At Sigma-HSE, we specialize in expert process safety consulting and testing solutions to help industries ensure compliance, mitigate risks, and protect their people and assets.

Proven Strategies in Process Safety

Experience-Based Case Studies

This resource presents experience-based case studies illustrating the complexities of managing process hazards. Each example highlights the site details, process conditions, and key concerns that informed our approach.

Applying proven methodologies in DHA and HAZOP, these studies demonstrate how targeted strategies can identify risks, guide informed decision-making, and deliver actionable recommendations — strengthening risk management and ensuring regulatory compliance while providing the flexibility to adapt to operational requirements and constraints.

At Sigma-HSE, we are committed to helping organizations navigate complex process safety challenges with data-driven insights and expert guidance. Contact us today to discuss how we can support your facility's safety initiatives.

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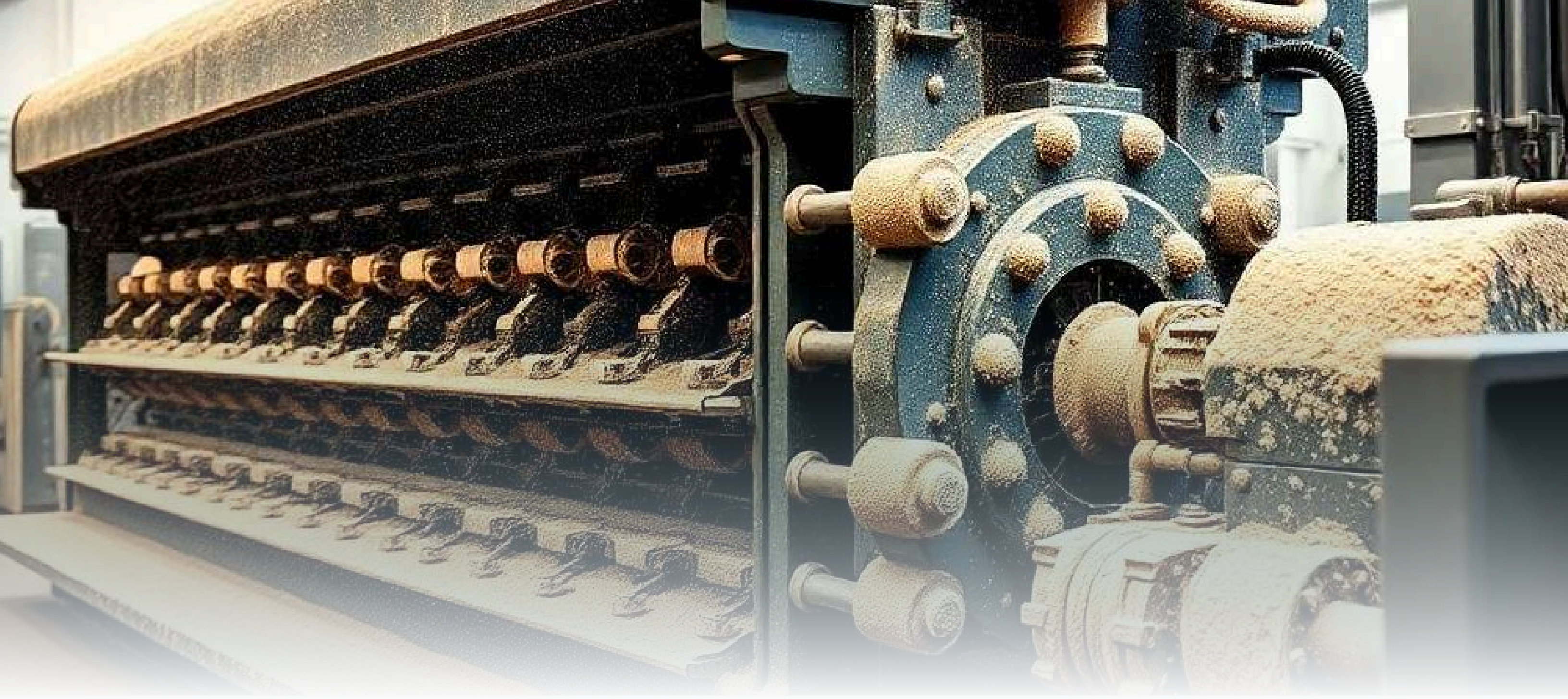


Sigma-HSE

Dust Hazard Analysis (DHA)
Case Studies

DHA is a critical process for identifying and mitigating combustible dust hazards in industrial environments. These case studies highlight how our expertise has helped clients achieve NFPA compliance, enhance workplace safety, and implement cost-effective mitigation strategies.

Case Study 1:
The Importance of Representative Testing on DHA Accuracy

Industry/Site Overview

Manufacturing facility producing plastic food containers.

Process Description

Pneumatic transport system to convey plastic pellets and flake.

Challenge:

A corporate engineer sought to minimize testing costs by gathering samples from five locations within the process and conducting particle size analysis. The finest sample, collected from a dust collector, was chosen for dust characterization testing to represent the entire process.

Key Concerns:

- **Non-Representative Testing Data:** The dust collector sample used for characterization did not accurately reflect the material present in process equipment, raising concerns about the validity of the DHA findings.
- **Overly Conservative Mitigation Measures:** Explosion protection recommendations were based on "worst-case" data, potentially leading to unnecessary or excessive safeguards and increasing costs.
- **Facility Personnel Uncertainty & Delays:** Engineers and plant personnel questioned the applicability of the data, resulting in confusion, internal disputes, and delays in implementing safety measures.
- **Erosion of Confidence in DHA Outcomes:** The debate over data representation created skepticism among the site team, reducing buy-in for the DHA recommendations.

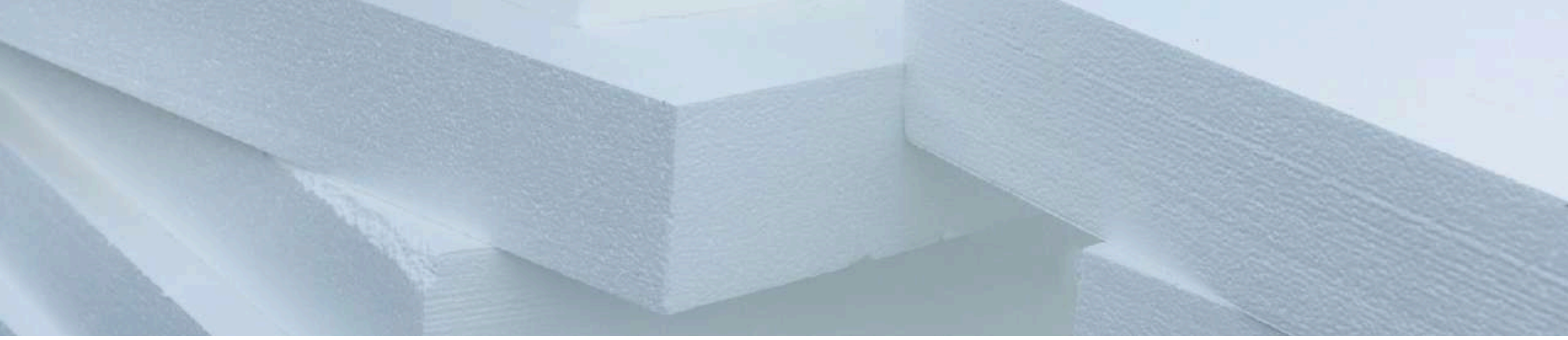
Recommendation:

To address this, multiple representative samples from the process equipment were tested before the DHA began. This ensured that the testing data accurately reflected the materials and conditions in each part of the process.

- ***Learning Point:*** *Conducting material testing prior to the DHA ensures that the analysis is performed in accordance with* ***NFPA 652, Section 5.5.1,*** *and provides accurate, representative data for hazard evaluation. This proactive approach not only strengthens compliance but can also lead to more precise risk assessments, potentially reducing unnecessary mitigation costs by avoiding overly conservative assumptions.*

Outcome:

- Recommendations were based on accurate, representative data, improving the credibility and effectiveness of the DHA.
- The facility avoided unnecessary costs associated with overprotecting equipment.
- Goodwill and trust were restored among the facility team, saving time and avoiding further delays.



Case Study 2:
Trim and Packing Manufacturer Remote DHA

Industry/Site Overview

Trim and packing manufacturing company with a CNC machine used to produce foam boards.

Process Description

CNC cutting of foam boards, generating combustible foam dust during the process

Challenge:

The facility required a Dust Hazard Analysis (DHA) to evaluate fire and explosion risks but opted for a desktop-style assessment due to budget and logistical constraints. Limited on-site data and operational details were available, requiring a thorough review of process information, equipment specifications, and historical safety records.

Key Concerns:

- Foam dust generated during CNC operations posed a potential fire and explosion hazard, particularly in areas where dust accumulated around the equipment or in the dust collection system.
- The facility had no previous DHA and was unsure if existing controls, such as their dust collection system, met NFPA compliance requirements.
- Without an on-site visit, the DHA had to rely on documentation, photos, videos, and equipment data provided by the facility team.

Methodology:

- A remote DHA was conducted by reviewing facility-provided documentation, including equipment specifications for the CNC machine and dust collection system, as well as process flow diagrams.
- Facility team members shared photos and videos of the CNC cutting operation and dust collection setup, which were analyzed remotely to identify hazard points.
- Combustible dust testing data for foam dust was obtained from similar industry studies, as facility-specific testing was not available.
- Potential hazards, including dust accumulations, ignition sources, and deficiencies in the dust collection system, were systematically identified and evaluated.

Recommendation:

- Since the DHA was conducted as a remote assessment, a follow-up on-site walkthrough was recommended to validate findings and ensure all recommendations were properly implemented.
- Recommendations were made to improve dust management practices, including increasing the frequency of cleaning in critical areas around the CNC machine.
- Modifications to the dust collection system were proposed, such as installing explosion venting and ensuring proper grounding and bonding to mitigate static discharge risks.
- The facility was advised to conduct site-specific combustible dust testing to validate assumptions and refine safety measures.

Outcome:

- The remote DHA provided the facility with actionable insights to address potential fire and explosion risks without the need for an on-site visit.
- The recommendations improved compliance with NFPA standards, reducing the risk of regulatory penalties.
- The facility gained clarity on safety priorities and a roadmap for further enhancements, including the potential for future on-site assessments.

Case Study 3:
Steel Coating and Welding Facility DHA

Industry/Site Overview

Manufacturing facility specializing in metal coating and fabrication processes, expanding its operations into a larger facility.

Process Description

Coating application areas, curing systems, and welding stations with fume extraction, processing various metals with combustible dust and fume hazards.

Challenge:

The facility sought to better understand the hazards associated with its operations, particularly the risks posed by combustible dust from powder coatings and fumes from welding activities. The larger footprint of the new building introduced uncertainties about hazard control effectiveness in the expanded space.

Key Concerns:

- Powder coating booths generated fine particulate matter with potential explosivity risks, particularly when combined with inadequate dust collection or cleaning practices.
- Welding fumes and fine particulate metals, including aluminum and stainless steel, posed ignition and explosion risks if accumulated in the fume extraction systems.
- Facility personnel were unsure if current safeguards, such as the Torit fume extractors, were sufficient for the increased scale of operations.

Methodology:

- A detailed DHA was performed across the new facility layout, focusing on the powder coating booths, welding bays, and fume extraction systems.
- Representative samples of powder coating dust and welding particulate were tested for explosivity, including Minimum Ignition Energy (MIE) and KSt values, to assess the risks in critical areas.
- The analysis evaluated the adequacy of existing controls, including fume extractors, ventilation systems, and cleaning procedures. Recommendations were made to address identified gaps.

Recommendation:

- Upgraded the dust collection system for the powder coating booths to include explosion venting and suppression features, ensuring compliance with NFPA 652 and 654.
- Implemented enhanced cleaning protocols for welding bays to prevent the accumulation of metal particulates.
- Conducted training sessions for staff on proper handling and maintenance practices for fume extraction systems.

Outcome:

- The expanded facility was prepared for safe operations with improved controls tailored to its larger footprint.
- Compliance with NFPA standards was achieved, minimizing regulatory risks.
- Employee confidence in safety procedures increased, fostering a proactive approach to hazard management

Hazard and Operability (HAZOP) Case Studies

HAZOP studies are a systematic approach to identifying process risks, ensuring operational safety, and maintaining regulatory compliance. These case studies demonstrate how we apply structured risk assessment methodologies to address potential hazards in various industries.

Case Study 1: Fly Ash Drying Process Design Virtual HAZOP

Industry/Site Overview

Fly ash drying plant under design and construction in Canada.

Process Description

Drying of fly ash to produce a stable product for further use or disposal. The process includes material handling, drying equipment, and dust collection systems.

Challenge:

The Owner's Engineer required a HAZOP study to identify and mitigate potential risks in the proposed plant design. Due to scheduling and logistical challenges, the HAZOP was conducted virtually, relying on detailed process documentation, 3D models, and participation from a multidisciplinary team.

Key Concerns:

- The drying process presented several safety risks, including the potential for fly ash accumulation, fire and explosion hazards, and equipment malfunctions.
- The project was in the early design stages, making it critical to address hazards proactively before construction began.
- Virtual collaboration posed challenges in facilitating effective communication and ensuring all team members could engage meaningfully in the study.

Methodology:

- A virtual HAZOP was conducted remotely using video conferencing and screen-sharing tools, allowing the team to review process flow diagrams (PFDs), piping and instrumentation diagrams (P&IDs), and 3D plant models in real time.
- Guidewords such as "No," "More," "Less," and "Reverse" were systematically applied to critical parameters, including temperature, flow, pressure, and material levels.
- The team included the Owner's Engineer, process designers, and operations personnel, who collaborated to identify potential deviations and their consequences.

Findings:

- Identified risks of fly ash accumulation in the drying system, which could lead to plugging and potential overpressure events.
- Evaluated ignition sources, including hot surfaces and static electricity, that could ignite fly ash dust during handling and drying.
- Recommended improvements to the dust collection system, such as enhanced grounding and bonding and the addition of explosion venting.
- Addressed potential operational challenges, such as equipment failure and insufficient operator training.

Recommendations:

- Design modifications were made to improve dust management and reduce ignition risks, including the selection of explosion-proof equipment and better sealing of conveyors and ducts.
- Process control strategies were refined, incorporating automated monitoring and shutdown systems to prevent unsafe conditions.
- Operator training plans were developed to ensure personnel could safely manage the drying process and respond to deviations.

Outcome:

- The HAZOP study provided the client with actionable recommendations to enhance safety and operability, reducing the risk of costly redesigns during construction.
- Remote collaboration tools allowed key team members to actively participate in the HAZOP, regardless of location. This approach accommodated the client's scheduling and travel constraints while ensuring a thorough and effective study.
- The process design was optimized for compliance with applicable Canadian safety regulations and industry best practices.

Case Study 2: Carbon Anode Baking Process HAZOP

Industry/Site Overview

Industrial manufacturing facility supporting high-temperature material processing for metal production.

Process Description

Thermal processing system utilizing a primarily manual firing operation with limited safeguards.

Challenge:

The client required a HAZOP study of the existing firing system to identify potential hazards and improve safety. Due to coordination with an international team, the study had to be completed within a strict 3-day timeline, presenting significant logistical and technical challenges.

Key Concerns:

- The manual nature of the firing system posed several risks, including inconsistent temperature control, potential gas leaks, and operator errors.
- Limited safeguards increased the likelihood of fire, explosions, and equipment damage.
- The compressed timeline required the HAZOP team to maximize efficiency without compromising the quality of the analysis.

Methodology:

- A multidisciplinary team was assembled, including process engineers, operations staff, and international safety experts.
- The study focused on critical aspects of the firing system, such as gas flow, temperature control, ventilation, and operator interactions.
- Guidewords like “No,” “More,” “Less,” and “Wrong” were systematically applied to process variables to identify deviations and assess potential consequences.
- Virtual collaboration tools and pre-meeting preparation were utilized to streamline the process, including sharing diagrams and data ahead of the study.

Findings:

- Identified risks of gas leaks due to manual valve operation and insufficient leak detection systems.
- Highlighted the potential for over-temperature events from delayed operator intervention, leading to fire risks.
- Found that ventilation in the firing area was inadequate to handle potential gas accumulation, increasing explosion risks.
- Highlighted gaps in operator training and emergency response protocols.

Recommendations:

- Recommended installing automated gas shutoff valves and leak detection systems to reduce manual intervention.
- Proposed adding temperature monitoring and alarms to ensure timely operator response to deviations.
- Enhanced ventilation system designs to mitigate the risk of gas accumulation.

Outcome:

- The HAZOP was completed on time, meeting the client’s tight 3-day schedule without sacrificing quality.
- Actionable recommendations provided a clear roadmap for improving safety and operability in the firing system.
- The study strengthened confidence among the international team, ensuring alignment on safety priorities and compliance with industry standards.

Trusted Expertise in Combustible Dust and Process Safety Management

At Sigma-HSE, we support manufacturers and processing facilities in navigating complex safety challenges with confidence. Through expert consulting and accredited testing, we deliver actionable, data-driven solutions that reduce risk, support compliance, and protect people, equipment, and operations.

With decades of technical expertise, our approach ensures every solution is tailored to your processes, production environment, and applicable regulatory standards. With locations in the US, UK, and India, Sigma-HSE provides process safety services to support compliance across global operations.

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