# International Conference on Safety 2017

*...promoting a culture of safety*

CONFERENCE PROGRAMME

3-6 January 2017

SAFETY CENTRE
IIT GANDHINAGAR

# INTERNATIONAL CONFERENCE ON SAFETY 2017

## ICS 2017 Program Overview

| MAIN CONFERENCE (JANUARY 03 – 04, 2017) | |
|---|---|
| ***January 03, 2017*** | |
| 08:00 - 09:00 | Registration |
| 09:00 - 09:30 | Welcome and Opening Address |
| 09:30 - 11:30 | Plenary Session I |
| 11:30 - 11:45 | Tea and Networking |
| 11:45 - 13:15 | Parallel Session 1 |
| 13:15 - 14:30 | Lunch |
| 14:30 - 16:00 | Parallel Session 2 |
| 16:00 - 16:30 | Tea and Networking |
| 16:30 - 18:00 | Parallel Session 3 |
| 18:00 - 19:00 | Poster Session |
| 18:30 - 20:30 | Conference Dinner |
| ***January 04, 2017*** | |
| 08:30 - 09:00 | Tea |
| 09:00 - 11:30 | Plenary II |
| 11:30 - 11:45 | Tea and Networking |
| 11:45 - 13:15 | Parallel Session 4 |
| 13:15 - 14:30 | Lunch |
| 14:30 - 16:30 | Parallel Session 5 |
| 16.30 -17.00 | Valedictory Function |

| SYMPOSIUM ON PROCESS SAFETY | SYMPOSIUM ON STRUCTURES UNDER FIRE |
|---|---|
| ***JANUARY 05 - 06, 2017*** | ***JANUARY 05 - 06, 2017*** |

**We gratefully acknowledge financial assistance from:**

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# Message from the Conference Convener

Dear Delegates and Colleagues,

It is my great pleasure to welcome you for the 3rd International Conference on Safety 2017 (ICS 2017) organized by IIT Gandhinagar Safety Centre.

We have learned a lot through multiple accidents around the world. Let us work together to make a 'safer world'. IIT Gandhinagar Safety Centre is committed to promote a culture of safety and pursuing this initiative through safety education, safety research and its practice. A biannual conference like ICS is one of the important platforms to learn from each other's mistake and sensitize our society. Let us take the resolution of 'Safer India' and 'Safer World' in this New Year.

The ICS 2017 program is divided into two parts. The Main Conference will cover several aspects of Process Safety, Fire Safety, Risk Analysis, Construction Safety, Behavioural Safety, Earthquake Safety, Disaster Management etc. through several plenary lectures and parallel sessions during January 3 – 4, 2017. The parallel sessions consist of about 60 paper presentations including about 18 invited talks from renowned safety professionals from India and abroad. In the second part of ICS 2017, we have two parallel symposiums – Symposium on Process Safety (SPS 2017) and Symposiums on Structures under Fire (SSUF 2017) during January 5 – 6, 2017. The symposiums will be conducted by eminent people in the field and they are going to discuss about number of safety related issues. Both the main conference and symposiums are going to be attended by about 200 participants which includes consultants, engineers, regulators and researchers from different parts of India and abroad. We are going to discuss and debate on various recent developments and extend the state-of-the-art in safety.

I hope you will enjoy the various sessions of ICS 2017 and join hands to Safety Centre's effort to promote a culture of safety in our society. Please do share your experience – it may save several lives!

I wish a fruitful meeting and enjoyable stay at Gandhinagar and Ahmedabad.

Chinmay Ghoroi, PhD
Conference Convenor
Co-Coordinator, Safety Centre, Indian Institute of Technology Gandhinagar

# International Programme Committee

## Program Chair

- Dr.Sam Mannan (Texas A&M University, USA)

## Program Members

- Dr. Hans Pasman (Texas A&M University, USA)
- Dr. James A. Milke (University of Maryland, USA)
- Dr. Paul Amyotte (Dalhousie University, Canada)
- Dr. Kathy Ann Notarianni (Worcester Polytechnic Institute, USA)
- Dr. Anthony Abu (University of Canterbury, New Zealand)
- Dr. Maria Papadaki (University of Patras, Greece)
- Dr. Faisal Khan (Memorial University, Canada)
- Dr. Venkatesh Kodur (Michigan State University, USA )
- Dr. Dongil Shin (Myongji University, South Korea)
- Dr. Syeda Sultana Razia (Bangladesh University of Engineering and Technology (BUET), Bangladesh)
- Dr. Pravinray.D.Gandhi (Underwriters Laboratories, USA)
- Dr. Mimi H. Hassim (University Teknologi Malaysia)
- Dr. Luc Vechot (Texas A&M University, Qatar)
- Dr. Chitra Rajagopal (Center for Fire, Explosive and Environment Safety, DRDO, India)
- Dr. M. Surianarayanan (Central Leather Research Institute, CSIR, India)

# Main Conference (January 03 - 04, 2017)

## PLENARY SPEAKERS

***From Bhopal to the current times: Are we making progress in process safety performance?***
**Prof. Sam Mannan**
**3 Jan 2017 09:30 - 10:20**

Dr. Sam Mannan is Regents Professor and Executive Director of the Mary Kay O'Connor Process Safety Center at Texas A&M University. Dr. Mannan is a registered professional engineer in the states of Texas and Louisiana and a Certified Safety Professional. Dr. Mannan has published more than 175 peer-reviewed journal publications, several books and book chapters on inherently safer processes and delivered about 175 technical meeting presentations as invited and Keynote speaker. Dr. Mannan is the recipient of numerous awards and recognitions from AIChE, TAMU, IChemE including the recent Bush Excellence Award for Faculty in Public Service
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***Public Safety in India***
**Shri. R.A. Venkitachalam**
**3 Jan 2017, 10:20 - 10:50**

Sri R.A.Venkitachalam is currently the Vice President (Public Safety) of Underwriters Laboratories and works proactively in advancing the cause of public safety across large parts of the developing world. Being passionate about catering the urgent need for enhanced measures to ensure Public Safety in the backdrop of accelerating economic growth and globalized markets, he spearheaded the establishment of safety councils in India - the first one for UL outside of North America, to facilitate constructive dialogue between multiple stake holders in tackling Public Safety challenges. As a managing director of UL before the current role, Venki led the growth of UL in the region for over 10 years, covering South East Asia, India, Middle East and Africa in terms of investments and expansion of UL's geographic footprint including technical, laboratory and service range and capabilities. Venki has been a speaker at several forums in India and abroad covering issues pertaining to Public Safety, Industry-specific issues as well as General Management & is actively associated with the CSR initiatives of UL, focusing on creating Safety Awareness among the public through public programs aimed at school children too. He is an alumnus of the Indian Institute of Technology, Chennai, holding a Bachelor of Technology degree in Chemical Engineering and a Masters in Industrial Management.

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***Risk Assessment and Management in Chemical Industries***
**Prof. Hans Pasman**
**3 Jan 2017, 10:50 - 11:30**

Prof. Hans Pasman is currently a Research Professor at Texas A&M University, where he had received the prestigious Mary Kay O'Connor Process Safety Center Merit Award in the year 2007. He was previously a Member of Ministerial Advisory Council on Hazardous Materials, The Hague, The Netherlands. He is well known for his contribution in the field of thermal stability, gas and dust explosions,

shock and blast, insensitive explosives, projectile and rocket propulsion, ordnance, weapon-target interaction, process safety, risk assessment methods, accident investigation. Prof. Pasman was previously affiliated with the Royal Institute of Engineers, KIvI, The Hague, The Netherlands as well as the Royal Netherlands Chemical Society, KNCV, The Hague, the Netherlands, including Netherlands Process Engineers, NPT. Presently, he is also a member of the Editorial Board Chinese Journal of Safety and Environment.

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### *Fire Safety in India*
**Shri. D. K. Shami**
**4 January 2017, 09:00-09:30**

Shri D. K. Shami is currently the Fire Advisor of India, DG FS, CG & HG Ministry of Home Affairs, Govt. of India. He is Chairman and Member of BIS Committee. He is member of OISD Standing Committee and member secretary of Standing Fire Advisory Committee. He is also member of Institution of Fire Engineers, U.K and Fellow of Institution of Fire Engineers, India. He has professional experience of 33 years in Industrial, State and Central Fire Services including Advisory role for Government of India. He has been awarded President's Fire Service Medal for Meritorious Services in 1999 and President's Fire Service Medal for Distinguished Services in 2006.

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### *Post 9-11 Construction Strategies in the US for Enhanced Fire Safety*
**Prof. Venkatesh Kodur**
**4 January 2017, 09:30-10:20**

Prof. Kodur is Chairperson and Director of Center on Structural Fire Engineering and Diagnostics at Michigan State University. His research interests include: Evaluation of fire resistance of structural systems through large scale fire experiments and numerical modeling and Characterization of materials under high temperature. Prof. Kodur is a professional engineer and Fellow of American Society of Civil Engineers, Fellow of American Concrete Institute and Fellow of Canadian Academy of Engineering, He is also a Foreign Fellow of Indian National Academy of Engineering, Chairman of ACI Fire Protection Committee, Chairman of ASCE-29 (Fire) Standards Committee and a member of UK-EPSRC College of Reviewers.

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**Shri. Hirak Dutta**
**Adviser, Essar Oil & Gas and Former ED of OISD**
**4 January 2017, 10:20-10:50**

Mr. Dutta is the Adviser Essar Oil & Gas. He looks after process safety aspects of both refinery & marketing functions since November 2015. Prior to this, Shri Dutta was Executive Director of Oil Industry Safety Directorate, technical wing of Ministry of Petroleum & NG, responsible for overseeing safety in the entire oil & gas industry in India as its Executive Director. He has over three and a half decades of rich and varied experience in Operations, Process design and engineering, trouble shooting, Safety management, Project Management, Human Resource Management in various Refineries, Refinery Headquarters and Corporate office of Indian Oil Corporation Limited.

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***Leadership for the global process safety in chemical process Industries*.**
**Prof. En soop Yoon**
**4 January 2017, 10:50-11:30**

Prof. En Sup Yoon is very active professor in Seoul National University at Chemical Engineering Department after his PhD from MIT in 1982. The main area of his research is Chemical Process Safety minimizing the human risk and the sustainability in Chemical industry. He was Adviser in Korean Society of Hazard Mitigation, Chair for World Conference of Safety of Oil and Gas Industry, President in Korean Association of Professional Safety Engineers. Prof. Yoon is currently coordinating the educational program on Safety & Disaster prevention at the national research center for the global engineering & development in Seoul National University which is the hosting organization in Korea as the Chief organizer & professor.

# Main Conference (January 03 - 04,2017)
# KEYNOTE SPEAKERS

***Risk Evaluation of Oil and NG pipeline and Steel Plants***
**Sm. Sutapa Bhattacharya**
**3 Jan 2017, 11:45, Parallel Session 1 (Process Safety I)**

Mrs. S. Bhattacharya is the Director of National Safety Council and instrumental in expanding the horizons of National Safety Council of India. She has introduced new Safety Rating System, various types of audits, risk assessments, training programmes on PSM, risk assessment etc. She has more than 30 years of experience in senior positions in Atomic Energy Departments - in Heavy Water Board and Atomic Energy Regulatory Board. She has enforced sound safety system in Atomic Energy units namely in Uranium Mines/Mills, Accelerators, Nuclear Power Plants as Inspector under Atomic Energy (Factories) Rules 1996. Mrs. Bhattacharya has drafted and actively involved in the preparation of BIS 15656 Code of Practice on Hazard Identification & Risk Assessment, the MOEF document on Risk Assessment Standard & Guidance Manual and revision of BIS 14489 on Safety Audit. She was lead auditor for HAZOP in China and actively involved in UNEP programme in Sri Lanka.

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***New Concepts for Hazardous Waste Cleanup by Combustion***
**Prof. Ali S. Rangwala**
**3 Jan 2017, 11:45, Parallel Session 1 (Fire Safety I)**

Dr. Ali S. Rangwala is Associate Professor of Fire Protection Engineering of Worcester Polytechnic Institute (WPI), USA. His research addresses combustion, industrial fire protection, and explosion protection. Prof. Rangwala's research team developing measurement and sensing devices designed to identify the presence, velocity, and flow direction of smoke. Also he is developing benchmark tests to better understand the physics of ignition and deflagration in dust-air premixed combustion. This research will enable scientists to study combustibility in ways that enable fire safety professionals to predict fire and explosion hazards.

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***Incorporating Sustainability Considerations in Process Systems Engineering: Design for economic, environmental and safety criteria***
**Dr. Debalina Sengupta**
**3 Jan 2017, 12:45, Parallel Session 1 (Process Safety I)**

Dr. Sengupta is the Associate Director of the Gas and Fuels Research Center for Texas A&M Engineering Experiment Station (TEES). Her roles include research collaboration development for the Center through mega project funds, industry partnerships, and other channels. After her PhD from Louisiana State University in Baton Rouge, she went to work as a post doctoral fellow at the National Risk Management Research Laboratory of the United States Environmental Protection Agency in Cincinnati, OH. There, she worked on multiple research initiatives on sustainability and systems analysis through the Sustainable Technology Division. Dr. Sengupta has held several leadership roles at AIChE, primarily at the Environmental Division. She was a Director for 2011-2015, and is the current Programming Chair for the Division.

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***Reactive Chemicals and Process Hazards***
**Dr. M. Surianarayanan**
**3 Jan 2017, 16:30, Parallel Session 3 (Risk Analysis I)**

Dr. Surianarayanan is currently the Principal Scientist at the Cell for Industrial Safety and Risk Analysis (CISRA), CSIR-Central Leather Research Institute. His research areas of interest are chemical process safety, thermo kinetic analysis of chemical process reactions, occupational safety and health, accident database, charge transfer polymerizations and Biocalorimetry. Dr Surianarayanan has over 100 publications in peer-reviewed journals. He pursued his postdoctoral research at the Kanagawa Industrial Technology Research Institute, Japan under Science and Technology Agency fellowship of Govt. of Japan and was also a visiting fellow at the Science and Technology Research Centre of Mitsubishi chemical corporation of Japan during 2000-2002.Currently he chairs the SHE committee of Indian Chemical Council (southern region) and also serves as a member of the regional committee of ICC, Executive committee of National safety Council, Tamil Nadu Chapter and State Crisis Group of the Government of Pondicherry.

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***Safety - Progress Made, Knowledge Gaps, and the role of CFD***
**Dr. Prankul Middha**
**3 Jan 2017, 14:30, Parallel Session 2 (Process Safety II)**

Dr.Prankul Middha is a Principal Engineer. He has a long experience in the field of process safety for the oil and gas industry, especially relating to ventilation, dispersion, fire and gas explosion. He has been associated with DNV GL and Gexcon, both world-leading companies within the field of safety and risk manageement. He has held several positions, including that of principal consultant, head of training and has had responsibilities for sales and support of the CFD software FLACS. Dr. Middha is an IIT Delhi alumnus who got his Master's degree from University of Delaware and PhD on hydrogen safety from University of Bergen, Norway. He has published about 30 articles in peer-reviewed, international journals as well as book chapters and has more about 70 presentations in international conferences around the world.

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***Full Scale lass Facade Fire Test @ IIT Gandhinagar***
**Dr. Gaurav Srivatsava**
**3 Jan 2017, 14:30, Parallel Session 2 (Fire Safety II)**

Gaurav received his bachelor's degree in Civil Engineering from IT-BHU (now IIT-BHU), Varanasi in 2007 and his master's and doctoral degrees in Civil Engineering from the University of Minnesota in 2008 and 2011. His doctoral work involved the development of efficient analysis methods for large systems with local modifications. He joined IIT Gandhinagar in 2013 after working as a post-doctoral researcher in the University of Notre Dame. He started working in the area of structural fire engineering after joining IIT Gandhinagar. His present research interests include efficient fire analysis of structural systems and development of material models at high temperatures including non-destructive characterization.

***Earthquake Hazard in India***

**Dr. Sumer.Chopra**

**3 Jan 2017, 14:30, Parallel Session 2 (Earthquake Safety I)**

Dr.Sumer Chopra is presently Director of Institute of Seismological Research. Dr.Chopra worked in the seismology division of Ministry of Earth Sciences, Government of India was Head of the Earthquake Hazard and Risk Analysis division of the newly established National Centre for Seismology, Ministry of Earth Sciences. Dr. Chopra's thrust areas of research are deterministic and probabilistic seismic hazard analysis, estimation of source parameters, site specific response studies etc. He has carried out deterministic seismic hazard analysis of entire Gujarat region. Seismic hazard of 32 cities/towns in Gujarat was estimated in terms of PGA and spectral accelerations. He has more than 25 years of experience in seismological research. He has published more than 100 research papers in international and national journals. He was awarded Certificate of Merit for outstanding contribution in the field of Geosciences by Ministry of Earth Sciences, Govt. of India in 2015.

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***Safety Management in Defence***

**Dr. Chitra Rajagopal**

**3 Jan 2017, 11:45, Parallel Session 1 (Explosion Safety)**

Dr. Chitra Rajagopal has a major role in formulation, amendment and implementation of explosive safety rules and regulations in Ministry of Defence (MOD) units storing, handling, processing and transporting explosives/ammunition and its compliance monitoring through siting, safety audit, hazard classification trials and accident investigation. She has also been responsible for implementation of environment rules and regulations in MOD establishments and formulation of Safety, Health & Environment Policy and Disaster Management Plan for DRDO. She has taken a major initiative in sensitising MOD users through training programmes, lectures, dissemination through electronic and print media. Her research areas are in the field of Process Safety, Environment Safety, Explosive Safety and Heat Transfer.

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***Six-Sigma reliability and the brain worker: Towards Error Proofing the Human Decision Maker***

**Prof. Rajagopalan Srinivasan**

**3 Jan 2017, 16:30, Parallel Session 3 (Behavioral Safety)**

Prof. Srinivasan is a Professor in Chemical Engineering at IIT Gandhinagar and Coordinator of Safety Centre. Currently, he is Visiting Professor at IIT Madras. He was Associate Professor in the Department of Chemical & Biomolecular Engineering at the National University of Singapore before moving to IIT Gandhinagar. He serves as the President of the AIChE Singapore section and an Editor of the IChem E journal - Process Safety & Environmental Protection. Inherent safety and inherently safer design is one of his major research areas. He has authored or co-authored over 320 international peer-reviewed publications with several books and patents. He received his B.Tech from Indian Institute of Technology Madras and PhD from Purdue University.

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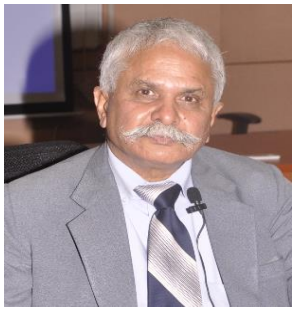
***Emerging Trends in Public Alert & Warning System***
**Dr.R.K.Dave**
**3 Jan 2017, 16:30, Parallel Session 3 (Disaster Management)**



Dr. Dave is Senior Specialist (Policy and Plans) at National Disaster Management Authority (NDMA) functioning under Ministry of Home Affairs, Government of India. He worked as a senior expert in Information and Communication Technology (ICT) in Gujarat State Disaster Management Authority, ADB, GIFT, State Governments of Karnataka, Jharkhand and Himachal between 2006-2012. Before that - during 22 years of his career as a civil servant, Dr. Dave worked in various capacities with MoC&IT (Government of India) and State Government of Gujarat. Dr. Dave holds PhD in Disaster Management, MBA (both from Gujarat University) and B.E degree in Electronics and Communication (from Engineering College Jodhpur) and possess extensive expertise in both ICT and Disaster Management domains.

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***Functional Safety in first generation process plants***
**Shri. G. Vishwanathan**
**4 Jan 2017, 11:45, Parallel Session 4 (Process Safety III)**

Mr. Vishwanathan has more than three decades of Operation and Technical Services experience in Petrochemicals in IPCL and Synthetic Fibre plants. He has also acquired Engineering and HSE experience for 10 years while working with L&T, L&T Chiyoda and Technip along with his association as a Risk & Safety Consultant with Germanischer Lloyd and MS Chola Risk Services on HAZOP, HAZID, SIL, and other safety studies. He has about 10 years of experience in handling highly toxic Acrylonitrile plant which produces lethal Hydrogen Cyanide as by product.

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***Safety: An Introspection***
**Shri. Debasish Kar**
**4 Jan 2017, 11:45, Parallel Session 4 (Construction Safety)**

Shri kar is currently the Director General of Kolkata Municipal Corporation. He is a competent administrator with 30 years of post-qualification and over 19 years of rich experience in projects business development, planning, design & detailed engineering & project management. He served in Kolkata Municipal Corporation for 28 years. He was Associated with Ambuja Realty Development as Project Chief for a period of two Years. He is graduated in Architecture (B. Arch) from Bengal Engineering College, Shibpur, in the year 1985. He is a Visiting Faculty of Jadavpur University.

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***Fire Behaviour of Reinforced Concrete Structural Elements***
**Dr.N. Gopalakrishnan**
**4 Jan 2017, 11:45, Parallel Session 4 (Fire Safety III)**

Dr. Gopalakrishan is the Director of CSIR- CBRI, Roorkee and well-known Scientists in the area of Structural Dynamics and Earthquake Safety. After his PhD from Indian Institute of Science Bangalore, he started his career with CSIR-SERC in the structural dynamics and machine foundation (SDL) division and later he shifted to Earthquake Engineering division of CSIR-SERC i.e. Advanced Seismic Testing and Research Laboratory (ASTaR). Dr. Gopalakrishan has been credited the prestigious Ramaiah's prize for significant resezarch contribution in his area. Also he had been a UNDP visiting fellow at the University of Michigan, Ann Arbor, State University of New York, Buffalo (SUNY-B) and Cornell University, Ithaca during 1994-95.

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***Atmospheric dispersion modelling and stochastic programming for optimal fence monitioring of gas release***
**Prof. Dong Il Shin**
**4 Jan 2017, 14:30, Parallel Session 5 (Process Safety IV)**

Prof. Shin is a Professor in Chemical Engineering and Disaster & Safety at Myongji University. He serves as the Vice President of the Safety Division of Korean Institute of Chemical Engineers (KIChE). Intelligent systems, complex system modeling, and autonomous plants for process safety are his major research areas. He received his B.S. and M.S. from Seoul National University and Ph.D. from Purdue University.

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***Challenges in Establishing Process Safety Management System: Bangladesh Perspective***
**Prof. Syeda Sultana Razia**
**3 Jan 2017, 12:15, Parallel Session 1 (Process Safety I)**

Dr. Syeda Sultana Razia is a Professor of the Department of Chemical Engineering, Bangladesh University of Engineering and Technology (BUET). She served as the Head of the department from September 2012- September 2014. She had her B.Sc. and M.Sc. in Chemical Engineering, from BUET and Ph.D. in Chemical Engineering from the University of Alberta, Canada. Her professional and research interests include chemical process safety and security, distillation/separation processes, zero discharge effluent treatment, heat transfer enhancement, etc. She serves as an expert in policymaking, investigation and selection committees dealing with technological and safety issues of chemical industries formed by the Government of Bangladesh. She is involved in assessing the safety and environmental aspects of different chemical industries in Bangladesh. Currently, she is leading safety audit of fertilizer factories of Bangladesh Chemical Industries Corporation (BCIC), the largest umbrella organization of chemical industry in Bangladesh. She is also leading collaborations between BUET and Mary Kay O'Connor Process Safety Centre, Texas A& M University System, US. She is a member of Global Advisory Team of Poland based International Centre for Chemical Safety and Security (ICCSS). She is a resource person to the National Authority of Chemical Weapon Convention, Armed Force Division, Bangladesh and is involved in different activities of Organization for the Prohibition of Chemical Weapons (OPCW). She is also carrying out projects and activities sponsored by Chemical Security Program (CSP), US Department of States.

***A Robust Pushover Analysis for Multi-Component Seismic Excitations- A New Frame Work***
**Dr. Dhiman Basu**
**4 Jan 2017, 14:30, Parallel Session 5 (Earthquake Safety II)**

Dr. Dhiman Basu is a faculty member in the discipline of civil engineering at Indian Institute of Technology Gandhinagar. His research interest includes rotational seismology, ground motion characterization, supplemental damping, irregular buildings and confined masonry and he is also involved in developing a network of early earthquake warning systems in India at Present. Dr. Basu received BE (civil Engg) from Jadavpur University (1995), M.Tech. (Structural Engg) from IIT Kanpur (1998) and Ph.d. (Structural Engg) from SUNY Buffalo (2012).

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***Barrier based Risk Assessment***
**Shri.Umesh Dhake**
**4 Jan 2017, 14:30, Parallel Session 5 (Risk Analysis II)**

Shri Umesh Dhake, Asia Pacific Regional Manager for Center for Chemical Process Safety (CCPS) is a Chemical engineer with more than 15 years of experience in Risk Consulting. Previously, Umesh worked with ABS Consulting- Risk Division and Germanischer Lloyds GmbH. He was involved in Preliminary Hazard Analysis, Consequence Analysis, QRA studies, MAH Bow Ties development, SIL verifications as per IEC 61511, Fit for Purpose Certifications for offshore ageing assets- pipelines and platforms. Umesh is also Lead auditor, Lead Tutor for Quality, Environmental, and Occupational Health & Safety management systems

# Symposium on Process Safety
# January 05 - 06, 2017

**Prof. Hans Pasman**

Prof. Hans Pasman is currently a Research Professor at Texas A&M University, where he had received the prestigious Mary Kay O'Connor Process Safety Center Merit Award in the year 2007. He was previously a Member of Ministerial Advisory Council on Hazardous Materials, The Hague, The Netherlands. He is well known for his contribution in the field of thermal stability, gas and dust explosions, shock and blast, insensitive explosives, projectile and rocket propulsion, ordnance, weapon-target interaction, process safety, risk assessment methods, accident investigation. Prof. Pasman was previously affiliated with the Royal Institute of Engineers, KIvI, The Hague, the Netherlands, including Netherlands Process Engineers, NPT. Presently, he is also a member of the Editorial Board Chinese Journal of Safety and Environment.

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**Dr. M. Surianarayanan**

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**Dr. Prankul Middha**

Dr.Prankul Middha is a Principal Engineer. He has a long experience in the field of process safety for the oil and gas industry, especially relating to ventilation, dispersion, fire and gas explosion. He has been associated with DNV GL and Gexcon, both world-leading companies within the field of safety and risk management. He has held several positions, including that of principal consultant, head of training and has had responsibilities for sales and support of the CFD software FLACS. Dr. Middha is an IIT Delhi alumnus who got his Master's degree from University of Delaware and PhD on hydrogen safety from University of Bergen, Norway. He has published about 30 articles in peer-reviewed, international journals as well as book chapters and has more about 70 presentations in international conferences around the world.

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**Prof. En soop Yoon**

Prof. En Sup Yoon is very active professor in Seoul National University at Chemical Engineering Department after his PhD from MIT in 1982. The main area of his research is Chemical Process Safety minimizing the human risk and the sustainability in Chemical industry. He was Adviser in Korean Society of Hazard Mitigation, Chair for World Conference of Safety of Oil and Gas Industry, President in Korean Association of Professional Safety Engineers. Prof. Yoon is currently coordinating the educational program on Safety & Disaster prevention at the national research center for the global engineering & development in Seoul National University which is the hosting organization in Korea as the Chief organizer & professor.

# Symposium on Structures Under Fire
# January 05 – 06, 2017

**Dr. Venkatesh Kodur**

Dr. Kodur, Fellow of Canadian Academy of Engineering, is a Professor and Director of the Centre on Structural Fire Engineering and Diagnostics at Michigan State University. His research interests include: Evaluation of fire resistance of structural systems through large scale fire experiments and numerical modeling and Characterization of materials under high temperature. Prof. Kodur is a professional engineer, Fellow of American Society of Civil Engineers, Fellow of American Concrete Institute. He is a Foreign Fellow of Indian National Academy of Engineering, Chairman of ACI Fire Protection Committee, Chairman of ASCE-29 (Fire) Standards Committee and a member of UK-EPSRC College of Reviewers.

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**Dr. Anil Agarwal**

Dr. Anil Agarwal is an assistant professor in the department of Civil Engineering at the Indian Institute of Technology Hyderabad. His research interests include behavior and design of structural systems under extreme loading conditions such as fire and earthquake, progressive collapse and prevention, structural dynamics and soil-structure interaction, etc. He has authored several refereed journal papers and conference proceedings in the area of structural fire safety. He serves as a reviewer for the Journal of Constructional Structural Steel and the ASCE Structural Engineering Journal. He has also worked for Bentley Systems, Inc., where he co-developed finite element based nonlinear collapse analysis and soil-structure interaction modules for offshore structures. He has also co-authored revised code and commentary of IS 1893 (Part 1) and IS 13920 for the Gujarat State Disaster Management Authority (GSDMA).

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**Dr. Gaurav Srivastava**

Gaurav received his bachelor's degree in Civil Engineering from IT-BHU (now IIT-BHU), Varanasi in 2007 and his master's and doctoral degrees in Civil Engineering from the University of Minnesota in 2008 and 2011, respectively. Later, he joined the computational physics group at the Department of Aerospace and Mechanical Engineering, University of Notre Dame as a postdoctoral researcher and subsequently joined IIT Gandhinagar in 2013. His research interests include development of efficient analysis methods for large dynamical systems, multi-physics modeling of physical phenomena and study of behaviour of structures subjected to fire.

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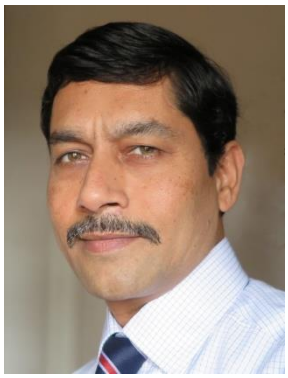
**Shri. Abhay Purandare**



Abhay Purandare has worked in the fire safety profession for over two and a half decades. He completed his Master in Fire Protection Engg from the University of Maryland, USA, is a Fellow of the Institution of Fire Engineers (UK) and Institution of Fire Engineers (India) and a Professional Member of the Society of Fire Protection Engineers (USA). His work experience spans the areas of fixed fire protection systems, fire safety training/ consultancy, firefighting equipment design & development, higher education in fire engineering, and major project engineering consultancy. He has visited a large number of sites, both industrial and infrastructure, with experience in India and the Middle East. He has also published a number of papers at national/international fora with the objective of promoting the interest of Fire safety. He presently works as a Fire & Life Safety Consultant.

# Invitation to Submit Manuscript for Special Issue

A Special Issue of Elsevier's Journal of Loss Prevention in the Process Industries will be published containing extended versions of selected papers presented at the International Conference on Safety 2017.

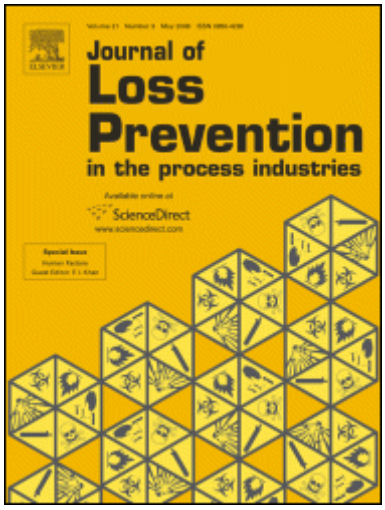
All submitted papers will go through the usual rigorous reviewing process of the journal.

**Timelines for the Special Issue**

Manuscript Submission Deadline : June 30, 2017

Final acceptance decision : March 31, 2018

Publication date : April – May, 2018




**Impact factor: 1.409**

If you are interested in submitting a paper for the special issue, please inform Dr.Chinmay Ghoroi by email (chinmayg@iitgn.ac.in or safety@iitgn.ac.in ) before

# NETWORKING EVENTS

## Conference Dinner

Date: 03 January, 2017

Time: 07:00 PM onwards

Venue: IIT Gandhinagar Auditorium Area

## Symposium Dinner

Date: 05 January, 2017

Time: 07:30 PM onwards

Venue: IIT Gandhinagar Auditorium Area

# About Gandhinagar and Ahmedabad

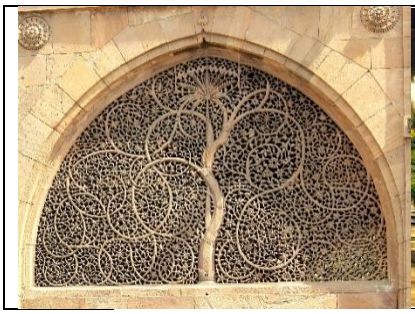
Gandhinagar is the green and the planned city which is located in the bank of the river Sabarmati. It is the capital city of Gujarat and very near to Ahmadabad. Gandhinagar is the administrative capital of Gujarat and now has changed into the knowledge hub of India with many institutes of National repute.

Ahmedabad is the business city of Gujarat It has excellent connectivity to all parts of India and beyond by air / road / rail. There are many places to visit in both Gandhinagar and Ahmedabad. Some of the places to visit are Siddi Sayyed Jali, Jumma Masjid, Gujarat Science City, Akshardham (Gandhinagar), Law Garden Market, Vaishnodevi Temple, Kankaria Lake, Sabarmati Riverfront Development Project, Sarkhej Roja, Adalaj Wav, Rani Sipri Mosque, Iskon Temple, Sola Temple, CG Road, Gandhi Ashram (Sabarmati), Calico Museum of Textiles (Shahibaugh)


Adalaj Stepwell


Calico Museum


Jama Masjid


Sidi Saiyad Mosque


Kankaria Lake


Akshardham

## For more details:

Tourism Corporation of Gujarat Ltd.,
H. K. House, Opp: Bata Showroom,
Ashram Road, Ahmedabad.
Tel: +91 79 26589172/ 26576434
Fax: +91 79 26582183
E-Mail: tibahd@gujarattourism.com Website: http://www.gujarattourism.com/

# Useful Information

**Travel from/to Airport:**

IITGN is located in the Palaj Campus which is approximately 24 km from the airport. Cab can be hired at cost of around Rs.500/-

**Travel from/to Railwaystation:**

The railway station at Gandhinagar has limited access by trains. However, the railway station at Ahamedabad located in in Kalupur which is approximately 32 km from the current IITGN campus. A taxi ride from the station will cost you between Rs. 350 and 400 depending on the time of your arrival; an auto ride will cost around Rs. Rs.500.

**Emergency Contact Numbers**

1. Campus Medical Officer : 7043208754
2. Fire : :079 2322 2742
3. Ambulance : 108
4. Police : 100
5. Campus security : 7622883913
6. Safety Centre : 9925029889

# Detailed Programme

| Time | Program Details | Venue |
|---|---|---|
| **Day 1 (January 03, 2017)** | | |
| | | |
| **08:00 - 09:00** | Registration | **Auditorium (600)** |
| **09:00 - 09:30** | Welcome and Opening address by **Dr. Chinmay Ghoroi** (Convenor, ICS 2017) and **Prof. S. K. Jain** (Director, IIT Gandhinagar) | **Auditorium (600)** |
| | | |
| **09:30 - 11:30** | **Plenary Session I** | **Auditorium (600)** |
| **09:30 - 10:20** | **Plenary 1: Prof.Sam Mannan**, Texas A&M University *From Bhopal to the Current Times: are We Making Progress in Process Safety Performance?* | |
| **10:20 - 10:50** | **Plenary 2: Shri.R.A.Venkitachalam**, Underwriters Laboratories. *Public Safety in India* | |
| **10:50 - 11:30** | **Plenary 3: Prof.Hans Pasman**, Texas A&M University *Risk Assessment and management in Chemical Industries* | |
| | | |
| **11:30 - 11:45** | **Tea and Networking** | **Academic Block 6 (1st floor)** |
| | | |
| **11:45 - 13:15** | **Parallel Session 1** | |
| | Process Safety I | **Academic Block 6/202** |
| | Fire Safety I | **Academic Block 6/203** |
| | Explosion Safety | **Academic Block 6/201** |
| | | |
| **13:15 - 14:30** | **Lunch** | **Auditorium Area** |
| | | |
| **14:30 - 16:00** | **Parallel Session 2** | |
| | Process Safety II | **Academic Block 6/ 202** |
| | Fire Safety II | **Academic Block 6/ 203** |
| | Earthquake Safety I | **Academic Block 6/ 201** |
| | | |
| **16:00 - 16:30** | **Tea and Networking** | **Academic Block 6 (1st floor)** |
| | | |
| **16:30 - 18:00** | **Parallel Session 3** | |
| | Risk Analysis I | **Academic Block 6/ 202** |
| | Behavioral Safety | **Academic Block 6/ 203** |

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|---|---|---|
| | Disaster and Public Management | **Academic Block 6/ 201** |
| | | |
| **18:00 - 19:00** | **Poster Session** | **Academic Block 6** |
| | | |
| **19:00 – 21:00** | **Conference Dinner** | **Outside 600 Auditorium Area (Fountain Area)** |

| **Day 2 (January 04, 2017)** | | |
|---|---|---|
| **08:30 - 09:00** | **Tea** | |
| | | |
| **09:00 - 11:30** | **Plenary Session II** | |
| **09:00 - 09:30** | **Plenary 4: Shri. D. K. Shami**, Fire Advisor, Govt. of India, *Fire Safety in India* | **Auditorium (600)** |
| **09:30 - 10:20** | **Plenary 5: Prof. Venkatesh Kodur**, Michigan State University, *Post 9-11 Construction Strategies in the US for Enhanced Fire Safety* | **Auditorium (600)** |
| **10:20 - 10:50** | **Plenary 6: Shri Hirak Dutta,** Advisor Essar Oil and Gas *HSE Challenges in Hydrocarbon Sector* | **Auditorium (600)** |
| **10:50 - 11:30** | **Plenary 7: Prof. En Soop Yoon**, Seoul National University, *Leadership for the Global Process Safety in Chemical Process Industries* | . **Auditorium (600)** |
| | | |
| **11:30 - 11:45** | **Tea and Networking** | **Auditorium Area** |
| | | |
| **11:45 - 13:15** | **Parallel Session 4** | |
| | Process Safety III | **Academic Block 6/202** |
| | Construction Safety | **Academic Block 6/201** |
| | Fire Safety III | **Academic Block 6/203** |
| | | |
| **13:15 - 14:30** | **Lunch** | |
| | | |
| **14:30 - 16:30** | **Parallel Session 5** | |
| | Process Safety IV | **Academic Block 6/202** |
| | Earthquake Safety II | **Academic Block 6/201** |
| | Risk Analysis II | **Academic Block 6/ 203** |
| | | |
| **16.30-17.30** | **Valedictory Function** | **Academic Block 6/ 202** |

| Day 1: 03 January 2017 | | |
|---|---|---|
| **PARALLEL SESSION 1 (11:45 - 13:15)** | | |
| | | |
| **SESSION 1** | **PROCESS SAFETY I (Academic Block 6/ 202)** | |
| **CHAIR** | **Prof. Sam Mannan (Texas A&M University)** | |
| **PAPER ID** | **TITLE OF THE PAPER** | **NAME OF THE AUTHORS** |
| **Keynote1 (Invited)** | **Risk Evaluation of Oil and NG pipeline and Steel Plants** | **Sm. Sutapa Bhattacharya (Director, National Safety Council)** |
| **Keynote 2 (Invited)** | **Challenges in Establishing Process Safety Management System:Bangladesh Perspective** | **Prof. Syeda Sultana Razia (Professor, Bangladesh University of Engineering and Technology)** |
| **Keynote 3 (Invited)** | **Incorporating Sustainability Considerations in Process Systems Engineering: Design for economic, environmental and safety criteria** | **Dr. Debalina Sengupta (Associate Director, Gas and Fuel Research Centre, Texas A&M Research Station)** |
| | | |
| **SESSION 2** | **FIRE SAFETY I (Academic Block 6/ 203)** | |
| **CHAIR** | **Prof. Venkatesh Kodur (Michigan State University)** | |
| **PAPER ID** | **TITLE OF THE PAPER** | **NAME OF THE AUTHORS** |
| **Keynote (Invited)** | **New Concepts for Hazardous Waste Cleanup by Combustion** | **Dr. Ali Rangwala (Associate Professor, Fire Protection Engineering, Worcester Polytechnic Institute, USA)** |
| FS1-P1 | 3D Physics-Based Modeling Of Large-Scale Flammable Cloud Dispersion Using FLACS | Varun Teja, Kirti Bhushan Mishra |
| FS1-P2 | Consequence Modelling for Propellant Storage Facilities | Vimlesh Kumar Bind, Kamlesh Kumar Meena, Chitra Rajagopal |
| FS1-P3 | A Study of The Causes And Events Leading to the Fire Disaster at Lac-Megantic, Canada On July 6, 2013" | Ajai Banerji |
| | | |
| **SESSION 3** | **EXPLOSION SAFETY (Academic Block 6/201)** | |
| **CHAIR** | **Prof. Hans Pasman (Texas A&M University)** | |
| **PAPER ID** | **TITLE OF THE PAPER** | **NAME OF THE AUTHORS** |
| **Keynote (Invited)** | **Safety Management in Defence** | **Dr. Chitra Rajagopal (Chief Controller R&D, System Analysis and Modelling DRDO, Ministry of Defence)** |
| EXS-P1 | Improvisation of the Minimum Ignition Energy device for studying the effect of partial inerting on the MIE of dusts | Purvali Chaudhari, Chad Mashuga |
| EXS-P2 | Estimation of TNT Explosion Potential for Aerial Fireworks Mixtures | V.Surendar, V.P.Sridhar, S. P. Sivapirakasam, M.Surianarayanan |
| EXS-P3 | Effect of Dispersion on Particle Breakage in Dust Explosion Phenomena | Pranav Bagaria, Jiaqi Zhang, Chad Mashuga |
| | | |
| **PARALLEL SESSION 2 (14:30 - 16:00)** | | |
| | | |
| **SESSION 4** | **PROCESS SAFETY- II (Academic Block 6/ 202)** | |
| **CHAIR** | **Prof. En Soop Yoon ( Seoul National University)** | |
| **PAPER ID** | **TITLE OF THE PAPER** | **NAME OF THE AUTHORS** |
| **Keynote (Invited)** | **Hydrogen Safety : Progress made, knowledge gap and role of CFD** | **Dr.Prankul Middha (Proncipal Engineer, Formerly at Gexcon and DNV GL, UK)** |
| PS2-P1 | Integrated Safety and Security Approach for Effective Risk Management of Hazardous Chemical Facilities | Satya Dobhal, Vimlesh Kumar Bind, Chitra Rajagopal |

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|---|---|---|
| PS2-P2 | Integration of Hazard Identification & Risk Assessment with Standardized Plant Analysis Risk-Human reliability analysis method in Automotive Industry | V.S.Vivek |
| PS2-P3 | Advancing Safety Management with Effective Statistical Data Analysis | Kaushik Jayaraman |
| | | |
| **SESSION 5** | **FIRE SAFETY II (Academic Block 6/ 203)** | |
| **CHAIR** | **Prof. Venkatesh Kodur (Michigan State University)** | |
| **PAPER ID** | **TITLE OF THE PAPER** | **NAME OF THE AUTHORS** |
| **Keynote (Invited)** | **Full Scale glass Facade Fire Test @ IIT Gandhinagar** | **Dr. Gaurav Srivastava (Assistant Professor, IIT Gandhinagar)** |
| FS2-P1 | Evaluating Visibility and Toxicity Effects of Indoor Fires on Occupants' Escape Ability | Abhay Purandare |
| FS2-P2 | Novel Approach to Fire Safety Training using 3D Virtual Simulation | Sayli Bhide, Luis Rabelo |
| FS2-P3 | Directional Intelligence Fire Suppression System | Manjuprakash Rama Rao, Surajit Borah ,Anand Bandyal,P.U. Kamruddin,. Clive Weston, C. S. Bhaskar Dixit |
| | | |
| **SESSION 6** | **EARTHQUAKE SAFETY I (Academic Block 6 /201)** | |
| **CHAIR** | **Dr. Dhiman Basu (IIT Gandhinagar)** | |
| **PAPER ID** | **TITLE OF THE PAPER** | **NAME OF THE AUTHORS** |
| **Keynote (Invited)** | **Earthquake Hazard in India** | **Dr. Sumer Chopra (Director, Institute of Seismological Research)** |
| ES1 – P1 | On Characteristics of Near-Field Ground Motion | Gopala Krishna Rodda and Dhiman Basu |
| ES1 – P2 | Evaluation of Safety Culture in Construction Industry for Nasik City based on a three-point Likert scale | Ninad Anil Bonde, Dharani Kumar K, Rupesh Kumar Koshe and Anuja Anil Dalvi |
| | | |
| **PARALLEL SESSION 3 (16:30-18.00)** | | |
| | | |
| **SESSION 7** | **RISK ANALYSIS I (Academic Block 6 /202)** | |
| **CHAIR** | **Prof.Hans Pasman (Texas A&M University)** | |
| **PAPER ID** | **TITLE OF THE PAPER** | **NAME OF THE AUTHORS** |
| **Keynote (Invited)** | **Safety in Design of Chemical Process Plants.** | **Dr. M. Surianarayanan (Principal Scientist, CSIR - CLRI)** |
| RA1-P1 | Fuzzy FMECA (Failure Mode Effect Criticality Analysis) in LNG Terminal Operations | V.R. Renjith, Manoj Jose Kalathil, Haresh Kumar, Dilip Madhavan |
| RA1-P2 | Integration of Risk and its Importance in the Process Industry | Ashutosh Kumar |
| RA1-P3 | Fuzzy LOPA of Sodium hypochlorite plant in a Chlor-Alkali industry – A case study. | Amal. S. George, Renjith V. R. |
| | | |
| **SESSION 8** | **BEHAVIORALSAFETY (Academic Block 6/203)** | |
| **CHAIR** | **Prof. En Soop Yoon (Seoul National University)** | |
| **PAPER ID** | **TITLE OF THE PAPER** | **NAME OF THE AUTHORS** |
| **Keynote (Invited)** | **Six-Sigma reliability and the brain worker: Towards Error Proofing the Human Decision Maker** | **Prof. Rajagopalan Srinivasan (IIT Gandhinagar)** |
| BS-P1 | Developing a Reporting Culture Through Behavioural Changes Beyond The Gates | Prabhanjan Dixit,Kaushik Jayaraman |
| BS-P2 | Development of Behavioral-Based Safety Culture in Industries -Need of the Hour | Srikanth P., Lokeshwaran P., Vijay M. |

| | | |
|---|---|---|
| BS-P3 | An integrative model towards improvement of the safety behaviour of employee at workplace | D. Shreyasi and S. Kalaiselvam |
| | | |
| **SESSION 9** | **DISASTER MANAGEMENT (Academic Block 6 /201)** | |
| **CHAIR** | **Prof. Dongil Shin ( Myongji University)** | |
| **PAPER ID** | **TITLE OF THE PAPER** | **NAME OF THE AUTHORS** |
| **Keynote (Invited)** | **Emerging Trends in Public Alert & Warning System** | **Dr. R. K. Dave (Head Government Initiatives, Information Technology Research Academy, Media Lab Asia, MeitY, Govt. of India)** |
| DM-P1 (Invited) | **Implementing INSARG Marking System for Urban Search and Rescue (USAR) in India** | **Anju Sharma** Chintan Pathak, Sachin Bhagat (GIDM, Gujarat) |
| DM-P2 | Structural Equation Modelling of Work Injuries in the Construction Sector | Dongre, P., Jha, K.N., Patel, D.A |
| | | |

## Day 2: 04 January 2017

**PARALLEL SESSION 4 (11:45 - 13:15)**

| | | |
|---|---|---|
| **SESSION 10** | **PROCESS SAFETY III (Academic Block 6/ 202)** | |
| **CHAIR** | **Prof. Dongil Shin ( Myongji University)** | |
| **PAPER ID** | **TITLE OF THE PAPER** | **NAME OF THE AUTHORS** |
| **Keynote (Invited)** | **Functional Safety in first generation process plants.** | **Mr. G.Vishwanathan (Former DGM, Reliance Industries)** |
| PS3-P1 | Centre of Excellence: Tata Steel way to Process Safety | Surya Bhushan Kumar Sinha, Amit Kumar Singh, Rakesh Kumar Sharma, Vilas N. Gaikwad |
| PS3-P2 | Safety issues in City Gas Distribution Network | Ajay kumar Sharma |
| PS3-P3**(Invited)** | **Off-site Emergency Plan for Chemical Disasters Mitigation** | **Dr. R. K. Dave (Head Government Initiatives, Information Technology Research Academy, Media Lab Asia, MeitY, Govt. of India)** |
| **SESSION 11** | **CONSTRUCTION SAFETY (Academic Block 6/ 201)** | |
| **CHAIR** | **Dr. Gaurav Srivastava (IIT Gandhinagar)** | |
| **PAPER ID** | **TITLE OF THE PAPER** | **NAME OF THE AUTHORS** |
| **Keynote (Invited)** | **Safety-An Introspection** | **Mr. Debasish Kar (Director General, Kolkata Municipal Corporation)** |
| CS3-P1 | A Fuzzy Multi Criteria Risk Assessment Methodology Based On Failure Mode And Effective Analysis: A Case Study In Construction Industry | Pavanaditya Badida, Jayapriya Jayaprakash |
| CS2-P2 | Experimental Determination of Natural Frequency of Confined Masonry buildings by Ambient and Forced Vibration Testing. | Harshit Nema and Dhiman Basu |
| | | |
| **SESSION 12** | **FIRE SAFETY III (Academic Block 6/203)** | |
| **CHAIR** | **Mr. D. K. Shami (Fire Advisor, Government of India)** | |
| **PAPER ID** | **TITLE OF THE PAPER** | **NAME OF THE AUTHORS** |
| **Keynote (Invited)** | **Fire Behaviour of Reinforced Concrete Structural Elements** | **Dr.N Gopalakrishnan (Director, CSIR -CBRI)** |
| FS3-P1 | Progressive Collapse Analysis of RCC Planar Frames Subjected to Fire | P.Ravi Prakash , Gaurav |
| **FS3-P2** | **CFT Columns at Elevated Temperatures: Behavior and** | **Dr.Anil Agarwal (Assistant Professor, IIT** |

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|---|---|---|
| **(Invited)** | **Design** | **Hyderabad)** |
| SF3-P3 | Need to Revisit Fire Loads - Findings of a Recent Survey at Ahmedabad | Nasar A Khan and Gaurav Srivastava |
| | | |
| **PARALLEL SESSION 5 (14:30 - 16:30)** | | |
| | | |
| **SESSION 13** | **PROCESS SAFETY IV (Academic Block 6/202)** | |
| **CHAIR** | **Prof. Sam Manan (Texas A&M University)** | |
| **PAPER ID** | **TITLE OF THE PAPER** | **NAME OF THE AUTHORS** |
| **Keynote (Invited)** | **Atmospheric dispersion modelling and stochastic programming for optimal fence monitoring of gas release** | **Prof. Dongil Shin (Chemical Engineering, Myongji University)** |
| PS4-P1 | Quantitative Risk Assessment for Highway Due to Explosive Storage Facilities | Vimlesh Kumar Bind, Bimal Kumar, Arti Bhatt, P. K. Rai, Chitra Rajagopal |
| PS4-P2 | Real-time, High-Sensitivity Chemical Sensing using LASERS for industrial process control and safety | Anirban Roy, Abhishek Upadhyay, Arup Lal Chakraborty |
| | | |
| **SESSION 14** | **EARTHQUAKE SAFETY II (Academic Block 6/ 201)** | |
| **CHAIR** | **Dr. Sumer Chopra (Director, Institute of Seismological Research)** | |
| **PAPER ID** | **TITLE OF THE PAPER** | **NAME OF THE AUTHORS** |
| **Keynote (Invited)** | **A Robust Pushover Analysis for Multi-Component Seismic Excitations- A New Frame Work** | **Dr. Dhiman Basu (Assistant Professor, IIT Gandhinagar)** |
| ES2-P1 | Response analysis of asymmetric-plan system with viscous damper subjected to random ground excitations | C. C. Patel |
| ES2-P2 | Probabilistic Seismic Hazard Assessment of Gujarat and its Implications on Seismic Design in the region. | Asim Bashir and Dhiman Basu |
| ES2-P3 | Improving Construction Workers Safety through Design | C.Vigneshkumar, Monica Shrivastava, J.Uma Maheswari |
| | | |
| **SESSION 15** | **RISK ANALYSIS II (Academic Block 6/ 203)** | |
| **CHAIR** | **Prof. Rajagopalan Srinivasan (IIT Gandhinagar)** | |
| **PAPER ID** | **TITLE OF THE PAPER** | **NAME OF THE AUTHORS** |
| **Keynote (Invited)** | **Barrier based Risk Assessment** | **Shri. Umesh Dhake (Asia Pacific Regional Manager, CCPS, AIChE)** |
| RA2-P1 | Safety Investment Optimization in Process Industry: A Risk-based Approach | Ankit Gupta and Sandip Roy |
| RA2-P2 | Risk Evaluation of Oil And Natural Gas Installations Due to Natural Hazards Using Fuzzy Fault Tree Analysis | Yakesh Balasubramaniam, Pavanaditya Badida, Jayapriya Jayaprakash |
| RA2-P3 | Industrial Risk Management and Land Use Planning in India | Anandita Sengupta |
| | | |

# Symposium on Process Safety

| January 05, 2017 (Day 1 ) | | Venue: Academic Block 6/202 |
|---|---|---|
| 08:30 | **Registration** | |
| 09:15 – 9:30 | **Welcome & Opening** | |
| 09:30 – 10:30 | **Prof. Sam Mannan**<br>Texas A&M University, USA | Safety Culture and Engineering Ethics |
| 10:30 – 11:00 | **Tea & Networking** | |
| 11:00 – 12:30 | **Prof. Sam Mannan**<br>Texas A&M University, USA | Safety Culture and Engineering Ethics |
| 12:30– 14:00 | **Lunch** | |
| 14:00 – 15:30 | **Prof. Hans Pasman**<br>Texas A&M University, USA | Root Cause Investigation |
| 15:30 – 16:00 | **Tea & Networking** | |
| 16:00 – 17:30 | **Dr. Prankul Middha**<br>Principal Engineer, | CFD and Technical Safety - Need, Value and Approaches |
| 19:30 | **Symposium Dinner & Networking**<br>**Venue:** IITGN - Auditorium Area | |

| January 06, 2017 (Day 2) | | Venue: Academic Block 6/202 |
|---|---|---|
| 08:30 | **Registration** | |
| 09:30 – 10:30 | **Prof. Sam Mannan and Prof. Hans Pasman**<br>Texas A&M University, USA | Leading and Lagging Indicators: Key Performance Indicators |
| 10:30 – 11:00 | **Tea & Networking** | |
| 11:00 – 12:00 | **Prof. Sam Mannan and Prof. Hans Pasman**<br>Texas A&M University, USA | Leading and Lagging Indicators: Key Performance Indicators |
| 12:00-13:00 | **Prof. En Soop Yoon**<br>Seoul National University | Sustainability and Safety in the future |
| 13:00 – 14:00 | **Lunch** | |
| 14:00 – 15:30 | **Dr. M. Surianarayanan**<br>CSIR-CLRI, Chennai | Reactive Chemicals and Process Hazards |
| 15:30 - 16:00 | **Valedictory** | |

# Symposium on Structures Under Fire

| January 05, 2017 (Day 1 ) | | Venue: Academic Block 6/203 |
|---|---|---|
| 8:30 | **Registration** | |
| 9:00 – 9:30 | **Dr. Gaurav Srivastava**<br>IIT Gandhinagar | Introduction and overview |
| 9:30 – 10:30 | **Prof. Venkatesh Kodur**<br>Michigan State University | **Introduction to fire safety**<br>- Historical perspectives, types of fire, codal provisions, objectives of fire safety design |
| 10:30 – 11:00 | **Tea & Networking** | |
| 11:00 – 12:00 | **Dr. Anil Agarwal**<br>IIT Hyderabad | **Fire behaviour**<br>- How fire behaves, different types of fire, growth rate calculations, link with FLED |
| 12:00 – 13:00 | **Dr. Anil Agarwal**<br>IIT Hyderabad | **Heat transfer principles**<br>- Mechanisms of heat transfer, design calculations for assessing temperatures inside structural members (RC and steel) |
| 13:00 – 14:00 | **Lunch** | |
| 14:00 – 15:00 | **Prof. Venkatesh Kodur**<br>Michigan State University | **Effect of fire on materials and structures**<br>- Mechanical and thermal properties of steel and concrete |
| 15:00 – 16:00 | **Dr. Anil Agarwal**<br>IIT Hyderabad | **Design of steel members** |
| 16:00 – 16:30 | **Tea & Networking** | |
| 16:30 – 17:30 | **Dr. Anil Agarwal**<br>IIT Hyderabad | **Hands on session on design of steel members under fire** |
| 19:30 | **Symposium Dinner & Networking**<br>**Venue: IIT Gandhinagar Auditorium Area** | |
| **January 06, 2017 (Day 2)** | | **Venue: Academic Block 6/203** |
| 8:30 | **Registration** | |
| 9:00 – 10:00 | **Dr. Gaurav Srivastava**<br>IIT Gandhinagar | **Design of reinforced concrete members** |
| 10:00 – 11:00 | **Dr. Gaurav Srivastava**<br>IIT Gandhinagar | **Hands on session on design of RC members under fire** |
| 11:00 – 11:30 | **Tea & Networking** | |
| 11:30 – 13:00 | **Prof. Venkatesh Kodur**<br>Michigan State University | **Fire safety provisions for high-rise buildings** |
| 13:00 – 14:00 | **Lunch** | |
| 14:00 – 15:00 | **Shri Abhay Purandare**<br>Consultant – Fire and Life Safety | **Provisions in Indian codes for fire safety (NBC part 4)** |
| 15:00 – 15:30 | **Prof. Venkatesh Kodur**<br>Michigan State University | **Performance-based fire design and research questions** |
| 15:30 – 16:00 | **Valedictory** | |

# ABSTRACTS

| **Session 1: Process Safety I** | |
|---|---|
| Session Chair: **Prof.Sam Mannan (Texas A&M University)** | **Venue:** Academic Block 6/ 202 |

**Sm. Sutapa Bhatacharya: Risk Evaluation of Oil and NG pipeline and Steel Plants**

**Abstract:** The presentation is a combination of data analysis of Oil and Natural Gas Installation, due to Natech Incidences (Natural Hazards causing Technological Disasters), Risk Assessment of Oil industry pipeline and of Steel Industries. Natech may pose tremendous risks to countries and communities that are unprepared for - examples are available all over the world. The presentation tries to highlight the types of Natech and their use in Risk Assessment, the integration of Risk Assessment (RA) with safety investment optimization based on case study of for Gas pipelines and Steel Industries.

**Dr. Syeda Sultana Razia: Challenges in Establishing Process Safety Management System: Bangladesh Perspective**

**Abstract:** Bangladesh is currently observing rapid growth of chemical process industries with a trend towards large and highly integrated production units with complex processes. The recent rise in chemical accidents in the country shows the growing need of improved safety culture in the industry. In this presentation some of the critical accidents in chemical industry are analyzed and key factors behind the accidents are identified. The existing legislations to address process safety issues are discussed. The latest initiative to establish a Process Safety Management system in Bangladesh Chemical Industries Corporation (BCIC), the largest umbrella organization of chemical industries in Bangladesh is also elaborated
.

**Dr. Debalina Sengupta: Incorporating Sustainability Considerations in Process Systems Engineering: Design for economic, environmental and safety criteria**

**Abstract:** Computational process design for sustainability using various available techniques is still limited to computer-aided design featuring process optimization of energy and material flow plus minimizing greenhouse gas emission and water conservation. Sustainable process demands more, such as minimizing the impacts from other harmful emissions, discharges, waste creation, economic, and societal impacts. Safety considerations in the early stages of design can help in prevention of impacts down the road through better design. The relevance of this talk is geared towards decision making during the early stages of process design, and the paper will focus on the introduction of such advanced design topics in the Chemical Engineering Curriculum.

| **Session 2: Fire Safety I** | |
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| Session Chair: **Prof. Venkatesh Kodur(Michigan State University)** | **Venue:** Academic Block 6/ 203 |

**Dr. Ali Rangwala: New Concepts for Hazardous Waste Cleanup by Combustion**

**Abstract:** Worcester Polytechnic Institute has been researching waste oil clean up by combustion for the past 7 years. This talk will summarize the research results and path going forwards. Two burning concepts are discussed: an in situ burn capable of enhanced combustion of oil slicks in containment booms and ice pits (for spills in the Arctic), and a waste incinerator that can burn off oil – water mixtures collected by a skimmer. Several large scale experiments are discussed. The application of the research ideas to other types of hazardous waste combustion is explored

**Varun Teja, Kirti Bhushan Mishra: 3D physics-based modeling of large-scale flammable cloud dispersion using FLACS**

**Abstract:** The number of accidents in refineries/storage terminals is increasing worldwide. Such events are disastrous to both human being and infrastructure. It is therefore necessary to utilize the best methods to study all possible risks associated with a process and/or plant. CFD (Computational Fluid Dynamics) models are one of the strong tools to perform 3D modelling of major events. Present work reports the 3Dphysics based modeling of large-scale flammable cloud dispersion in a real configuration. Most widely approved code for fire and explosion simulation FLACS (Flame Acceleration Simulator) was used to simulate the gases and liquids released from different leak sizes in a storage terminal. The leak was assumed to be at the pipes supplying the fuel to storage tank. The flow rate, surrounding condition and release duration were varied to study their influence on overall vapor cloud size i.e. diameter and depth and explosive strength. Depending on the extent of LFL (Lower Flammability Limit) total flammable cloud volume an equivalent explosion overpressure was predicted. It was found that such detailed modeling helped to understand the dispersion behavior much better than the phenomenological models. The strategic decisions on gas detectors layout can also be made for loss prevention and control. The worst-case scenario simulation led to the adoption of effective pre and post-incident mitigation measures.

**Vimlesh Kumar Bind, Kamlesh Kumar Meena, Chitra Rajagopal: Consequence Modelling For Propellant Storage Facilities**

**Abstract:** Propulsion systems such as rockets and missiles are integral part of any modern sovereign country. The peace time application of such systems are in space exploration, launching of satellite, etc. and in the event of war these system could be used for defense purposes. Solid as well as liquid propellant forms the backbone of such systems because it provides required propulsive power. The power inherent in propellant also poses hazard while processing, handling, transportation and storage. The objectives of this study are analysis of consequence due to propellants and comparison of various consequence prediction models used in different countries such as Norway, Sweden, Netherland, Switzerland. The study will also analyze presence of weaker section in propellant storage buildings. Traditional methods for design of store houses / magazines for HD 1.3 type explosive (propellants) has been also discussed which suggest a weaker section in the building for (should not be much greater than 50 kg/m2 ) rapid release of pressure build-up during any accident. In current study effectiveness of above criteria will be studied by carrying out mass and species balance for the propellant storage building. The burning of propellant will be a source term for mass and species and vent will be through weaker section of the building. The rate of pressure rise inside the building has been be estimated to predict the survival of the structure. Finally the dimensions of fireball / jet fire generated due to release or combustible gases such as CO, H2, etc. at temperature above their auto-ignition temperature will be estimated based on models available in literature. The jet fire result will be compared with experimental data. Proposed study will result in better understanding of hazard associated with propellant storage. Method presented in this study can be utilized for consequence prediction and in decision making while sitting facility in the vicinity of propellant storage facility

**Ajay Banerji: A study of the causes and events leading to the fire disaster at Lac-Megantic, Canada on July 6, 2013**

**Abstract**: A large part of the town of Lac-Megantic in eastern Canada was destroyed in a fire caused by the derailment of a freight train carrying crude oil on July 6, 2013. There was heavy loss of life as well. This was one of the world's worst accidents of damage to surrounding areas caused by a railway accident. This paper looks into the company policies, unsafe operating practices and negligence by the railway staff which led to this unprecedented disaster.
The main factors which led to this disaster included:

1) Additives to crude oil to increase viscosity which also caused volatility and greater likelihood of ignition.
2) Cost-cutting measures which led to a single railway employee having charge of a train with 5 locomotives and over 70 tank cars.
3) Unsafe practices such as leaving a heavy train unattended without adequate precautions to prevent it from starting and running out of control on a slope.
4) Unusual events which caused the train to start running out of control.
5) The use of less-crashworthy tank wagons as an economy measure.
6) Frequent changes of corporate ownership which was a factor in unsafe practices in train operation.
7) Other legal complexities which had a bearing on the accident, including those pertaining to an US-owned company running trains in Canada.

These topics will be discussed in more detail along with diagrams and other illustrations.
It will also be shown that operating practices for transport of hazardous material by rail in India appear to be considerably safer than those employed by the company involved here.

| **Session 3: Explosion Safety** | |
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| Session Chair: **Prof.Hans Pasman (Texas A&M University)** | **Venue: Academic Block 6/ 201** |

**Dr. Chitra Rajagopal and Ramesh Kumar Singh: Safety Management in Defence**

**Abstract:** Modern defence systems are very complex and possible accidents due to inherent hazards can lead to huge loss of life and assets. These accidents also results in loss of morale and other non-quantifiable effects. Therefore safety management is of utmost importance in defence sector. For effective safety management, the continuous development and absorption of technologies, processes, materials and assessment methodologies which can be leveraged to enhance safety is required.

Centre for Fire, Explosive and Environment Safety (CFEES), a DRDO laboratory is the nodal agency for safety management in Ministry of Defence; and is involved in development of safety technologies, tools and procedures for meeting the requirements of Ministry of Defence in the areas of explosive, fire, environment and process safety.

The paper brings out the contributions of Centre for Fire, Explosive and Environment Safety (CFEES) for providing comprehensive solutions to address Fire, Explosive, and Environment safety issues in Defence; and discusses various technologies developed at CFEES viz.Innovative designs of aboveground and underground explosive storage structures (LRC Igloo, URP, HPM, UG), Instant Fire Detection and Suppression System (IFDSS) for Armoured Fighting Vehicles, Water mist based fire suppression systems for Naval applications, Fire Protective Clothing and Fire Escape Chute, Halon alternatives, Advanced Oxidation Process Technology for Treatment of Hazardous Effluents, Photodegradable Polyethylene for Packaging Applications, Biofuel Reformer, Metal Oxide Nanoparticles as Reactive Adsorbents against Toxicants, and Treatment and Disposal Technology for Hazardous Heavy Metal Wastes. This paper also discusses initiatives taken by CFEES in evolving regulations and skill development in the areas of fire, explosive and environment safety.

**Purvali Chaudhari, Chad Mashuga: Improvisation of the Minimum Ignition Energy device for studying the effect of partial inerting on the MIE of dusts**

**Abstract:** Dust often presents an explosion hazard to manufacturing facilities in the process industries when dispersed in cloud form. The smallest amount of energy required for dust cloud ignition through a range of concentrations at a given temperature and pressure is the minimum ignition energy (MIE). Therefore, it is important to accurately determine the MIE of combustible dusts as it gives an understanding of the ignition probability. It can be used as a guide to identify ignition sources and levels that need to be eliminated in facilities handling such dusts. If a dust has

higher ignition energy, often general precautions will be followed such as grounding and bonding. However, if the ignition energy is sufficiently low, the entire process may be inerted with nitrogen to remove any oxygen rendering the dust non-flammable. Partial inerting is an important dust explosion mitigation technique potentially having wide application in several industries including chemical and general manufacturing. It allows an alternative to the common all or nothing inerting stratagies that are often currently practiced. Partial inerting involves reducing the oxygen content to a threshold value by increasing the nitrogen content of the atmosphere in process equipment or storage of a combustible dust. The reduction in oxygen thereby increases the MIE of the dust to a sufficiently high level such that there is no credible scenario for an ignition source to exist above this critical level in the given system. The Kühner MIKE3 device is the industrial and research standard for determining the Minimum Ignition Energy (MIE) of combustible dusts worldwide. The current MIKE3 device is not designed or intended to determine partial inerting ignition paramters. The major focus of this work is to show that simple modifications and additions to the MIKE3 device permits accurate partial inerting MIE testing to be performed. The effect of these modifications has been quantified by examining the partial inerting ignition energy levels for Niacin (CaRo15) dust. Therefore, this study demonstrates an improved dust testing method and dust hazard assessment and mitigation approach, and sets an exemplary standard for partial inerting dust testing.

**V.Surendar, V.P.Sridhar, S. P. Sivapirakasam, M.Surianarayanan.:**
**Estimation of TNT Explosion Potential For Aerial Fireworks Mixtures**

Abstract: Fireworks mixtures are prone to energetic and explosive decomposition due to impact, friction and thermal stimuli. When an accident occurs in fireworks industries, the neighboring facilities such as working sheds, magazines, drying platforms etc. are also subjected to heavy damage due to transfer of energy from over pressures. In a recent incident, many fatalities of onlookers outside the premises of the factory were reported. Although fireworks mixtures behave like high energetic explosives, reports categorizing them equivalent to TNT is not available. In this work four important fireworks mixtures were subjected to Accelerating Rate Calorimetric studies to assess the exothermic decomposition potential. The onset and final temperature of exothermic decompositions were observed as 330 $^{o}$C to 373C for gun powder, 240C to 296OC for red star composition, 190 $^{o}$C to 219 $^{o}$C for green star composition and 245 $^{o}$C to 296 $^{o}$C for silver star composition. The over pressure calculated from TNT equivalence for different quantities of fireworks mixtures suggest vulnerability to damages. The overpressures computed in this work for different fireworks mixtures were useful in deciding the inter safety distance of fireworks manufacturing sheds to avoid cascading effects.

**Pranav Bagaria, Jiaqi Zhang, Chad Mashuga: Effect of Dispersion on Particle Breakage in Dust Explosion Phenomena**

**Abstract:** For dust explosion studies, the standard parameters are the maximum overpressure (Pmax) and deflagration index (Kst) found with a 20-L dust explosion apparatus in accordance with ASTM standard (ASTM E1226). Recent studies have shown that the dispersion system for the required dust cloud formation in the standard 20-L apparatus induces significant mechanical shear resulting in breakage of dust particles.Therefore, the explosion parameters obtained (Pmax and Kst) are not representative of the original dust size distribution prior to testing.The 36-L dust explosion apparatus at the Mary Kay O'Connor Process Safety Center, Texas A&M University has an alternate dispersion system. In this apparatus, the dust does not pass through an outlet valve as it does in the standard 20-L apparatus. Rather, the dust storage container is situated just below the explosion chamber and the air passing through the outlet valve disperses it inside the chamber through an identical nozzle, thus avoiding the shearing action of an outlet valve. This project aims to study this novel dispersion system and its advantage over the traditional dispersion of the 20-L apparatus. The study also investigates the influence of the dispersion nozzle, dust cloud concentration and turbulence on particle breakage. Additionally, the dispersion behavior of nanomaterials has been studied. Finally, the influence of the dust dispersion in a

standard minimum ignition energy device will be presented. Anthraquinone, Acetaminophen (Paracetamol) and Ascorbic Acid are used to achieve the goals of the study. Carbon nanofibers (CNFs) are used to study the effect of dispersion process on nanomaterials in the 36-L apparatus. Results with Anthraquinone, Acetaminophen and Ascorbic Acid in the 36-L apparatus reveal that even in the absence of an outlet valve, particle breakage is significant and is comparable to that in a standard 20-L apparatus. It leads to conclusion that the dispersion nozzle and dispersion cloud turbulence has a major role in particle breakage. In addition, an inverse relationship between particle breakage and dust dispersion concentration was found based on the experiments. Experiments with carbon nanofibers (CNFs) show that significant de-agglomeration of nonmaterial occurs in the dispersion cloud generating very large surface area followed by re-agglomeration. Also, experiments in the MIE apparatus show particle breakage doesn't occur in the MIE apparatus, but for electrostatic materials such as Acetaminophen, the particle size distribution shifts significantly which can lead to erroneous MIE results.

| **Session 4: Process Safety II** | |
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| Session Chair: **Prof En Soop Yoon (Seoul National University)** | **Venue:** Academic Block 6/ 202 |

**Prankul Middha: Hydrogen Safety - Progress Made, Knowledge Gaps, and the role of CFD**

**Abstract:** Hydrogen is expected to play an important role as an energy carrier in a future low-carbon society. However, it is crucial to address hydrogen safety issues in order to demonstrate that the wide spread deployment and use of hydrogen and fuel cell technologies can occur with the same or lower level of hazards and associated risk compared to the conventional fossil fuel technologies. Computational Fluid Dynamics (CFD) is considered one of the key tools to investigate safety issues related to the production, storage, delivery and use of hydrogen. CFD techniques can provide an accurate analysis technique on the dynamics of hypothetical hydrogen accident and its consequences. The CFD-based consequence analysis is then used in risk assessments. This paper is an attempt to give a concise overview of the state-of-the-art in the recent hydrogen safety research, The up-to-date knowledge, recent progress, and existing gaps and how to address them is discussed.

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**Satya Dobhal, Vimlesh Kumar Bind, Chitra Rajagopal: Integrated Safety and Security Approach for Effective Risk Management of Hazardous Chemical Facilities**

**Abstract:** In the present security scenario, the key chemical industry resources such as critical chemical infrastructure, elements of chemical value chain involving plant and machinery, onsite and off-site storages, transportation and waste disposal facilities etc. may become attractive targets for terrorists and anti-social elements. Their main aim could be to disrupt the operation, make their presence felt; disrupt the economy and social harmony by causing large scale fire, exposition and toxic release or sometimes just petty theft. The management of hazardous chemical facilities becomes a serious business due to inherent hazard associated with these chemicals. Thus staying ahead of the adversaries posing potential threats is a necessity that can be realized through effective risk management to prevent human causalities, and damage to property and public morale. When dealing with safety at a chemical facility; occupational, fire, explosion, toxicity and environment related hazards are main concerns while focus of security in the same facility will traditionally be on protecting personnel and infrastructure using access control, perimeter patrol, emergency assistance and background checks for personnel. There is a undefined link between safety and security. Therefore we often find that in large organizations safety, physical security and cyber security operate in different silos and considered separately for resource allocation. This creates duplication on some aspects while gaps in some other aspects. For bridging the gaps and manage the overlaps efficiently between different operations, it is essential to review the traditional

approach for safety and security. Safety tools for the chemical facilities i.e. HAZOP, event tree analysis, fault tree analysis, consequence analysis etc. are well evolved and widely in use while security procedures are generally standard. To develop shared objectives of safety and security, this paper suggests using a four step cyclic process, starting from use of fundamentals of safety analysis, identification of Security Critical Resources (SCR), application of Design Basis Threats (DBT) analysis with vulnerability assessment and effective risk reduction. The outcome of safety analysis will facilitate the identification of SCR. The use of DBT analysis for every SCR followed by vulnerability analysis of the existing system, in the lines of nuclear facilities, will highlight the areas of interventions across functions, once implemented will lead to effective management of the risk. This activity needs to be repeated to cater for changes in the facility or in the environment it is operating. The outcome of the proposed methodology will provide input to the management for appropriate decisions for implementation. For example, an acceptable level of risk reduction for a security critical chemical may involve differing degrees of control which may includes some or all actions such as regular reports, monitored access control, transfer authorization, reconciliation, defined physical verification frequency, licenses / permits for sales, customer identification, notifications etc. Risk based effective chemical inventory Control will be a key requirement for integrated chemical safety and security. Post implementation of the changes, the training of stake holders and regular mock drills are essential to maintain the system for intended purpose. In brief, the integrated approach will result in efficient resources allocation, development of shared objectives, a reliable integrated system for safety and security providing higher assurance to stake holders

**V.S.Vivek.: Integration of Hazard Identification & Risk Assessment with Standardized Plant Analysis Risk-Human reliability analysis method in Automotive Industry**

**Abstract:** This paper aims an integration of Hazard Identification and Risk Assessment (HIRA) with a human error identification (HEI) technique. HIRA is the primary tool used in most industries to prevent accidents as a proactive approach of safety system.The impetus for the paper stems from the idea that the HIRA method overlooks one of the root causes of the accidents/incidents in the workplace, which is, the unsafe acts or human error. Standardized Plant Analysis Risk-Human reliability analysis (SPAR-H) method is one of most recent and effective human error identification techniques which assesses the human error probability and is chosen as the tool to integrate with the HIRA method in this paper. Thus, in order to make it more efficient towards the proactive approach of accident prevention in workplace, HIRA method has to consider human error assessment in the workplace which can be achieved through the integration of HIRA with SPAR-H. Also, the integration of HIRA with SPAR-H will result in giving an additional dimension in prioritizing the hazards identified and assessed and thus, making HIRA, a more effective and proactive tool for safety supervision in an industry. A leading international automotive manufacturing corporation in Chennai, Tamil Nadu, India, was chosen as a case study for the research work where the upgraded HIRA was implemented by which the hazards in the cylinder head rough machining line in the plant were identified and prioritized for the control measures.

**Kaushik Jayaraman: Advancing Safety Management with Effective Statistical Data Analysis**

**Abstract**: Budget time around the corner? Safety Managers entering debates on and off! What should the Safety Team do to convince the Management of the benefits from a recommendation? Is the Safety data being utilized effectively? Recent advances in information technology and its' applications to Safety (Occupational & Process) have led to a deluge of safety information. Safety Management has grown to encompass a wide array of aspects, which continuously build on the existing information databases. This includes data from Behavior-based Safety campaigns, audits,

incident & near miss reports/ investigation recommendations, substandard act/ condition reports, etc.

Most current use of statistics in safety data analysis is in the standardized depictions of number of events, or their frequencies (such as Accident/ Incident Frequency rates, Injury/ Disability Rates, etc.). This is what makes Safety data comparable for benchmarking and development purposes. This has led to stagnation in the arena of Data development and Analysis. It also shows the management all is well without focusing on exactly what goes wrong. One of the contributors to such a facsimile representation of the organizational safety culture is the need for showing development and justifications through performance appraisals. Evident in the inadvertent abuse of Performance Indicators showing continual improvement through a repetitive fall in frequency rates, this defies conventional wisdom. How do you keep the management on their toes and showing areas of concern and improvement when the performance shows improvement?

The use of statistical data analysis has helped in business analytics for handling all Health, Safety, and Environmental (HSE) data. Though the admitted use of these techniques has been mostly in the analysis of medical data, safety personnel have analyzed and presented various data to the management for years. This paper shows what data can be analyzed and how this analysis can benefit the organization. Most published analyses were found restricted to the varied graphical presentations (charts/ graphs) of incident statistics (such as distributions by area, time, type of activity/ work in progress, etc.). It has now become a part of organizational best practices to include safety data analysis on a monthly or quarterly-basis. But these need further depth. While querying for basic causes of incidents, there is a generic shortage even through advanced search engines such as Google. In an era of big data analytics, detailed root cause analysis can help and be furthered by use of statistical data analysis. The use of standard incident investigation trees/ charts such as TapRoot, RCAT, CLC, etc. has still not achieved global equanimity. Different organizations use different techniques and methodologies for their purposes. The use of Regression Analysis and the testing of Hypothesis can lend credence to safety practices and recommendations placed before the management for decisions. The lack of adequate forethought and actions in this area by governmental and statutory bodies has limited the spread of data analytics in HSE, and needs immediate and drastic action. To learn from the mistakes of our past, and avoid repeating adverse events (incidents/ failures), we must be able to effectively handle the information that has exploded around us. Today, we are receiving multiple Investigation Learnings that have yet to be analyzed and processed into actionable actions. Even basic statistical analysis can break this trend and highlight the areas of controls that need immediate action.

| **Session 5: Fire Safety II** | |
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| Session Chair: **Prof. Venkatesh Kodur(Michigan State University)** | **Venue:** Academic Block 6/ 203 |

**Dr. Gaurav Srivatsava**:**Full Scale glass Facade Fire Test @ IIT Gandhinagar**

**Abstract:** Glass façade are used very commonly in modern construction. In addition to being aesthetically pleasing, they enable better energy management of buildings and hence, have become an integral part of green building design. For acceptable performance, such systems must be constructed with appropriately rated materials following good installation practices. In case of a fire event, the performance of the façade as well as the fire stop material is crucial for the overall performance of the building as they can easily become vehicles for movement of fire along the building. A number of past fire incidents in buildings indicate the risks associated with using façade system.

To study the behaviour of facade systems when subjected to realistic fire scenarios, UL and IITGN ventured on a joint project to develop a one of its kind full-scale testing facility for facade systems. This is a three-storey structure constructed in IITGN premises, designed and instrumented to carry out such tests. Three full-scale tests have been completed and this talk will discuss some of the

interesting findings of these results. While some of these findings are in line with the established wisdom, some provide evidence to the contrary. Overall, it is expected that these findings will pave way for improving fire safety standards in India and will also shed light on behaviour facade systems to develop scientific mechanisms for firefighting.

**Abhay Purandare: Evaluating Visibility and Toxicity Effects of Indoor Fires on Occupants' Escape Ability**

**Abstract:** As is well known, smoke is the killer in building fires, not the heat. However, what is not known to most people is how smoke and fire effluents from indoor fires interact with occupants and affect the escape ability of occupants. Depending upon factors such as the composition of fuel, ventilation available and other factors, the quantity of solid particulate matter and aerosols, and fire effluents generated will vary. However, all types of indoor fires will generate smoke which affects visibility of occupants and fire gases (both irritant and toxic) which adversely impact the physiological systems of the human body. Scientists have attempted to understand and quantify these effects in order to assess whether design of life safety and fire protection systems provided in buildings are adequate considering these effects and whether these need to be modified/ reinforced to aid occupants' escape. This also helps to justify design of smoke detection systems, smoke control systems and choice of materials used in construction.

Exposure to smoke normally occurs first in a fire situation, which affects visibility (as smoke particles obscure illumination and vision), irritant gases affect nerve endings in the eyes and respiratory tract, affecting vision and causing swelling and pain in the respiratory tract and affecting breathing, while asphyxiant gases cause nervous system depression, and affect critical life systems. The effects of exposure to smoke and fire gases could be minor and in many cases, reversible. However, in many cases these effects can be significant enough to impair escape, cause incapacitation or even death. In some cases, occupants may survive but the level of exposure can result in long term or permanent damage to the human body.

Methods for estimating visibility have mostly included experimental assessment of the relations between the visibility and optical density of fire smoke (using different types of smoke), and practical equations have been developed based on this. Also, experimental research has been carried on subjects under limited fire smoke conditions for examining threshold of fire smoke density for safe evacuation. In reality, irritant smoke might impede vision at concentrations below those at which it blocks light transmission, as it causes watering in the eyes and affects vision; however, no adequate biological model has so far been developed for this.
Toxicity assessment is done using two different methods: one is to calculate the yields of individual toxic products produced by decomposing a given material, and combine this with mass loss rate and effluent dispersal calculations to obtain time versus concentration curves for each effluent identified. The other method is to expose laboratory animals to toxic gases released from decomposing material in small scale laboratory apparatus. Mass loss concentration is measured for a given toxicity endpoint (such as incapacitation or death) and expressed as such (e.g. LC50). The data obtained is used for assessing the effects of multiple effluents (as smoke include multiple effluents), by applying concepts such as the Fractional Effective Dose or Concentration. These concepts are also applied in evacuation models for assessing egress during fires, and are important reference points in forensic pathology

**Sayli Bhide, Luis Rabelo.: Novel Approach to Fire Safety Training using 3D Virtual Simulation**

**Abstract:** In present era, tall and complex building structures have become ubiquitous. Increasing incidences of fires in hospitals, offices, residential complexes and factories are being recorded worldwide. Unfortunately, fire accidents that happen in such structures result in significant property damage and loss of human life. Most of the casualties reported in fire accidents happen due to people not being adequately trained on fire emergency procedures. Best defense against fire accidents is proper safety training and it can also help in reducing human errors. Lectures by experts, emails, pamphlets, newsletters, signs posted on the walls and slides seen on personal computers are most common approaches to provide safety training. However, due to unidirectional flow of information, employees involved in such training are not learning actively. Hence, their response to understanding risks and mitigating them in real time workplace emergency situations is not as effective. This paper reports findings from research work that focused on the development of 3D virtual emergency evacuation safety training for residents, workers and employees using which, people can be trained in more engaging and effective manner. A 3D virtual fire safety and emergency evacuation training was developed for occupants of a building. Participants could visualize and interact with various objects, avatars and scenarios created in 3D virtual model of a real engineering college building on a standard desktop computer by controlling an avatar through keyboard and mouse. Expert interviews and literature review were utilized to develop contents of this training. A conventional slide based fire safety and emergency evacuation training was developed and made available through a website. An effort was made to develop both trainings comparable in terms of contents. A case study with two experiments comprising of 143 participants from university community was conducted to understand factors such as fidelity, simulation sickness, engagement and effectiveness of 3D virtual and conventional web based fire safety and emergency evacuation training. Results of fidelity and simulation sickness validated fitness of 3D virtual training for the purpose of training residents on fire safety and emergency evacuation. Knowledge test data analysis allowed to compare short term and long term effectiveness of 3D virtual training and slide based training. To further understand engagement, physiological measure-electroencephalogram (EEG) of 40 healthy participants was recorded in second set of experiments. Ratio of power in Beta and Alpha frequency bands was studied to understand level of attention and focus of participants in 3D virtual and slide based training. In summary, this paper reports a novel approach to fire and emergency evacuation training using virtual 3 D simulation. It is shown through various questionnaire and EEG measurements that the new approach for training is more effective and engaging. Moreover, the virtual 3D simulation based training can be implemented using minimal resources and cost as it can be deployed on any computer or mobile devices
.

**Manjuprakash Rama Rao, Surajit Borah ,Anand Bandyal,P.U. Kamruddin,. Clive Weston, C. S. Bhaskar Dixit: Directional Intelligence Fire Suppression System**

**Abstract**: Accidental fires in oil & gas installations, warehouses, waste processing units tend to spread rapidly. The first few minutes are crucial to detect and suppress a fire and mitigate large scale damages to life and property. An automatic fire detection and suppression system where-in the 3D location of fire is estimated and the position is used to activate and direct the suppressant towards the fire would be very effective to control the spread of the fire in the first few minutes as the fire breaks out. The false alarms from fire detectors cause considerable inconvenience to the users. A system which would incorporate flame detection techniques which are robust against false alarms would improve the acceptance of such a system for practical applications. Characterization and modeling of the trajectories of the suppressant jet at various operating conditions of line pressure, angle of elevation and choice of suppressant would help in pointing the trajectory as practically accurate as required for the operation. The ambient conditions of the wind and appropriate compensation will have to be incorporated to offset the accuracy issues. The present work builds upon the previous work in the field and proposes a system which has a robust performance for

flame detection and fully automated directional suppression. The results from a prototype system which was built and tested in outdoor conditions and future possible optimizations will be discussed.

| **Session 6: Earthquake Safety I** | |
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| Session Chair: **Dr. Dhiman Basu (IIT GANDHINAGAR)** | **Venue:** Academic Block 6/ 201 |

**Sumer Chopra.: Earthquake Hazard in India**

**Abstract:** The recent spate of earthquakes in and around the Indian region has highlighted the importance of having risk reduction strategy. The vulnerability of India's urban centers was demonstrated by Killari, Jabalpur and Bhuj earthquakes. The devastation caused by recent Nepal earthquake is well known. As population increases and cities expand, the potential for earthquake loss increase. There is an important saying that "Earthquake does not kill people but buildings do". The urban safety has gained importance in recent years with rapid increase in the construction activities as well as the growth in urban population all over the world. Several urban centers in India fall under 'moderate' to 'severe' seismic hazard zones. The seismic hazard in India is mainly from Himalayan region. In addition, earthquakes beneath ocean region and plate interior are also the causes for seismic hazard. The convergence of Indian plate and Eurasian plates has given rise to mighty Himalayas. The Alpine-Himalaya belt is the only region in the world where continent-continent collision is taking place. GPS and levelling measurements along the arc suggests the accumulation of strain all along the convergence zone. The accumulated strain energy is released during great earthquakes (M>8). As per seismic Zoning of the country over 59% of India's land area is under threat of moderate to severe seismic hazard i.e. prone to shaking of MSK Intensity VII & above. Several important cities lying in seismic zone III, IV & V are vulnerable to earthquake. In view of this seismic hazard assessment of major urban centres is necessary to safeguard the society from possible damage from a future large earthquake.During active seismic phase from 1897 to 1950, four great earthquakes have occurred, Shillong (1897),Kangra (1905), Bihar-Nepal region (1934) and last one in Assam (1950). It is more than 60 years since a great earthquake occurred in the Himalaya and every segment of the Himalayan arc is now considered to have the potential to produce at least one major earthquake. There is no doubt that a destructive earthquake could occur anywhere along the arc, although it is difficult to ascertain where it might occur or how large it could be.It poses a challenge to planners, administrators, engineers and architects, particularly when these urban centers are exposed to risks associated with natural disasters.

**Gopala Krishna Rodda and Dhiman Basu: On Characteristics of Near-Field Ground Motion**

**Abstract:** Ground motions close to a fault can be significantly different than those observed far away from the fault location. The response of the structures subjected to near-fault ground motions will be different from those of the far-field earthquakes. It is well known that near-field earthquake may contain distinct velocity pulse. Pulse-like ground motions occurring close to urban and metropolitan regions can place severe demands on buildings and other facilities in the near-fault region. Hence, study of characteristics of pulse is important. The objective of this present study is to represent the near-source ground motions in terms of simple analytical waveforms, the parameters of which have a physical meaning like a cosine form with a certain amplitude and time period. General characteristics of any pulse that is going to be extracted are the Amplitude, Time Period and Location (where the pulse originates). The period at which peak occurs in relative energy spectra may be considered as the pulse period while extracting the pulse from near fault records.An algorithm has been developed to obtain the characteristics of the velocity pulse from the given near-field motion. Differentiation of this velocity pulse results in the acceleration time history contributed from the pulse. The algorithm is further extended to account for multiple pulses in a near-field motion using the multiple platues in energy time history.

**Ninad Anil Bonde, Dharani Kumar K, Rupesh Kumar Koshe and Anuja Anil Dalvi*:* Evaluation of Safety Culture in Construction Industry for Nasik Citybased on a three-point Likert scale**

**Abstract:** In this study, several aspects and factors concerned with the evaluation of the safety culture in the Construction industry for Nasik city was done. The intention of the study wasto identify and to analyze values, beliefs, perceptions and attitudes affecting the worker and the safety culture in city's Construction industry. The data containing the influencing factors was collected using various tools such as conducting structured interviews of various individuals involved in this industry and also by seeking answers for ready questionnaire. This data was then employed to arrive at the extent of these factors over the safety performance. The evaluation was based on a three-point Likert scale. The score varied among each category and the final outcomes were established for all the categories. Other factors important for the construction companies like; health and safety policy, risk assessment, health, safety and working environment inspection were also studied minutely.The influence and act of each of the stakeholders, called as the informants, in the safety of construction worker and for the overall development of safety culture in Nasik city has been exposed during research.And at last, to improve the safety culture of construction companies and authorities, a set of recommendations were suggested.

| **Session 7: Risk Analysis I** | |
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| Session Chair: **Prof.Hans Pasman (Texas A&M University)** | **Venue:** Academic Block 6/ 202 |

**M.Surianarayanan: Safety in design of chemical process plants**

**Abstract**: A chemical process plant facility receives, stores and processes chemicals in a controlled manner. Most of the chemicals are flammable and toxic. Uncontrolled release of chemicals can occur due to loss of containment, loss of control of the process, external conditions such as failure of equipment and controls, abnormal process conditions and improper operation. Uncontrolled release of chemicals can result in loss of human life, financial loss and environmental impact. Safety in design means the integration of control measures in the design process to anticipate and minimize risks throughout the life cycle of the plant being designed. Safe design should begin at the conceptual development stage because there are more opportunities to eliminate hazards and incorporate compatible risk control measures to meet and withstand external and internal conditions for containment of uncontrolled releases. However, the traditional approach has beento go for on add- on- safety systems. Although the concept of inherently safer plant has been known for a long time, there are gaps in knowledge that require a change in approach for its implementation.
The presentation will address with suitable examples and case histories of accidents, the design needs and methods through which process safety can be enhanced in chemical process plants.

**V.R. Renjith,Manoj Jose kalathil, Haresh Kumar, Dilip Madhavan: Fuzzy FMECA (Failure Mode Effect Criticality Analysis) in LNG terminal operations**

**Abstract:** Every machine and process in manufacturing industry has its own modes of failure. In manufacturing industries, production machine failures can create many inconveniences. It may be responsible for machine downtime, unavailability, customer dissatisfaction, increased maintenance time and production costs, lower product quality, and delivery time delay. In chemical or nuclear plants, failures might be very expensive (catastrophic effects) in terms of money and safety. Failure Mode and Effects Analysis (FMEA) is a risk assessment tool that reduces potential failures in systems, processes, designs or services and has been used in a wide range of industries. When it is used in criticality analysis, it is also referred to as failure mode, effects and criticality analysis (FMECA). Many researchers pointed out the deficiencies of conventional RPN used in FMEA. This study focuses on addressing the limitations of RPN and also attempts to rectify them by introducing fuzzy logic in FMECA mainly in LNG operations

**Ashutosh Kumar: Integration of Risk and its Importance in the Process Industry**

**Abstract:** Risk is a function of the probability of a loss of containment (LOC) and the effect of that LOC to human beings in terms of individual risk & societal risk. Risks are so called "inherent risk" and "residual risk". The actual risk is depending on the wide range of activities being involved in the process operations, risk has its major impacts on the business, professionals, environmental, social and safety. To understand the integration and its complexity of acceptance, it is important to understand the core impacts on any process industry. In the earlier days the subject was not sensitized among the process industries, but in the current portfolio it becomes a biggest matter of concern. Approach for Risk assessment is to reduce the inherent risk as much as possible with the help of adequate control system. Statistical relationship between the current portfolio and decade's assessment, how the studies impacts to decide the design and performance of the system safer and precautionary against the accidents happening. Some parameters determine the probability of failure while others may only influence the consequence, the failure modes should be assessed and analyzed very minutely in QRA. For reference and establishment of correlation with the subject, modelling on some case study, its analysis and result which will be taken in the direction to think, how safe the system is. An interlink of the data in more realistic and logical manner, an analysis of results and its implementation in safe designing and decision making. Effects of LOPA and SIL in the actual risk calculation, domino effect on the results of risk, Classical linear hydrodynamic approach for more realistic results in many cases, more reliable predictions by using advanced method. Reduction of risk by various new thought process, modelling will be done in Phast Software. Results will be interlinked and analyzed to decide the various decisions for safety in process industry, not to have repetitions of the accidents like Bhopal, Jaipur fire etc. So to avoid the repetition of similar incidents it is very much important to understand the integrations and importance of risk to reduce the accident ratio globally. An analytical approach to form the realistic result based recommendations, which will help to reduce the level of risk in ALARP envelope.

**Saeed Nazari, Amal S. George, Renjith V. R.: Fuzzy LOPA of Sodium hypochlorite plant in a chlor- alkali industry – A case study.**

**Abstract:** The progress of technology has caused operating of many processes and resulted in more complexity of the chemical process industries and one of the main challenges for these companies is to manage the existing assets in the comprehensive and complex infrastructure. Thus, the safe operations of these systems are at least as important as their design. It should be noted; despite of implementing safety programs in today's industry, accidents still occur, and OSHA believes that all of these accidents follow typical patterns that help analyzers to recognize their root cause and take proper actions. On the other hand, the cost of maintenance is a considerable part of the total life cycle in these industries. Research has shown that some critical components account for most of the downtime in such operations. An improvement of maintenance practices which focused on risk based approach for critical components can improve the reliability and safety; at the same time can reduce maintenance costs. So, in order to reach a comprehensive risk management plan for these processes, we aim to prepare a domestic risk management model for chemical process based on Risk Based Maintenance (RBM) using FAHP technique. The initial steps involve literature review to identify critical assets and equipment. The subsequent interviews will be discussed these issues with experienced practitioners to identify their failures. The Delphi group method has been selected for data collection. Through three rounds of Delphi process experts helped to filter all the information to come up with a series of the most important strategic actions to RBM assessment of t systems. All of the RBM criteria have been localized by expert team and the risk number could be calculated according to these factors. There are several tools to analysis the risks of them. But, the classic approach always comes with great uncertainty. Thus, The FAHP model will be introduced as the most applicable approach for modeling of the risk management to overcome such limitations. However, by applying this technique, it will be anticipated that the safety of system improved, the environmental impacts and maintenance costs reduced, the spare parts allocated where necessary,

and finally lead to prioritization of the process's safety measures according to their risk levels.

| **Session 8: Behavioral Safety** | |
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| Session Chair: **Prof En Soop Yoon** (**Seoul National University)** | **Venue:** **Academic Block 6/ 203** |

**Prof. Rajagopalan Srinivasan**: ***Six-Sigma* reliability and the brain worker: Towards Error Proofing the Human Decision Maker**

**Abstract:** A Poka-Yoke is a mechanism used in lean manufacturing to prevent inadvertent human errors. Originally conceptualized by Shigeo Shingo in the 1960s as part of the Toyota Production System, Poka-Yoke devices are widely used to make it impossible for an error to occur or make the error obvious as soon as it has occurred. Examples include passive approaches such as interlocks that prevent incorrect assembly (such as USB connectors and Sim cards that can only be inserted one way) and active ones such as sensors that trigger automatic response (such as stopping the machine) in case of errors.
Automation has become prevalent in many high-risk industries and the tasks expected of the human operator require complex decision making. In this paper, we review the traditional techniques like checklists that have been used to improve the reliability of human operators and decision makers. These techniques have met with moderate success over the years. However, as systems become ever more complex, most accidents, large amount of non-productive time, and significant avoidable costsoriginate from incorrect human actions. There is hence a need for a new generation of technologies that can actively prevent human error. In this paper, we will also overview a new generation of cognitive engineering based interventions that promise significant improvement in the reliability of the brain worker

**Prabhanjan Dixit, Kaushik Jayaraman: Developing a reporting culture through behavioural changes beyond the gates**

**Abstract:** An aspect of establishing a successful Safety Management System is developing and sustaining a culture of reporting issues. These issues can be substandard acts, conditions, gaps in the procedures which have been developed or the implementation of these procedures. Reporting also requires good observation skills. It has always been a challenge for the HSE Managers to keep Safety as more than a priority; to move "Safety" into the axiom of organizational values. Understanding and acknowledging these have led us to look at solutions outside the norms. While discussing this among the plethora of forums and global experts, the base causes have been questioned, viz. Why blame human error? What would incite them to act in such a manner? Why do the personnel behave differently when no one in watching? How to make observing, reporting and correcting issues a part of the organizational culture? Some of the answers were interesting and have been experimented upon. Essar has conducted such studies in the past achieving favourable results at different junctures. The most recent success can be attributed to the encouragement of off-the-job safety observations and reporting. It was postulated that when we spend the majority of our time off-the-job (10-14 hrs), it is this set of behaviours that will affect us more than the behaviors we exhibit on-the-job. This led us to focus on the 'simple' things beyond the gates. Can training observers to look at deviations beyond the premises help them notice them at the workplace? How do you encourage personnel to develop 'safe behaviours' through positive reinforcement? Bringing in the family element really helped us move up the system percolation among the employees. They have helped improve the employee participation, actively outside the premises, and passively at site. Personnel have started increasing their participation and engagement in Safety activities (occupational and process safety). There has been a positive increase in the number of substandard conditions observed and reported, as well as a substantive decrease in the number of human errors than in the past few months. A more dedicated approach to implement this practice further and monitor these

indicators may give us a better idea of the scale of improvements noted. This paper discusses some of the initiatives undertaken as part of the 'off-the-job' safety campaigns that have helped in developing good observers, responsible citizens, and great employees driving a continually improving management system.

**Srikanth P., Lokeshwaran P., Vijay M. : Development of Behavioral-Based Safety Culture in Industries -Need of the Hour**

**Abstract:** Many studies on interaction between masonry infill and the RCC frame have revealed that masonry infill enhances the in-plane stiffness of the RCC frame. While masonry infill offers good resistance to in-plane loads, it is relatively weak under out of plane loading. Exposure to thermal gradients (e.g. in case of a fire) induces out of plane loads in masonry infill which can play a key role in its failure which may lead to an unexpected spread of fire. The present study details the development of a generic three dimensional finite-element model to determine the impact of thermal exposure on RCC masonry infill panels. Commercial finite element software, ANSYS has been utilized to model the coupled thermo-mechanical behavior of RCC masonry infill panels. Concrete and bricks have been modeled using solid elements while steel rebars have been modeled using the smeared reinforcement approach. Experimental data available in the literature has been utilized to validate the finite-element model that has been subsequently utilized to perform parametric studies. These parametric studies provide valuable insights in the behavior of such systems under thermal exposure, which can be further incorporated in the design process to improve their fire safety.

**D. Shreyasi and S. Kalaiselvam.: An integrative model towards improvement of the safety behaviour of employee at workplace**

**Abstract:** This paper investigates the main drivers of intention, as enunciated by the Theory of Planned Behavior (TPB), to comply with safety practices among a multiethnic workforce of a ship building and repair industry in India. A total of 349 male workers were surveyed on their safety behavior. The participants' ages ranged from 20 to 60 years with work experience range from 0 to 42 years. Hot works, Work at height, Machinery operation, Confined Space, and Material handling were identified as the most hazardous work groups in the studied ship building and repair industry using Hazard Identification & Risk Assessment (HIRA) tool. Behavior based safety study was done for the identified five work groups with the use of 16 questions prepared targeting four constructs of behaviour, namely, Attitude towards safe behavior, Perceived Behavior Control (PBC) & habits, Subjective norms and Intention. The survey questionnaire was translated from English to their regional language (i.e. Malayalam).The 349 samples taken in the ship building and repair industry were analyzed and the most violated behavior in each of the five groups were identified. The violated behaviors include, tidying up hot work location after work (hot work group), manual lifting of the material in safe postures and using of necessary PPE (material handling group), placing the hand tools at the right place after use and using of necessary PPE (machinery/tools and equipment usage group), cleaning of scrap/loose material on top of the scaffold and ensuring usage of required job specific PPE (height work group), and making sure access to escape route is provided and confirming proper illumination while working (confined space group). Further, an analysis was done using normal distribution, for identifying the most influential factor (Attitude towards safe behaviour, Perceived Behaviour Control (PBC) and habits, Subjective norms, and Intention) for workers intention to work safely in ship building and repair industry. The distribution was found to be statistically fit. The mean value of level of agreement for the 4 constructs of behaviour from the samples collected from the employee was calculated using normal distribution method. The mean values calculated in the research were $\mu$ = 3.3036(Attitude), $\mu$ = 3.6110(Habits and PBC), $\mu$ = 3.5589(Subjective norms) and $\mu$ = 4.0989(Intention) implying that the most influential factor for violation of safety behavior is Intention.

| Session 9:Disaster Management | |
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| Session Chair: **Prof. Dongil Shin (Myongji University)** | **Venue:** Academic Block 6/ 201 |

**R.K.Dave: Emerging Trends in Public Alert & Warning System**

**Abstract:** India did not have any systematic integrated mechanism for public alert and warning in place. Many of existing alert and delivering methods and mechanism are ineffective or obsolete in the current context with changed / changing pattern of (a) hazards and risks (b) citizen's need and (c) innovation in technologies. There are innumerable lessons in the country on how absence of timely alert and warning impacted into huge loss of property and life to the community in the risk area.

Public alert and warning system planned and being implemented under various schemes including Government of India's National Cyclone Relief and Mitigation Project (NCRMP) are piecemeal attempts, made in silos in different states, with no real connection with all-hazard environment and national coverage.

Increase in vulnerabilities with industrial growth, population increase and urbanization has enhances threat level for a common man which demand an urgent needs for a clear national mandate to plan, deploy and manage integrated systems capable of quickly sensing, analyzing and conveying relevant information to citizens before (on-set) / during and after an emergency situation.

Alert and warning is the first fundamental need for accomplishing disaster risk reduction (DRR) objective. An advance system of forecasting, monitoring and issuing early warnings would play the most significant role in determining whether a manmade or natural hazard will assume disastrous proportions or not. This paper aims to analyze emerging trends inalert & warning solutions for Safety& Hazard Management (SHM) and gives recommendation on future alert and warning system for India based on global best practices.

**Anju Sharma, Chintan Pathak, Sachin Bhagat: Implementing INSARG Marking System for Urban Search and Rescue (USAR) in India**

**Abstract:** Disasters that might cause structural collapse in India are increasing in frequency but also in intensity. This said the impact of such events can be substantially reduced by being prepared and ready to act. Authorities, individuals and communities should be equipped with the knowledge and capacities for effective disaster management. The term Urban Search and Rescue (USAR) refers to the area of science and the set of skills and abilities that are focused on searching, locating, reaching, medically stabilizing and extricating deeply entombed survivors of these disasters. Efficiently conducting USAR requires an effectively coordinated response of the various teams within the disaster area. These international incoming teams often have to cooperate with local or national authorities and follow their various coordination mechanisms to perform and complete their tasks. In order to increase coordination and cooperation a set of guidelines and methodologies is put in place by the United Nations (UN) covering various sequential phases during a USAR mission regarding coordination. In line with this the Asian country is creating policy regarding coordination mechanisms to prepare its Member States. This research aimed to compare the coordination mechanisms and related measures to enhance preparedness of india using comparative case study research. The research is focused on receiving international USAR in India and cases where national response entities are overwhelmed. The purpose of the research is to contribute to the preparedness of the contributory countries in the implementation of USAR coordination systems such as UN International Search and Rescue Advisory Group (INSARAG) and Asian policies. In order to conduct this comparison the UN INSARAG guidelines and methodology and India resolutions regarding preparedness and coordination were modeled on a local/regional, national and international level, based on the sequential phases of the INSARAG methodology cycle. The same modeling principle was also applied to the India using data collected in semi structured interviews/discussions with experts. The structures and mechanisms in place regarding USAR

preparedness and coordination were analyzed. This study would enlighten with the current scenario and implementations of the INSARG Marking System in India. .

**Dongre, P., Jha, K.N., Patel, D.A.: Structural Equation Modeling of Work Injuries in the Construction Sector**

**Abstract:** Construction sector has a challenge to ensure safe work places. On an average 38 fatal accidents occur daily in the Indian construction sector. Many near miss accidents and injuries go unreported. Construction safety is a complex and interdisciplinary subject. Individual and job related factors, besides a number of organizational related factors are directly or indirectly correlated and responsible for accidents in construction projects. Based on existing literature, this study identifies seven factors which cause work injuries and are related to construction workers and their behavior. These are: work hazard, social support, safe environment, job stress, negative personality, job dissatisfaction and safe work behavior. Deliberating causal interrelationships among these latent factors, a conceptual and measurement model is developed based on some hypotheses. The indicators of each latent factor were decided and a questionnaire was prepared. By a face- to -face questionnaire survey, this study collected 172 data samples and developed a structural equation model (SEM) to test the conceptual model. The results of the structural model show that job stress and job dissatisfaction are the major reasons contributing to work injuries at construction sites. Social support, safe environment, and work hazard have direct effects on job stress and job dissatisfaction thus they indirectly influence the work injuries of construction workers. Social support can improve negative personality and safe work behavior of workers. This study will be useful to decide the training needs and welfare for construction workers.

| **Session 10: Process Safety III** | |
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| Session Chair: **Prof. Dongil Shin (Myongji University)** | **Venue:** Academic Block 6/ 202 |

**Vishwanathan G.: Functional Safety in First generation Process plants**

**Abstract:** Functional safety standards IEC 61508 and IEC 61511/ISA 84 have come into existence in late nineties. It is estimated that about two thirds of the Programmable Electronic Systems (PES) running in the process industry have been installed before the publication of these safety standards.

The safety systems used in process plants which were built much before these standards came into existance were either general purpose PLCs or designs not satisfying current requirements of IEC 61508.Hence, it is essential to revisit the old safety systems to ensure that they meet the requirements and if not, be suitably modified so that the society at large continues to be safe.This is the objective of this paper.

The Functional safety review starts with the Hazard identification and a list is drawn by a team of experts from process, safety and instrumentation including an external facilitator. The next steps involves review of the existing safeguards to protect against theidentified risks ,specifically the SIFs and IPLs.

The first task is to assess and document site specific plan for operation and maintenance of all SIFs and IPLs. Functional Safety process audit is an important aspect in this way forward which can identify potential gaps and ways to make the system more efficient safety wise..

The SIFs and IPLs meant for functional safety would not have been activated for many years. Accordingly, dangerous failures are revealed only by proof testing. The present day systems come with automatic self diagnostics which may be missing in the old systems. The”loop test” was the only most common approach.

To have a perfect Proof test design is impossible and there would still be some undiscovered failures.

The major turnaround only offer maximum opportunity to test valves for full stroke as well as the sealing capabilities of the valve seat. Plugged impulse lines could hamper the functional integrity and flushing impulse lines need to be included while drafting proof test procedures.

In order to keep using a system that is not certified according to IEC61508, the operator must demonstrate "Proven in Use" and such demonstration shall have documented evidence that the likelihood of any failure of the subsystem is low enough so that the required safety integrity level of the safety function is achieved.

The best approach to dovetail the earlier generation safety systems to present day functional safety systems as per standards is to establish a Functional Safety Management System for the site and entrust all activities concerning every aspect right from Hazard identification to SIF validation to this specialist group. Depending upon requirements, this group can draw additional resources including an external facilitatator to review each and every SIF and document all details like Proof Test procedure, Proof Test Intervals, Proof test coverage, assessment of useful life of various components of each SIF, systematic failures and so on.

**Surya Bhushan Kumar Sinha, Amit Kumar Singh, Rakesh Kumar Sharma, Vilas N. Gaikwad: Centre of Excellence: Tata Steel way to Process Safety.**

**Abstract:** Scale of operations and increasing complexities in processes & technologies have raised the industrial hazards many folds in recent time. Even with the sophisticated controls, management of hazards are becoming more and more difficult. Iron and steel making is an inherently hazardous industry which involves various toxic gases, chemicals and materials processing at high pressure and temperature. Indian Steel industry has witnessed severe process incidences recently viz. pump house gas release at Bhilai steel plant in 2013, oxygen PRS explosion at Vizag steel plant in 2012 , dry pit explosion at Bhushan steel plant in 2013and gas holder explosion at Tata steel in 2014. Such events have not only affected the employees and nearby societies but have severely damaged the reputation of these companies. Such events were mostly caused by failure of critical equipment & interlocks, design deficiencies and inadequate knowledge of operating teams. Tata Steel, Jamshedpur works, established in 1907 as the first integrated steel plant in India, has gradually grown to 10 MT capacity. Being located amidst a densely populated community, Tata Steel realised the importance of a strong safety system much before. It, therefore, adopted Process Safety and Risk management (PSRM) in 2006 to address the process related risk and avoid any loss of containment. Its practical implementation has been guided by OSHA regulations addressing the 14 elements of PSRM wheel. However, assessment of PSM, post few process incidences at works in 2014, revealed certain gaps in implementation mainly attributed to lack of competency. Subsequently, senior leadership team decided to deploy PSM standards as a project at few high hazard operation units and develop it as Centre of excellence (CoE) followed by horizontal deployment across the organization. In pursuit to attain excellence in process safety management, the Centre of Excellence (CoE) journey has been undertaken in two of its units namely I Blast Furnace and LD-1 as pilot. The purpose of entire exercise is to get the answer of following three questions: i. Do we know what can go wrong? ii. Do we know what barriers we have to ensure that it doesn't go wrong? iii. Do we know that our barriers are effective and working properly? The Journey commenced with focus on four elements of PSRM wheel namely Process Safety Information (PSI), Process Hazard Analysis (PHA), Management of Change (MoC) & Pre Start-up Safety Review (PSSR). Certain advanced tools such as HaZOP, Consequence modelling through PHAST software, Bow-Tie analysis & Layer of protection analysis (LOPA), have been used. The outcome of this exercise has surfaced many unknown hazards as well as lapses in maintaining health of the safety critical equipment. This process has also helped to sensitise shop floor employees towards process safety and have equipped them better to manage process related risks. This paper discusses the complete methodology adopted at Tata Steel to implement the CoE journey and inculcating the belief that Safety is not a metric but is a condition of survival for our organisation.

**Ajay Kr. Sharma: Safety issues in City Gas Distribution Network**

**Abstract:** City Gas Distribution is one of the most assured businesses in current times as Natural Gas being a clean fuel becomes the first choice of consumers.
Though CGD Network has enormous potential and has evident advantages however, it brings alongwith it's own challenges but the biggest challenge is the vicinity of CGD Network with common public. A major factor for success of CGD Network depends on the discipline and involvement of common public in keeping CGD Network safe and effective.
This paper intends to discuss on HSE issues with focus on Single Call system for India, Indian regulations Vs other countries and Quality Assurance issues jeopardizing safety.
Single Call system for India is the most important issue of CGD Network that really needs to be deliberated. In India, more than 20 clearances need to be obtained from various statutory and civil authorities before execution of any CGD Network project which really affects the project cost, time, consumer benefits, emergency response and third party damages.
Now let's consider few international regulations like National Energy Board in Canada which is the nodal agency to ensure CGD pipelines are safe for public and environment. NEB regulations harmonize with provinces to ensure that any third party excavation work within pipeline corridor is carried out only after due communication to the pipeline company.
The 49 US Code 60114 - One Call notification system also mandates that any third party before carrying out any excavation needs to establish if there are underground facilities present in the area of the intended activity and contact appropriate system.
Indian regulations like T4S and ERDMP for CGD Network are indeed bringing all CGD companies at par in terms of design, safety, O&M and Integrity Management System. However, they need to sincerely look into Single Call System alongwith specific issues like interdistances, space constraints in big cities, compressor installation at height.
Quality Assurance involves periodic inspection and maintenance of CGD asset through a systematic plan including identification of critical equipments, Preventive Maintenance Schedules, carrying out maintenance as per the PM, maintaining a database of observations and defects. A key component is the generation of baseline data for implementing and monitoring Integrity Management System for CGD Network.
Hence, as CGD Network is a complex and dynamic distribution system involving public, private industries/commercials, civil authorities and wide geography, it is imperative to have a multi-pronged approach involving strict regulation enforcement, well informed public and latest technologies to ensure safe and efficient CGD Networks.

**R.K.Dave: Offsite Emergency plan for Chemical Disaster Mitigation**

**Abstract:** In India, all the hazardous process industries listed in the first schedule of the Factories Act, 1948 are mandated to draw up an on-site emergency plan and detailed disaster control measures as per relevant guidelines issued. But the jurisdiction of on-site emergency plan is confined to the factory premises, involving only the persons working in the factory and the property inside the factory. On-site plan does not cover off-site mitigation measures i.e. mitigating impacts outside the factory premises which are covered under a separate plan or an off-site plan.
Under the provisions of MS&IHC Rules 1989 as amended in 2000 (Rule No. 14), management of chemical disaster off-site emergency management plan for district/industrial estate is the responsibility of District Collector or District Emergency Authority designated by the State Government. The National Disaster Management Authority (NDMA) of India had come out with very specific guidelines on Chemical Disaster Management.
Wider geographic spread combined with uncontrolled and uncertain environment (not as captive and controlled as environment within factory premises) offers a huge challenge for designated authorities to prepare, implement, test and update off-site chemical disaster management plan on perpetual basis.
Bhopal gas tragedy has reminded whole world that how devastating absent off-site chemical disaster plan can be .There is an urgent need for review existing chemical disaster management capabilities (both onsite and off-site) and their effectiveness and effect revisions. In this paper author examines

current status of chemical disaster off-site plans and their effectiveness and suggests measures for strengthening off-site planning process and their management.

| **Session 11:Construction Safety** | |
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| Session Chair: **Dr. Gaurav Srivatsava (IIT Gandhinagar)** | **Venue:** **Academic Block 6/ 201** |

**Debasish Kar. Safety -An Introspection**

**Abstract:** Not available

**Pavanaditya Badida, Jayapriya Jayaprakash. A fuzzy multi criteria risk assessment methodology based on failure mode and efective analysis: a case study in construction industry**

**Abstract:** The construction industry is a major contributor towards India's GDP, both directly and indirectly. It employs 33 million people, and any improvements in the construction sector affect a number of associated industries such as cement, steel, technology and skill-enhancement. Due to the magnitude of worker participation taking part in the construction sites, the scrutiny of health and safety workers working in construction sites is heightened because of the ever growing list of accidents and fatalities that are occurring both in India and worldwide every year. Construction projects are always initiated in challenging environments of which high uncertainty and risks are some of the important parameters.

Failure Mode and Effects Analysis (FMEA) is an extensively used risk assessment technique utilized for the purpose of identifying, evaluating and eliminating the potential sources of failures, problems and errors from the identified field of problem. There are normally three parameters in FMEA identified for each activity in the area. They are Severity (S),Occurability (O), and Detectability (D). For each identified activity, the parameters are evaluated and a Risk Priority Number (RPN) is assigned by multiplying the parameters. There are many shortcomings associated with a crisp RPN score as outlined in previous literature.

To address these shortcomings, in this paper, a fuzzy approach enabling the experts to use the linguistic variables for evaluating the S, O and D is considered to reduce the uncertainties in decision making and RPN score. Several hazards were identified and evaluated using the parameters of S,O and D. The weights associated with the parameters were obtained using Fuzzy Analytical Hierarchy Process (FAHP). Then, the order of priority of various hazards identified is determined by using Fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method. The proposed integrated fuzzy AHP-fuzzy TOPSIS risk assessment methodology is applied to a construction site in Chennai Metropolitan Area to evaluate the hazards. Depending on the ranking order, the control measures were suggested for the hazards that are ranked at top.

**Harshit Nema and Dhiman Basu. Experimental determination of Natural Frequency of Confined Masonry buildings by Ambient and Forced Vibration Testing**

**Abstract:** Safety analysis of different High rise residential constructions has to be carried out to predict the safety aspects of employees using number of safety climate determinants determined through literature review. The analysis utilizes safety climate constructs (determinants) as inputs and safe work environment as an output. The analysis will be carried

out in three main phases of High rise residential constructions that is planning phase, execution phase and after execution phase. The responses from several construction projects across Pune and

Mumbai region will be collected through questionnaire survey. This analysis has great potential in aiding contractors, clients and owners in promoting safe work behavior and the efficient management of the safety of employees in construction projects.

| **Session 12: Fire Safety III** | |
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| Session Chair: **Shri. D. K. Shami (Fire Advisor, Government of India)** | **Venue:** Academic Block 6/ 202 |

**N Gopalakrishnan: Fire Behaviour of Reinforced Concrete Beams**

**Abstract:** Reinforced concrete (RC) structural systems are quite frequently used in high-rise buildings and other built infrastructure owing to a number of advantages over other materials. Reinforced concrete shows an acceptable resistance to high temperatures, which allows using concrete elements without the need of any additional protection. However, long periods of exposure of reinforced concrete to high temperatures introduce physical-chemical changes in its properties. These changes lead to decay in strength and stiffness of the structure and make the safety of the structure under question.

During the fire exposure the temperature of the RC beam increases and alters the strength as well as serviceability parameters of the beam. It is rare that the structural element collapse during fire rather than the members are ended up with decreased residual strength and stiffness. Generally concrete beams of normal strength concrete exhibit good performance under fire situation on account of good permeability and high thermal inertia however for high strength concrete due to spalling phenomenon high strength concrete beams results in lesser cross-section and higher temperature rise resulting in more reduction in HSC beams in comparison of NSC beams. The increase in temperature acts in two ways for the beam, in one way it acts as a load (generated axial force and positive as well as negative moments at the supports) on the other hand degrades the material strength of the constituent beam materials. Nevertheless, during and after fire exposure, its original properties are adversely affected. Mechanical strength, elasticity modulus and fracture energy get reduced depending on the duration and the intensity of the fire as well as on the properties of the virgin concrete itself. Moreover, when exposed to high temperatures, concrete cracks.

Studies have been carried out on reinforced concrete beams at elevated temperature to study the residual flexural behaviour of normal strength concrete and high strength concrete beams

**P.Ravi Prakash , Gaurav.: Progressive Collapse Analysis of RCC Planar Frames subjected to Fire**

**Abstract:** Reinforced concrete (RC) frames are one of the most commonly used structural systemsin high rise buildings and other built infrastructure utilities. These structural frames are susceptible to fire in addition to the usual service loads in their design life period. Hence, provision of appropriate fire resistance is one of the essential design requirements for these structures. RC frames when subjected to localized fire scenario, may result in local failure of structural elements which may in turn result in total or partial failure of structural system. This phenomenon is often referred to as progressive collapse of structures. Progressive collapse of structures under fire can be quantified numerically using nonlinear thermo-mechanical analysis frameworks. In the present study, study a direct stiffness method based frame work developed by Prakash and Gaurav [1] is utilized. Subsequently, a four bay six storied planar RC frame designed according to IS-456 [2] is subjected to different kinds of localized fire scenarios and deterministic progressive collapse analysis is carried out utilizing the aforementioned framework. Due consideration is given to the propagation of fire to neighboring compartments resulting due to failure of structural elements. Furthermore, columns in the vicinity of localized fire are modelled separately and a comparison of fire ratings of individual column vs entire structural frame subjected to progressive collapse is presented for different kinds of fire exposures. The work presented in this paper is mainly on deterministic progressive collapse analysis. Further work is under way to carry out the probabilistic progressive collapse analysis.

**Anil Agarwal and Athira Ravindran.** ***CFT Columns at Elevated Temperatures: Behavior and Design***

**Abstract:** Eurocode provides a calculation model to find the fire resistance of Concrete Filled Tube (CFT) columns.It assumes that a single value can be used to define curvature of steel and concrete components of the cross-section, i.e.no-slip condition is assumed between concrete and steel. AISC also provides an empirical formula to find the fire resistance of CFT columns where the concrete and steel is assumed to act together without any differential expansion. Various experimental studies, on the other hand, emphasize that there can be significant slip between steel and concrete and the Eurocode provisions are unconservative. These experiments are done with end plates applying compressive loads at both ends of the column. There are no shear-connectors (studs) between steel and concrete components.But in real columns,shear connectors are required to transfer loads from steel to concrete. Shear connectors have to be provided within the load introduction length.Therefore, the load transfer mechanism in actual columns is different from the columns studied in most of the experimental investigations. The effects of providing shear connectors on the column capacity in fire conditions are studied in this paper.
A sequentially coupled heat transfer and stress analysis of three dimensional CFT column is done in ABAQUS. The steel tube is modeled using S4R shell elements and the concrete infill is modeled using C3D8Rsolid elements. Shear connectors are modelled using DC1D2 truss element for heat transfer analysis and B31 beam element for stress analysis. Parametric study is done by varying the connector diameter, spacing and number of connectors. It was seen that there can beup to 30% increase in the column capacity compared to columns without shear connectors.

**Nasar A Khan and Gaurav Srivastava.: Need to revisit fire loads - findings of a recent survey at Ahmedabad**

**Abstract:** Fire load refers to the amount of combustibles present within a built-environment. Its estimation plays a key role in ascertaining fire safety demands of buildings and is quintessential in performance-based fire design. Building codes of several countries have prescribed representative values of fire loads for various occupancies. The prescribed values are usually derived fire load surveys that have been performed in the past. Such a survey was conducted in Ahmedabad for office and residential occupancies. The fire loads determined during this survey are considerably greater than the values prescribed in Indian codes. In fact, for some cases, the minimum load found during survey is about two times the values prescribed in the codes. This study aims to inform the audience about such discrepancies and investigates possible reasons for observing greater fire loads

| **Session 13: Process Safety IV** | |
|---|---|
| Session Chair: **Prof. Hans Pasman (Texas A&M University)** | **Venue:** **Academic Block 6/ 202** |

**Jaehoon Cho and Dongil Shin.: Atmospheric Dispersion Modeling and Stochastic Programming for Optimal Fence Monitoring of Gas Releases**

**Abstract:** For proper and timely detection and mitigation in the emergence of chemical release incidents, installing gas detectors at appropriate locations is one of the indispensable prerequisites in the implementation of emergency response plans. With strong global and domestic interests, optimal placement of gas detectors, especially for intra-plant monitoring, is developed based on the Computational Fluid Dynamics (CFD) simulations. In this research, using tools for calculating atmospheric dispersions, we investigate the optimal placement and operation of fixed and mobile gas detectors for fence monitoring. There are significant uncertainties in various factors to be considered: process operating conditions, impact of surrounding geometries on dispersion, probable weather conditions, physical limitation on land use, etc. The uncertainty associated with different leak scenarios is captured through process specific CFD simulations, using a package for rigorous modeling and simulation of gas dispersions. Combining simulation results from the dispersion modeling, a multi-scenario, mixed-integer linear programming formulation is developed to generate

the optimal policy of placement and operation of gas detectors, by maximizing the expectancy of detection over all scenarios. The result of this study can also help to place mobile sensors as well as fixed point-type or area sensors for better tracking of gas releases based on real-time monitoring of concentration data. Adoption of IoT in relation to cyber-physical systems is also discussed.

**Vimlesh Kumar Bind , Bimal Kumar, Arti Bhatt, P. K. Rai, Chitra Rajagopal :Quantitative Risk Assessment For Highway Due To Explosive Storage Facilities**

**Abstract:** Operational requirements of explosives and restricted land availability lead to deviations from regulatory norms. Current method of siting explosive storage and processing facilities is based on Quantity Distance criteria, which is based on worst case scenario. Quantitative Risk Assessment of such deviation cases based on probabilistic analysis and risk acceptance criteria provides more realistic information and enables the decision maker to assess the merits of siting proposal and allocation of safety resources. This could be used to supplement the current method based on Quantity Distances. A probabilistic approach for explosives safety risk analysis entails calculating the product of three components to estimate annual expected fatalities (i.e. the average number of fatalities expected per year) as the basic measure of risk. The probability of an explosives event per year per Potential Explosion Site (Pe), the probability of a fatality given an event (Pf/e), and the expected exposure of people (Ep) are multiplied to obtain the risk. The current study is aimed to determine quantitative risk for highway due to deviation of explosive storage buildings applying risk analysis tool AMRISK of Norway and Sweden. The study covers risk for person in the vicinity of explosive storage using AMRISK methodology which consists of probability of an explosive event, effect analysis and lethality due to various effects. Exposure analysis has been carried out for highway section in the vicinity of explosive storage facility. Individual risk of fatality due to combined effect of all buildings has been reported. The risk of fatality due to explosion increases as distance from highway decreases. Quantification of risk as a function of distance has been presented and has been compared with risk at outside quantity distance. As we move away from potential explosive site, the decrease in fatality due to Pressure and Impulse is more rapid as compared to Debris. Individual and Societal Risk associated with site could be applied by management for decision making in conjunction with risk acceptance criteria. As on date there is no risk acceptance criterion available for the country. Therefore risk acceptance criteria of various countries have been tabulated as guidance for decision making. Risk based standards could be used to supplement the current use of quantity distance approach.

**Anirban Roy, Abhishek Upadhyay, Arup Lal Chakraborty:Real-time, high-sensitivity chemical sensing using lasers for industrial process control and safety**

**Abstract:** Industrial safety applications require reliable and highly sensitive gas sensors for long-term monitoring of several gases both in early-warning systems as well as in process control and diagnostics. Gujarat being one of the heavily industrialized states of India is also vulnerable to industrial hazards (shown in Fig. 1(a)). Recent industrial accidents include the major fire at Indian Oil Corporation's depot at Surat in January 2013 (2 casualties) and the phosgene leak at a fertilizer plant at Bharuch in November 2016 (4 casualties). There is an urgent need to adopt robust sensing systems in the chemical and petrochemical industries to prevent or mitigate such accidents. Our current work focuses on real-time high-sensitivity monitoring of various gases that are commonly encountered in industrial settings. The outbreak of fire can be predicted by monitoring in real-time, the mole fraction and temperature of ambient carbon dioxide (CO2) and carbon monoxide (CO). Similarly, climate and atmospheric studies necessitate continuous monitoring of greenhouse gases (GHGs) such as carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) which typically occur in trace amounts (parts per million or parts per billion by volume) in the atmosphere. Tunable diode laser spectroscopy (TDLS) has emerged as a front-runner for such applications since it offers high sensitivity, high selectivity as well as the possibility of simultaneous detection of multiple species in harsh environments. More crucially, recently proposed methods [1] have rendered this technique calibration-free. In TDLS, the emission wavelength of a narrow-linewidth tunable diode laser is tuned

across a well-isolated absorption line of a target gas using a low-frequency ramp and the spectral distribution of the transmitted light intensity is recorded for recovering the absolute line shape. Gas parameters such as concentration and pressure are extracted by fitting a simulated line shape to the experimentally obtained absorption line. Depending on the operating pressure, the simulated line shape is modelled as Gaussian, Lorentzian, Voigt or Rautian using spectroscopic parameters available in the HITRAN database [2]. Higher detection sensitivities are obtained employing wavelength modulation spectroscopy (WMS) [3] in which a high-frequency sinusoidal modulation is applied to the laser in addition to the low-frequency ramp and narrow-band phase-sensitive detection is performed with a lock-in amplifier (LIA) at one of the higher harmonics (typically the second, termed as 2f).

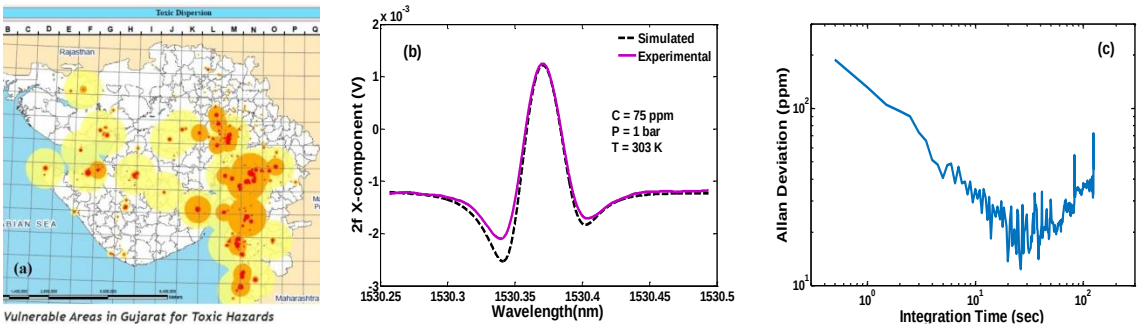


Fig. 1.(a) Industrial hazard-prone areas of Gujarat (Source: Gujarat state chemical disaster management plan, http://www.gsdma.org/documents/Gujarat_State_CDMP.pdf), (b) Simulated and experimental 2*f* signals for 75 ppm of acetylene ($C_2H_2$) at 1 bar and 303 K, (c) Allan variance plot for the system for a 28 cm long single-pass gas cell setting the detection limit of 16 ppm for an averaging time of 33 s

In our experiments, a 40 mW, 1531.52 nm distributed feedback (DFB) laser, a 10 mW, 1651.93 nm DFB laser and a 1 mW, 2004 nm vertical cavity surface emitting laser (VCSEL) are used to probe the P9 rotational-vibrational absorption line of acetylene (C2H2), the R4 transition of CH4 and R16 transition of CO2 respectively. Figure 1(b) shows the experimental and simulated 2f signal for 75 ppm C2H2 at 1 bar. Long-term stability and detection limit of the TDLS system are investigated using Allan variance analysis [4]. Figure 1(c) depicts the Allan variance plot for C2H2 showing a detection limit of 16 ppm for an optimum integration time of 33 seconds. To demonstrate the reliability of our sensor, we performed open-path real-time monitoring of atmospheric CO2 in outdoor environments. Measurements were carried out on multiple days at Gandhinagar with this portable TDLS system (Fig. 2(a)). The variation in atmospheric CO2 on 6 Nov 2016 is depicted in Fig. 2 (b). The mean CO2 concentration on that day was 463 ppm. Observations on ten other days showed mean values in the range 412 ppm to 496 ppm. These values are higher than the current global average of 400.72 ppm (Source: http://www.esrl.noaa.gov/gmd/ccgg/trends/global.html). With minor modifications, the system used to measure atmospheric CO2 can be deployed for gas detection in industrial environments. A digital signal processor-based signal generation and processing unit has been developed and will be deployed with this TDLS system to make it low-power, compact and light-weight. Such compact TDLS sensor systems are ideally suited for deployment in harsh industrial environments for long-term and remotely operated monitoring of key assets.

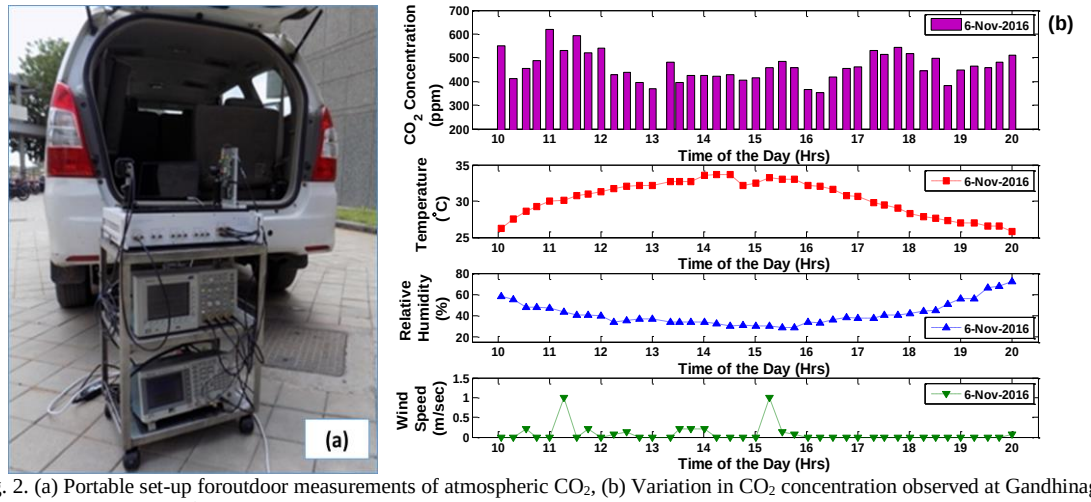


Fig. 2. (a) Portable set-up foroutdoor measurements of atmospheric $CO_2$, (b) Variation in $CO_2$ concentration observed at Gandhinagar on 6 Nov 2016 from 10:00 hrs to 20:00 hrs along with variations in temperature, relative humidity and wind speed

| **Session 14: Earthquake Safety II** | |
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| Session Chair: **Dr.Sumeer Chopra (Director,Institute of Seismological Research )** | **Venue:** Academic Block 6/ 201 |

**Dhiman Basu, Rojan Mathew: A Robust Pushover Analysis for Multi-Component Seismic Excitations- A New Frame Work**

**Abstract:** Seismic performance evaluation of a structure against seismic excitation is a crucial part of the safety examination. Incremental Dynamic Analysis (IDA) is the apt option for the performance evaluation which is not popular among the practicing engineers. Nonlinear Static Pushover (NSP) methods are approximate and reliable alternate for the time consuming and complex IDA. The conventional NSP methods are based on pushing a structure with constant load profile, however it is restricted to single mode response. In order to overcome these issues, NSP based on multiple modal pushovers were introduced. Among the various NSP methods, Modal Pushover Analysis (MPA) is one of the popular method. But the multiple modal methods are not able to predict the plastic hinge formation due to individual modal pushovers and the hinge formation is not directly related to the mode wise distribution. This study presents a new robust pushover (Alternate pushover analysis, APA) method which keeps the simplicity of conventional methods and gives a reliable solution. It is based on a single pushover and multiple modal target displacement calculations. The proposed pushover method is extended to buildings subjected to bidirectional and the multi-directional excitations including the torsional component. The APA is applied to two reinforced concrete buildings designed as per Indian standards, one is symmetric and other is asymmetric in nature. Seismic demands of these buildings under unidirectional, bidirectional and multidirectional including torsional components are calculated using the proposed Alternate pushover analysis (APA). The estimated demands by APA is compared with the benchmark solution obtained from nonlinear time history analysis (NLTH) as well as the predictions from MPA. It is demonstrated that the proposed APA is effectively calculating the seismic demands in all the cases.

**C. C. Patel: Response Analysis Of Asymmetric-Plan System With Viscous Damper Subjected To Random Ground Excitations**

**Abstract:** Supplemental viscous damper had been found to be effective in reducing deformations in the symmetric-plan system. In this paper, the performance of viscous damper to reduce edge deformations in asymmetric-plan system subjected to random excitation is investigated. The linear elastic response of one-story, asymmetric-plan system with fluid viscous damper, considering supplemental damping ratio and normalized supplemental damping eccentricity is compared with corresponding symmetric–plan system response. The responses are obtained and analysed, considering 10000 ground motion realization using Monte Carlo simulation. It was found that

supplemental damping reduces edge deformations, and viscous damper may be used to reduce edge deformations in asymmetric-plan systems up to or less than those in the corresponding symmetric-plan system.

**Asim Bashir and Dhiman Basu: Probabilistic Seismic Hazard Assessment of Gujarat and its Implications on Seismic Design in the region.**

**Abstract:** Seismic hazard assessment is the key tool for rational planning, safety and design in seismically vulnerable regions. The Gujarat state of India is the only state in peninsular India with the maximum seismic hazard of large shallow earthquakes originating from Interpolate seismicity. In the present study, seismic hazard assessment for the Gujarat is performed by using state-of-art probabilistic seismic hazard assessment procedures. Regional seismicity parameters are established for each of three regions of Gujarat state, namely, Katch, Saurashtra and Mainland Gujarat. It is done by reviewing the seism tectonic setting of the region and then by performing catalogue completeness based on available earthquake records. A novel procedure is developed for assigning the maximum magnitude to each fault considered in the analysis, given the limitation in the available seismicity data for the region. Probabilistic seismic hazard assessment in terms of the horizontal component of peak ground acceleration for the rock sites is carried out using a suitably selected ground motion prediction equation (GMPE). Seismic hazard curves are developed for some of the major cities of Gujarat and hazard map showing the variation and distribution of seismic hazard in the state of Gujarat is produced. The results show the need for revision of the Seismic zoning of Gujarat as per IS 1893 Part 1 (2002) due to the observation of increased seismic hazard in some parts of Saurastra.The output of the seismic hazard computations is also used to develop uniform hazard spectra (UHS) for the earthquake return periods (i.e. 475-years and 2475-years). The developed 2475 year uniform hazard spectra are compared with the spectra specified in the Indian seismic code IS 1893 Part 1 (2002) considering rock, medium and soft soil sites. While the codal spectra are found to be on the safer side, certain recommendations are put forth for modifications in the design response spectrum for Gujarat region. A practically reliable and more accurate definition of Importance factor assigned to buildings while designing is presented based on the obtained design spectra from hazard assessment. This is followed by assessing the effect of incorporating time dependent magnitude frequency model in the conventional seismic hazard analysis. While mostly the effect is not much, however in certain cases, the effect of using a time dependent model is found to be appreciable and hence cannot be neglected.

**C.Vigneshkumar, Monica Shrivastava, J.Uma Maheswari: Improving Construction Workers Safety through Design.**

**Abstract:** Globally construction industry is one of the hazardous industries. The problem regarding construction industry is not that the hazards and risks are not known, but it is quite challenging to accurately recognize, in a continually changing work environment. Construction hazards are one of the issues for project delays and cost overrun of the projects. The objective of this paper is to eliminate or reduce hazards occurring in different activities of building project. To achieve this, four commercial building projects were chosen as a case study in NCR region. Simple interview was conducted with the experts working in different projects to find out the hazards in different activities of commercial building projects. Failure mode effect analysis (FMEA) sheet is used to collect the hazards and the collected hazards were ranked using risk priority number (RPN). The critical hazard which has more RPN value was categorized and selected for elimination or reduction by implementing alternative design methods. The result shows that the hazard which has more RPN value is decreased by implementing alternative design methods. By mapping critical hazards and control measures with construction schedule it was found that marginal amount of time can be

saved. Further, this paper will helps to identify the hazards in building construction projects and the alternative design methods used here will also improves the safety performance of the projects.

| **Session 15: Risk Analysis II** | |
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| Session Chair: **Prof. Rajagopalan Srinivasan (IIT Gandhinagar)** | **Venue:** Academic Block 6/ 203 |

**Umesh Dhake: Barrier-based Risk Assessment**

**Abstract:** Barrier-based risk assessment has been applied to process safety risks for over two decades, frequently in the form of bow tie diagrams. Bowtie barrier analysis focuses on assessing barriers for prevention and mitigation of accident pathways, especially related to Major Accidents. Bow tie diagrams examine potential major accidents by diagrammatically mapping the hazards and causes that may lead to an event and the potential undesired consequences, including most importantly, all the barriers in place to reduce the risk. The bow tie diagram can assist with barrier management, on a systematic and continuous basis, to ensure that the necessary effective and robust barriers are implemented. They can provide an indication of where barriers may be insufficient either in number or effectiveness. Bow tie diagrams provide a picture of the risk and how the risk is being managed.

Bow tie diagrams provide a powerful means to communicate complex process safety information to staff and contractors, regulators, senior management, the public and other stakeholders. It can illustrate how the hazards associated with an operation are recognized, understood and managed – both from a prevention and mitigation perspective. Although the focus on barriers and maintaining barrier functions is applied in practice, there are currently no internationally accepted standards or accepted methodology available for development of bow tie diagrams. This has led to frequent quality issues and structural errors that weaken the value of the method. The intent of this presentation is to present guidance on the best practice use of bow tie diagram methods.

The increasing use of bow ties to communicate risks and barriers has led the CCPS Technical Steering Committee to authorize the creation of a project committee to develop Guidelines for Bow Tie Risk Management. Energy Institute (EI) and European Commission Major Accident Hazards Bureau are collaborating partners with CCPS on this project. To gather input from many experienced sources, CCPS invited representatives from many chemical and petroleum companies, trade associations, regulators, and academics involved in the field of process safety, as well as other key stakeholders or subject matter experts to participate in this committee's activities

**Ankit Gupta and Sandip Roy: Safety Investment Optimization in Process Industry: A Risk-based Approach**

**Abstract**: Process plant safety is a critical indicator of organizational performance. It also impacts the public and the government, as they are important stakeholders to process risk management activities. A major accident can cause substantial loss to company in both human and economic terms; hence investing adequate budget into safety practices to prevent such accidents is a worthy strategy.

This work aims at developing a safety investment optimization (SIO) framework for a typical process plant. Such an optimization targets maximal reduction of risk values across all potential hazards within a given constraint of safety investment budget ;such that it saves future cost to company by prevention of accident and simultaneously fulfills regulatory requirements imposed by the government. Increase of safety budget may not always entail adequate risk reduction as it is also necessary to ensure optimal utilization of the investment across various risk sources. The current industry practice of such investment approach appears to be driven largely by simple risk-based heuristics, organizational culture and management judgment. There is a lack of an overarching systematic approach for ensuring that the investment is undertaken optimally. There is, therefore, a

need for developing a robust decision-making framework for optimal allocation of financial resources across all significant risk elements within a process plant.

The development of a SIO frame work is based on a synthesis from various disciplines, namely finance (resource allocation), insurance and process risk management. To develop a solution for this problem, current methodologies and practices for solving such problems were reviewed across various industries including process plants. Also, relevant risk-based decision making techniques and economic assessment tools(for accidents) were studied and evaluated for further use. Since the purpose of this study is to develop a practicable SIO structure, insurance and regulatory requirements were integrated into the framework.

The key feature of the proposed SIO framework is a risk-governed resource allocation model. For this purpose it is first necessary to screen accident scenarios and prioritize them in order of the risk they pose. The framework next enables assessment of the degree of compliance with governmental regulations on acceptable individual risk (IR) profile of a plant. This is achieved by implementing the most cost-effective safeguard(s) for mitigating each risk scenario. Once the cumulative IR is brought within As-Low-as-Reasonably-Practicable (ALARP) region, an iterative exercise is performed to reduce the risk of economic (property) loss, through appropriate cost-benefit analyses and a global optimization algorithm. Lastly, based on relevant domain-based heuristics the framework integrates investment options in an insurance portfolio for managing residual risks. It is anticipated that the proposed SIO framework will help optimal resource allocation for managing the risk-space of a typical process plant.

**Yakesh Balasubramaniam, Pavanaditya Badida, Jayapriya Jayaprakash: Risk evaluation of oil and natural gas installations due to natural hazards using fuzzy fault tree analysis**

**Abstract:** Oil and gas sector plays a major role in influencing decision making for all the other important sections in a country's economy. Large amount of oil and gas transportation is done through pipelines. Many oil and gas sectors in India for example, Indian Oil Corporation Ltd. operates a network of about 11,750 km long crude oil, petroleum product and gas pipelines with a throughput capacity of 85.5 million metric tonnes per annum of oil and 9.5 million metric standard cubic meter per day of gas in India. But these pipelines are prone to risk natural disasters and have serious impacts on environment. The integrity of these oil and gas installations is of huge interest to the Oil and Gas companies, governments, and various stakeholders due to the adverse consequences posed by it and the heavy environmental, infrastructural and financial losses posed by them in case of failure. Fuzzy logic is a mathematical tool that is being used extensively to model the uncertainties and inaccuracies, the two main parameters which are characteristic of real world. The present Risk analysis methodologies are all mired in uncertainties and fuzzy logic can be integrated with the risk analysis to eliminate those uncertainties. Of the various methodologies utilized for the purpose of risk assessment, Fault tree analysis is an important technique which is used for probabilistic safety assessment. The analysis is only considered to be completed if the basic event probability is available. It is however, very difficult to obtain this data due to the ever changing environment or due to insufficient data sources of due to development of new components.

In the proposed model, fault tree analysis is applied to oil and gas installations to list down the failure modes they would faces in case of natural hazards or the hazards posed by the natural environment. Then, fuzzy logic combined with expert elicitation is utilized to obtain the failure probability of each base events in fault tree even in the absence of historical failure probability data. Fussel-Vesely Importance is utilized to determine the importance of each cutset to the top event in fault tree analysis. The results demonstrate that the proposed Fuzzy-Fault Tree analysis is suitable for evaluating the top event failure even in the absence of historical probability data. The results are expected to be of help to safety professionals while taking decisions related to the prevention of the hazards from happening.

# Safety Centre @IITGN

The objective of the IIT Gandhinagar Safety Centre is to promote safety in public and private spheres, industry and the informal sector. The Safety Centre advances these objectives with activities to:

**Discover-** ***Research projects, consultancy and project implementation. Promoting awareness and undertaking public advocacy around safety:***Safety centre undertakes a vigorous program of safety research, consultation and project implementation in the formal and informal sector. Some of the major consultancy projects currently in progress include Seismic design criteria for metro structures for MEGA, Identification of an Optimal Disinfectant for the Preservation of RO Purified Water and Safe Cities. Several research projects at PhD and Master's level have been undertaken by Faculty like computational modelling of condensed phase aerosol, cognitive engineering for process safety, study of human factors in process control and alarm management directed towards preventing accidents in chemical plants and design of inherently safe chemical plants. A number of undergraduate projects have also been initiated including development of an Indian Fire incident Database and development of an Android App for fire reporting.

**Teach:** IIT Gandhinagar endeavours to develop and integrate safety related courses into its graduate and undergraduate curriculum. Safety related elective courses currently being offered include Introduction to Fire Engineering, Fundamentals of Chemical Process Safety and Design of structures under fire. IIT Gandhinagar has also become a member of Safety and Chemical Engineering Education SACHE program of the American Institute of Chemical Engineers (AIChE) Which provides teaching material and programs that bring elements of process safety into student curriculum and also access to a wide range of educational materials prepared by AIChE's Centre for Chemical Process Safety for the students. Regular Industry visits and field trips are arranged for students for a first-hand view of how the concepts covered in classes translate to industrial practice. Safety centre is also exploring the potential of developing minor courses and certificate, graduate programs in industrial safety in the coming years.

**Outreach:** Safety Centre conducts conferences, workshops, seminars and training for Researchers, academicians, safety professionals and policy makers around the world to advance their expertise, professional knowledge and skills and to introduce them to the state-of-the-art. Several Workshops, professional Training programs and short courses have been organized by the centre covering Disaster Mitigation, Confined Masonry, Profess Safety Management, Seismic Retrofitting, Seismic Design of Reinforced Concrete Buildings and Earth and Rock filled Dams, Fire Safety, geotechnical Aspects of Earthquake Engineering, Soil Structure Interaction, Fire Investigation, Enclosure Fire Dynamics, Industrial Hazard Identification and Process safety. In addition, centre organizes a biennial International Conference on Safety (ICS) covering all areas of safety (Design and Operations, Regulations and Standards, Planning and Economics, Risk management, Testing, behavioural and occupational safety) spread across various sectors such as Buildings and structures, consumer, fire, industrial, process, construction and transportation and informal sectors. A symposium on process safety (SPS) with special focus on process safety is also organized by the centre every year.

**Practice:** Safety Centre oversees and Monitors safety at Institute level and ensures safe working environment in all laboratories and all aspects of institute operations. Safety committee has formulated policies, developed a safety manual and conducts regular training programs for staff and students. The safety management system also undertakes regular checks, audits, inspections; incident investigation and proper follow up.

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# SAFETY CENTRE