

Process Safety News

Summer 2017
Volume 24,
Number 3

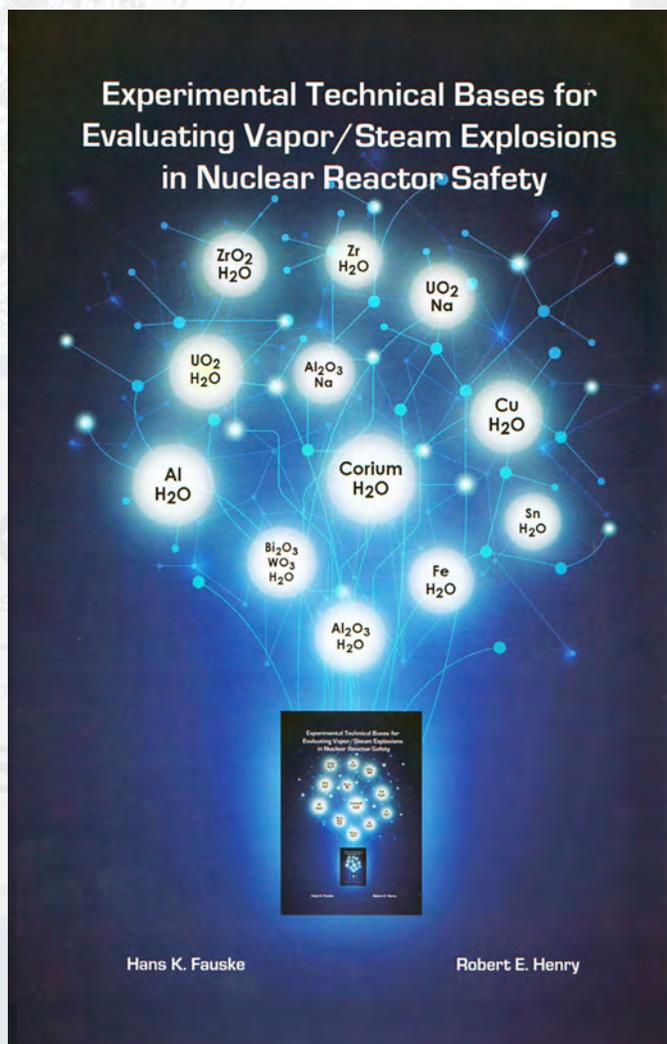
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INTRODUCING: The Definitive Guide on how to Evaluate Vapor/Steam Explosions

While the emphasis is given to Nuclear Safety, the controlling phenomena of steam/vapor explosion are also relevant to chemical process safety and foundry operational safety assessments.

By: Drs. Hans K. Fauske and Robert E. Henry (retired), Fauske & Associates, LLC (FAI)

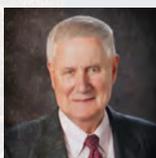
Vapor/Steam explosions are important considerations for a safety assessment where a high temperature molten mass would contact a liquid coolant. It is essential that these potential accident conditions are evaluated in a manner consistent with the available experimental technical bases. This book provides a common reference for the extensive experimental data base that has been accumulated due to the substantial works of industrial, national, and university laboratories throughout the world, to help all studies include the total experimental data base as well as that which directly relates to the molten materials and coolant of interest. In addition, it provides a common reference so that such evaluations can either reference this book, or consult the references given within to find the sources where further details can be obtained when needed. Lastly, the measured energy releases for key experiments are compared with straightforward bounding calculations that can be used to facilitate discussions between reactor designers, utilities, and regulatory agencies.



Hans K. Fauske

Robert E. Henry

We would like to recognize the efforts of the American Nuclear Society Book Publishing Committee and its members for their comments and advice. The book can be purchased at <http://www.ans.org/store/item-300036/>



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



Dr. Robert E. Henry is an original founding partner of Fauske & Associates, LLC

Letter From the President



One of our customer service focuses at Fauske & Associates, LLC (FAI) has always been ensuring that we are constantly communicating with our clients. In this day and age it is even more critical to our business.

I realize that customers are bombarded daily with various forms of messaging, and for this reason we are constantly seeking ways to make our's stand out from the crowd. One of the steps we have taken in this area is our recent website revamp. Not only is the new look visually exciting, we have employed state of the art tools to ensure that finding us online is easier. Additionally, the pages within the website are simpler to navigate and revised contact forms make it painless to reach out to us for subscriptions to our Nuclear Technical Bulletin, *Process Safety News* and targeted information, or just to ask for assistance. Check out our new look at www.fauske.com

If you are a fan of social media, never fear, we have also increased our presence there. Follow us on Twitter, Facebook or LinkedIn - or even on all three applications, and you will can find us posting regularly on timely and interesting process safety topics.

And, if you want to speak to a live person, you can always call us at (630)323-8750 and we are happy to discuss how we can help you find a solution to your safety management needs.

It is my sincere hope that these updated and new methods will make it easier for you to access our expert resources and stay in touch with us. And, as always I welcome your feedback on additional improvements that we can make to further improve our service.

Stay safe this summer,

H. Kristian Fauske
President



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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.

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FURTHER CLARIFICATION OF NON-EQUILIBRIUM AND EQUILIBRIUM FLASHING FLOWS THROUGH TOP LOCATED SAFETY RELIEF VALVES (SRVS)

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

Non - Equilibrium Flashing Flow

If all liquid exist at the stagnation condition (no vapor), extensive data suggests that a simple length criterion of the order of 100 mm characterizes the residence time (~ of the order of 1 ms) requirement for approaching equilibrium flashing flows which are well described by the Equilibrium Rate Model (ERM) (Fauske, 1985)

$$G_{\text{ERM}} = \frac{\lambda}{v_{\text{fg}}} (\text{TC})^{-1/2} \quad (1)$$

where λ is the latent heat of evaporation, v_{fg} is the change in liquid-vapor specific volume, T is the temperature and C is the liquid specific heat, all evaluated at stagnation condition. In contrast, the maximum non-equilibrium mass flux as the length approaches zero is given by

$$G_{\text{max}} = (2P\rho)^{1/2} \quad (2)$$

where P is the stagnation gauge pressure and ρ is the liquid stagnation density. Considering that

$$G_{\text{max}} \gg G_{\text{ERM}} \quad (3)$$

determines the relevant velocity and the length requirement of about 100 mm for all liquid stagnation condition (near saturated liquid and subcooling).

Equilibrium Flashing flow

If liquid-vapor (void fraction > 0.1) exist at the stagnation condition, the length L (mm) required to satisfy a residence time of about 1 ms is given by

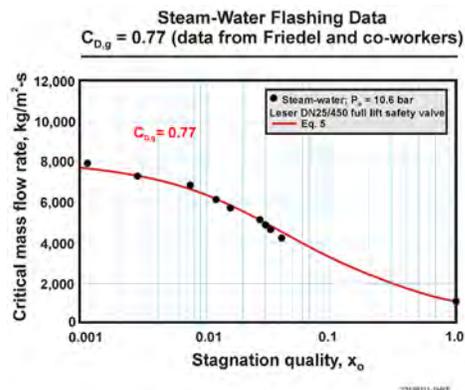
$$L \text{ (mm)} = 1 \text{ (ms)} \cdot G_{\text{ERM}} / \rho \text{ (mm/ms)} \quad (4)$$

resulting in a length requirement much smaller than 100 mm. In other words 100 mm length requirement is only relevant to all liquid stagnation conditions.

Given the above observations, Eq. 1 can be used without modification to estimate flashing two-phase flows through top located SRVs for relief sizing purposes using the following equation (Fauske, 1999) if Eq. 4 and stagnation vapor void fraction $\alpha > 0.1$ are satisfied

$$G = \left[\frac{1 - x_o}{G_{\text{ERM}}^2} + \frac{x_o}{C_{\text{Dg}}^2 G_g^2} \right]^{-1/2} \quad (5)$$

where x_o is the stagnation quality, C_{Dg} is the valve manufacturer certified discharge coefficient for gas flow, and G_g is the gas flow (sonic or subsonic) through an ideal nozzle. An example of comparison with Eq. 5 and experimental data is illustrated below. In this case Eq. 4 suggests a length L of only about 10 mm to satisfy equilibrium flashing which is clearly satisfied by the SRV. Furthermore a stagnation quality of $x_o = 0.001$ is equivalent to $\alpha = 0.14$ at the 10.6 bar stagnation pressure.



Both requirements to satisfy equilibrium flashing flow are sensitive to the stagnation pressure. As an example consider a stagnation pressure of 62 bar, result in $L = 40$ mm and $x_o = 0.0048$, which is consistent with experimental data (Sozzi and Sutherland, 1975.)

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- Sozzi, G. L. and Sutherland, W. A., "Critical Flow of Saturated and Subcooled Water at High Pressure," Report NEDO-13418, General Electric Company, San Jose, CA (July 1975).



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ADD VALUE AND REDUCE RISK FOR COMBUSTIBLE DUST HAZARDS

By: Ursula Malczewski, Process Safety Engineer, Fauske & Associates, LLC

FAI Offers a Turnkey Solution

In the past, some clients have contacted us only after a combustible dust incident or after OSHA inspected their facility. There has been a shift now that the new NFPA 652 standard and NFPA 654 revision have been published. Companies are being proactive by testing their materials and conducting dust hazard analyses (DHAs) to identify and manage the flammable and/or explosive dust hazards in their facility. These updated standards require owner/operators to determine and mitigate the hazards associated with combustible particulate solids used in their processes within the next few years.

Fauske & Associates, LLC (FAI) offers a unique approach to evaluating combustible dust hazards that allows customers to incorporate a cost-effective method to reduce risk and achieve compliance with Occupational Safety and Health Administration (OSHA) Combustible Dust National Emphasis Program (NEP) and National Fire Protection Association (NFPA) standards.



Testing

A proper sampling plan for testing can reduce expenses for test results that are not representative of the combustible dust hazards in the process. Improperly collected material or samples collected

from an inappropriate location can yield test results that do not accurately characterize the explosibility characteristics of the material. This can lead to inadequately designed explosion protection equipment. FAI can assist you to develop a sampling plan, including best location of sampling and proper handling of materials. We can also work with you or your contractors to develop a testing plan/campaign to identify your material's hazards and get the results you need the first time.

To get started, we offer an ASTM E1226 Go/No Go Explosibility Screening Test and a VDI 2263 burning behavior test. These inexpensive tests are the first step in defining whether or not your material is combustible. If the results are negative, further testing can be delayed until a change in the material or process triggers a re-evaluation. If the results are positive, FAI offers individual tests as well as an OSHA Combustible Dust NEP Testing package to characterize the hazards of your material.

Training

Training employees regarding combustible dust hazards is required per OSHA 29 CFR 1910.1210, Hazard Communication. Specific requirements include proper labeling of hazardous chemical containers, the collection and use of Safety Data Sheets (SDSs), and employee training. Workers – including contractors – need to be informed that combustible dust is present and instructed how to prevent fires and explosions. Training should include how to recognize and prevent the hazards of the dusts in the facility, recognize unsafe conditions, and take preventative action and alert management. Management needs to understand how to take effective action regarding

Training employees regarding combustible dust hazards is required per OSHA 29 CFR 1910.1210, Hazard Communication.

information about the identified hazards and utilize a management of change (MOC) program that investigates the safety implications of changes to processes with combustible materials. Design work needs to be completed in accordance to industry or commodity specific standards. Engineers need to be aware of the hazards associated with combustible particulate solids in order to minimize the risks in the plant and to seek professional expertise when required. [1,2]



Fauske & Associates, LLC offers a variety of training courses which we can tailor to the needs of your specific facility and/or industry. We offer job specific training for operators, engineers, and managers. Our program focuses on the needs of all levels of employees from new hires to executives.

We also provide both public and private DHA training courses. This two-day class is geared for personnel and professionals whose job responsibilities include conducting dust hazard assessments at facilities. Training can be customized to address specific hazards and at your facility and meet the availability of your personnel. See our website for upcoming cities and dates.

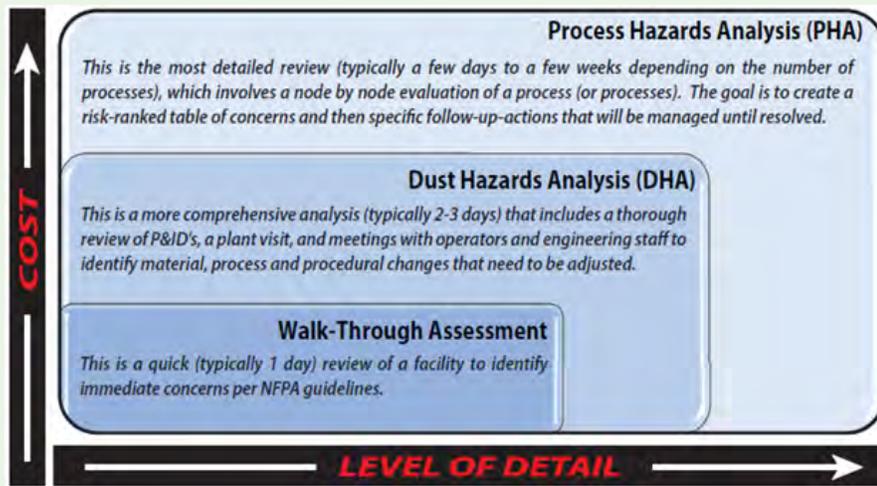
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Dust Hazard Analysis (DHA) Services

FAI offers tiered levels of combustible dust analysis services to most cost-effectively meet the needs and expectations of our clients – detailed in Figure 1. The walk-through assessment level provides a gap analysis of relevant NFPA standards to identify the immediate concerns associated with combustible particulate solids. Our DHA and PHA reports delve deeper and meet the requirements of NFPA 652 while offering pragmatic recommendations for common combustible dust issues such as electrical area classification, housekeeping, and preventative maintenance.

Figure 1 – FAI Tiered Onsite Assessment Services*



*The DHA and PHA levels meet the NFPA 652 requirements of a Dust Hazard Analysis.

Additional services we offer that are frequently required by facilities with combustible dust include:

- Classification of Class I, II, and III Hazardous (Classified) Locations (Area Classification)
- NFPA 70E Compliance Assessment
- Arc Flash Risk Assessment (to ensure compliance with NFPA 70E)
- Electrostatic Hazard Assessment
- Bonding & Grounding Assessment

Consulting

FAI's expertise allows us to offer clients risk-based solutions to meet compliance requirements by satisfying the performance-based approach that NFPA has outlined. This reduces cost for the client rather than requiring a prescriptive approach that can be cost-prohibitive for a legacy facility that may require extensive upgrades for minimal risk reduction. We work with each client to review measures required to reduce risk and discuss what is feasible in both the long term and short term.

Closing Thoughts

Reports by the National Safety Council show that many companies see a financial return on investment on safety through increased productivity, improved customer service, and money savings from fewer injuries and time off. The cost of not implementing safety, however, can be tremendous.

Besides regulatory fines, a fire or explosion can create significant expenses through increased insurance premiums, lawyer bills, repair or purchase of new equipment, complete closure of the facility, etc. During this downtime, the line or whole plant will not be generating revenue and clients may be lost as they take their business elsewhere to meet their needs. Many times after such industrial disasters, companies can never recover. [3,4]

Having a process that handles or generates combustible particulate solids, powders, or dusts requires an ongoing effort to mitigate or prevent the risk of fires and explosions. That being said, there are many cost effective measures a facility can take to reduce their risk of a combustible dust incident or OSHA fine. If you have questions regarding onsite facility assessments, performing testing, or are interested in training, please contact dha@fauske.com.

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Ursula Malczewski is a Chemical Engineer in the Onsite Safety Services department at Fauske & Associates, LLC



FAUSKE & ASSOCIATES, LLC (FAI) TECHNICIANS PROVIDE ARC REBUILDS IN-HOUSE

Fauske & Associates, LLC (FAI) has expanded its in-house service capability by training technicians to provide Accelerating Rate Calorimeter (ARC) rebuild services.

Performing an ARC rebuild will optimize the performance of the instrument and should be performed when there are obvious signs of catastrophic oxidation, corrosion, wear to insulation, heater color change, etc. similar to that illustrated in the photos below.



The following photos are of a mug that has been replated and enclosures that have been repainted as part of the rebuild process.



FAI is able to rebuild classic ARC calorimeters that are capable of tracking chemical reactions at 15-20 °C per minute. For more information on our ARC rebuild services contact parts@fauske.com.



A typical rebuild begins with a visual inspection and quote and typically involves some or all of the following steps:

- Top and bottom portions of ARC enclosure are disassembled and cleaned
- Mug and mug lid are sandblasted and replated with electroless nickel plating
- Existing thermocouples are removed and replaced with new thermocouples that have been tested to ensure they are reading in the same range
- Fiberglass insulation is removed and replaced
- Calorimeter enclosure is repainted with high temperature paint
- Heaters are replaced
- Wiring is replaced
- Ceramic blocks for top and bottom are replaced if needed
- Any other miscellaneous parts such as ferrules and screws, etc. are replaced as needed





There is Still Time to Register for Our NFPA 652- An Introduction to Dust Hazard Analysis

- August 29-30 Renaissance Boston Waterfront Hotel
- September 19-20 Marriott St. Louis Airport
- October 17-18 Dallas/Fort Worth Airport Marriott
- November 14-15 Renaissance Charlotte Suites Hotel

Day 1 - NFPA 652- An Introduction to Dust Hazard Analysis CEU's: 0.7
 Day 2 - Advanced Dust Hazard Analysis Workshop CEU's: 0.7

To learn more or to register, call (630) 323-8750 or email FAIUniversity@Fauske.com



Fauske & Associates, LLC Connected to the Community

FAI HITS A HOLE IN ONE FOR CHARITY

In May 2017, Fauske & Associates, LLC (FAI) participated in the Willowbrook/Burr Ridge Illinois Kiwanis at their Annual Golf Outing, both sponsoring a hole and playing in the tournament. Kiwanis is a global organization of volunteers dedicated to improving the world one child and one community at a time.

Three FAI employees including from left to right: Kris Fauske, AnnMarie Fauske and Gabe Wood joined Mr. Clifton Downing to form a foursome for the outing.



On July 10, 2017 Fauske & Associates, LLC (FAI) sponsored a hole and the President and his family played in the 19th annual Miracle Michael Charity Golf Outing to raise awareness and generate financial support for the on-going research of Osteogenesis Imperfecta.

Pictured is President Kris Fauske with his sons Jaden and Jake and father-in-law, James Pearson, at the Fauske & Associates, LLC hole.

