FAUSKE
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New Format

Process Safety News
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IN THIS ISSUE

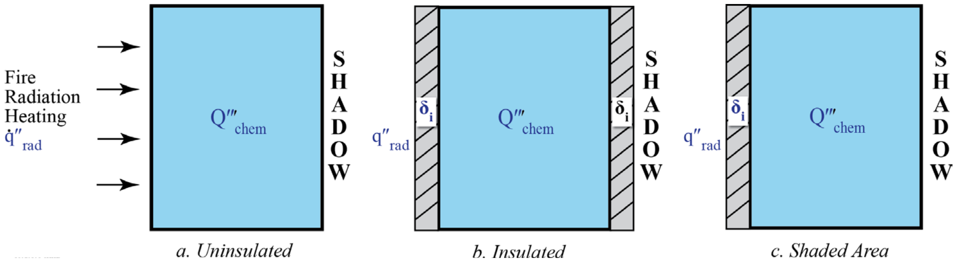
Passive Prevention of Chemical Runaway in Case of Fire Radiation Heating

Self-reacting chemicals stored in vessels subjected to fire radiation heating is of interest in assessing the potential for chemical runaway reactions

By Hans K. Fauske

Here, consideration is given to cases where one-half of the surface area of the vessel is in the “shadow” of the fire and does not receive fire radiation heating as illustrated below.

If the runaway reactions occur at temperatures higher than 100°C, active prevention can be provided by a water spray system limiting the vessel temperature to 100°C.



a. Uninsulated *b. Insulated* *c. Shaded Area*

Figure 1, Insulation Configurations

Given the location of the fire is relatively close to the vessel in question, an uninsulated vessel is likely to experience runaway reaction (figure 1,a). The energy balance on the vessel in this case can be stated as:

$$\frac{1}{2} A \, \dot{q}''_{rad} + \dot{Q}'''_{chem} \, V = A \, h \, (T - T_\infty) \quad (1)$$

Where A and V are, respectively, the surface area and volume of the vessel, $\dot{q}''_{rad}$ (in W m^{-2}) is the incident fire (radiant) heat flux at the vessel wall, T is the temperature of the reactive chemical, and T_∞ is the ambient temperature. The heat transfer coefficient h in Eq. (1) includes both natural convention and thermal radiation cooling of the vessel.

The radiant heat flux $\dot{q}''_{rad}$ in Eq. (1) can be decreased if the vessel is covered with insulation material of thickness δ_i, and thermal conductivity k_i (Figure 1,b). The relevant overall energy balance in this case is:

$$\frac{1}{2} A \, \dot{q}''_{rad} + \dot{Q}'''_{chem} \, V \left(1 + \frac{\delta_i \, h}{k_i}\right) = A \, h \, (T - T_\infty) \quad (2)$$

Upon comparing Eq. (2) with the energy balance for the uninsulated vessel, Eq. (1), it can be seen that the effect of the insulation is equivalent to increasing the self-heat rate

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Letter From The President

Happy New Year from me and the team at Fauske & Associates, LLC (FAI).

The years seem to go by faster and we have come a long way from our beginnings in 1980.

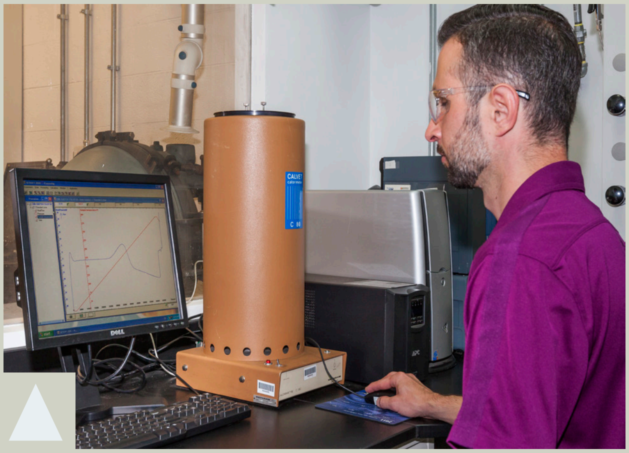
Although technology, methodology and faces may have changed throughout the years, our commitment to conducting business safely while continuing to meet or exceed customer expectations remains the same.

I have designated 2018 ‘the year of improvement’ for FAI. FAI employees are always encouraged to go above and beyond at 110% to create a good customer experience for you. We try hard, but we know there is always room for improvement.

That said, I welcome your feedback. because you are key to our success. Contact me directly at kfauske@fauske.com or call me at 630.887.5224. Tell me what we are doing well and what we can do to serve you better, because safety and service have and will always be the heart of our business. I look forward to hearing from you.

Stay Safe,

A birds eye view of our
state-of-the-art Combustible Dust Lab



Ken Kurko, Process Safety Services Director, working on a C89, a reaction thermal and scanning calorimeter that operates like a larger version of a DSC

Read his article on page 3

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AVOIDING HAZARDOUS RUNAWAY REACTIONS IN COLD/FREEZING TEMPERATURES

By Ken Kurko

Colder temperatures mean lower sample reactivity at those temperatures (less heat generation) so, shipping is generally safer from a UN testing perspective. But, there is one thing that comes to mind relating to problems that could arise from dropping temperatures. If a container of a liquid chemical becomes frozen due to colder conditions (whether it be during shipping or storage), the container will have to be heated up to melt the chemical before use. If it is simply moved to a warmer room, it could take several days to thaw depending on the quantity of material and temperatures involved. Sometimes, people will throw band heaters on these frozen containers to expedite the thawing process. Incidents have been caused by people accidentally heating the containers too much (sometimes way past the melting point), causing runaway reactions. This **link** discusses this issue in depth for a common industrial solvent, DMSO.

Here is another useful **link** to an acrylic acid handling guide by Arkema, BASF, and Dow Chemical. In section 6.2, it describes the issue in depth for a monomer. Later on, it also talks about avoiding using acrylic acid from a partially thawed container. This thawed material could be void of inhibitor, making it much more hazardous.

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Safety: Its More Than Compliance

Corporate compliance with regulations does not equate to corporate safety

By Harry J. Elston, Ph.D., CIH

There are many organizations that are compliance driven. They think that if they are compliant with OSHA regulations then their organizations are working safely. This thinking is not necessarily true.

Don't misunderstand me. Compliance with regulations is important, but corporate compliance with regulations does not equate to corporate safety. I know of, and have worked for, a number of organizations that have been subjected to OSHA Compliance visits with the accompanying fines and they are naturally afraid of the cost for regulatory non-compliance. Likewise, I am also aware of corporations who view regulatory fines as a "cost of doing business."

RMS Titanic

Let me provide a non-chemical example of how compliance does not equate to safety. The RMS Titanic was fully compliant with all applicable engineering and safety regulations at the time of her construction. And yet, she now lies silent at the bottom of the ocean. Compliance did not spare over 1500 passengers from their deaths.

Here are a couple of reasons why compliance does not equal safety:

- **Regulations cannot keep pace with best practices:** Technology will always outpace the regulatory landscape. For a concrete example of this, OSHA has yet to incorporate "inherently safer technology" (IST) into the Process Safety Management standard (29CFR1910.119) although IST is part of a 2014 report to the Obama Administration and the following Executive Order 13650. Regulations are changed through a lengthy political process and can stagnate, while best practices can be flexibly executed at the corporate level.

- **Regulations generally focus on hazard, not risk:** Hazard identification is generally pretty easy: Unguarded saws are easily spotted. However, an unguarded saw that is (1) dedicated to a single process by a written administrative control and high-level operator supervision and (2) has numerous jigs hanging next to it for those processes looks just like any other unguarded saw and may incur a "serious" –level OSHA violation, even though the risk may be sufficiently managed and the process may be deemed "safe" for the operator. From a laboratory-scale chemical safety perspective, hazards associated with reactive chemicals or reactive chemistry (highly exothermic processes), though very real, are simply not addressed by the Laboratory Standard. Risk is certainly not addressed by the Laboratory Standard.

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by the factor $1 + \delta_i \, h / k_i$. While initially the insulation slows the rate of heat transport to the vessel, ultimately the added resistance to heat loss from the vessel decreases the critical heat flux and accordingly increases the potential for a runaway reaction.

Based upon the above observations, the advantage of insulation can be achieved by leaving the shaded area uninsulated (figure 1,c), resulting in an increased heat removal of the order of $h / (k_i / \delta_i)$ which provides the potential of passively ruling out the potential for a runaway reaction in the presence of fire radiant heating.

The following example illustrates the case with a tank (volume $V = 23.4 \text{ m}^3$ and surface area $S = 47.7 \text{ m}^2$) containing a self-reacting chemical (with density $\rho = 960 \text{ kg m}^{-3}$ and specific heat $c = 2000$ J kg-1 K^{-1}) with an Arrhenius expression

$$\dot{T} \, (\text{K s}^{-1}) = 3.22 \cdot 10^{18} \, e^{-19{,}934/T} \qquad (3)$$

Leaving the shaded area uninsulated and the other half of the vessel surface area receiving fire radiant heating insulated with a thickness, $\delta_i = 0.1 \text{ m}$ (4") and thermal conductivity $k_1 = 0.1 \text{ W m}^{-1} \text{ K}^{-1}$, results in a fire heat flux $q_f = 800 \text{ W m}^{-2}$ at a vessel temperature of 100°C (373 K), or a total fire heat input of $1.9 \cdot 10^4$ W.

Considering an ambient temperature of 20°C (293 K), the heat loss from the shaded area (uninsulated) considering radiation $(\varepsilon = 0.8)$ and free convection with $h = 19.7 \text{ W m}^{-2} \text{K}^{-1}$ results in a total heat loss of about $3.8 \cdot 10^4$ W (note that in the presence of insulation this heat loss would be reduced by a factor of about 20).

Estimating conservatively the chemical reation self-heating rate at 120°C results in $\dot{T} = 3 \cdot 10^{-4} \text{ K s}^{-1}$ and total chemical heating of about $1.35 \cdot 10^4$ W.

This rules out the potential for a chemical runaway reaction since the radiant fire heat input of $1.9 \cdot 10^4$ W plus the chemical reaction heat input totaling $3.25 \cdot 10^4$ W is less than heat loss from the shaded area of the tank of $3.8 \cdot 10^4$ W.

Dr. Hans K. Fauske is an original founding partner of Fauske & Associates, LLC and currently serves as Regent Advisor

Calculating Heat of Reaction from Adiabatic Calorimetry Data and Further Understanding the Differences between Reaction and Adiabatic Calorimetry

This article expands on the information presented in "Reaction Calorimetry vs. Adiabatic Calorimetry: Which Method is Right for Me?" and "Scale Up Aspects of Phenol-Formaldehyde Reactions" available on the Fauske & Associates, LLC website

By Elizabeth Raines, Chemical Engineer

Thermal hazards screening is a quick and cost-effective tool used to obtain the required data for the safe scale-up of new or altered chemical processes. One parameter often used to understand the specifications of equipment required for large-scale manufacturing is the heat of reaction. While general studies found in literature can be useful for screening thermal hazards, oftentimes the characteristics of a particular reaction and reaction conditions are not available, and must be determined experimentally. Fauske & Associates, LLC (FAI) employs many tools to collect this necessary data including both reaction and adiabatic calorimeters. It was previously discussed in *"Reaction Calorimetry vs. Adiabatic Calorimetry: Which Method is Right for Me?"* the primary differences between the two types of instruments. The objective of this discussion is to give an example of one such difference with special emphasis on how to use adiabatic calorimetry to calculate the heat of reaction. The heat of reaction measured here is indicative of the process heat that needs to be handled in the plant as opposed to solely the theoretical heat of reaction since factors such as addition temperature can alter results.

As discussed in *"Scale Up Aspects of Phenol-Formaldehyde Reactions,"* producing phenolic resins is a very old but still very active process in the industry. The chemistry has a wide variety of uses such as ablation, abrasives, coatings, composites, wood bonding, and much more. This example explores a generic semi-batch phenol formaldehyde process where a controlled addition of 37% aqueous formaldehyde was added to a mixture of phenol and 50% caustic (catalyst). The same recipe was tested in both the FAI VSP2™ and Mettler Toledo RC1. The VSP2 test was performed with a 50°C starting temperature while the RC1 was performed isothermally at 70°C.

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The ways to prevent such an occurrence extend back to truly understanding the characteristics and reactivity of the chemical you are using – what temperature or pressure can incite a negative reaction, and have safe handling processes in place. MSDS information and testing can help.

> ***If you think there is a chance you will need to thaw before use, incorporate the safe thawing time into the process schedule to ensure that it thaws safely***

Ideally, the most obvious manner of prevention is to avoid the chemical freezing if at all possible. However, if you think there is a chance you will need to thaw before use, incorporate the safe thawing time into the process schedule to ensure that it thaws safely. This is definitely one of those situations where proceeding 'low and slow' can make a huge difference between the desirable outcome and disaster.

If you are unsure of proper chemical process safety including handling in colder temperatures, our engineers can help. Please feel free to contact Ken Kurko at 630-887- 5266 or Kurko@fauske.com for more information.

www.fauske.com

Ken Kurko is Process Safety Services Director at Fauske & Associates, LLC

How We Safely Handle Reagents and Decomposition Products in Testing Activities at FAI-

Case Study of Dimethyl Sulfoxide (DMSO) Decomposition

By: Charles Askonas

An important consideration in our testing business is knowing we can safely handle both the initial reagents and any post-test products of combustion or decomposition. The availability and use of appropriate PPE and engineering controls go a long way in the safe conduct of testing activities. However, a potentially overlooked but important consideration is to determine what the reaction products are before performing tests in order to properly handle them. Most of the time decomposition products are not fully known. However because of personnel safety and environmental considerations, we cannot take chances in our operations. While personnel safety is of course expected, our unique environmental consideration is the close proximity to the property line in the industrial park we are located in, as well as to a residential area. Therefore, our commitment to safe operations on a day-by-day basis has provided valuable experience to enable us to assess and handle new challenges presented by our customers' samples.

The ability to safely (and confidently) handle a reagent or reaction by-product depends on various properties including the volatility (e.g. normal boiling point), permissible exposure limit, specific toxic characteristics, and the ability to neutralize or destroy it by "scrubbing" using an appropriate solution. A few specific examples will be provided below.

While anhydrous hydrogen chloride is a toxic gas, it can be readily neutralized using sodium hydroxide solution. If it is used as a reagent, the lecture bottle must be equipped with a regulator to reduce the pressure to near atmospheric pressure in order to control the addition rate. Hydrogen chloride produced as a reaction product can be completely scrubbed in 10% sodium hydroxide solution. Workers working in a properly functioning fume hood wearing full facepiece cartridge respirators are adequately protected. The OSHA PEL is 5 PPM.

By comparison, reagents that are "slow scrubbers" with a high vapor pressure and high toxicity pose a much greater risk of exposure, and hence are generally not handled as reagents at our testing facility. A material which reacts slowly with water is much harder to destroy. Furthermore, for some highly toxic materials, respirator cartridges have unknown sorbent effectiveness. The thermal hazards testing group can perform on-site testing services in VSP2/ARSST equipment in these kinds of situations. Examples of such reagents include phosgene, hydrogen cyanide, and methyl isocyanate. While hydrogen cyanide can be scrubbed with sodium hydroxide, its high vapor pressure makes a lethal exposure easy to achieve in the event of a leak during handling. On-site testing services have been successfully provided at client facilities having the appropriate PPE (including supplied air respirators) and procedures for handling HCN and methyl isocyanate as reagents.

We can, however, perform tests that produce HCN, as it can be scrubbed with sodium hydroxide. In this case, the use of supplied air respirators and dedicated lab space for the clean-up necessitate premium pricing for these tests, but still less than going on-site.

High molecular weight diisocyanates, on the other hand, can be handled at our facilities owing to very low volatility. Although the short

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Figures 1 and 2 show the temperature and temperature rise rate profiles from the adiabatic calorimeter experiment. While this instrument is also useful in gathering pressure related information, those data are not included here.

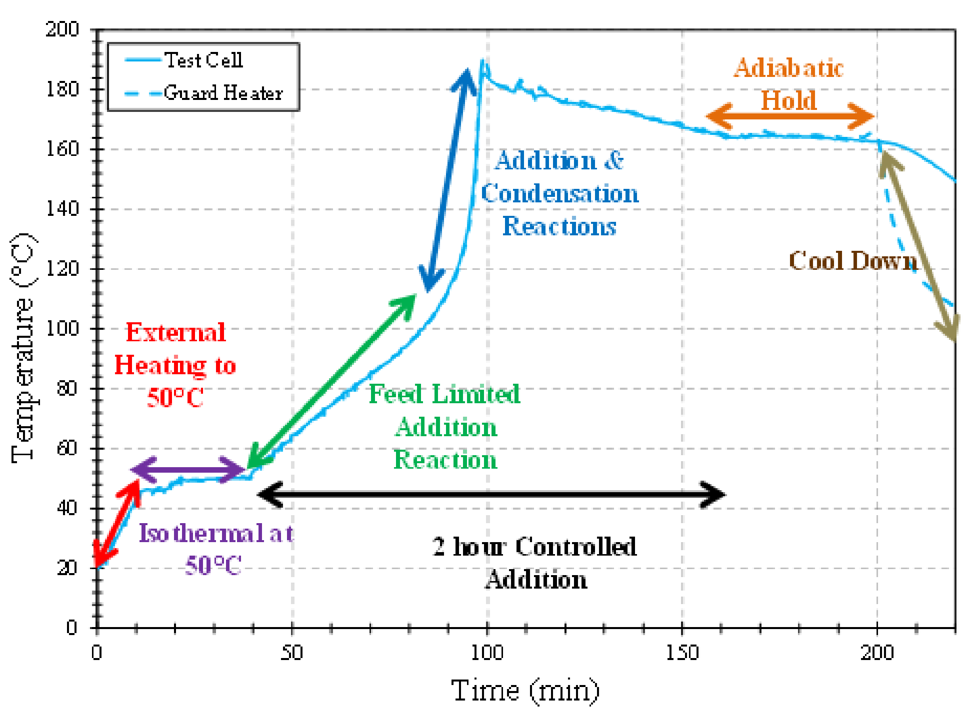

Figure 1: Temperature vs. Time for the VSP2 Phenol Formaldehyde Reaction

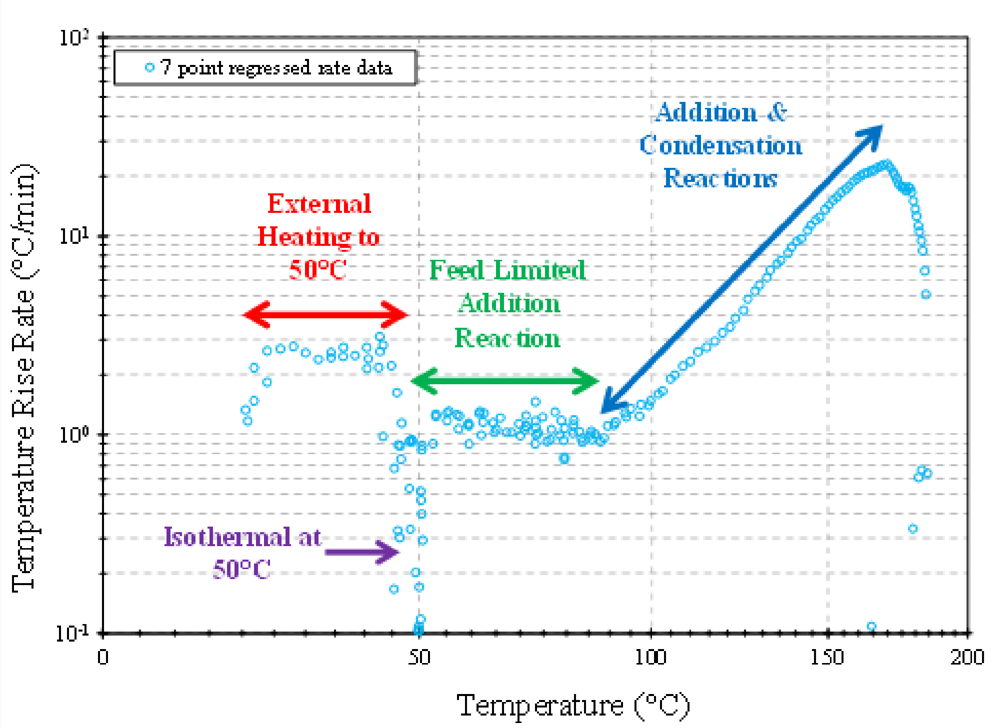

Figure 2: Temperature Rise Rate vs. Temperature for the VSP2 Phenol Formaldehyde Reaction

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term exposure limit for toluene diisocyanate, for example is, 0.02 PPM, the low vapor pressure coupled with the use of a fume hood permits this material to be handled in our facilities. When handled at room temperature, conventional full facepiece cartridge respirators can be used. Great care must be taken to avoid skin exposure of these materials because they are strong skin and respiratory sensitizers and they have a slow reaction rate with water. Decontamination of tools/surfaces is done using an overnight soak in an aqeuous baking soda solution. Thermal decomposition and the reaction with water produces CO_2 and by-products which are expected to be less toxic than the original diisocyanate. (Experience has shown these reactions tend to be foamy in nature.) Combustion, however is expected to produce HCN which must be appropriately scrubbed.

Volatile carcinogenic reagents such as ethylene oxide, 1,3-butadiene, and vinyl chloride can be handled at our facilities. In the case of ethylene oxide, OSHA mandates the use of a supplied air respirator. These materials are handled in generally small quantities with appropriate equipment to handle the high vapor pressure. In the case of 1,3-butadiene, the inhibitor is removed by passing the 1,3-butadiene through a column of alumina and then condensing the uninhibited monomer in a dry ice and acetone bath. The cold temperature permits the appropriate amount to be quickly weighed out using a syringe.

Case study of Dimethyl Sulfoxide (DMSO) Decomposition

When we started conducting tests involving dimethyl sulfoxide in the mid 1990s, the available MSDS listed the decomposition products as sulfur dioxide, methyl mercaptan, and formaldehyde. Thus one would expect non-condensable gas to be generated. In closed system VSP2 tests, we observed decompositions beginning in the 200°C to 240°C range. The temperature rise rates typically approach 100°C/min with associated pressure rise rates at 300°C of around 1000 psi/min in a closed VSP2 test cell. Owing to the small headspace volume (~30 ml) and the continued increase in temperature and pressure, the test cell ruptures since the standard containment pressure is limited to 1300 psi for safe operation. (The containment vessel is isolated from the nitrogen source when the pressure reaches 1300 psi and the test cell is then allowed to rupture). Upon cool-down the gas in the containment vessel must be scrubbed to treat the gases.

Using the MSDS listed products as a guide for post-test scrubbing, the sulfur dioxide can be handled using sodium hydroxide solution. To handle the strong stench of methyl mercaptan, a proprietary solution called Epoleon N-100 is used. (This material can be purchased through suppliers like McMaster Carr, where it is listed as a cutting fluid and coolant deodorizer.) To accommodate both of these sulfur compounds in a single stage scrubber, we make a weight percent sodium hydroxide in water. Although it would be ideal to scrub in multiple stages, we typically use a single stage and pass the gas (using a metering type valve) through a Pyrex® tube with a 40-60 micron frit on the end. Since VSP2 testing typically ends at an elevated pressure, a prohibitively long scrubbing time would be required using multiple stages. Owing to the smell and nature of the decomposition products, on-site VSP2 testing has been conducted when the client requires multiple tests in a campaign.

Recently in the course of testing (at FAI facilities) an employee asked how we knew we were safe in our scrubbing procedures and PPE used in handling DMSO decomposition products. An available 1993 memorandum from Ciba-Geigy, Ltd. dealing with hazards of DMSO provided the mechanism of the decomposition reaction with the associated products(1).

Table 1 provides some of the properties of the expected DMSO decomposition products. Conducting test operations in a properly functioning fume hood and venting the gasses slowly through an Epoleon N-100/caustic scrubbing solution mitigates the methyl mercaptan and sulfur dioxide. Therefore, the concentration of gases in the fume hood should be very low. Typically containment vessels are purged with nitrogen after the gases have been initially scrubbed. By following these operating procedures, we use full facepiece respirators equipped with multicontaminant cartridges. Furthermore, the other listed decomposition products are liquids for which the 3M Respirator Guide recommends organic vapor/acid gas cartridges. By replacing the cartridges twice during the workday (e.g. in the morning and afternoon), the "short service life" pertaining to methyl mercaptan is accommodated. The use of full facepiece cartridge respirators versus supplied air respirators facilitates test operator mobility and efficiency.

Table 1: DMSO Decomposition Products and Characteristics

Species CAS #, MW	NBP (°C)	Exposure Limit	Odor Threshold (if available)	Hazard Characteristics (Shipping)	Respirator Cartridge Required[1,2]
Formaldehyde 50-00-0, 30	-21 gas	0.016 PPM TWA; 0.1 PPM 15 minute ceiling (Carcinogen)	0.871 PPM[1]	Toxic, flammable, and corrosive gas	Formaldehyde
Methyl Mercaptan (Methanethiol, methyl sulfide) 74-93-1, 48.1	6	0.5 PPM 15 minute ceiling	0.001 PPM[1]	Toxic and flammable gas. Poison Inhalation Hazard, Zone C	Organic Vapor (short service life)
Dimethyl Disulfide 624-92-0, 94.20	109	0.5 PPM TWA[3]	N/A	Flammable liquid with a poison subrisk	Organic Vapor/Acid Gas
Dimethyl Sulfide 75-18-3, 62.13	38	10 PPM TWA[3]	0.003 PPM[1]	Flammable liquid	Organic Vapor/Acid Gas
Dimethyl Sulfone (67-71-0, 94.13)	238	None established	N/A	-	-
Bis(methylthio)methane 1618-26-4, 108.23	147	None established	Described as stench	Flammable liquid	-

[1] From the 2015 edition of the 3M Respirator Selection Guide.

[2] Subject to operation in a properly functioning fume hood and contaminant concentrations below IDLH.

[3] From available MSDS.

REFERENCES

(1) "POTENTIAL HAZARDS INVOLVED IN THE HANDLING AND USE OF DIMETHYL SULFOXIDE (DMSO)," CIBA-GEIGY LTD., CORPORATE SAFETY AND ENVIRONMENT, INFORMATION B31, BASLE, APRIL 1993

Charles Askonas is Chief Testing and Safety Engineer at Fauske & Associates, LLC

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Fauske & Associates, LLC
16W070 83rd Street
Burr Ridge, IL 60527
+001 889 5687
info@fauske.com
EXECUTIVE DIRECTOR:
H. Kristian Fauske
ART DIRECTOR:
Sara Peters
CONTRIBUTORS.
Charles Askonas
AnnMarie Fauske
Dr. Hans K. Fauske
Kris Fauske
Ken Kurko
Sara Peters
Elizabeth Raines
Carol Raines

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:

FAI's "Process Safety News" is published by
Fauske & Associates, LLC
16W070 83rd Street, Burr Ridge, IL 60527
Toll Free: 877 FAUSKE1, +1-630-323-8750
Fax: +1-630-986-5481
info@fauske.com www.fauske.com

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For this experiment, the phenol and 50% caustic (catalyst) were preloaded to the test cell. The mixture was heated to 50°C and held isothermally to equilibrate. A 2 hour controlled addition of 37 wt.% formaldehyde was performed beginning around 40 minutes. The formaldehyde was heat traced so that the formaldehyde was added at 50°C. For this base catalyzed recipe, the formaldehyde to phenol ratio was greater than one (2.2) as is typical for a resole resin. Typically, these reactions are intentionally not reacted to completion. The resole product carries pendent methylene hydroxyl moieties that allow the resin to be self-crosslinking at higher temperature. The phenol-formaldehyde reactive system is very complex and difficult to understand solely from thermal data, however, the results from the test do show a constant temperature rise rate from 50°C to around 90°C. The first thermal profile ("Feed Limited Addition Reaction") appears to be feed-rate limited and is likely primarily the addition reaction between formaldehyde's methylol groups and phenol's aromatic ring. The second thermal profile could be a combination of the addition reaction and condensation reactions between aromatic rings to form a higher molecular weight species with additional crosslinking by condensation within the higher molecular weight polymer to form a three dimensional network. After the maximum temperature of 186°C at 99 minutes is achieved, the temperature is observed to decrease during the remainder of the addition. This is due to a combination of a significant decrease in the reaction heat generated along with adding the formaldehyde at a cooler temperature to the reaction mixture. At 157 minutes the addition was complete and the mixture was held adiabatically without any additional reactivity observed. At 200 minutes the heaters were disabled and cooldown data were collected.

This data can be used to determine many important parameters such as the required relief area (vent sizing), characteristic time of adiabatic runaway, the moles of noncondensable gas generated, kinetic parameters, temperature of no return, self-accelerating decomposition temperature, heat of reaction, and others.

In order to calculate the heat of reaction, it is assumed that the heat of reaction and heat capacity are constant throughout the reaction, and that there is zero conversion of the limiting reagent at the onset temperature of reaction. Together with these assumptions, the following equation can be utilized to determine the heat of reaction.

$$\Delta H_r = \frac{-\Phi C_s(\mathrm{ATR})}{\frac{m}{m_t}}$$

ΔH_r = the heat of reaction (J/g)

Φ = the phi-factor or thermal inertia for the experiment (-)

C_s = sample heat capacity (3.2 J/g-K)

ATR = the adiabatic temperature rise (K)

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Risk is the combination of the probability of a consequence occurring and the severity of that consequence. Risk is reduced by reducing the probability of an incident and/or reducing the severity. While hazard abatement is an important part of risk reduction, it is not the only part. Since regulatory compliance is often hazard-based, other important aspects of overall risk reduction can be missed or neglected, such as incorporating work practices to reduce injury severity as a result of an incident. An example would be including polycarbonate shielding in addition to a laboratory chemical hood for reactive chemical processes in order to prevent or reduce injury in the event of a run-away reaction.

I've seen far too many organizations that focus on compliance are still experiencing worker injuries that are costing them thousands per year in dollars and non-production. Moving to a risk-centric safety system often results in reduced workplace injury while simultaneously obtaining regulatory compliance.

Dr. Elston is a physical chemist and a Certified Industrial Hygienist and is the Principal and senior scientist at Midwest Chemical Safety, LLC. He can be contacted at helston@midwestchemsafety.com or 217-971-6047.

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> ***-Brian Clark-***

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- *Is a ST Class 1 Dust Dangerous?*
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$\frac{m}{m_t}$ = the mass fraction of limiting reagent (0.3 based on the mass of phenol)

The phi-factor is specific to the experimental design. To calculate the phi-factor, the following equation can be utilized.

$$\Phi = \frac{C_s m_s \quad C_b m_b}{C_s m_s}$$

C_s = sample heat capacity (3.2 J/g-K)

C_b= sample holder heat capacity (0.5 J/g-K)

m_s= sample mass (74 g)

m_b= sample holder mass (50 g)

For this experiment, the phi-factor is calculated to be 1.11

When external heating is not applied during the reaction, the adiabatic temperature rise, ATR, is the difference between the maximum temperature and the onset temperature. In this experiment, the reaction begins at 50°C when the addition is initiated. The maximum temperature observed in the experiment was 186°C, but the addition continued after it was realized. A cooling effect was observed bringing the temperature to 165°C at the end of the addition. Because this was the final temperature at the end of the reaction at known conditions (mass and heat capacity), 165°C is to be used as the maximum temperature. The ATR or difference between the maximum temperature and the onset temperature (165-50°C) is 115°C. The phi-corrected ATR, ("ΦATR)", is found to be 128°C.

The results of this calculation indicate that for the measured ATR (128°C when phi-corrected) the heat of reaction for the phenol-formaldehyde reaction (both the initial and secondary reaction) is calculated to be 1,362 kJ/kg phenol.

The same reaction was studied in the RC1 (not shown in this article) and the measured heat of reaction was determined to be 982 kJ/kg phenol. The calculated ATR for the reaction was 95°C. Because the RC1 experiment was conducted at 70°C as opposed to the 50°C starting temperature in the VSP2, the sensible heat correctioin for the formaldehyde was adjusted in the RC1 to be representative of the VSP2 experimental conditions.

Why the difference? The RC1 was capable of controlling the reaction allowing only the desired reaction to occur. The VSP2 showed the total thermal potential when the reaction cannot be controlled (a loss of cooling scenario) resulting in more heat and a higher temperature rise. It is invaluable to have both pieces of this information to best prepare for how the desired process needs to be run and what could happen when an upset scenario occurs.

Elizabeth Raines is a Chemical Engineer in the Thermal Hazards Group at Fauske & Associates, LLC

NFPA 652

– An Introduction to Dust Hazard Analysis

2018 Dates and Locations:

March 20-21, 2018	Courtyard Phoenix Airport
May 15-16, 2018	Houston Airport Marriott at George Bush Intercontinental
July 17-18, 2018	Fauske & Associates, LLC, Burr Ridge, IL

Course Description

***Day 1** (Prerequisite for Day 2)* *Time: 8 am - 4:30 pm* *CEU's: 0.7*

This course will ensure all participants are aware of important issues associated with NFPA 652 and describe how this standard interacts with other relevant NFPA codes and guidelines. A special emphasis will be placed on explaining the requirements for a Dust Hazard Analysis (DHA) and an overview of the methodologies that can be employed to perform a DHA. The course will also include a logical approach to characterizing a powder's hazardous dust properties, 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
- Overview of NFPA 652
- Fundamentals of Dust Explosions
- Introduction to DHA methodology
- Mock DHA on a Small Blending Operation

Outcomes

- Protection Options
- Daily Learning Assessment
- Questions and Answers
- Course Evaluation Instruction

Day 2 *Time: 8 am - 4:30 pm* *CEU's: 0.7*

Advanced DHA Workshop

The Advanced DHA Workshop will focus on how to organize, lead, and implement the DHA study. This will include how to utilize appropriate test methods to determine potential dust hazards; as well as how to apply appropriate mitigation techniques to prevent or control combustible dust hazards. During the workshop, participants will have the opportunity to apply DHA methodologies to realistic combustible dust scenarios.

Pricing

Two Day Course: $895
Day 1 only: $495
Day 2 only: $495

ACCREDITED IACET PROVIDER

For hotel information or to register, please contact: FAIUniversity@fauske.com

Please direct instructor or course related questions to Ashok G. Dastidar - dastidar@fauske.com

www.fauske.com **(630) 323-8750**

FAUSKE & ASSOCIATES, LLC
World Leader in Nuclear and Chemical Process Safety

AUTHORIZED IACET PROVIDER

REGISTRATION FORM

NFPA 652 - An Introduction to Dust Hazard Analysis

Time: 8:00 am - 4:30 pm each day

CEU's: 0.7 per day

Pricing: ○ Day1 only - $495 ○ Day 2 - $495 ○ Both Days - $895

☐ March 20-21 Courtyard Phoenix Airport
☐ May 15-16 Houston Airport Marriott at George Bush Intercontinental
☐ July 17-18 Fauske & Associates, LLC, Burr Ridge, IL

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- **Fees must be received prior to course commencement**
- **Hotel accommodations and travel expenses are the responsibility of the participant**
- **Fees include course notes, continental breakfast and lunch**

Technological/ Education Requirements:
There are no technological requirements for this introductory course. Grade 12 or higher education and 2-3 years professional experience are required.

CEU Credit Eligibility: FAI is an IACET (International Association for Continuing Education & Training) Authorized Provider. In order to be eligible for CEU credit (0.7 per course), attendees must be present for the duration of the course, score 85% or higher on the course assessment and complete the course evaluation.

Privacy: Fauske & Associates, LLC has a written policy to ensure privacy and confidentiality of participant training records and information. Training records will only be released with the expressed written permission of the participant. The participant record will be released to the participant or designated third party within 14 business days of the request.

Cancellation Policy: Cancellations will be accepted up to one month prior to course date.

To register, please email: FAIUniversity@fauske.com, Fax: (630) 986-5481
(Please direct instructor or course related questions to: Ashok Dastidar, dastidar@fauske.com)