Mary Kay O'Connor Process Safety Center

Chemical Engineering Division of the Texas Engineering Experiment Station

The Texas A&M University System

Centerline

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SPRING 2009

INSIDE

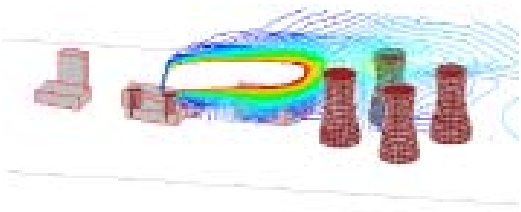
Alumni Reunion

Welcome Back! The Center hosted its Second Annual Alumni Reunion in January of this year. The event was attended by over one hundred alumni, staff and current students of the Center. *See page 5 for more.*

MKOPSC and US Dept. of Homeland Security Host Inherently Safer Technology Workshop

The Mary Kay O'Connor Process Safety Center and the U.S. Department of Homeland Security co-hosted the workshop "Partnering for the Development of Inherently Safer Technologies and Alternatives" in Houston on January 15, 2009. The purpose of the workshop was to provide stakeholders an open forum with DHS for discussions of Inherently Safer Technology (IST), methods and implementation. A primary objective of the workshop was to develop partnerships between stakeholders and to develop methodologies leading to cost-effective implementation of inherently safer approaches to reduce hazards and risks of industrial systems.

3D Simulation in Risk Analysis Studies



Contributed by Fluidyn, this article discusses the applications of a CFD approach to 3-D modeling for precise evaluation of the dynamics of dispersion, explosion and fires in open, semi-confined or confined surroundings. *See article on page 14.*

Director's Corner

A Note of Thanks to Irene Jones

It has been my distinct pleasure to have known and worked with Irene Jones for almost 20 years. I first got to know Irene through our interactions at the Texas Chemical Council Safety Seminar. Over the years she and George have become personal and cherished family friends. Words cannot describe my gratitude to her for her friendship as well as her support of process safety activities in general and the activities of the Mary Kay O'Connor Process Safety Center in particular. Irene's commitment to process safety has always been very personal and sincere.

Within the context of improving safety in the process industry and making safety second nature, I and many others at the Center have had the pleasure of working with Irene on many issues. Her extensive knowledge of chemical process safety hazards has been instrumental in giving substance, content, and credibility to many of the activities of the Center. Throughout the industry, Irene not only enjoys the highest regard of practitioners and researchers, but also is equally well regarded by all stakeholders. Because of her knowledge, passion, and commitment to chemical safety, Irene Jones is sought after for input on important issues with regard to workplace safety in the chemical industry.

On a personal note, Irene has always been there with advice and support whenever I have sought it. As an example, I remember the time that I was contemplating my transition from industry back to academia. Naturally I was going through a lot of confusing thoughts and emotions as I was trying to make this major decision. One again, Irene's well thought out advice and input helped me make the transition. I am indebted to say that once the decision was made, she continued to help me and the Center each step of the way. I can say without reservation that my life and career has been enriched because of my interactions with Irene Jones. Her retirement will definitely be felt at Huntsman, the Mary Kay O'Connor Process Safety Center, and the process safety world at large. To remember her many contributions, I attach some pictures which speak for themselves.

M. Sam Mannan
January 30, 2009

Thanks Irene!
Happy Retirement!

DISTANCE LEARNING

Safety Engineering Courses Fall 2009

The Mary Kay O'Connor Process Safety Center (MKOPSC) is offering the following safety education and process safety engineering courses in Fall 2009, via the Petroleum Engineering Department's Distance Learning Program.

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

Fall 2009 Offerings

CHEN 321 - SENG 321: Industrial Safety Engineering - Instructor: Dr. Ray Mentzer

Concepts of designing, operating and maintaining optimally safe systems, risk management, economic impact, legislation, performance measurement and accident investigation/analysis; principles and practices in industrial hygiene engineering, fire protection engineering, and introduction to systems safety engineering. Prerequisite: Junior classification.

SENG 422: Fire Protection Engineering - Instructor: Thomas Sturtevant

Fire protection design concepts and considerations for chemical, petrochemical and hydrocarbon processing facilities. Special attention given to fire hazard analysis, fire risk assesment, fire protection features, and emergency response. Specifice fire protection design considerations are studied for the various types of facilities and processes. Prerequisite: Instructor approval

CHEN 430 - SENG 430: Risk Analysis in Safety Engineering: - Instructor: Dr. William J. Rogers

Concepts of risk and risk assessment, which uses all available information to provide a foundation for risk-informed and cost-effective engineering practices; examples and exercises are drawn from a variety of engineering areas. Prerequisite: Junior or senior classification.

CHEN 455/655 - SENG 455/655: Chemical Process Safety - Instructor: Dr. Sam Mannan

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

To register for a course, contact:

Mary Lu Epps
Texas A&M Petroleum Engineering
3116 TAMU - 407 Richardson Building
College Station, TX 77843-3116
Phone: (979) 458-4297
E-mail: marylu.epps@pe.tamu.edu

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

Distance Learning Objectives

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

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

http://psc.tamu.edu/education/safety-engineering-program

2nd Alumni Reunion Held in January

The Center hosted its Second Annual Alumni Reunion in January of this year. The event was attended by over one hundred alumni, staff and current students of the Center. The alumni learned about the ongoing projects being conducted as each student gave a presentation about their research. The current students then had the privilege of learning about the careers and experiences of the alumni in the process safety industry and academia.

Also attending the event was Chemical Engineering Department Head, Dr. Michael Pishko, Associate Dean of Engineering, Dr. Hall, Mr. Michael O'Connor and Mr. Mike Sawyer.

After the formal introductory session in the afternoon, the alumni toured the center library and the research laboratories. A poster competition was held with the alumni judging posters submitted by the graduate students. Prizes were awarded to the top three research posters. Following the festivities, the alumni, staff and students of the center attended a dinner, held at the University Apartments Community Center.

Recent Publications

1. Díaz-Ovalle, C.O., R. Vázquez-Román y M.S. Mannan, "Determinación de los Factores del Peor Escenario en la Emisión de Gases Tóxicos, Información Tecnológica," vol. 20, no. 1, pp. 3-10, 2009.

2. Henning, J. B., C.J. Stufft, S.C. Payne, M.E. Bergman, M.S. Mannan and N. Keren, "The influence of individual differences on organizational safety attitudes," Safety Science, vol. 47, no. 3, March 2009, pp. 337-345.

3. Liu, L., C. Wei, Y. Guo, W.J. Rogers, and M. Sam Mannan, "Hydroxylamine Nitrate Self-Catalytic Kinetics Study with Adiabatic Calorimetry," Journal of Hazardous Materials, vol. 162, no. 2-3, March 2009, pp. 1217-1222.

4. Mannan, M.S., T.M. O'Connor and N. Keren, "Patterns and Trends in Injuries Due to Chemicals Based on OSHA Occupational Injury and Illness Statistics," Journal of Hazardous Materials, vol. 163, no. 1, April 2009, pp. 349-356.

Mannan Receives Norton H. Walton/ Russell L. Miller Award

Dr. M. Sam Mannan, professor in the Artie McFerrin Department of Chemical Engineering at Texas A&M University, has been selected by the Safety and Health Division of the American Institute of Chemical Engineers (AIChE) as the recipient of the Norton H. Walton/ Russell L. Miller Award for 2009.

The award recognizes an individual's outstanding chemical engineering contributions and achievements in the fields of loss prevention, safety and health. Mannan will be honored at this year's AIChE spring meeting April 27 in Tampa, Fla.

Prof S. Mannan and Prof H. Pasman Visit Lodz Technical University in Poland

By Prof. Adam S. Markowski, Head of Process Safety and Ecological Division at TU Lodz

International Scientific Symposium on 10th Anniversary of post graduate study "Industrial Processs Safety" was organized at the Technical University of Lodz, Poland on 12th of December 2008. During opening session the Medal of Honor of the Technical University of Lodz was presented to internationally recognized process safety expert Prof Sam Manann, Director of the MKOPSC-TAMU by Rector of the Technical University Prof S. Bielecki. The significant contribution to the scientific cooperation between our Universities as well as recognition of his support to the process safety education and research in the Technical University of Lodz were a principal of that award.

During the Symposium, attended by about 200 participants from industry and students, prof. S. Mannan presented the paper titled "Buncefield Fire" and Prof H. Pasman the paper: "Risk analysis: History, Problems and Perspective", which were met with a big interest among the participants. The Symposium was successful in presenting a future risk analysis technology as well in conformation the meaning of the close cooperation between MKOPSC Texas A&M University and TU Lodz in development of better approaches to process safety analysis.

As usual in TU Lodz, the Symposium were accompanied with vernisage of Art Gallery : "Shortly and Knotty" where well known Polish painter Mrs J. Schmidt presented wonderful pastel paintings. The presentation of arts and music are considered in our University as essential contributing factors in development of the imagination so important in application of the process safety methods.

We thank you very much to professor Sam Mannan and professor Hans Pasman of the MKOPSC for their interesting presentation and visit to Lodz Technical University, Poland.

Roy Sanders at MKOPSC

Mr. Roy Sanders spent a week at the Center in February. He presented guest lectures to students in Process Safety and Safety Engineering academic couses, and spent time with many of the MKOPSC graduate students. On Tuesday, February 10, 2009, Mr. Sanders gave an interactive presentation for Center personnel. The presentation, entitled What Went Wrong, Learning from Case Histories, covered the fundamentals of Chemical Process Safety and provided a practical awareness of chemical process risks and how to effectively deal with these risks. MKOPSC appreciates Mr. Sanders' time and effort.

Spring Visitors to the Center

The Center welcomes **Dr. Hans Pasman**, Research Professor, and **Dr. Simon Waldram** and **Tomasz Olewski** from TAMU-Qatar, as they visit the Center to discuss collaborative research.

AIChE Spring National Meeting

Mannan Presents Keynote at 9th Topical Conference on Gas Utilization Luncheon

Dr. Sam Mannan will give the keynote address at the 9th Topical Conference on Gas Utilization Luncheon held in conjunction with the AIChE 2009 Spring National Meeting. The conference will be held on Wednesday, April 29 at the Tampa Convention Center in Tampa, Florida. Dr. Mannan will present "Recent Advances in LNG Field Experiments and Modeling of LNG Release and Mitigation Scenarios."

Papers being presented by MKOPSC graduate students at the Spring National meeting are: "Will a Molecular Simulation Approach Help You Predict Thermodynamic Properties?" presented by **Qingsheng Wang**; "Approach for the Development of a More Efficient and Safer Process in the Pharmaceutical Industry," by **Lina Saenz**; "Absorption Characteristic of LNG as a Function of IR Wavelength," by **Carolina Herrera**; "Reaction Mechanism of CHP Decomposition and Its Application to Reactivity Hazards Evaluation," by **Yuan Lu**; "Water Curtain Application for Forced Dispersion of LNG Vapor," by **Morshed Rana**; "Study on the Heat Transfer of Expansion Foam on LNG Pool," by **Geun Woong Yun**; and "LNG Vapor Dispersion Consequence Modeling with CFD Codes," presented by **Ruifeng Qi**.

SOCMA Safety and Security Committee

The U.S. Department of Homeland Security (DHS) plans to issue Chemical Facility Anti-Terrorism Standards (CFATS) tier confirmation levels to U.S. manufacturing facilities over the coming months. In advance of this development, all SOCMA members in the Houston area attended the March 12 Safety & Security Committee meeting in Houston. The Chemical Sector Infrastructure Security Compliance Division of DHS, along with process safety expert **Sam Mannan**, briefed SOCMA members on CFATS developments, Site Security Plans and inherently safer technology (IST). Mannan informed the group about his research on inherently safer technology.

First Harry West Fellowship Awarded

MKOPSC graduate student, **Mahdiyati,** was the first recipient of the *Harry West Memorial Endowment for Process Safety* fellowship, for the spring 2009 semester. The endowment was established in memory of Harry West, a long time friend of the Mary Kay O'Connor Process Safety Center. He was an advocate for the process safety industry and he was devoted to its innovation and advancement. The initial gift by Mr. and Mrs. T. Michael O'Connor was provided to support students of the Mary Kay O'Connor Process safety Center through scholarships or fellowships pursuing academic and research programs in process safety.

MKOPSC Student Serves as Interpreter for Korean Delegation

The Committee on Accreditation for the National Professional Qualifications Board (ProBoard) recently conducted a site visit at the Seoul Fire Service Academy (SFSA) in Korea.

Following the visit, several members of the SFSA traveled to the US to attende a ProBoard conference on January 24, 2009 in Houston. **Seungho Jung,** MKOPSC student, attended a dinner/reception held for the Korean delegation. Said Thomas Sturtevant, program director at TEEX Fire Protection Training Division and ProBoard member, "Seungho attended the dinner/reception to assist with translation. I appreciate his willingness to help and also the continued benefit of our two organizations working together."

Management Corner:

Why Your Employees Seem to be Doing What You Don't Want Them to Do

Mindy E. Bergman, Department of Psychology, Texas A&M University

Management sets the direction of the company and the people in it. After all, organizational goals cannot be accomplished if the people inside the organization aren't working toward them. But many managers become confused, frustrated, and even angry when it seems employees ignore the firm's vision and act in ways that go against organizational goals. This management corner reviews some reasons why by drawing on the classic paper, "On the Folly of Rewarding A while Hoping for B" by Steven Kerr (full citation listed below)—a highly readable academic article from the organizational sciences.

One of the most basic facts about human behavior is that people act to gain pleasure and rewards and to avoid cost and punishment. However, there can be disconnects between intended and actual contingencies between action and rewards/punishments. For example, management might explicitly say that all injuries should be reported and that no one who reports an injury will be punished by the organization. However, the reporting process itself might be require a lot of time and effort, so the worker has to stay after hours or must be pulled away from his or her "real work" and fall behind when making a report. Reporting might also mark the employee as a "tattletale" among peers. And, if there are rewards tied to consecutive no-injury days—whether there are bonuses, parties, or simply pride in working at a safe place—the worker, peers, or supervisors might react negatively to injury reports.

It is essential that rewards and punishments align with the actual behaviors that will lead to organizational goals. Management must not only consider what they are explicitly rewarding and punishing but also what they are implicitly rewarding and punishing. Some roadblocks include:

(1) *Goal displacement*, or when people focus on the means for achieving the ultimate goal rather than the ultimate goal itself. In the example above, this would be focusing on the number of days without an injury report, rather than the actual lack of injury.

(2) *Failure to make meaningful differentiations between different levels of performance*. Imagine that it is expected that the average raise in the company is 5% per annum, but top performers get 6%, above average get 5%, and everyone else gets 4%. This does not encourage employees to become top performers, because "getting by" will earn a worker nearly the same raise as those workers who are "doing their all."

(3) *Focusing too much on objective data*. Some organizational activities are easier to measure than others. For example, it is much easier to count absences than it is to observe and monitor compliance with safety guidelines. Managers do not like to make judgments about their employees. Our society places a premium on being fair. Together, these cause managers to focus on objective data rather than desired behaviors. Keep this issue in mind when considering absence in a performance review. It is absolutely the case that employees need to be present to perform, but presence at work does not ensure good performance.

(4) *Too much attention on highly visible behaviors*. Some parts of performance are easier to see than others. For example, it is much easier to observe whether employees are wearing their PPE than whether they are thinking about safety in every action they perform. So, we emphasize the visible behaviors in our reward systems. Although we are interested in employees doing these visible behaviors, that's not all we want from them. And, importantly, we want them to understand the principles behind the expected behaviors and live up to these expectations, rather than just "work to rule."

(5) *Hypocrisy*. Despite best intentions, management can be hypocritical when it comes to rewards. Even though managers say that they want employees to "tell it like it is," not all managers really want to hear it. When an employee tells a hard truth to a

(Mgmt Corner, Cont'd)

manager, the manager might subtly punish the employee by being less kind or by providing fewer positive or greater negative observations about the employee's work. What does the employee learn to do? Alter the message to convey what the manager would rather hear.

(6) *Other important values compete with the desired behaviors*. There are a number of competing values within any organization's culture. For example, some workplaces spread around the less-favorable tasks, so everyone equally shares in the dirty work. But some of workers are better at these tasks than others. On one hand, it is not fair to make some workers do the less desirable jobs more often. On the other hand, it is not efficient to have everyone take a turn. What is the right choice? From an economic standpoint, the efficient choice is the right one. But good management is not solely about economic justifications. Although there is no right answer to this problem, it is important that management is aware of this dilemma.

In sum, this management corner is designed to encourage you to ask the question: *What are we* **really** *rewarding around here?* When your workers seem to be acting in ways that go against corporate goals and policies, a closer look might show that your workers are in fact acting exactly how your reward system encourages them to act. To rectify the situation, changes are needed top-down to the managerial message and the reward system—both formal (e.g., pay) and informal (e.g., encouragement, praise)—so employee behavior aligns with organizational goals.

Reference:

Kerr, S. (1975). On the folly of rewarding A, while hoping for B. *Academy of Management Journal, 18,* 769-783.

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Case History Presented by MKOPSC Graduate Student December 17th Steering Committee Meeting

Formosa Plastics Vinyl Chloride Monomer Explosion

Presented by Katherine Prem

On April 23 2004, an explosion and subsequently a fire resulted in the Minneapolis plant of Formosa Plastics. The incident resulted in five fatalities and three injuries. The Vinyl Chloride Monomer (VCM) reactor facility and the adjacent storage area were completely destroyed. In addition, about 150 residents in the vicinity of the plant were evacuated for two days. Following this incident the facility was shut down and has not been rebuilt.

The incident occurred during a normal cycle of cleaning procedure of the reactor following the manufacture of VCM. The operator cleaning the reactor accidentally opened the bottom valve on the wrong reactor which was still manufacturing VCM. The bypassing of the safety interlock led to the release of a large number of hot VCM which ignited resulting in an explosion and subsequent fire.

Chemical Safety Board (CSB) investigation revealed inadequate training of workers to evacuate employees in time. Only one safety interlock existed to prevent the reactor bottom valve from being opened and that could easily be bypassed. All reactors were similar and clustered together. Any type of gauges, indicators or warning lights were lacking on the reactors. The operators had no access to radio to check the operational status of the VCM reactors. All these factors increased the possibility of human error.

Based on their findings, the CSB made recommendations to be implemented throughout the Formosa Plastics Corporation. Formosa plastics had to review the design and operation of all existing U.S. PVC facilities. The designing of the chemical processes so as to minimize the possibility of human error and its consequences were stressed. The overall improvement of safety interlock control was advised. Owing to the lack of proper PHAs, the corporation was urged to perform thorough evaluation of all hazards especially the high risk hazards. All near-misses were to be followed by consequence investigations. In addition, improvements on the emergency response and evacuation training along with periodic drills were recommended to the corporation.

Trevor's Corner No.10

DOES ANYONE REMEMBER THIS FIRE?

The fire described below occurred many years ago at a road tanker filling station belonging to one of the World's largest oil companies. The report contains messages that may apply to you today even if you don't operate any filling stations.

Automatic equipment had recently been installed for loading road tankers. The grade and quantity required were set on a meter; the driver inserted a card which indicated that he was authorised to draw product and then pressed the start-button; an automatic valve then opened; when the required quantity had been delivered, it closed. The filling arm had first to be lowered as the pump was started by a switch attached to the arm.

A manual valve was installed in each filling arm for use when the automatic equipment was out of order. To use the manual valves the automatic valves had first to be opened and this was done by operating a series of special switches in the control room. These were kept in a locked cupboard and a notice on the cupboard door reminded the operators that before they opened the automatic valves they must first check that the manual valves were closed.

On the day of the fire the automatic equipment broke down and the supervisor decided to change over to manual filling. **He asked the drivers to check that the manual valves were shut and then operated the switches to open the automatic valves.** Some of the manual valves were not closed and gasoline and other products came out of the filling arms and either overfilled the tankers or splashed directly on the ground. The gasoline caught fire and as a result three men were killed and eleven injured and the whole row of eighteen filling points was destroyed.

The official report includes the following:

The decision to override the individual controls on the loading arms by means of a central switchboard, without the most rigid safeguards, was a tragic one. After its installation an accident from that moment on became inevitable sooner or later.

That this switchboard was installed, with the approval of the terminal management and with the knowledge of the Company's safety officer, in a switch room from which the loading stands were not visible, suggests some failure to take into account the basic fundamentals of safety in operation of plant.

It would have been expected that the installation of sophisticated equipment would have demanded concurrently an organised system of training for all personnel... On occasions even when training sessions were arranged no-one turned up, as personnel were unable to be spared from the daily operational tasks of the Terminal.

Had the same imagination and the same zeal been displayed in matters of safety as was applied to sophistication of equipment and efficient utilisation of plant and men, the accident need not have occurred. 1 2

Some very curious beliefs were expressed to me during the course of the enquiry, notably by the drivers. It would seem, therefore, to be of advantage to give all personnel some instruction in the properties of highly flammable liquids, in the hazards to which they give rise and how they can be minimised. This would lead to a better understanding of the rules which are laid down to ensure safety in handling these liquids, and would probably promote a better acceptance and observance of the rules to the increased safety of all concerned.

Many managerial instructions have to be issued to staff. As the control staff are very busy people it would help in their control of plant, and have an influence on safety, if all instructions were codified and put in ready reference files, so doing away with the bundles of unsorted documents that were handed to me for study.

Some system of regular supervision of operations and regular inspection of equipment and services should be instituted in order to maintain proper safety standards.

Some general thoughts: When someone in the control room takes an action, can anyone see that it has had the

(Trevor's Corner - cont'd.)

desired effect? For example, has the right pump stopped or started?

Do you have bundles of unsorted papers in your control room (or anywhere else)? Are permanent instructions mixed up with temporary ones?

Do you allow vehicle drivers and other non-employees to operate equipment and if so what training do you give them and do you check their knowledge and understanding?

Before you allow anyone to put liquid into a tanker or other vessel does anyone check that there is enough room? Spillages have occurred because some liquid has been left in a vessel or because the filler thought there was one tank in a tanker when there were two or more.

Do you realise that people often ignore instructions such as checking that all valves are closed, especially if they have checked a few times and never found anything wrong? In the case described it would have been possible to install interlocks so that the automatic valves could not be opened or the pumps started, if the hand valves were already open.

Finally, a reminder that many similar incidents are described in the ICI monthly Safety Newsletters, going back many years. They are available for free download at www.icheme.org. Follow the links to "Safety," "Safety Newsletters," "More Details…," and complete the online order process (including registration). The Institution of Chemical Engineers will send you an email containing a link for download. I suggest you download the lot, not just one or two

Does anyone remember this fire or know about it, apart from the relatives of the men who were killed? I would like to know.

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Case History Presented by MKOPSC Graduate Student February 12th Steering Committee Meeting

Synthron Chemical Explosion, Morgantown, NC, 2006

Presented by Linh Dinh

On January 31, 2006 an explosion occurred at Synthron Inc, a paint additive chemical manufacturer's plant in Morgantown, North Carolina.

The accident occurred when plant managers attempted to fulfill an order for acrylic polymer that exceeded the normal batch size for this product. Instead of making two smaller batches to fill the order, managers decided to make a single, larger batch. He also decided to add all the extra acrylic monomer during the first stage of the reaction process, which was a critical mistake. The effect of the changes released more than doubled the rate of energy in the reactor, exceeding the cooling capacity of the reactor condenser and causing a runaway reaction. The reactor pressure increased rapidly. Solvent vapors vented from the reactor's manway, forming a flammable cloud inside the building. The vapors found an ignition source, and the resulting explosion.

In the end, 14 people were injured in the blast, of whom one man later died. The blast destroyed the facility and broke windows up to one-third of a mile away. Synthron filed for bankruptcy following the accident, and the facility has not been rebuilt.

At Synthron, management of reactive chemical hazards was inadequate. The facility was unprepared for a chemical process emergency. The accident at Synthron emphasizes the need for effective corporate oversight, emergency planning, and reactive chemical process training and safeguards.

Texas A&M at Qatar Starts BP Sponsored Research Project on LNG Safety

DOHA, Qatar — Texas A&M University at Qatar (TAMUQ) and BP announced the start of a $3 million research project for an initial five-year period, studying liquefied natural gas safety.

The project establishes a top-tier LNG safety research program in collaboration with Qatar Petroleum and the Qatar Foundation. Dr. Simon Waldram, Senior Professor of chemical engineering, and Dr. Ahmed Abdel-Wahab, Senior Assistant Professor of chemical engineering, will lead a team of postdoctoral researchers, graduate students and undergraduate students under the guidance of PI Dr Sam Mannan, Regents Professor of Chemical Engineering and Director of the Mary Kay O'Connor Process Safety Centre in College Station.

"LNG processing and transportation are some of the key pieces of Qatar's industrial jigsaw, and much of the remainder of Qatar's economy are based on these foundations," Waldram said. "Our research will develop new safety procedures and standards that will permeate the land based gas industry in Qatar."

The experimental part of the LNG research will be conducted at the new facilities of the Ras Laffan Emergency and Safety Training College being built by QP, Abdel-Wahab said. "Highly instrumented, large-scale studies of real LNG spills, dispersion and fires will be conducted under carefully controlled conditions," he said. Data from these experiments will be modeled and interpreted using Computational Fluid Dynamics (CFD) software.

Dr. Brian Hunter, country manager for BP in Qatar, and Dr. Jim Holste, Associate Dean for Research and Graduate Studies at TAMUQ attended a ceremony to mark the start of the research at the Qatar Offshore Conference and Exhibition. Chemical Engineering students Mohammed Albaker, Omar Basha and Raid Hassiba, undergraduate student researchers on the project, were also present.

"The research program, the first of its kind in Qatar, also aims to provide a new opportunity for home grown graduates educated at the Qatar Foundation and seeking to develop their talents further through research and innovation while at the same time contributing to the science of safety in Qatar's global LNG industry," Hunter said. "It is therefore a great pleasure to mark the appointment of our first research undergraduates who I am sure will contribute greatly to the program."

Albaker, in his Senior year of chemical engineering and from Qatar, said he is excited to participate in the LNG safety research project. "The results of this research can help increase the LNG output in Qatar, and that would have a positive impact on my country's growth and development."

The new project complements a separate research program, also funded by BP, at the University's main campus in College Station, Texas. "I am pleased that the years of LNG research collaborations with BP and the Mary Kay O'Connor Process Safety Centre has helped lead to this project with TAMU-Qatar," said Mannan. The Centre graduate students and research staff will travel to Qatar to work on this project as well. In addition, staff and students from TAMUQ will travel to the Centre to observe the set up of LNG tests at the Brayton Fire School.

About Texas A&M at Qatar

Texas A&M University, recognized as having one of the premier engineering programs in the world, has offered undergraduate degrees in chemical, electrical, mechanical and petroleum engineering at Qatar Foundation's Education City campus since 2003. Thirty-four engineers have graduated from Texas A&M at Qatar since 2007. In addition to engineering courses, Texas A&M University at Qatar provides supporting classes in science, mathematics, liberal arts and the humanities. The curricula offered at Texas A&M at Qatar are materially identical to the ones offered at the main campus in College Station, Texas, and courses are taught in English in a co-educational setting. The reputation for excellence is the same, as is the commitment to training engineers equipped to lead the next generation of engineering discovery. Visit www.qatar.tamu.edu to learn more about Texas A&M at Qatar.

FLUIDYN 3D Simulation in Risk Analysis Studies

By Bobby Kaushik, Amita Tripathi, Claude Souprayen

Introduction:

Currently France is witnessing one of the biggest court trials in its industrial history, that of the accidental explosion at an ammonium nitrates storage facility of Toulouse on September 21, 2001 causing thirty fatalities with thousands injured. It is hoped that this trial will finally shed some light on the circumstances of this explosion. But even without this insight, the AZF explosion has had long-lasting consequences in the French and European industrial landscape. A new safety regulatory policy on the technological risk assessment, control and management has been adopted by the French government. The previous regulations in the frame of SEVESO relied on quantifications of large-scale scenarios so that other scenarios with lesser consequences were not studied in depth. One of the significant aspects of this new law enforcement requires investigating all "realistic" scenarios and putting appropriate measures in place.

This new awareness leads in turn to a need for higher performance tools than the statistical, analytical and empirical methods traditionally used for the realistic estimation of consequences of catastrophic events such as toxic and flammable gas dispersion, gaseous explosion and fires. The computational fluid dynamics (CFD) approach is based on physical description of the phenomena. It takes into account all the forces acting on the fluid, more specifically for dispersion: the convection, gravity forces, viscosity and turbulence. It includes reflections, dissipations, and channeling of the pressure front propagation for explosions. These models have therefore a wider range of applications on time scales, spatial ranges, gas behavior and complex in situ industrial 3D environment than more simplistic empirically tuned formulations.

In this article, we have tried to demonstrate some applications of a CFD approach to 3-D modeling for precise evaluation of the dynamics of dispersion, explosion and fires in open, semi-confined or confined surroundings.

Computational Fluid Dynamics (CFD):

CFD has been developed and used for more than 50 years now, first in aeronautics and now in several industrial processes. In the field of environment and industrial risk analysis, the first projects on CFD were performed in the US as early as the 1960's for the simulation of radioactive products with global weather prediction models. At the time, these models required huge computational power. Their use had been very restricted until the mid-1990's, when new powerful and cheap PC-computing became widespread.

The 3-dimensional digital simulation of disasters putting placing particular concern on flammable or explosive products is now an operational tool that safety experts can use as a decision-making aid. While not replacing experimental tests, modeling provides a complementary technique for cases where no experiment can be achieved such as full-scale large domains, highly varying topography & meteorological conditions or for large toxic releases. The CFD approach can be used to validate assumptions in the root-cause analysis of a disaster. The improvements in data-processing capability and user interfaces make it possible to use these type of models in an industrial setting.

Fluidyn™ Approach:

Fluidyn™ (France, India, UK, USA) was created with the aim of providing high-quality numerical engineering solutions to complex multi-physics applications to European, Asian and American industries, academic institutions and consultancy groups. Fluidyn™ is the exclusive agent of the TRANSOFT™ International group which has developed a large family of software dedicated to fluid dynamics and fluid-structure interaction phenomena. The Fluidyn™ software modules are based on state-of-the-art computational technologies and physical models thanks to close collaboration with renowned universities and research institutes.

Based on the Fluidyn™ general multiphysics software family, a range of software modules has been developed in the fields of Environment and Risk analysis. All the modules are based on 3D fluid dynamics modeling as well as empirical and analytical formulations from industrial know-how. This approach gives extremely reliable results allowing a clear improvement on previous methods. In order to provide quality and timely support, Fluidyn™ has a global network of more than 70 engineers and scientists distributed in agencies in France,

UK, Germany, USA, India, Korea and Japan providing easy access to highly qualified modeling engineers ready to tackle complex problems.

Below are shown applications related to industrial risk focusing on toxic gas dispersion. Other applications shown briefly cover the topics of toxic indoor dispersion, explosion and fires.

Toxic and flammable gas dispersion : fluidyn-PANEPR

The numerical tool Fluidyn-PANEPR, analyses the consequences of accidental dispersion of gaseous and particle releases on the environment for toxic risk or flammable/explosion risk assessment. It simulates the temporal evolution of a pollutant plume by solving 3D Fluid dynamics Navier Stokes equations applied to a curvilinear mesh and by taking into account the terrain and obstacles.

The terrain roughness and the effects of ground occupation parameters on wind-field are also modeled with respect to the areas (urban area, vegetation, water bodies, wasteland). These parameters essentially slow down the wind at ground level and above the ground by friction.

The first step for a CFD dispersion analysis is to create the numerical model of terrain, i.e. the numerical representation of physical reality. It includes:

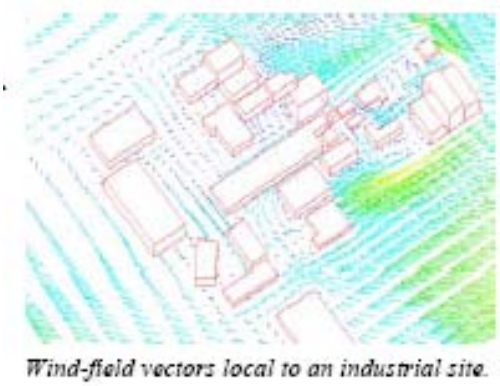
- the topography, obstacles (buildings) and land usage
- meteorological conditions
- emission sources

Numerical model of terrain

The information of the terrain model is usually extracted from the local maps and from the site layouts provided by the industrial client. From this information, the software extracts the 3D information and the altitude contours in the computational domain. Image at right shows a sample terrain.

The vectors of transport and diffusion of the atmospheric pollutants are the air and its movements. A good definition of the weather conditions is fundamental to a proper simulation. They are applied to the limits of the computational domain, and the software calculates the 3D wind-field (velocity and direction) for the transport 3D pattern as well as the turbulent fields necessary to the calculation of the turbulent/random mixing and diffusion, at all points in the domain. Fluidyn-PANEPR is integrated with an elaborate atmospheric turbulence model. It is based on the calculation of sensible heat flux released into the atmosphere and which determines the vertical structure of the atmospheric boundary layer. The total sensible heat flux, based on an energy balance between the radiated solar flux, the heat flux released by human activities and flux absorbed or returned by the ground is a criterion for atmospheric stability (equivalent to Pasquill class). In our 3D CFD simulations, the local variations of the wind-field in the presence of obstacles or momentum sources are taken into account for each wind direction. In addition to atmospheric background turbulence, extra mechanisms such as shear, turbulent wakes, jet induced turbulence etc. are integrated in the turbulence production/dissipation equations.

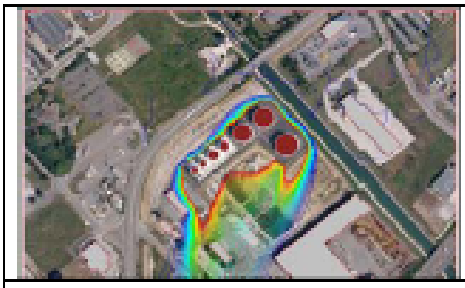
The wind-field is thus largely influenced by the terrain features, varying due to the local roughness parameter of each area cover and the topography and obstacles of the site. Image at right shows wind-field vectors in the domain. Once the wind and turbulence fields are established, the dispersion of gaseous species or particles or mist/aerosols, be it transient or steady-state emission, can be computed. The calculations can also be extended to interiors e.g. confined spaces with the module fluidyn-VENTCLIM.



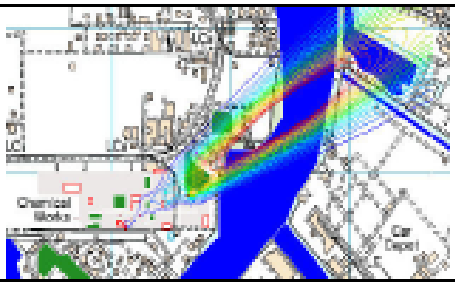
Wind-field vectors local to an industrial site.

Examples of results taken from the software interface for several situations are shown below, including pool evaporation of hydrocarbons/toxic

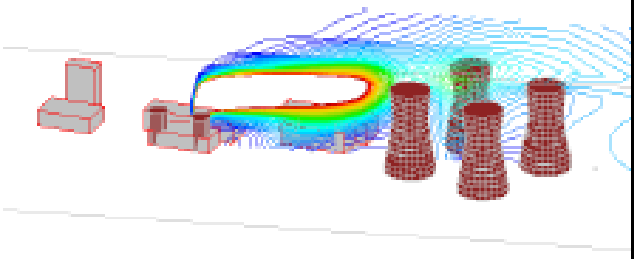
material, release in a nuclear plant and indoor deuterium dispersion. Only a few representative examples are included - a full range of software modules and application examples can be seen at www.fluidyn.com .



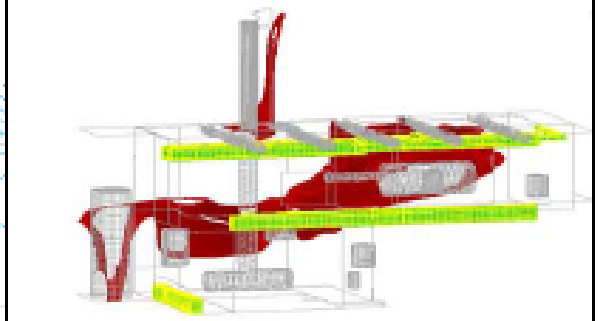
Pool evaporation from a hydrocarbon pool in a bund.



Pool evaporation of toxic material after leakage.



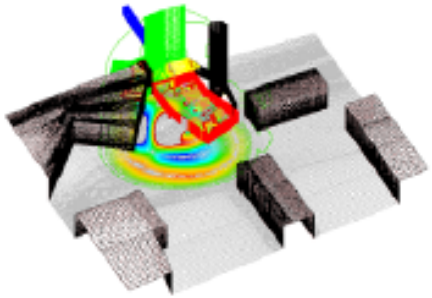
Accidental release on a nuclear plant with cooling towers.



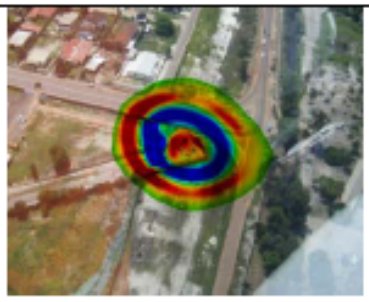
Indoor deuterium accidental dispersion showing region of explosion risk.

Deflagrations and detonations: fluidyn-VENTEX

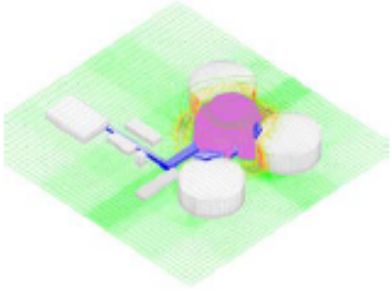
Subsequent to dispersion, the consequences of possible explosion can be evaluated using the VENTEX module. Since the time scales for explosion events are much shorter, specific solvers for fast transient and sharp pressure front tracking are embedded in the program. CFD simulations for explosions can be performed for safety and structural damages assessment. Examples of explosion modeling are shown below for indoor/outdoor gas explosions, unconfined vapor cloud explosion (UVCE) and LNG terminal dispersion/explosion.



Indoor and outdoor gas explosion in building showing hospital heat and vapor production system (in red), mesh, and pressure fronts.



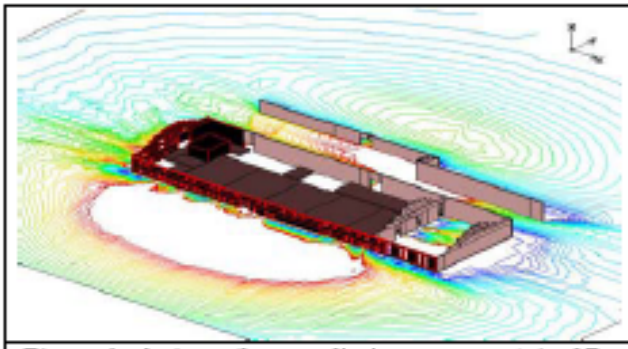
Outdoor gas explosion, UVCE from methane showing optimization and protection wall for roads and houses.



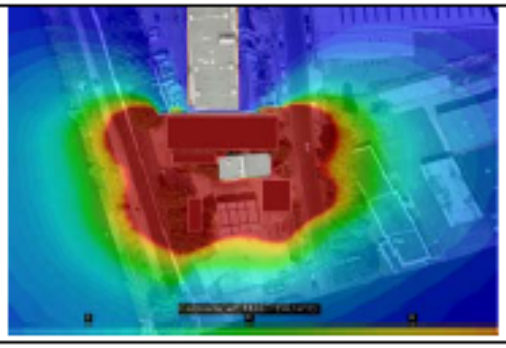
LNG terminal explosion assessment showing leak in piping and subsequent dispersion, on-site propagation and explosion.

Fire & Radiations simulations: fluidyn-PANFIRE

Firewalls and specific layouts for minimizing fire risk are often used for warehouse storage of toxic and flammable solids/liquids. In these cases, simplistic analytical formulations for fire radiation may not give results with sufficient confidence. For these situations, fluidyn-PANFIRE can provide an in-depth analysis of the efficiency of fire walls and/or help in the optimization of storage layout and internal dispatching.



Fire calculations (heat radiation contours) in 3D with fire walls and openings, to restrict to risk to a single side of the warehouse.



Top view of similar warehouse as on left showing heat radiation clouds.

Conclusions:

We have shown that CFD modeling can be a powerful tool in the precise modeling of risk scenarios for process safety experts in chemicals, petrochemicals or environmental industries. We have only presented a few selected examples here of the vast range of applications. The advantage of this approach is that it is physics-based rather than empirical, leading to higher confidence in the results and less conservative estimates of dispersion distances as has been seen in several validation studies. Further, the numerical solvers provide sufficient accuracy without compromising computational time and cost. Also the friendly user-interfaces make the software easy to use for process safety engineers. In addition to process safety, Fluidyn™ also offers CFD modules coupled with heat transfer and fluid-structure modeling for situations in offshore platforms, vortex-induced vibrations and process/reactor design and optimization.

The authors are with the Fluidyn Software & Consultancy Services company; B.Kaushik at the US office in Austin TX & A.Tripathi/C.Souprayen at the Paris, France office.