“Global Process Safety Regulation with Incidents and Lesson Learned (US, UK, China, India and Singapore)”

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An AIChE Technology Alliance
CCPS
Center for Chemical Process Safety

Outline

- Introduction
- US regulations
- EU regulations
- UK regulations
- China regulations
- India regulations
- Other Regulations
- PSM Key Success Factors

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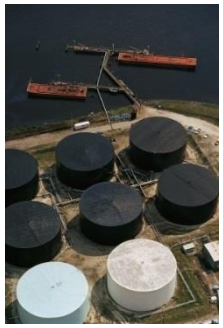
PSRG Overview



- Established, 1997 (Houston)
- Established, 2015 (Singapore), as PTE. LTD. Company
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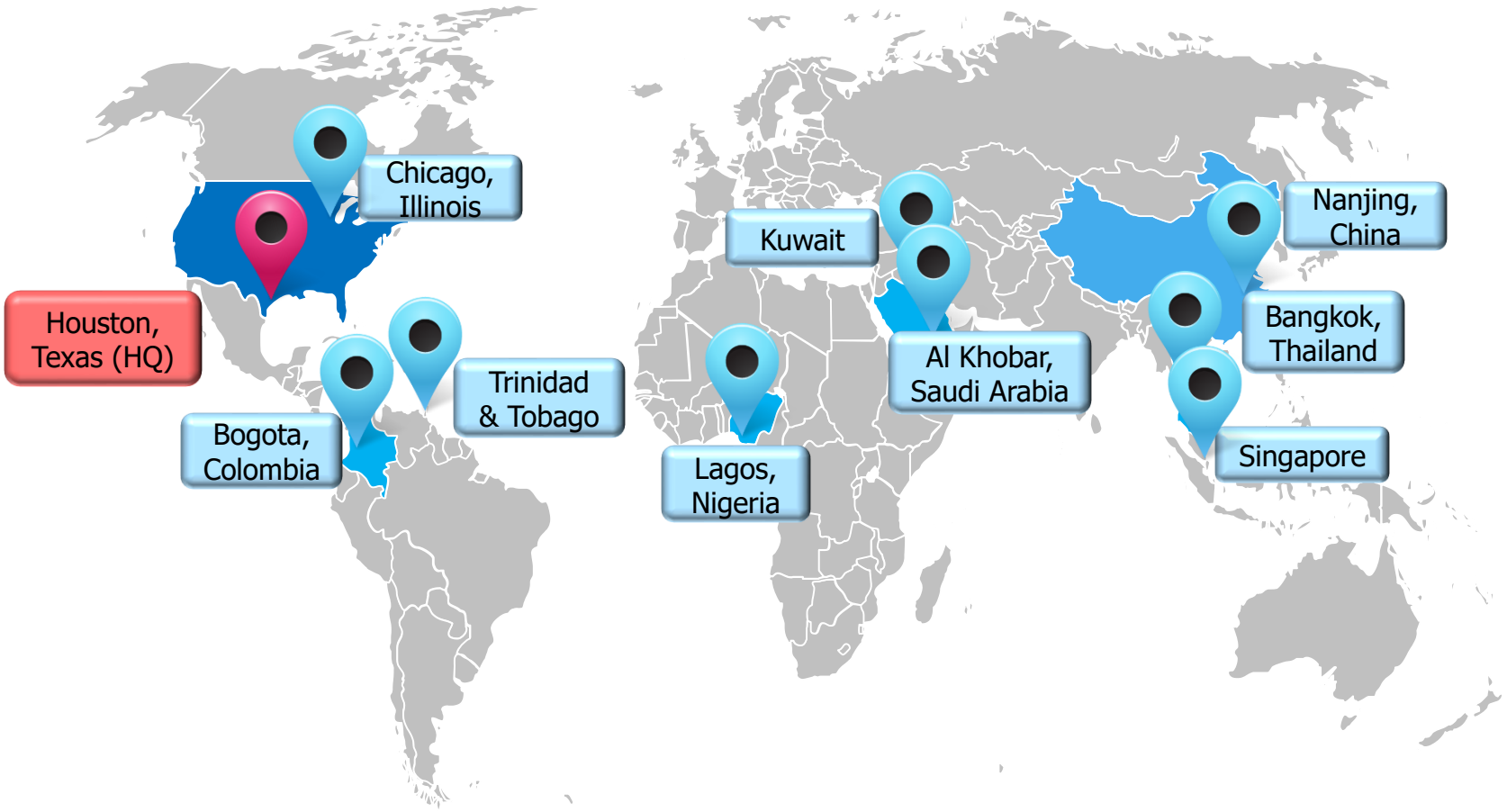
PSRG Locations



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Why PSM? Motivating Factors

- History of incidents - a series of catastrophic releases of chemicals leading to fires, explosions and fatalities have occurred in chemical processing plants around the world over the years
- Public reaction
- Legislative / regulatory activity
- Industry reaction
- Increased awareness of benefits
- Protection of assets, human life, environment, reputation and image, business continuity
- The development of process safety regulations has been continual
  - Significant incidents occur, industry grows and new technology is developed

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US History Incidents – Lesson Learned and Regulation

Pasadena, Texas – October 23, 1989
Phillips Pasadena Chemical Complex (Vapor Cloud Explosion)

- Incident: Explosion with a force of 2.4 tons of TNT.
  - Release occurred due to the deviation from well established maintenance procedures of removing plug from the reactor settling leg.
- Consequences:
  - 23 fatalities more than 130 injured.
  - Property damage was $750MM+.
  - Release of flammable mixture containing ethylene, isobutene, hexane and hydrogen.

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Pasadena, Texas – October 23, 1989
Phillips Pasadena Chemical Complex (Vapor Cloud Explosion)

- Lesson Learned - OSHA investigation found the following deficiencies
  - Lack of process hazard analysis leading to serious safety deficiencies being ignored
  - No provision for the development and implementation of effective permit systems
  - Lack of fail safe and double block and bleed valves
  - Lack of Facility siting
- Led to establishment to Mary Kay O'Connor Process Safety Center at Texas A&M University.

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US History Regulation

- Process Safety Management was initiated by OSHA in 1992 as a way to respond with government oversight of industries using highly hazardous chemicals (HHCs)
- Emphasize the management of hazards associated with highly hazardous chemicals and establishment of a comprehensive management program that integrated technologies, procedures, and management practices

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OSHA PSM 1910.119 - 14 Elements of Process Safety

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US Regulations

- EPA Risk Management Plan (RMP) – 1996
  - Goal:
    - Protection against a threshold volume of hazardous chemical and focuses on protecting any offsite and environmental conditions
  - There are 12 elements; RMP is updated every 5 years
  - 3 program levels - defined based on the facility's accident history, distance from the public and if the facility is subject to OSHA PSM

- Chemical Safety Board (CSB) - 1998
  - Goal:
    - Investigate process safety incidents and potential hazards to determine the root cause and to provide recommendations
  - Independent of all other agencies

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History of Process Safety

Regulations have not changed since their promulgation, but……

- OSHA Petroleum Refinery Process Safety Management National Emphasis Program (NEP) Directive – 2007
- OSHA' PSM Covered Chemical Facilities National Emphasis Program (NEP) Directive – 2011

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BP Texas City, TX – March 23, 2005 (Vapor Cloud Explosion)

- Incident:
  - Vapor cloud explosion at the BP refinery isomerization unit
  - The splitter tower was overfilled to approximately 98 feet
- Consequences:
  - 15 workers were killed and more than 170 others were injured.
- Lesson Learned:
  - A lack of knowledge about the system,
  - Combined with faulty instrumentation,
  - And a failure to properly plan and manage temporary trailers,
  - With pressure to get the plant online,
  - An unclear responsibilities,
  - Led to plant being operated well outside of its design parameters,
  - Leading to loss of containment,

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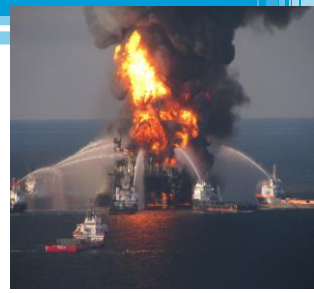

Deepwater Horizon – April 20, 2010 BP/Transocean/Halliburton

- Incident:
  - Explosion and sinking of the Deepwater Horizon oil rig followed by oil release
- Consequences:
  - Considered the largest accidental marine oil spill in the history of the petroleum industry.
  - Eleven workers were never found despite a three-day Coast Guard (USCG) search operation
  - Oil flowed for ~90 days; 134MM – 176 MM bbls spilled.
  - On 15 April 2014, BP claimed that cleanup along the coast was substantially complete, but the USCG says that a lot of work remained.
  - Cost to BP: $20B+, dissolution of assets.
- Lesson Learned:
  - A White House commission likewise blamed BP and its partners for a series of cost-cutting decisions and an insufficient safety system, but also concluded that the spill resulted from "systemic" root causes and "absent significant reform in both industry practices and government policies.

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EU History Incidents – Lesson Learned and Regulation

Seveso, Italy – 1976

- Incident:
  - 2,3,7,8- tetrachlorodibenzo-p-dioxin (TCDD) forming vapor cloud
- Consequence
  - No direct human deaths reported
  - Thousands of animals in the area died and thousands of inhabitants of Seveso were at risk of being exposed
- Lesson Learned
  - Siting of major hazard installations
  - Hazard of undetected exotherms, lack of proper hazard evaluation
  - Inherently safer design
  - Adherence to operating procedures
  - Planning for emergencies

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EU Regulations

- Seveso Directive - 1982
  - Goal:
    - Decrease the frequency and severity of process safety incidents & standardize regulations between EU member states
  - Provided a list of hazardous substances, but did not provide penalties for violators
- Seveso II Directive - 1996
  - Created a classification system for substances identified as hazardous
  - Threshold amounts were determined for each substance
    - Facilities labeled as top or lower tier based on the amount of these substances used relative to established threshold values
    - Both top and lower tier facilities were required to submit a Major Accident Prevention Policy (MAPP) which describes the process safety management system at the facility

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EU Regulations

- Seveso III Directive - 2012
  - Updated:
    - Classification of dangerous chemicals
    - Right to information for all citizens
- The requirements for compliance differ depending on the ranking of a facility as upper-tier or lower-tier.
- Upper tier sites carry out more dangerous processes and/or use more hazardous substances than lower tier sites. They are required to prepare a Major Accident Prevention Plan (MAPP) and have a safety management system, emergency plans and make information public.
- However, lower tier sites are now also required to submit a MAPP as part of the updated Seveso III Directive

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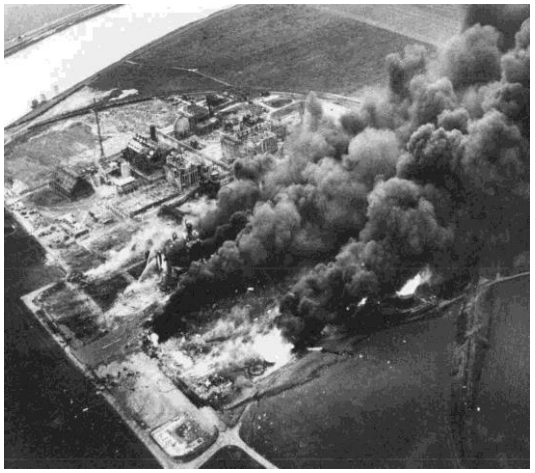
UK History Incidents – Lesson Learned and Regulation

Nypro Limited facility at Flixborough, England – 1974



- Incident:
  - Explosion of vapor cloud of cyclohexane
- Consequences:
  - 28 deaths and 89 injuries
- Lesson Learned:
  - Lack of plant modification/change control. Management of "temporary changes".
  - Lack of design codes for pipework.
  - Lack of siting considerations for placement of control room and other occupied buildings.
  - Plant site contained large inventories of dangerous compounds such as 330,000 gallons of cyclohexane, 26,400 gallons of naphtha, 11,000 gallons of toluene, 26,400 gallons of benzene, 450 gallons of gasoline

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UK Regulations

- In response to the Seveso I Directive (Directive 82/501/EEC), the UK created the Control of Industrial Major Accident Hazards (CIMAH) Regulations in 1984. This regulation requires that companies identify hazards, implement the required control schemes, document the hazard control procedures, prepare an off-site emergency plan working with the Local Authority, and communicate the potential hazards to the public
- In 1999, the Control of Major Accidents Hazards (COMAH) regulation replaced CIMAH as the UK's method to implement the Seveso II Directive (Directive 96/82/EC).
- The COMAH regulation was updated in June 2015 based on Seveso II Directive (Directive, 2012/18/EC) that was passed in 2012. This revision included updates to the hazardous substances and additional requirements for public information and emergency planning

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CIMAH vs COMAH

Differences between CIMAH and COMAH (Ansell et al., 1998; PE, 2000).

CIMAH	COMAH
• Applied to facilities based on specific substances and quantities	• Applied to facilities based on categories of substances
• Lower-tier facilities only required to show safe operations and report any incidents	• Lower-tier facilities must prepare a MAPP and report to the Competent Authority (CA)
• Top-tier facilities required to prepare safety reports and emergency plans	• Top-tier facilities safety reports were expanded, focus on safety management systems, more public access to safety documents, expanded requirements for emergency plans, and requirements for restoration of environment after an incident
• No inspection systems	• Inspection systems are required
• No land-use planning requirements	• Includes land-use planning requirements
• Less focus on the environment (HSE was only Competent Authority)	• Increased environmental protection focus by including the Environment Agency and Scottish Environmental Protection Agency as Competent Authorities

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China History Incidents – Lesson Learned and Regulation

China National Petroleum, Chongqing – 2003

- Incident:
  - Blowout occurred at a gas field, releasing a cloud of natural gas and hydrogen sulfide
- Consequences:
  - 191 fatalities, hundreds injuries and forced 31,000 residents to evacuate within five kilometers.
- Lesson Learned:
  - Lack of training in operating procedure.
  - Lack of emergency plant and local emergency

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Tianjin facility, China – 2015

- Incident
  - Explosion because of self ignition of nitro-cotton, causing the ignition of ammonium nitrate among other chemicals
- Consequences
  - 300 buildings destroyed, 173 people dead and 800 others injured
  - 49 people were jailed in connection with the incident
    - Included regulators and those associated with the facility
- Lesson Learned
  - Lack of chemical Management
  - Poor emergency Reponses
  - Lack of training in safety procedures.

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China Regulations

- In 2010, State Administration of Work Safety (SAWS) passed the PSM regulation (AQ/T 3034-2010) which consist of 12 elements and is modeled after OSHA PSM regulation (except without the employee participation and trade secret section)

- In July 2013, SAWS issued "*Guidance on Strengthening the Chemical Process Safety Management, Supervision and Administration, Division III [2013] No.88" (国家安全监管总局关于加强化工过程安全管理的指导意见,安监总管三[2013]88号)*, the risk identification analysis of production and storage facilities involving key hazardous chemicals, key hazardous chemical processes, and major hazardous sources of hazardous chemicals (referred as "two key one major") are required to perform HAZOP study at least every three (3) years. For other production storage facilities, the risk identification analysis is required every five (5) years

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China Regulations

- In November 2014, " *Guidance on Strengthening Chemical Safety Instrumented System Management, Supervision and Administration, Division III [2014] No.116" (国家安全监管总局关于加强化工安全仪表系统管理的指导意见,安监总管三[2014]116号)*, from January 1,2018, for all newly-built chemical installations and hazardous chemical storage facilities involving “two key one major”, Safety Instrumented System (SIS) must be designed to meet the requirements.

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India History Incidents – Lesson Learned and Regulation

Union Carbide facility, Bhopal – 1984 (the world's worst industrial disaster)

- Incident:
  - Vapor cloud containing approximately 25 tons of methyl isocyanate released and spread throughout the nearby area
- Consequences:
  - Over 2000 fatalities
  - Demise of Union Carbine, one of the world's largest integrated chemical companies

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Union Carbide facility, Bhopal – 1985 (the world's worst industrial disaster"

- Lesson Learned
  - Poor safety management practices
  - Poor early warning system
  - Entry of water into the system through a jumper line installed without following company's MOC procedures
  - Protective systems disabled/maintenance [Asset Integrity]
  - Lack of understanding of the hazards [Workforce Involvement]
  - Cost cutting in safety management systems [Safety Culture]
  - Insufficient emergency response plan [Emergency Planning and Response]
  - No facility siting [Process Hazard Analysis]

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Indian Oil Corporation Terminal, Jaipur - 2009

- Incident:
  - The incident occurred when petrol was being transferred from the Indian Oil Corporation's oil Depot to a pipeline.
  - A leak of gasoline continued for 75 mins, when the vapor cloud ignited, resulting in a severed vapor cloud explosion.
- Consequences
  - 11 people fatalities and over 300 injuries, half of million people were evacuated from the area
- Lesson Learned
  - Absence of specific written-down procedures for the tasks to be undertaken, therefore, reliance on practices.
  - Lack of stopping devices from a remote location and insufficient understanding of hazards and risk and consequences.
  - Lack of PPE for response team.

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India Regulations

- To response the Bhopal incident, Manufacture, Storage and Import of Hazardous Chemical Rules (MSIHC) passed in 1989. The rules cover processes that use hazardous materials, the storage of hazardous materials, and the transport of nonflammable gas through pipelines.
- MSIHC Rules Split factories into three different tiers (low, middle or high tier) based on the materials used by the facility
- The base requirement to apply to all tiers include:

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India Regulations

- MSIHC rules with the base requirement to apply to all tiers include:
  - Identify and prevent major accidents
  - Supply works with necessary equipment, training and information
  - Provide notification if an incident occurs and prepare safety data sheets for chemicals
  - Middle and high tier facilities are required to prepare safety reports/audits
- Chemical Accidents Rules (1996), focus on development of on-site and off-site emergency plans and reduction in risks during the processing of hazardous chemicals.

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Total employment, total fatalities and fatality rate per region

Total Employment, Total Fatalities, and Fatality Rate per region from ILO 2001 data (Horiguchi, 2010; ILO, 2005).

Occupational Fatal Injury Rates (2001)			
Country (Country Code)	Total Employment	Total Fatalities	Fatality Rate (per 100,000 workers)
United Kingdom (GBR)	28,225,400	236	0.84
European Union (EU15)	162,712,925	5740	3.53
United States (USA)	135,073,000	6643	4.92
India (IND)	402,510,000	40,133	9.97
China (CHN)	733,705,100	90,295	12.31

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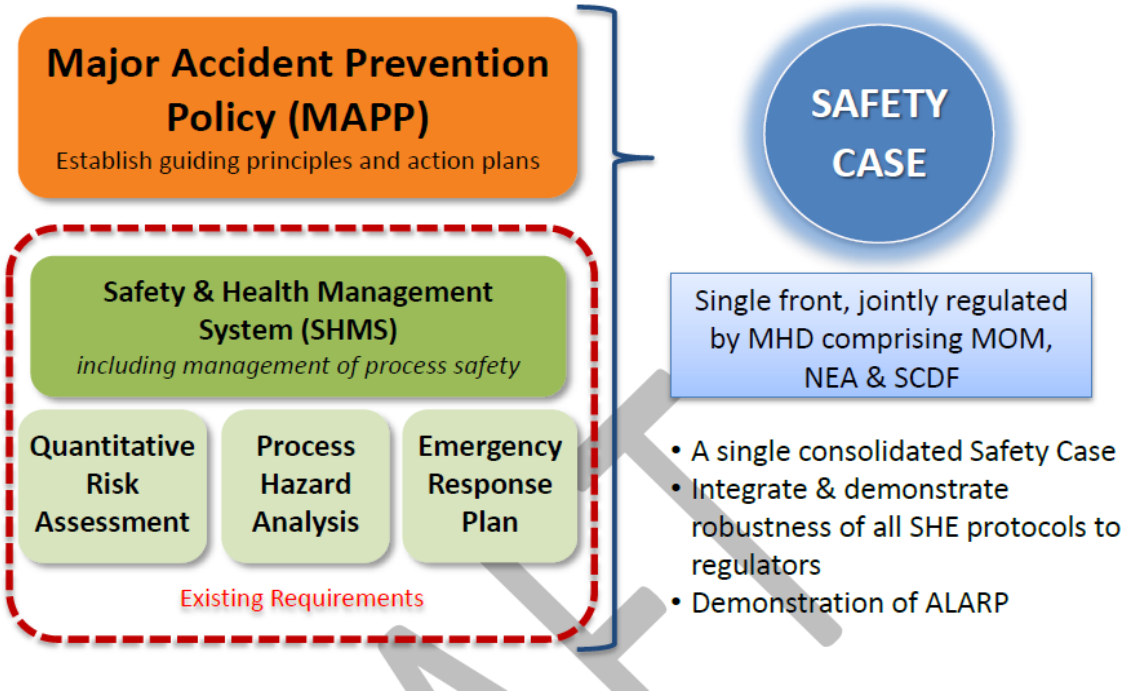
Other Regulation in Asia Region

Singapore Regulations

- Targeted at installations which are defined as (Major Hazard Installations) MHIs under Workplace Safety and Health (MHI) Regulations

- Taking reference from countries with established Safety Case (SC) regimes such as the EU member states and Australia



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Thai Regulation

- In June 2016, PSM regulation is effective for Map Ta Phut Industrial Estate in Rayong, Thailand " "*Regulations of the Board of Directors of the Industrial Estate Authority of Thailand, Rules, Procedures and Conditions of Business Operations (No. 4) BE 2559"*
  - (1) Processes involving the presence of hazardous chemicals in quantities at any one time equal to or greater than the amount specified in the Hazardous Chemical List attached to this rule.
  - (2) Processes involving flammable or combustible liquids with a quantities of up to 10,000 pounds (4545 kg) at any one time.

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International Laws and Regulations

- Australian National Standard for the Control of Major Hazard Facilities
- Canadian Environmental Protection Agency - Environmental Emergency Planning, CEPA, 1999 (section 200)
- Korean OSHA PSM standard
- Malaysia - Department of Occupational Safety and Health (DOSH) Ministry of Human
- Resources Malaysia, Section 16 of Act 514
- Mexican Integral Security and Environmental Management System (SIASPA)
- Thailand

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CCPS Risk Based Process Safety (RBPS)

- Process Safety Culture
- Compliance with Standards
- Process Safety Competency
- Workforce Involvement
- Stakeholder Outreach
- Process Knowledge Management
- Hazard Identification and Risk Analysis
- Operating Procedures
- Safe Work Practices
- Asset Integrity and Reliability
- Contractor Management
- Training and Performance Assurance
- Management of Change
- Operational Readiness
- Conduct of Operations
- Emergency Management
- Incident Investigation
- Measurement and Metrics
- Auditing
- Management Review and Continuous Improvement
- Implementation and the Future

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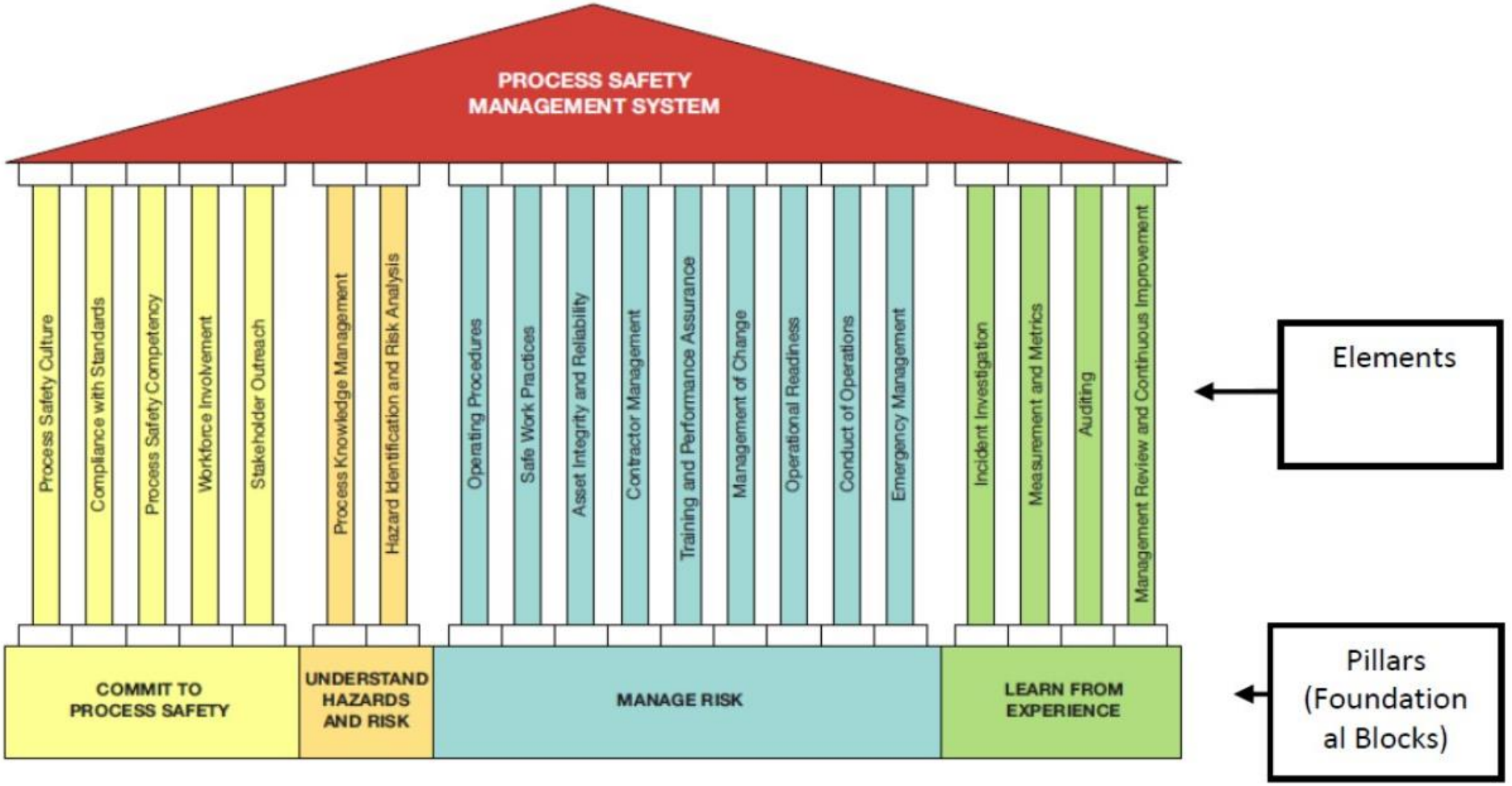
CCPS Risk Based Process Safety (RBPS)



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PSM Key Success Factors

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PSM Key Success Factors

1. Process Safety Leadership
2. Process Safety Competency
3. Process Safety Culture
4. Clearly Defined Expectations and Accountability
5. Leading and Lagging Indicators
6. Audit and Continuous Improvement
7. Community Outreach

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Process Safety Leadership

- The executive leadership must provide and demonstrate effective leadership and establish clear process safety goals and objectives.
- Management and leadership must clearly demonstrate their commitment to process safety by articulating a consistent message on the importance of process safety.
- Policies and actions should match that message.

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Process Safety Competency

- Company must establish and implement a system to ensure that its executive management, its line management, and all employees – including managers, supervisors, workers, and contractors – possess the appropriate level of process safety knowledge and expertise to prevent and mitigate accidents.

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Process Safety Culture

- Company must involve employees at all levels in order to develop a sustainable, positive, trusting, and open process safety culture.
- Company must promote a culture of individual ownership of the Process Safety program.
- Process Safety should be EVERYONE's responsibility; not just the responsibility of the Process Safety Manager or HSE Department.

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Clearly Defined Expectations & Accountability

- Company must clearly define expectations and strengthen personnel accountability for process safety.
- At all levels of the organization – the executive leadership, management, supervisors, line employees, contractors, etc.

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Leading & Lagging Indicators

- Company should develop and implement an integrated set of Key Performance Indicators (KPIs), including leading and lagging metrics for more effectively monitoring the performance of the process safety management system.
- KPIs should be realistic and measurable.
- KPIs should also be regularly monitored and periodically updated to reflect industry changes, best practices, and lessons learned around the world.

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Audit & Continuous Improvement

- Company must establish and implement an efficient and effective system to periodically audit and continuously improve process safety performance relative to regulatory requirement and international peers.
- Plan-Do-Check-Act
- Documentation Documentation Documentation

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Community Outreach

- Company should out and work closely with local community leaders to promote its Process Safety image.
- Will lead to increased reputation and goodwill, improved safety and quality performance of workers and suppliers.
- More adequate preparedness and response in case of a catastrophic emergency,
- Part of corporate social responsibility.

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Path Forward

REALIZE THE BENEFITS: SEVEN (7) KEY STEPS

1. Assign personnel who will be accountable.
2. Adopt a personalized Company philosophy of process safety.
3. Learn more about process safety.
4. Take advantage of strong synergy process safety has with your other business drivers.
5. Set achievable process safety goals.
6. Track your performance.
7. Revisit your process safety program / continuous improvement.

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Thank You!

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