

Process Safety Management at LNG Plants

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Topics

- Explain the value proposition and framework for Process Safety Management (PSM)
- Explain the history of PSM development and regulations in US from 1984 to present day
- Describe industry best practice introduced in 2007
- Describe proposed OSHA changes and issues for future regulations

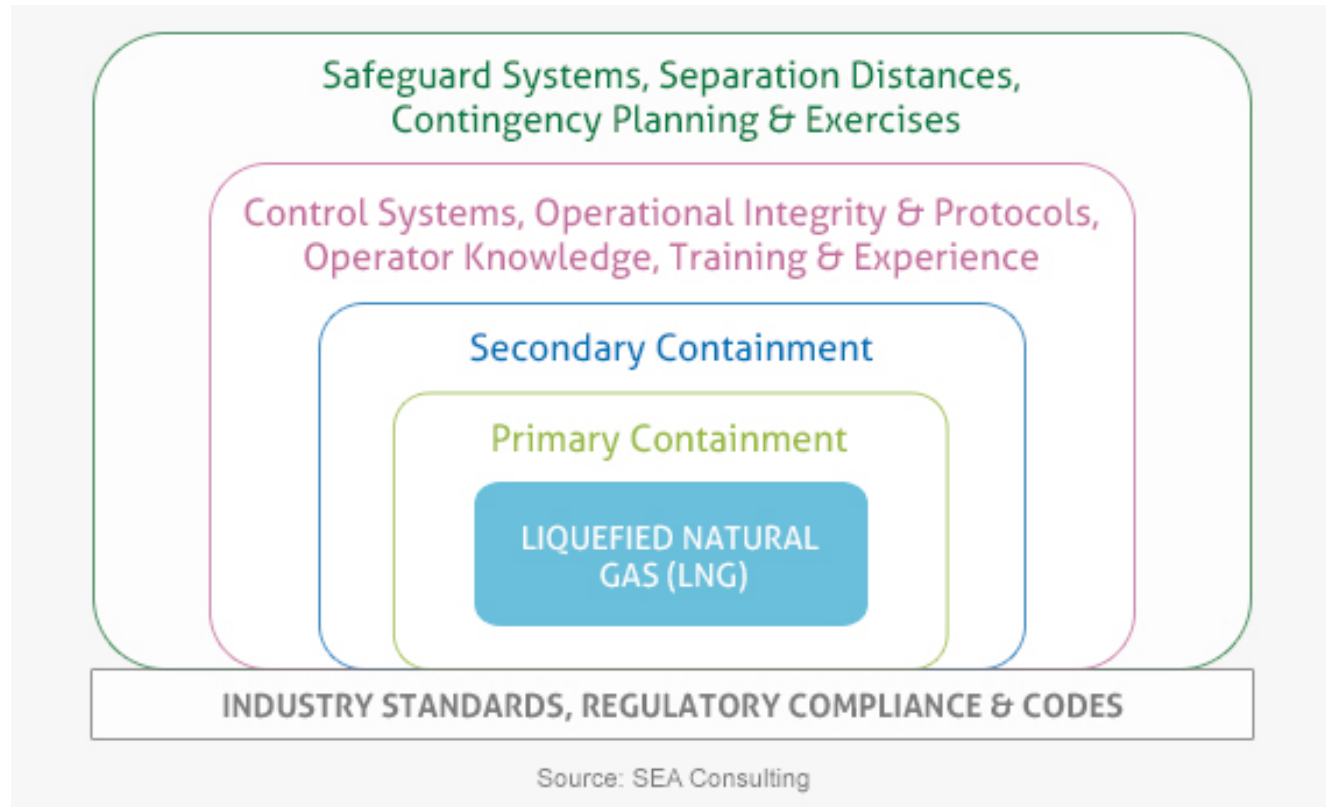
Management of Process Hazards

- The handling, storing, or processing of hazardous chemicals must be managed in a structured, risk-based management system.
- This is recognized to be:
 - Global best practice in the process industries
 - Socially responsible to protect lives, property, the environment, and the world's economies
 - Multi-element, comprehensive, continuous improvement process
 - Good business practice and beneficial to all
- The LNG industry has been most successful in managing LNG safety using a combination of conservative industry practices and regulations that exceed most other similar industry or regulatory models.

Fundamentals of a Strong Process Safety Management System

- Leadership commitment from very top including the Corporate Board
- Stakeholder engagement
- Inclusion of key management systems elements
- Setting of goals and reviewing of process safety performance
- Incorporating safety into major management decisions as a critical criterion
- Employee empowerment and training
- Resource availability and commitment
- Positive safety culture

Traditional LNG Safety Concepts



[GIIGNL Information Paper No. 7](#)

Managing Process Safety

Process Safety Management Application of management systems to the identification, understanding, and control of process hazards to prevent process-related incidents and injuries.



Process Safety Management Systems PSM Systems are comprehensive sets of policies, procedures, and practices designed to ensure that barriers to episodic incidents are in place, in use, and effective.

Regulatory Responses to Bhopal India and Other Incidents

Clean Air Act Amendments of 1990

- OSHA Process Safety Management Regulations – (29 CFR 1910.119) concerned with accident prevention in the workplace (www.osha.gov)
- EPA Risk Management Program Regulations (40 CFR Part 68) - concerned with accident prevention to protect the public and environment (www.epa.gov/swercepp)
- The Amendments also established the independent U.S. Chemical Safety and Hazard Investigation Board (42 U.S.C. 7412) (www.csb.gov)

Two Noteworthy US Regulations

- Process Safety Management of Highly Hazardous Chemicals (OSHA, 1992)
 - general requirements for managing hazardous substances; with focus to protect on-site people
 - 14 major sections: process safety information, process hazard analysis, management of change, audits, employee participation, etc.
- Risk Management Plan (EPA, 1996)
 - aimed at decreasing number & magnitude of accidental releases of toxic & flammable substances, with focus to protect off-site people & environment
 - applicable to facilities producing greater than a threshold amount of hazardous substances
 - 4 major elements: hazard assessment, prevention program, emergency response & handling and sharing of this information

Regulatory Responses

- In addition to this federal activity, several states created Risk Management Program analogs that predated the promulgation of federal RMP regulations. For example:
 - New Jersey, Toxic Catastrophe Prevention Act (TCPA), 1986
 - California, Risk Management and Prevention Program Regulations (RMPP), 1988
 - Delaware, Extremely Hazardous Substances Risk Management Act, 1989
 - Nevada, Chemical Catastrophe Prevention Act, 1991

Industry Guidelines and Groups with PSM Emphasis

- American Institute of Chemical Engineers (AIChE) established Center for Chemical Process Safety (CCPS) 1985 (www.aiche.org/ccps)
 - CCPS Process Safety Guidelines may be considered as RAGAGEP by OSHA
- Chemical Manufacturers Association's (CMA) established Responsible Care[®] (1988) Program [now American Chemistry Council (ACC)] – voluntary program for PSM, security, environmental, value chain
- American Petroleum Institute (API) Recommended Practice (RP) 750 - Management of Process Hazards (www.api.org) and other RAGAGEP
- Texas A&M University established Mary K O'Connor Process Safety Center (<http://process-safety.tamu.edu/>)
- Other trade associations (SOCMA, IIAR, etc.)

OSHA PSM Regulations

Who Must Comply?

- A process which involves a chemical at or above the specified threshold quantities listed in Appendix A to this section;
- A process which involves a Category 1 flammable gas (as defined in 1910.1200(c)) or a flammable liquid with a flashpoint below 100 °F (37.8 °C) on site in one location, in a quantity of 10,000 pounds (4535.9 kg) or more except for:
 - Hydrocarbon fuels used solely for workplace consumption as a fuel (e.g., propane used for comfort heating, gasoline for vehicle refueling), if such fuels are not a part of a process containing another highly hazardous chemical covered by this standard;
 - Flammable liquids with a flashpoint below 100 °F (37.8 °C) stored in atmospheric tanks or transferred which are kept below their normal boiling point without benefit of chilling or refrigeration.

OSHA PSM Regulations

- Threshold quantities of toxic and reactive highly hazardous chemicals
 - Standard Number: 1910.119 App A
 - CAS Number: CAS Registry Number, also referred to as CASRN or CAS Number, is a unique numerical identifier assigned by Chemical Abstracts Service (CAS) to every chemical substance described in the open scientific literature

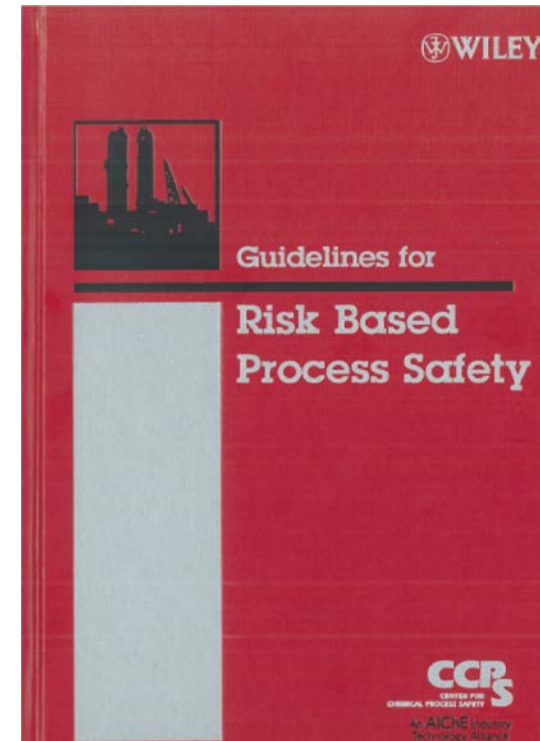
OSHA PSM Elements

14-element Management System

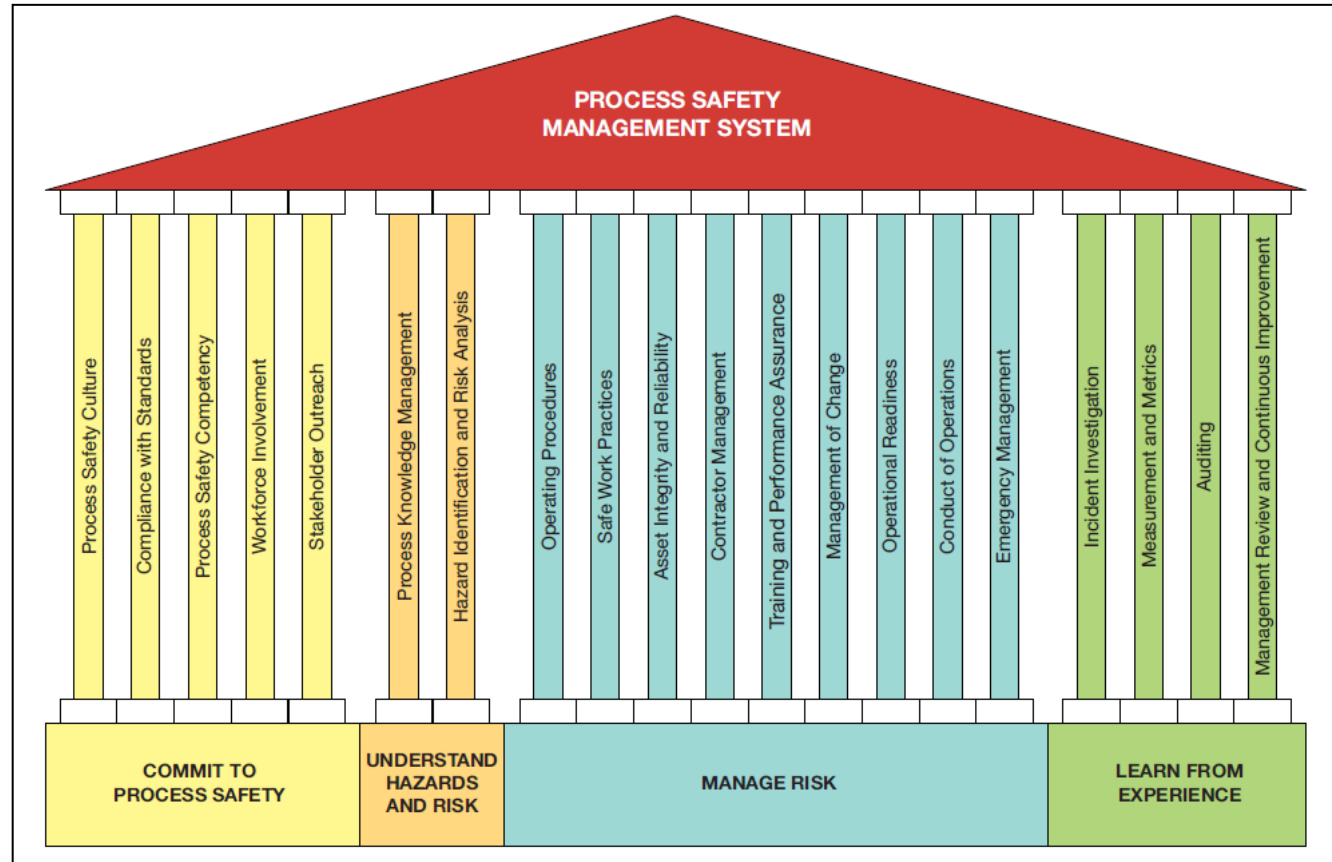
Employee Participation	Mechanical Integrity
Process Safety Information	Hot Work Permit
Process Hazard Analysis	Management of Change
Operating Procedures	Incident Investigation
Training	Emergency Planning and Response
Contractors	Compliance Audits
Pre- startup Safety Review	Trade Secrets

Risk-Based Process Safety Management (2007)

- AIChE CCPS www.aiche.org/ccps
RBPS Program Elements
- Built on Four Underlying Accident Prevention Pillars
 - Commit to Process Safety
 - Understand Hazards and Risk
 - Manage Risk
 - Learn from Experience
- These Pillars are Supported by 20 Elements



AICHE CCPS Risk Based Process Safety Management System Elements (2007)



PSM Elements

(US OSHA 1992 vs CCPS RBPS 2007)

USA OSHA PSM – 1992 14 Elements	CCPS RBPS - 2007 20 Elements	
Employee Participation	Management Commitment	Asset Integrity and Reliability
Process Safety Information	Process Safety Culture	Contractor Management
Process Hazard Analysis	Compliance With Standards	Training and Performance Assurance
Operating Procedures	Process Safety Competency	Management of Change
Training	Workforce Involvement	Operational Readiness
Contractors	Stakeholder Outreach	Conduct of Operations
Pre- startup Safety Review	Process Knowledge Management	Goals, Objectives and Plans
Mechanical Integrity	Hazard Identification and Risk Assessment	Emergency Management
Hot Work Permit	Operating Procedures	Incident Investigation
Management of Change	Safe Work Practices	Measurement and Metrics
Incident Investigation	Auditing	Management Review and Continuous Improvement
Emergency Planning and Response		
Compliance Audits		
Trade Secrets		

Similarities and Differences Between 49 CFR Part 193 and 29 CFR 1910.119 Requirements

49 CFR Part 193	29 CFR 1910.119
Primarily a specification for safety	Performance standard
Engineering design, operations, maintenance standard	Management systems standard for design and operation
Concept of thermal and vapor dispersion exclusion zones	Risk based, with no specified consequence criteria
Requires specific rule-based design releases to be modeled by specified consequence models using required assumptions	Consequence modeling is not required
100% of plans are submitted and reviewed	No plans are reviewed except during selected inspections
Requirements are specific to LNG facilities	Requirements broadly apply to any flammable or specifically named toxic highly hazardous chemicals handled about a threshold quantity
Requirements are applicable if facility either receives from or delivers to a 49 CFR Part 192 pipeline with some exceptions	Exempts facilities covered by Part 193 but also has different exemptions than those of Part 193

Key Differences Between 49 CFR Part 193 and 29 CFR 1910.119 Requirements

29 CFR 1910.119	
Management of Change	Any change to process safety information
Process Hazards Analysis	Specific methods and frequency of analysis and revalidation
Employee Participation	Expectation of employee involvement
Compliance Audits	Tri-annual self audits but not 100% inspections
Mechanical Integrity - RAGAGEP	Expectation of evaluating and adopting all relevant standards and engineering practices
Contractors	Responsibility for managing contractor safety
PSSR	Pre-startup safety reviews required after all changes

Similarities and Differences Between 49 CFR Part 193 and 29 CFR 1910.119 Requirements

49 CFR Part 193	29 CFR 1910.119
<p>§193.2119 Records - Each operator shall keep a record of all materials for components, buildings, foundations, and support systems, as necessary to verify that material properties meet the requirements of this part. These records must be maintained for the life of the item concerned.</p>	<p>(d) Process safety information. In accordance with the schedule set forth in paragraph (e)(1) of this section, the employer shall complete a compilation of written process safety information before conducting any process hazard analysis required by the standard. The compilation of written process safety information is to enable the employer and the employees involved in operating the process to identify and understand the hazards posed by those processes involving highly hazardous chemicals. This process safety information shall include information pertaining to the hazards of the highly hazardous chemicals used or produced by the process, information pertaining to the technology of the process, and information pertaining to the equipment in the process.</p>

Similarities and Differences Between 49 CFR Part 193 and 29 CFR 1910.119 Requirements

49 CFR Part 193	29 CFR 1910.119
<p>§193.2303 Construction acceptance - No person may place in service any component until it passes all applicable inspections and tests prescribed by this subpart and NFPA 59A (incorporated by reference, see §193.2013).</p>	<p>(i) Pre-startup safety review.</p> <p>(1) The employer shall perform a pre-startup safety review for new facilities and for modified facilities when the modification is significant enough to require a change in the process safety information.</p> <p>(2) The pre-startup safety review shall confirm that prior to the introduction of highly hazardous chemicals to a process:</p> <ul style="list-style-type: none"> (i) Construction and equipment is in accordance with design specifications; (ii) Safety, operating, maintenance, and emergency procedures are in place and are adequate; (iii) For new facilities, a process hazard analysis has been performed and recommendations have been resolved or implemented before startup; and modified facilities meet the requirements contained in management of change, paragraph (I). (iv) Training of each employee involved in operating a process has been completed.

Similarities and Differences Between 49 CFR Part 193 and 29 CFR 1910.119 Requirements

49 CFR Part 193	29 CFR 1910.119
<p>§193.2503 Operating procedures.</p> <p>Each operator shall follow one or more manuals of written procedures to provide safety in normal operation and in responding to an abnormal operation that would affect safety. The procedures must include provisions for:</p> <ul style="list-style-type: none"> (a) Monitoring components or buildings according to the requirements of §193.2507. (b) Startup and shutdown, including for initial startup, performance testing to demonstrate that components will operate satisfactory in service. (c) Recognizing abnormal operating conditions. (d) Purging and inserting components according to the requirements of §193.2517. (e) In the case of vaporization, maintaining the vaporization rate, temperature and pressure so that the resultant gas is within limits established for the vaporizer and the downstream piping.... 	<p>(f) Operating procedures (1) The employer shall develop and implement written operating procedures that provide clear instructions for safely conducting activities involved in each covered process consistent with the process safety information and shall address at least the following elements.</p> <ul style="list-style-type: none"> (i) Steps for each operating phase: <ul style="list-style-type: none"> (A) Initial startup; (B) Normal operations; (C) Temporary operations; (D) Emergency shutdown including the conditions under which emergency shutdown is required, and the assignment of shutdown responsibility to qualified operators to ensure that emergency shutdown is executed in a safe and timely manner. (E) Emergency Operations; (F) Normal shutdown; and, (G) Startup following a turnaround, or after an emergency shutdown. (ii) Operating limits: <ul style="list-style-type: none"> (A) Consequences of deviation; and (B) Steps required to correct or avoid deviation...

Similarities and Differences Between 49 CFR Part 193 and 29 CFR 1910.119 Requirements

49 CFR Part 193	29 CFR 1910.119
<p>§193.2509 Emergency procedures.</p> <p>(a) Each operator shall determine the types and places of emergencies other than fires that may reasonably be expected to occur at an LNG plant due to operating malfunctions, structural collapse, personnel error, forces of nature, and activities adjacent to the plant.</p> <p>(b) To adequately handle each type of emergency identified under paragraph (a) of this section and each fire emergency, each operator shall follow one or more manuals of written procedures. The procedures must provide for the following:</p> <p>(1) Responding to controllable emergencies, including notifying personnel and using equipment appropriate for handling the emergency.</p> <p>(2) Recognizing an uncontrollable emergency and taking action to minimize harm to the public and personnel, including prompt notification of appropriate local officials of the emergency and possible need for evacuation of the public in the vicinity of the LNG plant.</p>	<p>(n) Emergency planning and response. The employer shall establish and implement an emergency action plan for the entire plant in accordance with the provisions of 29 CFR 1910.38. In addition, the emergency action plan shall include procedures for handling small releases. Employers covered under this standard may also be subject to the hazardous waste and emergency response provisions contained in 29 CFR 1910.120 (a), (p) and (q).</p>

Similarities and Differences Between 49 CFR Part 193 and 29 CFR 1910.119 Requirements

49 CFR Part 193	29 CFR 1910.119
<p>§193.2509 Emergency procedures.</p> <p>(3) Coordinating with appropriate local officials in preparation of an emergency evacuation plan, which sets forth the steps required to protect the public in the event of an emergency, including catastrophic failure of an LNG storage tank.</p> <p>(4) Cooperating with appropriate local officials in evacuations and emergencies requiring mutual assistance and keeping these officials advised of:</p> <ul style="list-style-type: none"> (i) The LNG plant fire control equipment, its location, and quantity of units located throughout the plant; (ii) Potential hazards at the plant, including fires; (iii) Communication and emergency control capabilities at the LNG plant; and, (iv) The status of each emergency. <p>[Amdt. 193-2, 45 FR 70390, Oct. 23, 1980; as amended by Amdt. 193-18, 69 FR 11330, March 10, 2004]</p>	<p>(n) Emergency planning and response. The employer shall establish and implement an emergency action plan for the entire plant in accordance with the provisions of 29 CFR 1910.38. In addition, the emergency action plan shall include procedures for handling small releases. Employers covered under this standard may also be subject to the hazardous waste and emergency response provisions contained in 29 CFR 1910.120 (a), (p) and (q).</p>

Introduction

- The PSM Standard 29 CFR 1910.119 was adopted by OSHA on May 26, 1992, and has remained unchanged since then.
- On August 1, 2013 the president signed Executive Order 13650 ordering the relevant agencies of the federal government to improve the safety and security of the chemical industry in the U.S. as a result of the catastrophic incident involving an ammonium nitrate explosion at a fertilizer distribution facility in West, Texas, in April 2013.
- The EO has served as a catalyst for OSHA to suggest a number of issues that they have been evaluating for awhile for possible revision to the PSM Standard.
- On November 9, 2013 OSHA submitted a draft Advanced Notice of Proposed Rulemaking (ANPR) to OMB for revising the PSM Standard - has not appeared in FR yet. On December 3, 2013, OSHA published a Request for Information (RFI) soliciting comments on 17 areas of possible revision to the PSM Standard.
- This is the most important development in PSM since the inception of the Standard and has wide ranging ramifications to industry.

1. Expanding PSM Coverage and Requirements for Reactivity Hazards

- The CSB has recommended to OSHA several times that the applicability of the PSM Standard be expanded to include additional reactive chemicals and materials that are stable under normal circumstances but may become unstable when mixed with other chemicals, water, or air.
- OSHA has also received several petitions requesting that the PSM Standard be revised to include reactive chemical hazards.
- In 2004, New Jersey's Toxic Catastrophe Prevention Act (TCPA) regulations were amended to include a wide list of such chemicals and associated functional groups based on their properties (e.g., heat of reaction) and other factors, including the use of mixture groups of various reactive materials. The RFI specifically refers to New Jersey's TCPA experience in this area.

2. Updating the List of Highly Hazardous Chemicals in Appendix A of the PSM Standard

- The original PSM Standard Appendix A list of toxic and reactive chemicals was derived from a number of domestic and international public and private sources, including New Jersey's TCPA, Delaware EHS regulation, the EU, the UK COMAH regulations, the World Bank list, and others.
- In the RFI, OSHA is soliciting comments on what other chemicals should be added to Appendix A, as well as comments on how Appendix A should be periodically revised to keep pace with incident investigations, new technology, new research on properties or materials, etc.
- We expect that this will be adopted and that certain chemicals otherwise exempt but involved in recent catastrophic incidents (e.g., ammonium nitrate) will be included as well as this will trigger a more frequent review and addition to or modification of Appendix A of the Standard.

3. Revising the PSM Standard to Require Additional Management System Elements

- OSHA desires to add management system elements that would ‘modernize’ the scope of PSM.
- OSHA references the CCPS *Risk Based Process Safety* book (2007) which includes elements such as Conduct of Operations, PSM Metrics and performing periodic Management Reviews of PSM programs.
- OSHA notes that the Bureau of Safety and Environmental Enforcement (BSEE) has included additional management systems elements in the offshore Safety and Environmental Management System (SEMS) regulation, such as Stop Work Authority and Ultimate Work Authority.
- If adopted this possible change to the PSM Standard would expand the number of PSM elements and the number and type of facility activities that would be formally included in a PSM program.
- This would make the PSM Standard more in agreement with a current industry consensus PSM model, and would also align PSM programs Plan-Do-Check-Act model of management systems.

4. Amending PSI Element to Require Evaluation of Updates to Applicable RAGAGEPs

- Currently, the PSI element - (d)(3)(iii) - includes a requirement that “For existing equipment designed and constructed in accordance with codes, standards, or practices that are no longer in general use, the employer shall determine and document that the equipment is designed, maintained, inspected, tested, and operating in a safe manner.”
- OSHA has clarified this requirement to mean that changes to relevant RAGAGEPs be monitored by PSM covered facilities, and when equipment modifications are required as a result of those changes, that they be made accordingly.

5. Clarifying the PSM Standard by Adding a Definition for RAGAGEP

- The term RAGAGEP is used in both the PSI and MI elements.
- These usages invoke broad requirements that RAGAGEPs be followed and their use documented in:
 - the design and construction of PSM facilities
 - the testing and inspection of PSM covered process and equipment.
- The PSM Standard does not include a definition of this crucially important term.
- Another important related issue addressed in the RFI is whether internal standards can be used when industry consensus RAGAGEPs are not available.

5. Clarifying the PSM Standard by Adding a Definition for RAGAGEP (cont'd)

- In the RFI, OSHA references the definition of RAGAGEP offered in the CCPS book *Guidelines on Mechanical Integrity Systems* (2006):
“Simply stated, RAGAGEPs are engineering, operating, or maintenance performance expectations based on an established law, regulation, code, standard, or recommended practice (or a document of a similar name). They describe in detail the best way to perform a specific engineering or maintenance task, such as fabricating a pressure vessel or servicing relief valves. Many of these documents were developed after obtaining broad industry and expert public technical input, and many were accepted by consensus of industry and technical organizations...”
- The current general meaning of the term RAGAGEP is limited to the Codes, Standards, and other documents published and maintained by Standards Developing Organizations, e.g., ASME, ANSI, API, NFPA, etc.
- In the NEP inspection checklist OSHA has treated CCPS Guidelines books as RAGAGEPs.

6. Expanding the Scope of MI Element to Cover Any Safety-Critical Equipment

- The MI element currently requires that six types of equipment be included in the Mechanical Integrity program.
- This list of equipment does not explicitly include several types of equipment that are critical to process safety, including:
 - fire protection equipment
 - testing equipment (e.g., calibrators, digital voltmeters, test pressure gages, etc.)
 - structural components that support the weight or movement of fixed or rotating equipment (e.g., pipe supports, foundations, structural supports, etc.)
 - **critical utilities** whose failure could contribute to or are safeguards against a release of PSM-covered materials (e.g., electrical power, cooling water, air, etc.)
 - other equipment that is important to process safety.
- The RFI did not offer any specific examples, or a definition of “critical.”

7. Clarifying MOC Element to Include Management of Organizational Changes

- A number of companies and facilities in the PSM community have taken the initiative on their own to expand their MOC program to include management of organizational change (MOOC).
- The original intent of the MOC element in the PSM Standard did not include or contemplate organizational changes.
- OSHA's current interpretation of the PSM Standard MOC provisions is that if changes to personnel, budgets, etc., can affect process safety then they should be covered by MOC.
- Accordingly, OSHA is soliciting comments on whether the MOC element of the PSM Standard should be revised to include MOOC.

8. Revising ERP Element to Require Coordination of Emergency Planning with Local Emergency Response Authorities

- The emergency response element of the PSM Standard only addresses onsite emergency action and response activities, which is consistent with OSHA's charter to regulate worker safety and health.
- If offsite responders do not have sufficient or accurate information regarding the hazards present onsite, they are at greater risk when trying to respond to onsite emergencies, as demonstrated in the West, TX incident.
- OSHA is soliciting opinions on whether the PSM Standard should be revised to require facility coordination with local offsite emergency responders.
- If adopted this possible change to the PSM Standard would bring it more in line with the requirements of EPA's RMP Rule (40 CFR 68).

9. Revising Audit Element to Require Third-Party Compliance Audits

- The PSM Standard requires triennial audits of PSM programs.
- There are no stipulations regarding who should perform the audits, their qualifications, or their independence from the facility or PSM program being audited.
- OSHA notes that the CSB identified flawed internal PSM audits as a contributor to the BP Texas City incident .
- OSHA also notes that the SEMS regulation has been amended by BSEE to require third-party audits of SEMS programs by COS-accredited auditors.
- OSHA is soliciting comments on whether this type of requirement should be included in the PSM Standard, as well as comments on the frequency of PSM audits, which are currently required at least every three years.

10. Changing Enforcement Policy of the PSM Exemption for Retail Facilities

- In the PSM Standard OSHA exempted retail facilities, but did not define “retail.”
- OSHA’s intent was to exempt facilities that sell small containers of PSM-covered materials to the public.
- OSHA has also clarified the Standard stating that a facility that is primarily engaged in selling anhydrous ammonia product to farmers (a wholesale operation under the NAICS definition) could qualify for the retail exemption because the farmers were the "end users" of the product.
- Applying the retail facility exemption in this way is inconsistent with the normal meaning of "retail" and the preamble's explanation of the purpose of the exemption.

10. Changing Enforcement Policy of the PSM Exemption for Retail Facilities (cont'd)

- As stated in the preamble, OSHA chose to exclude retail facilities from PSM coverage because the limited container, package, or allotment sizes of the chemicals typically found at these facilities do not present the same safety hazards as those encountered at establishments working with large, bulk quantities of materials.
- As a result of increased workplace hazards associated with large, bulk quantities of highly hazardous chemicals, OSHA believes that only retail trade facilities listed in NAICS sectors 44 and 45 that sell highly hazardous chemicals in small containers, packages, or allotments to the general public qualify for the retail facilities exemption.

11. Changing Enforcement Policy for Appendix A HHCs Without Specific Concentrations

- In the Compliance Directive for PSM (CPL 02-02-045, formerly CPL 2-2.45A Ch-1) in 1994, OSHA used the maximum commercial grade of Appendix A chemicals to invoke PSM coverage if the Standard itself did not specify a concentration to be used (the Standard specifies concentrations for 11 chemicals).
- OSHA believes the use of the maximum commercial grade may not in all cases provide a sufficient threshold for determining PSM coverage, as revealed in CSB's investigations.

11. Changing Enforcement Policy for Appendix A HHCs Without Specific Concentrations (cont'd)

- OSHA is soliciting comments on whether it should adopt the EPA's mixture rule policy for RMP listed substances as a simpler and more practical approach to addressing hazards associated with Appendix A chemicals that do not have listed concentrations.
- Using the same mixture rules as in the RMP Rule, OSHA would consider a PSM-listed chemical in a mixture to be covered if the concentration of the chemical was greater than one percent and the calculated weight of the chemical in the mixture was greater than the threshold quantity.

Issues & Elements Not Explicitly Addressed in the RFI

- Inherently Safer Technologies (IST included in Section of EO 13560)
- PHA
- Contractors
- SOPs
- Training

About the Presenter

David Moore is the President and CEO of the AcuTech Consulting Group, a risk management consulting firm based in Vienna, Virginia, USA, and founded in 1994 (www.acutech-consulting.com). AcuTech has been actively engaged in chemical safety and security consulting since 1987.

Mr. Moore has over 35 years of experience in chemical safety and security management and is a recognized expert in and frequent speaker on these topics. He has provided risk consulting services and training to industrial companies worldwide, including at petroleum refineries, chemical plants, gas plants, pipelines, pharmaceuticals, defense, biotech, and manufacturing plants. Mr. Moore has taught process safety and security courses to many of the world's largest corporations and the US Government.

Mr. Moore was formerly a Senior Engineer with Mobil Corporation and a Fire Protection Engineer with the National Fire Protection Association . Mr. Moore is a Registered Professional Engineer. He has an MBA, (NYU 1987), and a B.Sc., Fire Protection Engineering (University of Md. 1979).

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