Practical Examples of Fire Protection Engineering Practices and Technology for PSM

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Overview

- Background on the fire problem
- The Nexus of Fire Protection Engineering and PSM
- Key Fire Protection Principles in PSM
- Recommendations

Challenges and Opportunities

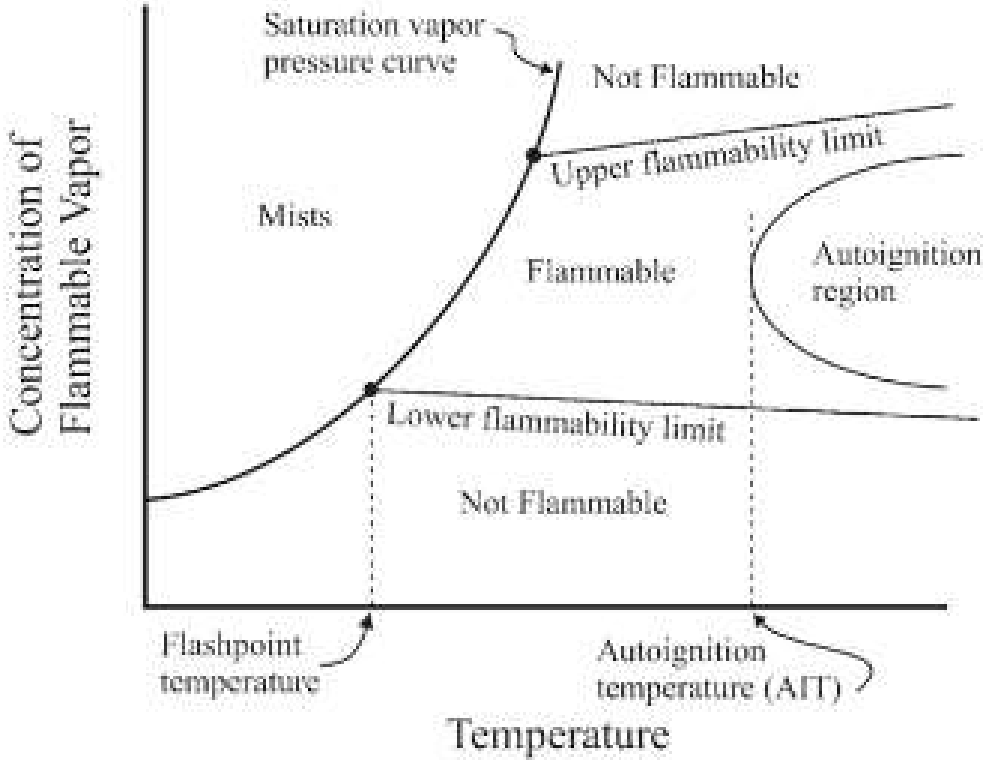
The number one hazard based on PSM incident experience is fire & explosion and related combustion hazards

The most significant PSM events of the past 40 years have been major fires and explosions

Fire and Explosion Phenomena

- Jet Fires
- Pool Fires
- Vapor Cloud Explosions
- Pressure Vessel Burst
- BLEVE
- Flash Fire Hazards
- Dust Explosions
- Reactive Hazards

1970 Beaumont Gas Plant BLEVE



Incidents That Have Defined PSM

1947 – Texas City, TX

1974 – Flixborough, England

1984 - Mexico City, Mexico

1988 – Piper Alpha, Scotland

1989 – Phillips Pasadena, TX

2001 - Toulouse, France

2005 – BP Texas City, TX

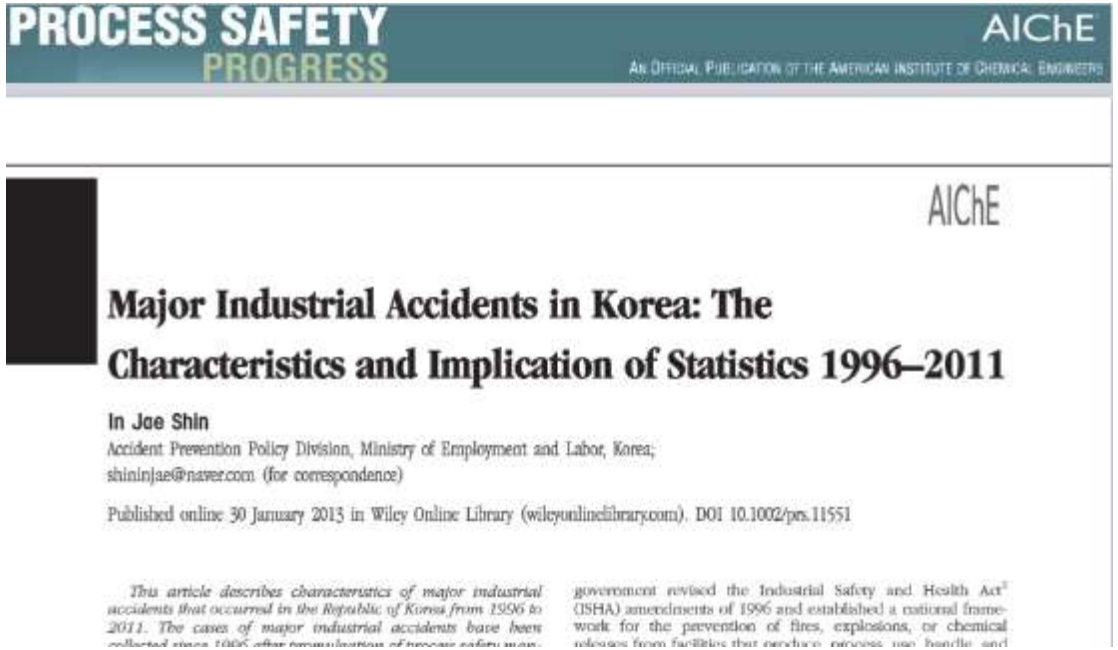
2005 - Buncefield, England

2008 - Port Wentworth, Georgia

2010 – Deepwater Horizon, LA

Challenges and Opportunities

- This article describes characteristics of major industrial accidents that occurred in the Republic of Korea from 1996 to 2011
- The cases of major industrial accidents have been collected since 1996 after promulgation of process safety management (PSM) regulations.
- The author analyzed 147 cases:
  - 50% were explosions
  - 36% were fires
  - 13% were chemical releases
  - 2% were asphyxiations.



PROCESS SAFETY PROGRESS
AIChE
An Official Publication of the American Institute of Chemical Engineers

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Major Industrial Accidents in Korea: The Characteristics and Implication of Statistics 1996–2011

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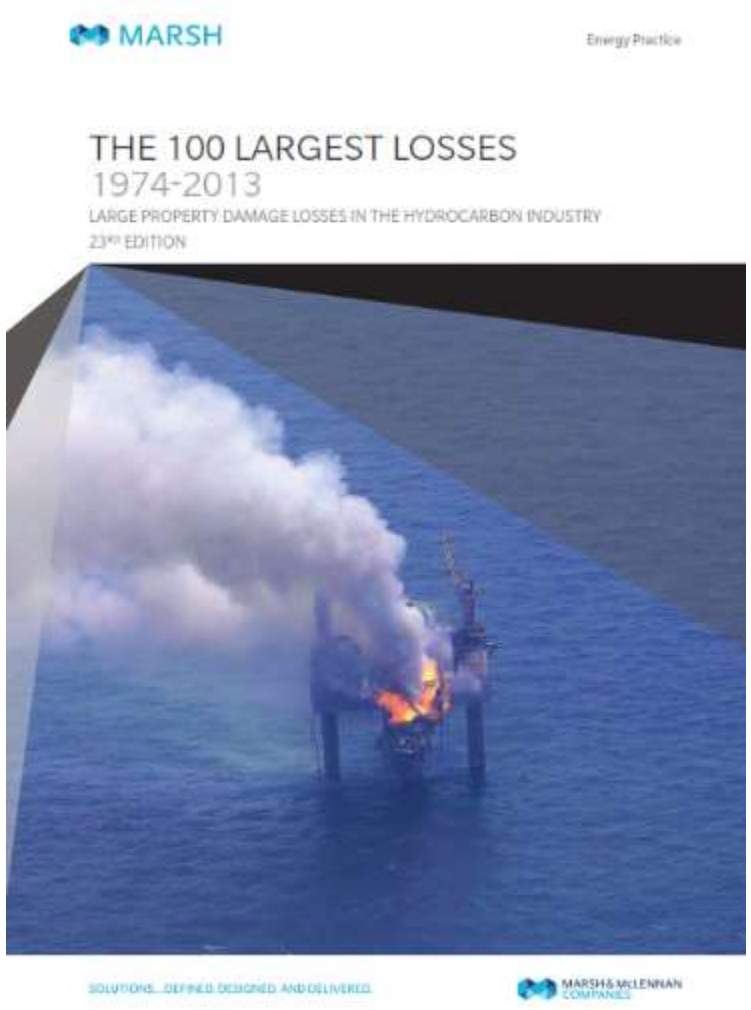
This article describes characteristics of major industrial accidents that occurred in the Republic of Korea from 1996 to 2011. The cases of major industrial accidents have been

government revised the Industrial Safety and Health Act[2] (ISHA) amendments of 1996 and established a national framework for the prevention of fires, explosions, or chemical

20 Largest Losses 1974-2013



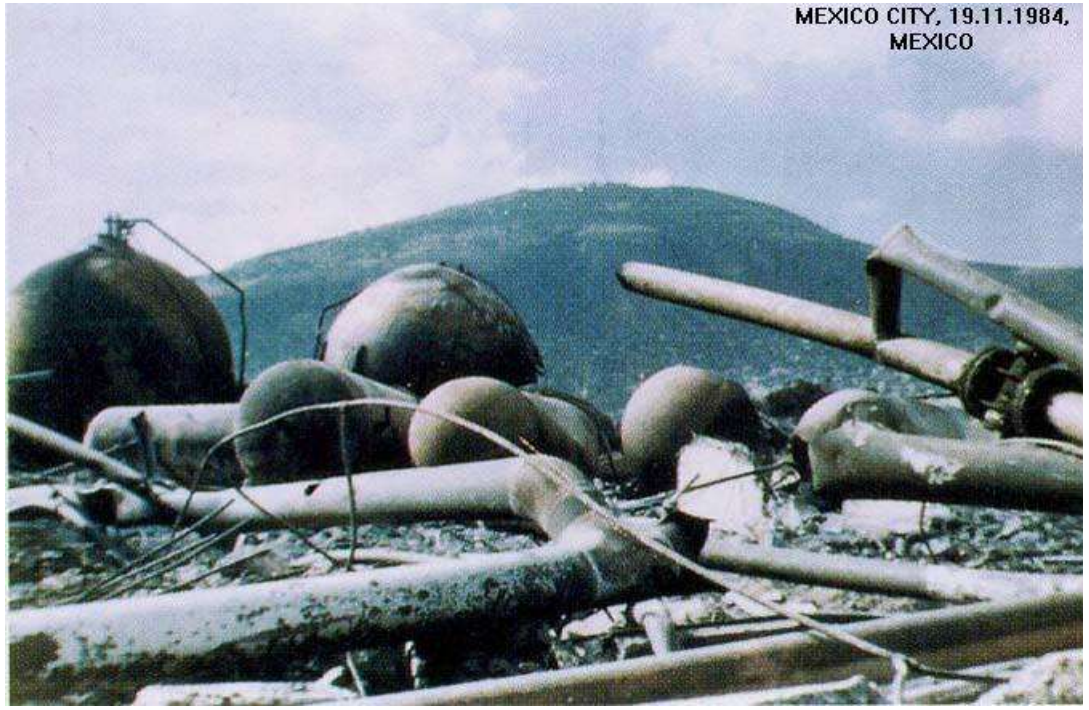
- 19 of 20 of the largest industrial losses were causes by fire or explosion (only exception was a hurricane in 2008 that damaged a refinery)

THE 20 LARGEST LOSSES

DATE	PLANT TYPE	EVENT TYPE	LOCATION	COUNTRY	PROPERTY LOSS US$ (MILLIONS[1])
07/07/1988	Upstream	Explosion/fire	Piper Alpha, North Sea	UK	1,810
10/23/1989	Petrochemical	Vapor cloud explosion	Pasadena, Texas	USA	1,400
01/19/2004	Gas processing	Explosion/fire	Skikda	Algeria	940[2]
06/04/2009	Upstream	Collision	Norwegian Sector	North Sea	840
03/19/1989	Upstream	Explosion/fire	Gulf of Mexico	US	830
06/25/2000	Refinery	Explosion/fire	Mina Al-Ahmadi	Kuwait	820[2]
05/15/2001	Upstream	Explosion/fire/sinking	Campos Basin	Brazil	790
09/25/1998	Gas processing	Explosion	Longford, Victoria	Australia	750
04/24/1988	Upstream	Blowout	Enchova, Campos Basin	Brazil	700
09/21/2001	Petrochemical	Explosion	Toulouse	France	680
05/04/1988	Petrochemical	Explosion	Henderson, Nevada	US	640
05/05/1988	Refinery	Vapor cloud explosion	Norco, Louisiana	US	610
03/11/2011	Refinery	Earthquake	Sendai	Japan	600[3]
04/21/2010	Upstream	Blowout/explosion/fire	Gulf of Mexico	US	600
09/12/2008	Refinery	Hurricane	Texas	US	550
06/13/2013	Petrochemical	Explosion/fire	Geismar, Louisiana	US	510[4]
04/02/2013	Refinery	Flooding/fire	La Plata, Ensenada	Argentina	500[4, 5]
12/25/1997	Gas processing	Explosion/fire	Bintulu, Sarawak	Malaysia	490[2]
07/27/2005	Upstream	Collision/fire	Mumbai High North Field	India	480
11/14/1987	Petrochemical	Vapor cloud explosion	Pampa, Texas	US	480

The Nexus of Fire Protection Engineering and PSM

- Managing the risks of uncontrolled combustion is the objective of fire protection engineers and PSM specialists
- Fire Protection Engineering is the application of scientific principles for analyzing fire hazards and risks, preventing accidental fires, and mitigating the effects of fires for the protection of life and property and continuity of operations
- This is a mature and well established practice based on science and engineering principles
- Is the PSM industry making maximum use of the science and practice of fire protection engineering?



Introduction to Fire Protection Engineering

- The application of scientific principles for analyzing fire hazards and risks, preventing accidental fires, and mitigating the effects of fires for the protection of life and property and continuity of operations
- University degree programs:
  - Armour Institute of Technology (IIT, Chicago) started a fire protection engineering program in 1908
  - University programs have been available since 1937 with the start of the Oklahoma State University Fire Protection and Safety Engineering Technology program.
  - University of Maryland has been the leading ABET accredited university degree program on FPE since 1956.
  - In 1979, Worcester Polytechnic Institute established the first U.S. graduate degree program in fire protection engineering
  - California Polytechnic Institute started a program in FPE in 2010
- Graduates have taken a variety of positions including industrial fire protection assignments
- Many of these have also evolved into fulltime Process Safety Management positions

Introduction to PSM

- A more recent concept, it is a “blend of engineering and management skills focused on preventing catastrophic accidents, particularly explosions, fire and toxic releases associated with the use of chemicals and petroleum products” (CCPS, 2010)
- The Mary Kay O’Connor Process Safety Center is the leading PSM institution of higher learning since 1995
- MKOPSC provides classes on PSM including fire and explosion hazards analysis and conducts research on those topics
- Texas A&M Extension Service provides realistic, large-scale and hands-on training on industrial fire fighting
- Located adjacent to the Texas A&M University campus, the 297-acre facility attracts more than 45,000 emergency responders from all 50 states and more than 45 countries each year

Opportunities

- The disciplines of Fire Protection Engineering and Process Safety Management have common interests and these intersections produce opportunities for collaboration between the two leading university programs on the topics
- A number of opportunities including:
  - Joint research
  - Technical exchange
  - Collaboration on coursework
  - Recruiting of students
  - and other developing tools and resources

Challenge

- PSM involves many engineers and managers making decisions on fire and explosion risks
- PSM encourages hazards analysis and management systems to control risks but is performance based and the body of knowledge is not well understood
- Few companies have formal knowledge in fire hazards analysis, fire protection engineering principles, and prevention and suppression practices
- Therefore the ongoing PSM activities (particularly PHAs, MOCs, MI, Audits, and other elements) are often done without the benefit of sufficiently informed personnel

Areas of Need

- Fundamental knowledge of the hazard properties of chemicals, mixtures, dusts
- Inaccuracy of estimation of these hazards and risks during decision-making in PSM activities, particularly during PHAs
- Lack of appreciation for fire prevention principles
- Lack of appreciation for fire protection systems including their design, benefits, limitations, integrity, and maintenance

Suppression vs Prevention

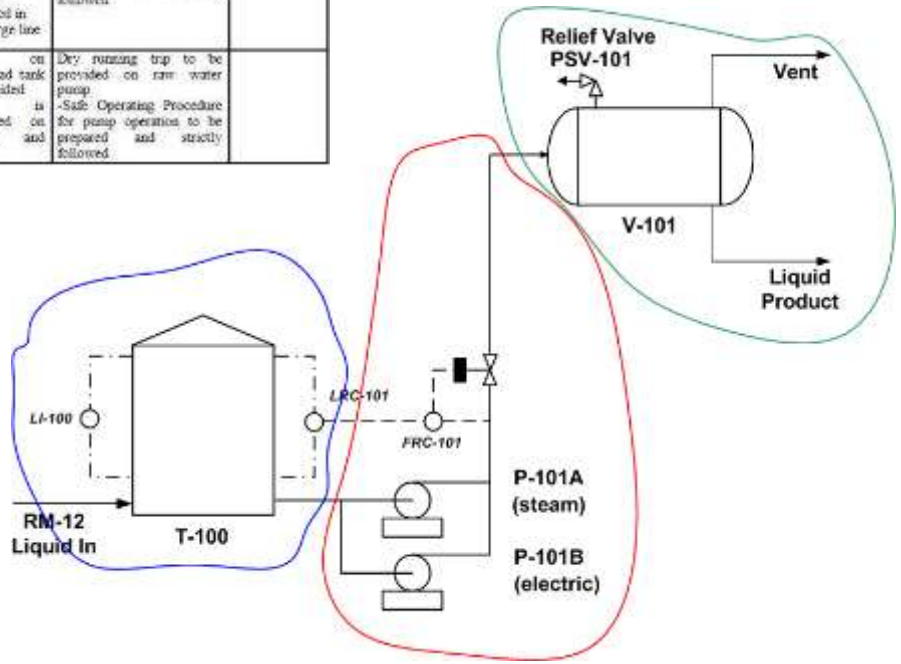
- The safety lifecycle should emphasize prevention through hazards recognition and avoidance
- Fire and explosion hazards must be then controlled by methods including effective practices, limitation of the effects, selection of appropriate engineered systems
- The role of fire protection engineering throughout the safety lifecycle is essential, not only as an afterthought for suppression
- Still see a lack of integration of known practices for prevention in design of capital projects and modifications of existing plant

Understanding Fire Hazards

- **Hazard properties**
  - Flammability
  - Reactivity
  - Mixtures
  - Dusts
- **Ignition estimation**
  - Likelihood
  - Control
- **Fire risk analysis**
  - Inconsistency in hazards analysis
    - Safety Audits
    - HAZOPs
    - Event Tree and Fault Tree Analysis
    - Checklists
  - Simple vs complex analysis methods
  - Development of standardized estimation tools
  - Training

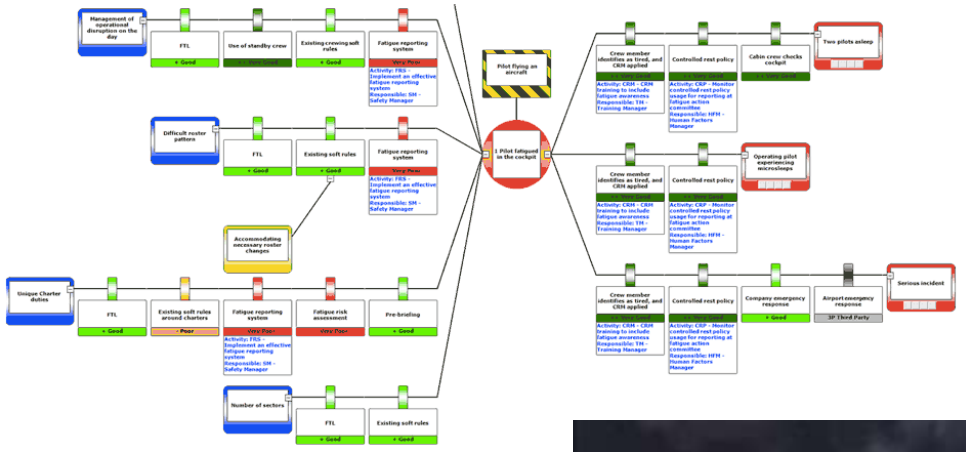
HAZOP WORKSHEET

NODE NO. 1	DISCRIPTION: / DESIGN INTENTION:			Risk Rating	PFD No.: 001 TITLE:	
Guidewords	**Line**	**Causes**	**Consequences**	**Safeguards**	**Recommendation**	**Responsible agency**
1. No/Low Flow/ Quantity	Raw water overhead tank to pre-heater tank	-No level in over head tank	-High temp. of pre-heating tank	-LI on overhead tank is provided	-Safe Operating Procedure for pump operation to be prepared and strictly followed	
	Line from pre-heater tank to boiler via boiler pump	-No level in pre-heater tank	High temp. & high pressure in boiler	-LI is provided in boiler -At low level of boiler, boiler pump is trip -PG is provided in discharge line	Dry running trip to be provided on raw water pump -Safe Operating Procedure for pump operation to be prepared and strictly followed	
	Line from over head water tank to RO plant via high pressure pump	-No level in over head tank -Filter choking	-Dry running of raw water pump	-LI on overhead tank is provided -PG is provided on pump and filter	Dry running trip to be provided on raw water pump -Safe Operating Procedure for pump operation to be prepared and strictly followed	



Issues in Fire Protection Engineering and PSM

- **Consequence Analysis**
  - Fire behavior
  - Estimation
    - Energy release
    - Fire spread
    - Explosion impacts



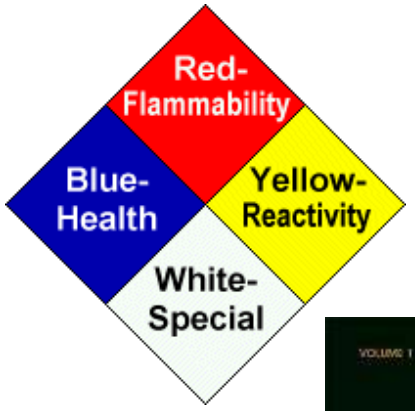
- **Barrier analysis**
  - Effectiveness of FP systems

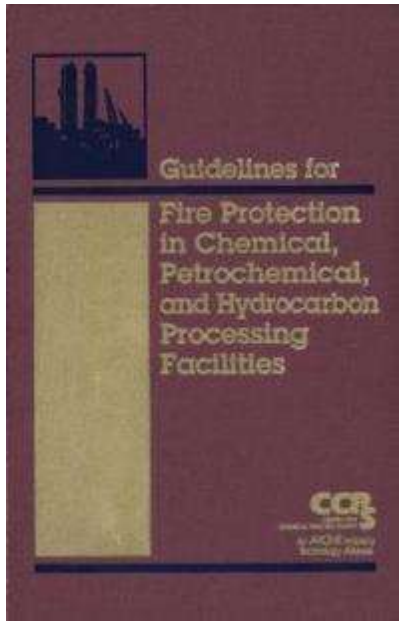
Issues in Fire Protection Engineering and PSM

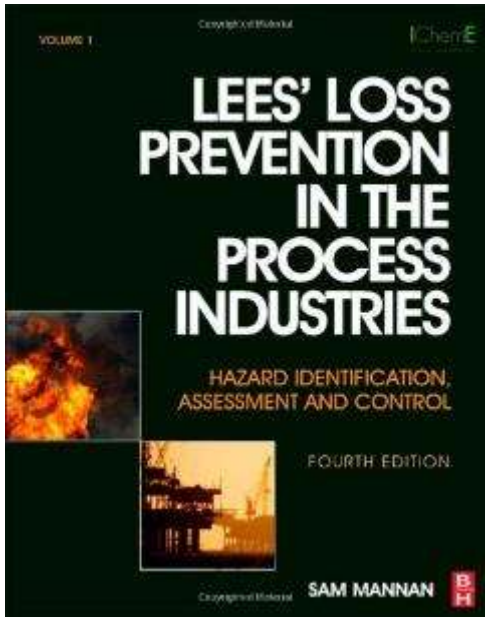
- **PSM Management Systems**
  - Guidance on how to evaluate fire hazards
  - Guidance on selection of appropriate controls
  - Training on fundamentals of applying these principles and practices
  - Resources such as RAGAGEP
- **All PSM Elements Have Relevance**
  - PHA
  - MOC
  - MI
  - Procedures
  - Training
  - Culture

Codes, Standards, Legislation, and Guidance

- There are many RAGAGEP available from numerous sources such as NFPA standards, CCPS, insurance guidance
- Has this body of knowledge been assimilated?







FPE & PSM Prevention and Mitigation Elements

- Process Design
- Passive vs. Active Control Systems
- Selection of Materials
- Layout and Spacing
- Control of Ignition Sources
- Housekeeping
- Incident Investigation
- Inherently Safer Design
- Fire Protection Equipment Maintenance and Inspection
- Management of Change
- Material Hazards Management
- Employee Training
- Alarm and Surveillance
- Emergency Planning, Drills and Exercises, and Response
- Audit Program

Recommendations

- Emphasize this issue, identify gaps and research needs and opportunities, focus on risk-based solutions, and begin a new level of collaboration with fire protection engineering specialists and researchers
- Some ideas –
  - Additional guidance on how to integrate PSM and fire protection engineering
  - Practical tools for fire and explosion hazards analysis and consequence estimation during PHAs
  - Guidance on fire and explosion prevention in design
  - Training on loss prevention and fire protection principles
  - Research on key issues of common interest
  - Seminars on the topics

Questions?