FAUSKE & ASSOCIATES, LLC

PROCESS SAFETY NEWS
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What's Inside:

Letter from the President

Dear Colleagues,

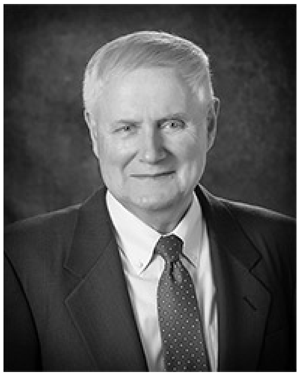
Many of you have learned of the recent passing of our company founder and namesake Dr. Hans K. Fauske, DSc. Hans touched the lives of countless people around the world through his illustrious career of technical leadership in nuclear and chemical process safety.

I'll never forget my first technical presentation in front of Hans when I was an intern at FAI many years ago. I presented on explosion severity testing – a basic concept for Dr. Fauske yet he devoted his full attention, asked several questions, and at the end came and personally thanked me for my contributions during my internship. Needless to say I finished up my internship feeling that my work was important, and I was thereby exposed to a key facet of leadership – one of many that Hans demonstrated through his actions. Like many of our employees, I'll forever be grateful for the opportunity to work and learn from him. We will miss his intelligent companionship and are proud to be part of the tremendous legacy he leaves in the process safety community.

Sincerely,

Zach Hachmiester

In Memory of Dr. Hans K. Fauske, DSc



Dr. Hans Kare Fauske, age 85, passed from this life on September 27, 2021. Hans was the beloved husband of Judith ("Judi") Gerdes Fauske for 57 years, loving father of Hans Kristian ("Kris") Fauske (AnnMarie Fauske) and Kirk Ivar Fauske (partner Tori Harmon), devoted grandfather of Jake, Jaden and Kayd Fauske, and loving brother to Sigmund (preceded in death Riordan Fauske). At the time of his passing Dr. Fauske was Emeritus President of Fauske & Associates, LLC, an ANS Fellow, an AIChE Fellow, and Member of the National Academy of Engineering.

Dr. Fauske completed his graduate education with a MSc in Chemical Engineering from the University of Minnesota and a DSc from the Norwegian Institute of Technology. Following his academic studies, he joined the staff at Argonne National Laboratory (ANL). Notable academic involvements while at ANL included thesis supervision of MSc and PhD graduate students doing research at Argonne through collaboration with the University of Chicago, including students from the University of Minnesota, University of Notre Dame and Northwestern University. While at ANL he served for two years as the director of the DOE Fast Reactor Safety Technology Management Center, responsible for the planning and management of the U.S. programs and was widely considered to be a leading world authority on fast breeder reactor safety. During this period, he was also chairman of the Argonne National Laboratory Committee A, which was responsible for the hiring and promotion of scientific and engineering staff.

In 1980, Dr. Fauske and colleagues Dr. Michael A. Grolmes and Dr. Robert E. Henry left ANL to establish Fauske & Associates, Inc. (FAI), and in 1986 FAI became a part of Westinghouse Electric Company. During the past 41 years, FAI has maintained a national and international reputation for innovation and is considered a world leader in nuclear and chemical process safety. At FAI Dr. Fauske was involved in many challenging projects covering a wide range of safety issues in both the nuclear power and chemical process industries. He served as president of FAI from 1980 to 2012 and then as FAI's Regent Advisor through 2019.

Dr. Fauske's career included leadership roles addressing many aspects of chemical and nuclear reactor safety including:

- **Senior Consultant to the Industry Degraded Core Rulemaking program (IDCOR) that followed the accident at the Three Mile Island Unit 2 plant:** He had a leadership role in initiating the MAAP computer code (now EPRI owned) that is used by utilities around the globe to assess possible accident behavior and action plans to counter that behavior, for commercial water-cooled nuclear power plants.
- **Senior Technical Advisor to the Clinch River Breeder Project with responsibility for developing the severe accident energetics evaluations:** This eventually led to the licensing of the liquid sodium cooled Clinch River Breeder design.
- **Technical leadership of the AIChE Design Institute for Emergency Relief Systems (DIERS), which was sponsored by 28 domestic and international chemical firms:** This program resulted in state-of-the-art methodologies to account for two-phase flow during venting and specialized laboratory tools (VSP2 and ARSST) to obtain the needed runaway reaction data. These methods and tools are widely used to design emergency relief systems for diverse chemical processes at leading companies and institutions around the world.
- **Safety studies of possible chemical reactivity vulnerabilities were employed at the US Hanford high-level waste tanks to support Containment-In-Place as a viable long term alternative remediation strategy that has been used effectively**
- **Contributing author for the process safety section of Perry's Chemical Engineering Handbook (9th edition)**
- **He served on the editorial boards of the Journal of Loss Prevention in the Process Industries, the International Journal of Multi-Phase Flow and the AIChE Process Safety Progress Journal**

Dr. Fauske published more than 200 scientific articles and held numerous patents in the areas of nuclear and chemical process safety. Together with Dr. Henry he coauthored the book *Experimental Technical Bases for Evaluating Vapor/Steam Explosions in Nuclear Reactor Safety*. In addition, he was the recipient of the following prestigious awards:

- **The first University of Chicago Medal for Distinguished Performance at Argonne National Laboratory in the field of Nuclear Reactor Technology (1975)**
- **The third recipient of the ANS Tommy Thompson Award in the field of reactor safety (1982)**
- **The ANS Thermal-Hydraulics Division Technical Achievement Award (1991)**
- **The prestigious AIChE Donald Q. Kern Award (1992) for Heat Transfer and Fluid Flow Technology**
- **The AIChE Robert E. Wilson Award (1996) for assuring nuclear and chemical industries safety**
- **The University of Minnesota Outstanding Achievement Award (2004) for worldwide impact on nuclear and chemical reactor safety, and**
- **The ANS George C. Lawrence Pioneering Award (2012) for Nuclear Safety**

Dr. Fauske was born and raised in Bergen Norway, spoke seven languages, and recently became a U.S. citizen, something he carefully weighed for many years. Beyond his many scientific publications and awards he was an inspiring leader, patient mentor, tireless competitor, and devoted family man. He was especially proud of his sons and the grandchildren who called him “Grampy”, and he adored his wife Judi who was always his “very pretty lady”. When not engaging with his family, Hans’ favorite place to be was solving technical problems at his office chalk board, developing practical equations to better illuminate our understanding of the complex physical phenomena important to process safety.

Reaction Calorimetry: A Customizable Technique to Support Safe Process Scale-Up

By Clayton R. Johnson, PhD, Laboratory Scientist, Fauske & Associates, LLC

FAI specializes in characterizing, preventing, and mitigating chemical reactivity hazards. Reaction and adiabatic calorimetry are two laboratory techniques FAI relies on to determine the thermal potential and reactivity of chemical systems. Reaction calorimetry (RC) quantifies the heat evolution and heat evolution rate of a chemical process under the desired reaction conditions. Adiabatic calorimetry does not hold the reaction conditions constant and is generally used to explore the undesired runaway reaction which could be caused by a process deviation such as a loss of cooling, overcharging, or heating by external fire. The undesired reaction(s) commonly have their own heats of reaction which may lead to temperature and/or pressure increases that should be evaluated so that the proper safeguards can be implemented to prevent or mitigate unintended consequences.

Mettler-Toledo RC1

While FAI is well known for our adiabatic testing capabilities using instruments like the FAI-invented Vent Sizing Package (VSP2) and Advanced Reactive System Screening Tool (ARSST), as well as the Accelerated Rate Calorimeter (ARC), we also offer a suite of RC testing capabilities. RC seeks to quantify the total heat of a desired reaction, heat rate of the reaction, and the heat capacity of the reaction mass, with the goal of supporting the safe scale-up of a chemical process. RC data can be used to calculate key process safety parameters, such as the adiabatic temperature rise caused by the desired reaction, to evaluate the potential severity of the reactive hazard and the instantaneous or peak heat generation rates for determining the necessary cooling requirements at process scale. Additionally, RC data can help determine the gas generation rate of a reaction, size important process equipment such as a scrubber for hazardous off-gas and establish the temperature-dependent kinetics of a reaction. Additionally, the thermochemical RC data can be used to optimize process conditions such as process temperature, addition rate, and reagent, catalyst or solvent selection.

THT μRC

ChemiSens CPA202

FAI's RC lab utilizes the Mettler-Toledo RC1, Thermal Hazards Technology (THT) µRC, and/or ChemiSens CPA202 as determined by the system of interest. Our RC instruments are highly customizable allowing for evaluation of a range of processes. Our array of calorimeter configurations allows for flexible experiment design by which we can vary, measure, or control key parameters such as temperature, pressure, wetted material(s) of construction, baffling,agitation type, stir rate, pH, gas generation, and means of dosing (solids, liquids, and gases). Our ability to precisely control testing conditions allows us to study processes that involve flammables, moisture-sensitive, and air-reactive materials and perform chemical compatibility assessments. Please see the table below to better understand how our suite of reaction calorimeters can be tailored to study your process.

In summary, RC data are used to support chemical process scaleup (e.g., determine the cooling requirements for the plant heat exchangers), which results in improved safety, cost efficiency, or sustainability of the chemical processes. We are happy to discuss your new or legacy processes, confirm safe processing conditions, and evaluate other engineering parameters to comply with the OSHA Process Safety Standard 29 CFR 1910.119 and various National Fire Protection Association (NFPA) Standards. Remember that both OSHA and NFPA require the use of recognized and generally accepted good engineering practices (RAGAGEP). RC is considered a RAGAGEP technique for the safer batch and semi-batch chemical reactions processing by providing critical quantitative engineering thermal and kinetic data.

For reaction calorimetry inquiries, please contact Clayton Johnson at thermalhazardsgroup@fauske.com.

FAI's RC Capabilities		
Reactors	**Temperature:** -73°C to +230°C **Pressure:** Ambient to 20 bar **Volume:** 1.5 mL to 1 L **Construction:** Hastelloy C, borosilicate glass, 316 stainless steel, custom designed	
Mixing	**Overhead Stirrers**: Various agitator attachments with glass or Hastelloy construction, up to 2000 rpm **Magnetic Stir Bar:** Small volume reactions **Baffling:** Optional, various designs and constructions	
Modes	**Modes:** Isothermal, temperature scanning/ramps, titration, heat capacity determination **Calibration:** Automated heat transfer coefficient (U) and reaction mass heat capacity (Cp) determinations or not required for heat flux calorimeters which provide a true heat flow signal	
Add-Ons	• pH monitoring and control • Automated liquid additions • Various solid addition options • Off-gas quantification and characterization	• Automated titrations • High sensitivity testing (5 µW) • Additions against pressure • Gas additions (gas induction impeller and gas uptake rig)
Applications	• Near-ambient condition reactions • Low pressure reactions w/ gas generation • Small volume reactions • Titrations • Water reactivity testing • Heat capacity measurements	• Two component reactions • Batch, semi-batch, and continuous processes • Hydrogenation reactions • Gas generating reactions • High pressure reactions • Gas uptake reactions

Learn More

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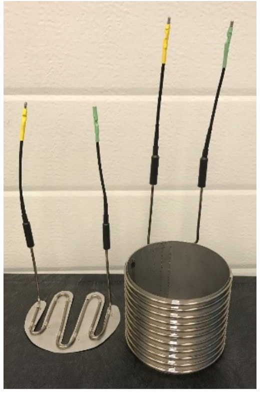
High Pressure VSP2 Calorimetry – A Unique Technique to Get Needed Data

By Gabe Wood, Senior Chemical Engineer, Fauske & Associates, LLC

The versatile Vent Sizing Package 2 (VSP2) was originally developed as the DIERS Bench Scale Apparatus in 1985 and was later commercialized by FAI in 1987 as the VSP. This low thermal inertia (low phi-factor) calorimeter essentially functions as a small-scale reactor due to its effective stirring and multiple fill ports for metered or shot additions. The VSP2 collects temperature and pressure data over time to determine the temperature and pressure rise rates of a runaway chemical reaction as a function of temperature, and these rates are directly scalable to large process vessels thanks to the low phi-factor design.



"Super guard heater" for high pressure VSP2 applicaitons

The standard VSP2 containment vessel has a maximum allowable working pressure (MAWP) of 1900 psig. To operate safely and protect the rupture disk, test pressures are usually limited to 1400 psi. This is sufficient to collect low thermal inertia vent sizing data for most processes. However, some processes do operate at higher pressures, or a closed system test may be needed on non-condensable gas-generating chemistry where a much higher pressure capability is required to study the entire reaction. For these unique cases, we have the ability to convert our standard VSP2 system into a high-pressure system. A 5,000 psig containment vessel is used along with a modified solenoid control box for pressure balancing and a high-pressure nitrogen cylinder. This system is capable of safely testing up to 4,000 psig, while still using the same lightweight VSP2 test cells which allow for the collection of low thermal inertia data which are optimal for relief system design. To better compensate for heat losses associated with high pressures, an additional "super guard heater" (see picture) is used to maintain the desired adiabatic conditions, even at high temperature and pressure.

Please contact Gabe at thermalhazardsgroup@fauske.com to discuss this technique and how it can be employed.

Learn More **Contact Us**

Hazard Assessment Strategy

Evaluating potential chemical hazards is a crucial part of process safety, and reactive chemical hazards are a unique and potentially devastating subset of chemical hazards that can be present whether the reaction is intended or not. It is critical to study both desired and undesired reactions to ensure that the proper safeguards, procedures, or safety related equipment are installed to provide adequate protection during process operations. Identifying potential reactive hazards is completed through a detailed reactive hazard analysis (RHA). An RHA is dedicated to the identification of reactive chemical hazards and can be considered a more focused version of a process hazard analysis (PHA).

The general strategy for developing a robust process involves:

1 Process and Material Characterization

Generate a thorough understanding of both the chemistry (e.g. balanced equations) and thermochemistry (e.g. theoretical or experimental heat of reaction) by conducting a desktop review and a literature search for similar chemistry incidents. Please note the lack of a previously reported incident is not an indication the chemistry is safe to scale up.

Conduct small-scale thermal screening tests to discover and quantify potential thermal hazards and gas-generating reactions

2 Identify the Process Hazards and Hazardous Condition

Utilize a PHA technique such as a "What-If" analysis to identify potential hazards, understanding that reactive hazards may be present whether it is intended or not, and consider both normal operation and process deviations

3 Understand the Risk in Terms of Likelihood and Severity

Employ techniques such as reaction calorimetry and adiabatic calorimetry to characterize the impact of process hazards and designate the risk level

4 Reduce, Eliminate, Substitute, Prevent or Mitigate the Hazard

Based on the risk level, identify the best multi-layered safeguards to provide layers of protection (e.g. emergency relief systems, operating procedures and training, secondary containment, etc.)

5 Document and Manage Changes

FAI can produce a comprehensive process safety report that understandably documents the assessment results. In addition, we can provide training on the process and control of the process so that any change is evaluated prior to implementation

Contact FAI to evaluate your process to identify and characterize reactive hazards and support the development of an inherently safe design and scale-up

7 Basics of Combustible Dust Sampling and Testing

By Ronald L. Allen, MS, PE, CSP, Senior Consulting Engineer, Fauske & Associates, LLC

Understanding the characteristics of combustible dusts is essential to ultimately managing the risks associated with the material. The testing schema presented in Figure 1 below can be used to characterize the explosibility and combustibility of dusts. But many questions need to be answered before valid samples can be taken and tested. Mistakes can lead to wasted time and money – or worse – incorrect assessment of risk. This article provides a brief overview of the essential factors.

1. Who Should Perform the Testing?

While many labs may claim the ability to conduct hazardous dust tests, the truth is that not all labs have the qualifications or experience to do so. Engagement of a laboratory that is ISO 17025 certified to perform the specific tests that are needed will assure high quality results. These internationally recognized labs also have the resources to explain test results and offer guidance to their clients.

2. What Tests to Perform?

Generally speaking, tests fall into three categories:

- Combustibility Screening Test: Commonly known as a “Go/No Go” test, this initial screen determines whether the particulate is “explosible”. If the material proves to be “explosible”, additional characterization should be completed to understand ignition sensitivity and explosion severity. (Stage 3a in Figure 1)
- Ignition Sensitivity Tests: These “before the ignition” tests are chosen based upon the environment and potential risks that may be present where the dust is generated, processed, conveyed, or stored. The most common tests answer the following questions (Stage 4a and 4b in Figure 1):
    - » How much energy is required to ignite the dust? This test for Minimum Ignition Energy (MIE) is critical to determine if a dust can be ignited by low-energy sources like static electricity or if a higher energy source (e.g., sparking motors) would be necessary for ignition. Results are reported in millijoules (mJ).
    - » How much material must be suspended in the atmosphere before ignition can be supported? The test for Minimum Explosible Concentration (MEC) is often compared to the Lower Explosive Level (LEL) for flammable vapors and liquids. Results are measured in grams per cubic meter (g/m3)
    - » At what temperature will airborne dust autoignite? The test for Minimum Ignition Temperature – Cloud (MIT) determines when airborne dust can ignite by contacting hot objects (e.g., oven cabinet surfaces, motors, overheated bearings) or heated environments. Results are reported in degrees Celsius.

» At what temperature will layered dust autoignite? The test for Layer Ignition Temperature (LIT) determines when layered dust can ignite when in contact with heated surfaces (e.g., oven cabinet surfaces, motors, overheated bearings). Results are reported in degrees Celsius

- Explosion Severity Tests: These “after the ignition” tests determine how much energy is generated when a specific dust is ignited in a contained vessel. The test results are demanded when designing explosion protection equipment (e.g., explosion relief panels, chemical isolation systems) to mitigate the effects of an explosion involving a specific material. The most common tests answer the following questions (Stage 4a in Figure 1):

» What is the maximum pressure that will be generated by a dust cloud explosion? Maximum Pressure (Pmax) is reported in bars (standard atmospheres) and is not normalized.

» What is the normalized speed of pressure rise created by the dust cloud explosion? The Deflagration Index (KSt) is reported in bar-meters/second (bar-m/sec).

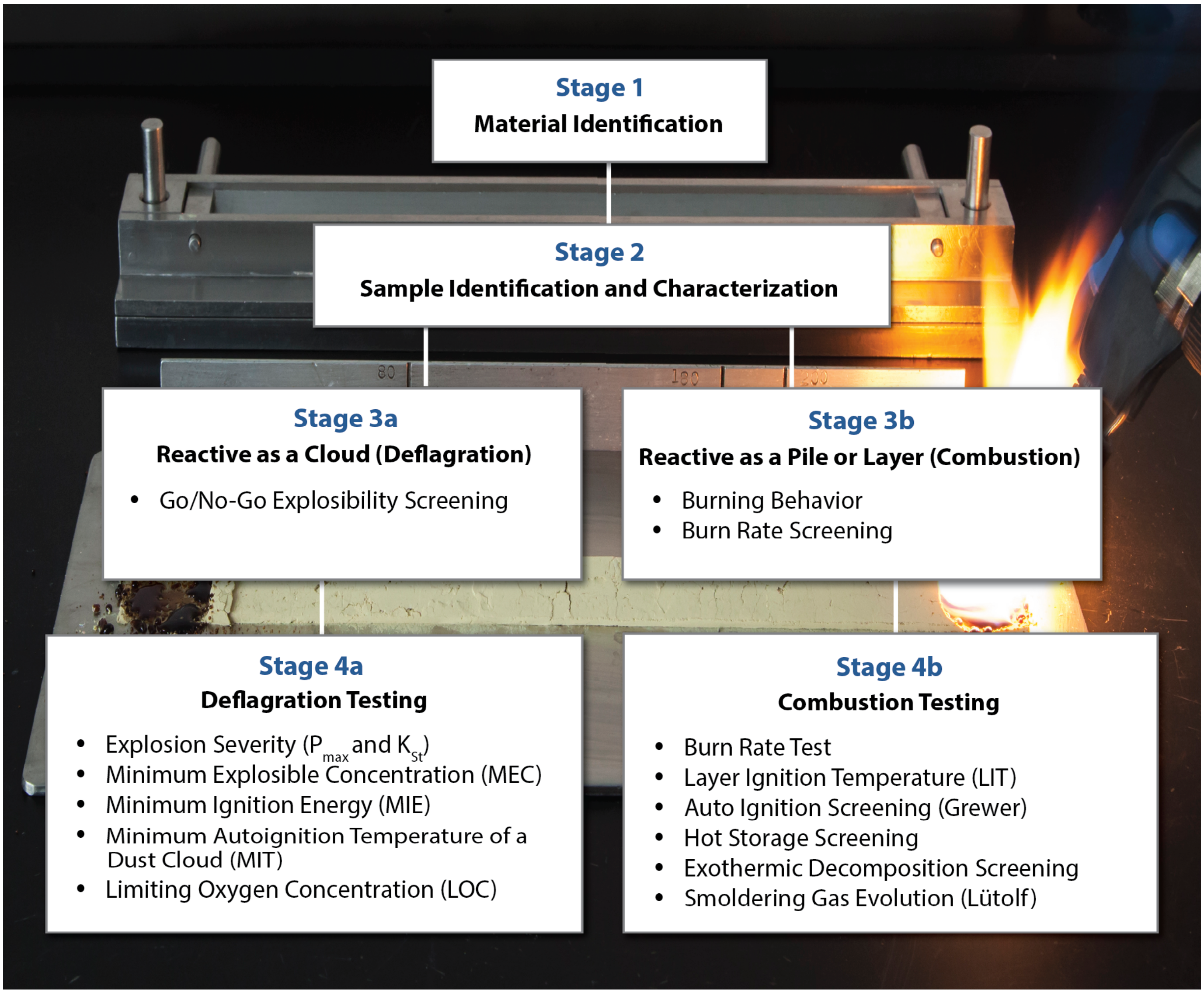


Figure 1 Dust Testing Schema

3. Should Samples be Tested "As Received"?

ASTM International has published a series of standards (E1226, E1515, E2019, E1491, and E2021) that determine how dust samples should be tested for explosivity potentials and characteristics. Without exception, ASTM recommends that tested material have a particle size of <75 microns and a moisture content of <5%. In some cases, samples must be ground, sieved, and/or dried to meet these ASTM recommendations. Sizing and drying material often produces more conservative results than testing the material "as received". Assuring consistent particle size and moisture content produces the consistent, reliable results needed for specifying explosion protection equipment (e.g., explosion vents, suppression systems). The conservative nature of the recommendations to test fine, dry material addresses many concerns about the potential for fines to accumulate in some location (e.g., duct elbow, dust collector, interior walls of bins) in the process or fine fugitive dust on elevated building surfaces like I-beams, pipes/ducts and light fixtures.

While the advantages of sizing and drying material are clear, there can also be value in testing particulate "as received" to understand how the material will behave in its specific native environment if particle segregation/classification did not take place. "As received" test data can be particularly beneficial when considering ignition sensitivity. For example, material that is sized and dried to meet ASTM recommendations may best represent the "worst case" dust characteristics that could be present inside of a dust collector where the most conservative protection techniques could be demanded. However, "as received" samples of the same material taken from an upstream location in the process where the particulate displays a larger particle size and/or increased moisture content could (for example) present a significantly higher minimum ignition energy (MIE) value than samples that have been sized and dried. The higher MIE value in the "as received" sample maybe more reflective of the actual risk and could justify reducing controls at the point of the process where the sample was taken. For example, static dissipative shoes could be required when working at the dust collector where lower MIE values could be expected, but the same precaution may not be warranted at the upstream location where an elevated MIE is documented.

Many firms choose to test material in both fashions – ground and dried (if needed) and "as received".

4. Where to Take Samples?

Generally speaking, it is recommended that samples be taken from the "dirty" side of dust collectors since that material tends to include relatively dry, small particles. The "best samples" are taken from dust collectors as directed below in order of preference:

- Use non-sparking tools to scrape or otherwise remove the material directly from the dust collector filters or cartridges. This technique will increase the probability of collecting fine particles.
- If it is not feasible to remove the material directly from the dust collector filters or cartridges, "pulse" the dust collector prior to collecting the sample from a clean storage collection drum or container.
- If possible, avoid taking samples from the dust collection drum/container (e.g., 55 gallon drum) unless the drum/container has been emptied or cleaned before a "pulsed" sample is generated

(see above). Otherwise, the sample will include a composite of material discharged from the dust collector that has the potential of including larger particles that may understate the risk posed by the material. Because of their mass, larger particles may "fall" into the collection drum/container without being collected onto the filters or cartridges. In this case, screening may be warranted to remove those coarse particles.

"Elevated surfaces" provide another preferred location to sample since smaller particle material tends to rise, disperse (aka, "float"), and collect on building steel, pipes, ductwork, and the tops of equipment. Often times, a vertical lift is required to safely access such areas for sampling purposes. Collecting samples from elevated surfaces is most appropriate in operations where dust collection systems do not exist. Relatively dry, small particle material suitable for testing may also be found on the interior walls of bins and ductwork.

Generally speaking, the "age" of the sample is unimportant. The primary exception relates to metal dust. Since explosible characteristics of metal dust can be understated if the sample material is allowed to oxidize, it is advised that "fresh material" be sampled. These "fresh samples" should be tightly sealed to prevent entry of moisture that could lead to oxidation prior to testing.

5. How to Take Samples?

Use of non-sparking equipment (e.g., natural bristle brushes, plastic antistatic shovels, scoops, or dust pans) is recommended to collect samples. Samples should be collected in sealed plastic (e.g., Ziploc) bags or other sealed, non-conductive containers. Sample size requirements vary (100 – 1000 grams) dependent upon the test(s) that will be conducted. ISO 17025 – certified labs usually provide sampling instructions to clients and may even provide test kits. Samples should be clearly labeled to identify the location where they were taken.

6. How to Transport Samples?

Entities shipping combustible dust samples should consult DOT Hazardous Materials regulations prior to shipping samples. Warning labels or special shipping precautions are not needed for most common, small volume (e.g., <1000 grams) particulate samples, but exceptions can exist. Labs receiving the samples will require documentation that must accompany sample shipments.

7. Common Problems Associated with Combustible Dust Sampling

- Not submitting adequate sample size or sample quantity to complete needed tests (lab should assist with direction or provide a kit)
- Submitting incomplete test request forms
- Samples not collected from proper locations (e.g., takes sample from floor or easily accessed locations where particle size tends to be large and may be moist)

Summary

Preparing and executing a strategy for combustible dust sampling and testing is a manageable task but can present challenges for the unindoctrinated. Partnering with an ISO 17025 laboratory can help address questions about jargon and recommended practices. More importantly, such expert advice from a certified lab can ultimately help reduce and manage risks.

Learn More

Contact Us

Gas, Vapor, and Solids Flammability

At Fauske & Associates, LLC (FAI) we can help you assess your risk exposure by characterizing the flammability potential of your combustible gas, vapor or solids.

The following is a list of the most common tests that are performed for flammability hazard characterization and the standards by which FAI can perform these tests. Specialized testing can be performed to more closely match your process conditions and thereby better gauge your risk.

Testing Services

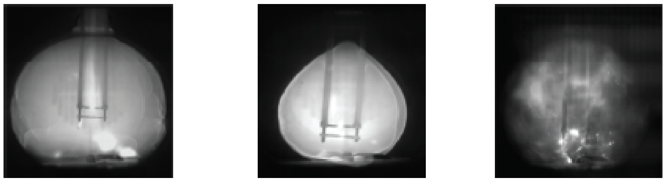
- **Process Safety**
  - Explosion Severity - P_{MAX} & K_{ST}
  - Flash Point Testing (open and closed cup)
  - Limiting Oxygen Concentration (LOC)
  - Flammability Limits (LFL, UFL)
  - Minimum Ignition Energy (MIE)
  - Autoignition Temperature (AIT)
  - Maximum Experimental Safe Gap (MESG)
  - Off-Gas Analysis (GC-MS)

- **DOT**
  - Class 2 Aerosols Classification
  - Class 3 Flammable Liquids Classification
  - Class 4 Flammable Solids Classification
  - Class 5 Oxidizers Classification

Experiment running on FAI's MIE apparatus

Consulting Services

- Desktop and/or on-site assessments per NFPA or OSHA for handing, processing or storing of flammable materials
- Flammable hazard calculations
  - Estimating flammable properties (LFL, UFL, AIT, etc.) or explosion severity
  - Modeling flammable gas distribution and hazards during an upset scenario
- Process Hazard Analysis (PHA) assistance



Flame propagation and venting of a flammable event in a 5-L glass sphere
Venting was initially seen at 45 ms

Small Modular Reactor and Isotope Production Experience

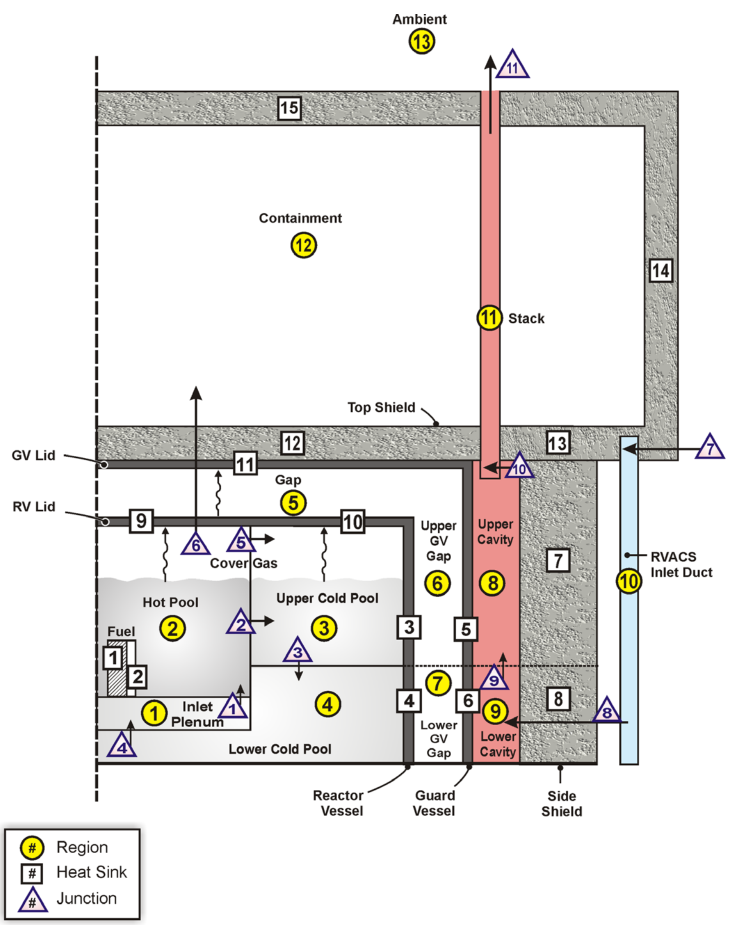
By Dr. Martin G. Plys, Chief Technology Officer and Vice President, Fauske & Associates, LLC

FAI has recently supported several Small Modular Reactor (SMR) and Isotope Production (ISP) vendors by providing a combination of systems and safety consulting, detailed source term modeling, and contributions leading to vendor Preliminary Safety Analysis Reports (PSARs). We have created a mixture of individual phenomena models, simplified integral facility models, and applications of our generalized facility safety software FATE (Facility Aerosol, Thermal, and Explosion model). We have experience with light water reactors, liquid metal cooled reactors, gas cooled reactors, heat pipe cooled reactors, and salt cooled reactors in addition to non-reactor subcritical isotope facilities.

FATE has been our key tool for liquid metal and heat pipe reactors. For liquid metal reactors, we have merged FATE with the Argonne National Laboratory (ANL) tool SAS4A/SASSYS-1 which predicts the details of the core and primary system. (It is interesting to note that before founding FAI Dr. Fauske and ANL colleagues worked on liquid metal fast reactor designs.) An example FATE nodalization is shown in the diagram below. FATE can duplicate primary system and secondary system behavior for loss of power accidents. The principal use of FATE however is as the containment/confinement module to track conditions external to the primary and secondary systems. When FATE is supplied with liquid metal flow sources from a pipe break, it predicts consequences of metal droplet burning. FATE also takes fission product sources from the break and predicts contamination transport throughout the facility, ultimately providing the input to the analysis of on-site and off-site dose consequences.

For heat pipe reactors, FATE is used to predict heat-up rates of the core and surrounding reflector and shielding. These predictions include consideration of engineered passive heat removal paths from the enclosure surrounding the shielding. We have examined graphite block cores with TRISO fuel. Using correlations for fission product release from damaged TRISO fuel, and given leakage assumptions for the enclosure, FATE has been able to estimate source terms for a heat pipe reactor.

For salt cooled reactors we have contributed to the Phenomenological Identification and Ranking Table (PIRT) process and co-authored the PIRT study. The PIRT study is directly used by the vendor to rank the needs for experimental data, model development, and model validation, which feeds into the PSAR. We have also created methods to estimate fission product release from liquid salts and methods to estimate liquid salt droplet formation during accident scenarios.



These methods are used for integral source term quantification which also feeds into the PSAR. Non-reactor subcritical isotope facilities require custom analysis for the processes that govern fission product release. We have created bespoke software to model evolution of volatile fission product vapor including effects of pH from regions containing either current or spent working fluid. We have also created models for evolution of non-volatile fission products contained within liquid droplets entrained by physical processes. These models have been coupled with appropriate aerosol and vapor transport models based upon the methods used in FATE.

In summary, FAI has broad capabilities and direct experience in evaluation of SMRs and isotope production facilities. The variety of SMRs requires deep experience in accident analysis, severe accident phenomena, and familiarity with experimental data for a wide range of physical and chemical systems. FAI has this depth of experience which allows us to tailor solutions for a particular SMR and production facility design.

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Facility Siting Assessments

The Fauske On-site Safety Studies group (OSS) is active across a number of industries, performing both DHA and PHA studies. A site assessment can involve a number of cross discipline elements to assess the costs, risks and health of the occupants. The various elements focus on the identification of hazards, the characterization of those hazards and delivering a mitigation strategy. As a wholly owned subsidiary of Westinghouse Electric Company, we support Westinghouse on nuclear fire safety studies and have access to risk analysis experts who can support non-nuclear site assessments.

Westinghouse and Fauske have collaborated on many site assessments. Most recently the team is working on a fire hazards assessment (FHA). The FHA evaluates potential fire hazards and appropriate fire protection systems and features used to mitigate the effects of a fire in any waste management location. The FHA will be performed to demonstrate that the waste management maintains the ability to safely maintain operation or shut down if operations cannot be maintained while minimizing radioactive material releases to the environment in the event of a fire. FHA work for nuclear facilities is based on NUREG-1805.

This type of assessment combines skills from walk-downs, fire PRA such as the use of fire modeling tools, and explosion analysis. Fauske investigates three explosion hazards: (1) Explosion of fuels, solvents, dust, and other transient materials that may be present, (2) Explosion hazards associated with radiolytically generated gases, and (3) Explosion hazards associated with decomposition/heating of organic ion exchange resins.

Explosions and fires may be correlated and, in many instances an explosion can precede (trigger) or follow a fire event. While it is expected that the explosion mechanism will result in a more bounding screening distance values (SDV), the fire mechanism is generally evaluated. For the fire mechanism, our team identifies fixed or transient sources where the initiating event could impact the plant, considering immediate impact, propagation, impacts of smoke/soot on site ventilation systems and impacts on off-site power equipment.

A secondary effect of fire is smoke and aerosolized particulates (soot) which can disrupt operations through impact on plant personnel, require fire brigades to protect facilities, impose limitations on outdoor operations and impact HVAC through particulate clogging of HVAC filters.

Transitory fire events consider the impact of human activity in surrounding areas that may directly or indirectly be the cause of fires.

The overall assessment is documented in a detailed report which identifies any deficiencies, recommends solutions, and provides suggestions for improvement. For more information on how fire hazards and other evaluations can support a site assessment, please visit: https://www.fauske.com/blog/what-is-a-facility-siting-assessment

Learn More   Contact Us

Upcoming Events:

AIChE Annual Meeting
November 7th – 19th (Boston, MA)

American Nuclear Society Meeting
November 30th – December 3rd (Washington DC)

2021 P2SAC Conference
December 6th – 8th (Virtual)

National Cleanup Workshop
December 7th – 9th (Alexandria, VA)

6th CCPS Global Summit on Process Safety
December 14th – 16th (Virtual)

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