Process Safety News

Winter 2012
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Number 1

# UNDERSTANDING RECENTLY ISSUED OSHA PSM NEP

## PROCESS SAFETY MANAGEMENT OF HIGHLY HAZARDOUS CHEMICALS (29 CFR 1910.119)

**By: Amy Theis, PE, Manager, Risk Management Services, Fauske & Associates, LLC (FAI) and Timothy Cullina, PE, Safety Consulting Engineer, Fauske & Associates, LLC (FAI)**

In late November 2011, OSHA released the National Emphasis Program (NEP) for Process Safety Management (PSM) officially replacing the limited-scope 2009 pilot NEP for PSM - covered chemical facilities. The PSM requirements remain challenging, but essentially unchanged. This article will focus on changes of the new Chemical PSM NEP and how your facility can be prepared.

### Facilities Affected and Inspection Process

1) All federal and state-plan OSHA offices are required to participate in the new Chemical PSM NEP. Formerly, only regions I, VII and X (14 states) were affected by the original pilot program. In addition, each OSHA area office is required to complete 3 to 5 inspections per year.

2) As before, the target list includes the usual suspects plus some new less common additions including:

- Facilities identified for maintaining greater than threshold quantities of flammable liquids
- Facilities identified on the EPA's Risk Management Program database
- Facilities with NAICS codes that match the NAICS codes of past PSM - offenders

3) Two categories will be used:

- Facilities using ammonia in refrigeration use as the only highly hazardous chemical (HHC) ~ 25% of inspections
- Facilities using ammonia for other than refrigeration or using HHCs other than ammonia ~ 75% of inspections

The inspection process will include the use of investigative questions that are designed to gather facts related to requirements of the PSM standard which include guidance for reviewing documents, interviewing workers and verifying full implementation. An emphasis is placed on the assessor evaluating effective implementation of the PSM elements in addition to sufficient program documentation. The questions will be asked based on a dynamic list of questions that will not be public domain.

### Citation History

OSHA outreach efforts have provided summaries of the pilot program results as measured by citations. Table 1 on page 4 provides a summary of completed inspection citations from the first 18 months of the pilot program. If asked, most managers responsible for PSM implementation may identify the more challenging elements to be the same as OSHA's list of most cited elements. Roughly 75% of the citations came from just 4 elements: Mechanical Integrity, Process Safety Information, Process Hazard Analysis, and Operating Procedures. Training and Management of Change programs captured an additional 9%.

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### Upcoming Events

- FAI Spring 2012 Process Safety Training Courses, March 22-23, 2012 in Burr Ridge, IL (see pages 14 & 15 for more information)
- Visit FAI at booth #1352 at the PTXi/Powder Bulk Solids Conference, May 8-10, 2012 in Rosemont, IL
- FAI Relief Systems Design Course, May 21-22 in Burr Ridge, IL (see page 11 for more information)
- FAI User Group Forum, May 23-25, 212 in Burr Ridge, IL (visit www. fauske.com for more information)

# Letter From the President

With the close of 2011, we at Fauske & Associates, LLC, (FAI), look back on a year marked by changes both organizationally as well as related to our business and the industries we serve.

Organizationally, FAI saw a changing of the guard with me assuming the role of President of the company. Although my responsibilities have changed, my commitment to our customers and to our company has not. I am proud to be associated with a great company and the talented group of professionals that work here and endeavor to continue strengthening FAI's industry leadership position and growth into 2012 and beyond.

2011 also saw OSHA take a significant step to further their regulations related to Process Safety Management (PSM) with the release of their National Emphasis Program (NEP) for PSM covered chemical facilities in late November. This NEP replaces the 2009 pilot program by extending the regulatory enforcement to bring more industries under scrutiny by encouraging inspectors to proactively visit facilities within those industries.

At FAI, we have always considered our "safety first" approach as being integral to our overall success and urge all of our customers to regard safety in the same manner. If your industry is one covered by the new NEP, then you will want to pay close attention to our cover story in this issue of Process Safety News which provides tips for how your company can be prepared for an OSHA PSM inspection.

A solid PSM program is not only a smart way to do business, but can also result in reduced costs, greater efficiencies and happier employees for the long term.

If you feel you need assistance with PSM, we can help.

Our extensive knowledge of all elements of PSM and experience providing safety reviews related to hazardous processes, make us uniquely qualified to assist with PSM program development, review or inspection. And, as always, we remain your one-stop shop for all of your chemical and dust testing needs.

I wish all of you a happy and healthy 2012 and look forward to the opportunity to continue serving you in my newest position at FAI.

H. Kristian Fauske
President

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## FAI Welcomes New Employees

Vincenzo DiBenedetto
Electrical Engineer

Robert Tsai
Sr. Consulting Engineer

### Statement of Purpose:

FAI's "Process Safety News" is intended to be a forum on recent advances in chemical process safety and FAI's current and related offerings in this area. It will address subscriber's concerns regarding issues and practices for relief system design as well as laboratory testing and techniques for process safety management.

### Inquiries:

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Continued from page 1

| Element | Description | % Citations | % Citations |
|---|---|---|---|
| **Mechanical Integrity** | | 22.5% | |
| 119(j)(2) | MI written procedures | | 3.8% |
| 119(j)(4)(i) | MII&T performed | | 2.2% |
| 119(j)(4)(iii) | I&T frequency | | 2.0% |
| 119(j)(4)(iv) | MII&T documentation | | 1.6% |
| 119(j)(5) | MI equipment deficiencies | | 1.8% |
| | Other MI citations | | 11.1% |
| **Process Safety Information** | | 21.6% | |
| 119(d)(3)(i)(B) | PSI P&IDs | | 1.6% |
| 119(d)(3)(i)(D) | PSI-relief system design & basis | | 0.9% |
| 119(d)(3)(i)(E) | PSI-ventilation system design | | 0.9% |
| 119(d)(3)(ii) | PSI RAGAGEP | | 3.8% |
| | Other PSI citations | | 16.4% |
| **Process Hazard Analysis** | | 17.9% | |
| 119(e)(1) | PHAs performed | | 1.5% |
| 119(e)(3)(iii) | PHA engineering controls | | 1.5% |
| 119(e)(5) | PHA findings & recommendations | | 2.0% |
| 119(e)(3)(i) | PHA-address process hazards | | 1.1% |
| 119(e)(6) | PHA-re-evaluations at least every 5 years | | 1.1% |
| | Other PHA citations | | 10.7% |
| **Operating Procedures** | | 12.1% | |
| 119(f)(3) | OP certification | | 1.5% |
| 119(f)(4) | OP safe work practices | | 1.5% |
| 119(f)(1) | OP not developed & implemented | | 1.2% |
| | Other OP citations | | 7.9% |
| **Training** | | 4.4% | |
| 119(g)(1)(i) | Initial Training | | 1.2% |
| | Other Training citations | | 3.2% |
| **Management of Change** | | 4.3% | |
| 119(l)(1) | MOC not performed | | 1.3% |
| | Other MOC citations | | 3.0% |
| **Contractors** | | 3.5% | |
| **Compliance Audits** | | 3.5% | |
| 119(o)(1) | Compliance Audits performed | | 1.6% |
| | Other Audit citations | | 1.9% |
| **Employee Participation** | | 3.0% | |
| **Incident Investigation** | | 2.5% | |
| **Emergency Planning & Response** | | 2.3% | |
| **Pre-startup Review** | | 1.6% | |
| **Hot Work** | | 0.7% | |
| **Non-PSM, Frequently Cited** | | 5.8% | |
| 29(b)(1) | Mobile ladders & scaffolds | | 1.9% |
| 151(c) | Eyewash stations | | 1.5% |
| 23(c)(1) | Guarding floor openings | | 1.2% |
| GDC | General Duty Clause | | 1.2% |

**Table 1**

PSM Pilot NEP Citations as of December 21, 2010
OSHA Directorate of Enforcement, General Industry Enforcement

## Hypothetical Citation Example

Looking at the specified citations we can see that PSM elements form interrelated responsibilities as illustrated by the following hypothetical example.

During a PSM NEP inspection, the compliance officer checked Mechanical Integrity records and noted that maintenance changed a component from the original specification (it no longer met the applicable code) to an unspecified item. Since the old component is no longer made, a different type of component needed to be selected and installed. Under PSM, this replacement required Management of Change process approval. The inspector cross-checked the MOC log and found the change both documented and approved.

The type of component selected mandated different steps for the operators (Operating Procedures) who required training and verification in the new procedures (Training). The OSHA inspector found updated procedures in use and documented training. The rationale for selecting the component was covered in the training and made available for review by employees and their representatives (Employee Participation). No citations were issued.

When the new component was installed by the supplier (Contractors), it involved shutting down part of the process (Pre-startup Safety Review) as well as brazing some of the lines (Hot Work Permit). The employer reviewed the response plan (Emergency Planning) to ensure that procedures were adequate for the installation hazards. Workers completed the hot work permit and a copy remained in the records. No records were available to indicate how the contractor interacted with the facility when working on a PSM covered process. Several citations could be issued under 119(h). Proposed fines could exceed $7,000.

Although Management of Change provisions covered interim changes, when the new component was placed in service the Process Safety Information was not updated. The Process Hazard Analysis was revalidated, but the records could not account for potential hazards associated with the new component. Fortunately, inspection and maintenance procedures and training were updated (Mechanical Integrity). Multiple citations could be issued under 119(d)(3)(i) for the P&IDs and other PSI that were not updated and 119(e)(3)(i) for not evaluating the process hazard of the new component during the PHA. Again, proposed fines could exceed $7,000. In fact, the average financial penalties per inspection under the pilot program exceeded $25,000. However, single citations from two recent PSM inspections drew violation penalties of $25,000 each for failure to calibrate a device used for vibration analysis in one case and for failure to follow the flange bolt torque specification in the other.

As illustrated, 11 PSM elements can be affected by changing one component. The NEP instructs the OSHA inspector to check a representative number of the elements to confirm that the required follow-up activities have been implemented across the spectrum of PSM elements for the new component.

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## What to Expect

When OSHA visits, the facility management should expect to be asked for their OSHA 300 logs, typically for the last three years. When the OSHA Inspector visits a PSM covered facility, expect the same and more. The OSHA Inspectors will attempt to identify the most hazardous process for inspection under the Chemical NEP based on the quantity of chemicals in the process, the age of the process unit, maintenance activities and logs, previous audit findings, employee input and injury and incident logs.

Among the first inspection topics covered will be personal protective equipment (PPE) determinations and hazardous location classifications. Though not specifically PSM -related, PPE and location classifications apply to multiple PSM elements. The inspectors will request that you provide an overview of the facility's PSM program including identification of key responsible personnel and descriptions of records created for PSM management and compliance demonstration. They will ask to see a list of PSM chemicals, their quantities on site, processes used and process descriptions. Process and safety system descriptions should include safe upper and lower operating limits, design codes and standards for the selected unit(s) PFDs, P&IDs and Plot Plans will be required. This information should be available as part of the Process Safety Information (PSI) file. In addition, the inspector will request to review the most recent Process Hazard Analysis (PHA) or revalidation complete with the PSI. All of this can be expected to happen before an initial walk around. Providing adequate and complete information to the investigator will make a good first impression.

OSHA inspectors will look for evidence of program implementation in the maintenance department, at the operator's positions and in the field, rather than just accepting what is written in PSM program plans. The NEP equips inspectors with questions and guidance to navigate from written programs to required records. The NEP also directs Compliance Safety and Health Officers (CSHOs) to review past PSM-related citations issued to the same employer (not just the same facility) going back 6 years and identify potential failures to abate and possibly repeat willful violations.

## Develop an Action Plan

It is helpful to evaluate your PSM program's effectiveness by examining successful implementation of the top 4 cited elements: Mechanical Integrity, Process Safety Information, Process Hazard Analysis and Operating Procedures. This will give a good indication of whether your PSM program needs improvement to be compliant. Another key element is Management of Change, which triggers actions in each of the previously mentioned elements. If procedures are not in place or properly completed, there could be a domino effect resulting in multiple citations. A gap analysis is useful to determine areas of highest risk.

## Conclusion

Many new facilities will be included in the target list, which were not affected by the previous pilot program in 2009. The NEP will conduct programmed inspections for those companies with known risks and encourage unprogrammed inspections for typically low-profile PSM - covered facilities. OSHA will evaluate compliance using specially developed "dynamic inspection lists" that are re-generated on a regular basis.

FAI engineers are familiar with OSHA auditing techniques and can help your facility prepare for an OSHA PSM NEP inspection. We can perform a PSM gap analysis to identify priority elements needing attention. FAI can also provide assistance with PSM program development including Emergency Response Procedures and Process Safety Information (proper vent sizing, process chemistry and safe operating limits).

Contact Mr. Jeff Griffin at (630) 887-5278 or via email at griffin@fauske.com for more information regarding how FAI can support your facility in preparation for an OSHA PSM NEP inspection.

### References

Occupational Safety and Health Administration, Directive Number: CPL 03-00-014, PSM Covered Chemical Facilities National Emphasis Program, November 29, 2011.

L. Long, M. Marshall and J. Lay, Update on OSHA's PSM National Emphasis Programs, Process Safety Progress, Vol. 30, No. 4, December 2011.

Amy Theis, Risk Management Services Manager at FAI, will be a featured presenter at the AIChE Global Congress on Process Safety, Loss Prevention Symposium April 3rd, in Houston, Texas

# Waterhammer Modeling in Thermo-Hydraulic Systems

By: Damian Stefanczyk
Acting Manager, Thermal Hydraulic Services
Fauske & Associates, LLC

There are two types of waterhammer transients observed in thermo-hydraulic systems during the transient due to a liquid's inertia moving against the gas and then abruptly coming to a stop: gas compression and gas condensation. Depending on the amount of gas present (which dictates if the system is stagnated due to a waterhammer or an inertial slowdown), the transient could be damaging to the system either structurally due to failed supports or piping, or by a relief valve being lifted (if present in the system). The compression and consequential rarefaction waves (waves that induce flow in the opposite direction of nominal flow, which results in the check valve closing) that travel through the system could also induce secondary waterhammers due to a check valve slam.

The conditions that will lead to waterhammer transients are numerous. A few examples of potential waterhammer transients include: gas (condensable or non-condensable) resident in piping when a pump is started, a rapid closure of a valve, or column separation and rejoining following a stop and restart of a system.

Condensation induced waterhammer transients result in much more energetic transients compared to non-condensable gas-water waterhammers. Steam-water waterhammer transients can also behave as non-condensable gas-water waterhammer transients if the water interfacing the gas is equal to the temperature of the gas, which therefore reduces or even eliminates the condensation of the gas.

Condensation induced waterhammer transients are also more energetic due to the very rapid pressure rise,which is in the range of a few milliseconds, whereas non-condensable gas waterhammers might have rise times in the range of 10 milliseconds or higher.

Typically, the goal is to maintain systems at a "liquid solid" state, where the entire piping system is completely filled with liquid and no gas is present. However, gas could leak into the system due to various pathways or methods and it might be difficult to immediately detect. Thus, it is more reasonable to engineer a system for a "liquid full" state: one in which some gas could exist in the piping, and the pumps, valves and piping can continue to fulfill the system design function.

Even though waterhammer phenomena are complex in nature due to the large number of components in the system and the complexity of the piping system, there are tools available that allow for a complete evaluation of the system. Once the system's model is developed in one of the available computational tools, the system could be evaluated with a matrix of transients where, for example, the gas volume is varied. Then, the pressures and forces from each transient are compared against the allowable peak pressures and forces in the system, providing an operability range for a system where the presence of gas will not necessarily lead to qualifying the system as inoperable. This methodology enables cost effective operation of a system allowing for removal of over-conservatism in the safe operation of piping, pumps, valves, etc.

Figures 1 and 2 demonstrate the process of identifying the acceptance criteria for a system, where the peak pressure and force from numerous transients were compared against the allowable pressure and force for the system, respectively. Each data point represents a transient that was analyzed with one of the computational tools. As seen from the keys, the different color and shape points represent sampling at different times, thus each point of the same type (color/shape) represent a run at increasing gas void volumes.

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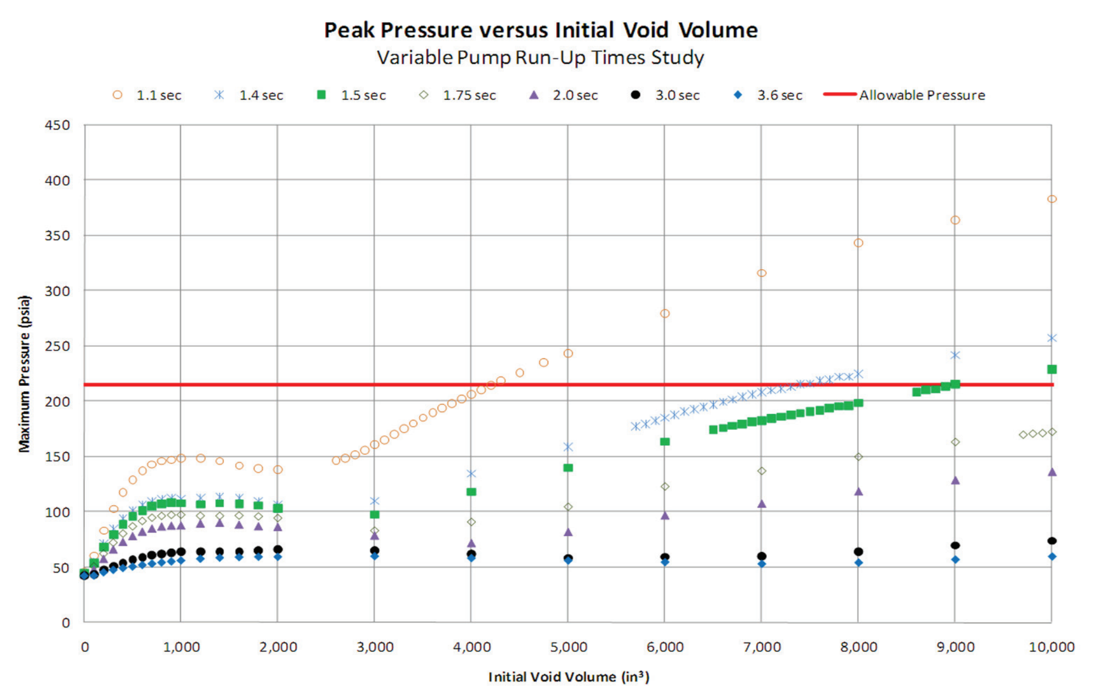



**Figure 1: Pressure Versus Initial Void Volume**

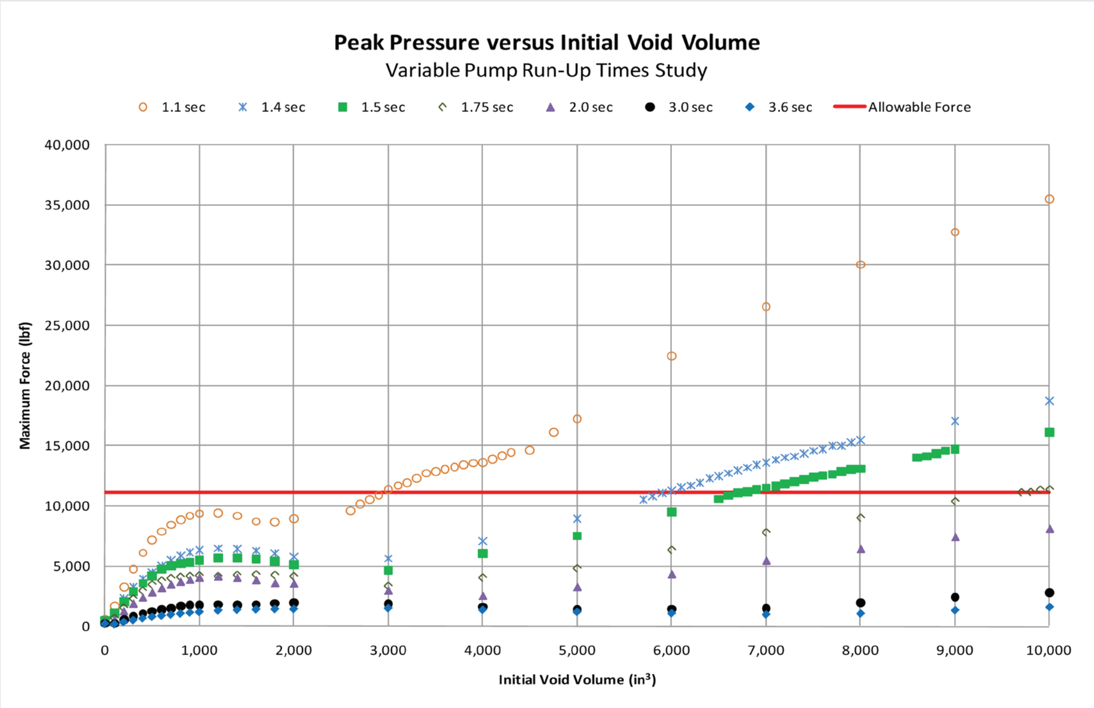
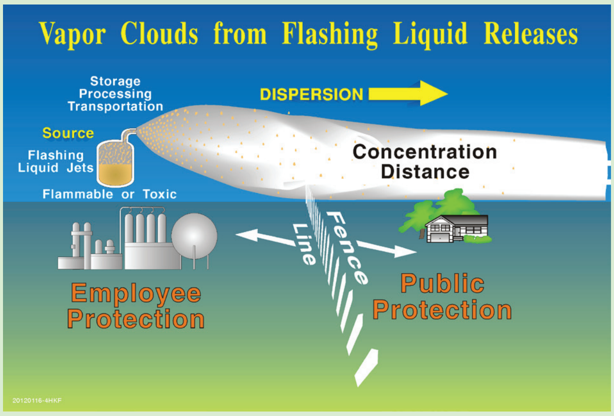



**Figure 2: Force Versus Initial Void Volume**

Fauske and Associates, LLC has performed numerous such evaluations. Multiple computational tools have been utilized and many additional ones developed to optimize the computation. Such optimization allows for a large number of scenarios to be evaluated leading to an optimal solution. As a result, the client is provided with an answer where unnecessary conservatism has been removed and the system can be operated cost effectively, while maintaining safe/acceptable operating conditions.

# Vapor Clouds from Flashing Liquid Releases

By: Hans K. Fauske, D.Sc.,
Regent Advisor, Fauske & Associates, LLC




Emergency releases of flashing liquid jets and vapor cloud formation as illustrated above calls for simple physical models to allow consequence assessment to be carried out in a timely and cost effective manner. As an example, simple models are particularly desirable to address the following questions:

- Will the concentration downwind of the plant site exceed critical toxicity levels or explosive limits?
- When will the cloud disperse to a safe level?

Answers to these questions will largely determine the needs for further considerations related to location, prevention, mitigation and emergency planning.

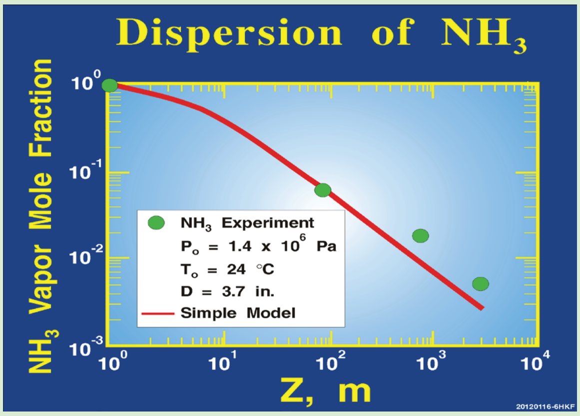
Models with a level of detail which seems appropriate for the purpose of carrying out risk evaluations in connection with high momentum jet releases are provided by Fauske and Epstein (1988 and 1989). These consider:

- Release Type: Consideration of vapor disengagement to distinguish between vapor and two-phase jet releases
- Jet Expansion: Consideration of equilibrium jet expansion parameters, including jet velocity, jet density and jet radius
- Aerosol Formation: Consideration of jet breakup to distinguish between aerosol formation and liquid rainout based upon initial release conditions
- Aerosol Dispersion: Consideration of turbulent mixing of the jet with the atmosphere leading to downwind concentration profile

An example of level of detail is illustrated by (Fauske and Epstein, 1989)

$$Y = \frac{1}{1 + 0.16\left(\frac{\rho_\infty}{\rho_j}\right)^{1/2}\frac{Z}{R_j}} \qquad (1)$$

where Y represents the mole fraction of the hazardous jet material at position Z, $\rho_\infty$ is the density of the atmosphere, and $\rho_j$ and $R_j$ are the jet density and jet radius, respectively, at the end of the depressurization zone. This simple expression is in excellent agreement with the far field concentration predictions obtained by the detailed model provided by Epstein, Fauske and Hauser (1989), that accounts for the effect of "Laminar" wind velocity, jet trajectory, aerosol evaporation, and the condensation of the entrained water vapor. Moreover, the simple expression as can be seen from the below figure, can reproduce field observation data from a high momentum release of liquid ammonia (Goldwire, 1986) to a degree of accuracy that is more than adequate for most hazard assessment purposes. The only input data used for this calculation comparison are the known initial stagnation pressure and temperature and the break diameter.




While, given the ability to predict the downstream concentrations associated with high momentum jet releases, it is important to recognize that many emergency releases can happen too fast to allow effective evacuation such as the Seveso and Bhopal type releases, which reinforces the need to contain and/or mitigate such releases. Practical containment and passive near-field mitigation concepts are identified, including pertinent test results are discussed and typical field installations are described by Fauske (1990) and Fauske and Grolmes (1992). Again, relatively simple models are illustrated to be consistent with experimental results.

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# Evaluating the Flammability Hazards of Liquid Vapors

**By: Paul Osterberg**
**Manager, Flammability Testing, Fauske & Associates, LLC**

With the growing concern of fires or explosions resulting from processing or handling hazardous material, it is important to characterize the flammable properties of that material. The flammability properties of fuels have been extensively studied for many years and are relatively well understood. Essentially, there are three elements required for a fire or an explosion to occur: a fuel, an oxidizer, and an ignition source. Through removal of one of these requirements, a fire/explosion will not occur. However, eliminating the ignition source as the sole means of fire/explosion prevent of hazardous chemicals is not a practical means of prevention due to flammable vapors having very low minimum ignition energies as well as numerous different ignition sources (known and unknown). Therefore, other means are necessary for reducing the risk of a fire/explosion. These revolve around moderating the fuel and oxidizer concentration to avoid a flammable concentration of gases/vapors.

In the chemical industry, processing and handling of chemicals could result in the formation of a flammable or explosive atmosphere. For liquid chemicals, this may occur at temperatures other than at ambient conditions. Figure 1 shows the relationship between the flammable properties of a combustible chemical and how they are related to temperature.

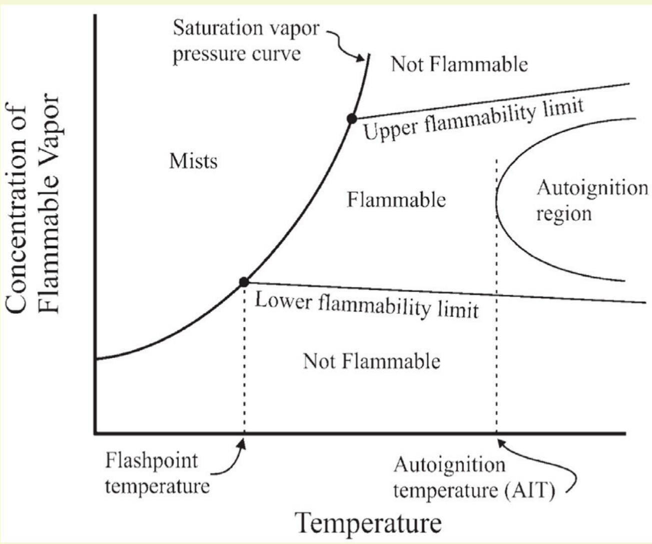


**Figure 1:**
**Temperature Effects on a Combustible Mixture (Crowl, 2003)**

As you increase temperature and move along the vapor pressure curve for a flammable substance, there becomes a point where the concentration of the vapor is sufficient for producing a flammable mixture. This temperature is commonly known as the Flash Point (FP). In theory, the lower flammability limit (LFL) should intersect the vapor pressure curve at the flashpoint temperature; as a result this temperature is also referred to as the Lower Temperature Limit of Flammability (LTFL). However, these two temperatures, FP and LTFL, may not always be observed to be similar with experimental data. Knowledge of the disparity between these two points will help better assess the flammability hazards of a specific chemical as well as help implement the proper safety precautions during handling.

To understand the variation between the lower temperature limit of flammability and the flash point, tests were performed to compare the results. The lower temperature limit of flammability tests were conducted using ASTM E1232 "Standard Test Method for Temperature Limit of Flammability of Chemicals" modified to be conducted in a 5.3-L stainless steel spherical vessel using a fuse wire ignition source for safety and environmental purposes. The criterion for a positive ignition was a 7% pressure rise above the starting pressure. The flash point tests were performed per ASTM D3278 "Standard Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus". These tests were performed on 4 different chemicals and their results are summarized in Table 1.

**Table 1:**
**Flash Point and Lower Temperature Limit of Flammability Results**

| Chemical | Flash Point (°C) | LTFL (°C) |
|---|---|---|
| Organosulfer Compound | 89.5 | 81 |
| Lactam Ring compound | 81.5 | 79 |
| Pyridine compound 1 | 100 | 92 |
| Pyridine compound 2 | 137 | 119 |

The deviation between the values determined for these two tests is a result of differences in the test apparatus and methodology used in each of these experiments.

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# Introducing: Heat of Combustion (HOC) Testing

By: Tom Johnson
Flammability Testing Engineer,
Fauske & Associates, LLC

The heat of combustion for a chemical is defined as the heat released when that chemical undergoes complete combustion with oxygen at standard conditions, typically 1 atmosphere of pressure and 20 °C. The heat of combustion can be measured experimentally through a few different laboratory equipment arrangements. One such setup is an Oxygen Bomb Calorimeter, shown in Figure 1, which can be used to determine the Higher Heating Value (HHV) heat of combustion for any solid or liquid sample.

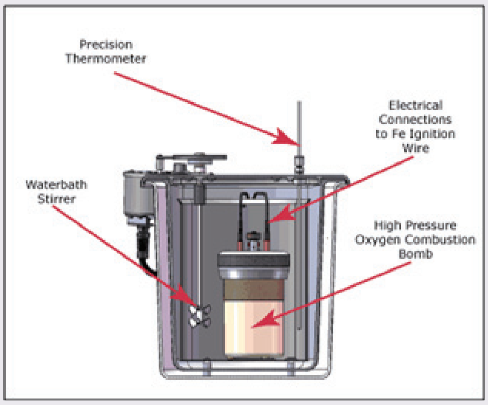


**Figure 1: Oxygen Bomb Calorimeter Schematic**

The HHV is determined by cooling the reaction products down to the starting temperature, typically around 20 °C. Heat of combustion is an important test for anyone concerned with the energy content of a solid or liquid, including fuels (particularly for use in weight-limiting craft such as aircraft and hydrofoils), combustible wastes, food items and feeds. The heat of combustion value is also important for determining the thermal efficiency of equipment for producing power or heat. The theoretical heat released is compared with the delivered power or heat, giving the user the efficiency of their equipment.

An Oxygen Bomb Calorimeter has recently been acquired by Fauske & Associates in order to diversify our testing capabilities. With a few small modifications, the test method is performed to comply with ASTM International Standard D240, "*Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimetry*." This standard is the basis for the allowed precision and bias of our testing. Another potential HOC standard is ASTM International Standard D4809, "*Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)*," which calls for more precise mass and temperature measurements and reagent quality water.

For both methods, the heat capacity for the system is determined using a standard reference material for which the heat of combustion is known and has been previously verified. Benzoic acid is the industrial standard typically used for oxygen bomb calorimetry and was used for FAI's standardization procedures. Table 1 shows the heat capacity of the oxygen bomb system and repeatability of the heat capacity after 10 standardization test runs.

**Table 1: System Heat Capacity and Accuracy**

| Heat Capacity (cal/°C) | Standard Deviation (cal/°C) | Relative St. Dev. (%) |
|---|---|---|
| 2429.2 | 9.25 | 0.38 |

The procedures for both ASTM D240 and D4809 are very similar. The chemical is weighed and placed inside the bomb reactor, which is submerged into a pre-measured quantity of water. A high degree of repeatability in the quantity of water used between experiments is very important in order to maintain a high degree of precision and low bias. The bomb reactor is charged with oxygen and then ignition is initiated via a fuse wire.

The measured temperature rise of the water from the oxidation reaction can be used in combination with the heat capacity of the system to determine the heat of combustion for the chemical of interest. The accuracy of the experimental test method and the values it generates has also been validated against other chemicals with known heats of combustion. Methanol, ethanol and tert-butanol were chosen as the three chemicals to be tested for validation of the apparatus and test methodology. Each test was performed in triplicate to provide a baseline statistical error and standard deviation measurement. Table 2 compares the experimental and literature values for the heat of combustion of these three chemicals.

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An example of jet condensation data for flashing water and model prediction of complete condensation length is illustrated below.

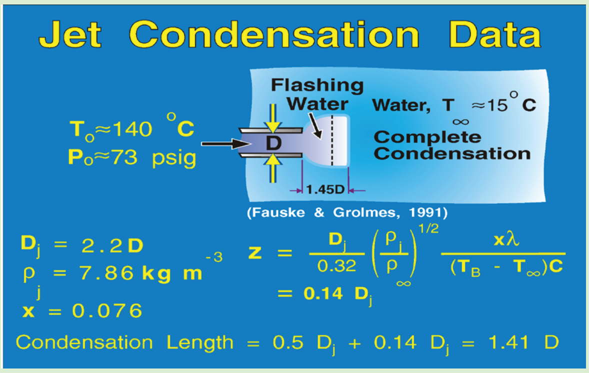




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**Table 2: Calorimetry Comparison**

| | Experimental HOC (cal/g) | Reported HOC (cal/g) [1] | Relative Error (%) | Relative St Dev of Experiment (%) |
|---|---|---|---|---|
| Methanol | 5 396 | 5 419 | 0.33 | 0.67 |
| Ethanol | 7 077 | 7 094 | 0.26 | 1.23 |
| Tert-butanol | 8 472 | 8 504 | 0.38 | 0.08 |

[1] CRC Handbook

As shown in Table 2, the relative error for all three chemicals is less than the standard deviation of the system reported in Table 1. This error is less than the error allowed in the ASTM Standard D240.

Heat of combustion can be very useful for many industries, including fuels, building materials, and explosives, and oxygen bomb calorimetry is a standard test method used to determine heat of combustion. For technical questions, please contact Mr. Tom Johnson, Flammability Testing Engineer, at 630-887-5209. For all other questions, please contact Mr. Jeff Griffin at 630-887-5278 or email at griffin@fauske.com.

## References

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# Meet Chuck Kozlowski Chemical Engineer

By: Sara Peters
Marketing Specialist ,
Fauske & Associates, LLC

**Q:** Where did you go to school and what was your major?

**A:** I attended the University of Iowa where I earned a BS in Chemical Engineering and minored in chemistry.

**Q:** How long have you worked at FAI?

**A:** In total, I have worked with FAI for 2 and ½ years. I began working with FAI as an intern and then was fortunate enough to be offered a full-time position with the company upon graduation.

**Q:** What is your official title?

**A:** I am a chemical engineer.

**Q:** What are your job responsibilities and particular areas of expertise?

**A:** My work includes testing and consulting responsibilities. I provide customers with vent sizing and other thermal hazards calculations, work with customers to develop VSP testing procedures according to their individual needs and perform calorimetry testing.

**Q:** What do you consider the most rewarding part of your job at FAI?

**A:** I really enjoy working and interacting with customers and being able to share my knowledge to help them successfully implement solutions appropriate to their unique situations.

**Q:** What do you consider to be the most challenging aspect of your job at FAI and how do you work to mitigate its challenges?

**A:** I work with a variety of different customers from different sectors and each utilizes different chemistries. Working with each customer to learn and understand their different chemistries is an interesting challenge that ensures that there is always something new for me to learn.

**Q:** How does your job benefit FAI customers?

**A:** Utilizing my knowledge and experience with different chemistries and vent sizing implications, I am able to effectively work with customers to help them minimize costs, while implementing the most effective process safety strategies.

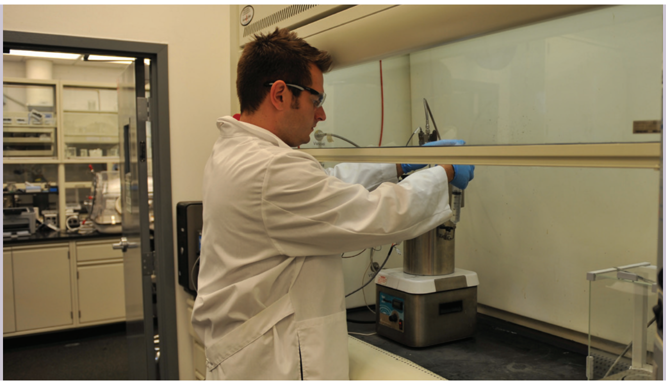
**Q:** What do you see on the horizon as far as customer needs and potential areas of growth for FAI?

**A:** Some areas of personal interest to me and ones where I see opportunities for FAI to potentially grow services is in the design of large header systems, effluent handling projects and the furthering of the PrEVent software capabilities so that it is more tailored to the needs of our customers.

**Q:** You are also a Subject Matter Expert at John Wiley and Sons. How did you become an SME and what does that role entail?

**A:** John Wiley and Sons is a global publishing company specializing in academic publishing. I became involved when I was in college. I was a Teaching Assistant and the company asked me to provide input regarding how I thought they could make the online experience more efficient for both students and instructors. From there, I eventually started proofing questions that were included in their online texts, and then, after graduation, was asked to work with them as an SME.

As an SME, I work with editors and the programming team to improve the online component of text books by reviewing and formatting questions, often algorithmically so answers can't be shared, and also identifying the appropriate sections where more information pertaining to each question can be found.



Chuck conducting a VSP test in a FAI laboratory

Continued from page 9

Flammability limits are influenced by numerous factors and offer an explanation into the differences between the two test results:

1. Vessel size and geometry – As the size of the vessel increases, the heat losses to the vessel wall becomes negligible. Through minimizing heat losses to the vessel wall, more heat is transferred to the combustion reaction, therefore, promoting flame propagation. This results in a widening of the flammable region and combustion can occur at lower temperatures.

2. Ignition source location – A lower ignition source location in a vessel has shown to widen the flammable region as compared to a central ignition source location (Van den Schoor, Norman, & Verplaetsen, 2006). With a lower ignition source, a larger percentage of the combustible mixture participates in the combustion reaction with minimal heat losses to the wall, thereby, resulting in a high pressure increase.

3. Homogeneity of mixture – Slight changes in the vapor concentration could result in a mixture becoming flammable or not flammable. In the LTFL tests, the vapor mixture is stirred to provide a homogenous mixture of the fuel in air unlike the flash point tests where the vapor space is not stirred and thus concentration gradients my form. Furthermore, the LTFL tests provide a more uniform heating of the vessel as well as a longer mixing time to allow the vapor and the liquid to reach equilibrium. All of these factors will impact the concentration of the fuel in the vapor space, thereby, influencing the flammability results.

4. Flame propagation – Generally, the flammable region is wider for upward flame propagation than for downward flame propagation due to flame buoyancy. Tests performed in the 5.3L vessel measures upward flame propagation as compared to the flash point tester which is measuring downward flame propagation (EU-Project SAFEKINEX). This wider range means that the LTFL will occur at a lower temperature than the FP.

These results demonstrate that it is imperative to fully characterize the flammability hazards of chemicals. The use of the flash point by itself may not always be sufficient in providing proper safety precautions to avoid flammable temperatures when assessing the hazards of flammable liquids. As shown from the LTFL and FP tests, there can be large deviations between the two values. Therefore, the use of a safety margin with the flash point value may not always be adequate. A better approach would be to conduct a LTFL test to assess the temperature at which there is sufficient vapor for flame propagation.

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# Spring 2012 Process Safety Training Courses

## March 22 - 23, 2012

Fauske & Associates, LLC (FAI), presents two individual process safety courses, designed to identify hazards and control strategies that allow for explosion and fire hazard risk minimization in the process industries.

**Topics to be covered:**

- Flammability and electrostatic hazards
- Dust/flammable explosion hazards and prevention and protection practices, including OSHA Combustible Dust National Emphasis Program.

**Who should attend?**

FAI designed these introductory courses for personnel including – but not limited to – chemists, engineers, technicians and operational staff in R&D, Process Development, kilo, pilot and full-scale production in the chemical, petrochemical, food, cosmetic, detergent, plastic, paper, agrochemical and pharmaceutical industries.

### Day 1 – Thursday, March 22

***Introduction to Understanding and Controlling Flammability Hazards***

**Description**

This course will allow engineers and process safety personnel to identify hazards of conducting processes with combustible and flammable solvents. A review of common flammable and electrostatic principles will be discussed, in terms of theory and case reviews.

**Scheduled Agenda**

- Introduction – Basic Theory and Definitions
- Review of Significant Incidents
- Conditions for Fire & Explosion
- Small-Scale Tests
- Theoretical Calculations (Predictions)
- Ignition Factors, Including Electrostatics
- Explosion Control
- Case Studies
- Daily Learning Assessment
- Questions and Answers
- Course Evaluation

**Outcomes**

After completing this course, participants will be able to describe and define the fundamental principles of flammability and electrostatic hazards in various industry settings, including:

- Defining what constitutes flammability and electrostatic hazards
- Identifying and mitigating conditions that create such hazards
- Interpreting and reporting on such hazards

### Day 2 – Friday, March 23

***Introduction to Dust Explosions Hazards, Prevention and Protection Practices***

**Description**

This course will ensure all participants are aware of important issues associated with OSHA's Combustible Dust National Emphasis Program, NFPA 654 and other relevant standards and codes. A logical approach to characterizing a powder's hazardous dust properties will be presented, as well as a description of various techniques used to control and/or avoid dust explosions in a safe and compliant manner.

**Scheduled Agenda**

- Introduction
- Review of Recent Dust Explosions
- Fundamentals of Dust Explosions
- How to Comply With NFPA Codes and OSHA's Program on Combustible Dust Compliance
- Protection Options
- Daily Learning Assessment
- Questions and Answers
- Course Evaluation

**Outcomes**

After completing this course, participants will be able to identify potential dust hazards and know how to utilize appropriate test methods to determine levels of potential hazards; as well as apply appropriate mitigation techniques to prevent combustible dust hazards, including:

- Identifying levels of hazard
- Determining appropriate testing methodology
- Ascertaining process application

Each one-day course runs from 9 am to 4 pm over two consecutive days. Each course may be attended individually.

**Prices:** $575.00 per day or
$1150.00 for both days

Fees include hotel room, continental breakfast, lunch and two snacks for each day of attendance.

**Location:**
Chicago Marriott Southwest at Burr Ridge
1200 Burr Ridge Pkwy
Burr Ridge, IL 60527
(630) 986-4100

**Contact Lisa Karcz: karcz@fauske.com, (630) 887-5232, Fax: (630) 986-5481**

## SPRING 2012 PROCESS SAFETY TRAINING COURSES

*Introduction to Understanding and Controlling Flammability Hazards* - *Thursday, March 22*

*Introduction to Dust Explosions Hazards, Prevention and Protection Practices* - *Friday, March 23*

## REGISTRATION FORM

**Location**:
Chicago Marriott Southwest at Burr Ridge
1200 Burr Ridge Pkwy
Burr Ridge, IL 60527
(630) 986-4100

**Trainer/Host:**
Fauske & Associates, LLC
16w070 83rd Street
Burr Ridge, IL 60527
1+877-FAUSKE1

First Name: ______________ Last Name: ______________

Company Name: ______________ Position: ______________

Address: ______________

City: ______________ State: ______ Zip: ______

Phone: ______________ Cell: ______________ Fax: ______________

Email: ______________

Price:
$575.00 per day or
$1,150.00 for both days

Fee includes hotel room, continental breakfast, lunch and two snacks for each day of attendance.
All fees must be received prior to course commencement.
We accept Visa, Mastercard, American Express, purchase order or company check.

Payment Method: _____ Visa _____ Mastercard _____ AmEx _____ Purchase Order _____ Company Check

Name on Account: ______________

Account Number: ______________ Expiration Date: ______________

Signature authorizing Fauske & Associates, LLC, to charge credit card:

______________

Please select which day(s) you will be attending:

☐ Day 1: Thursday, March 22 - *Introduction to Understanding and Controlling Flammability Hazards*
☐ Day 2: Friday, March 23 - *Introduction to Dust Explosions Hazards, Prevention and Protection Practices*

**Cancellation Policy: Cancellations will be accepted up to March 12, 2012**

**Contact Lisa Karcz: karcz@fauske.com, (630) 887-5232, Fax: (630) 986-5481**

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