process vents through the column’s pressure relief valves. Through a series of missteps, the emergency flare was inadvertently extinguished, allowing the uncontrolled release of hot naphtha from the flare stack. The naphtha...
release was ignited and the subsequent flash fire injured three workers. This presentation discussed the causal factors of the accident and described corrective actions that could have prevented this incident. The similarity between this incident and other recent flammable liquid releases was discussed with an emphasis on lessons learned.

**Derek Engel** with GexCon presented “A Devastating Metal Dust Explosion in a Crushing Plant.” A dust explosion in a facility producing ferrosilicon magnesium in Norway resulted in serious damage to the facility and the building containing the facility. One employee was killed. The presentation described in detail how the accident developed, its cause and the consequences. The facility consisted of two crushers, a number of classifiers and a number of silos/hoppers. Dust was removed at several locations in the plant using an aspiration system including a cyclone and filter. Sparks generated in one of the crushers resulted in a fire in the metal dust on one of the transport belts. The installation was stopped but no attempts were made to fight the metal fire. The belt caught fire and after a while a part of the belt fell down swirling up metal dust lying on the floor of the production hall. The dust cloud immediately ignited (a “flash” occurred) igniting dust present in one of the lines of the aspiration system. The dust flame accelerated in the aspiration line causing a devastating explosion in the cyclone and filter. The presentation addressed not only lacking technical preventive and protective measures but also necessary safety awareness and training of personnel.

**A.W. Armstrong** with Kestrel Management presented “Where to Focus Resources—Using Human Performance Reliability to Identify Weakness in Internal Controls.” Human performance is a significant source of risk in any organization. The majority of accidents, both occupational and process safety, are at least in part the result of human error. Companies manage risks associated with human performance through a variety of administrative controls, including policies, procedures, work instructions, employee selection and training, auditing, etc. Incidents and accidents occur when there is a failure in one or more of these controls. The initial challenge is to know which of these controls are contributing to accidents and need improvement. However, this is only part of the solution – to improve safety performance, companies must also take deliberate action to strengthen the controls contributing to the unintended events. This presentation provided an overview of Human Performance Reliability as a process to assess existing controls and to identify which are contributing to human error within an organization. In addition, the presentation included example of integrating Human Performance Reliability into a global chemical manufacturer’s process safety management program.

**Antonino Nicotra** with Bechtel Oil Gas & Chemicals presented “Human Factors Engineering is Contributing to the Safe Operation and Maintenance of an LNG Plant.” Maintenance accessibility and material handling studies provide important information related to Process Safety and overall facility design. Designing for maintenance ensures that handling of critical equipment and materials are given priority and that safe lifting and handling practices are actively implemented throughout the facility life cycle. One of the primary goals of material handling studies is to ensure that all maintainable equipment can be safely and efficiently accessed, isolated, maintained, removed, and re-installed as required during periods of planned/preventive maintenance, as well as shutdown conditions. In the current study, major equipment items were studied for maintenance accessibility, handling and transport from their installed positions to and from maintenance or warehouse facilities. This study investigated the lift, laydown, transfer, and offload of equipment items and materials, and identified lifting devices required to safely perform these actions. A database was compiled with the objective of providing the operating company with a comprehensive lift and removal plan for all maintainable equipment items in the facility. This database was populated via thorough, multidisciplinary review of the detailed design three-dimensional computer model of the facility, as well as vendor models and drawings. Input from numerous disciplines was incorporated to ensure that the proper equipment, tools, and strategies are selected and available to safely execute any lift of equipment and handling of material that will be associated with routine maintenance activities. Contributions of this effort include: 1) the assurance that layout and design considers safe and efficient maintenance of equipment over the life of the facility, and 2) a database which provides a valuable tool for planning lifts during routine maintenance activities, thus minimizing shutdown time and cost while ensuring that all maintainable items are studied for safe accessibility, handling, and transport.

**Greg Alvarado** with Mobideo Technologies presented “Improving Human Performance in Field Data Collection Impact of Granularity and Validation at the Point of Service.” Human based data collection activities are complicated by different types of errors resulting in...
poor accuracy and questionable actionable information. These errors impact data quality and consistency, poor compliance to safety and other protocols, weak defect identification and ineffective maintenance. An Institution of Chemical Engineers (IChemE) report declares that 20% of equipment failures in chemical process industries are the result of human and organizational errors. Human errors may result from a failure to follow procedures correctly, inaccurately recording or capturing field level data or not triggering proper follow-on procedures related to task execution. Human error generation may also be exasperated by poor contractor control, lack of planning and weak management and supervision. It is recognized that the use of printed service manuals or similar formats in computer form (such as PDF) are often not followed for a variety of reasons including not being available, reasonable or understandable. This presentation focused on the study and causes of human error formation resulting from widely prevalent methods of field level data collection and ways to improve these processes to increase human performance, accuracy, compliance and lack of input to the work process and work instruction content from subject matter experts. He explored the need and impact for data granularity, the ability to monitor compliance to protocols in real time or near real-time, and task execution that accounts for the coordination of crafts and their adherence to protocols and data validation methods. Lastly, it was considered human error formation and solutions within the contexts of how work is done and accountability reflected in policy, culture, organization and technology frameworks to make institutionalizing a work execution and reporting framework based on best practices sustainable.

Benjamin Poblete with Atkins presented “Lessons Learned from the Application of Human Factors Engineering (HFE) in Process Safety Assessments.” Hazard analyses are a cornerstone of any process safety program. However, until recently hazard analyses had not formally included consideration of the human as a source of hazards. The US Bureau of Safety and Environmental Enforcement (BSEE) promulgated the rule on Safety Environment Management Systems (SEMS), API RP 75 in 2010, which now formally recognizes human factors during the design lifecycle and operations. In particular, for the element of hazard analysis, the SEMS regulation states “human factors should be considered in this analysis”. Additionally, Oil & Gas Producers (OGP) Report No. 454, Human Factors Engineering in Projects (2011) provides appropriate guidance within the HAZOP framework to address human factors in hazard analysis. Over the last 10-15 years, there have been industry papers that have discussed this topic at a high level, mostly about integration with Hazards and Operability Studies (HAZOPs). Despite this history and guidance, it is evident that the lessons learned during the application of HFE in design continue to evolve. In order to address this gap, this presentation discussed practical illustrations and guidance gained from the authors’ experiences on major offshore design projects on a range of hazard analyses such as HAZOPs, Hazard Identification Studies (HAZIDs), Qualitative Risk Assessments (QRAs) and Escape, Evacuation and Rescue Analyses (EERAs), etc. The aim is to provide specific tools and lessons for application to most any system in the process industry. The challenge continues in integrating HFE during hazard and risk management activities in all engineering design activities, but applying knowledge gained to date will facilitate the evolution.

Rune Kleiveland with ComputIT presented “Simulation of Accidental Releases of LNG: pool spreading, vapor dispersion, and fire.” LNG is becoming an increasingly important energy technology worldwide and the extensive development of LNG production, loading, transportation, and offloading facilities poses serious challenges for the safety of personnel, equipment, installations and facilities regarding fire and explosions. It is therefore of great importance to develop reliable simulation tools to make it possible to predict the consequences of accidental releases of LNG. Kameleon FireEx KFX® is a highly advanced CFD tool developed specifically for simulating gas dispersion and fires in complex geometries. KFX™ has been extensively validated and has become one of the leading CFD tools for predicting the consequences of fires and gas leaks in the petroleum industry. To meet the safety challenges faced by the LNG industry KFX™ has been further developed to handle processes which are particularly important for LNG releases. These developments include a detailed heat transfer model to calculate the heat transferred to the cold LNG from the surroundings. The transient model takes into account the cooling process of the underlying surface and as a result structural effects due to cryogenic exposure can be assessed. A correct heat transfer rate is essential for calculating the correct evaporation rate of LNG and subsequent vapor dispersion. In addition, a shallow layer pool spreading model has been developed for an accurate representation of the spreading of cryogenic liquid. KFX™
The validation results were presented. Both large and small scale experiments and excerpts from the validation data include comparisons with data from available experimental data for LNG pool spreading and evaporation, LNG vapor dispersion and LNG fires. The validation data has been thoroughly tested and validated by comparison with available experimental data for LNG pool spreading and evaporation, LNG vapor dispersion and LNG fires. The validation data includes comparisons with data from both large and small scale experiments and excerpts from the validation results were presented.

Daniel Nguyen with ioMosaic presented “Mechanical Integrity Considerations in LNG Depressurization.” In a typical LNG installation, a rapid depressurization can cause cryogenic temperatures in both the upstream and downstream of the connecting process equipment and piping. This phenomena is sometimes referred to as auto-refrigeration, compromising the equipment’s mechanical integrity and posing a risk for material embrittlement. As vessel metal walls are exposed to temperatures below the minimum design metal temperature (MDMT), permanent damage is possible. The potential for brittle failure is even more pronounced for a non-fire scenario. The level of severity depends on the initial pressure, initial temperature, content inventory, depressurizing rate, fluid compositions, surrounding conditions, and heat transfer mechanisms. Emergency depressurizing valves must therefore be sized to ensure a reasonable compromise between the impact of pressure and temperature. This presentation examined the effects of different liquid levels, depressurizing valve sizes, vessel wall thicknesses, and thermal insulations. The primary objective was to identify and illustrate the key factors that influence the mechanical integrity of a typical LNG installation.

Drew Botwinick with GexCon presented “CFD Based QRA of an LNG Liquefaction Facility.” Quantitative risk assessments (QRAs) of oil and gas or chemical process facilities have historically been performed using analytical tools (often referred to as “2D” models because of the familiar two-dimensional footprint representation of the risk contours). Analytical models rely upon correlations and simple equations to calculate the hazard distances for fire, flammable or toxic gas dispersion and gas explosion scenarios. Therefore, a large number of scenarios can be calculated in a short period of time and risk contours can be calculated. Analytical models, however, incorporate several critical assumptions which can limit their applicability and/or strongly affect their accuracy. For example, they neglect the presence of obstacles and obstructions on gas dispersion, the shielding effect of buildings or large equipment on thermal radiation, and are generally unable to accurately describe the flame propagation and resulting overpressures within congested areas. The typical solution to these limitations is to increase the degree of conservatism in the analysis, but this approach does not improve the accuracy of the analysis – instead, it masks obvious limitations by overdesigning the facility and ultimately increasing the financial burden on the project’s owner. A more accurate approach to QRAs is to perform the analysis using computational fluid dynamics (CFD) models, which can eliminate many of the limitations and conservative assumptions required by analytical models. The most frequent criticism of CFD models for QRAs is that “it would take years...”. The presentation introduced how a CFD based QRA can be performed properly and within reasonable times. It represents the first in a series of papers on CFD based QRAs, which will demonstrate a QRA performed on a small-scale LNG liquefaction facility using the CFD tool FLACS. The future work will demonstrate how a QRA can be performed properly and within reasonable times, and how CFD results compare to those obtained using the traditional analytical approach.

Bilkis Islam with MKOPSC presented “Risk Management Strategy for LNG Road Transportation.” Liquefied Natural Gas (LNG) plays an important role in the energy market. In the near future, LNG used as fuel in road transportation will be increased due to some significant advantages. Since LNG has safety hazards, the risk management process is essential to ensure minimum risk during transportation. In this project, a database has been created with all LNG road transportation accidents in order to identify the associated risks and hazards. A HAZID has been done for the identification of risks and hazards associated with LNG truck tankers and heavy duty vehicles using LNG fueling. For a complete overview of major risks and hazards a bow-tie analysis was performed. Based on the identification and assessment of incident scenarios and study of existing codes and standards, recommendations on risk management strategy will be provided in the future.

Jacob Lindler with aeSolutions presented “Experienced Facilitators Use Baffles to Stop the Swirl and Improve Study Results.” Effective Process Hazard Analysis (PHA) facilitators combine soft skills with technical knowledge to guide PHA teams through a thorough identification and analysis of process hazards. PHAs for complex processing units place a significant demand on the time of
valuable engineering, design, and operations personnel, so conducting an efficient PHA is key to minimizing team fatigue and maximizing available resources. Inevitably, there are hazard scenarios at which the team’s discussion begins to swirl, circling around multiple consequence definitions or risk rankings without coming to agreement. Facilitators should consider the presented examples of tools successfully used to stop the swirl by providing the PHA team with the right information at the right time.

Jennifer Morgan with Shell presented “Identifying True Safety Critical Equipment by Evaluating an Asset’s Major Hazard Potential.” This presentation detailed the process used at a current Onshore Unconventionals Asset to determine an accurate number of Safety Elements. This particular asset previously had a count of over 7000 pieces of equipment that were deemed Safety Elements. The process used to understand and to evaluate that equipment for its current use as associated with Safety or Integrity began with understanding the potential Process Safety events for the asset. These potential events were evaluated for each piece of kit at either the wellpad or the liquids gathering facility. Once the equipment-specific events were evaluated for potential risk, the individual elements associated with the equipment pertaining to those events meeting our Major Hazard criteria were further evaluated. This evaluation was done in a group setting involving operations, safety, and mechanical integrity. Each element currently marked Safety was discussed and re-evaluated based on the potential events associated. If the element (e.g. PSV, pump motor, ESD logic) was capable of mitigating or preventing the potential Major Hazard event, it remained as a Safety Element; however, if that element was not associated with mitigation or prevention it was reduced to an Integrity Element. The initial workshop resulted in de-rating of about 50% of the elements associated the multi-well facility, and about 40% for the LGS. It should be noted that some elements received an increase from Integrity to Safety based on the understanding of the potential events. The results of the workshop performed to evaluate both a multi-well facility and a liquids gathering facility will be tested at other assets to determine the applicability of similar results.

Taylor Schuler with aeSolutions presented “Who and What Equals How I’m Closing My Gaps.” Following a layer of protection analysis (LOPA), numerous recommendations and proposals are identified to close gaps associated with process safety performance. This presentation explored a methodology created to allocate the targeted risk reduction factor (RRF) between different types of work and stakeholders. The fundamental concepts are creating actions with lower scenario target RRF or decreasing the probability of failure on demand (PFD) of the protection layers to account for portions of the target while also calculating a % Impact to compare dissimilar mitigation strategies. By slicing the data by types of work and stakeholders, analysts can see what is closing the most gaps, validating applied credits with technical authorities, and communicating across stakeholders to ensure investments are of the correct magnitude throughout the lifecycle of the safety initiatives.

Paul Amyotte with Dalhousie University presented “Current Status of Nanopowder Dust Explosion Research: A Critical Review.” Use of powders in the nm-range in industrial settings has increased due to the unique properties exhibited by these materials. This increase in demand for nanopowders in industry has led to a greater need for an understanding of the safety hazards associated with their use. A hazard that has received significant attention is exposure to skin or inhalation in the lungs, and many guidelines can be found for the safe handling of nanopowders. One important concern that cannot be neglected is the potential for nanopowders to form explosible clouds. Numerous studies have been conducted on this topic for dust with diameters in the micron range; this work has shown that a decrease in particle size corresponds to increased explosion overpressures and rates of pressure rise, as well as heightened ignition sensitivities. By extrapolating these trends to nanopowders, one might expect extreme explosion severity and ignition sensitivity for such materials. High ignition sensitivity has indeed been measured for some nanopowders which display low values of minimum ignition energy (MIE) and minimum ignition temperature (MIT). However, the anticipated significant increase in explosion severity (overpressure and rate of pressure rise) for nanodusts has not been observed in recent laboratory studies. Particle agglomeration is believed to be the major factor for this explosion severity behaviour, since inter-particle forces are much stronger for fine dusts. Some other changes in behaviour exist when moving into the nano-scale that may be affecting experimental results – for example, the high ignition sensitivity of nanopowders has led to pre-ignition of the powder upon dispersion in some cases. The presentation provided an overview of the openly available research conducted to date on the explosibility of nanopowders and its relation to process safety, and concluded with some
thoughts on ongoing and further research requirements.

Scott Davis with GexCon presented “Scaling of Metal Dust Explosions.” Dust explosions hazards have been addressed in a number of standards and guidelines aiming at supporting industry to work safely (including NFPA 61, 68, 69, 654 and 484). These standards are partly based on research carried out through the years. Experiments have been carried out, with many being conducted on the large scale, to understand how dust explosions develop and progress. Protective systems have also been developed and tested to reduce the potential consequences of dust explosions. The overwhelming majority of these experiments were conducted with organic dusts, and very little work has been performed using metal dusts. Metal dust explosions may behave differently from organic dust on large scale due to the contribution of radiation to the flame propagation mechanism. Radiation levels caused by especially light metal flames can be very high due to high flame temperatures. The incident radiation at a position ahead of the flame is related to the size of the flame ball, and hence it is scale dependent. This presentation discussed a theory demonstrating that flame propagation rates in clouds of light metal dusts are expected to be scale-dependent and that a KSt-value determined in a 20-l sphere may underestimate dust explosion effects on an industrial scale. The presentation reviewed large-scale dust explosion experiments performed with metal dusts supporting the theory.

Zhe Han with MKOPSC presented “Study of Ammonium Nitrate Thermal Hazards with Additives.” Ammonium nitrate (AN) has been widely used as a fertilizer for decades and is considered one of the best nitrogen sources for plants. However, AN explosion hazards continue to occur time and again, despite the fact that AN has been investigated for several decades. There have been more than 70 AN-related incidents during the last century, the most recent of which occurred on April 17, 2013, in West, Texas. The explosion at the West Fertilizer Company occurred 21 minutes after the fire was reported, killing 15 people and injuring more than 250. The plant was completely destroyed by the blast wave, along with damage to buildings, businesses, and homes far from the facility. The incident reemphasized the dire need for further research on AN reactive hazards. This research focuses on the alternatives to make AN safer as a fertilizer by reducing its explosivity. The Reactive Systems Screening Tool (RSST) has been used to study the thermal decomposition of AN in the presence of different types of inhibitors, including sodium hydrogen carbonate, potassium carbonate, and ammonium sulfate. The RSST is capable of handling a few grams of sample, which is almost three orders of magnitude more than the Differential Scanning Calorimeter (DSC), which tests a few milligrams of sample. The experimental data are compared to the DSC data published in literature.

Dzulkarnain Zaini with Universiti Teknologi PETRONAS presented “Inherent Safety Quantification for Toxic Release at Preliminary Design Stage.” This work proposes a new technique that can quantify the level of inherent safety for process routes, streams and evaluate the inherent risk for toxic release accidents during the preliminary design stage. The combination of the above techniques is known as 3-Tier Inherent Safety Quantification (3-TISQ). The 3-TISQ allows for risk reduction through the implementation of inherent safety principles and to quantify and prioritize the level of inherent safety of the process route and stream, determine the inherent risk and modify the design up to the acceptable level.

Olav Hansen with Lloyd’s Register presented “Estimation of Explosion Loading on Equipment from CFD Simulations.” For oil and gas facilities offshore, and often onshore, the computational fluid dynamics (CFD) tool FLACS is usually applied, while others use simple blast curve formulations, like the TNO-Multi Energy Method. The purpose of the explosion studies is usually to give guidance on required design strength of equipment, piping, blast walls or buildings during design. One key element is to translate the results from an explosion simulation into actual forces on equipment. For CFD studies loads on large objects that can be properly resolved on the grid, can usually be well estimated by reporting differential pressures across the objects. For objects with key dimensions less than 2-3 grid cells (typically ~1m-2m), and in particular less than 1 grid cell, this approach is not feasible. Industry guidance exists on how to estimate explosion loads on piping and smaller equipment using a drag force formulation. This presentation discussed how the current guidance may lead to too low predicted explosion loads on equipment, and more precise methods for load prediction onto piping and small equipment are thereafter proposed and evaluated. The presentation detailed a feasibility study and its cooperation with industry.
Alejandro Torres-Echeverria with Risktec Solutions presented “On the Use of LOPA and Risk Graphs for SIL Determination.” Safety Integrity Level (SIL), as defined in ANSI/ISA S84.00.01 (IEC 61511-mod), is a widely used safety performance measure for safety instrumented functions. The standard ISA S84.00.01 suggests several methods for SIL determination, ranging from fully quantitative methods to fully qualitative methods. The large number of safety functions to evaluate during plant design and the need to integrate multidisciplinary design and operation knowledge to achieve effective risk reduction, has made necessary the use of multi-disciplinary-team workshop approaches. Two widely used methods in the O&G industry for SIL determination are Layer of Protection Analysis (LOPA) and Risk Graphs. Each of these methods has their own advantages and disadvantages. LOPA allows the required risk reduction to be incorporated into the SIL values with higher precision. This enables a more detailed consideration of the available protection layers and leaves an objective traceable record of the decision-making process. In contrast, the simplicity of Risk Graphs makes them convenient for screening a large number of safety functions. This can make Risk Graphs useful as a first screening pass prior to using LOPA. However, Risk Graphs are still widely used as a stand-alone method. This presentation explored the differences between LOPA and Risks graphs and to investigate whether the Risk Graphs method can provide the same level of SIL determination rigor as LOPA.

Qingsheng Wang with Oklahoma State University presented “Prediction of Fire Behavior and Properties of Polymer Composites using Mathematical Modeling.” Prediction of thermal behavior of polymers relies on experimental analysis as their behavior varies with external heat flux they are exposed to and their composition. Desired data is obtained but it has its own time, equipment and cost implications. On the other hand a mathematical model derived from a series of experiments, can make determination and reproduction of fire behavior independent of experiments. Mathematical model equations have been developed and validated by Luche et al. based on first principals of mass and energy balance. These models relate external heat flux with ignition time and averaged specific mass loss rate for polymer exposed to pyrolysis condition. The models have been validated for Poly Methyl Meth Acrylate (PMMA). We have validated their work with other literature data for PMMA, resulting in good resemblance. We intend to apply the model to other commonly used polymers such as Polyethylene, Polystyrene, Polypropylene and polymer composites. Basically these models are equations of straight line which relate ignition time and specific mass loss rate to external heat flux with help of physical and thermal properties of polymer. This approach can serve two distinct purposes. First being that, we can predict the thermal behavior of given polymer independent of any experiments just based on its properties and heat flux based on the applicable fire scenario. On the other hand for a given polymer composite whose thermal & physical properties are not readily available, we can determine its thermal inertia by performing couple of cone calorimeter tests. So, this concept can serve efficiently, as one particular polymer and or its composites only need one set of experiments and then that data can be readily applied for future works. Physical and thermal properties which are dealt within model equation are thermal conductivity, specific heat, vaporization heat, etc.
The Instrumentation and Automation Symposium for the Process Industries, now in its 70th 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 400 attendees at the 2014 Symposium.

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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
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SENG 312/674: System Safety Engineering
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.

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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.

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Calendar of Events

Short Courses

**1162—Alarm Management**
Instructor: Mr. Mike Carter  
Date: February 2-3, 2015  
Location: SIS-TECH Solutions, Houston TX

**2052 Process Hazard Analysis Leadership Training**
Instructor: Mr. Watson Dupont  
Date: March 11-12, 2015  
Location: SIS-TECH Solutions, Houston TX

**4232—Dust Explosion Hazards**
Instructor: Dr. Scott Davis  
Date: TBD  
Location: TBD

**3102—Pressure Relief Systems**
Instructor: Dr. Nancy Faulk  
Date: March 18-19, 2015  
Location: SIS-TECH Solutions, Houston TX

**3151—Disposal Systems Analysis**
Instructor: Mr. Ben Pratt  
Date: March 20, 2015  
Location: Siemens, Houston TX

**2073—SIS Implementation**
Instructor: Mr. Bill Hearn  
Date: March 24-26, 2015  
Location: SIS-TECH Solutions, Houston TX

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