Process Safety Management

8-Hour Course

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- History of Process Safety
- Application, Exemptions
- Key Definitions

- Employee participation

- Process safety information
    - Hazards of the HHC in the process
    - Technology of the process
    - Equipment in the process

- PHAs
    - Methodologies & Team
    - Management System, Communications
    - PHA Revalidation and Retention

- Operating Procedures
    - Steps for each operating phase
    - Operating limits, Consequences of deviation, Steps required to correct / avoid
    - Safety and Health considerations
    - Quality control for raw materials and control of inventory levels
    - Special or unique hazards
    - Safety systems and their functions
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- Safe work practices (LOTO, PRCS, LB, Controlled Access, etc.)

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    - New & Modified facilities

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- Hot work permit
    - Scope & 1910.252(a)

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- Emergency planning and response
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    - Hazardous waste and emergency response provisions contained in 29 CFR 1910.120 (q)

- Compliance Audits
    - Frequency
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    - Report, Follow-up, Documentation
    - Retain the two (2) most recent compliance audit reports

- Trade secrets

- EPA's Risk Management (Propane and Anhydrous Ammonia)

- OSHA & EPA Resources

The PSM Standard Is a Performance-based Standard

- Performance-based Standards
  - The PSM Standard is a performance-based standard.
  - That means it is goal-oriented and what you should judge is a program's effectiveness.
  - The specifications are not spelled out, just the desired results.
  - The PSM Standard gives each facility flexibility to design its own program to match its needs, as long as the outcome prevents or minimizes spills, fires and explosions.
- Specification-based Standards
  - Some OSHA standards are specification-based standards.
  - That means they give exact rules for compliance such as height of a guard rail, lengths of pipe, exact limits of exposure, etc.

Another way to understand the accident prevention requirement of a performance standard is to think in terms of our five senses. We can look and listen for hazards; we can feel for vibrations and smell for leaks; and, at times, we may even be alerted by our sense of taste. But the most important sense we bring to the job is our work experience — in other words, our horse sense.

The major objective of process safety management of highly hazardous chemicals is to prevent unwanted releases of hazardous chemicals especially into locations which could expose employees and others to serious hazards. An effective process safety management program requires a systematic approach to evaluating the whole process. Using this approach the process design, process technology, operational and maintenance activities and procedures, nonroutine activities and procedures, emergency preparedness plans and procedures, training programs, and other elements which impact the process are all considered in the evaluation. The various lines of defense that have been incorporated into the design and operation of the process to prevent or mitigate the release of hazardous chemicals need to be evaluated and strengthened to assure their effectiveness at each level. Process safety management is the proactive identification, evaluation and mitigation or prevention of chemical releases that could occur as a result of failures in process, procedures or equipment.

The process safety management standard targets highly hazardous chemicals that have the potential to cause a catastrophic incident. This standard as a whole is to aid employers in their efforts to prevent or mitigate episodic chemical releases that could lead to a catastrophe in the workplace and possibly to the surrounding community. To control these types of hazards, employers need to develop the necessary expertise, experiences, judgment and proactive initiative within their workforce to properly implement and maintain an effective process safety management program as envisioned in the OSHA standard. This OSHA standard is required by the Clean Air Act Amendments as is the Environmental Protection Agency's Risk Management Plan. Employers, who merge the two sets of requirements into their process safety management program, will better assure full compliance with each as well as enhancing their relationship with the local community.

While OSHA believes process safety management will have a positive effect on the safety of employees in workplaces and also offers other potential benefits to employers (increased productivity), smaller businesses which may have limited resources available to them at this time, might consider alternative avenues of decreasing the risks associated with highly hazardous chemicals at their workplaces. One method which might be considered is the reduction in the inventory of the highly hazardous chemical. This reduction in inventory will result in a reduction of the risk or potential for a catastrophic incident. Also, employers including small employers may be able to establish more efficient inventory control by reducing the quantities of highly hazardous chemicals on site below the established threshold quantities. This reduction can be accomplished by ordering smaller shipments and maintaining the minimum inventory necessary for efficient and safe operation. When reduced inventory is not feasible, then the employer might consider dispersing inventory to several locations on site. Dispersing storage into locations where a release in one location will not cause a release in another location is a practical method to also reduce the risk or potential for catastrophic incidents.

OSHA's PSM Standard — The 14 Required Elements

The OSHA Process Safety Management Standard, 29 CFR 1910.119, enacted in 1992, is composed of 16 sections: Applications, Definitions and the 14 elements (c through p). These elements are listed below and are described in detail in this manual.

(a) Application

(b) Definitions

14 Required Elements

(c) Employee Participation

(d) Process Safety Information

(e) Process Hazard Analysis (PHA)

(f) Safe Operating Procedures

(g) Training

(h) Contractors

(i) Pre-startup Safety Review

(j) Mechanical Integrity

(k) Hot Work Permit

(l) Management of Change

(m) Incident Investigation

(n) Emergency Planning and Response

(o) Compliance Audits

(p) Trade Secrets

Application - Paragraph (a)

What is covered:

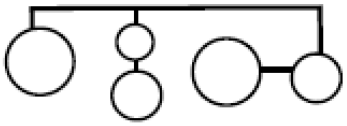
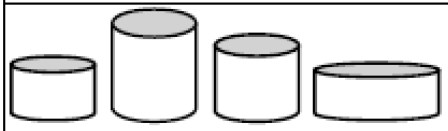
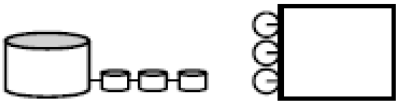
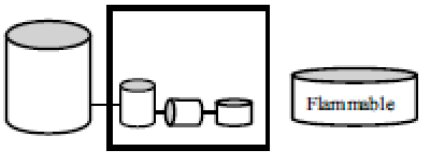
- A process that involves a chemical which is present at or above certain levels (see Appendix A); and
- A process which involves a Category 1 flammable gas (as defined in 1910.1200(c)) or a flammable liquid with a flashpoint below 100 °F (37.8 °C) on site in one location, in a quantity of 10,000 pounds (4535.9 kg) or more

Except:

1. 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 stored in atmospheric tanks below their boiling point, which don't need cooling (unless interconnected or involved in a process); and
2. 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's CRITERIA FOR FLAMMABLE GASES (1910.1200 Appendix B)	
Category	**Criteria**
1	Gases, which at 20°C (68°F) and a standard pressure of 101.3 kPa (14.7 psi): (a) are ignitable when in a mixture of 13% or less by volume in air; or (b) have a flammable range with air of at least 12 percentage points regardless of the lower flammable limit.
2	Gases, other than those of Category 1, which, at 20°C (68°F) and a standard pressure of 101.3 kPa (14.7 psi), have a flammable range while mixed in air.

PROCESS

Schematic Representation	Description	Interpretation
	1 vessel 1 regulated substance above TQ	1 process
	2 or more connected vessels *same* regulated substance above TQ	1 process
	2 or more connected vessels *different* regulated substance each above TQ	1 process
	pipeline feeding multiple vessels total above TQ	1 process
	2 or more vessels co-located *same* substance total above TQ	1 process
	2 or more vessels co-located *different* substances each above TQ	1 process
	2 vessels, located so they won't be involved in a single release *same or different* substances each above TQ	2 processes
	2 locations with regulated substances each above TQ	1 or 2 processes depending on distance
	1 series of interconnected vessels *same or different* substances above TQs *plus* a co-located storage vessel containing flammables	1 process

Definitions — Paragraph (b)

Atmospheric Tank means a storage tank which has been designed to operate at pressures from atmospheric through 0.5 p.s.i.g. (pounds per square inch gauge, 3.45 Kpa).

Boiling Point. The boiling point of a liquid at a pressure of 14.7 pounds per square inch absolute (p.s.i.a.) (7650 mm).

> For the purposes of this section, where an accurate boiling point is unavailable for the material in question, or for mixtures which do not have a constant boiling point, the 10 percent point of a distillation performed in accordance with the Standard Method of Test for Distillation of Petroleum Products, ASTM D-86-62, which is incorporated by reference as specified in Sec. 1910.6, may be used as the boiling point of the liquid.

Catastrophic Release means a major uncontrolled emission, fire or explosion involving one or more highly hazardous chemicals, that presents serious danger to employees in the workplace.

Facility means the buildings, containers or equipment which contain a process.

Highly Hazardous Chemical means a substance possessing toxic, reactive, flammable or explosive properties and specified by paragraph (a)(1) of this section.

Hot Work means work involving electric or gas welding, cutting, brazing or similar flame or spark-producing operations.

Normally Unoccupied Remote Facility means a facility which is operated, maintained or serviced by employees who visit the facility only periodically to check its operation and to perform necessary operating or maintenance tasks. No employees are permanently stationed at the facility. Facilities meeting this definition are not contiguous with, and must be geographically
remote from, all other buildings, processes or persons.

Process means any activity involving a highly hazardous chemical including any use, storage, manufacturing, handling or the onsite movement of such chemicals or combination of these activities. For purposes of this definition, any group of vessels which are interconnected and separate vessels which are located such that a highly hazardous chemical could be involved in a potential release shall be considered a single process.

Replacement in Kind means a replacement which satisfies the design specification.

Trade Secret means any confidential formula, pattern, process, device, information or compilation of information that is used in an employer's business and that gives the employer an opportunity to obtain an advantage over competitors who do not know or use it.

Employee Participation - Paragraph (c)

The intent of this paragraph is to require employers to involve employees at an elemental level of the PSM program. Minimum requirements for an Employee Participation Program for PMS must include a written plan of action for implementing employee consultation on the development of process hazard analyses and other elements of process hazard management contained within 1910.119. The employer must also provide ready access to all the information required to be developed under the standard.

Requirements:

- Employers shall develop a written plan of action regarding the implementation of the employee participation required by this paragraph.
- Employers shall consult with employees and their representatives on the conduct and development of process hazards analyses and on the development of the other elements of process safety management in this standard.
- Employers shall provide to employees and their representatives access to process hazard analyses and to all other information required to be developed under this standard.

Employee Involvement in Process Safety Management. Section 304 of the Clean Air Act Amendments states that employers are to consult with their employees and their representatives regarding the employers efforts in the development and implementation of the process safety management program elements and hazard assessments. Section 304 also requires employers to train and educate their employees and to inform affected employees of the findings from incident investigations required by the process safety management program. Many employers, under their safety and health programs, have already established means and methods to keep employees and their representatives informed about relevant safety and health issues and employers may be able to adapt these practices and procedures to meet their obligations under this standard. Employers who have not implemented an occupational safety and health program may wish to form a safety and health committee of employees and management representatives to help the employer meet the obligations specified by this standard. These committees can become a significant ally in helping the employer to implement and maintain an effective process safety management program for all employees. OSHA believes that employers must consult with employees and their representatives on the development and conduct of hazard assessments (OSHA's process hazard analyses) and consult with employees on the development of chemical accident prevention plans (the balance of the OSHA required elements in the process safety management standard). And, as prescribed by the CAAA, OSHA is requiring that all process hazard analyses and all other information required to be developed by this standard be available to employees and their representatives.

Therefore, as suggested by several rulemaking participants, OSHA has added language contained in the CAAA to the final rule in a new provision, paragraph (c). OSHA believes that this new provision, which requires broad and active employee participation in all elements of the process safety management program through consultation will enhance the overall program. OSHA also believes that the CAAA requirements demand that an employer carefully consider and structure the plant's approach to employee involvement in the process safety management program. Consequently, OSHA believes that it must require the employer to address this issue to ensure that the employer actively considers the appropriate method of employee participation in the implementation of the process safety management program at the workplace. Thus, OSHA has included a specific requirement that an employer develop a plan of action on how the employer is going to implement the employee participation requirements.

Paragraph (d) - Process Safety Information

The intent of this paragraph is to provide complete and accurate information concerning the process which is essential for an effective process safety management program and for conducting process hazard analyses. Therefore in accordance with the schedule set forth in paragraph (e)(1) the employer is required to compile written process safety information on process chemicals, process technology, and process equipment before conducting any process hazard analysis. 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**.

Information pertaining to the hazards of the highly hazardous chemicals in the process shall consist of at least the following:

- Toxicity information;
- Permissible exposure limits;
- Physical data;
- Reactivity data;
- Corrosivity data;
- Thermal and chemical stability data; and
- Hazardous effects of inadvertent mixing of different materials that could foreseeably occur.

Note: Safety data sheets meeting the requirements of 29 CFR 1910.1200(g) may be used to comply with this requirement to the extent they contain the information required by this subparagraph.

Information concerning the technology of the process shall include at least the following:

- A block flow diagram or simplified process flow diagram (see Appendix B to this section);
- Process chemistry;
- Maximum intended inventory;
- Safe upper and lower limits for such items as temperatures, pressures, flows or compositions; and,
- An evaluation of the consequences of deviations, including those affecting the safety and health of employees.
- Where the original technical information no longer exists, such information may be developed in conjunction with the process hazard analysis in sufficient detail to support the analysis.

Information pertaining to the equipment in the process shall include:

- Materials of construction;
- Piping and instrument diagrams (P&ID's);
- Electrical classification;
- Relief system design and design basis;
- Ventilation system design;
- Design codes and standards employed;
- Material and energy balances for processes built after May 26, 1992; and,
- Safety systems (e.g. interlocks, detection or suppression systems).

The employer shall document that equipment complies with recognized and generally accepted good engineering practices.

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.

Complete and accurate written information concerning process chemicals, process technology, and process equipment is essential to an effective process safety management program and to a process hazards analysis. The compiled information will be a necessary resource to a variety of users including the team that will perform the process hazards analysis as required under paragraph (e); those developing the training programs and the operating procedures; contractors whose employees will be working with the process; those conducting the pre-startup reviews; local emergency preparedness planners; and insurance and enforcement officials. The information to be compiled about the chemicals, including process intermediates, needs to be comprehensive enough for an accurate assessment of the fire and explosion characteristics, reactivity hazards, the safety and health hazards to workers, and the corrosion and erosion effects on the process equipment and monitoring tools. Current safety data sheet (SDS) information can be used to help meet this requirement which must be supplemented with process chemistry information including runaway reaction and over pressure hazards if applicable.

Process technology information will be a part of the process safety information package and it is expected that it will include diagrams of the type shown in Appendix B of this section as well as employer established criteria for maximum inventory levels for process chemicals; limits beyond which would be considered upset conditions; and a qualitative estimate of the consequences or results of deviation that could occur if operating beyond the established process limits. Employers are encouraged to use diagrams which will help users understand the process. A block flow diagram is used to show the major process equipment and interconnecting process flow lines and show flow rates, stream composition, temperatures, and pressures when necessary for clarity. The block flow diagram is a simplified diagram.

Process flow diagrams are more complex and will show all main flow streams including valves to enhance the understanding of the process, as well as pressures and temperatures on all feed and product lines within all major vessels, in and out of headers and heat exchangers, and points of pressure and temperature control. Also, materials of construction information, pump capacities and pressure heads, compressor horsepower and vessel design pressures and temperatures are shown when necessary for clarity. In addition, major components of control loops are usually shown along with key utilities on process flow diagrams.

Piping and instrument diagrams (P&Ids) may be the more appropriate type of diagrams to show some of the above details and to display the information for the piping designer and engineering staff. The P&IDs are to be used to describe the relationships between equipment and instrumentation as well as other relevant information that will enhance clarity. Computer software programs which do P&Ids or other diagrams useful to the information package, may be used to help meet this requirement.

The information pertaining to process equipment design must be documented. In other words, what were the codes and standards relied on to establish good engineering practice. These codes and standards are published by such organizations as the American Society of Mechanical Engineers, American Petroleum Institute, American National Standards Institute, National Fire Protection Association, American Society for Testing and Materials, National Board of Boiler and Pressure Vessel Inspectors, National Association of Corrosion Engineers, American Society of Exchange Manufacturers Association, and model building code groups.

In addition, various engineering societies issue technical reports which impact process design. For example, the American Institute of Chemical Engineers has published technical reports on topics such as two phase flow for venting devices. This type of technically recognized report would constitute good engineering practice.

For existing equipment designed and constructed many years ago in accordance with the codes and standards available at that time and no longer in general use today, the employer must document which codes and standards were used and that the design and construction along with the testing, inspection and operation are still suitable for the intended use. Where the process technology requires a design which departs from the applicable codes and standards, the employer must document that the design and construction is suitable for the intended purpose.

Paragraph (e) - Process Hazard Analysis (PHA)

The intent of this paragraph is to require the employer to develop a thorough, orderly, systematic approach for identifying, evaluating and controlling processes involving highly hazardous chemicals. Minimum requirements include:

1. Setting a priority order and conducting analyses according to the required schedule;
2. Using an appropriate methodology to determine and evaluate the process hazards;
3. Addressing process hazards, previous incidents with catastrophic potential, engineering and administrative controls applicable to the hazards, consequences of failure of controls, facility siting, human factors, and a qualitative evaluation of possible safety and health effects of failure of controls on employees;
4. Performing PHA by a team with expertise in engineering and process operations, the process being evaluated, and the PHA methodology used;
5. Establishing a system to promptly address findings and recommendations, assure recommendations are resolved and documented, document action taken, develop a written schedule for completing actions, and communicate actions to operating, maintenance and other employees who work in the process or might be affected by actions;
6. Updating and revalidating PHA's at least every 5 years; and
7. Retaining PHA's and updates for the life of the process.

Process Hazard Analyses (PHAs), also called process hazard evaluations, use various methods to identify, evaluate and control the hazards involved in a process.

The employer shall perform an initial process hazard analysis (hazard evaluation) on processes covered by this standard.

The process hazard analysis shall be appropriate to the complexity of the process and shall identify, evaluate, and control the hazards involved in the process.

Employers shall determine and document the priority order for conducting process hazard analyses based on a rationale which includes such considerations as extent of the process hazards, number of potentially affected employees, age of the process, and operating history of the process.

The process hazard analysis shall be conducted as soon as possible, but not later than the following schedule:

- No less than 25 percent of the initial process hazards analyses shall be completed by May 26, 1994;
- No less than 50 percent of the initial process hazards analyses shall be completed by May 26, 1995;
- No less than 75 percent of the initial process hazards analyses shall be completed by May 26, 1996;
- All initial process hazards analyses shall be completed by May 26, 1997.

Process hazards analyses completed AFTER May 26, 1987 which meet the requirements of this paragraph are acceptable as initial process hazards analyses. These process hazard analyses shall be updated and revalidated, based on their completion date, in accordance with paragraph (e)(6) of this standard.

The employer shall use one or more of the following methodologies that are appropriate to determine and evaluate the hazards of the process being analyzed.

- What-If;
- Checklist;
- What-If/Checklist;
- Hazard and Operability Study (HAZOP);
- Failure Mode and Effects Analysis (FMEA);
- Fault Tree Analysis; or

- An appropriate equivalent methodology.

The process hazard analysis shall address:

- The hazards of the process;
- The identification of any previous incident which had a likely potential for catastrophic consequences in the workplace;
- Engineering and administrative controls applicable to the hazards and their interrelationships such as appropriate application of detection methodologies to provide early warning of releases.
    - (Acceptable detection methods might include process monitoring and control instrumentation with alarms, and detection hardware such as hydrocarbon sensors.);
- Consequences of failure of engineering and administrative controls;
- Facility siting;
- Human factors; and
- A qualitative evaluation of a range of the possible safety and health effects of failure of controls on employees in the workplace.

The process hazard analysis shall be performed by a team with expertise in engineering and process operations, and the team shall include at least one employee who has experience and knowledge specific to the process being evaluated.

Also, one member of the team must be knowledgeable in the specific process hazard analysis methodology being used.

The employer shall establish a system to

- promptly address the team's findings and recommendations;
- assure that the recommendations are resolved in a timely manner and that the resolution is documented;
- document what actions are to be taken;
- complete actions as soon as possible;
- develop a written schedule of when these actions are to be completed;
- communicate the actions to operating, maintenance and other employees whose work assignments are in the process and who may be affected by the recommendations or actions.

At least every five (5) years after the completion of the initial process hazard analysis, the process hazard analysis shall be updated and revalidated by a team meeting the requirements in paragraph (e)(4) of this section, to assure that the process hazard analysis is consistent with the current process.

Employers shall retain process hazards analyses and updates or revalidations for each process covered by this section, as well as the documented resolution of recommendations described in paragraph (e)(5) of this section for the life of the process.

The selection of a PHA methodology or technique will be influenced by many factors including the amount of existing knowledge about the process. Is it a process that has been operated for a long period of time with little or no innovation and extensive experience has been generated with its use? Or, is it a new process or one which has been changed frequently by the inclusion of innovative features? Also, the size and complexity of the process will influence the decision as to the appropriate PHA methodology to use. All PHA methodologies are subject to certain limitations. For example, the checklist methodology works well when the process is very stable and no changes are made, but it is not as effective when the process has undergone extensive change. The checklist may miss the most recent changes and consequently the changes would not be evaluated. Another limitation to be considered concerns the assumptions made by the team or analyst. The PHA is dependent on good judgment and the assumptions made during the study need to be documented and understood by the team and reviewer and kept for a future PHA.

The team conducting the PHA need to understand the methodology that is going to be used. A PHA team can vary in size from two people to a number of people with varied operational and technical backgrounds. Some team members may only be a part of the team for a limited time. The team leader needs to be fully knowledgeable in the proper implementation of the PHA methodology that is to be used and should be impartial in the evaluation. The other full or part time team members need to provide the team with expertise in areas such as process technology, process design, operating procedures and practices, including how the work is actually performed, alarms, emergency procedures, instrumentation, maintenance procedures, both routine and nonroutine tasks, including how the tasks are authorized, procurement of parts and supplies, safety and health, and any other relevant subject as the need dictates. At least one team member must be familiar with the process.

The ideal team will have an intimate knowledge of the standards, codes, specifications and regulations applicable to the process being studied. The selected team members need to be compatible and the team leader needs to be able to manage the team and the PHA study. The team needs to be able to work together while benefiting from the expertise of others on the team or outside the team, to resolve issues, and to forge a consensus on the findings of the study and the recommendations.

The application of a PHA to a process may involve the use of different methodologies for various parts of the process. For example, a process involving a series of unit operations of varying sizes, complexities, and ages may use different methodologies and team members for each operation. Then the conclusions can be integrated into one final study and evaluation. A more specific example is the use of a checklist PHA for a standard boiler or heat exchanger and the use of a Hazard and Operability PHA for the overall process. Also, for batch type processes like custom batch operations, a generic PHA of a representative batch may be used where there are only small changes of monomer or other ingredient ratios and the chemistry is documented for the full range and ratio of batch ingredients. Another process that might consider using a generic type of PHA is a gas plant. Often these plants are simply moved from site to site and therefore, a generic PHA may be used for these movable plants. Also, when an employer has several similar size gas plants and no sour gas is being processed at the site, then a generic PHA is feasible as long as the variations of the individual sites are accounted for in the PHA. Finally, when an employer has a large continuous process which has several control rooms for different portions of the process such as for a distillation tower and a blending operation, the employer may wish to do each segment separately and then integrate the final results.

Additionally, small businesses which are covered by this rule, will often have processes that have less storage volume, less capacity, and less complicated than processes at a large facility. Therefore, OSHA would anticipate that the less complex methodologies would be used to meet the process hazard analysis criteria in the standard. These process hazard analyses can be done in less time and with a few people being involved. A less complex process generally means that less data, P&IDs, and process information is needed to perform a process hazard analysis.

Many small businesses have processes that are not unique, such as cold storage lockers or water treatment facilities. Where employer associations have a number of members with such facilities, a generic PHA, evolved from a checklist or what-if questions, could be developed and used by each employer effectively to reflect his/her particular process; this would simplify compliance for them.

When the employer has a number of processes which require a PHA, the employer must set up a priority system of which PHAs to conduct first. A preliminary or gross hazard analysis may be useful in prioritizing the processes that the employer has determined are subject to coverage by the process safety management standard. Consideration should first be given to those processes with the potential of adversely affecting the largest number of employees. This prioritizing should consider the potential severity of a chemical release, the number of potentially affected employees, the operating history of the process such as the frequency of chemical releases, the age of the process and any other relevant factors. These factors would suggest a ranking order and would suggest either using a weighing factor system or a systematic ranking method. The use of a preliminary hazard analysis would assist an employer in determining which process should be of the highest priority and thereby the employer would obtain the greatest improvement in safety at the facility.

Detailed guidance on the content and application of process hazard analysis methodologies is available from the American Institute of Chemical Engineers' Center for Chemical Process Safety (see Appendix D).

Paragraph (f) - Safe Operating Procedures

The intent of this paragraph is to provide clear instruction for conducting activities involved in covered processes that are consistent with the process safety information. The operating procedures must address steps for each operating phase, operating limits, safety and health considerations, and safety systems and their functions.

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.

- Steps for each operating phase:
    - Initial startup;
    - Normal operations;
    - Temporary operations;
    - 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.
    - Emergency Operations;
    - Normal shutdown; and,
    - Startup following a turnaround, or after an emergency shutdown.
- Operating limits:
    - Consequences of deviation; and
    - Steps required to correct or avoid deviation.
- Safety and health considerations:
    - Properties of, and hazards presented by, the chemicals used in the process;
    - Precautions necessary to prevent exposure, including engineering controls, administrative controls, and personal protective equipment;
    - Control measures to be taken if physical contact or airborne exposure occurs;
    - Quality control for raw materials and control of hazardous chemical inventory levels; and,
    - Any special or unique hazards.
- Safety systems and their functions.

Operating procedures shall be readily accessible to employees who work in or maintain a process.

The operating procedures shall be reviewed as often as necessary to assure that they reflect current operating practice, including changes that result from changes in process chemicals, technology, and equipment, and changes to facilities. The employer shall certify annually that these operating procedures are current and accurate.

The employer shall develop and implement safe work practices to provide for the control of hazards during operations such as

- lockout/tagout;
- confined space entry;
- opening process equipment or piping; and
- control over entrance into a facility by maintenance, contractor, laboratory, or other support personnel.

These safe work practices shall apply to employees and contractor employees.

Operating procedures describe tasks to be performed, data to be recorded, operating conditions to be maintained, samples to be collected, and safety and health precautions to be taken. The procedures need to be technically accurate, understandable to employees, and revised periodically to ensure that they reflect current operations. The process safety information package is to be used as a resource to better assure that the operating procedures and practices are consistent with the known hazards of the chemicals in the process and that the operating parameters are accurate. Operating procedures should be reviewed by engineering staff and operating personnel to ensure that they are accurate and provide practical instructions on how to actually carry out job duties safely.

Operating procedures will include specific instructions or details on what steps are to be taken or followed in carrying out the stated procedures. These operating instructions for each procedure should include the applicable safety precautions and should contain appropriate information on safety implications. For example, the operating procedures addressing operating parameters will contain operating instructions about pressure limits, temperature ranges, flow rates, what to do when an upset condition occurs, what alarms and instruments are pertinent if an upset condition occurs, and other subjects. Another example of using operating instructions to properly implement operating procedures is in starting up or shutting down the process. In these cases, different parameters will be required from those of normal operation. These operating instructions need to clearly indicate the distinctions between startup and normal operations such as the appropriate allowances for heating up a unit to reach the normal operating parameters. Also the operating instructions need to describe the proper method for increasing the temperature of the unit until the normal operating temperature parameters are achieved.

Computerized process control systems add complexity to operating instructions. These operating instructions need to describe the logic of the software as well as the relationship between the equipment and the control system; otherwise, it may not be apparent to the operator.

Operating procedures and instructions are important for training operating personnel. The operating procedures are often viewed as the standard operating practices (SOPs) for operations. Control room personnel and operating staff, in general, need to have a full understanding of operating procedures. If workers are not fluent in English then procedures and instructions need to be prepared in a second language understood by the workers. In addition, operating procedures need to be changed when there is a change in the process as a result of the management of change procedures. The consequences of operating procedure changes need to be fully evaluated and the information conveyed to the personnel. For example, mechanical changes to the process made by the maintenance department (like changing a valve from steel to brass or other subtle changes) need to be evaluated to determine if operating procedures and practices also need to be changed. All management of change actions must be coordinated and integrated with current operating procedures and operating personnel must be oriented to the changes in procedures before the change is made. When the process is shutdown in order to make a change, then the operating procedures must be updated before startup of the process.

Training in how to handle upset conditions must be accomplished as well as what operating personnel are to do in emergencies such as when a pump seal fails or a pipeline ruptures. Communication between operating personnel and workers performing work within the process area, such as nonroutine tasks, also must be maintained. The hazards of the tasks are to be conveyed to operating personnel in accordance with established procedures and to those performing the actual tasks. When the work is completed, operating personnel should be informed to provide closure on the job.

Paragraph (g) - Training

The intent of this paragraph helps employees and contractor employees understand the nature and causes of problems arising from process operations, and increases employee awareness with respect to the hazards particular to a process. An effective training program significantly reduces the number and severity of incidents arising from process operations, and can be instrumental in preventing small problems from leading to a catastrophic release. Minimum requirements for an effective training program include: Initial Training, Refresher Training, and Documentation.

The PSM Standard has different training requirements for operators, maintenance workers and contractors. This element addresses operators.

Initial Training

Each employee presently involved in operating a process, and each employee BEFORE being involved in operating a newly assigned process, shall be trained in an overview of the process and in the operating procedures as specified in paragraph (f) of this section.

The training shall include **EMPHASIS** on

- the specific safety and health hazards,
- emergency operations including shutdown, and
- safe work practices

applicable to the employee's job tasks.

In lieu of initial training for those employees already involved in operating a process on May 26, 1992, an employer may certify in writing that the employee has the required knowledge, skills, and abilities to safely carry out the duties and responsibilities as specified in the operating procedures.

Refresher training

Refresher training shall be provided at least every three years, and more often if necessary, to each employee involved in operating a process to assure that the employee understands and adheres to the current operating procedures of the process.

The employer, in consultation with the employees involved in operating the process, shall determine the appropriate frequency of refresher training.

Training documentation

The employer shall ascertain that each employee involved in operating a process has received and understood the training required by this paragraph.

The employer shall prepare a record which contains the identity of the employee, the date of training, and the means used to verify that the employee understood the training.

All employees, including maintenance and contractor employees, involved with highly hazardous chemicals need to fully understand the safety and health hazards of the chemicals and processes they work with for the protection of themselves, their fellow employees and the citizens of nearby communities. Training conducted in compliance with 1910.1200, the Hazard Communication standard, will help employees to be more knowledgeable about the chemicals they work with as well as familiarize them with reading and understanding SDSs. However, additional training in subjects such as operating procedures and safety work practices, emergency evacuation and response, safety procedures, routine and nonroutine work authorization activities, and other areas pertinent to process safety and health will need to be covered by an employer's training program.

In establishing their training programs, employers must clearly define the employees to be trained and what subjects are to be covered in their training. Employers in setting up their training program will need to clearly establish the goals and objectives they wish to achieve with the training that they provide to their employees. The learning goals or objectives should be written in clear measurable terms before the training begins. These goals and objectives need to be tailored to each of the specific training modules or segments. Employers should describe the important actions and conditions under which the employee will demonstrate competence or knowledge as well as what is acceptable performance.

Hands-on-training where employees are able to use their senses beyond listening, will enhance learning. For example, operating personnel, who will work in a control room or at control panels, would benefit by being trained at a simulated control panel or panels. Upset conditions of various types could be displayed on the simulator, and then the employee could go through the proper operating procedures to bring the simulator panel back to the normal operating parameters. A training environment could be created to help the trainee feel the full reality of the situation but, of course, under controlled conditions. This realistic type of training can be very effective in teaching employees correct procedures while allowing them to also see the consequences of what might happens if they do not follow established operating procedures. Other training techniques using videos or on-the-job training can also be very effective for teaching other job tasks, duties, or other important information. An effective training program will allow the employee to fully participate in the training process and to practice their skill or knowledge.

Employers need to periodically evaluate their training programs to see if the necessary skills, knowledge, and routines are being properly understood and implemented by their trained employees. The means or methods for evaluating the training should be developed along with the training program goals and objectives. Training program evaluation will help employers to determine the amount of training their employees understood, and whether the desired results were obtained. If, after the evaluation, it appears that the trained employees are not at the level of knowledge and skill that was expected, the employer will need to revise the training program, provide retraining, or provide more frequent refresher training sessions until the deficiency is resolved. Those who conducted the training and those who received the training should also be consulted as to how best to improve the training process. If there is a language barrier, the language known to the trainees should be used to reinforce the training messages and information.

Careful consideration must be given to assure that employees including maintenance and contract employees receive current and updated training. For example, if changes are made to a process, impacted employees must be trained in the changes and understand the effects of the changes on their job tasks (e.g., any new operating procedures pertinent to their tasks). Additionally, as already discussed the evaluation of the employee's absorption of training will certainly influence the need for training.

Paragraph (h) - Contractors

The intent of this paragraph is to require employers who use contractors to perform work in and around processes that involve highly hazardous chemicals to establish a screening process so that they hire and use contractors who accomplish the desired job tasks without compromising the safety and health of employees at a facility. The contractor must assure that contract employees are trained on performing the job safely, of the hazards related to the job, and applicable provisions of the emergency action plan.
NOTE: The term contractor includes subcontractor.

This paragraph applies to contractors performing maintenance or repair, turnaround, major renovation, or specialty work on or adjacent to a covered process. It does NOT apply to contractors providing incidental services which do not influence process safety, such as janitorial work, food and drink services, laundry, delivery or other supply services.

Host Employer Responsibilities

The employer, when selecting a contractor, shall obtain and evaluate information regarding the contract employer's safety performance and programs.
The employer shall

- inform contract employers of the known potential fire, explosion, or toxic release hazards related to the contractor's work and the process
- explain to contract employers the applicable provisions of the emergency action plan required by paragraph (n) of this section
- develop and implement safe work practices consistent with paragraph (f)(4) of this section, to control the entrance, presence and exit of contract employers and contract employees in covered process areas.
- periodically evaluate the performance of contract employers in fulfilling their obligations as specified in paragraph (h)(3) of this section.
- maintain a contract employee injury and illness log related to the contractor's work in process areas.

Contract Employer Responsibilities

The contract employer shall

- assure that each contract employee is trained in the work practices necessary to safely perform his/her job
- assure that each contract employee is instructed in the known potential fire, explosion, or toxic release hazards related to his/her job and the process, and the applicable provisions of the emergency action plan
- document that each contract employee has received and understood the training required by this paragraph.
    - prepare a record which contains
        - the identity of the contract employee,
        - the date of training, and
        - the means used to verify that the employee understood the training
- assure that each contract employee follows the safety rules of the facility including the safe work practices required by paragraph (f)(4) of this section.
- advise the employer of any unique hazards presented by the contract employer's work, or of any hazards found by the contract employer's work.

Employers who use contractors to perform work in and around processes that involve highly hazardous chemicals, will need to establish a screening process so that they hire and use contractors who accomplish the desired job tasks without compromising the safety and health of employees at a facility. For contractors, whose safety performance on the job is not known to the hiring employer, the employer will need to obtain information on injury and illness rates and experience and should obtain contractor references. Additionally, the employer must assure that the contractor has the appropriate job skills, knowledge and certifications (such as for pressure vessel welders). Contractor work methods and experiences should be evaluated. For example, does the contractor conducting demolition work swing loads over operating processes or does the contractor avoid such hazards?

Maintaining a site injury and illness log for contractors is another method employers must use to track and maintain current knowledge of work activities involving contract employees working on or adjacent to covered processes. Injury and illness logs of both the employer's employees and contract employees allow an employer to have full knowledge of process injury and illness experience. This log will also contain information which will be of use to those auditing process safety management compliance and those involved in incident investigations.

Contract employees must perform their work safely. Considering that contractors often perform very specialized and potentially hazardous tasks such as confined space entry activities and nonroutine repair activities it is quite important that their activities be controlled while they are working on or near a covered process. A permit system or work authorization system for these activities would also be helpful to all affected employers. The use of a work authorization system keeps an employer informed of contract employee activities, and as a benefit the employer will have better coordination and more management control over the work being performed in the process area. A well run and well maintained process where employee safety is fully recognized will benefit all of those who work in the facility whether they be contract employees or employees of the owner.

Paragraph (i) - Pre-startup Safety Review

The intent of this paragraph is to make sure that, for new facilities an for modified facilities when the modification necessitates a change to process safety information, certain important considerations are addressed before any highly hazardous chemicals are introduced into the process. Minimum requirements include that the pre-startup safety review confirm the following: construction and equipment is in accordance with design specifications; safety, operating, maintenance, and emergency procedures are in place and adequate; for new facilities, a PHA has been performed and recommendations resolved or implemented; modified facilities meet the requirements of paragraph (1), management of change; and training of each employee involved in the process has been completed.

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.

The pre-startup safety review shall confirm that prior to the introduction of highly hazardous chemicals to a process:

- Construction and equipment is in accordance with design specifications;
- Safety, operating, maintenance, and emergency procedures are in place and are adequate;
- For new facilities, a process hazard analysis has been performed and recommendations have been resolved or implemented BEFORE startup;
- For modified facilities, meet the requirements contained in management of change (MOC), paragraph (l).
- Training of each employee involved in operating a process has been completed.

For new processes, the employer will find a PHA helpful in improving the design and construction of the process from a reliability and quality point of view. The safe operation of the new process will be enhanced by making use of the PHA recommendations before final installations are completed. P&IDs are to be completed along with having the operating procedures in place and the operating staff trained to run the process before startup. The initial startup procedures and normal operating procedures need to be fully evaluated as part of the pre-startup review to assure a safe transfer into the normal operating mode for meeting the process parameters.

For existing processes that have been shutdown for turnaround, or modification, etc., the employer must assure that any changes other than "replacement in kind" made to the process during shutdown go through the management of change procedures. P&IDs will need to be updated as necessary, as well as operating procedures and instructions. If the changes made to the process during shutdown are significant and impact the training program, then operating personnel as well as employees engaged in routine and nonroutine work in the process area may need some refresher or additional training in light of the changes. Any incident investigation recommendations, compliance audits or PHA recommendations need to be reviewed as well to see what impacts they may have on the process before beginning the startup.

Paragraph (j) - Mechanical Integrity

The intent of this paragraph is to assure that equipment used to process store, or handle highly hazardous chemicals is designed, constructed; installed, and maintained to minimize the risk of releases of such chemicals. This requires that a mechanical integrity program be in place to assure the continued integrity of process equipment. The elements of a mechanical integrity program include the identification and categorization of equipment and instrumentation, development of written maintenance procedures, training for process maintenance activities, inspection and testing, correction of deficiencies in equipment that are outside acceptable limits defined by the process safety information, and development of a quality assurance program.

These requirements only apply to six (6) types of process equipment where failure is likely to be catastrophic. The process equipment covered includes:

1. Pressure vessels and storage tanks;
2. Piping systems (including piping components such as valves);
3. Relief and vent systems and devices;
4. Emergency shutdown systems;
5. Controls (including monitoring devices and sensors, alarms, and interlocks) and,
6. Pumps.

Written Procedures

The employer shall establish and implement written procedures to maintain the on-going integrity of process equipment.

Training for Process Maintenance activities

The employer shall train each employee involved in maintaining the on-going integrity of process equipment in an overview of that process and its hazards and in the procedures applicable to the employee's job tasks to assure that the employee can perform the job tasks in a safe manner.

Inspection and Testing

Inspections and tests shall be performed on process equipment.

Inspection and testing procedures shall follow recognized and generally accepted good engineering practices.

The frequency of inspections and tests of process equipment shall be consistent with applicable manufacturers' recommendations and good engineering practices, and more frequently if determined to be necessary by prior operating experience.

The employer shall document each inspection and test that has been performed on process equipment. The documentation shall identify the date of the inspection or test, the name of the person who performed the inspection or test, the serial number or other identifier of the equipment on which the inspection or test was performed, a description of the inspection or test performed, and the results of the inspection or test.

Equipment Deficiencies

The employer shall correct deficiencies in equipment that are outside acceptable limits (defined by the process safety information in paragraph (d) of this section) before further use or in a safe and timely manner when necessary means are taken to assure safe operation.

Quality Assurance

In the construction of new plants and equipment, the employer shall assure that equipment as it is fabricated is suitable for the process application for which they will be used. Appropriate checks and inspections shall be performed to assure that equipment is installed properly and consistent with design specifications and the manufacturer's instructions. The

employer shall assure that maintenance materials, spare parts and equipment are suitable for the process application for which they will be used.

Employers will need to review their maintenance programs and schedules to see if there are areas where "breakdown" maintenance is used rather than an on-going mechanical integrity program. Equipment used to process, store, or handle highly hazardous chemicals needs to be designed, constructed, installed and maintained to minimize the risk of releases of such chemicals. This requires that a mechanical integrity program be in place to assure the continued integrity of process equipment. Elements of a mechanical integrity program include the identification and categorization of equipment and instrumentation, inspections and tests, testing and inspection frequencies, development of maintenance procedures, training of maintenance personnel, the establishment of criteria for acceptable test results, documentation of test and inspection results, and documentation of manufacturer recommendations as to meantime to failure for equipment and instrumentation.

The first line of defense an employer has available is to operate and maintain the process as designed, and to keep the chemicals contained. This line of defense is backed up by the next line of defense which is the controlled release of chemicals through venting to scrubbers or flares, or to surge or overflow tanks which are designed to receive such chemicals, etc. These lines of defense are the primary lines of defense or means to prevent unwanted releases. The secondary lines of defense would include fixed fire protection systems like sprinklers, water spray, or deluge systems, monitor guns, etc., dikes, designed drainage systems, and other systems which would control or mitigate hazardous chemicals once an unwanted release occurs. These primary and secondary lines of defense are what the mechanical integrity program needs to protect and strengthen these primary and secondary lines of defenses where appropriate.

The first step of an effective mechanical integrity program is to compile and categorize a list of process equipment and instrumentation for inclusion in the program. This list would include pressure vessels, storage tanks, process piping, relief and vent systems, fire protection system components, emergency shutdown systems and alarms and interlocks and pumps. For the categorization of instrumentation and the listed equipment the employer would prioritize which pieces of equipment require closer scrutiny than others. Meantime to failure of various instrumentation and equipment parts would be known from the manufacturers data or the employer's experience with the parts, which would then influence the inspection and testing frequency and associated procedures. Also, applicable codes and standards such as the National Board Inspection Code, or those from the American Society for Testing and Material, American Petroleum Institute, National Fire Protection Association, American National Standards Institute, American Society of Mechanical Engineers, and other groups, provide information to help establish an effective testing and inspection frequency, as well as appropriate methodologies.

The applicable codes and standards provide criteria for external inspections for such items as foundation and supports, anchor bolts, concrete or steel supports, guy wires, nozzles and sprinklers, pipe hangers, grounding connections, protective coatings and insulation, and external metal surfaces of piping and vessels, etc. These codes and standards also provide information on methodologies for internal inspection, and a frequency formula based on the corrosion rate of the materials of construction. Also, erosion both internal and external needs to be considered along with corrosion effects for piping and valves. Where the corrosion rate is not known, a maximum inspection frequency is recommended, and methods of developing the corrosion rate are available in the codes. Internal inspections need to cover items such as vessel shell, bottom and head; metallic linings; nonmetallic linings; thickness measurements for vessels and piping; inspection for erosion, corrosion, cracking and bulges; internal equipment like trays, baffles, sensors and screens for erosion, corrosion or cracking and other deficiencies. Some of these inspections may be performed by state or local government inspectors under state and local statutes. However, each employer needs to develop procedures to ensure that tests and inspections are conducted properly and that consistency is maintained even where different employees may be involved. Appropriate training is to be provided to maintenance personnel to ensure that they understand the preventive maintenance program procedures, safe practices, and the proper use and application of special equipment or unique tools that may be required. This training is part of the overall training program called for in the standard.

A quality assurance system is needed to help ensure that the proper materials of construction are used, that fabrication and inspection procedures are proper, and that installation procedures recognize field installation concerns. The quality assurance program is an essential part of the mechanical integrity program and will help to maintain the primary and secondary lines of defense that have been designed into the process to prevent unwanted chemical releases or those which control or mitigate a release. "As built" drawings, together with certifications of coded vessels and other equipment, and materials of construction need to be verified and retained in the quality assurance documentation. Equipment installation jobs need to be properly inspected in the field for use of proper materials and procedures and to assure that qualified craftsmen are used to do the job. The use of appropriate gaskets, packing, bolts, valves, lubricants and welding rods need to be verified in the field. Also, procedures for installation of safety devices need to be verified, such as the torque on the bolts on ruptured disc installations, uniform torque on flange bolts, proper installation of pump seals, etc. If the quality of parts is a problem, it may be appropriate to conduct audits of the equipment supplier's facilities to better assure proper purchases of required equipment which is suitable for its intended service. Any changes in equipment that may become necessary will need to go through the management of change procedures.

Paragraph (k) - Hot Work Permit

The intent of this paragraph is to require employers to control, in a consistent manner, nonroutine work conducted in process areas. Specifically, this subparagraph is concerned with the permitting of hot work operations associated with welding and cutting in process areas. Minimum requirements include: that the employer issue a hot work permit for hot work operations conducted on or near a covered process and that hot work permits shall document compliance with the fire prevention and protection requirements of 29 CFR 1910.252(a).

The employer shall issue a hot work permit for hot work operations conducted on or near a covered process.

The permit shall document that the fire prevention and protection requirements in 29 CFR 1910.252(a) have been implemented prior to beginning the hot work operations; it shall indicate the date(s) authorized for hot work; and identify the object on which hot work is to be performed.

The permit shall be kept on file until completion of the hot work operations.

1910.252(a) Fire Prevention and Protection

Basic Precautions

For elaboration of these basic precautions and of the special precautions of paragraph (d)(2) of this section as well as a delineation of the fire protection and prevention responsibilities of welders and cutters, their supervisors (including outside contractors) and those in management on whose property cutting and welding is to be performed, see, *Standard for Fire Prevention in Use of Cutting and Welding Processes*, NFPA Standard 51B,1962, which is incorporated by reference as specified in Sec. 1910.6.

The basic precautions for fire prevention in welding or cutting work are:

- Fire hazards
  - If the object to be welded or cut can **NOT** readily be moved, all movable fire hazards in the vicinity shall be taken to a safe place.
- Guards
  - If the object to be welded or cut can NOT be moved and if all the fire hazards can NOT be removed, then guards shall be used to confine the heat, sparks, and slag, and to protect the immovable fire hazards.
- Restrictions
  - If the requirements stated above cannot be followed then welding and cutting shall NOT be performed.
- Special Precautions
  - When the nature of the work to be performed involves an object to be welded or cut that can NOT be moved and if all the fire hazards can NOT be removed, then certain additional precautions may be necessary:
    - Wherever there are floor openings or cracks in the flooring that cannot be closed, precautions shall be taken so that no readily combustible materials on the floor below will be exposed to sparks which might drop through the floor.
    - The same precautions shall be observed with regard to cracks or holes in walls, open doorways and open or broken windows.
    - Suitable fire extinguishing equipment shall be maintained in a state of readiness for instant use.
      - Such equipment may consist of pails of water, buckets of sand, hose or portable extinguishers depending upon the nature and quantity of the combustible material exposed.

- Fire watchers shall be required whenever welding or cutting is performed in locations where other than a minor fire might develop, or any of the following conditions exist:
    - Appreciable combustible material, in building construction or contents, closer than 35 feet (10.7 m) to the point of operation.
    - Appreciable combustibles are more than 35 feet (10.7 m) away but are easily ignited by sparks.
    - Wall or floor openings within a 35-foot (10.7 m) radius expose combustible material in adjacent areas including concealed spaces in walls or floors.
    - Combustible materials are adjacent to the opposite side of metal partitions, walls, ceilings, or roofs and are likely to be ignited by conduction or radiation.
- Fire watchers shall have fire extinguishing equipment readily available and be trained in its use.
    - They shall
        - be familiar with facilities for sounding an alarm in the event of a fire.
        - watch for fires in all exposed areas, try to extinguish them only when obviously within the capacity of the equipment available, or otherwise sound the alarm.
        - be maintained for at least a half (1/2) hour after completion of welding or cutting operations to detect and extinguish possible smoldering fires.
- Before cutting or welding is permitted, the area shall be inspected by the individual responsible for authorizing cutting and welding operations.
    - He/She shall designate precautions to be followed in granting authorization to proceed preferably in the form of a written permit.
- Where combustible materials such as paper clippings, wood shavings, or textile fibers are on the floor, the floor shall be swept clean for a radius of 35 feet (10.7 m).
    - Combustible floors shall be kept wet, covered with damp sand, or protected by fire-resistant shields. Where floors have been wet down, personnel operating arc welding or cutting equipment shall be protected from possible shock.
- Cutting or welding shall not be permitted in the following situations:
    - In areas not authorized by management.
    - In sprinklered buildings while such protection is impaired.
    - In the presence of explosive atmospheres (mixtures of flammable gases, vapors, liquids, or dusts with air), or explosive atmospheres that may develop inside uncleaned or improperly prepared tanks or equipment which have previously contained such materials, or that may develop in areas with an accumulation of combustible dusts.
    - In areas near the storage of large quantities of exposed, readily ignitable materials such as bulk sulfur, baled paper, or cotton.
- Where practicable, all combustibles shall be relocated at least 35 feet (10.7 m) from the work site.
    - Where relocation is impracticable, combustibles shall be protected with flameproofed covers or otherwise shielded with metal or asbestos guards or curtains.
- Ducts and conveyor systems that might carry sparks to distant combustibles shall be suitably protected or shut down.
- Where cutting or welding is done near walls, partitions, ceiling or roof of combustible construction, fire-resistant shields or guards shall be provided to prevent ignition.
- If welding is to be done on a metal wall, partition, ceiling or roof, precautions shall be taken to prevent ignition of combustibles on the other side, due to conduction or radiation, preferably by relocating combustibles.

        - Where combustibles are not relocated, a fire watch on the opposite side from the work shall be provided.
    - Welding shall not be attempted on a metal partition, wall, ceiling or roof having a combustible covering nor on walls or partitions of combustible sandwich-type panel construction.
    - Cutting or welding on pipes or other metal in contact with combustible walls, partitions, ceilings or roofs shall not be undertaken if the work is close enough to cause ignition by conduction.
- Management shall recognize its responsibility for the safe usage of cutting and welding equipment on its property and:
    - Based on fire potentials of plant facilities, establish areas for cutting and welding, and establish procedures for cutting and welding, in other areas.
    - Designate an individual responsible for authorizing cutting and welding operations in areas not specifically designed for such processes.
    - Insist that cutters or welders and their supervisors are suitably trained in the safe operation of their equipment and the safe use of the process.
    - Advise all contractors about flammable materials or hazardous conditions of which they may not be aware.
- The Supervisor shall:
    - be responsible for the safe handling of the cutting or welding equipment and the safe use of the cutting or welding process.
    - determine the combustible materials and hazardous areas present or likely to be present in the work location.
    - protect combustibles from ignition by the following:
        - Have the work moved to a location free from dangerous combustibles.
        - If the work cannot be moved, have the combustibles moved to a safe distance from the work or have the combustibles properly shielded against ignition.
        - See that cutting and welding are so scheduled that plant operations that might expose combustibles to ignition are not started during cutting or welding.
        - Shall secure authorization for the cutting or welding operations from the designated management representative.
        - Shall determine that the cutter or welder secures his approval that conditions are safe before going ahead.
        - Shall determine that fire protection and extinguishing equipment are properly located at the site.
        - Where fire watches are required, he shall see that they are available at the site.
- Cutting or welding shall be permitted only in areas that are or have been made fire safe.
    - When work cannot be moved practically, as in most construction work, the area shall be made safe by removing combustibles or protecting combustibles from ignition sources.
- Welding or cutting containers.
    - No welding, cutting, or other hot work shall be performed on used drums, barrels, tanks or other containers until they have been cleaned so thoroughly as to make absolutely certain that there are no flammable materials present or any substances such as greases, tars, acids, or other materials which when subjected to heat, might produce flammable or toxic vapors.
    - Any pipe lines or connections to the drum or vessel shall be disconnected or blanked.
    - All hollow spaces, cavities or containers shall be vented to permit the escape of air or gases before preheating, cutting or welding. Purging with inert gas is recommended.

Nonroutine Work Authorizations. Nonroutine work which is conducted in process areas needs to be controlled by the employer in a consistent manner. The hazards identified involving the work that is to be accomplished must be communicated to those doing the work, but also to those operating personnel whose work could affect the safety of the process. A work authorization notice or permit must have a procedure that describes the steps the maintenance supervisor, contractor representative or other person needs to follow to obtain the necessary clearance to get the job started. The work authorization procedures need to reference and coordinate, as applicable, lockout/tagout procedures, line breaking procedures, confined space entry procedures and hot work authorizations. This procedure also needs to provide clear steps to follow once the job is completed in order to provide closure for those that need to know the job is now completed and equipment can be returned to normal.

Paragraph - (l) Management of Change

The intent of this paragraph is to require management of all modifications to equipment, procedures, raw materials and processing conditions other than "replacement in kind" by identifying and reviewing them prior to implementation of the change. Minimum requirements for management of change include:

1. establishing written procedures to manage change;
2. addressing the technical basis, impact on safety and health, modification to operating procedures, necessary time period, and authorizations required;
3. informing and training employees affected; and
4. updating process safety information and operating procedures or practices.

The employer shall establish and implement written procedures to manage changes (except for "replacements in kind") to process chemicals, technology, equipment, and procedures; and, changes to facilities that affect a covered process.

The procedures shall assure that the following considerations are addressed prior to any change:

- The technical basis for the proposed change;
- Impact of change on safety and health;
- Modifications to operating procedures;
- Necessary time period for the change; and,
- Authorization requirements for the proposed change.

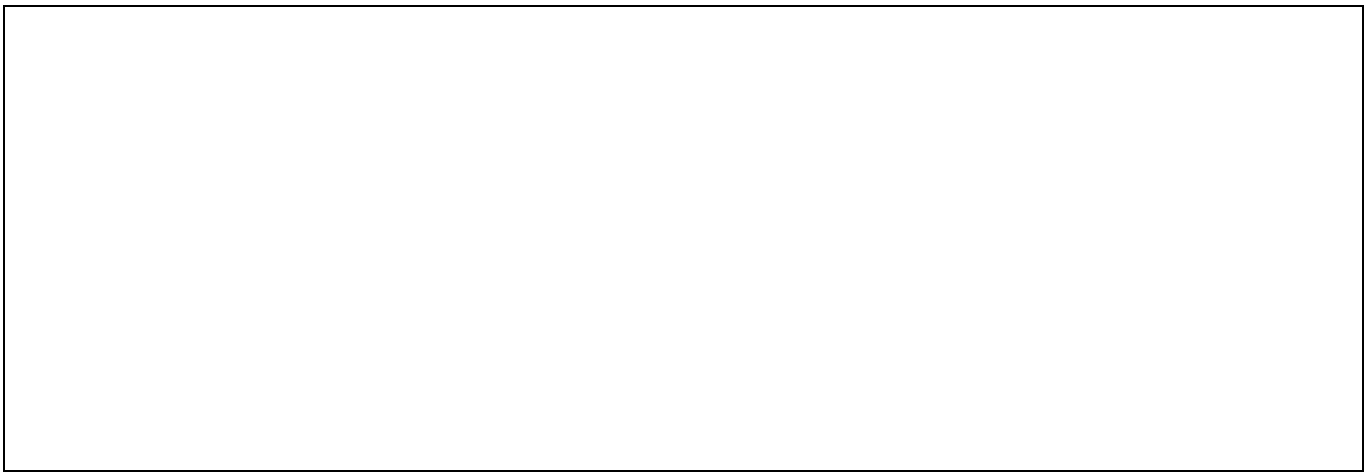
Employees involved in operating a process and maintenance and contract employees whose job tasks will be affected by a change in the process shall be informed of, and trained in, the change prior to start-up of the process or affected part of the process.

If a change covered by this paragraph results in a change in the process safety information required by paragraph (d) of this section, such information shall be updated accordingly.

If a change covered by this paragraph results in a change in the operating procedures or practices required by paragraph (f) of this section, such procedures or practices shall be updated accordingly.

To properly manage changes to process chemicals, technology, equipment and facilities, one must define what is meant by change. In this process safety management standard, change includes all modifications to equipment, procedures, raw materials and processing conditions other than "replacement in kind." These changes need to be properly managed by identifying and reviewing them prior to implementation of the change. For example, the operating procedures contain the operating parameters (pressure limits, temperature ranges, flow rates, etc.) and the importance of operating within these limits. While the operator must have the flexibility to maintain safe operation within the established parameters, any operation outside of these parameters requires review and approval by a written management of change procedure. Management of change covers such as changes in process technology and changes to equipment and instrumentation. Changes in process technology can result from changes in production rates, raw materials, experimentation, equipment unavailability, new equipment, new product development, change in catalyst and changes in operating conditions to improve yield or quality. Equipment changes include among others change in materials of construction, equipment specifications, piping pre-arrangements, experimental equipment, computer program revisions and changes in alarms and interlocks. Employers need to establish means and methods to detect both technical changes and mechanical changes.

Temporary changes have caused a number of catastrophes over the years, and employers need to establish ways to detect temporary changes as well as those that are permanent. It is important that a time limit for temporary changes be established and monitored since, without control, these changes may tend to become permanent. Temporary changes are subject to the management of change provisions. In addition, the management of change procedures are used to insure that the equipment and procedures are returned to their original or designed conditions at the end of the temporary change. Proper documentation and review of these changes is invaluable in assuring that the safety and health considerations are being incorporated into the operating procedures and the process. Employers may wish to develop a form or clearance sheet to facilitate the processing of changes through the management of change procedures. A typical change form may include a description and the purpose of the change, the technical basis for the change, safety and health considerations, documentation of changes for the operating procedures, maintenance procedures, inspection and testing, P&IDs, electrical classification, training and communications, pre-startup inspection, duration if a temporary change, approvals and authorization. Where the impact of the change is minor and well understood, a check list reviewed by an authorized person with proper communication to others who are affected may be sufficient. However, for a more complex or significant design change, a hazard evaluation procedure with approvals by operations, maintenance, and safety departments may be appropriate. Changes in documents such as P&IDs, raw materials, operating procedures, mechanical integrity programs, electrical classifications, etc., need to be noted so that these revisions can be made permanent when the drawings and procedure manuals are updated. Copies of process changes need to be kept in an accessible location to ensure that design changes are available to operating personnel as well as to PHA team members when a PHA is being done or one is being updated.



Paragraph (m) - Incident Investigation

The employer is required to investigate each incident which resulted in, or could reasonably have resulted in a catastrophic release of highly hazardous chemical in the workplace. An investigation shall be initiated no later than 48 hours following the incident. An investigation team shall be established and a report prepared which includes:

1. Date of incident
2. Date investigation began
3. Description of incident
4. Factors that contributed to the incident
5. Recommendations from the investigation.

The employer is required to establish a system to promptly address the incident report findings and recommendations, documenting all resolutions and corrective actions.

Incident reports shall be reviewed with all affected personnel whose job tasks are relevant to the investigation and retained for five years.

Resolutions and corrective actions shall be documented.

The report shall be reviewed with all affected personnel whose job tasks are relevant to the incident findings including contract employees where applicable.

Incident investigation is the process of identifying the underlying causes of incidents and implementing steps to prevent similar events from occurring. The intent of an incident investigation is for employers to learn from past experiences and thus avoid repeating past mistakes. The incidents for which OSHA expects employers to become aware and to investigate are the types of events which result in or could reasonably have resulted in a catastrophic release. Some of the events are sometimes referred to as "near misses," meaning that a serious consequence did not occur, but could have.

Employers need to develop in-house capability to investigate incidents that occur in their facilities. A team needs to be assembled by the employer and trained in the techniques of investigation including how to conduct interviews of witnesses, needed documentation and report writing. A multi-disciplinary team is better able to gather the facts of the event and to analyze them and develop plausible scenarios as to what happened, and why. Team members should be selected on the basis of their training, knowledge and ability to contribute to a team effort to fully investigate the incident. Employees in the process area where the incident occurred should be consulted, interviewed or made a member of the team. Their knowledge of the events form a significant set of facts about the incident which occurred. The report, its findings and recommendations are to be shared with those who can benefit from the information. The cooperation of employees is essential to an effective incident investigation. The focus of the investigation should be to obtain facts, and not to place blame. The team and the investigation process should clearly deal with all involved individuals in a fair, open and consistent manner.

Paragraph (n) - Emergency Planning and Response

The intent of this paragraph is to require the employer to address what actions employees are to take when there is an unwanted release of highly hazardous chemicals. The employer must establish and implement an emergency action plan in accordance with the provisions of 29 CFR 1910.38(a) and include procedures for handling small releases.

Certain provisions of the hazardous waste and emergency response standard, 29 CFR 1910.120(a), (p), and (q), may also apply.

[NOTE: 1910.120(a) addresses scope, application, and definitions for the entire standard. 1910.120(p) addresses treatment, storage, and disposal (TSD) facilities under the Resource Conservation and Recovery Act (RCRA). 1910.120(q) addresses requirements for facilities that are not RCRA TSD's, where there is the potential for an emergency incident involving hazardous substances.

Cleanup operations--including corrective actions and post-emergency response cleanup--are covered by 1910.120(b) through (o).

For further guidance, refer to the forthcoming directive on 29 CFR 1910.120.]

Emergency Action Plan - 1910.38

An employer must have an emergency action plan whenever an OSHA standard in this part requires one (PSM REQUIRES one).

An emergency action plan must be in writing, kept in the workplace, and available to employees for review. However, an employer with 10 or fewer employees may communicate the plan orally to employees.

An emergency action plan must include at a minimum:

1. Procedures for reporting a fire or other emergency;
2. Procedures for emergency evacuation, including type of evacuation and exit route assignments;
3. Procedures to be followed by employees who remain to operate critical plant operations before they evacuate;
4. Procedures to account for all employees after evacuation;
5. Procedures to be followed by employees performing rescue or medical duties; and
6. The name or job title of every employee who may be contacted by employees who need more information about the plan or an explanation of their duties under the plan.

An employer must have and maintain an employee alarm system.
The employee alarm system must use a distinctive signal for each purpose and comply with the requirements in § 1910.165.

An employer must designate and train employees to assist in a safe and orderly evacuation of other employees.

An employer must review the emergency action plan with each employee covered by the plan:

- When the plan is developed or the employee is assigned initially to a job;
- When the employee's responsibilities under the plan change; and
- When the plan is changed.

Employee alarm systems - 1910.165

This section applies to all emergency employee alarms installed to meet a particular OSHA standard (Emergency Action Plan and PSM).

> This section does not apply to those discharge or supervisory alarms required on various fixed extinguishing systems or to supervisory alarms on fire suppression, alarm or detection systems unless they are intended to be employee alarm systems.

The requirements in this section that pertain to maintenance, testing and inspection shall apply to all local fire alarm signaling systems used for alerting employees regardless of the other functions of the system.

All pre-discharge employee alarms installed to meet a particular OSHA standard shall meet the requirements of paragraphs (b)(1) through (4), (c), and (d)(1) of this section.

The employee alarm system shall:

- provide warning for necessary emergency action as called for in the emergency action plan, or for reaction time for safe escape of employees from the workplace or the immediate work area, or both
- be capable of being perceived above ambient noise or light levels by all employees in the affected portions of the workplace
    - Tactile devices may be used to alert those employees who would not otherwise be able to recognize the audible or visual alarm.
- be distinctive and recognizable as a signal to evacuate the work area or to perform actions designated under the emergency action plan.

The employer shall explain to each employee the preferred means of reporting emergencies, such as manual pull box alarms, public address systems, radio or telephones.

The employer shall post emergency telephone numbers near telephones, or employee notice boards, and other conspicuous locations when telephones serve as a means of reporting emergencies.

Where a communication system also serves as the employee alarm system, all emergency messages shall have priority over all non-emergency messages.

The employer shall establish procedures for sounding emergency alarms in the workplace.

> For those employers with 10 or fewer employees in a particular workplace, direct voice communication is an acceptable procedure for sounding the alarm provided all employees can hear the alarm. Such workplaces need not have a back-up system.

The employer shall assure that all devices, components, combinations of devices or systems constructed and installed to comply with this standard are approved.

> Steam whistles, air horns, strobe lights or similar lighting devices, or tactile devices meeting the requirements of this section are considered to meet this requirement for approval.

The employer shall assure that all employee alarm systems are restored to normal operating condition as promptly as possible after each test or alarm.

> Spare alarm devices and components subject to wear or destruction shall be available in sufficient quantities and locations for prompt restoration of the system.

The employer shall assure that all employee alarm systems are maintained in operating condition except when undergoing repairs or maintenance.

The employer shall assure that a test of the reliability and adequacy of non-supervised employee alarm systems is made every two months.

A different actuation device shall be used in each test of a multi-actuation device system so that no individual device is used for two consecutive tests.

The employer shall maintain or replace power supplies as often as is necessary to assure a fully operational condition.

Back-up means of alarm, such as employee runners or telephones, shall be provided when systems are out of service.

The employer shall assure that employee alarm circuitry installed after January 1, 1981, which is capable of being supervised is supervised and that it will provide positive notification to assigned personnel whenever a deficiency exists in the system.

The employer shall assure that all supervised employee alarm systems are tested at least annually for reliability and adequacy.

The employer shall assure that the servicing, maintenance and testing of employee alarms are done by persons trained in the designed operation and functions necessary for reliable and safe operation of the system.

The employer shall assure that manually operated actuation devices for use in conjunction with employee alarms are unobstructed, conspicuous and readily accessible.

Emergency response program – 1910.120(q)

This paragraph covers employers whose employees are engaged in emergency response no matter where it occurs except that it does not cover employees engaged in operations specified in paragraphs (a)(1)(i) through (a)(1)(iv) of this section.

Each employer must address what actions employees are to take when there is an unwanted release of highly hazardous chemicals. Emergency preparedness or the employer's tertiary (third) lines of defense are those that will be relied on along with the secondary lines of defense when the primary lines of defense which are used to prevent an unwanted release fail to stop the release. Employers will need to decide if they want employees to handle and stop small or minor incidental releases. Whether they wish to mobilize the available resources at the plant and have them brought to bear on a more significant release. Or whether employers want their employees to evacuate the danger area and promptly escape to a preplanned safe zone area, and allow the local community emergency response organizations to handle the release. Or whether the employer wants to use some combination of these actions. Employers will need to select how many different emergency preparedness or tertiary lines of defense they plan to have and then develop the necessary plans and procedures, and appropriately train employees in their emergency duties and responsibilities and then implement these lines of defense.

Employers at a minimum must have an emergency action plan which will facilitate the prompt evacuation of employees when an unwanted release of highly hazardous chemical. This means that the employer will have a plan that will be activated by an alarm system to alert employees when to evacuate and, that employees who are physically impaired, will have the necessary support and assistance to get them to the safe zone as well. The intent of these requirements is to alert and move employees to a safe zone quickly. Delaying alarms or confusing alarms are to be avoided. The use of process control centers or similar process buildings in the process area as safe areas is discouraged. Recent catastrophes have shown that a large life loss has occurred in these structures because of where they have been sited and because they are not necessarily designed to withstand over-pressures from shockwaves resulting from explosions in the process area.

Unwanted incidental releases of highly hazardous chemicals in the process area must be addressed by the employer as to what actions employees are to take. If the employer wants employees to evacuate the area, then the emergency action plan will be activated. For outdoor processes where wind direction is important for selecting the safe route to a refuge area, the employer should place a wind direction indicator such as a wind sock or pennant at the highest point that can be seen throughout the process area. Employees can move in the direction of cross wind to upwind to gain safe access to the refuge area by knowing the wind direction.

If the employer wants specific employees in the release area to control or stop the minor emergency or incidental release, these actions must be planned for in advance and procedures developed and implemented. Preplanning for handling incidental releases for minor emergencies in the process area needs to be done, appropriate equipment for the hazards must be provided, and training conducted for those employees who will perform the emergency work before they respond to handle an actual release. The employer's training program, including the Hazard Communication standard training is to address the training needs for employees who are expected to handle incidental or minor releases.

Preplanning for releases that are more serious than incidental releases is another important line of defense to be used by the employer. When a serious release of a highly hazardous chemical occurs, the employer through preplanning will have determined in advance what actions employees are to take. The evacuation of the immediate release area and other areas as necessary would be accomplished under the emergency action plan. If the employer wishes to use plant personnel such as a fire brigade, spill control team, a hazardous materials team, or use employees to render aid to those in the immediate release area and control or mitigate the incident, these actions are covered by 1910.120, the Hazardous Waste Operations and Emergency Response (HAZWOPER) standard. If outside assistance is necessary, such as through mutual aid agreements between employers or local government emergency response organizations, these emergency responders are also covered by HAZWOPER. The safety and health protections required for emergency responders are the responsibility of their employers and of the on-scene incident commander.

Responders may be working under very hazardous conditions and therefore the objective is to have them competently led by an on-scene incident commander and the commander's staff, properly equipped to do their assigned work safely, and fully trained to carry out their duties safely before they respond to an emergency. Drills, training exercises, or simulations with the local community emergency response planners and responder organizations is one means to obtain better preparedness. This close cooperation and coordination between plant and local community emergency preparedness managers will also aid the employer in complying with the Environmental Protection Agency's Risk Management Plan criteria.

One effective way for medium to large facilities to enhance coordination and communication during emergencies for on plant operations and with local community organizations is for employers to establish and equip an emergency control center. The emergency control center would be sited in a safe zone area so that it could be occupied throughout the duration of an emergency. The center would serve as the major communication link between the on-scene incident commander and plant or corporate management as well as with the local community officials. The communication equipment in the emergency control center should include a network to receive and transmit information by telephone, radio or other means. It is important to have a backup communication network in case of power failure or one communication means fails. The center should also be equipped with the plant layout and community maps, utility drawings including fire water, emergency lighting, appropriate reference materials such as a government agency notification list, company personnel phone list, SARA Title III reports and safety data sheets, emergency plans and procedures manual, a listing with the location of emergency response equipment, mutual aid information, and access to meteorological or weather condition data and any dispersion modeling data.

Paragraph (o) - Compliance Audits

The intent of this paragraph is to require employers to self-evaluate the effectiveness of their PSM program by identifying deficiencies and assuring corrective actions. Minimum requirements include: audits at least every three years; maintenance of audit reports for at least the last two audits; audits conducted by at least one person knowledgeable in the process; documentation of an appropriate response to each finding; documentation that the deficiencies found have been corrected.

Employers need to select a trained individual or assemble a trained team of people to audit the process safety management system and program. A small process or plant may need only one knowledgeable person to conduct an audit. The audit is to include an evaluation of the design and effectiveness of the process safety management system and a field inspection of the safety and health conditions and practices to verify that the employer's systems are effectively implemented. The audit should be conducted or lead by a person knowledgeable in audit techniques and who is impartial towards the facility or area being audited. The essential elements of an audit program include planning, staffing, conducting the audit, evaluation and corrective action, follow-up and documentation.

Planning in advance is essential to the success of the auditing process. Each employer needs to establish the format, staffing, scheduling and verification methods prior to conducting the audit. The format should be designed to provide the lead auditor with a procedure or checklist which details the requirements of each section of the standard. The names of the audit team members should be listed as part of the format as well. The checklist, if properly designed, could serve as the verification sheet which provides the auditor with the necessary information to expedite the review and assure that no requirements of the standard are omitted. This verification sheet format could also identify those elements that will require evaluation or a response to correct deficiencies. This sheet could also be used for developing the follow-up and documentation requirements.

The selection of effective audit team members is critical to the success of the program. Team members should be chosen for their experience, knowledge, and training and should be familiar with the processes and with auditing techniques, practices and procedures. The size of the team will vary depending on the size and complexity of the process under consideration. For a large, complex, highly instrumented plant, it may be desirable to have team members with expertise in process engineering and design, process chemistry, instrumentation and computer controls, electrical hazards and classifications, safety and health disciplines, maintenance, emergency preparedness, warehousing or shipping, and process safety auditing. The team may use part-time members to provide for the depth of expertise required as well as for what is actually done or followed, compared to what is written.

An effective audit includes a review of the relevant documentation and process safety information, inspection of the physical facilities, and interviews with all levels of plant personnel. Utilizing the audit procedure and checklist developed in the preplanning stage, the audit team can systematically analyze compliance with the provisions of the standard and any other corporate policies that are relevant. For example, the audit team will review all aspects of the training program as part of the overall audit. The team will review the written training program for adequacy of content, frequency of training, effectiveness of training in terms of its goals and objectives as well as to how it fits into meeting the standard's requirements, documentation, etc. Through interviews, the team can determine the employee's knowledge and awareness of the safety procedures, duties, rules, emergency response assignments, etc. During the inspection, the team can observe actual practices such as safety and health policies, procedures, and work authorization practices. This approach enables the team to identify deficiencies and determine where corrective actions or improvements are necessary.

Paragraph (p) - Trade Secrets

The intent of this paragraph is to require employers to provide all information necessary to comply with the standard to personnel developing paragraphs (d), (e), (f), (n) and (o) without regard to possible trade secrets. In addition, employees and their designated representatives shall have access to trade secret information contained within documents required to be developed by the standard.

List of Highly Hazardous Chemicals, Toxics and Reactives (Mandatory) - 1910.119 App A

This Appendix contains a listing of toxic and reactive highly hazardous chemicals which present a potential for a catastrophic event at or above the threshold quantity.

OSHA continues to believe that the potential hazard of a catastrophic release exists when the highly hazardous chemical is concentrated in a process and therefore agrees with these commenters. OSHA has clarified the language contained in the application paragraph to reflect its intent that coverage is triggered by a specified threshold quantity of an Appendix A substance being used in a single process. This revision also clarifies the fact that the presence of a threshold quantity of a highly hazardous chemical in a process is to be at one point in time; not aggregated over a period of time.

In the application section (paragraph (b)(1)(i)) of the proposal, a process would be covered if it involved a toxic or reactive highly hazardous chemical listed in Appendix A, at or above a specified threshold quantity. Appendix A was a compilation of highly hazardous chemicals that could cause a serious chemical accident, by toxicity or reactivity, and a consequent potential danger to employees in a workplace.

The Appendix A list has been drawn from a variety of relevant sources which include: the New Jersey "Toxic Catastrophe Prevention Act," the State of Delaware's "Extremely Hazardous Substances Risk Management Act," the World Bank's "Manual of Industrial Hazard Assessment Techniques," the Environmental Protection Agency's "Extremely Hazardous Substance List," the European Communities Directive on major accident hazards of certain industrial activities (82/501/EEC, sometimes called the Seveso Directive), the United Kingdom's "A Guide to the Control of Industrial Major Accident Hazards Regulations 1984," the American Petroleum Institute's RP 750, "Management of Process Hazards," the National Fire Protection Association's NFPA 49, "Hazardous Chemicals Data," and the Organization Resources Counselors, Inc.'s "Recommendations for Process Hazards Management of Substances with Catastrophic Potential."

Every chemical listed in Appendix A is on at least one list compiled by these agencies and organizations as warranting a high degree of management control due to its extremely hazardous nature. Most of the chemicals are on several lists. Not every list contains the same chemicals or quantities. Based on a review of these sources, OSHA has sought to include those toxic and reactive chemicals it believes are most significant in potentially becoming a catastrophic event. OSHA has also sought to develop a reasonable listing of threshold quantities which, when used in a process, would invoke coverage of the standard.

Those Appendix A highly hazardous chemicals which are highly reactive or explosive-type chemicals have been drawn from chemicals listed in the National Fire Protection Association (NFPA) document, NFPA 49, "Hazardous Chemicals Data" and cross-referenced with other sources mentioned above. The Agency decided to include substances with the two highest or most dangerous reactivity ratings from NFPA 49 because these chemicals present the most severe exposure potential to workers. These substances, which are rated 3 or 4 by NFPA 49, are those which are capable of undergoing detonation or explosive decomposition. These are the substances which can generate the most severe blast or shock wave, and can cause fragmentation of piping, vessels and containers, as well as causing serious damage to buildings and structures.

The minimum threshold quantities for the highly reactive chemicals covered by the standard have been determined by calculating the amount of material needed to propagate a blast wave that creates an overpressure of 2.3 psi (15.85 kPa) to a flat surface perpendicular to the direction of the blast wave at a distance of 100 meters from the point of origin. This approach is similar to that used by the State of Delaware.

The toxic chemicals contained in Appendix A were drawn from the various resource documents discussed above. Most of the toxic chemicals listed in Appendix A are on a majority of the lists produced by these resource documents.

In determining threshold quantities for toxic chemicals, OSHA used the Turner described Gaussian dispersion model. This approach, again, is similar to that used by the State of Delaware. Both OSHA and Delaware made the following assumptions: average conditions of 4.3 m/sec. wind speed and D stability with urban dispersion coefficients; continuous steady-state release for one hour; no liquid pools; all released chemicals in vapor or gaseous state; chemical release is at ambient temperature and at ground level; chemical gas or vapor cloud is neutrally buoyant; and no design features prevent downwind dispersion. The calculated threshold quantities were rounded by OSHA to further simplify the standard.

The lowest threshold quantity that the Agency has used is 100 pounds (45.4 kg) for the most hazardous of the chemicals listed. The OSHA threshold quantities are the same or somewhat greater than the Delaware "sufficient quantity level" (threshold quantity) due to the rounding up by the Agency for the vast majority of the toxic chemicals listed. This has been done to simplify the application of this final rule and also in recognition that the Agency has other standards which address the hazards of lower quantities of toxic materials in the workplace.

Rules of the Course

- This is an Open Discussion Course
  - Relax and Learn
  - Ask Questions
  - Participate in Discussions
  - Share Experiences
  - Share Best Practices
  - Enjoy Yourself

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Course Outline & Schedule

Day 1

- History of Process Safety
- Application of 29 CFR 1910.119
  - Exemptions
- Key Definitions
- Employee participation (1910.119(c)
- Process safety information (1910.119(d)
- Process Hazards Analysis

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Course Outline & Schedule

Day 2

- Operating Procedures
  - Safe work practices
- Training
  - Initial & Refresher training, Testing & Documentation
- Contractors
  - Host Employer & Contract Employer responsibilities
- Pre-startup safety review
  - New & Modified facilities
- Mechanical integrity

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Course Outline & Schedule

Day 3

- Hot work permit
- Management of change
- Incident investigation
- Emergency planning and response
- Compliance Audits
- Trade secrets
- EPA's Risk Management (if applicable)
- OSHA & EPA Resources

History of PSM Catastrophes

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.

These incidents lead to the passage of the Process Safety Management Rule in May 1992.

History of PSM Standard

1984 Toxic chemical release in **Bhopal, India**, kills over 4,000 people

1985 Release from a chemical plant in **Institute, West Virginia**, injures 135
American Institute of Chemical Engineers forms the Center for Chemical Process Safety and publishes Guidelines for Hazard Evaluation Procedures

1989 **Phillips Chemical Plant** explosion kills 23, injures 132

1990 **Arco Chemical plant explosion** kills 17 workers, flattened an area the size of a city block
American Petroleum Institute (API) publishes Management of Process Hazards voluntary guidelines
OSHA releases a Proposed Safety Standard based on the API Guidelines and Recommendations
Congress passes the Clean Air Act Amendments, which mandate that OSHA enact process safety rules covering 14 specific areas

1990 **Cincinnati, OH** vapor cloud explosion kills 2 @ BASF

1991 **Sterlington, LA** Waste Gas Explosion kills 8 and 128 injuries @ Angus Chemical Company

1991 OSHA releases study of the effects of using contract workers in the petrochemical industry.

1992 The final OSHA PSM Standard is issued. One year later, EPA released its Risk Management Program Regulation.

Why Did OSHA Develop PSM?

- Standard contains requirements for preventing or minimizing the consequences of catastrophic releases of chemicals that are:
  - ◆Toxic,
  - ◆Reactive,
  - ◆Flammable,
  - ◆Explosive

- These releases may result in toxic, fire or explosion hazards
- A number of catastrophic accidents have occurred resulting in loss of life and great property damage.

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Ammonium Nitrate Explosion

Oppau, Germany – Sept. 21, 1921

Photo shows crater and destruction at plant following explosion. At 7:30 a.m. on September 21, 1921, two powerful explosions occurred at the BASF plant in Oppau, Germany.
Hazardous material: Ammonium sulfate & ammonium nitrate (50/50)
Facility type: fertilizer manufacturing
Deaths: 430-530 (differing numbers on reported fatalities)

Ammonium Nitrate Explosion

Texas City, Texas – April 16, 1947

This aerial photograph, looking south over Monsanto Chemical Co., was taken about 30 minutes following the blast of the ship S. S. GRANDCAMP during loading of ammonium nitrate. The accident damaged more than 90% of the city's buildings and killed nearly 600 people.

Major PSM related incidents

1974 - 2001

Location of Accident	Date	Type of Event	Some Resulting Consequences	Regulatory Response
Flixborough, UK	1974	Explosion and fire	28 killed, over 100 injured	COMAH 1984
Seveso, Italy	1976	Runaway reaction	Large Dioxin environment contamination massive evacuations, Large animal kill	Initial Seveso Directive
Bhopal, India	1984	Runaway MIC reaction	~ 2500 people killed and 100,000 injured, high litigation costs	USA Emerg. Planning & Community Right to know Act- CMA CAER Program
Basel, Switzerland	1986	Warehouse Fire	Massive contamination of Rhine and very large fish kill	Changes in Seveso Directive
Pasadena, USA	1989	Explosion and fire	23 deaths, ~ 100 injured Over $1 billion in losses	Triggered 1990 USA CAAct & RMP & PSM process Stds
Longford, Victoria, Australia	1998	Explosions and fires	Two deaths, gas supply to Melbourne cut for 19 days. Losses over $1.3 Billion	Process Regulatory initiatives Victoria
Enschede, The Netherlands	2000	Explosion and fire	22 deaths, ~ 1000 injured, 350 houses and factories destroyed	Changes in Seveso Directive
Toulouse, France (Oppau[c] & Texas City[d])	2001	Explosion and fire	30 deaths, ~ 2000 injured, 600 homes destroyed, 2 schools demolished	Changes in Seveso Directive

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Seveso, Italy - 1976

The Seveso accident happened in 1976 at a chemical plant manufacturing pesticides and herbicides. A dense vapor cloud containing tetrachlorodibenzoparadioxin (Dioxin) was released from a reactor, used for the production of trichlorofenol.

Commonly known as dioxin, this was a poisonous and carcinogenic by-product of an uncontrolled exothermic reaction. Although no immediate fatalities were reported, kilogram quantities of the substance lethal to man even in microgram doses were widely dispersed which resulted in an immediate contamination of some ten square miles of land and vegetation.

More than 600 people had to be evacuated from their homes and as many as 2,000 were treated for dioxin poisoning. This lead to the European "Seveso Directive" to try to prevent similar incidents.

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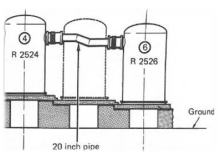
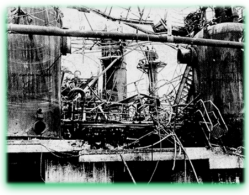
Cyclohexane Release & Explosion

Flixborough, England – June 1, 1974





On June 1, 1974 the Nypro Co. site at Flixborough, England was severely damaged by a large explosion. Twenty-eight workers were killed and a further 36 suffered injuries. It is recognized that the number of casualties would have been more if the incident had occurred on a weekday, as the main office block was not occupied. Offsite consequences resulted in fifty-three reported injuries. Property in the surrounding area was damaged to a varying degree.

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Methyl Isocyanate Release

Bhopal, India – Dec. 2-3, 1984

On the night of December 2-3, 1984, a sudden release of about 30 metric tons of methyl isocyanate (MIC) occurred at the Union Carbide pesticide plant at Bhopal, India. The accident was a result of poor safety management practices, poor early warning systems, and the lack of community preparedness. The accident led to the death of over 2,800 people (other estimates put the immediate death toll as high as 8000) living in the vicinity and caused respiratory damage and eye damage to over 20,000 others. At least 200,000 people fled Bhopal during the week after the accident. Estimates of the damage vary widely between $350 million to as high as $3 billion.

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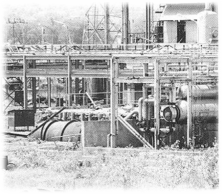
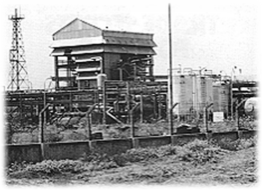
Bhopal Aftermath



Water entered "Tank 610" in foreground of picture reacting with MIC and caused an uncontrolled release of a vapor cloud.



Bhopal flare tower with corroded and missing section of pipe. Plant enclosed by fence in foreground.

Phillips 66 Houston Chemical Complex

Pasadena, Texas – Oct. 23, 1989

On October 23, 1989, at approximately 1:00 p.m., an explosion and fire ripped through the Phillips 66 Company Houston Chemical Complex in Pasadena, Texas. Twenty-three workers were killed and more than 130 were injured. Property damage was nearly three-quarters of a billion dollars. The accident resulted from a release of extremely flammable process gases that occurred during regular maintenance operations on one of the plant's polyethylene reactors. The evidence showed that more than 85,000 pounds of highly flammable gases were released through an open valve. A vapor cloud formed and traveled rapidly through the polyethylene plant. Within 90 to 120 seconds, the vapor cloud came into contact with an ignition source and exploded with the force of 2.4 tons of TNT.

This event AND Bhopal triggered the development of the PSM standard

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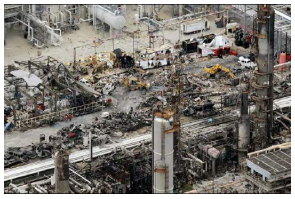
BP Refinery Explosion – Texas City, TX

March 23, 2005



At approximately 1:20 p.m. on March 23, 2005, a series of explosions occurred at the BP Texas City refinery during the restarting of a hydrocarbon isomerization unit. Fifteen workers were killed and 180 others were injured. Many of the victims were in or around work trailers located near an atmospheric vent stack. The explosions occurred when a distillation tower flooded with hydrocarbons and was overpressurized, causing a geyser-like release from the vent stack.

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Summary of Chemical Accidents

1994-1999

# of Facilities & Processes	15,430 facilities	(20,588 covered processes)
Facilities with at least 1 accident in 5 yr period	1,205 (7. 8%)	(2.3% multiple Accidents)
Total number of Accidents	1969	(394 event per year)
Deaths (Workers)	32	
Injuries (Workers)	1987	
Injuries (Public & First Responders)	167 injuries, 215 hospitalizations, 6,057 medical care (over 200,000 evacuated & shelter-in-place)	
Property damage	~ $1 billion, (Total estimated at ~ $5 to 10 billion including business interruption, and other losses associated with accidents)	
Ecological damage	104 accidents with significant damage	
Off site property damage	$11.7 million	

Source: Kleindorfer, P., Belke, J., Elliott, M., Lee, K., Lowe, R., Feldman, H.,"Accident Epidemiology & U.S. Chemical Industry: Accident History & Worst-Case Data from RMP*Info", Risk Analysis, Vol.23, No 4, 2003, pp 865-881.

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Honda PSM/RMP HHC/EHS's

	HFO-1234yf*	Ammonia	Propane
Molecular Formula	$C_3H_2F_4$	NH_3	C_3H_8
Appearance (@ Std Temp & Pressure)	colorless gas	colorless gas	colorless gas
Boiling Point (@ Std Temp & Pressure)	−29°C (−22°F)	-33°C (-28°F)	-42°C (-44°F)
Vapor Pressure (@ Std Temp & Pressure)	4,551 mmHg	6,500 mmHg	7,500 mmHg
Flammable Range	6% - 12%	16% - 28%	2%-10%
Vapor Density (Air = 1)	4 ↓	0.7 ↑	1.6 ↓
Autoignition Temperature	405°C (761°F)	651°C (1,204°F)	470°C (878°F)
Minimum Ignition Energy (mJ)	5,000	680	0.25

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PSM Development

In 1991, OSHA and EPA respectively, released the standards, PSM & RMP that applies to facilities that are affected by the standards.

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Purpose of PSM?

Process Safety Management is a regulation, promulgated by OSHA, intended to prevent an incident like the 1984 Bhopal Disaster

And…to Prevent Release of:
- Toxic,
- Reactive,
- Flammable, or
- Explosive chemicals

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Not Only PSM, But RMP

A great many industrial facilities must comply with OSHA's Process Safety Management (PSM) regulations as well as the quite similar EPA Risk Management Program (RMP) regulations (Title 40 CFR Part 68).

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PSM vs. RMP - What's the Difference?

- **PSM**
  - Protects Workers
  - "Inside the fence"
- **RMP**
  - Protects the Community
  - "Outside the fence"

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PSM Standard Is "Performance-Based"

- The PSM Standard is a **performance-based standard**. That means it is goal-oriented and what you should judge is a program's effectiveness.
- The exact specifications are **NOT** spelled out
- The PSM Standard gives each facility the flexibility to design its own program to match its needs, as long as the outcome prevents or minimizes major releases, spills, fires, and explosions.
- Specification-based OSHA standards prescribe precise rules, such as a guardrail's height, exact limits of exposure, etc.

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What Facilities are Covered

- A process which involves a chemical at or above the specified threshold quantities listed in **Appendix A:** ***A List of highly hazardous chemicals, toxics and reactive***
  - Contains a listing of toxic and reactive highly hazardous chemicals which present a potential for a catastrophic event at or above the threshold quantity

Examples:

Chemicals	Threshold Quantity (TQ)
Anhydrous Ammonia	**10,000 lbs**
Chlorine	1,500 lbs
Flammables	**10,000 lbs**

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What Facilities are Covered

- 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

1910.1200 Flammable Gases

Flammable gas means a gas having a flammable range with air at 20°C (68°F) and a standard pressure of 101.3 kPa (14.7 psi).

OSHA's CRITERIA FOR FLAMMABLE GASES (1910.1200 Appendix B)	
Category	**Criteria**
1	Gases, which at 20°C (68°F) and a standard pressure of 101.3 kPa (14.7 psi): (a) are ignitable when in a mixture of 13% or less by volume in air; or (b) have a flammable range with air of at least 12 percentage points regardless of the lower flammable limit.
2	Gases, other than those of Category 1, which, at 20°C (68°F) and a standard pressure of 101.3 kPa (14.7 psi), have a flammable range while mixed in air.

Which category of flammable gases is 2,3,3-Tetrafluoropropene (HFO-1234yf) and Propane/LPG?

Exceptions

- 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**

Exceptions

- PSM Standard does **NOT** apply to:
  - Retail facilities
  - Oil or gas well drilling or servicing operations
  - Normally unoccupied remote facilities

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Exceptions - The Meer Decision

- Court decision implemented by directive
- Language in standard for flammable liquids "unconstitutionally vague"

  MEER ruling and the MEER Memorandum addressed in the Secretary's letter, OSHA's enforcement policy that the Agency would not cite employers for violations of 1910.119 where stored flammable liquids in atmospheric tanks were connected to a process, unless the process outside of the amount in storage contained more than 10,000 pounds of the substance

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RECENT CHANGES w/ PSM

(2015)

- Covered Concentrations (1% Rule)
- RAGAGEP (Shall and Should)
- Retail Exemption GONE! (Court Overturned in October 2016)

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Key Definitions

Atmospheric tank means a storage tank which has been designed to operate at pressures from atmospheric through 0.5 p.s.i.g. (pounds per square inch gauge, 3.45 Kpa).

Catastrophic release means a major uncontrolled emission, fire, or explosion, involving one or more highly hazardous chemicals, that presents serious danger to employees in the workplace.

Facility means the buildings, containers or equipment which contain a process.

Key Definitions

Highly hazardous chemical means a substance possessing toxic, reactive, flammable, or explosive properties and specified by paragraph (a)(1) of this section.

Hot work means work involving electric or gas welding, cutting, brazing, or similar flame or spark-producing operations.

Key Definitions (cont.)

Normally unoccupied remote facility means a facility which is operated, maintained or serviced by employees who visit the facility only periodically to check its operation and to perform necessary operating or maintenance tasks. No employees are permanently stationed at the facility. Facilities meeting this definition are not contiguous with, and must be geographically remote from all other buildings, processes or persons.

Key Definitions (cont.)

Process means any activity involving a highly hazardous chemical including any use, storage, manufacturing, handling, or the on-site movement of such chemicals, or combination of these activities. **For purposes of this definition, any group of vessels which are interconnected and separate vessels which are located such that a highly hazardous chemical could be involved in a potential release shall be considered a single process.**

Replacement in kind means a replacement which satisfies the design specification.

1910.119(c)

Employee Participation (EP)

- Develop a **written plan of action** regarding the implementation of EP
- **Consult with employees and their representatives** on the conduct and development of PHAs and on the development of the other PSM elements
- Provide to employees and their representatives **access to PHA(s)** and to **ALL other PSM information**

1910.119(d)

Process Safety Information (PSI)

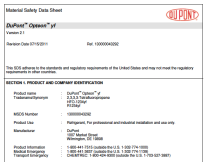
- Complete a compilation of written **PSI BEFORE conducting any PHA**
- PSI is to enable the employer/employees involved in operating the process to **identify and understand the hazards** posed by those processes
- PSI shall include:
  - information pertaining to the **HAZARDS** of the HHC used or produced by the process,
  - information pertaining to the **TECHNOLOGY** of the process, and
  - information pertaining to the **EQUIPMENT** in the process

1910.119(d)

Process Safety Information (PSI)

Information pertaining to the **HAZARDS** of the HHCs shall consist of at least the following:

- ✓ Toxicity information
- ✓ Permissible exposure limits
- ✓ Physical data
- ✓ Reactivity data
- ✓ Corrosivity data
- ✓ Thermal and chemical stability data
- ✓ Hazardous effects of inadvertent mixing of different materials that could foreseeably occur


Material Safety Data Sheet

DuPont™ Opteon™ yf

Version 2.1

Revision Date 07/15/2011 Ref. 110000044392

This SDS adheres to the standards and regulatory requirements of the United States and may not meet the regulatory requirements in other countries.

SECTION 1. PRODUCT AND COMPANY IDENTIFICATION

Product name : DuPont™ Opteon™ yf
Trade name/Synonyms : HFO-1234yf
HFO-1234yf
R1234yf

MSDS Number : 110000044392

Product Use : Refrigerant. For professional and industrial installation and use only.

Manufacturer : DuPont
1007 Market Street
Wilmington, DE 19898

Product Information : 1-800-441-7515 (outside the U.S. 1-302-774-1000)
Medical Emergency : 1-800-441-3637 (outside the U.S. 1-302-774-1139)
Transport Emergency : CHEMTREC® - 1-800-424-9300 (outside the U.S. 1-703-527-3887)

Note: Safety data sheets meeting the requirements of 29 CFR 1910.1200(g) may be used to comply with this requirement to the extent they contain the information required by this subparagraph

1910.119(d)

Process Safety Information (PSI)

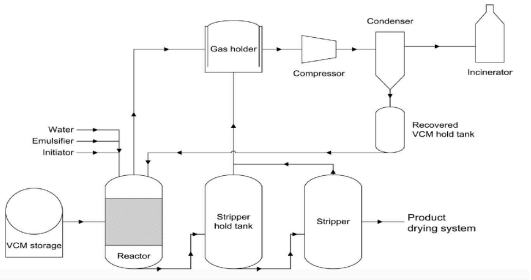
Information concerning the **TECHNOLOGY** of the process:

- ✓ Block flow diagram or simplified process flow diagram
- ✓ Process chemistry
- ✓ Maximum Intended Inventory (MII)
- ✓ **Safe upper and lower limits** for such items as temperatures, pressures, flows or compositions
- ✓ An evaluation of the consequences of deviations, including those affecting the S&H of workers
- ✓ Where the original technical information no longer exists, such information may be developed in conjunction with the PHA in sufficient detail to support the analysis

1910.119(d)

Process Safety Information (PSI)

- ✓ Block flow diagram or simplified process flow diagram



1910.119(d)

Process Safety Information (PSI)

✓Process chemistry

Reactions that produce acid anhydrides are dehydration reactions. For example: acetic acid (CH3COOH) forms acetic anhydride ((CH3CO)2O) and water by the dehydration reaction

2 CH3COOH → (CH3CO)2O + H2O

Dehydration reactions are also involved in the production of many polymers.

1910.119(d)

Process Safety Information (PSI)

✓Maximum Intended Inventory

Document the maximum intended inventory of any vessel in which you store or process a regulated substance above its threshold quantity. If you are not sure of the capacity of the vessel, you can obtain this information from the manufacturer of the vessel. In some cases, this information will be attached to the vessel itself.

You may want to check with any trade association or standards group that develops standards for your industry to determine if there are any limitations on inventories. For example, in some cases the maximum capacity of a tank may be 10,000 gallons, but an industry standard may recommend that the tank never be filled to more than 85 percent capacity. If you follow the standard, your maximum inventory would be 8,500 gallons.

1910.119(d)

Process Safety Information (PSI)

✓Safe upper and lower limits for such items as temperatures, pressures, flows or compositions

Tank 101

	Upper	Lower
TK-101 Level	85%	15%
TK-101 Pressure	130 psi	0 psi

NOTE: Base these on an evaluation of the consequences of deviations, including those affecting the S&H of workers

1910.119(d)

Process Safety Information (PSI)

Information pertaining to the **EQUIPMENT** in the process:

- ✓Materials of construction
- ✓Piping and instrument diagrams (P&ID's)
- ✓Electrical classification
- ✓Relief system design and design basis
- ✓Ventilation system design
- ✓Design codes and standards employed
- ✓Material and energy balances for processes built after May 26, 1992 and,
- ✓Safety systems (e.g. interlocks, detection or suppression systems)

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1910.119(d)

Process Safety Information (PSI)

✓Materials of construction

- ➢Hoses
- ➢Gaskets
- ➢Piping
- ➢Pumps
- ➢Vessels
- ➢Instruments

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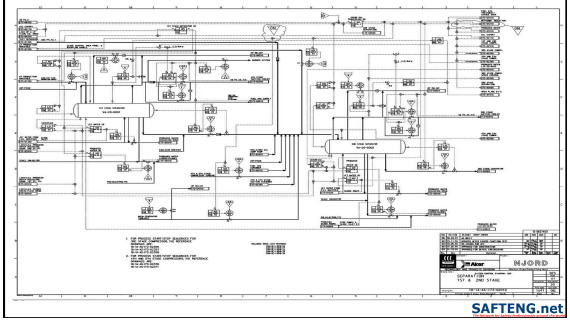
1910.119(d)

Process Safety Information (PSI)

✓Piping and instrument diagrams (P&ID's)



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1910.119(d)

Process Safety Information (PSI)

✓Electrical Classification

NFPA 497 *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas* 2008 Edition

Class I Locations

Class I locations are those in which flammable gases, flammable liquid–produced vapors, or combustible liquid–produced vapors are or may be present in the air in quantities sufficient to produce explosive or ignitible mixtures. Class I locations shall include those specified in 500.5(B)(1) and (B)(2).

Class II Locations

Class II locations are those that are hazardous because of the presence of combustible dust. Class II locations shall include those specified in 500.5(C)(1) and (C)(2).

Class III Locations

Class III locations are those that are hazardous because of the presence of easily ignitible fibers or where materials producing combustible flyings are handled, manufactured, or used, but in which such fibers/flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitible mixtures. Class III locations shall include those specified in 500.5(D)(1) and (D)(2).

1910.119(d)

Process Safety Information (PSI)

✓Electrical Classification

1 Class I, Division 1 is a location:

1. ignitible concentrations of flammable gases, vapors can exist under normal operating conditions, or
2. which ignitible concentrations of such flammable gases, vapors, or combustible liquids above their flash points may exist frequently because of repair or maintenance operations or because of leakage, or
3. which breakdown or faulty operation of equipment or processes might release ignitible concentrations of flammable gases, flammable liquid–produced vapors, or combustible liquid–produced vapors and might also cause simultaneous failure of electrical equipment in such a way as to directly cause the electrical equipment to become a source of ignition

1910.119(d)

Process Safety Information (PSI)

✓Electrical Classification

Class I, Division 2 location is a location:

1. which volatile flammable gases and/or vapors are handled, processed, or used, but in which the liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems or in case of abnormal operation of equipment, or
2. which ignitible concentrations of flammable gases and/or vapors are normally prevented by positive mechanical ventilation and which might become hazardous through failure or abnormal operation of the ventilating equipment, or
3. is adjacent to a Class I, Division 1 location, and to which ignitible concentrations of flammable gases and/or flammable liquids above their flash points might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

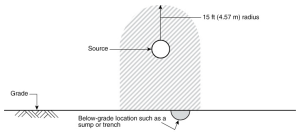
Informational Note No. 1: This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used but that, in the judgment of the authority having jurisdiction, would become hazardous only in case of an accident or of some unusual operating condition. The quantity of flammable material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location.

Informational Note No. 2: Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Depending on factors such as the quantity and size of the containers and ventilation, locations used for the storage of flammable liquids or liquefied or compressed gases in sealed containers may be considered either hazardous (classified) or unclassified locations. See NFPA 30-2015, Flammable and Combustible Liquids Code, and NFPA 58-2014, Liquefied Petroleum Gas Code.

1910.119(d)

Process Safety Information (PSI)

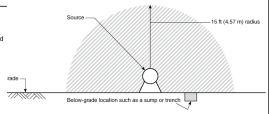
✓Electrical Classification



Material: Flammable liquid, liquefied flammable gas, compressed flammable gas, and cryogenic liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure		X	X
Flow rate	X	X	

Division 1
Division 2



Material: Flammable liquid, liquefied flammable gas, compressed flammable gas, and cryogenic liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure		X	X
Flow rate	X	X	

Division 1
Division 2

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1910.119(d)

Process Safety Information (PSI)

✓Relief system design and design basis

- ➢RAGAGEP used
- ➢Fire Scenario or Blocked-In Scenario
- ➢Rupture Disc vs. Relief Valve vs. Dual System
- ➢Header vs. Direct to ATM
- ➢Sizing Calcs based on chosen worst case scenario
- ➢RV/RD Set Point(s)

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1910.119(d)

Process Safety Information (PSI)

✓Ventilation system design (DuPont/Honeywell)

- ✓Provide mechanical ventilation at filling zones and storage areas or other locations where leakage is probable
- ✓Determine if existing local ventilation is adequate for other operating and storage areas
- ✓Ventilation rate should prevent vapor–air concentrations **BELOW 25% of LFL**

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1910.119(d)

Process Safety Information (PSI)

✓For example, NFPA 497 *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, 2008 Edition defines adequate ventilation as a ventilation rate that affords either 6 air changes per hour, or **1 cfm per 1 sq. ft. of floor area**, or other similar criteria that **prevent the accumulation of significant quantities of vapor–air concentrations from exceeding 25% of LFL**.

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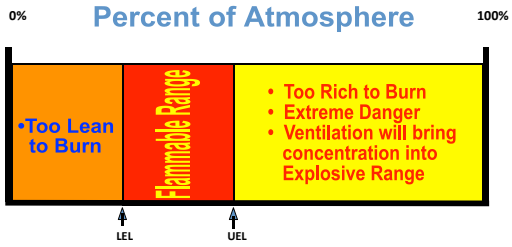
Flammable Properties



CAUTION!

It should be noted that many LELs and UELs are theoretical calculations and, accordingly, should be regarded as guide values only!!!!!

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1910.119(d)

Process Safety Information (PSI)

✓Design codes and standards employed

- ASME Section VIII
- ANSI B31.3
- NFPA 58
- NFPA 497
- NFPA 70
- IP-2: Hose Handbook (Eighth Edition, 2009)
- ANSI/ISA-84.01 – 2004
- ANSI/ASHRAE Addendum ak to ANSI/ASHRAE Standard 34-2007
- API 510, 570, 520

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1910.119(d)

Process Safety Information (PSI)

- ✓Material and energy balances for processes built **after May 26, 1992**
  - ✓Chemical reactions play a vital role in manufacturing process. For design of chemical process equipment, the operating conditions such as pressure, temperature, composition and flow of the streams should be known.
  - ✓The material balance and energy balance calculations come to the rescue of the designer and allows him to calculate the various flow rates and temperature of the streams.

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1910.119(d)

Process Safety Information (PSI)

- ✓Safety systems (e.g. interlocks, detection or suppression systems)
  - ➢Level and Pressure Interlocks and Alarms
  - ➢Relief System(s)
  - ➢Gas Detection
  - ➢Ventilation System(s)
  - ➢Bonding and Grounding Systems
  - ➢Safety Showers/Eye Wash
  - ➢Sprinklers?, Monitor Nozzles?, Deluge Systems?
  - ➢Secondary Containment
  - ➢Flare, Scrubber, Diffuser Tank, etc.

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1910.119(d)

Process Safety Information (PSI)

- Document that equipment complies with **R**ecognized **A**nd **G**enerally **A**ccepted **G**ood **E**ngineering **P**ractices (RAGAGEP)
- 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

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1910.119(e)

Process Hazard Analysis (PHA)

- PHA shall be appropriate to the complexity of the process and shall **IDENTIFY**, **EVALUATE**, and **CONTROL THE HAZARDS** involved in the process
- Determine and document the **priority order** for conducting PHA(s) based on a rationale which includes such considerations as
  - extent of the process hazards,
  - number of potentially affected employees,
  - age of the process, and
  - operating history of the process

1910.119(e)

Process Hazard Analysis (PHA)

- Use one or more of the following methodologies that are appropriate to determine and evaluate the hazards of the process being analyzed.
  - What-If
  - Checklist
  - What-If/Checklist
  - Hazard and Operability Study (HAZOP)
  - Failure Mode and Effects Analysis (FMEA)
  - Fault Tree Analysis
  - An appropriate equivalent methodology

1910.119(e)

Process Hazard Analysis (PHA)

- PHA shall address:
  - **HAZARDS** of the process
  - **PREVIOUS INCIDENT(S)** which had a likely potential for catastrophic consequences
  - **ENGINEERING AND ADMINISTRATIVE CONTROLS** applicable to the hazards and their interrelationships such as appropriate application of detection methodologies to provide early warning of releases.
  - **CONSEQUENCES OF FAILURE** of engineering & admin controls
  - Facility Siting & Human Factors
  - A qualitative evaluation of a range of the possible S&H effects of failure of controls on workers

1910.119(e)

Process Hazard Analysis (PHA)

- PHA team MUST have **expertise in engineering and process operations**
  - **at least one employee who has experience and knowledge** specific to the process
  - one member **knowledgeable in the specific PHA methodology**
- Establish **a system to promptly address** the team's recommendations
- Recommendations are resolved in a **timely manner** and the **resolution is documented**
  - Document what actions are to be taken
  - Complete actions as soon as possible
  - Develop a written schedule of when these actions are to be completed

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1910.119(e)

Process Hazard Analysis (PHA)

- Communicate the actions to **ALL** personnel whose work assignments are in the process and who may be affected by the recommendations or actions
- **At least every five (5) years** after the completion of the initial PHA, the PHA shall be updated and revalidated by a team meeting the requirements in paragraph (e)(4) to assure that the PHA is consistent with the current process.
- Employers shall retain PHA(s) and updates or revalidations, as well as the documented resolution of recommendations described in paragraph (e)(5) of this section for the **LIFE OF THE PROCESS**

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1910.119(f)

Operating Procedures (SOP)

- Develop and implement **WRITTEN** SOPs 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.
- **Steps for each operating phase**:
  - ✓ Initial startup
  - ✓ Normal operations
  - ✓ Temporary operations
  - ✓ Emergency shutdown including the conditions under which emergency shutdown is required and assignment of shutdown responsibilities to ensure that ESD is executed in a safe and timely manner.
  - ✓ Emergency Operations
  - ✓ Normal shutdown
  - ✓ Startup following a turnaround, or after an emergency shutdown.

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1910.119(f)

Operating Procedures (SOP)

Operating limits:

- Consequences of deviation
- Steps required to correct or avoid deviation

Safety and health considerations:

- Properties and hazards presented by chemicals
- Precautions necessary to prevent exposure, including engineering controls, administrative controls, and PPE
- Control measures to be taken if exposure occurs
- Quality control for raw materials and inventory levels
- Any special or unique hazards

Safety systems and their functions

1910.119(f)

Operating Procedures (SOP)

- SOPs shall be **READILY ACCESSIBLE** to employees who work in or maintain a process
- SOPs shall be **REVIEWED AS OFTEN AS NECESSARY** to assure that they reflect current operating practice, including changes that result from changes in process chemicals, technology, and equipment, and changes to facilities.
- **CERTIFY ANNUALLY** that operating procedures are current and accurate

1910.119(f)

Operating Procedures (SOP)

- Develop and implement safe work practices (SWP) to provide for the control of hazards during operations such as
  - Lockout/tagout
  - Confined space entry
  - Opening process equipment or piping; and
  - Control over entrance into a facility by maintenance, contractor, laboratory, or other support personnel
- SWPs shall **APPLY TO EMPLOYEES AND CONTRACTOR** employees

1910.119(g)

Training

Initial Training

- Each employee presently involved in operating a process, and each employee **BEFORE** being involved in operating a newly assigned process, shall be trained in:
  - overview of the process and
  - operating procedures
- Training shall include **EMPHASIS** on:
  - specific safety and health hazards,
  - emergency operations including shutdown, and
  - safe work practices applicable to the employee's job tasks.

1910.119(g)

Training

- In lieu of initial training for those employees already involved in operating a process on May 26, 1992, an employer may certify in writing that the employee has the required knowledge, skills, and abilities to safely carry out the duties and responsibilities as specified in the operating procedures.

1910.119(g)

Training

Refresher Training

- Provided **AT LEAST EVERY THREE** (3) years, and more often if necessary, to each employee involved in operating a process to assure that the employee understands and adheres to the current operating procedures of the process.
- **In consultation with the employees** involved in operating the process, determine the appropriate frequency of refresher training.

1910.119(g)

Training

Training Documentation

- Ascertain that each employee involved in operating a process has **RECEIVED AND UNDERSTOOD** the training
- Prepare a record which contains the:
  - **Identity** of the employee
  - **Date** of training, and
  - **MEANS USED TO VERIFY** that the employee understood the training

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1910.119(h)

Contractors

- Applies to contractors performing *maintenance or repair, turnaround, major renovation, or specialty work* ***on or adjacent to a covered process***.
- It does **NOT** apply to contractors providing incidental services which do **NOT** influence process safety, such as janitorial work, food and drink services, laundry, delivery or other supply services

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1910.119(h)

Contractors

Employer Responsibilities

- **OBTAIN** and **EVALUATE** information regarding the contract employer's safety performance and programs.
- **INFORM** contract employers of the known potential fire, explosion, or toxic release hazards related to the contractor's work and the process.
- **EXPLAIN** applicable provisions of the emergency action plan required by paragraph (n) of this section.
- **DEVELOP** and **IMPLEMENT** safe work practices to control the entrance, presence and exit of contractors in covered process areas.
- **PERIODICALLY EVALUATE** the performance of contract employers in fulfilling their obligations as specified in paragraph (h)(3) of this section.
- **MAINTAIN** a contract employee injury and illness log related to the contractor's work in process areas.

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1910.119(h)

Contractors

Contractor Employer Responsibilities

- Assure that each contract employee is **trained in the work practices** necessary to safely perform his/her job.
- Assure that each contract employee **is instructed in the known potential fire, explosion, or toxic release hazards related to his/her job and the process**, and the applicable provisions of the **emergency action plan**
- **Document** that each contract employee has **received and understood the training**
- Prepare a record which contains
  - the **identity** of the contract employee,
  - the **date** of training, and
  - the **means used to verify that the employee understood the training**
- Assure that **each contract employee follows the safety rules** of the facility including the safe work practices
- Advise the host employer of any **unique hazards presented by the contract employer's** work, or of any hazards found by the contract employer's work

1910.119(i)

Pre-Startup Safety Review (PSSR)

- Employer shall perform a PSSR for **NEW** facilities and for **MODIFIED** facilities when the ***modification is significant enough to require a change in the PSI***
- PSSR shall confirm that **prior to the introduction of the HHC to a process**:
  - Construction and equipment is **in accordance with design specifications**
  - SWPs, SOPs, Maintenance procedures, and emergency procedures **are in place and are adequ**ate
  - For new facilities, a PHA has been performed and recommendations have been resolved or implemented **BEFORE** startup
  - Modified facilities meet the requirements contained in the management of change review
  - Training of **each employee involved in operating a process** has been completed

1910.119(j)

Mechanical Integrity (MI)

Application

- Applies to the following process equipment:
  - Pressure vessels and storage tanks
  - Piping systems (including piping components such as valves)
  - Relief and vent systems and devices
  - Emergency shutdown systems
  - Controls (including monitoring devices and sensors, alarms, and interlocks) and,
  - Pumps

1910.119(j)

Mechanical Integrity (MI)

Written Procedures

- **Establish and implement written procedures** to maintain the on-going integrity of process equipment

Training for process maintenance activities

- Train each employee involved in maintaining the on-going integrity of process equipment in an **overview of that process and its hazards** and in the **procedures applicable to the employee's job tasks** to assure that the employee can perform the job tasks in a safe manner.

1910.119(j)

Mechanical Integrity (MI)

Inspection and testing

- Shall be performed on process equipment
- Shall follow RAGAGEP
- Frequency shall be consistent with **manufacturers' recommendations** and RAGAGEP
  - more frequently if determined to be necessary by experience
- Document EACH inspection/Test
- Documentation shall identify
  - **DATE** of the inspection/test
  - name of the **PERSON** who performed the inspection/test
  - **SERIAL NUMBER** or other identifier of the equipment on which the inspection or test was performed
  - **DESCRIPTION** of the inspection or test performed
  - **RESULTS** of the inspection or test

1910.119(j)

Mechanical Integrity (MI)

Equipment Deficiencies

- **CORRECT DEFICIENCIES** in equipment that are outside acceptable limits (defined by the PSI) **BEOFRE** further use ***OR*** in **A SAFE AND TIMELY** manner when necessary means are taken to assure safe operation.

Quality Assurance

- In the construction of new plants and equipment, assure that **equipment as it is fabricated is suitable** for the process application for which they will be used.
- **Appropriate checks and inspections shall be performed** to assure that equipment is installed properly and consistent with design specifications and the manufacturer's instructions.
- Assure that maintenance **materials, spare parts and equipment are suitable for the process** application for which they will be used.

Hot Work Permit (HW)

1910.119(k)

- Employer shall issue a hot work permit for hot work operations conducted **ON** or **NEAR** a covered process
- Permit shall document that the fire prevention and protection requirements in **29 CFR 1910.252(a)** have been implemented **PRIOR** to beginning the hot work operations
- Permit shall indicate
  - **DATE(s)** authorized for hot work
  - **IDENTIFY THE OBJECT** on which hot work is to be performed
- Permit shall be kept on file until completion of the HW

Management of Change (MOC)

1910.119(l)

- Establish and implement written procedures to manage changes (except for "replacements in kind") to
  - process chemicals
  - Technology
  - equipment
  - procedures
  - changes to facilities that affect a covered process
- Procedures shall assure that the following considerations are addressed prior to any change:
  - Technical basis for the proposed change
  - Impact of change on S&H
  - Modifications to operating procedures
  - Necessary time period for the change; and
  - Authorization requirements for the proposed change

Incident Investigation (II)

1910.119(m)

- Investigate each incident which resulted in, or could reasonably have resulted in a catastrophic release of highly hazardous chemical in the workplace.
- An incident investigation shall be initiated as promptly as possible, but not later than 48 hours following the incident.
- An incident investigation team shall be established and consist of at least one person knowledgeable in the process involved, including a contract employee if the incident involved work of the contractor, and other persons with appropriate knowledge and experience to thoroughly investigate and analyze the incident.

1910.119(m)

Incident Investigation (II)

- A report shall be prepared at the conclusion of the investigation which includes at a minimum:
  - Date of incident
  - Date investigation began
  - Description of the incident
  - Factors that contributed to the incident
  - Recommendations resulting from the investigation
- Establish a system to promptly address and resolve the incident report findings and recommendations.
- Resolutions and corrective actions shall be documented.
- Report shall be reviewed with all affected personnel whose job tasks are relevant to the incident findings including contract employees where applicable.
- Incident investigation reports shall be retained for five years.

1910.119(n)

Emergency Planning and Response

- Establish and implement an emergency action plan for the entire plant in accordance with the provisions of 29 CFR 1910.38.
  - EAP 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).

1910.119(o)

Compliance Audits (CA)

- Certify they have evaluated compliance with the PSM provisions
- **At least every three (3) years** to verify that the procedures and practices developed under the standard are adequate and are being followed
- Audit shall be conducted by at least **one (1) person knowledgeable in the process**
- A report of the findings of the audit shall be developed
- Promptly determine **and document an appropriate response to each of the findings** of the compliance audit, and **DOCUMENT THAT DEFICIENCIES HAVE BEEN CORRECTED**
- Retain the two (2) most recent compliance audit reports

1910.119(p)

Trade Secrets (TS)

- Make all information necessary to comply with PSM available to:
  - those persons responsible for compiling the PSI,
  - those assisting in the development of the PHA,
  - those responsible for developing the SOPs, and
  - those involved in incident investigations, emergency planning and response and compliance without regard to possible trade secret status of such information.
- Nothing in this paragraph shall preclude the employer from requiring the persons to whom the information is made available to enter into confidentiality agreements not to disclose the information

AP Images/Matt Slocum

Process Safety is a team effort. Know your role and work with your fellow employees to protect yourself and others.

Know the hazards associated with mixing, separating, or storing process materials, including:

- Which chemicals are reactive or able to cause a runaway reaction.
- Toxic, fire, or explosive hazards associated with your process chemicals.
- What to do during an incident or unusual process condition.

Be aware of equipment operation and maintenance requirements, including:

- Signs of corrosion, leakage, or other signs of equipment problems.
- Who to alert when you see a problem.

Know your process:

- Follow operating, safety, and emergency procedures.
- Keep up-to-date with changes to procedures, equipment, and chemicals.
- Provide feedback – report all incidents and near misses.

For more information on OSHA's Process Safety Management Standard, visit www.osha.gov.

For more complete information:

OSHA® Occupational Safety and Health Administration

U.S. Department of Labor

www.osha.gov (800) 321-OSHA

OSHA 3315-01N-09

Rules of the Course

- This is an Open Discussion Course
  - Relax and Learn
  - Ask Questions
  - Participate in Discussions
  - Share Experiences
  - Share Best Practices
  - Enjoy Yourself

Course Outline & Schedule

Day 1

- History of Process Safety
- Application of 29 CFR 1910.119
  - Exemptions
- Key Definitions
- Employee participation (1910.119(c)
- Process safety information (1910.119(d)
- Process Hazards Analysis

Course Outline & Schedule

Day 2

- Operating Procedures
  - Safe work practices
- Training
  - Initial & Refresher training, Testing & Documentation
- Contractors
  - Host Employer & Contract Employer responsibilities
- Pre-startup safety review
  - New & Modified facilities
- Mechanical integrity

Course Outline & Schedule

Day 3

- Hot work permit
- Management of change
- Incident investigation
- Emergency planning and response
- Compliance Audits
- Trade secrets
- EPA's Risk Management (if applicable)
- OSHA & EPA Resources

History of PSM Catastrophes

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.

These incidents lead to the passage of the Process Safety Management Rule in May 1992.

History of PSM Standard

1984 Toxic chemical release in **Bhopal, India**, kills over 4,000 people

1985 Release from a chemical plant in **Institute, West Virginia**, injures 135

American Institute of Chemical Engineers forms the Center for Chemical Process Safety and publishes Guidelines for Hazard Evaluation Procedures

1989 **Phillips Chemical Plant** explosion kills 23, injures 132

1990 **Arco Chemical plant explosion** kills 17 workers, flattened an area the size of a city block

American Petroleum Institute (API) publishes Management of Process Hazards voluntary guidelines

OSHA releases a Proposed Safety Standard based on the API Guidelines and Recommendations

Congress passes the Clean Air Act Amendments, which mandate that OSHA enact process safety rules covering 14 specific areas

1990 **Cincinnati, OH** vapor cloud explosion kills 2 @ BASF

1991 **Sterlington, LA** Waste Gas Explosion kills 8 and 128 injuries @ Angus Chemical Company

1991 OSHA releases study of the effects of using contract workers in the petrochemical industry.

1992 The final OSHA PSM Standard is issued. One year later, EPA released its Risk Management Program Regulation.

Why Did OSHA Develop PSM?

- Standard contains requirements for preventing or minimizing the consequences of catastrophic releases of chemicals that are:
  - Toxic,
  - Reactive,
  - Flammable,
  - Explosive

- These releases may result in toxic, fire or explosion hazards

- A number of catastrophic accidents have occurred resulting in loss of life and great property damage.

Ammonium Nitrate Explosion

Oppau, Germany – Sept. 21, 1921

Photo shows crater and destruction at plant following explosion. At 7:30 a.m. on September 21, 1921, two powerful explosions occurred at the BASF plant in Oppau, Germany.

Hazardous material: Ammonium sulfate & ammonium nitrate (50/50)

Facility type: fertilizer manufacturing

Deaths: 430-530 (differing numbers on reported fatalities)

Ammonium Nitrate Explosion

Texas City, Texas – April 16, 1947

This aerial photograph, looking south over Monsanto Chemical Co., was taken about 30 minutes following the blast of the ship S. S. GRANDCAMP during loading of ammonium nitrate. The accident damaged more than 90% of the city's buildings and killed nearly 600 people.

Major PSM related incidents

1974 - 2001

Location of Accident	Date	Type of Event	Some Resulting Consequences	Regulatory Response
Flixborough, UK	1974	Explosion and fire	28 killed, over 100 injured	COMAH 1984
Seveso, Italy	1976	Runaway reaction	Large Dioxin environment contamination massive evacuations, Large animal kill	Initial Seveso Directive
Bhopal, India	1984	Runaway MIC reaction	~ 2500 people killed and 100,000 injured, high litigation costs	USA Emerg. Planning & Community Right to know Act- CMA CAER Program
Basel, Switzerland	1986	Warehouse Fire	Massive contamination of Rhine and very large fish kill	Changes in Seveso Directive
Pasadena, USA	1989	Explosion and fire	23 deaths, ~ 100 injured Over $1 billion in losses	Triggered 1990 USA CAAct & RMP & PSM process Stds
Longford, Victoria, Australia	1998	Explosions and fires	Two deaths, gas supply to Melbourne cut for 19 days. Losses over $1.3 Billion	Process Regulatory initiatives Victoria
Enschede, The Netherlands	2000	Explosion and fire	22 deaths, ~ 1000 injured, 350 houses and factories destroyed	Changes in Seveso Directive
Toulouse, France (Oppau[c] & Texas City[d])	2001	Explosion and fire	30 deaths, ~ 2000 injured, 600 homes destroyed, 2 schools demolished	Changes in Seveso Directive

Source: Wharton Risk Management and Decision Processes Center of the University of Pennsylvania.

Seveso, Italy - 1976

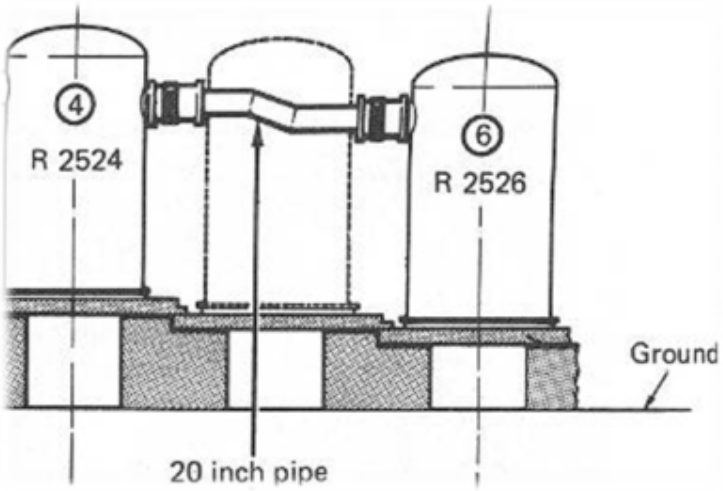
The Seveso accident happened in 1976 at a chemical plant manufacturing pesticides and herbicides. A dense vapor cloud containing tetrachlorodibenzoparadioxin (Dioxin) was released from a reactor, used for the production of trichlorofenol.

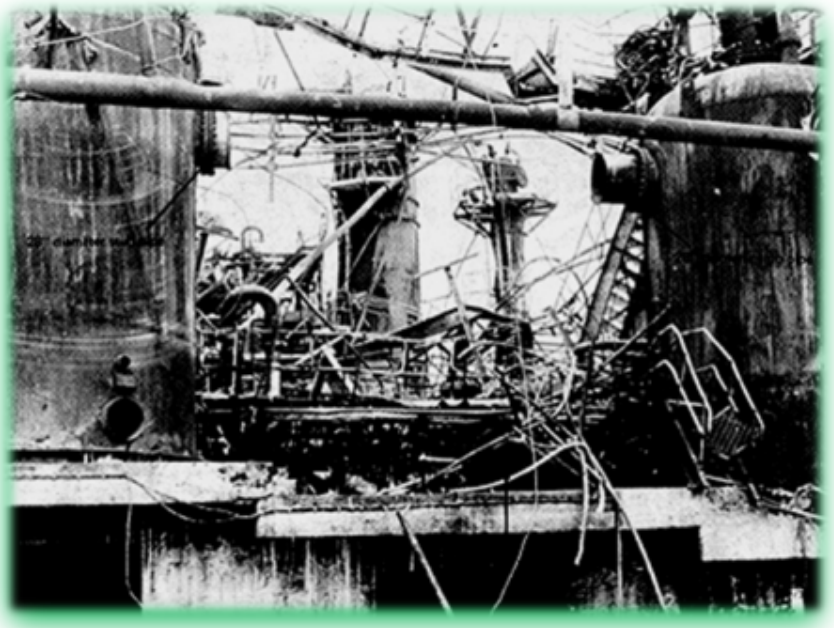
Commonly known as dioxin, this was a poisonous and carcinogenic by-product of an uncontrolled exothermic reaction. Although no immediate fatalities were reported, kilogram quantities of the substance lethal to man even in microgram doses were widely dispersed which resulted in an immediate contamination of some ten square miles of land and vegetation.

More than 600 people had to be evacuated from their homes and as many as 2,000 were treated for dioxin poisoning. This lead to the European “Seveso Directive” to try to prevent similar incidents.

Cyclohexane Release & Explosion

Flixborough, England – June 1, 1974





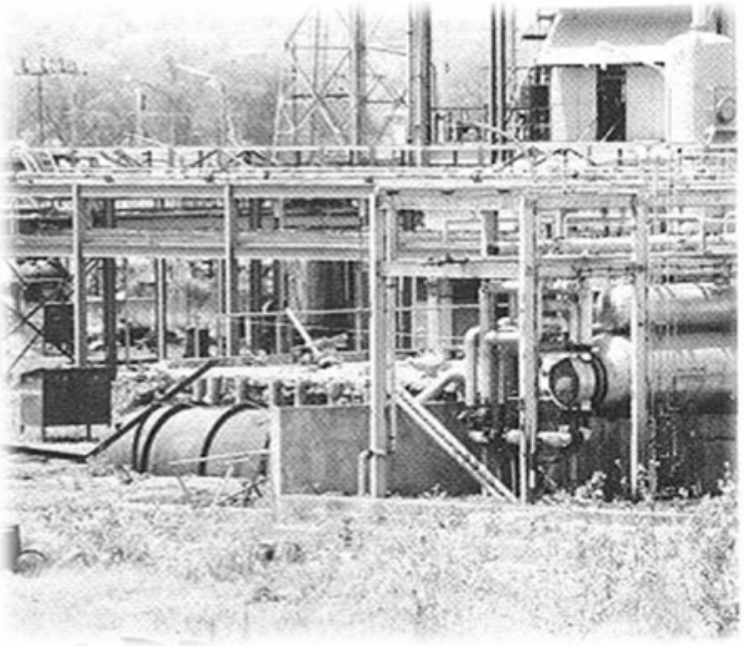
On June 1, 1974 the Nypro Co. site at Flixborough, England was severely damaged by a large explosion. Twenty-eight workers were killed and a further 36 suffered injuries. It is recognized that the number of casualties would have been more if the incident had occurred on a weekday, as the main office block was not occupied. Offsite consequences resulted in fifty-three reported injuries. Property in the surrounding area was damaged to a varying degree.

Methyl Isocyanate Release

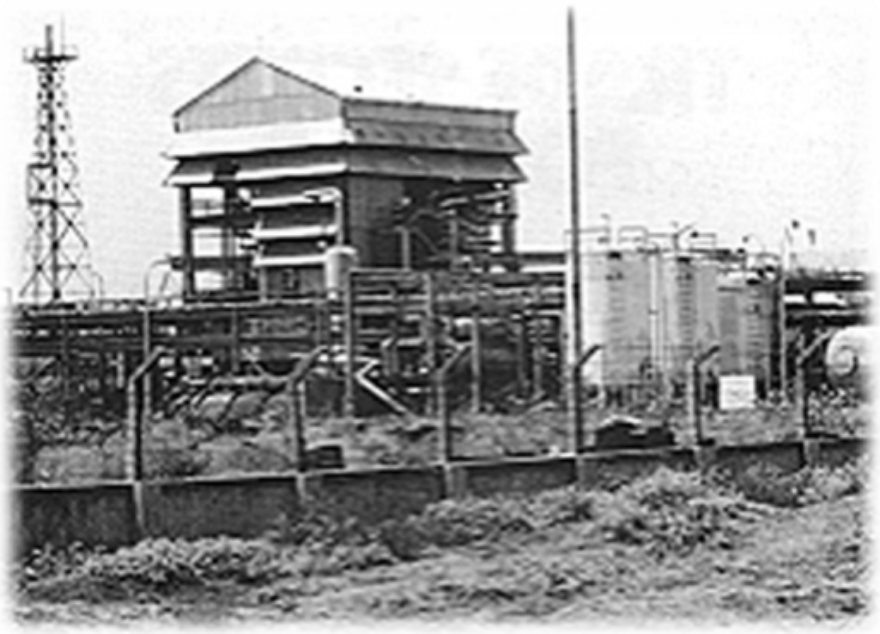
Bhopal, India – Dec. 2-3, 1984

On the night of December 2-3, 1984, a sudden release of about 30 metric tons of methyl isocyanate (MIC) occurred at the Union Carbide pesticide plant at Bhopal, India. The accident was a result of poor safety management practices, poor early warning systems, and the lack of community preparedness. The accident led to the death of over 2,800 people (other estimates put the immediate death toll as high as 8000) living in the vicinity and caused respiratory damage and eye damage to over 20,000 others. At least 200,000 people fled Bhopal during the week after the accident. Estimates of the damage vary widely between $350 million to as high as $3 billion.

Bhopal Aftermath



Water entered “Tank 610” in foreground of picture reacting with MIC and caused an uncontrolled release of a vapor cloud.



Bhopal flare tower with corroded and missing section of pipe. Plant enclosed by fence in foreground.

Phillips 66 Houston Chemical Complex

Pasadena, Texas – Oct. 23, 1989

On October 23, 1989, at approximately 1:00 p.m., an explosion and fire ripped through the Phillips 66 Company Houston Chemical Complex in Pasadena, Texas. Twenty-three workers were killed and more than 130 were injured. Property damage was nearly three-quarters of a billion dollars. The accident resulted from a release of extremely flammable process gases that occurred during regular maintenance operations on one of the plant's polyethylene reactors. The evidence showed that more than 85,000 pounds of highly flammable gases were released through an open valve. A vapor cloud formed and traveled rapidly through the polyethylene plant. Within 90 to 120 seconds, the vapor cloud came into contact with an ignition source and exploded with the force of 2.4 tons of TNT.

This event AND Bhopal triggered the development of the PSM standard

BP Refinery Explosion – Texas City, TX

March 23, 2005

At approximately 1:20 p.m. on March 23, 2005, a series of explosions occurred at the BP Texas City refinery during the restarting of a hydrocarbon isomerization unit. Fifteen workers were killed and 180 others were injured. Many of the victims were in or around work trailers located near an atmospheric vent stack. The explosions occurred when a distillation tower flooded with hydrocarbons and was overpressurized, causing a geyser-like release from the vent stack.

Summary of Chemical Accidents

1994-1999

# of Facilities & Processes	15,430 facilities	(20,588 covered processes)
Facilities with at least 1 accident in 5 yr period	1,205 (7. 8%)	(2.3% multiple Accidents)
Total number of Accidents	1969	(394 event per year)
Deaths (Workers)	32	
Injuries (Workers)	1987	
Injuries (Public & First Responders)	167 injuries, 215 hospitalizations, 6,057 medical care (over 200,000 evacuated & shelter-in-place)	
Property damage	~ $1 billion, (Total estimated at ~ $5 to 10 billion including business interruption, and other losses associated with accidents)	
Ecological damage	104 accidents with significant damage	
Off site property damage	$11.7 million	

Source: Kleindorfer, P., Belke, J., Elliott, M., Lee, K., Lowe, R., Feldman, H.,"Accident Epidemiology & U.S. Chemical Industry: Accident History & Worst-Case Data from RMP*Info", Risk Analysis, Vol.23, No 4, 2003, pp 865-881.

Honda PSM/RMP HHC/EHS's

	HFO-1234yf*	Ammonia	Propane
Molecular Formula	$C_3H_2F_4$	NH_3	C_3H_8
Appearance (@ Std Temp & Pressure)	colorless gas	colorless gas	colorless gas
Boiling Point (@ Std Temp & Pressure)	−29°C (−22°F)	-33°C (-28°F)	-42°C (-44°F)
Vapor Pressure (@ Std Temp & Pressure)	4,551 mmHg	6,500 mmHg	7,500 mmHg
Flammable Range	6% - 12%	16% - 28%	2%-10%
Vapor Density (Air = 1)	4 ↓	0.7 ↑	1.6 ↓
Autoignition Temperature	405°C (761°F)	651°C (1,204°F)	470°C (878°F)
Minimum Ignition Energy (mJ)	5,000	680	0.25

PSM Development

In 1991, OSHA and EPA respectively, released the standards, PSM & RMP that applies to facilities that are affected by the standards.

Purpose of PSM?

Process Safety Management is a regulation, promulgated by OSHA, intended to prevent an incident like the 1984 Bhopal Disaster

And…to Prevent Release of:

- Toxic,
- Reactive,
- Flammable, or
- Explosive chemicals

Not Only PSM, But RMP

A great many industrial facilities must comply with OSHA's Process Safety Management (PSM) regulations as well as the quite similar EPA Risk Management Program (RMP) regulations (Title 40 CFR Part 68).

PSM vs. RMP - What's the Difference?

- **PSM**
  - Protects Workers
  - "Inside the fence"
- **RMP**
  - Protects the Community
  - "Outside the fence"

PSM Standard Is "Performance-Based"

- The PSM Standard is a **performance-based standard**. That means it is goal-oriented and what you should judge is a program's effectiveness.

- The exact specifications are **NOT** spelled out

- The PSM Standard gives each facility the flexibility to design its own program to match its needs, as long as the outcome prevents or minimizes major releases, spills, fires, and explosions.

- Specification-based OSHA standards prescribe precise rules, such as a guardrail's height, exact limits of exposure, etc.

What Facilities are Covered

- A process which involves a chemical at or above the specified threshold quantities listed in **Appendix A: *A List of highly hazardous chemicals, toxics and reactive***
  - Contains a listing of toxic and reactive highly hazardous chemicals which present a potential for a catastrophic event at or above the threshold quantity

Examples:

Chemicals	Threshold Quantity (TQ)
Anhydrous Ammonia	**10,000 lbs**
Chlorine	1,500 lbs
Flammables	**10,000 lbs**

What Facilities are Covered

- 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

1910.1200 Flammable Gases

Flammable gas means a gas having a flammable range with air at 20°C (68°F) and a standard pressure of 101.3 kPa (14.7 psi).

OSHA's CRITERIA FOR FLAMMABLE GASES (1910.1200 Appendix B)	
Category	**Criteria**
1	Gases, which at 20°C (68°F) and a standard pressure of 101.3 kPa (14.7 psi): (a) are ignitable when in a mixture of 13% or less by volume in air; or (b) have a flammable range with air of at least 12 percentage points regardless of the lower flammable limit.
2	Gases, other than those of Category 1, which, at 20°C (68°F) and a standard pressure of 101.3 kPa (14.7 psi), have a flammable range while mixed in air.

Which category of flammable gases is 2,3,3-Tetrafluoropropene (HFO-1234yf) and Propane/LPG?

Exceptions

- 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**

Exceptions

- PSM Standard does **NOT** apply to:
  - Retail facilities
  - Oil or gas well drilling or servicing operations
  - Normally unoccupied remote facilities

Exceptions - The Meer Decision

- Court decision implemented by directive

- Language in standard for flammable liquids "unconstitutionally vague"

  MEER ruling and the MEER Memorandum addressed in the Secretary's letter, OSHA's enforcement policy that the Agency would not cite employers for violations of 1910.119 where stored flammable liquids in atmospheric tanks were connected to a process, unless the process outside of the amount in storage contained more than 10,000 pounds of the substance

RECENT CHANGES w/ PSM

(2015)

- Covered Concentrations (1% Rule)
- RAGAGEP (Shall and Should)
- Retail Exemption GONE! (Court Overturned in October 2016)

Key Definitions

Atmospheric tank means a storage tank which has been designed to operate at pressures from atmospheric through 0.5 p.s.i.g. (pounds per square inch gauge, 3.45 Kpa).

Catastrophic release means a major uncontrolled emission, fire, or explosion, involving one or more highly hazardous chemicals, that presents serious danger to employees in the workplace.

Facility means the buildings, containers or equipment which contain a process.

Key Definitions

Highly hazardous chemical means a substance possessing toxic, reactive, flammable, or explosive properties and specified by paragraph (a)(1) of this section.

Hot work means work involving electric or gas welding, cutting, brazing, or similar flame or spark-producing operations.

Key Definitions (cont.)

Normally unoccupied remote facility means a facility which is operated, maintained or serviced by employees who visit the facility only periodically to check its operation and to perform necessary operating or maintenance tasks. No employees are permanently stationed at the facility. Facilities meeting this definition are not contiguous with, and must be geographically remote from all other buildings, processes or persons.

Key Definitions (cont.)

Process means any activity involving a highly hazardous chemical including any use, storage, manufacturing, handling, or the on-site movement of such chemicals, or combination of these activities. **For purposes of this definition, any group of vessels which are interconnected and separate vessels which are located such that a highly hazardous chemical could be involved in a potential release shall be considered a single process.**

Replacement in kind means a replacement which satisfies the design specification.

Employee Participation (EP)

- Develop a **written plan of action** regarding the implementation of EP

- **Consult with employees and their representatives** on the conduct and development of PHAs and on the development of the other PSM elements

- Provide to employees and their representatives **access to PHA(s)** and to **ALL other PSM information**

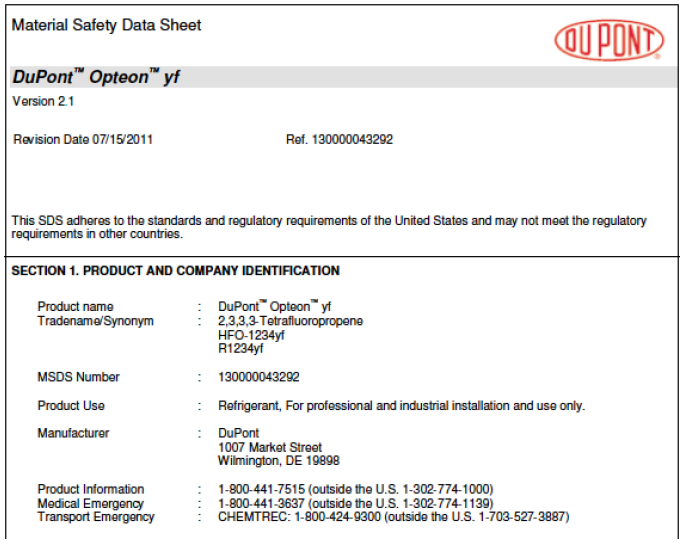
Process Safety Information (PSI)

- Complete a compilation of written **PSI <u>BEFORE conducting any PHA</u>**
- PSI is to enable the employer/employees involved in operating the process to **<u>identify and understand the hazards</u>** posed by those processes
- PSI shall include:
  - information pertaining to the **<u>HAZARDS</u>** of the HHC used or produced by the process,
  - information pertaining to the **<u>TECHNOLOGY</u>** of the process, and
  - information pertaining to the **<u>EQUIPMENT</u>** in the process

Process Safety Information (PSI)

Information pertaining to the **HAZARDS** of the HHCs shall consist of at least the following:

- ✓ Toxicity information
- ✓ Permissible exposure limits
- ✓ Physical data
- ✓ Reactivity data
- ✓ Corrosivity data
- ✓ Thermal and chemical stability data
- ✓ Hazardous effects of inadvertent mixing of different materials that could foreseeably occur



Material Safety Data Sheet

DuPont™ Opteon™ yf

Version 2.1

Revision Date 07/15/2011 Ref. 130000043292

This SDS adheres to the standards and regulatory requirements of the United States and may not meet the regulatory requirements in other countries.

SECTION 1. PRODUCT AND COMPANY IDENTIFICATION

Product name	:	DuPont™ Opteon™ yf
Tradename/Synonym	:	2,3,3,3-Tetrafluoropropene HFO-1234yf R1234yf
MSDS Number	:	130000043292
Product Use	:	Refrigerant, For professional and industrial installation and use only.
Manufacturer	:	DuPont 1007 Market Street Wilmington, DE 19898
Product Information	:	1-800-441-7515 (outside the U.S. 1-302-774-1000)
Medical Emergency	:	1-800-441-3637 (outside the U.S. 1-302-774-1139)
Transport Emergency	:	CHEMTREC: 1-800-424-9300 (outside the U.S. 1-703-527-3887)

Note: Safety data sheets meeting the requirements of 29 CFR 1910.1200(g) may be used to comply with this requirement to the extent they contain the information required by this subparagraph

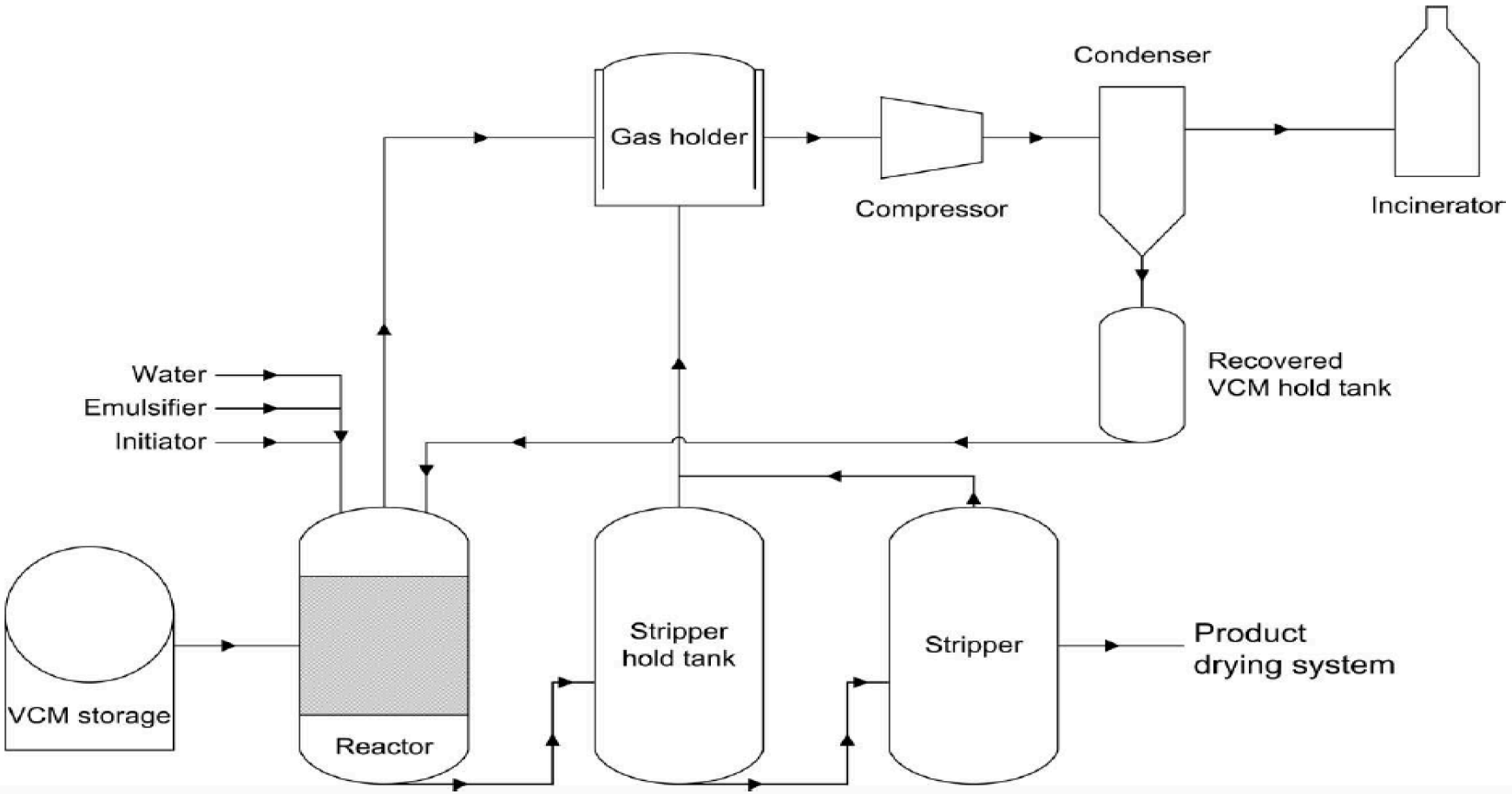
Process Safety Information (PSI)

Information concerning the **TECHNOLOGY** of the process:

- ✓ Block flow diagram or simplified process flow diagram
- ✓ Process chemistry
- ✓ Maximum Intended Inventory (MII)
- ✓ **Safe upper and lower limits** for such items as temperatures, pressures, flows or compositions
- ✓ An evaluation of the consequences of deviations, including those affecting the S&H of workers
- ✓ Where the original technical information no longer exists, such information may be developed in conjunction with the PHA in sufficient detail to support the analysis

Process Safety Information (PSI)

- ✓Block flow diagram or simplified process flow diagram



Process Safety Information (PSI)

✓ Process chemistry

Reactions that produce acid anhydrides are dehydration reactions. For example: acetic acid (CH3COOH) forms acetic anhydride ((CH3CO)2O) and water by the dehydration reaction

2 CH3COOH → (CH3CO)2O + H2O

Dehydration reactions are also involved in the production of many polymers.

Process Safety Information (PSI)

- ✓Maximum Intended Inventory

Document the maximum intended inventory of any vessel in which you store or process a regulated substance above its threshold quantity. If you are not sure of the capacity of the vessel, you can obtain this information from the manufacturer of the vessel. In some cases, this information will be attached to the vessel itself.

You may want to check with any trade association or standards group that develops standards for your industry to determine if there are any limitations on inventories. For example, in some cases the maximum capacity of a tank may be 10,000 gallons, but an industry standard may recommend that the tank never be filled to more than 85 percent capacity. If you follow the standard, your maximum inventory would be 8,500 gallons.

Process Safety Information (PSI)

- ✓Safe upper and lower limits for such items as temperatures, pressures, flows or compositions

Tank 101

	Upper	Lower
TK-101 Level	85%	15%
TK-101 Pressure	130 psi	0 psi

NOTE: Base these on an evaluation of the consequences of deviations, including those affecting the S&H of workers

Process Safety Information (PSI)

Information pertaining to the **EQUIPMENT** in the process:

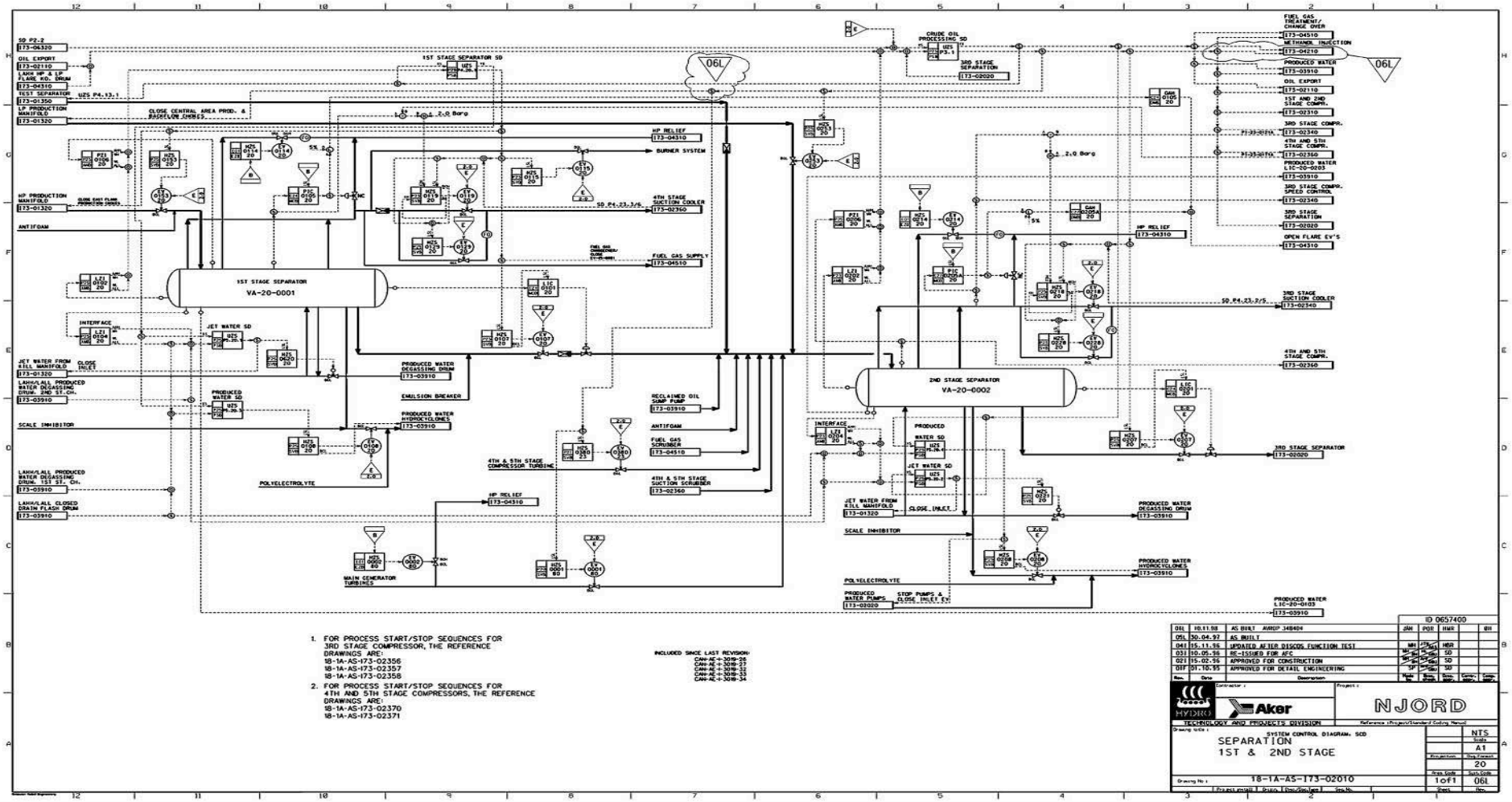
- ✓Materials of construction
- ✓Piping and instrument diagrams (P&ID's)
- ✓Electrical classification
- ✓Relief system design and design basis
- ✓Ventilation system design
- ✓Design codes and standards employed
- ✓Material and energy balances for processes built after May 26, 1992 and,
- ✓Safety systems (e.g. interlocks, detection or suppression systems)

Process Safety Information (PSI)

- ✓ Materials of construction
  - ➢ Hoses
  - ➢ Gaskets
  - ➢ Piping
  - ➢ Pumps
  - ➢ Vessels
  - ➢ Instruments

Process Safety Information (PSI)

✓ Piping and instrument diagrams (P&ID's)



Process Safety Information (PSI)

✓Electrical Classification

NFPA 497 *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas* 2008 Edition

Class I Locations

Class I locations are those in which flammable gases, flammable liquid–produced vapors, or combustible liquid–produced vapors are or may be present in the air in quantities sufficient to produce explosive or ignitible mixtures. Class I locations shall include those specified in 500.5(B)(1) and (B)(2).

Class II Locations

Class II locations are those that are hazardous because of the presence of combustible dust. Class II locations shall include those specified in 500.5(C)(1) and (C)(2).

Class III Locations

Class III locations are those that are hazardous because of the presence of easily ignitible fibers or where materials producing combustible flyings are handled, manufactured, or used, but in which such fibers/flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitible mixtures. Class III locations shall include those specified in 500.5(D)(1) and (D)(2).

Process Safety Information (PSI)

✓Electrical Classification

1 Class I, Division 1 is a location:

1. ignitible concentrations of flammable gases, vapors can exist under normal operating conditions, or
2. which ignitible concentrations of such flammable gases, vapors, or combustible liquids above their flash points may exist frequently because of repair or maintenance operations or because of leakage, or
3. which breakdown or faulty operation of equipment or processes might release ignitible concentrations of flammable gases, flammable liquid–produced vapors, or combustible liquid–produced vapors and might also cause simultaneous failure of electrical equipment in such a way as to directly cause the electrical equipment to become a source of ignition

Process Safety Information (PSI)

✓Electrical Classification

Class I, Division 2 location is a location:

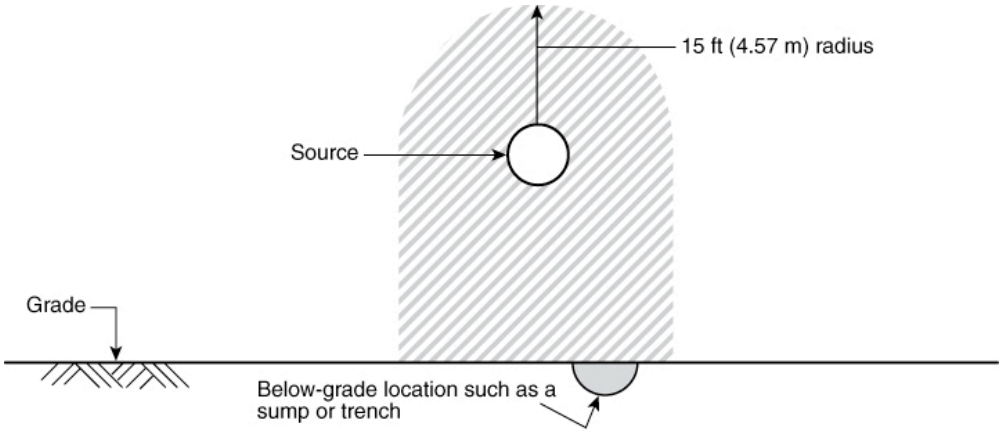
1. which volatile flammable gases and/or vapors are handled, processed, or used, but in which the liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems or in case of abnormal operation of equipment, or
2. which ignitible concentrations of flammable gases and/or vapors are normally prevented by positive mechanical ventilation and which might become hazardous through failure or abnormal operation of the ventilating equipment, or
3. is adjacent to a Class I, Division 1 location, and to which ignitible concentrations of flammable gases and/or flammable liquids above their flash points might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

Informational Note No. 1: This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used but that, in the judgment of the authority having jurisdiction, would become hazardous only in case of an accident or of some unusual operating condition. The quantity of flammable material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location.

Informational Note No. 2: Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Depending on factors such as the quantity and size of the containers and ventilation, locations used for the storage of flammable liquids or liquefied or compressed gases in sealed containers may be considered either hazardous (classified) or unclassified locations. See NFPA 30-2015, Flammable and Combustible Liquids Code, and NFPA 58-2014, Liquefied Petroleum Gas Code.

Process Safety Information (PSI)

✓Electrical Classification

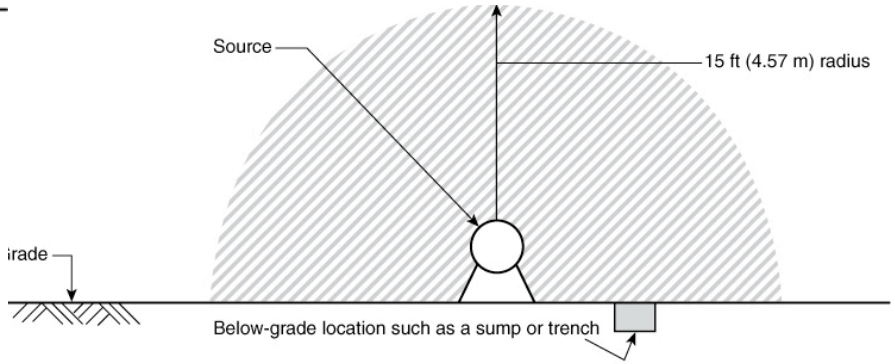


Material: Flammable liquid, liquefied flammable gas, compressed flammable gas, and cryogenic liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure		X	X
Flow rate	X	X	

Division 1

Division 2



Material: Flammable liquid, liquefied flammable gas, compressed flammable gas, and cryogenic liquid

	Small/low	Moderate	Large/high
Process equipment size	X	X	
Pressure		X	X
Flow rate	X	X	

Division 1

Division 2

Process Safety Information (PSI)

- ✓Relief system design and design basis
  - ➢RAGAGEP used
  - ➢Fire Scenario or Blocked-In Scenario
  - ➢Rupture Disc vs. Relief Valve vs. Dual System
  - ➢Header vs. Direct to ATM
  - ➢Sizing Calcs based on chosen worst case scenario
  - ➢RV/RD Set Point(s)

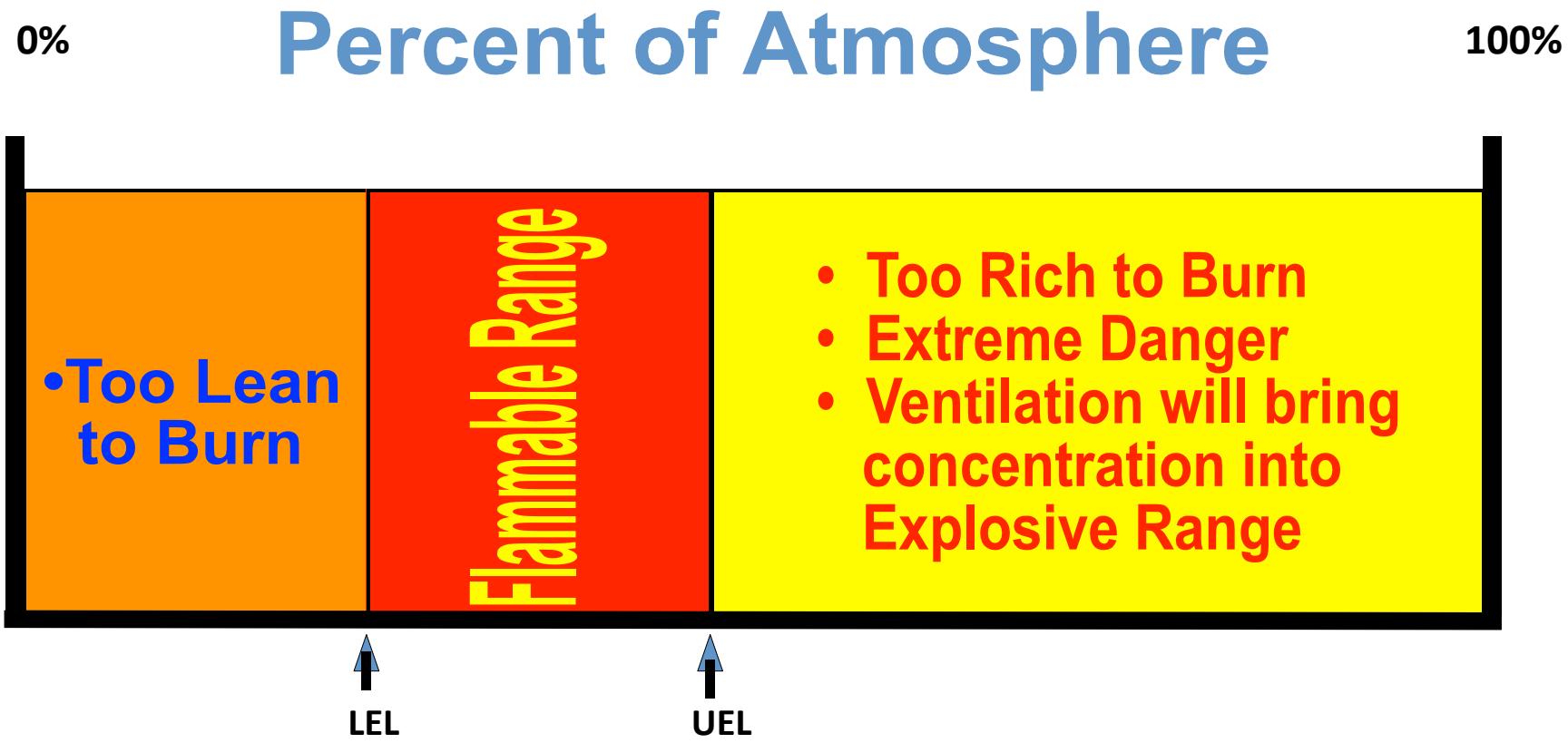
Process Safety Information (PSI)

- ✓Ventilation system design (DuPont/Honeywell)
  - ✓Provide mechanical ventilation at filling zones and storage areas or other locations where leakage is probable
  - ✓Determine if existing local ventilation is adequate for other operating and storage areas
  - ✓Ventilation rate should prevent vapor–air concentrations **BELOW 25% of LFL**

Process Safety Information (PSI)

- ✓ For example, NFPA 497 *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas,* 2008 Edition defines adequate ventilation as a ventilation rate that affords either 6 air changes per hour, or **1 cfm per 1 sq. ft. of floor area**, or other similar criteria that **prevent the accumulation of significant quantities of vapor–air concentrations from exceeding 25% of LFL**.

Flammable Properties



CAUTION!

It should be noted that many LELs and UELs are theoretical calculations and, accordingly, should be regarded as guide values only!!!!!

Process Safety Information (PSI)

✓ Design codes and standards employed

- ASME Section VIII
- ANSI B31.3
- NFPA 58
- NFPA 497
- NFPA 70
- IP-2: Hose Handbook (Eighth Edition, 2009)
- ANSI/ISA-84.01 – 2004
- ANSI/ASHRAE Addendum ak to ANSI/ASHRAE Standard 34-2007
- API 510, 570, 520

Process Safety Information (PSI)

- ✓Material and energy balances for processes built **after May 26, 1992**
  - ✓Chemical reactions play a vital role in manufacturing process. For design of chemical process equipment, the operating conditions such as pressure, temperature, composition and flow of the streams should be known.
  - ✓The material balance and energy balance calculations come to the rescue of the designer and allows him to calculate the various flow rates and temperature of the streams.

Process Safety Information (PSI)

- ✓Safety systems (e.g. interlocks, detection or suppression systems)
  - ➢Level and Pressure Interlocks and Alarms
  - ➢Relief System(s)
  - ➢Gas Detection
  - ➢Ventilation System(s)
  - ➢Bonding and Grounding Systems
  - ➢Safety Showers/Eye Wash
  - ➢Sprinklers?, Monitor Nozzles?, Deluge Systems?
  - ➢Secondary Containment
  - ➢Flare, Scrubber, Diffuser Tank, etc.

Process Safety Information (PSI)

- Document that equipment complies with **R**ecognized **A**nd **G**enerally **A**ccepted **G**ood **E**ngineering **P**ractices (RAGAGEP)

- 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

Process Hazard Analysis (PHA)

- PHA shall be appropriate to the complexity of the process and shall **IDENTIFY**, **EVALUATE**, and **CONTROL THE HAZARDS** involved in the process
- Determine and document the **priority order** for conducting PHA(s) based on a rationale which includes such considerations as
  - extent of the process hazards,
  - number of potentially affected employees,
  - age of the process, and
  - operating history of the process

Process Hazard Analysis (PHA)

- Use one or more of the following methodologies that are appropriate to determine and evaluate the hazards of the process being analyzed.
  - What-If
  - Checklist
  - What-If/Checklist
  - Hazard and Operability Study (HAZOP)
  - Failure Mode and Effects Analysis (FMEA)
  - Fault Tree Analysis
  - An appropriate equivalent methodology

Process Hazard Analysis (PHA)

- PHA shall address:
  - **HAZARDS** of the process
  - **PREVIOUS INCIDENT(S)** which had a likely potential for catastrophic consequences
  - **ENGINEERING AND ADMINISTRATIVE CONTROLS** applicable to the hazards and their interrelationships such as appropriate application of detection methodologies to provide early warning of releases.
  - **CONSEQUENCES OF FAILURE** of engineering & admin controls
  - Facility Siting & Human Factors
  - A qualitative evaluation of a range of the possible S&H effects of failure of controls on workers

Process Hazard Analysis (PHA)

- PHA team MUST have **expertise in engineering and process operations**
  - **at least one employee who has experience and knowledge** specific to the process
  - one member **knowledgeable in the specific PHA methodology**
- Establish **a system to promptly address** the team's recommendations
- Recommendations are resolved in a **timely manner** and the **resolution is documented**
  - Document what actions are to be taken
  - Complete actions as soon as possible
  - Develop a written schedule of when these actions are to be completed

Process Hazard Analysis (PHA)

- Communicate the actions to **ALL** personnel whose work assignments are in the process and who may be affected by the recommendations or actions

- **At least every five (5) years** after the completion of the initial PHA, the PHA shall be updated and revalidated by a team meeting the requirements in paragraph (e)(4) to assure that the PHA is consistent with the current process.

- Employers shall retain PHA(s) and updates or revalidations, as well as the documented resolution of recommendations described in paragraph (e)(5) of this section for the **LIFE OF THE PROCESS**

Operating Procedures (SOP)

- Develop and implement **WRITTEN** SOPs 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.
- **Steps for each operating phase**:
  - ✓ Initial startup
  - ✓ Normal operations
  - ✓ Temporary operations
  - ✓ Emergency shutdown including the conditions under which emergency shutdown is required and assignment of shutdown responsibilities to ensure that ESD is executed in a safe and timely manner.
  - ✓ Emergency Operations
  - ✓ Normal shutdown
  - ✓ Startup following a turnaround, or after an emergency shutdown.

Operating Procedures (SOP)

Operating limits:

- Consequences of deviation
- Steps required to correct or avoid deviation

Safety and health considerations:

- Properties and hazards presented by chemicals
- Precautions necessary to prevent exposure, including engineering controls, administrative controls, and PPE
- Control measures to be taken if exposure occurs
- Quality control for raw materials and inventory levels
- Any special or unique hazards

Safety systems and their functions

Operating Procedures (SOP)

- SOPs shall be **READILY ACCESSIBLE** to employees who work in or maintain a process

- SOPs shall be **REVIEWED AS OFTEN AS NECESSARY** to assure that they reflect current operating practice, including changes that result from changes in process chemicals, technology, and equipment, and changes to facilities.

- **CERTIFY ANNUALLY** that operating procedures are current and accurate

Operating Procedures (SOP)

- Develop and implement safe work practices (SWP) to provide for the control of hazards during operations such as
  - Lockout/tagout
  - Confined space entry
  - Opening process equipment or piping; and
  - Control over entrance into a facility by maintenance, contractor, laboratory, or other support personnel

- SWPs shall **APPLY TO EMPLOYEES AND CONTRACTOR** employees

Training

Initial Training

- Each employee presently involved in operating a process, and each employee **BEFORE** being involved in operating a newly assigned process, shall be trained in:
  - overview of the process and
  - operating procedures
- Training shall include **EMPHASIS** on:
  - specific safety and health hazards,
  - emergency operations including shutdown, and
  - safe work practices applicable to the employee's job tasks.

Training

- In lieu of initial training for those employees already involved in operating a process on May 26, 1992, an employer may certify in writing that the employee has the required knowledge, skills, and abilities to safely carry out the duties and responsibilities as specified in the operating procedures.

Training

Refresher Training

- Provided **AT LEAST EVERY THREE** (3) years, and more often if necessary, to each employee involved in operating a process to assure that the employee understands and adheres to the current operating procedures of the process.
- **In consultation with the employees** involved in operating the process, determine the appropriate frequency of refresher training.

Training

Training Documentation

- Ascertain that each employee involved in operating a process has **RECEIVED AND UNDERSTOOD** the training
- Prepare a record which contains the:
  - **Identity** of the employee
  - **Date** of training, and
  - **MEANS USED TO VERIFY** that the employee understood the training

Contractors

- Applies to contractors performing *maintenance or repair, turnaround, major renovation, or specialty work* ***on or adjacent to a covered process***.

- It does **NOT** apply to contractors providing incidental services which do **NOT** influence process safety, such as janitorial work, food and drink services, laundry, delivery or other supply services

Contractors

Employer Responsibilities

- **OBTAIN** and **EVALUATE** information regarding the contract employer's safety performance and programs.
- **INFORM** contract employers of the known potential fire, explosion, or toxic release hazards related to the contractor's work and the process.
- **EXPLAIN** applicable provisions of the emergency action plan required by paragraph (n) of this section.
- **DEVELOP** and **IMPLEMENT** safe work practices to control the entrance, presence and exit of contractors in covered process areas.
- **PERIODICALLY EVALUATE** the performance of contract employers in fulfilling their obligations as specified in paragraph (h)(3) of this section.
- **MAINTAIN** a contract employee injury and illness log related to the contractor's work in process areas.

Contractors

Contractor Employer Responsibilities

- Assure that each contract employee is **trained in the work practices** necessary to safely perform his/her job.
- Assure that each contract employee **is instructed in the known potential fire, explosion, or toxic release hazards related to his/her job and the process**, and the applicable provisions of the **emergency action plan**
- **Document** that each contract employee has **received and understood the training**
- Prepare a record which contains
  - the **identity** of the contract employee,
  - the **date** of training, and
  - the **means used to verify that the employee understood the training**
- Assure that **each contract employee follows the safety rules** of the facility including the safe work practices
- Advise the host employer of any **unique hazards presented by the contract employer's** work, or of any hazards found by the contract employer's work

Pre-Startup Safety Review (PSSR)

- Employer shall perform a PSSR for **NEW** facilities and for **MODIFIED** facilities when the ***modification is significant enough to require a change in the PSI***

- PSSR shall confirm that **prior to the introduction of the HHC to a process**:
  - Construction and equipment is **in accordance with design specifications**
  - SWPs, SOPs, Maintenance procedures, and emergency procedures **are in place and are adequ**ate
  - For new facilities, a PHA has been performed and recommendations have been resolved or implemented **BEFORE** startup
  - Modified facilities meet the requirements contained in the management of change review
  - Training of **each employee involved in operating a process** has been completed

Mechanical Integrity (MI)

Application

- Applies to the following process equipment:
  - Pressure vessels and storage tanks
  - Piping systems (including piping components such as valves)
  - Relief and vent systems and devices
  - Emergency shutdown systems
  - Controls (including monitoring devices and sensors, alarms, and interlocks) and,
  - Pumps

Mechanical Integrity (MI)

Written Procedures

- **Establish and implement written procedures** to maintain the on-going integrity of process equipment

Training for process maintenance activities

- Train each employee involved in maintaining the on-going integrity of process equipment in an **overview of that process and its hazards** and in the **procedures applicable to the employee's job tasks** to assure that the employee can perform the job tasks in a safe manner.

Mechanical Integrity (MI)

Inspection and testing

- Shall be performed on process equipment
- Shall follow RAGAGEP
- Frequency shall be consistent with **manufacturers' recommendations** and RAGAGEP
  - more frequently if determined to be necessary by experience
- Document EACH inspection/Test
- Documentation shall identify
  - **DATE** of the inspection/test
  - name of the **PERSON** who performed the inspection/test
  - **SERIAL NUMBER** or other identifier of the equipment on which the inspection or test was performed
  - **DESCRIPTION** of the inspection or test performed
  - **RESULTS** of the inspection or test

Mechanical Integrity (MI)

Equipment Deficiencies

- **CORRECT DEFICIENCIES** in equipment that are outside acceptable limits (defined by the PSI) **BEOFRE** further use ***OR*** in **A SAFE AND TIMELY** manner when necessary means are taken to assure safe operation.

Quality Assurance

- In the construction of new plants and equipment, assure that **equipment as it is fabricated is suitable** for the process application for which they will be used.
- **Appropriate checks and inspections shall be performed** to assure that equipment is installed properly and consistent with design specifications and the manufacturer's instructions.
- Assure that maintenance **materials, spare parts and equipment are suitable for the process** application for which they will be used.

Hot Work Permit (HW)

- Employer shall issue a hot work permit for hot work operations conducted **ON** or **NEAR** a covered process
- Permit shall document that the fire prevention and protection requirements in **29 CFR 1910.252(a)** have been implemented **PRIOR** to beginning the hot work operations
- Permit shall indicate
  - **DATE(s)** authorized for hot work
  - **IDENTIFY THE OBJECT** on which hot work is to be performed
- Permit shall be kept on file until completion of the HW

Management of Change (MOC) 1910.119(l)

- Establish and implement written procedures to manage changes (except for "replacements in kind") to
  - process chemicals
  - Technology
  - equipment
  - procedures
  - changes to facilities that affect a covered process
- Procedures shall assure that the following considerations are addressed prior to any change:
  - Technical basis for the proposed change
  - Impact of change on S&H
  - Modifications to operating procedures
  - Necessary time period for the change; and
  - Authorization requirements for the proposed change

Incident Investigation (II)

- Investigate each incident which resulted in, or could reasonably have resulted in a catastrophic release of highly hazardous chemical in the workplace.

- An incident investigation shall be initiated as promptly as possible, but not later than 48 hours following the incident.

- An incident investigation team shall be established and consist of at least one person knowledgeable in the process involved, including a contract employee if the incident involved work of the contractor, and other persons with appropriate knowledge and experience to thoroughly investigate and analyze the incident.

Incident Investigation (II)

- A report shall be prepared at the conclusion of the investigation which includes at a minimum:
  - Date of incident
  - Date investigation began
  - Description of the incident
  - Factors that contributed to the incident
  - Recommendations resulting from the investigation
- Establish a system to promptly address and resolve the incident report findings and recommendations.
- Resolutions and corrective actions shall be documented.
- Report shall be reviewed with all affected personnel whose job tasks are relevant to the incident findings including contract employees where applicable.
- Incident investigation reports shall be retained for five years.

Emergency Planning and Response

- Establish and implement an emergency action plan for the entire plant in accordance with the provisions of 29 CFR 1910.38.
  - EAP 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).

Compliance Audits (CA)

- Certify they have evaluated compliance with the PSM provisions
- **At least every three (3) years** to verify that the procedures and practices developed under the standard are adequate and are being followed
- Audit shall be conducted by at least **one (1) person knowledgeable in the process**
- A report of the findings of the audit shall be developed
- Promptly determine **and document an appropriate response to each of the findings** of the compliance audit, and **DOCUMENT THAT DEFICIENCIES HAVE BEEN CORRECTED**
- Retain the two (2) most recent compliance audit reports

Trade Secrets (TS)

- Make all information necessary to comply with PSM available to:
  - those persons responsible for compiling the PSI,
  - those assisting in the development of the PHA,
  - those responsible for developing the SOPs, and
  - those involved in incident investigations, emergency planning and response and compliance without regard to possible trade secret status of such information.
- Nothing in this paragraph shall preclude the employer from requiring the persons to whom the information is made available to enter into confidentiality agreements not to disclose the information

AP Images/Matt Slocum

Process Safety is a team effort. Know your role and work with your fellow employees to protect yourself and others.

Know the hazards associated with mixing, separating, or storing process materials, including:

- Which chemicals are reactive or able to cause a runaway reaction.
- Toxic, fire, or explosive hazards associated with your process chemicals.
- What to do during an incident or unusual process condition.

Be aware of equipment operation and maintenance requirements, including:

- Signs of corrosion, leakage, or other signs of equipment problems.
- Who to alert when you see a problem.

Know your process:

- Follow operating, safety, and emergency procedures.
- Keep up-to-date with changes to procedures, equipment, and chemicals.
- Provide feedback – report all incidents and near misses.

For more information on OSHA's Process Safety Management Standard, visit www.osha.gov.

For more complete information:

OSHA® Occupational Safety and Health Administration

U.S. Department of Labor

www.osha.gov (800) 321-OSHA

OSHA 3315-01N-09