



Dust explosions in baghouse dust collectors: A state-of-the-art review

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ABSTRACT

Baghouse dust collectors are central to combustible-dust hazards, yet a collector-specific synthesis that explains the time evolution of dust explosions inside confined, obstacle-rich housing has been missing. This work presents, to the authors' knowledge, the first equipment-specific literature review focused on baghouse dust collectors. A dedicated literature corpus derives a bibliometric map focused on collector research and systematizes full-scale and pilot-scale evidence on explosions in filter units. Viewed through this lens, the record shows how cleaning-driven transients and filter-pack congestion govern the observed pressure–time evolution in baghouses. Predictions of vessel-derived venting rules for the available baghouse campaigns and place them alongside collector-specific congestion formulations calibrated on nine full-scale tests, clarifying where each agrees with the evidence. Overall, this review offers a clear, collector-focused synthesis of the evidence to date, identifies the outstanding gaps and practical needs, and maps current research directions, giving researchers and practitioners a coherent entry point to the field.

1. Introduction

Industrial facilities release dust whenever solid materials are processed. Fine particles become airborne during handling, transformation, or transport operations, and can spread throughout the workspace, far beyond the point of origin.

Dust must be carefully removed from such environments for several critical reasons. Protecting the health of workers comes first. Inhaling fine particulate matter can trigger asthma, silicosis, and, for certain substances, cancers of the upper airways (Acheson et al., 1968; Donaldson et al., 2000; Hoy et al., 2022). Occupational exposure limits such as U.S. Department of Labor, Occupational Safety and Health Administration and OSHA's 29 CFR 1910.1000 (1971) in the United States and the Binding OELs introduced by Directive (2022)/431/EC of the European Parliament amending Directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens, mutagens or reproductive toxic substances at work are designed to prevent these diseases.

Dust that settles on products, sensors, or moving parts degrades quality and accelerates wear (Zhao and Zhang, 2023). Most importantly, many industrial powders are explosible. When dispersed and suspended in air, they can form potentially explosive dust–air atmospheres, and

past accidents have shown that a single ignition source can generate overpressures strong enough to rupture steel housings and endanger lives (Eckhoff, 2009; Amyotte et al., 1988).

Regulatory compliance with explosion safety law provides an imperative. The ATEX workplace Directive 1999/92/EC (1999) in Europe and NFPA 660 (2025) in the United States, consolidating and updating the combustible dust requirements previously covered by NFPA 652 (2019), both oblige facilities to assess hazards associated with combustible dust, classify zones where an explosive cloud may form, and adopt certified protective measures (Novak et al., 2023; Peng et al., 2005; Balsari et al., 2013).

To mitigate these risks, dedicated baghouse dust collector systems were developed to capture airborne particles before they can settle, degrade equipment, or ignite.

1.1. Dust explosion

As said in the introduction, combustible dust hazards arise whenever fine solids are generated, handled or accumulate on surfaces (Cloney and Snoeys, 2019). Grinding, pneumatic conveying and fugitive dust emissions from small, recurrent leaks at joints, flanges, seals and transfer points can all disperse particles that behave like flammable gas once

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suspended (Eckhoff, 2003).

Even at the minimum explosible concentration, over-pressures of between 1 and 4 bar(g) are typical, while stoichiometric clouds can exceed 10 bar(g) well above the 0.3 bar(g) needed to rupture sheet steel housings (Eckhoff, 2009). The primary blast wave can also loft settled layers, producing secondary dust clouds that ignite and propagate through open plant areas, vastly amplifying damage and potential injury (Amyotte and Eckhoff, 2010). Flame turbulence feedback further intensifies the threat (Amyotte et al., 1988). In full-scale studies, it has been shown that congestion/obstacles and roughness in ducts and collectors can strongly accelerate dust flames, increase turbulence and flame surface area and lead to very high flame speeds and pressure-rise rates (Eckhoff and Li, 2021).

Earlier, Eckhoff (1993) offered a seminal state-of-the-art survey that systematized dust-explosion science covering cloud formation, ignition mechanisms, turbulent flame propagation and blast-wave effects and, on the applied side, pinpointed persistent engineering gaps such as realistic test procedures, reliable venting, robust isolation devices and the often-overlooked risk posed by dust layers themselves, thereby setting the research agenda that later works have continued to pursue.

Yuan et al. (2015) present a global survey of 2000 plus dust-explosion accidents recorded between 1785 and 2012 and show that dust-collecting systems form the single most frequently involved equipment class. Their data demonstrates that these collectors, together with conveying lines, offer the easiest path for a combustible cloud to form and meet an ignition source, explaining why incidents in collectors dominate statistics for both mature and rapidly industrializing economies.

Amyotte and Eckhoff (2010) overview delivers a compact but holistic state of the art picture. It traces how dust explosions originate linking key parameters such as, maximum explosion pressure, P_{max} and, deflagration index for dust, K_{St} , to the classical fire triangle (Fig. 1, which shows the three simultaneous requirements for ignition: a combustible fuel, an oxidizer, and an effective ignition source). They then broaden the analysis to the dust-explosion pentagon (Fig. 2, which adds two further requirements: sufficient dispersion of dust into a flammable cloud and confinement of that cloud within equipment), clarifying how pressure can build over time inside obstacle-rich housings such as baghouse collectors.

On the prevention side, Amyotte and Eckhoff (2010), arrange control measures in a clear hierarchy inherent safety first, followed by passive and active engineered safeguards and, lastly, procedural defenses arguing that effective risk reduction depends on removing at least one pentagon element, preferably at source. The authors stress that technical fixes alone are insufficient; enduring protection requires a supportive safety culture and a formal process safety management system, a lesson repeatedly underscored by historical case studies. An explosion confined to one piece of equipment is already dangerous, but the risk escalates

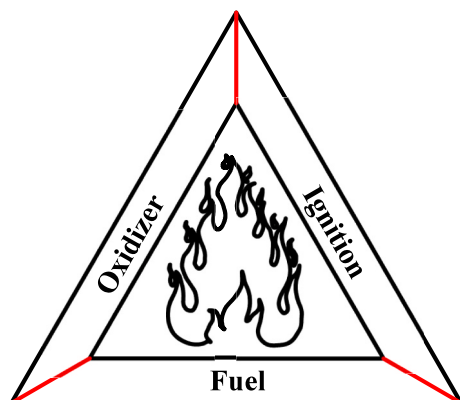


Fig. 1. Dust fire triangle.

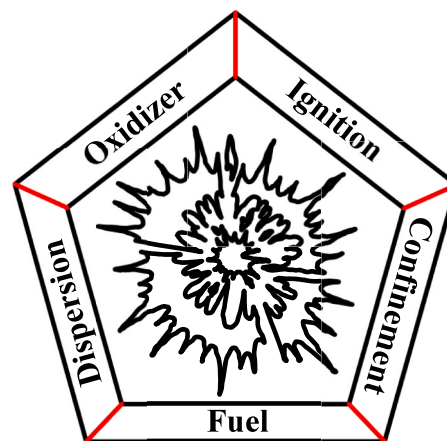


Fig. 2. Dust explosion pentagon.

dramatically when it disturbs settled dust and triggers a secondary blast in the wider plant (Taveau, 2012).

Finally, a comprehensive bibliometric study by Guan et al. (2023) that screened 1276 papers from 1998 to 2021, highlighting trends on explosion characteristics, research media, suppression, and numerical simulation. Their analysis is field-wide rather than equipment-specific and does not focus on dust collectors; our review addresses that gap with a collector-centered synthesis.

By contrast, our equipment-focused incident breakdown underscores why collectors warrant dedicated treatment. As shown in Fig. 3, dust collectors are consistently among the most frequently involved equipment categories in dust-explosion incidents over 2016–2023, alongside silos and elevators/conveyors (Pinna et al., 2025a).

1.2. Bibliometric study

As shown by global survey, by Pinna et al. (2025a) of dust-explosion incidents, dust collectors and silos are the two equipment families most frequently involved both recently and historically. To analyze how the literature treats these systems, parallel queries on Web of Science and Scopus, (Pranckutė, 2021), with identical Boolean strings and then mapped keywords in VOSviewer (Van Eck and Waltman, 2016). The consolidated database, after deduplication and manual screening, covers records retrieved as of October 1, 2025.

Scopus was retained for network analysis because it provides a longer backfile and broader silo coverage while remaining comparable for collectors: dust collectors, 105 records (1974–2025) and silos, 223 records (1971–2025), versus 114 (1991–2025) and 38 (1998–2025) respectively in WoS. The exact search strings used for both corpora are reported in Table 1. In VOSviewer author keywords and index terms and applied a minimum occurrence threshold of 6 to compute the co-occurrence networks. The resulting maps are reported in Fig. 4 (a) for silos, and Fig. 4 (b) for dust collectors.

The two Scopus maps highlight a clear asymmetry. The silo corpus forms a dense, cohesive network that connects classic dust-explosion topics (venting, K_{St} , P_{max} , ignition sources, materials handling) with storage-specific issues, indicating a mature and well-connected research backbone. The dust-collector corpus is sizeable but comparatively fragmented: high-level safety terms dominate, while links to collector-specific mechanisms remain sparse. This imbalance is notable given that dust collectors are at least as hazardous in practice as silos and often drive severe losses, reinforcing the need for focused, mechanism-level evidence specific to baghouse and cartridge units.

For transparency and reproducibility, the Scopus and Web of Science exports were first cross-checked, then manually curated the dust-collector dataset by verifying each record and retaining only items that are publicly retrievable today. The resulting validated corpus, used

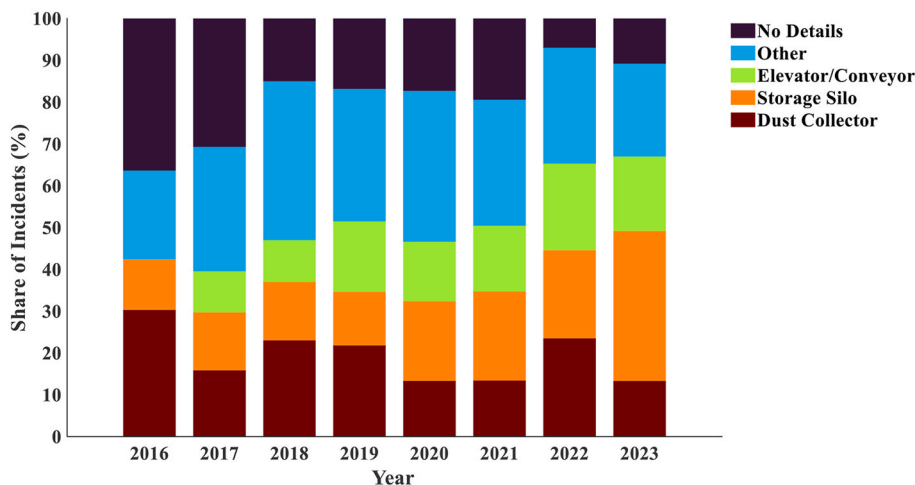


Fig. 3. Share of dust-explosion incidents by equipment type (2016–2023). Dust collectors consistently rank among the most frequently involved categories, alongside storage silos and elevators/conveyors. Adapted by Pinna et al. (2025a).

for all Bibliometrix analyses, is listed in Table A1 in Appendix A.

Using this curated Scopus set, the corpus to Bibliometrix (Aria and Cuccurullo, 2017; Saccone et al., 2025) and then post-processed the output with a custom MATLAB script to correct archiving artefacts.

The cleaning included harmonizing author names (surname + initials), normalizing country labels, mapping journal titles to a unique source field, and filtering obvious noise in keywords, like removing generic tokens such as dust, explosion, dust explosions, dust collector.

Fig. 5 presents the publications and citations per year. The time series is sparse before the mid-1990s, followed by intermittent activity and a clear step-change after 2015. Output remains consistently higher in 2016–2025, while the citation curve shows sharp spikes associated with a few highly cited papers and then fluctuates as new items accumulate citations.

The apparent dip for the most recent years is consistent with truncation effects (publications too recent to have accrued citations). In the last few years, both publication volume and citation activity show an upward tendency, indicating growing interest and a wider recognition of the problem across the community.

As shown in Fig. 6, publications are concentrated on process-safety outlets. Journal of Loss Prevention in the Process Industries (JLPP) clearly dominates the corpus by volume, followed at a distance by industry venues, like Staub, Reinhaltung der Luft, and a small number of research journals such as Advanced Powder Technology, Process Safety Progress, Process Safety and Environmental Protection, and Journal of Hazardous Materials. The absence of general combustion or structural-dynamics journals suggests that dust-collector explosion studies are framed primarily as applied process-safety work rather than as fundamental combustion or structural mechanics. This also explains why early contributions often appeared in trade/industry sources and conference series.

JLPP also concentrates the largest share of citations in our curated set, indicating that it is not only the most common venue but also the one where dust-collector work gains the most visibility within the process-safety community. Journal of Hazardous Materials and Process Safety and Environmental Protection accrue substantial citations despite fewer records, consistent with broader readership and the presence of influential case studies or reviews. Powder Technology and Journal of the China Coal Society contribute region- and material-focused impact (e.g., coal and metal powders). Note that total citations are age-biased; older papers have had more time to accumulate citations.

Fig. 7 shows that the distribution is long-tailed, with no single dominating group. The list includes historical anchors, together with more recent contributors from East Asia and North America. The authorship pattern points to a fragmented yet active field. Output is

spread across many small teams, top authors contribute 3–5 papers each, instead of being centralized within a few large collaborations, consistent with the multiple small clusters seen in the VOSviewer map.

The country distribution is led by the United States (41 records), followed by China (20), Germany (12), Italy (5), and the United Kingdom (4). This pattern mirrors where process-safety scholarship on dust-collector incidents and mitigation has been most active, that is the U.S. combines a large industrial base with mature publication venues, China shows rapid growth in recent decades, and Germany contributes steadily through a long tradition in explosion safety. Italy and the UK appear smaller in raw counts, which likely reflects both the narrower scope of this corpus database coverage, some national reports and conference proceedings are not indexed and therefore do not enter our count.

The top keywords reported in Fig. 8 remark that the high-frequency terms are predominantly high-level safety concepts combustion, explosion-proofing and protection, accident prevention, hazards, risk assessment alongside material-specific entries like aluminum and coal dust. Notably scarce are collector-mechanism terms, reinforcing the VOSviewer finding that collector-specific mechanisms are underrepresented in the indexed metadata.

The Bibliometrix indicators, after cleaning, corroborate the mapping analysis, studies highlighting clear research gaps: dust collectors have grown, but the knowledge base is dispersed and leans toward general safety terminology. This motivates our focus on consolidating collector-specific mechanisms (filter-pack turbulence, pulse-jet transients, vent location and ducting penalties, reaction-force duration) into design-useful relationships and validation targets.

Taken together, the VOSviewer maps and the cleaned Bibliometrix indicators show that, despite frequent real-world involvement, dust-collector research remains less consolidated than silo research. Collector-specific mechanisms are underrepresented, full-scale evidence tailored to filter units is sparse, and reporting is often inconsistent on geometry and operating conditions. As a result, standards and commonly used correlations provide only partial guidance for bag-houses and cartridge-filters, especially when predicting the reduced pressure, P_{red} , reaction forces and their duration, and the effects of vent location and ducting.

This article addresses the above-mentioned research gap in two ways. First, it assembles a curated view of the main collector typologies and geometries used in industry and consolidates what has been learned to date about their explosion behavior, with emphasis on venting effectiveness, load transfer, and worst-case operating conditions. Second, it translates this synthesis into a research agenda aimed at design-relevant predictions, identifying which geometric and operating

Table 1
Database queries used to build the silos vs. dust-collector corpora and VOSviewer maps.

Corpus	Database	Boolean query	Field and filters	Records (year span)	Used for VOSviewer
Dust collectors	Scopus	TITLE-ABS-KEY(("dust collector" sm OR "dust-collector" sm OR baghouse sm OR "fabric filter" sm OR "bag filter" sm OR "cartridge filter" sm OR "pulse-jet filter" sm OR "pulse jet filter" sm OR "dust extraction system" sm OR "filter house" sm) AND ("dust explosion" sm OR "combustible dust" OR deflagrat* OR "explosion vent" sm OR "vent* sizing" OR Pred OR Pmax OR KSt))	Field: TITLE-ABS-KEY; Source type: Journals; Document type: Article, Review; Language: all	105 (1974–2025)	Yes
Silos	Scopus	TITLE-ABS-KEY(("silo" sm OR "grain bin" sm OR "grain elevator" sm OR "storage bin" sm OR hopper sm OR bunker sm OR "coal silo" sm OR "cement silo" sm OR "flour silo" sm OR "sugar silo" sm) AND ("dust explosion" sm OR "grain dust" sm W/1 explosion*) OR "combustible dust" OR deflagrat* OR "explosion vent" sm OR Pred OR Pmax OR KSt))	Field: TITLE-ABS-KEY; Source type: Journals; Document type: Article, Review; Language: all	223 (1971–2025)	Yes
Dust collectors	Web of Science Core Collection	TS=("dust collector" sm OR "dust-collector" sm OR baghouse sm OR "fabric filter" sm OR "cartridge filter" sm OR "pulse-jet filter" sm OR "pulse jet filter" sm OR "dust extraction system" sm OR "filter house" sm) AND ("dust explosion" sm OR "combustible dust" OR deflagrat* OR "explosion vent" sm OR "vent* sizing" OR Pred OR Pmax OR KSt))	Field: Topic (TS = title/abstract/keywords/ Keywords Plus); Doc types: Article, Review; Language: all	38 (1998–2025)	No (used for cross-check)
Silos	Web of Science Core Collection	TS=("silo" sm OR "grain bin" sm OR "grain elevator" sm OR "storage bin" sm OR hopper sm OR bunker sm OR "coal silo" sm OR "cement silo" sm OR "flour silo" sm OR "sugar silo" sm) AND ("dust explosion" sm OR "grain dust" sm NEAR/1 explosion*) OR "combustible dust" OR deflagrat* OR "explosion vent" sm OR Pred OR Pmax OR KSt))	Field: Topic (TS = title/abstract/keywords/ Keywords Plus); Doc types: Article, Review; Language: all	114 (1991–2025)	No (used for cross-check)

descriptors must be reported to enable reproducibility, and highlighting where full-scale, instrumented evidence is most needed to validate models of P_{red} vent-thrust time histories, and the influence of vent placement and ducting. The focus throughout is practical, to give designers a coherent baseline of what is known for dust collectors and to chart the most direct path toward closing the remaining uncertainties in vent sizing and structural loading.

After this introduction, section 2 summarizes baghouse and cartridge-filter architectures and operating variants to fix terminology and the parameters that matter for explosion loading. Section 3 consolidates the principal studies focused on dust collectors and the specific problems posed by dust explosions in these units, critically comparing their assumptions and findings against available large-scale evidence and current standards. Section 4 translates the most reliable insights into design-useful implications and outlines the priority gaps that require targeted experiments and validated modelling.

2. Baghouse dust collectors

Baghouse dust collectors are engineered systems that clean process air by trapping airborne dust before it can circulate back into the workspace. Particle size matters. Large particles (over 50 μm) are heavy enough to fall out of the air quickly, so gravity or inertia removes them. Fine, respirable particles (10 μm or smaller) stay suspended, slip deeper into filter layers, and are the most dangerous to health. Fig. 9 shows a common centralized arrangement. Dust-laden air is captured at local hoods, travels through a branched duct network, and enters a central filtration unit a baghouse collector. Inside the housing, the flow slows, and fine particles accumulate on the exterior of fabric filter elements, forming a dust cake. Periodic cleaning cycles release this cake, which drops into the hopper for safe disposal or product recovery. The clean air then moves through the outlet manifold and is driven by the downstream fans either back into the plant or to the atmosphere, completing the circuit (Cecala et al., 2012).

Table 2 summarizes the key characteristics of the baghouse collectors retrieved from Lo et al. (2010), Simon et al. (2010), and Cecala et al. (2012).

Historical interest in baghouse technology goes back more than half a century. In 1954, one of the earliest comparative studies examined shaker, reverse-jet and rapping collectors, already showing that the reverse-jet design best maintained steady airflow and minimized dust build-up (Billings et al., 1954). In the final of this chapter, the modern variants of baghouse collectors and outline the key characteristics that define their performance and safety were present (Cecala et al., 2012).

2.1. Mechanical-shaker

Mechanical-shaker baghouses, in Fig. 10, form the oldest family of commercial dust collectors. Dust-laden air rises through vertical bags; particles build a cake on the outside while clean air leaves at the roof. When the pressure drop becomes too high, the fan (or an isolating damper) is closed, and a motor-driven bar shakes the bag tops. The vibration cracks the cake, which slides down the fabric and drops into the hopper, finally filtration then resumes.

This design offers several advantages. Because cleaning relies on a simple oscillating mechanism, it needs neither compressed air nor complex valves, so capital cost and maintenance are low. The gentle shaking puts little mechanical stress on the housing, and the absence of high-pressure pulses makes it suitable for fragile media and moderate dust loads.

The same features also limit its use. Shaking is effective only if airflow is stopped, so either production must pause or the collector must be split into compartments, increasing size and cost. Air-to-cloth ratios remain low about two cubic meters of gas square meter of fabric meaning a large filter area and extensive floor space. Finally, only sturdy woven bags withstand repeated flexing; felt media that give higher

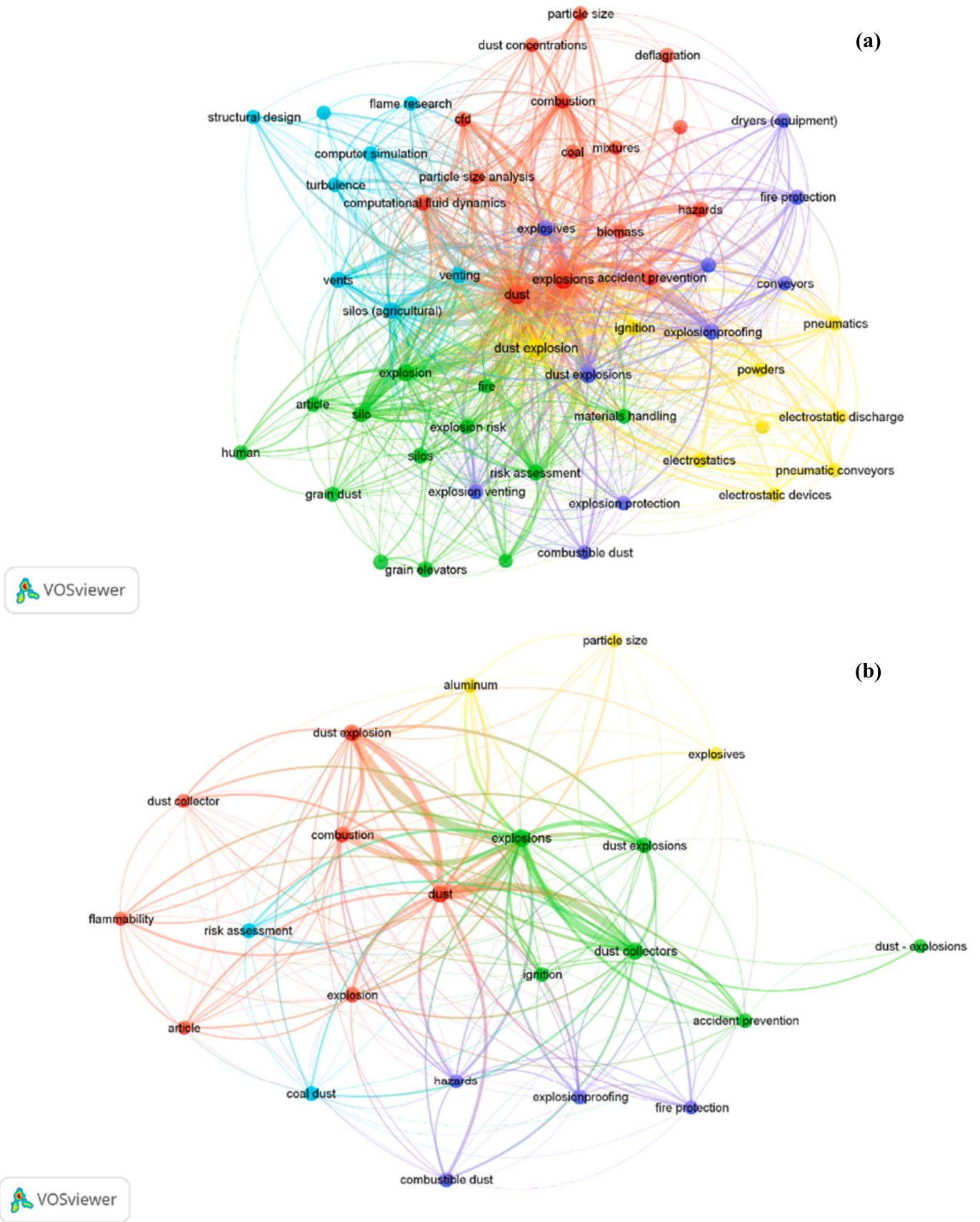


Fig. 4. VOSviewer keyword co-occurrence networks (Scopus): (a) Silos, $n = 223$ (1971–2025); (b) Dust collectors, $n = 105$ (1974–2025). Queries in Table 1; author keywords + index terms; full counting; minimum occurrences ≥ 6 .

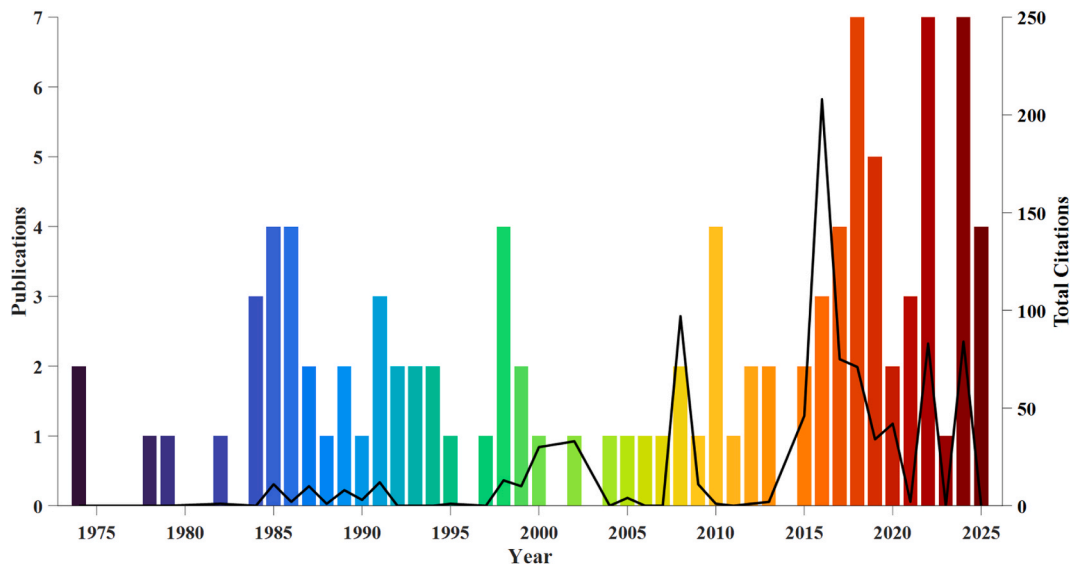


Fig. 5. Publications (bars) and total citations (black line) for year for the Scopus dust-collector corpus (1974–2025). Data from Bibliometrix export, cleaned in MATLAB.

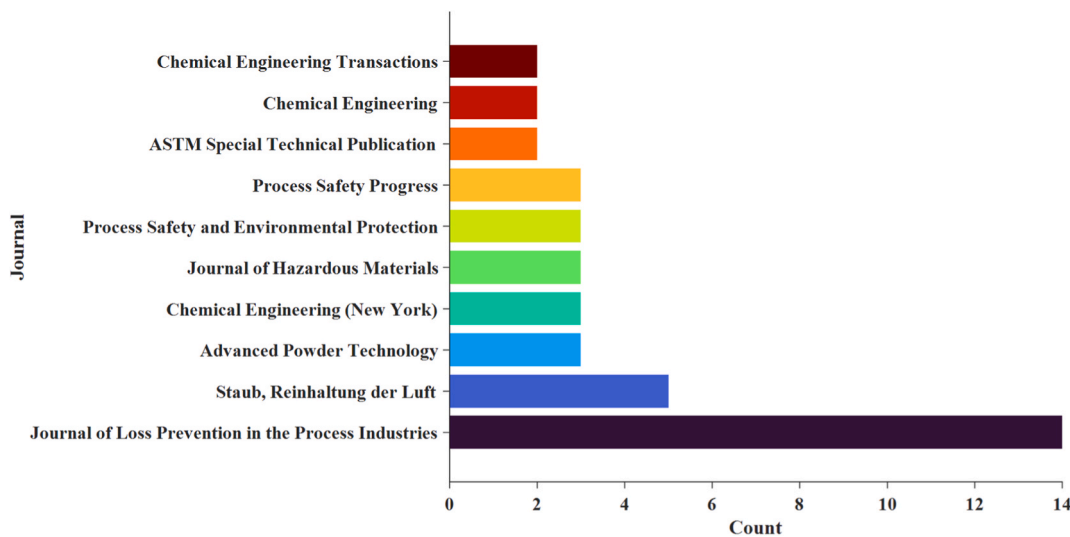


Fig. 6. Counts of records for source titles after mapping variants to a unique name. Leading venues include Journal of Loss Prevention in the Process Industries, Process Safety and Environmental Protection, Journal of Hazardous Materials, Advanced Powder Technology, and Process Safety Progress. Scopus dust-collector corpus.

efficiency in pulse-jet units are not practical here.

Thomas et al. (2015) demonstrate, through accelerated lab loading and a three-month winter trial in a swine farrowing room, that a fabric-filter shaker dust collector can lift overall collection efficiency from about 60 % to > 90 % once a thin cake forms while keeping pressure drop below 250 Pa, proving that low-cost shaker units are a practical option for recirculating ventilation systems that aim to curb airborne dust and the attendant explosion and health hazards in agricultural settings.

2.2. Reverse-air

Reverse-air baghouses, shown in Fig. 11, were developed as a gentler alternative for high-temperature or fragile filter media. Dust-laden air flows upward outside long tubular bags; a dust cake forms while clean air exits at the roof. When resistance rises, dampers isolate one compartment, and a traveling manifold blows low-pressure air in the

reverse direction. The bags flex inward, the cake breaks loose and falls into the hopper, and normal filtration then resumes.

This method has clear advantages. It needs only a small blower no compressed-air lines to install or freeze and the mild backflow minimizes mechanical stress, making it suitable for glass-fiber and other delicate fabrics used in hot or corrosive gas streams.

Yet the same traits impose limits. Cleaning works only with the compartment off-line, so multi-section housings are essential, increasing footprint and cost. Because the reverse pulse carries little energy, air-to-cloth ratios stay low, comparable to shaker units, and the moving manifold and damper system add maintenance points. As a result, reverse-air collectors are now chosen mainly where compressed air is unavailable, but space is abundant.

2.3. Pulse-jet

Pulse-jet baghouses, see Fig. 12, often called reverse-jet collectors

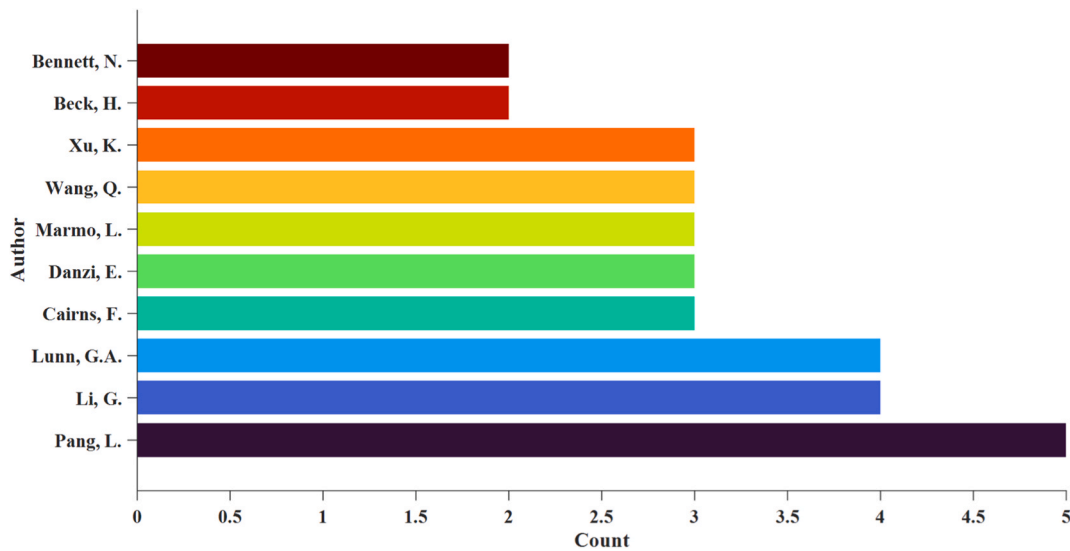


Fig. 7. Top authors. Counts = number of documents for author in the Scopus dust-collector corpus; harmonized names (surname + initials) and spurious entries removed with MATLAB post-processing.

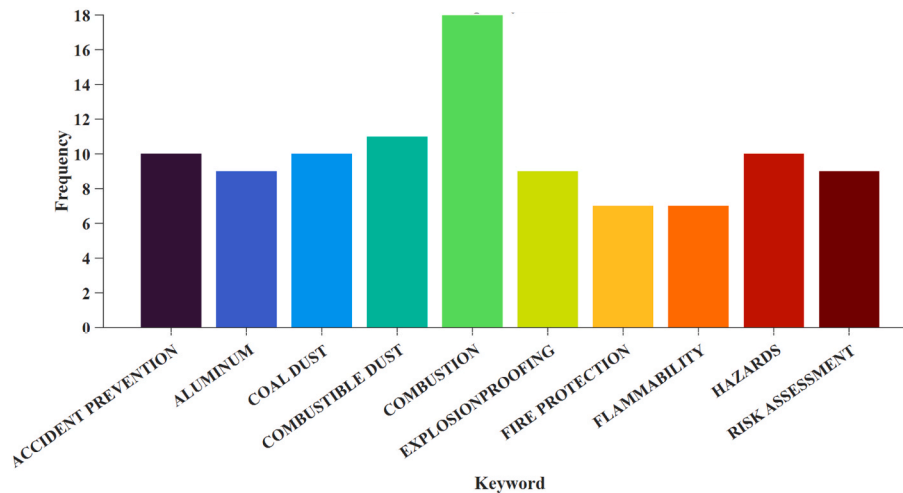


Fig. 8. Top keywords (exclusions applied). Author keywords + index terms after normalization (case/hyphenation/punctuation) and removal of generic tokens (“dust”, “explosion”, “dust collector(s)”, etc.). Frequencies computed on the Scopus dust-collector records.

place each filter bag over a wire cage fixed to a tube sheet at the top of the housing. Dust-laden air enters below the tube sheet and moves from the outside to the inside of the bags, building a cake on the exterior while clean air escapes through the plenums above. When the pressure drop reaches its control limit a very short pulse of clean, dry compressed air, typically 4-6 bar(g) [0.4-0.6 MPa], is injected through a nozzle and a short converging-throat-diverging piece that accelerates the jet and entrains additional air to amplify the cleaning pulse.

The resulting shock wave makes the bag pop outward, cracks the cake and propels it into the hopper. Because the pulse lasts only a fraction of a second and affects one row at a time, filtration continues uninterrupted, and the collector does not need to be split into compartments.

The high frequency, on-line cleaning keeps resistance low and allows air-to-cloth ratios far above those of shaker or reverse-air units; suppliers routinely quote six cubic meters of gas for square meter of felt, although values around four are recommended when the dust is abrasive.

The design is compact, has no moving dampers or manifolds, and has been the dominant type of baghouse since the late 1950s for product recovery as well as emission control. Reliance on compressed air,

however, introduces its own constraints. The supply must be oil-free and low in moisture, otherwise droplets and condensate blind the felt and reduce cleaning efficiency. Pulses also drive particles deep into woven fabrics, so pulse-jet bags are almost always made from needled felts that resist penetration. Very high velocities after a pulse can re-entrain dust and shorten bag life, and performance can fluctuate if gas temperature or humidity varies widely.

Despite these limits, the combination of continuous operation, small footprint and moderate capital cost makes the pulse-jet collector the first choice where a stable source of dry compressed air is available.

2.4. Cartridge

Cartridge collectors, in Fig. 13, represent the most recent evolution in fabric filtration. Instead of long fabric bags, they employ rigid canisters whose filtering medium is folded into tight pleats, greatly increasing surface area for the same diameter. Dust-laden air enters the housing and flows from the outside to the inside of each cartridge, depositing a cake on the pleat surfaces; short pulses of clean, dry compressed air then blow down the core of the canister to dislodge the cake,

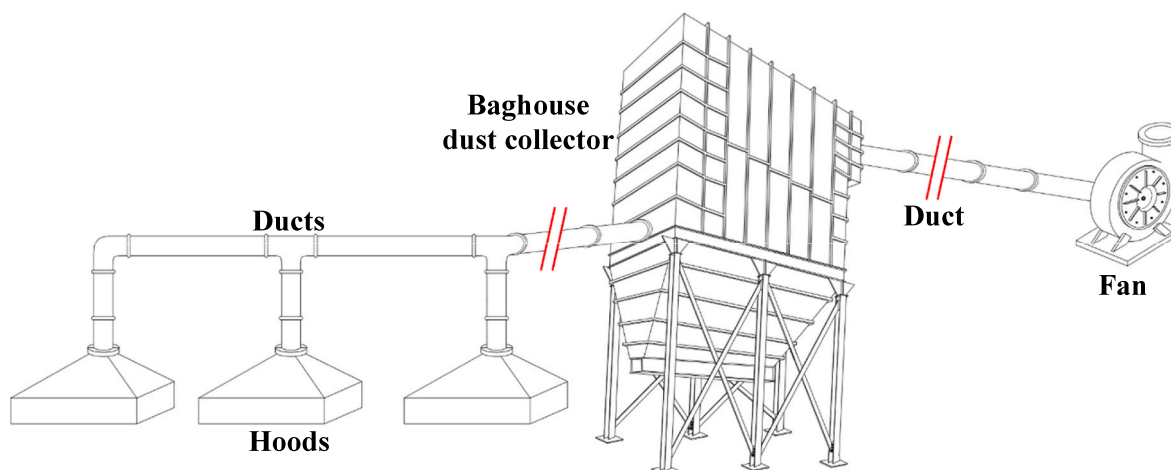


Fig. 9. Simplified layout of an industrial dust-collection system: capture hoods feed branch and header ducts into a central baghouse dust collector; cleaned gas is pulled by downstream fans. Red marks indicate typical locations for explosion-isolation between the collector and upstream and downstream ductwork. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 2
General characteristics of the baghouse collectors.

Characteristics	Design points
Operating window	Most units run at 1–1.5 mp (0.01–0.015 bar(g)) of pressure drop yet still reach HEPA-level removal (>99.97% of fine dust) (ISO 29463, 2022).
Bag materials	Cotton is cheap and works at room temperature, synthetics, like polyester, aramid, PTFE or glass fiber bags resist heat, chemical or moisture. Designs that let bags be changed from outside the housing cut maintenance time.
Economic sizing	Pressure loss, cleaning frequency and total cloth area must be balanced for lowest life-cycle cost (Caputo and Pelagagge, 2000).
Bulk density	Very light powders (<480 kg/m ³) need wide spacing between bags, shorter bags, and side inlets to keep upwards gas velocity down.
Air-to-cloth ratio	The finer the dust, the lower this ratio must be. Correct cloth choice and cleaning methods are therefore central to reliable performance.

in much the same way as a pulse-jet baghouse. Because each cartridge offers far more cloth than a conventional bag, a complete unit occupies less floor space and requires less headroom, cartridges slide in from the side, so change-out is quick and exposes maintenance staff to minimal dust. The high cloth area also means that fewer elements and therefore lower capital cost are needed to handle a given airflow.

These same characteristics introduce constraints. The pleated geometry creates narrow channels where the gas approaches the media, raising local velocity and making re-entrainment likely, for that reason, suppliers limit the air-to-cloth ratio to roughly two cubic meters of gas for square meter of cloth, far below values common in pulse-jet baghouses. Cartridge media are generally non-woven polyesters or synthetic blends and tolerate operating temperatures only up to about 80–90 °C, with few options for corrosive or wet gases. Pleats do not clean as thoroughly as smooth bags, so inlet dust loading must be lower, and horizontally mounted cartridges can suffer from dust cascading from the rows above. Finally, although fewer elements are required, each cartridge is more expensive than a bag and is usually sourced from the original equipment vendor, reducing the buyer's leverage on replacement costs. For these reasons cartridge collectors excel in dry, moderate-temperature applications such as laser cutting, pharmaceutical blending or fine powder packaging where space is tight and dust loads are modest, but they are less suitable for hot, moist or highly abrasive service.

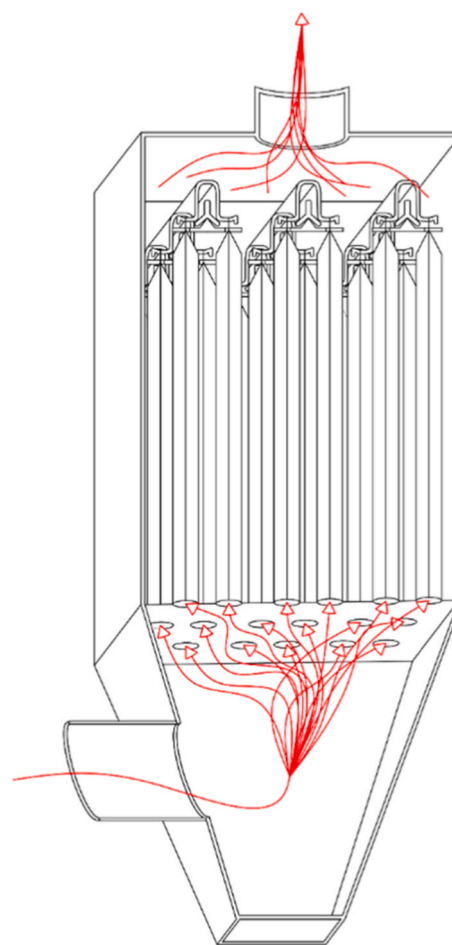


Fig. 10. Schematic of a mechanical-shaker baghouse: dust-laden gas enters at the hopper/inlet, flows around the hanging fabric bags, and passes from outside to inside into the clean-gas plenum before exiting at the outlet stack. Red arrows indicate process airflow. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

2.5. Comparative overview of collector types

To situate the subsequent analysis, it begins with a concise typology

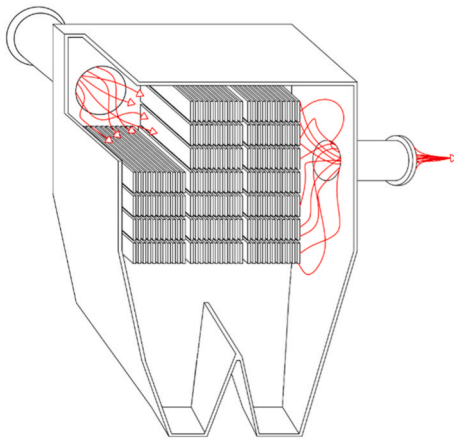


Fig. 11. Schematic of a reverse-air baghouse: dust-laden gas is distributed across multiple compartments and flows from the outside of the long fabric bags through the media into the clean-gas plenum; cleaned gas exits at the outlet duct. Red arrows indicate process airflow and reverse-air cleaning streams. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

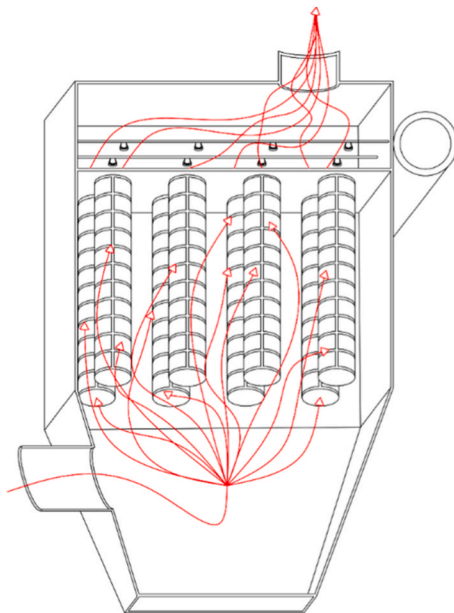


Fig. 12. Schematic of a pulse-jet baghouse: dust-laden gas enters at the hopper/inlet, flows around the vertical filter bags, and passes from the bag exterior through the media into the clean-gas plenum before exiting at the outlet stack. Red arrows indicate process airflow and pulse-jet streams. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

of industrial dust collectors and their operating envelopes.

Table 8 compares the main dust-collector families used in industry, mechanical shakers, reverse-air, pulse-jet baghouses, and cartridge units, highlighting how they operate and the practical trade-offs. For each type it is reported the cleaning method, the cleaning mode (online = cleaning while filtration continues, offline = compartment isolated), an indicative A/C (air-to-cloth, i.e., filtration velocity in m/min), representative filter media (examples), and the principal operational advantages and limitations. Ranges are indicative and depend on dust characteristics, temperature and moisture, and vendor practice.

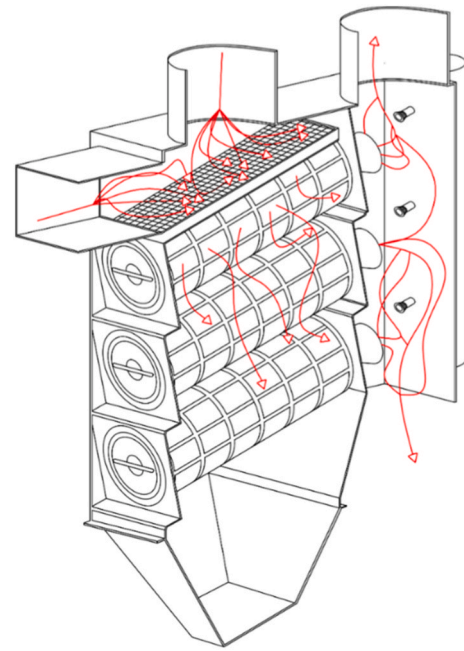


Fig. 13. Schematic of a cartridge baghouse: dirty gas enters the inlet plenum (top left) and is distributed across horizontal pleated cartridges; air passes through the media into the clean-gas plenum, while a pulse-jet system (right: valves and blowpipes) injects short bursts to detach the dust cake into the hopper. Red arrows indicate process airflow and pulse-jet streams. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

3. Explosion in dust collectors

Having outlined the main collector typologies and flow paths, the evidence on how deflagrations arise in dust collectors and what this implies designing it.

Simon et al. (2010) show that when a reverse-jet baghouse is cleaned row by row the first bags hit by the compressed air pulse experience face velocities more than twice the normal flow, which squeezes the leftover dust cake, drives a burst of powder deep into the fabric, and ejects a dense cloud of particles downstream. In their 24-bag pilot plant the first nine bags generated about two thirds of all particles emitted during each cleaning cycle, meaning that puffs created by the cleaning sequence govern the real explosion threat and must be considered when sizing vents or revising pulse-jet timing.

Zalosh (2015) introduces the first fully quantitative method for judging how likely baghouse or cartridge collectors are to explode. The model links routine reverse-jet pulsing to momentary dust-cloud peaks: even with inlet loads a tenth of the minimum explosible concentration, the equations predict clouds well above that limit, and partial-volume blasts of 0.2-1 bar(g) enough to buckle most housings. It then extends the analysis to upset scenarios where half the filter cake can detach, filling the entire vessel and driving pressures close to a dust's P_{max} . Five worked examples and a decision flow-chart show that explosion vents or other safeguards are essential for today's collectors.

Li et al. (2022) couple laboratory tests with CFD to explain why aluminum powder exploded inside a baghouse during the 2014 Kunshan accident (Chan et al., 2015). They measure a minimum ignition temperature and a lower explosion limit for 19 μm powder, then simulate routine operation and show that dust accumulates at the hopper bucket interface where concentrations reach 0.126 kg/m^3 and local temperatures exceed 600 $^\circ\text{C}$. That proves that self-heating and poor cake removal can generate full conditions for a baghouse deflagration.

Pang et al. (2024) show that what sits inside the inlet duct matters as much as what filters reach the bags. Even a thin, 10-15 g layer of

corn-starch on the duct walls can push the peak explosion pressure in the downstream collector from about 2.1 bar(g) [0.21 MPa] to nearly 2.8 bar(g) [0.28 MPa] and reshape the flame path. Moving that same dust layer farther along the pipe changes where the pressure wave hits the housing but still lengthens the flame, proving that housekeeping and layout of the inlet duct are critical controls for baghouse explosion severity.

Taken together, these studies indicate that collector-specific transients, pulse-jet puffs, partial cake detachment, non-uniform suspension, and inlet-duct resuspension, govern fuel availability and the pressure–time history that sets P_{red} and the duration of vent thrust. Assumptions of well-mixed, vessel-type behavior are therefore often inadequate.

3.1. Ignition, smoldering and prevention

Dust explosions in baghouse and cartridge dust collectors are often governed by practical ignition and pre-combustion phenomena that are specific to filtration duty, where deposits, intermittent dispersion events and confined congestion coexist. In this equipment, ignition can originate from a wide spectrum of sources, including impact sparks, mechanical heating and hot surfaces, due to malfunctioning or misaligned components, hot work, electrical faults, and electrostatic discharges. Additional practical contributors include foreign objects and upstream process upsets that generate hot material (Factory Mutual Insurance Company, 2024). In industrial guidance and accident investigations, dust collectors are repeatedly identified as locations where ignition hazards and hazardous dust clouds can coincide, particularly under transient or abnormal conditions, because the collector inherently concentrates fine dust and cleaning events can generate short-lived high dust concentrations, while ignition can be introduced or develop locally, including the documented transport of burning embers from upstream equipment into downstream dust collectors and subsequent dust-collector fires (U.S. Chemical Safety and Hazard Investigation Board, 2023). Therefore, ignition-source control, e.g., hot-work management, control of potential ignition from foreign objects, and electrostatic control via bonding in baghouse-type collectors, should be treated as a primary protection layer, complementary to explosion protection measures (Occupational Safety and Health Administration, 2020).

A critical escalation pathway in baghouses is the occurrence of dust fires and smoldering within the dust cake, hopper deposits, or dead zones. Smoldering can be initiated by hot particles/embers, self-heating of reactive dust, or localized hot surfaces, and may persist for long periods because the porous cake can provide thermal insulation and access to oxidizer (U.S. Chemical Safety and Hazard Investigation Board, 2023). The transition from smoldering/deposit combustion to a deflagration is strongly influenced by events that suddenly disperse fuel into a cloud, such as pulse-jet cleaning, partial cake detachment, hopper discharge disturbances, or air leaks that re-entrain deposits. For this reason, a dust collector should not be interpreted only as a “vessel to vent”, but also as a system where deposit management and early smoldering detection can interrupt escalation before cloud formation and ignition coincide (Factory Mutual Insurance Company, 2024).

Because baghouses serve multiple industries, the set of materials that can generate explosions in this equipment spans typical combustible dust classes such as wood and biomass dust, food and agricultural powders, polymers and additives, pharmaceuticals, carbonaceous dust, and metal dusts (Eckhoff, 2003). In practice, the hazard assessment should be based on the collected dust (as actually present in the filter/hopper), characterized through standard flammability and explosibility parameters: minimum explosible concentration (MEC, sometimes reported analogously to “LEL” for dust clouds), minimum ignition energy (MIE), minimum ignition temperature for clouds and for layers (MIT_{cloud} and MIT_{layer}), and explosion severity indices (P_{max} and K_{St}) (ASTM E 1515-07, 2007). These properties are not fixed “material constants” in the strict sense, because they depend on physicochemical

features such as particle size distribution, moisture content, volatile fraction, and contamination, which can vary with process conditions and with the segregation occurring in ducts and hoppers. Finer particles typically increase reactivity and sensitivity to ignition, while moisture can modify dispersion and ignition sensitivity; consequently, the same nominal material may exhibit different ignitability and severity once it is collected, dried, ground or mixed with other powders during plant operation (Di Benedetto et al., 2010).

The role of dust cloud concentration and turbulence is particularly relevant in dust collectors because the internal flow is non-uniform and operational transients can generate local concentration peaks. Even when average inlet loading is modest, pulse-jet cleaning and local re-entrainment can create short-lived but intense dust clouds in confined regions, while the internal congestion introduced by filter elements, support cages, baffles and ducts promotes turbulence and enhances flame acceleration. This coupling between transient dispersion, turbulence and congestion provides a physically consistent explanation for why severe events may occur in collectors and connected ductwork even when “steady” process indicators appear acceptable, and it reinforces the need to discuss ignition and prevention explicitly in a state-of-the-art review on baghouse dust explosions.

Mitigation in baghouse dust collectors therefore must include prevention measures, not only explosion protection (Occupational Safety and Health Administration, 2020). Prevention focuses on avoiding the formation of hazardous clouds and removing credible ignition sources: robust housekeeping and deposit control, including hopper management and avoidance of dead zones, preventive maintenance to avoid overheating/friction, control of hot work and abnormal operations, electrostatic control via bonding/grounding and suitable filter media where relevant, and upstream measures aimed at stopping hot particles before they enter the collector like sparks detection and extinguishing, or equivalent engineering controls. Where feasible, monitoring strategies that provide early warning of smoldering or abnormal temperatures further support prevention by enabling timely shutdown and safe intervention before pulse events or re-entrainment disperses fuel into an ignitable cloud (NFPA 660, 2025).

3.2. Design for resistance

In the containment approach, dust collectors and similar enclosures are designed to withstand the internal deflagration without rupture or hazardous fragment projection.

Hollingshead (2008) review sets the benchmark. Collectors that handle combustible dust can be built strong enough to survive an internal blast, the housing and every potential weak spot, flanges, access doors, valves, and hoppers must all be reinforced to withstand explosion pressures in the range of 0.3 to 0.6 MPa, which corresponds to roughly 3 to 6 bar(g).

In Europe, EN 14460 (2018) defines explosion pressure shock resistant equipment and prescribes a design route that begins with a design pressure representing the worst credible event. Structural verification is then performed either by typical design rules with allowable stress (including weld seam factors and flange requirements) or by finite element analysis (FEA) with documented software validation, with materials meeting ductility criteria and allowances for temperature and additional loads.

In the NFPA framework, NFPA 660 (2025) recognizes containment as an acceptable protection method but requires that enclosures and their interconnections be designed to withstand the resultant deflagration pressures derived from the Dust Hazard Analysis (DHA) scenarios. In practice, this heavy-duty solution is now chosen mainly for comparatively small collectors or for processes that cannot safely vent hot, toxic, or corrosive gases. Otherwise, venting or suppression is typically preferred. When containment is adopted, designers must verify not only the shell but also doors, flanges, filter frames, hoppers, and transitions, and either include the interconnecting ductwork in the pressure

evaluation or provide suitable explosion isolation.

In modern practice this heavy-duty design-to-resistance approach is chosen only for relatively small collectors or for processes that cannot safely vent gases outside the building.

3.3. Venting

As soon as reliable vent panels became available, standards shifted toward controlled pressure relief. An example of vent panels is shown in Fig. 14. Venting as the prime passive engineered safeguard, sitting just below inherent safety in the hierarchy of controls (Eckhoff, 2003).

The canonical vent-sizing framework, nomograms for dust classes St1 ($0 \text{ bar(g)} \cdot \text{m/s} < K_{St} \leq 200 \text{ bar(g)} \cdot \text{m/s}$) and St2 ($200 \text{ bar(g)} \cdot \text{m/s} < K_{St} \leq 300 \text{ bar(g)} \cdot \text{m/s}$), traces back to Bartknecht (1981), whose synthesis of large-scale dust-explosion tests was distilled into the well-known nomograms. In log-log form these charts give the minimum relief area A required to limit the reduced pressure P_{red} in a vessel of volume, V , for a given dust class, K_{St} , and P_{max} . Their validity rests on a common set of assumptions, a single, essentially unobstructed vessel, a near-uniform cloud with central ignition, negligible or short ducting, and vent panels with predictable inertia. Subsequent large-scale campaigns, including the 236 m^3 silo cell work by Eckhoff et al. (1987), contributed to validating and extending early venting correlations. In parallel, the European methodology evolved through the revision of VDI 3673 Blatt 1 (2002), which transitioned from nomographs to empirical equations for vent sizing (Siwek, 1994; Bruderer, 1995), later forming the computational backbone of EN 14491 (2012). On the US side, NFPA 68 (2023) similarly moved toward a unified vent-sizing equation applicable to both weak and strong enclosures (Ural, 2001) and subsequently introduced explicit provisions to account for turbulence in dust/powder processing equipment (Zalosh, 2007). More recent comparative studies further highlight persistent differences between EN 14491/VDI 3673-based and NFPA approaches, particularly regarding slenderness (L/D) corrections and their practical implications for vent-area requirements (Tascón et al., 2016).

As a visual baseline for the discussion that follows, Fig. 15 (a) and (b) present the Bartknecht-type nomograms.

Radandt (1984) translated the nomogram into explicit power-law correlations for elongated round silos, writing the minimum vent area at zero ducting, A_{v0} , as:

$$A_{v0} = \left(a + \frac{b}{P_{red,max}} \right) \cdot V^c \quad (1)$$

Where V is the vessel of the volume, the coefficients a, b, c were calibrated for the class St1 ($0 \text{ bar(g)} \cdot \text{m/s} < K_{St} \leq 200 \text{ bar(g)} \cdot \text{m/s}$) and St2 ($200 \text{ bar(g)} \cdot \text{m/s} < K_{St} \leq 300 \text{ bar(g)} \cdot \text{m/s}$) dusts and for two pressure ranges ($P_{red,max} < 0.5 \text{ bar(g)}$ and $\geq 0.5 \text{ bar(g)}$) under the standard assumptions used in the classic charts (e.g. $P_{max} \approx 9 \text{ bar(g)}$ and panel static burst $P_{stat} \approx 0.1 \text{ bar(g)}$). Table 3 reports on the factors taken from Radandt.

Modern practice sizes vent with the K_{St} method, place them close to likely ignition points and minimize duct length to avoid pressure losses principles reaffirmed by Amyotte and Eckhoff (2010) overview. Field tests still show nuance: long or elbowed vent ducts can treble the internal pressure, so layouts matter as much as panel area.

Full-scale field campaigns show why layout matters as much as panel area. Working inside an operating baghouse, Lunn and Cairns (1985) measured real dust explosions inside a working baghouse and showed that vent location is the decisive control. When the relief panel sat right next to the ignition source, the vent opened almost immediately and the peak overpressure stayed near 0.02 bar(g) [2 kPa], but when the panel is placed the flame thread through the filter packs and created extra turbulence, the same collector saw peaks up to 0.14 bar(g) [14 kPa]. Those higher values were still broadly predicted by the standard K_{St} nomograph (Bartknecht, 1978), yet the authors note that gas-explosion data can greatly overestimate dust pressures. The study therefore argues that sizing vents with K_{St} curves is acceptable provided the whole dusty volume is used in the calculation, but that designers should always place vents as close as possible to likely ignition points to keep real pressures within about 0.01 bar(g) [1 kPa].

Lunn et al. (1998) ran full-scale tests on baghouse collectors and found that adding a long or sharply bent vent duct can raise explosion pressures from the nominal 0.1 bar(g) opening value to roughly $0.25\text{--}0.31 \text{ bar(g)}$, showing that duct length, bends and end-caps must be included in vent-sizing calculations for dust collectors.

For the sake of clarity, in Tables 4–6 also report on the principal dust parameters used in those tests K_{St} , P_{max} , geometric characteristics of the dust collector, and their vent area together with the maximum P_{red} recorded in the Lunn and Cairns (1985) and Lunn et al. (1998) campaigns.

Pinna et al. (2025ba) review how today's main vent-sizing rules perform when applied to dust collectors and find they often miss the mark: their formulas can both under-predict and over-predict the reduced pressure, P_{red} , and the duration of the vent-reaction force, t_r , when compared with large-scale baghouse tests. Because dust collectors now account for roughly a quarter of all recorded dust-explosion

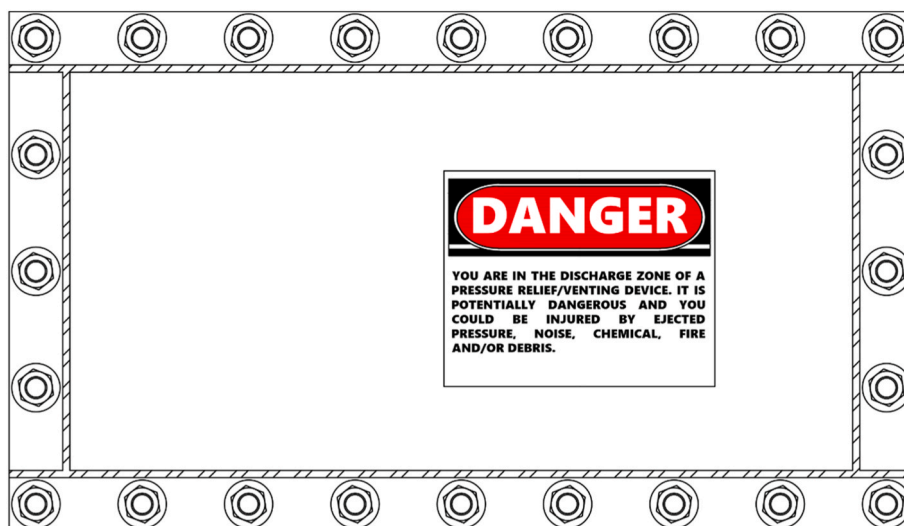


Fig. 14. Example hazard signage for the discharge zone of an explosion relief/venting device on a baghouse.

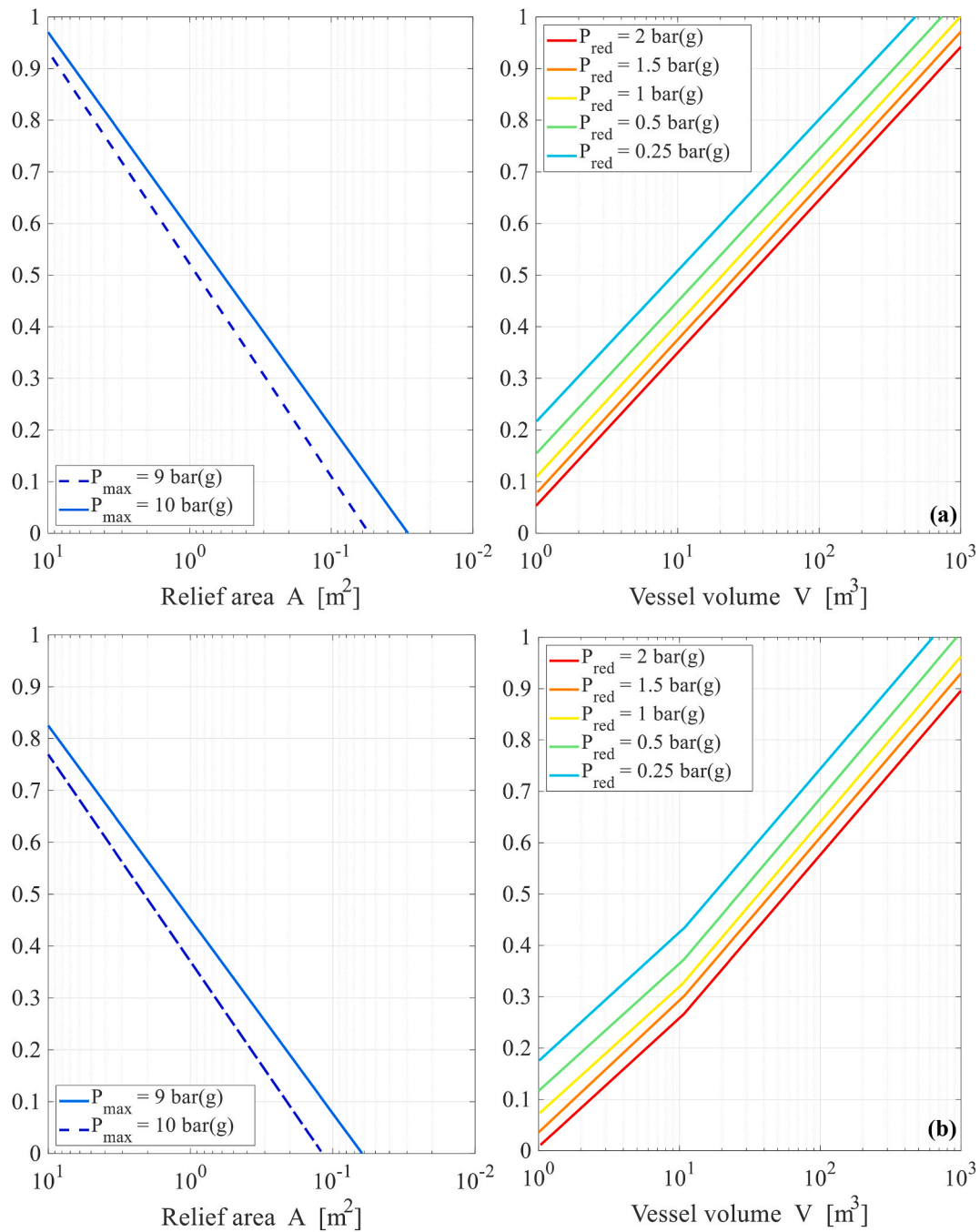


Fig. 15. Classic venting nomograms recreated in MATLAB for dust classes St1 (a) and St2 (b). Curves give the minimum vent area $A [m^2]$ required to limit the reduced pressure P_{red} to the indicated values as a function of vessel volume $V [m^3]$. The left panels show the reference lines associated with $P_{max} = 9$ and 10 bar(g) used in the nomogram scaling.

incidents, the authors argue that relying on silo-derived correlations is no longer acceptable. Instead, updated experimental data and correction factors tailored to the complex geometry and turbulence of filter units are needed so vents are neither undersized nor excessively conservative.

$$P_{red,dust\ collectors} = \alpha_{dc} \cdot P_{red,standards} \tag{2}$$

Where $P_{red,dust\ collectors}$ is the resulting reduced pressure for dust collectors, i.e., the peak internal gauge overpressure after vent opening used for structural design (in bar(g)), $P_{red,standards}$ is the reduced pressure predicted by standard vent-sizing equations (in bar(g)), α_{dc} is the correction factor is, they conclude that revising the standards to reflect these findings would give engineers more reliable pressure limits and help plants

choose vent panels that truly contain collector blasts without imposing unnecessary cost. The factors taken from Pinna et al. (2025a), α_{dc} for NFPA 68 (2023) and EN 14491 (2012) depends on whether the effective vent area is used: based on total vent area it is 5.68, for NFPA 68 and 4.68, for EN 14491, whereas using the effective vent area reduces it to 1.46 and 1.39, respectively.

Finally, Pinna et al. (2025b), propose collector-specific venting correlations for baghouses based on a logarithmic congestion framework that makes P_{red} depend explicitly on dust energetics P_{max} , K_{St} , vent area A_{v0} , dirty-side volume V_{dirty} , and the congestion ratio $V_{filters}/V_{dirty}$. A logarithmic form (with exponent γ) and a linearized variant are calibrated against nine full-scale baghouse tests (Lunn and Cairns, 1985; Lunn et al., 1998).

Table 3
Dust-collector typologies: operation and practical trade-offs.

Collector type	Cleaning method	Cleaning mode ^a	A/C ^b	Filter media	Advantages	Limitations
Mechanical shaker	Motor-driven shaking of bag tops	Offline (fan closed or compartment isolated)	1–2	Woven fabrics; examples: cotton, woven polyester, acrylic, polypropylene	Simple; no compressed air; low capex/maintenance; gentle on bags/housing	Requires downtime or compartments; larger footprint; lower throughput; felts generally unsuitable
Reverse-air	Low-pressure reverse flow with traveling manifold	Offline (compartment isolated)	1–2	Delicate/high-T media; examples: woven fiberglass, PTFE-coated glass, basalt cloth, aramid	No compressed air; mild mechanical stress; suited to high T/corrosive duty	Bigger housings; dampers/manifold to maintain; lower throughput
Pulse-jet	Short compressed-air pulse with nozzle	Online (row-by-row)	3–6 (≈4 recommended with abrasive dusts)	Needled felts; examples: polyester (PE), aramid (Nomex), PPS (Ryton), P84 (polyimide), PTFE felt; often; PTFE membrane laminated	Continuous operation; compact; stable ΔP; no dampers/manifold	Needs dry, oil-free air; re-entrainment risk at high can velocity; performance sensitive to T/RH; compressed-air quality/cost
Cartridge	Pulse down cartridge core	Online	0.5–2 (kept low to limit re-entrainment)	Pleated media; examples: cellulose, cellulose–polyester blends, spunbonded polyester, nanofiber/PTFE overlayer	Very compact; high area/element; quick side-load changeout	Lower T tolerance (~80–90 °C); pleats clean less thoroughly; lower allowable inlet loading; higher element cost/vendor dependence

^a Cleaning mode: Online = cleaning while filtration continues. Offline = compartment/flow is stopped during cleaning.

^b A/C (air-to-cloth): volumetric flow for unit filter area (filtration velocity), in m/min.

Table 4
Factors for the calculation of vent area A as a function of vessel size V, reported by Radandt (1984), with P_{max} = 9 bar(g), P_{stat} = 0.1 bar(g), and P_{red,max} ≤ 2 bar(g).

Dust explosion class	P _{red,max} bar(g)	a	b	c
St 1	<0.5	0.04	0.021	0.741
	≥0.5	0.04	0.021	0.766
St 2	<0.5	0.048	0.039	0.686
	≥0.5	0.048	0.039	0.722

Table 5
Properties of the dust measured in a 20-L, geometric characteristics of the dust collector, and their vent area experimental observations for the P_{red} in dust collector of Lunn and Cairns (1985).

Test	Dust	P _{max} bar (g)	K _{St} bar (g) m/s	Dirty Volume m ³	Area Total Vent m ²	Experimental bar(g)
1	Polyethylene	7.21	138	4.23	1.7	0.14
2	Phenolic Resin	6.67	140	4.23	1.7	0.02
3	Toner	7.52	169	4.23	1.7	0.09
4	Aspirin	7.75	190	4.23	1.7	0.14

$$P_{red} = \left[C \cdot \frac{P_{max} \cdot K_{St} \left[1 + \alpha \ln \left(1 + \beta_{St} \frac{V_{Filters}}{V_{Dirty}} \right) \right] \cdot V_{Dirty}^{\frac{3}{4}}}{A_{V0}} \right]^{\frac{1}{\gamma}} \quad (3)$$

Where C = 3.264 · 10⁻⁵, A_{V0} is the vent area in m², K_{St} is the deflagration index in bar(g) m/s, P_{max} is the maximum pressure developed in an unvented explosion in bar(g), V_{Filters} is the volume of filter elements

Table 6
Properties of the dust measured in a 20-L, geometric characteristics of the dust collector, and their vent area experimental observations for the P_{red} in dust collector, UMA 250, of Lunn et al. (1998).

Test	Dust	P _{max} bar(g)	K _{St} bar(g) m/s	Dirty Volume m ³	Effective Area Vent m ²	Experimental bar(g)
5	Maize Starch	8	140	0.67	0.28	0.11
6	Anthraquinone	8	318	0.67	0.28	0.16
7	Toner	7.1	222	0.67	0.28	0.12

inside the collector in m³, and V_{Dirty} is the volume of the dirty side of the collector in m³. The value of the optimized coefficients α, β_{St,slow}, β_{St,fast}, and γ are reported in Table 7:

The congestion formulations show lower bias and absolute error in P_{red} for collectors, indicate that the logarithmic congestion trend more faithfully represents collector congestion effects across the tested range. The authors remark that the congestion formulation was derived and calibrated on baghouse dust collectors and validated within that domain. Use beyond this range should be treated with caution. Additional full-scale campaigns covering different collector geometries and a broader dust matrix are needed to confirm transferability and, if required, re-calibrate the coefficients. The authors further remark that, starting from Eq. (3), if the logarithmic congestion contribution is removed the correlation reduces to the following baseline form:

$$P_{red} = \left[C \cdot \frac{P_{max} \cdot K_{St} \cdot V_{Dirty}^{\frac{3}{4}}}{A_{V0}} \right]^{\frac{1}{\gamma}} \quad (4)$$

This baseline expression is useful to highlight how neglecting the logarithmic congestion effect can lead to markedly different predictions of P_{red}. This sensitivity becomes evident in the subsequent comparative results reported in Table 9, where the uncongested formulation shows substantially larger discrepancies with respect to the experimental data than the congestion-based correlations.

Table 9 collates predicted reduced pressures, P_{red} (bar(g)), from NFPA 68 (2023), EN 14491 (2012), Radandt (1984), the Bartknecht-type nomogram, and the collector-specific congestion formulations by Pinna et al. (2025a,b), benchmarked against full-scale baghouse measurements from Lunn and Cairns (1985) and Lunn et al. (1998), reported previously in Tables 4–6.

Across all nine baghouse tests, NFPA 68 and EN 14491 systematically under-predict the reduced pressure, which would tend to undersize vents and underestimate structural demand. The Bartknecht nomogram sits at the opposite extreme, over-predicting in every case, hence often

Table 7

Properties of the dust measured in a 20-L, geometric characteristics of the dust collector, and their vent area experimental observations for the P_{red} in dust collector, UMA 750, of Lunn et al. (1998).

Test	Dust	P_{max} bar(g)	K_{St} bar(g) m/s	Dirty Volume m ³	Effective Area Vent m ²	Experimental bar(g)
8	Toner	8	318	2.36	0.63	0.12
9	Anthraquinone	7.1	222	2.36	0.63	0.11

Table 8

Optimized parameters for the reduced pressure equation reported in Pinna et al. (2025a,b).

α	$\beta_{St,slow}$	$\beta_{St,fast}$	γ
$9.3752 \cdot 10^4$	$+1.0755 \cdot 10^{-5}$	$-8.6434 \cdot 10^{-6}$	0.87268

overly conservative. Radandt's power law performs mid-pack, but still shows a consistent low bias, especially at the lower P_{red} cases. The collector-aware congestion formulations track the measurements more closely, the logarithmic variant yields the lowest error and near-zero bias, while the linearized form reduces the spread relative to standards but over-shoots in a few P_{red} points. Overall, the table confirms that vessel-derived rules are not reliable in collectors, whereas collector-specific correlations materially improve agreement with full-scale baghouse data.

3.4. Suppression and isolation

Because many collectors sit indoors or are linked by pneumatic piping, venting alone may not prevent flame travel between enclosures. In such cases, active explosion suppression detects the incipient deflagration and injects a suppressant within milliseconds to quench the flame and limit the maximum reduced explosion pressure, P_{red} , below the allowable strength of the protected equipment. The functional arrangement is illustrated in Fig. 16.

UNI EN 14373 (2025) formalizes this approach, it defines system components (detectors, high-rate discharge suppressors, control and indicating equipment, dispersion nozzles), lays out design objectives: detect early, respond fast, achieve vessel limit. Finally requires validated performance testing and documentation, with attention to detector thresholds, suppressant dispersion and geometry effects.

In parallel, explosion isolation prevents flame and, in some cases, pressure, from propagating through ducts and pipes to other units. UNI EN 15089 (2009) covers both passive and active isolation defines minimum or maximum installation distances and extinguishing distances, and mandates efficacy testing with modules for explosion resistance, flame transmission and functional performance. It also stresses integration with other protections venting, containment, or suppression so that the isolation device actuates in time and withstands the local loads.

Because many collectors sit indoors or are linked by pneumatic piping, venting alone may not stop flame propagation. Active

Table 9

Predicted reduced pressure P_{red} (bar(g)) for dust-collector tests versus measurements. Columns report NFPA 68 (2023), UNI EN 14491 (2012), Radandt (1984) power law, Bartknecht-type Nomogram, and the collector-specific Congestion formulations (linear and logarithmic) by Pinna et al. (2025a,b) calibrated for baghouses.

Test	Dust	Experimental bar (g)	NFPA 68 bar (g)	EN 14491 bar (g)	Radandt bar (g)	Nomogram bar (g)	Congestion linear bar (g)	Congestion logarithmic bar(g)
1	Polyethylene	0.14	0.005	0.006	0.039	0.250	0.037	0.064
2	Phenolic Resin	0.02	0.005	0.006	0.039	0.250	0.034	0.059
3	Toner	0.09	0.007	0.010	0.039	0.250	0.049	0.084
4	Aspirin	0.14	0.010	0.013	0.039	0.250	0.058	0.100
5	Maize starch	0.11	0.013	0.017	0.063	0.250	0.068	0.110
6	Toner	0.16	0.028	0.030	0.122	0.250	0.101	0.162
7	Anthraquinone	0.12	0.065	0.070	0.122	0.250	0.176	0.097
8	Toner	0.12	0.037	0.038	0.129	0.250	0.118	0.174
9	Anthraquinone	0.11	0.084	0.088	0.129	0.250	0.205	0.130
Δ	Mean difference	0	-0.084	-0.081	+0.032	-0.138	-0.018	-0.003

suppression systems that detect the flame kernel and discharge an extinguishing agent in milliseconds now provide an alternative defense, while fast-acting valves or chemical barriers isolate upstream and downstream equipment (Davis and Pagliaro, 2019). The 2014 plywood case study illustrates why these layers must be designed as an integrated system: inadequate airflow, mis-sited isolation dampers and obstructed vents let a small sander fire escalate into a fatal baghouse blast.

4. Discussion

Dust collectors are widely used and disproportionately represented in dust-explosion incidents, yet they remain under-studied compared with silos and generic vessels. Interpreting a collector as a single, well-mixed vessel with a short vent can overlook equipment-defining features, internal congestion, non-uniform dispersion, pulse-jet transients, dust-cake dynamics, and interconnected ductwork, that govern the pressure history, flame acceleration, and flame transmission risk. The available evidence remains fragmented: full-scale collector tests are scarce, operating-state descriptors are often missing, and this limits cross-comparison, model validation, and the transferability of vent-sizing guidance across collector types. The discussion below therefore focuses on (i) the most consequential outstanding problems, (ii) practical recommendations for dust-collector design and protection layout, (iii) recommendations for the application of current vent-sizing standards to collectors, and (iv) priority research directions and collector-specific improvements that could be reflected in future standard revisions.

The dominant uncertainty is not only the peak reduced pressure, but the entire pressure-time evolution and its coupling with collector-specific transients. Pulse-jet cleaning, partial cake detachment, and non-uniform suspension can generate short-lived local concentration peaks that are not represented by well-mixed assumptions, while filter-pack congestion and ductwork promote turbulence and flame acceleration. In addition, ignition and pre-combustion phenomena (smoldering or localized fires) can persist within deposits and transition to a deflagration when a dispersion event suddenly forms an ignitable cloud. These mechanisms are routinely discussed qualitatively but are still under-quantified with consistent, time-resolved full-scale measurements, especially for modern geometries and realistic interconnections.

Design and operation should treat deposit management and transient dispersion as safety-critical variables rather than secondary operating details. Layout choices that reduce re-entrainment and limit turbulent flame paths are beneficial, including minimizing dead zones, ensuring

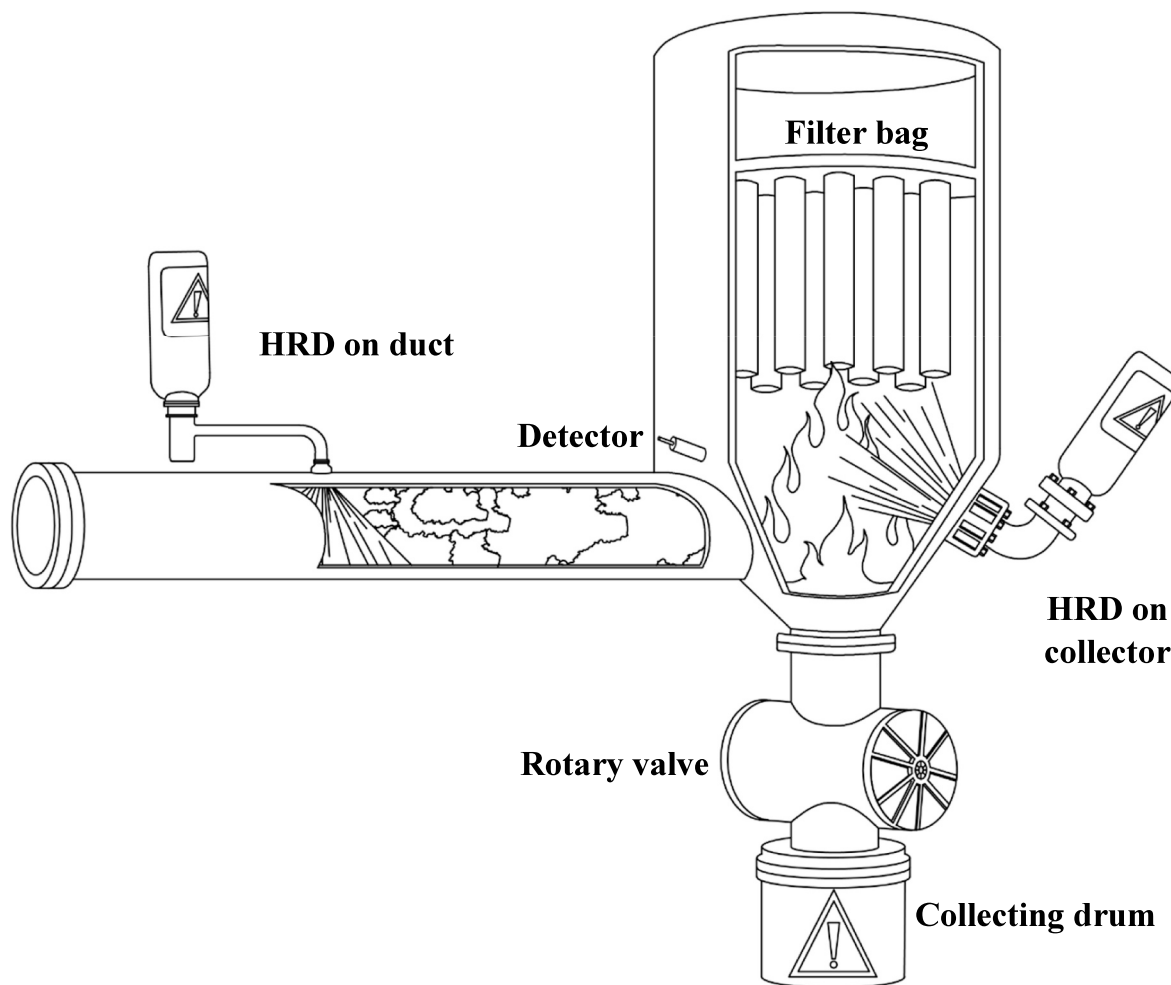


Fig. 16. Example of a coordinated explosion-protection layout for an indoor baghouse.

effective hopper discharge, and avoiding inlet-duct geometries that promote layer resuspension. Protection layouts should be collector-aware: vent placement should be as close as practicable to likely ignition locations, and interconnecting ductwork should be treated as part of the hazard scenario unless robust isolation is installed and validated for the expected pressure and flame transmission conditions. In practice, venting alone may be insufficient for indoor installations or for collectors connected to other equipment through ducts; integrated venting + isolation (or suppression + isolation) should be treated as a coupled system design problem rather than as independent components.

Current vent-sizing standards remain the starting point, but dust collectors often violate the assumptions underlying vessel-derived correlations because of congestion, transient concentration fields, and ducting/vent-location effects. Conservative application requires that the relevant “dusty volume” used in calculations reflects the actual dust-laden region at ignition, that effective vent area and ducting penalties are treated consistently, and that vent placement is evaluated as a first-order driver of reduced pressure rather than a secondary detail. Where collector-specific correlations calibrated on full-scale baghouse evidence are available, they provide a useful complement to standard methods; however, their validity should be limited to the geometries and operating envelopes for which calibration data exist.

Progress toward practice-ready guidance requires more full-scale and pilot-scale campaigns that report a minimum reproducible dataset: collector geometry and congestion descriptors, ignition location, dust properties, operational state, vent characteristics and opening kinematics, ducting layout, and time-resolved pressure traces both in the

collector and across interconnections. Standards could be improved by introducing clearer, collector-specific provisions that explicitly account for congestion and turbulence, vent location and ducting effects, and the distinction between “dusty volume at ignition” and nominal vessel volume. Publishing benchmark datasets and reference calculation workflows would accelerate independent verification and reduce the current spread between under- and over-conservative designs.

5. Conclusion

This review opens with a bibliometric map of the available literature, showing that studies explicitly addressing the structural response of dust collectors remain scarce compared with general safety and process-focused work. It then summarizes the main collector typologies and operating envelopes, highlighting how geometry, congestion and flow management can create collector-specific vulnerabilities under deflagration, and it provides a concise appraisal of protection options, containment, venting, suppression and isolation, clarifying typical effectiveness, integration needs and limits in collector applications.

Available evidence indicates that collector-specific transients, like pulse-jet puffs, partial cake detachment, non-uniform suspension and duct resuspension, govern not only the peak reduced pressure P_{red} but also the pressure–time history relevant to vent thrust and flame transmission; therefore, treating collectors as well-mixed vessels is often inadequate for design verification and Dust Hazard Analysis (DHA).

Because full-scale evidence is still sparse and uneven, future work should converge on a minimum reporting set that enables cross-

comparison and model auditability, including the active dusty volume at ignition, ignition location, collector geometry and congestion descriptors, vent characteristics and opening kinematics, including P_{stat} and inertia effects, duct layout and differentials, cleaning state, dust energetics, and time-resolved pressure traces. Translating these measurements into structural demand will benefit from simplified but validated nonlinear checks and probabilistic workflows suitable for reliability-based DHA and fragility assessments (Pinna and Stochino, 2025). Accessible experimental rigs potentially leveraging low-cost additively manufactured hinges and connections can accelerate high-fidelity measurements of opening kinematics and deformation in representative components and mock-ups (Sanna et al., 2025). Finally, the coupled thermal dimension relevant to smoldering, post-event fires and enclosure effects should be addressed with the same emphasis on auditable modelling and calibration, drawing on transferable CFD-based approaches for fire hazards in enclosed structures (La Scala et al., 2022) and elevated-temperature calibration workflows for polymeric materials (La Scala et al., 2024).

With a stronger and more transparent evidence base, results can be distilled into collector-specific guidance aligned with NFPA/EN processes and disseminated as open datasets and reference implementations to accelerate independent verification and adoption.

CRedit authorship contribution statement

F. Pinna: Writing – review & editing, Writing – original draft,

Appendix A

This appendix reports the validated dust-collector literature corpus used for the bibliometric indicators in §1.2. The dataset was assembled by cross-checking Scopus and Web of Science exports, then manually verifying each record and retaining only items that are publicly retrievable; names, venues, and keywords were harmonized as described in the text to enable replication. Table A1 lists, for each entry, the title, authors, venue, country, year, and DOI.

Tab. A1

Validated Scopus corpus for dust-collector explosion research (1974–2025): title, authors, journal/conference, country, year, and DOI. Records were cross-checked against Web of Science and manually curated to include only items publicly retrievable at the time of analysis.

Title	Authors	Journal/Conference	Country	Year	DOI
<i>Dust technology</i>	Jahn, G.	VDI-Z	Germany	1974	n/a
<i>DUST COLLECTORS FOR ELECTROSTATIC PAINT SPRAYING EQUIPMENT</i>	Klimczak, W.J.	SME Tech Pap FC74-581	United States	1974	n/a
<i>SPECIALTY CONFERENCE ON: THE USER AND FABRIC FILTRATION EQUIPMENT 3</i>	n/a	n/a	n/a	1978	n/a
<i>Guidelines in Application of Explosion Vents</i>	Reinauer, T.V.	Journal of the Air Pollution Control Association	United States	1979	10.1080/00022470.1979.10470792
<i>EXPLOSION PROTECTION FOR FABRIC DUST COLLECTORS</i>	Bennett, N.	Specifying engineer	n/a	1982	n/a
<i>EXPLOSION VENTING</i>	Dickie, L.	Professional safety	United States	1984	n/a
<i>EXPLOSION PROTECTION FOR BAG FILTERS</i>	Acaroglu, A.C.	Process Engineering (Sydney)	Australia	1984	n/a
<i>DISPOSAL OF GRAIN DUST</i>	Thomas, D.	National Conference Publication - Institution of Engineers	Australia	1984	n/a
<i>The venting of dust explosions in a dust collector</i>	Lunn, G.A.;Cairns, F.	Journal of Hazardous Materials	United Kingdom	1985	10.1016/0304-3894(85)80027-3
<i>PREVENTING FIRES AND EXPLOSIONS IN DUST REMOVAL SYSTEMS</i>	Daveloose, F.	Filtration and Separation	Belgium	1985	n/a
<i>Method for the determination of burning and explosion characteristics of dust</i>	Beck, H.; Glienke, N.	Staub, Reinhaltung der Luft	Germany	1985	n/a
<i>COAL DUST CONTROL AND EXPLOSION MITIGATION</i>	Zbasnik, G.;Tice, G.A.;Dilla, T.A.;Gese, R.A.; Henderson, J.R.	Coal Technology, International Coal Utilization Conference and Exhibition	United States	1985	n/a

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Visualization, Validation, Software, Methodology, Investigation, Formal analysis. **M. Zucca:** Writing – review & editing, Project administration. **M. Simoncelli:** Writing – review & editing, Project administration, Funding acquisition. **F. Stochino:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Funding acquisition, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Tab. A1 (continued)

Title	Authors	Journal/Conference	Country	Year	DOI
FABRIC DUST COLLECTOR EXPLOSION VENTING		American Institute of Chemical Engineers, National Meeting	United States	1986	n/a
Dust explosions in an industrial dust collector	Bennett, N.;Cairns, F.;Cooper, S.O.	Staub, Reinhaltung der Luft	Germany	1986	n/a
Protection Against Dust Explosion in Changing Times	Lunn, G.A.;Cairns, F. Beck, H.	Staub, Reinhaltung der Luft	Germany	1986	n/a
X-PAC EXPLOSION ISOLATION SYSTEM AND DELTA PAC FIRE SYSTEM	Charney, M.	Proceedings of the Washington State University International Particleboard/Composite Materials Ser	United States	1986	n/a
Secondary Dust Explosions		ASTM Special Technical Publication	United States	1987	10.1520/STP28168S
A Sugar Dust Explosion and Some Measures to Limit Its Consequences	Srinath, S.R.; Kauffma, C.W.;Nicholls, J.A.;Sichel, M.	ASTM Special Technical Publication	Belgium	1987	10.1520/STP28177S
DUST SUPPRESSION VS DUST COLLECTION AT COAL-FIRED POWER PLANTS	Geysen, W.J.;Belmans, R.;Scheys, L.	Power Engineering (Barrington, Illinois)	United States	1988	n/a
Venting requirements for weak dust-handling equipment	Gese, R.A.;Pircon, J.J.				
Optical fire detection	Lunn, G.A.	Chemical Engineer (London)	United Kingdom	1989	n/a
Industrial explosion protection - venting or suppression?	Cholin, J.	Chemical Engineering Progress	United States	1989	n/a
Brace your plant against a dust explosion	Moore, P.E.	TRANS. ICHEME PART B: PROCESS SAFETY AND ENVIRONMENTAL PROTECTION	United Kingdom	1990	n/a
Boosting safety margins in dusty areas	Godbey, T.	Chemical Engineering (New York)	United States	1991	n/a
Characteristics and applications of browncoal-dust. Safety measurements at workplace and in the environment	Godbey, S.T.	Chemical Engineering (New York)	United States	1991	n/a
Cleaning of exhaust air and waste gas with wet scrubbers	Schafer, H.G.	Staub, Reinhaltung der Luft	Germany	1991	n/a
Construction of industrial vacuum cleaners and small dust-removing devices: Avoiding sources of ignition to prevent dust explosions. 'Bauart 1'	Tagali, A.	Chemie-Technik (Heidelberg)	Germany	1992	n/a
Field evaluation of a diesel particulate filter system using a copper-based fuel additive for regeneration	Beck, H.	Staub, Reinhaltung der Luft	Germany	1992	n/a
Dust explosions. Four questions you should be able to answer	McKinnon, D.L. ;Dasys, A.A.;Myers, C. J.	Proceedings of the US Mine Ventilation Symposium	Canada	1993	n/a
Dust explosion and fire protection in filter plants	n/a	Process and Control Engineering	n/a	1993	n/a
Dust collector venting don't take chances	n/a	Verfahrenstechnik	Germany	1994	n/a
Instruments for measuring dust accumulation and composition in underground coal mines	Black, G.J.	Chemical Engineering (New York)	United States	1994	n/a
Operating below the lower explosion limit - fact or fiction?	Lucci, C.E.;Cortese, R.A.	Proceedings of the US Mine Ventilation Symposium	United States	1995	n/a
Effects of vent ducts on the reduced pressures from explosions in dust collectors	Knoetze, T.P.	Vector (Electrical Engineering)	South Africa	1997	n/a
Explosion protection methods for the power generation industry: Evaluating the hazard and reviewing explosion protection methods		Journal of Loss Prevention in the Process Industries	United Kingdom	1998	n/a
Modeling of coal dust explosions in a long duct	Lunn, G.A.;Nicol, A.M.;Collins, P.D.; Hubbard, N.R. Nixon, C.I.	American Society of Mechanical Engineers, Fuels and Combustion Technologies Division (Publication) FACT	United States	1998	n/a
Resistance evaluation of a cyclone on dust explosion pressure	Zhong, S.;Deng, X.	Progress in Safety Science and Technology: Proceedings of the 1998 International Symposium on Safety Science and Technology	China	1998	n/a
Experiments on the propagation of vented dust explosions to connected equipment	Li, G.	Progress in Safety Science and Technology: Proceedings of the 1998 International Symposium on Safety Science and Technology	China	1998	n/a
	Valiulis, J.V.;Zalosh, R.G.;Tamanini, F.	Process Safety Progress	United States	1999	10.1002/prs.680180209

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Tab. A1 (continued)

Title	Authors	Journal/Conference	Country	Year	DOI
Facility safety special. Prevention is better: Explosion protection in filter facilities	Siwek, R.	Chemie-Technik (Heidelberg)	Germany	1999	n/a
Tantalum dust deflagration in a bag filter dust-collecting device	Matsuda, T.; Yamaguma, M.	Journal of Hazardous Materials	Japan	2000	10.1016/S0304-3894(00)00242-9
Accident investigation of an ABS plant	Kao, C.; Duh, Y.	Journal of Loss Prevention in the Process Industries	Taiwan	2002	10.1016/S0950-4230(01)00068-7
New coal dust filter with two-stage separation	n/a	Aufbereitungs-Technik/Mineral Processing	Germany	2004	n/a
Dust explosion scenarios and case histories in the CCPS guidelines for safe handling of powders and bulk solids	Zalosh, R.; Grossel, S.; Kahn, R.; Sliva, D.	2005 AIChE Spring National Meeting, Conference Proceedings	United States	2005	n/a
Fatal 2003 incident	n/a	Die Casting Engineer	United States	2006	n/a
Case study: Aluminum-dust explosion	Ebadat, V.; Prugh, R.W.	AIChE Annual Meeting, Conference Proceedings	United States	2007	n/a
Living safely with combustible dust	Constance, J.A.	Powder and Bulk Engineering	United States	2008	n/a
Reducing aluminum dust explosion hazards: Case study of dust inerting in an aluminum buffing operation	Myers, T.J.	Journal of Hazardous Materials	United States	2008	10.1016/j.jhazmat.2008.02.106
Investigation of the Jahn Foundry and CTA Acoustics dust explosions: similarities and differences	Myers, T.; Ibarreta, A.	Journal of Loss Prevention in the Process Industries	United States	2009	10.1016/j.jlpl.2009.08.016
Careful handling of hazardous cargos	Svensson, A.	Bulk Solids Handling	Sweden	2010	n/a
Numerical simulation and experimental research of coal dust explosion dangerousness in guide-chute: Based on dust concentration analysis	Ge, S.; Jing, D.; Shao, L.	Journal of Natural Disasters	China	2010	n/a
Explosion prevention	LePree J.	Chemical Engineering	United States	2010	n/a
Root cause analysis of dust collector deflagration incident	Garland, R.W.	Process Safety Progress	United States	2010	10.1002/prs.10393
Collecting dust	LePree, J.	Chemical Engineering	United States	2011	n/a
OSHA's combustible dust national emphasis program and combustibility characteristics testing of PVC resins and PVC dusts	Krock, R.; Halprin, L.P.; De La, C.P.	Annual Technical Conference - ANTEC, Conference Proceedings	United States	2012	n/a
Selecting fume collectors for welding applications: The seven most important things to take into consideration when searching for a cartridge fume-collection system are addressed	Schreier, G.	Welding Journal	United States	2012	n/a
Guidelines for applying process hazard analysis techniques to combustible dust applications	Morrison, D.T.; Marr, K.C.	5th CCPS Latin American Conference on Process Safety 2013, LACPS 2013	United States	2013	n/a
Dust deflagration hazards in pharmaceutical OSD facilities	Kaelin, S.D.E.	Chimica Oggi/Chemistry Today	United States	2013	n/a
Dust collector explosions: A quantitative hazard evaluation method	Zalosh, R.	Journal of Loss Prevention in the Process Industries	United States	2015	10.1016/j.jlpl.2015.03.011
Small magnitude explosion of aluminium powder in an abatement plant: A telling case	Marmo, L.; Piccinini, N.; Danzi, E.	Process Safety and Environmental Protection	Italy	2015	10.1016/j.psep.2015.06.014
A catastrophic aluminium-alloy dust explosion in China	Li, G.; Yang, H.; Yuan, C.; Eckhoff, R.K.	Journal of Loss Prevention in the Process Industries	China	2016	10.1016/j.jlpl.2015.11.013
Mitigating fire and explosion hazards of metal powders: Update on changing consensus standards	Myers, T.; Ibarreta, A.; O'Hern, S.	Advances in Powder Metallurgy and Particulate Materials (2016) - Proceedings of the 2016 International Conference on Powder Metallurgy and Particulate Materials	United States	2016	n/a
Dry Media Dust Collectors vs. Wet Scrubbers: Two Technologies for Combustible Dust Control	Dauber, J.; Davidson, J.; Walters, M.	Occupational health & safety (Waco, Tex.)	United States	2016	n/a
Dust explosion propagation and isolation	Taveau, J.	Journal of Loss Prevention in the Process Industries	United States	2017	10.1016/j.jlpl.2017.04.019
Development of a mobile medium scale dispersed dust flame effects testing apparatus	Rockwell, S.R.; Petrow, D.; Hanks, C.; Curran, E.	10th U.S. National Combustion Meeting	United States	2017	n/a

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Tab. A1 (continued)

Title	Authors	Journal/Conference	Country	Year	DOI
Experimental investigation and application of dry-type filtering dust collection technology in fully mechanized excavation face	Zhou, F.;Li, J.;Li, S.;Wang, F.	Meitan Xuebao/Journal of the China Coal Society	China	2017	10.13225/j.cnki.jccs.2016.1150
Silo explosion from smoldering combustion: A case study	Russo, P.;De Rosa, A.; Mazzaro, M.	Canadian Journal of Chemical Engineering	Italy	2017	10.1002/cjce.22815
Explosion hazards of aluminum finishing operations	Taveau, J.;Hochgre, S.;Lemkowitz, S.; Roekaert, D.	Journal of Loss Prevention in the Process Industries	United States	2018	10.1016/j.jlp.2017.11.011
Metal waste dusts from mechanical workings - explosibility parameters investigation	Marmo, L.;Danzi, E.	Chemical Engineering Transactions	Italy	2018	10.3303/CET1867035
Importance of properly designing dust explosion protection systems: Case study – 2014 Georgia pacific Corrigan facility fire and explosion	Davis, S.G.;Pagliaro, J.L.	33rd Center for Chemical Process Safety International Conference 2018, CCPS 2018 - Topical Conference at the 2018 AIChE Spring Meeting and 14th Global Congress on Process Safety	United States	2018	n/a
Preventive Explosion Protection in coal and secondary fuel combustible dust environments: Monitoring and control	Becker, R.	Cement International	Germany	2018	n/a
Combustible-dust flash fires: Flame-resistant clothing	Prugh, R.	Global Congress on Process Safety 2018, GCPS 2018 - Topical Conference at the 2018 AIChE Spring Meeting and 14th Global Congress on Process Safety	United States	2018	n/a
Risk assessment of explosion of mixed dust generated in semiconductor manufacturing	Park, C.;Kim, C.	Transactions of the Korean Institute of Electrical Engineers	South Korea	2018	10.5370/KIEE.2018.67.3.474
Challenging Paradigms by Optimizing Combustible Dust Separator	Strasser, W.;Strasser, A.	Journal of Fluids Engineering, Transactions of the ASME	United States	2018	10.1115/1.4039234
A semi-quantitative tool to estimate risks of combustible dust fires and explosions from process equipment	Addai, E.K.; Foisel, J.; Wincek, J.; Headen, C.	34th Center for Chemical Process Safety International Conference 2019, CCPS 2019 - Topical Conference at the 2019 AIChE Spring Meeting and 15th Global Congress on Process Safety	United States	2019	n/a
Thermodynamic self-consistent dynamic model of wood dust explosion	Hu, T.;Yu, Z.;Guo, L.;Xu, C.	Journal of Forestry Engineering	China	2019	10.13360/j.issn.2096-1359.2019.04.004
Dust explosion risk in metal workings	Danzi, E.;Marmo, L.	Journal of Loss Prevention in the Process Industries	Italy	2019	10.1016/j.jlp.2019.06.005
Lessons learned from a milling explosion	Smyth, S.;Cox, B.;Hetrick, T.;Ogle, R.	Journal of Loss Prevention in the Process Industries	United States	2019	10.1016/j.jlp.2019.103928
Importance of properly designing dust explosion protection systems: Case study – 2014 plywood manufacturing facility fire and explosion	Davis, S.G.;Pagliaro, J.L.	Process Safety Progress	United States	2019	10.1002/prs.12036
Flame propagation of corn starch in a modified Hartmann tube with branch structure	Han, B.;Li, G.;Yua, C.;Wang, Q.	Powder Technology	China	2020	10.1016/j.powtec.2019.10.014
Using soybean isoflavone to prevent hydrogen production reaction of aluminium dust and water in wet dust removal systems	Wang, B.;Xu, K.;Wang, Y.;Parker, T.; Wang, Q.	Journal of Loss Prevention in the Process Industries	China	2020	10.1016/j.jlp.2020.104233
Challenges in the design of safe handling system for explosive dust	Kurakula, N.;Muniyandy, E.	Lecture Notes in Mechanical Engineering	India	2021	10.1007/978-981-15-6619-6_49
Taking Action on Your DHA Action Items	Cox, B.L.;Walters, M.S.;Dee, S.J.;Ogle, R.A.	2021 Spring Meeting and 17th Global Congress on Process Safety, GCPS 2021	United States	2021	n/a
Dust Hazards and their Control in Mechanical Processing Plants of Hard Coal Mines	Lutyński, A.	Inzynieria Mineralna	Poland	2021	10.29227/IM-2021-01-02Copy to clipboard
Explosion propagation in a dust removal pipeline under dust collector explosion		Journal of Loss Prevention in the Process Industries	China	2022	10.1016/j.jlp.2021.104662

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Tab. A1 (continued)

Title	Authors	Journal/Conference	Country	Year	DOI
Explosion Suppression of Combustible Polymer Dust in the Fabric Filter	Pang, L.;Cao, J.;Xiao, Q.;Yang, K.;Shi, L.	International Journal of Environmental Sciences(IND)	Czech Republic	2022	n/a
Dust Explosion Risk Assessment of Extruded Food Production Process by Fault Tree Analysis	Vidlička, M.;Balog, K.;Dudáček, A.; Chudová, D.	ACS Chemical Health and Safety	Thailand	2022	10.1021/acs.chas.1c00036
Gas-liquid dual phase inhibition method for explosion accident of wet Al dust collection system based on KH ₂ PO ₄	Pahasup-Anan, T.;Kreetachat, T.; Ruengphrathuengsuka, W.; Wongcharee, S.;Usahanunth, N.; Imman, S.; Suwannahon, K.	Advanced Powder Technology	China	2022	10.1016/j.appt.2022.103516
Research on law and mechanism of dust explosion in bag type dust collector	Liu, B.;Xu, K.;Zhang, Y.;Ge, J.	Advanced Powder Technology	China	2022	10.1016/j.appt.2022.103619
Influence of inlet duct turning on dust-collector explosion	Li, X.;Chen, H.;Zhan, Y.;Zhang, X.;Li, R.	Journal of Loss Prevention in the Process Industries	China	2022	10.1016/j.jlpi.2022.104839
Dust Explosion Risk Assessment for Dry Dust Collector Based on AHP-Fuzzy Comprehensive Evaluation	Pang, L.;Jin, X.;Ou, S.;Sun, S.	Processes	China	2022	10.3390/pr10122616
Explosion Characteristics Analysis of Low-Density Polyethylene Dust	Sun, S.;Mao, T.;Lv, P.;Pang, L.	Korean Chemical Engineering Research	South Korea	2023	10.9713/kcer.2023.61.1.180
Management of sugar dust in the sugar industry	Kwon, H.;Oh, K.;Baek, J.;Seo, D.	Heliyon	Nigeria	2024	10.1016/j.heliyon.2023.e23158
Sugar Dust Explosion in the Sugar Industry: Case Studies and Prevention Strategies	Iwuzor, K.O.; Ojeyemi, T.; Emenike, E.C.; Umeh, C.T.; Egbemhenge, A.; Ayoku, B.D.; Ogunsanya, T.I.; Ogunniyi, S.;Ighalo, J.O.;Adeniyi, A.G.	Sugar Tech	Nigeria	2024	10.1007/s12355-023-01307-7
The influence of pipeline deposited dust on the explosion propagation of dust collector	Mohammed, K.;Iwuzor, K.O.; Anyanwu, V.U.; Olaniyi, B.O.	Powder Technology	China	2024	10.1016/j.powtec.2023.119341
Performance of catechin as a sustainable-green inhibitor to inhibit the hydrogen production of Al alloy waste dust	Pang, L.;Jin, X.;Li, G.;Li, T.;Jin, L.;Lv P.	Journal of Cleaner Production	China	2024	10.1016/j.jclepro.2024.140963
Simulation and experimental study of a wall attached swirl air curtain dust collection System based on FLUENT	Hao, T.;Xu, K.;Zhang, Y.;Li, J.;Zheng, X.;Zhang, R.	Journal of Safety and Environment	China	2024	10.13637/j.issn.1009-6094.2023.1439
Recent progress and perspectives on coal dust sources, transport, hazards, and controls in underground mines	Jia, B.;Wu, J.;Chen, X.;Liu, Y.;Wang, Z.	Process Safety and Environmental Protection	China	2024	10.1016/j.psep.2024.04.095
Research on the explosion vent external composite disaster induced by dust explosion inside the dust collector	Cao, Y.;Xiao, Y.;Wang, Z.;Li, Q.;Shu, C.; Jiang, X.;Wu, S. Pang, L.;Liu, J.	Journal of Loss Prevention in the Process Industries	China	2024	10.1016/j.jlpi.2024.105376

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Tab. A1 (continued)

Title	Authors	Journal/Conference	Country	Year	DOI
<i>Impact of Explosion Isolation Measures on the Reduced Explosion Overpressure in Vented Vessels</i>	Schepp, P.;Faißt, U.	Chemical Engineering Transactions	Germany	2025	10.3303/CET25116110
<i>Fusing multi-sensor data for bag filter system risk early warning based on deep learning</i>	Hou, Y.;Wang, Q.;Lin, Y.;Zhang, S.;Jiang, L.	Process Safety and Environmental Protection	China	2025	10.1016/j.psep.2025.107096
<i>Research on the characteristics of coal dust explosion in mine cartridge filter based on numerical simulation</i>	Li, S.;She, X.;Nan, S.;Jin, H.;Geng, F.;Ding, J.;Ren, B.;Zhou, G.;Ouyang M.;Wie, Y.;Hu, S.	Advanced Powder Technology	China	2025	10.1016/j.apt.2025.105015
<i>Explosion venting in dust collectors: A critical review of standards for reduced pressure and reaction force duration</i>	Pinna, F.;Zucca, M.;Simoncelli, M.;Stochino, F.	Journal of Loss Prevention in the Process Industries	Italy	2025	10.1016/j.jlpi.2025.105670
<i>A New Logarithmic Congestion Model for Vent Sizing and Reduced Pressure Prediction in Baghouse Dust Collectors</i>	Pinna, F.;Zucca, M.;Simoncelli, M.;Stochino, F.	Journal of Loss Prevention in the Process Industries	Italy	2025	10.1016/j.jlpi.2025.105829

Data availability

Data will be made available on request.

References

- Acaroglu, A.C., 1984. Explosion protection for bag filters. *Process Eng.* 12 (6), 23–25.
- Acheson, E.D., Cowdell, R.H., Hadfield, E., Macbeth, R.G., 1968. Nasal cancer in woodworkers in the furniture industry. *Br. Med. J.* 2 (5605), 587. <https://doi.org/10.1136/bmj.2.5605.587>.
- Addai, E.K., Foisel, J., Wincek, J., Headen, C., 2019. A semi-quantitative tool to estimate risks of combustible dust fires and explosions from process equipment. In: *Proceedings of the 34th Center for Chemical Process Safety International Conference (CCPS 2019): Topical Conference at the 2019 Aiche Spring Meeting and 15th Global Congress on Process Safety.* AIChE/CCPS.
- Amyotte, P.R., Eckhoff, R.K., 2010. Dust explosion causation, prevention and mitigation: an overview. *J. Chem. Health Saf.* 17 (1), 15–28. <https://doi.org/10.1016/j.jchas.2009.05.002>.
- Amyotte, P.R., Chippett, S., Pegg, M.J., 1988. Effects of turbulence on dust explosions. *Prog. Energy Combust. Sci.* 14 (4), 293–310. [https://doi.org/10.1016/0360-1285\(88\)90016-0](https://doi.org/10.1016/0360-1285(88)90016-0).
- Aria, M., Cuccurullo, C., 2017. Bibliometrix: an R-tool for comprehensive science mapping analysis. *Journal of Informetrics* 11 (4), 959–975. <https://doi.org/10.1016/j.joi.2017.08.007>.
- ASTM E 1515-07, 2007. *Standard Test Method for Minimum Explosible Concentration of Combustible Dusts.* ASTM International, West Conshohocken.
- Balsari, P., Manzone, M., Marucco, P., Tamagnone, M., 2013. Evaluation of seed dressing dust dispersion from maize sowing machines. *Crop Prot.* 51, 19–23. <https://doi.org/10.1016/j.cropro.2013.04.012>.
- Bartknecht, W., 1978. Gas, vapour and dust explosions: fundamentals, prevention, control. Ciba-Geigy Limited. Contribution Prepared for the International Symposium on Grain Elevator Explosions, Organized by the US. National Research Council, Washington, D.C., July 11–12, 1978. <https://nap.nationalacademies.org/read/20025/chapter/7#146>
- Bartknecht, W., 1981. *Explosions-Course, Prevention, Protection.*
- Beck, H., 1986. Protection AGAINST dust explosion in changing TIMES. *Staub Reinhalt. Luft* 46 (4), 206–210.
- Beck, H., 1992. Construction of industrial vacuum cleaners and small dust-removing devices: avoiding sources of ignition to prevent dust explosions. 'Bauart 1'. *Staub Reinhaltung der Luft* 52 (10), 379–385.
- Beck, H., Glienke, N., 1985. Method for the determination of burning and explosion characteristics of dust. *Staub-Reinhalt. Luft*(Germany, Federal Republic of) 45 (11), Bennett, 1982. Explosion protection for fabric dust collectors. *Specif. Eng.* 48 (3), 81–83.
- Bennett, N., Cairns, F., Cooper, S.O., 1986. Fabric dust collector explosion venting. In: *Proceedings of the American Institute of Chemical Engineers (Aiche) National Meeting.* AIChE.
- Billings, Charles E., Dennis, Richard, Silverman, Leslie, 1954. Performance of three types of fabric dust collectors. *Air Repair* 4 (3), 131–136. <https://doi.org/10.1080/00966665.1954.10467655>.
- Black, G.J., 1994. Dust collector venting: don't take chances. *Chem. Eng.* 101 (2), 128.
- Bruderer, R.E., 1995. Advantages of the new version VDI 3673. Part 1 in comparison with the chapter 7 of NFPA 68. *Process Saf. Prog.* 14 (1), 45–51. <https://doi.org/10.1002/prs.680140108>.
- Cao, Y., Xiao, Y., Wang, Z.P., Li, Q.W., Shu, C.M., Jiang, X.R., Wu, S.L., 2024. Recent progress and perspectives on coal dust sources, transport, hazards, and controls in underground mines. *Process Saf. Environ. Prot.* 187, 159–194. <https://doi.org/10.1016/j.psep.2024.04.095>.
- Caputo, A.C., Pelagage, P.M., 2000. Baghouse system design based on economic optimization. *Environ. Prog.* 19 (4), 238–245. <https://doi.org/10.1002/ep.670190410>.
- Cecala, A.B., O'Brien, A.D., Schall, J., Colinet, J.F., Fox, W.R., Franta, R.J., et al., 2012. *Dust Control Handbook for Industrial Minerals Mining and Processing.*
- Chan, E.Y., Wang, Z., Mark, C.K., Da Liu, S., 2015. Industrial accidents in China: risk reduction and response. *Lancet* 386 (10002), 1421–1422. [https://doi.org/10.1016/S0140-6736\(15\)00424-9](https://doi.org/10.1016/S0140-6736(15)00424-9).
- Charney, M., 1986. X-PAC explosion isolation system and DELTA PAC fire system. In: *Proceedings of the Washington State University International Particleboard/Composite Materials Series.*
- Cholin, J., 1989. Optical fire detection. *Chem. Eng. Prog.* 85 (7), 62–68.
- Cloney, C., Snoeys, J., 2019. Dust explosions: a serious concern. *Methods in chemical process safety* 3, 33–69. <https://doi.org/10.1016/bs.mcps.2019.04.001>.
- Constance, J.A., 2008. Living safely with combustible dust. *Powder Bulk Eng.* 22 (5), 16, 18, 20.
- Cox, B.L., Walters, M.S., Dee, S.J., Ogle, R.A., 2021. Taking action on your DHA action items. In: *Proceedings of the 2021 Aiche Spring Meeting and 17th Global Congress on Process Safety (GCPS 2021).* AIChE/CCPS.
- Danzi, E., Marmo, L., 2019. Dust explosion risk in metal workings. *J. Loss Prev. Process. Ind.* 61, 195–205. <https://doi.org/10.1016/j.jlpi.2019.06.005>.
- Dauber, J., Davidson, J., Walters, M., 2016. Dry media dust collectors vs. wet scrubbers: two technologies for combustible dust control. *Occup. Health Saf* 85 (5), 34–36.
- Daveloose, F., 1985. Preventing fires and explosions in dust removal systems. *Filtration + Separation* 22 (3), 182–183.
- Davis, S.G., Pagliaro, J.L., 2019. Importance of properly designing dust explosion protection systems: case study–2014 plywood manufacturing facility fire and explosion. *Process Saf. Prog.* 38 (4), e12036. <https://doi.org/10.1002/prs.12036>.

- Di Benedetto, A., Russo, P., Amyotte, P., Marchand, N., 2010. Modelling the effect of particle size on dust explosions. *Chem. Eng. Sci.* 65 (2), 772–779. <https://doi.org/10.1016/j.ces.2009.09.029>.
- Dickie, 1984. Explosion venting. *Prof. Saf.* 29 (8), 22–25.
- Directive 1999/92/EC Of the European parliament and of the council of 16 December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres. *Off. J. Eur. Union* L 23, 57–64. Retrieved from. <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex:31999L0092>.
- Donaldson, K., Ian Gilmour, M., MacNee, W., 2000. Asthma and PM10. *Respiratory research* 1 (1), 12–15. <https://doi.org/10.1186/rr5>.
- Dust explosion and fire protection in filter plants, 1994. *Verfahrenstechnik*.
- Dust explosions: Four questions you should be able to answer, 1993. *Process and Control Engineering*.
- Ebadat, V., Prugh, R.W., 2007. Case study: aluminum-dust explosion. *Process Saf. Prog.* 26 (4), 324–329. <https://doi.org/10.1002/prs.10231>.
- Eckhoff, R.K., 1993. Dust explosion research. State-of-the-art and outstanding problems. *J. Hazard Mater.* 35 (1), 103–117. [https://doi.org/10.1016/0304-3894\(93\)85026-B](https://doi.org/10.1016/0304-3894(93)85026-B).
- Eckhoff, R.K., 2003. Dust Explosions in the Process Industries: Identification, Assessment and Control of Dust Hazards. *elsevier*.
- Eckhoff, R.K., 2009. Understanding dust explosions. The role of powder science and technology. *J. Loss Prev. Process. Ind.* 22 (1), 105–116. <https://doi.org/10.1016/j.jlp.2008.07.006>.
- Eckhoff, R.K., Li, G., 2021. Industrial dust explosions. A brief review. *Appl. Sci.* 11 (4), 1669. <https://doi.org/10.3390/app11041669>.
- Eckhoff, R.K., Fuhre, K., Pedersen, G.H., 1987. Dust explosion experiments in a vented dust explosion experiments in a vented 236 m3 silo cell. *J. Occup. Accid.* 9, 161–175.
- European Committee for Standardization (CEN), 2009. EN 15089: Explosion Isolation Systems. CEN. Retrieved from. <https://store.uni.com/en/uni-en-15089-2009>.
- European Committee for Standardization (CEN), 2012. EN 14491: Dust Explosion Venting Protective Systems. CEN. Retrieved from. <https://store.uni.com/uni-en-14491-2012>.
- European Committee for Standardization (CEN), 2018. EN 14460: Explosion Resistant Equipment. CEN. Retrieved from. <https://cont.uni.com/uni-en-14460-2018>.
- European Committee for Standardization (CEN), 2025. EN 14373: Explosion Suppression Systems. CEN. Retrieved from. <https://store.uni.com/en/uni-en-14373-2025>.
- European Parliament & Council, 2004. Directive 2004/37/EC of the European Parliament and of the Council of 29 April 2004 on the protection of workers from the risks related to exposure to carcinogens or mutagens at work. *Off. J. Eur. Union* L 158, 50–76. Retrieved from. <https://eur-lex.europa.eu/eli/dir/2004/37/oj>.
- European Parliament & Council, 2022. Directive (EU) 2022/431 of the European Parliament and of the Council of 9 March 2022 amending directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens or mutagens at work. *Off. J. Eur. Union* L 88, 1–14. Retrieved from. <https://eur-lex.europa.eu/eli/dir/2022/431/oj/eng>.
- Factory Mutual Insurance Company, 2024. Combustible Dusts (FM Property Loss Prevention Data Sheet 7-76).
- Fatal 2003 incident, 2006. *Die Cast. Eng.* 50 (1), 60–63.
- Garland, R.W., 2010. Root cause analysis of dust collector deflagration incident. *Process Saf. Prog.* 29 (4), 340–344. <https://doi.org/10.1002/prs.10393>.
- Ge, S.-C., Jing, D.-j., Shao, L.-S., 2010. Numerical simulation and experimental research of coal dust explosion dangerousness in guide-chute: based on dust concentration analysis. *J. Nat. Disasters*. Retrieved from: https://www.researchgate.net/publication/288860946_Numerical_simulation_and_experimental_research_of_coal_dust_explosion_dangerousness_in_guide-chute_Based_on_dust_concentration_analysis.
- Gese, R.A., Pircon, J.J., 1988. Dust suppression vs dust collection at coal-fired power plants. *Power Eng.* 92 (6).
- Geysen, W.J., Belmans, R., Scheys, L., 1987. A sugar dust explosion and some measures to limit its consequences. In: *Industrial Dust Explosions*. ASTM International, pp. 234–242, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959.
- Godbey, T., 1991. Brace your plant against a dust explosion. *Chem. Eng.* 98 (4), 130.
- Godbey Sr, T., 1991. Boosting safety margins in dusty areas. *Chemical Engineering(NY)* 98 (4), 130–132.
- Guan, W., Jin, M., Dong, C., Gong, H., 2023. Analysis on research trends with dust explosions by bibliometric approach. *J. Loss Prev. Process. Ind.* 81, 104958. <https://doi.org/10.1016/j.jlp.2022.104958>.
- Han, B., Li, G., Yuan, C., Wang, Q., 2020. Flame propagation of corn starch in a modified Hartmann tube with branch structure. *Powder Technol.* 360, 10–20. <https://doi.org/10.1016/j.powtec.2019.10.014>.
- Hao, T., Xu, K., Zhang, Y., Li, J., Zheng, X., Zhang, R., 2024. Performance of catechin as a sustainable-green inhibitor to inhibit the hydrogen production of Al alloy waste dust. *J. Clean. Prod.* 442, 140963. <https://doi.org/10.1016/j.jclepro.2024.140963>.
- Hollingshead, A.F., 2008. Dust collector design and safety. In: 2008 IEEE Cement Industry Technical Conference Record. IEEE, pp. 52–64. <https://doi.org/10.1109/CITCON.2008.10>.
- Hou, Y., Wang, Q., Lin, Y., Zhang, S., Jiang, L., 2025. Fusing multi-sensor data for bag filter system risk early warning based on deep learning. *Process Saf. Environ. Prot.* 198, 107096. <https://doi.org/10.1016/j.psep.2025.107096>.
- Hoy, R.F., Jeebhay, M.F., Cavalin, C., Chen, W., Cohen, R.A., Fireman, E., et al., 2022. Current global perspectives on silicosis—Convergence of old and newly emergent hazards. *Respirology* 27 (6), 387–398. <https://doi.org/10.1111/resp.14242>.
- Hu, T.P., Yu, Z., Guo, L., Xu, C.Y., 2019. Thermodynamic self-consistent dynamic model of wood dust explosion. <https://doi.org/10.13360/j.issn.2096-1359.2019.04.004>.
- International Organization for Standardization, 2022. ISO 29463: High-Efficiency Filters and Filter Media for Removing Particles from Air. Author, Geneva, Switzerland. Retrieved from. <https://www.iso.org/standard/77740.html>.
- Iwuozor, K.O., Ojeyemi, T., Emenike, E.C., Umeh, C.T., Egbemhenghe, A., Ayoku, B.D., et al., 2024. Management of sugar dust in the sugar industry. *Heliyon* 10 (1), e23158. <https://doi.org/10.1016/j.heliyon.2023.e23158>.
- Jahn, G., 1974. Dust technology. VDI-Z. *Integrierte Produktion* 116 (9), 719–725.
- Jia, B., Wu, J., Chen, X., Liu, Y., Wang, Z., 2024. Simulation and experimental study of a wall-attached swirl air curtain dust collection system based on FLUENT. *J. Saf. Environ.* <https://doi.org/10.13637/j.issn.1009-6094.2023.1439>.
- Kaelin Sr., D.E., 2013. Dust deflagration hazards in pharmaceutical OSD facilities. *CHIMICA OGGI-CHEMISTRY TODAY* 31 (3), 38–41.
- Kao, C.S., Duh, Y.S., 2002. Accident investigation of an ABS plant. *J. Loss Prev. Process. Ind.* 15 (3), 223–232. [https://doi.org/10.1016/S0950-4230\(01\)00068-7](https://doi.org/10.1016/S0950-4230(01)00068-7).
- Klimczak, 1974. Dust Collectors for Electrostatic Paint Spraying Equipment. Society of Manufacturing Engineers. SME Technical Paper No. FC74-581).
- Knoetze, T.P., 1997. Operating below the lower explosion limit—fact or fiction? *Vector*.
- Krock, R., Halprin, L.P., De La Cruz, P., 2012. OSHA's combustible dust national emphasis program and combustibility characteristics testing of PVC resins and PVC dusts. In: *Annual Technical Conference (ANTEC) Proceedings*. Society of Plastics Engineers.
- Kurakula, N., Muniyandy, E., 2020. Challenges in the design of safe handling System for explosive dust. In: *Innovative Design, Analysis and Development Practices in Aerospace and Automotive Engineering: Proceedings of I-DAD 2020*. Springer Singapore, Singapore, pp. 451–455. https://doi.org/10.1007/978-981-15-6619-6_49.
- Kwon, H.G., Oh, K.S., Baek, J.B., Seo, D.H., 2023. Explosion characteristics analysis of low-density polyethylene dust. *Korean Chemical Engineering Research* 61 (1), 80–88.
- La Scala, A., Sabbà, M.F., Foti, D., 2022. Fire hazard of electric vehicles in enclosed structures. In: 2022 AEIT International Annual Conference (AEIT). IEEE, pp. 1–6.
- La Scala, A., Sliwa-Wieczorek, K., Rizzo, F., Sabbà, M.F., Zajac, B., 2024. Flexible polyurethane adhesives: predictive numerical model calibration through experimental testing at elevated temperature. *Appl. Sci.* 14 (5), 1943.
- LePree, J., 2010. Explosive solutions: from the first line of defense to the last, explosion prevention and protection firms are upping their game to preserve yours. *Chem. Eng.* 117 (12), 23–26.
- LePree, J., 2011. Collecting dust. *Chem. Eng.* 118 (12), 21–25.
- Li, G. Resistance evaluation of a cyclone on dust explosion pressure. *SAFETY SCIENCE AND TECHNOLOGY.*, 699-705.
- Li, G., Yang, H.X., Yuan, C.M., Eckhoff, R.K., 2016. A catastrophic aluminium-alloy dust explosion in China. *J. Loss Prev. Process. Ind.* 39, 121–130. <https://doi.org/10.1016/j.jlp.2015.11.013>.
- Li, X., Chen, H., Zhang, Y., Zhang, X., Li, R., 2022. Research on law and mechanism of dust explosion in bag type dust collector. *Adv. Powder Technol.* 33 (6), 103619. <https://doi.org/10.1016/j.apt.2022.103619>.
- Li, S., She, X., Nan, S., Jin, H., Geng, F., Ding, J., et al., 2025. Research on the characteristics of coal dust explosion in mine cartridge filter based on numerical simulation. *Adv. Powder Technol.* 36 (9), 105015. <https://doi.org/10.1016/j.apt.2025.105015>.
- Liu, B., Xu, K., Zhang, Y., Ge, J., 2022. Gas-liquid dual phase inhibition method for explosion accident of wet Al dust collection system based on KH2PO4. *Adv. Powder Technol.* 33 (3), 103516. <https://doi.org/10.1016/j.apt.2022.103516>.
- Lo, L.M., Chen, D.R., Pui, D.Y., 2010. Experimental study of pleated fabric cartridges in a pulse-jet cleaned dust collector. *Powder Technol.* 197 (3), 141–149. <https://doi.org/10.1016/j.powtec.2009.09.007>.
- Lucci, C.E., Cortese, R.A., 1995. Instruments for Measuring Dust Accumulation and Composition in Underground Coal Mines (No. CONF-9506227-). Society for Mining, Metallurgy, and Exploration, Inc., Littleton, CO (United States).
- Lunn, G., 1989. Venting requirements for weak dust-handling equipment. *CHEM. ENGINEER.* (456), 18–21.
- Lunn, G.A., Cairns, F., 1985. The venting of dust explosions in a dust collector. *J. Hazard Mater.* 12 (1), 87–107. [https://doi.org/10.1016/0304-3894\(85\)80027-3](https://doi.org/10.1016/0304-3894(85)80027-3).
- Lunn, G., Cairns, F., 1986. Dust explosions in an industrial dust collector. *Staub; (Germany, Federal Republic of)* 46 (2).
- Lunn, G.A., Nicol, A.M., Collins, P.D., Hubbard, N.R., 1998. Effects of vent ducts on the reduced pressures from explosions in dust collectors. *J. Loss Prev. Process. Ind.* 11 (2), 109–121. [https://doi.org/10.1016/S0950-4230\(97\)00036-3](https://doi.org/10.1016/S0950-4230(97)00036-3).
- Lutynski, A., 2021. Dust hazards and their control in mechanical processing plants of hard coal mines. *J. Pol. Miner. Eng. Soc* 1, 13–18.
- Marmo, L., Danzi, E., 2018. Metal waste dusts from mechanical workings—explosibility parameters investigation. *Chemical engineering transactions* 67, 205. <https://doi.org/10.3303/CET1867035>.
- Marmo, L., Piccinini, N., Danzi, E., 2015. Small magnitude explosion of aluminium powder in an abatement plant: a telling case. *Process Saf. Environ. Prot.* 98, 221–230. <https://doi.org/10.1016/j.psep.2015.06.014>.
- Matsuda, T., Yamaguma, M., 2000. Tantalum dust deflagration in a bag filter dust-collecting device. *J. Hazard Mater.* 77 (1-3), 33–42. [https://doi.org/10.1016/S0304-3894\(00\)00242-9](https://doi.org/10.1016/S0304-3894(00)00242-9).
- McKinnon, D.L., Dasys, A.A., Myers, C.J., 1993. Field evaluation of diesel particulate filter system using a copper based fuel additive system for regeneration. In: *The 6th US Mine Ventilation Symposium*. SME).
- Mohammed, K., Iwuozor, K.O., Anyanwu, V.U., Olaniyi, B.O., 2024. Sugar dust explosion in the sugar industry: case studies and prevention strategies. *Sugar Tech* 26 (1), 12–19. <https://doi.org/10.1007/s12355-023-01307-7>.

- Moore, P.E., 1990. Industrial explosion protection-venting or suppression? *Process Saf. Environ. Prot.* 68, 167–175.
- Morrison, D.T., Marr, K.C., 2013. Guidelines for applying process hazard analysis techniques to combustible dust applications. In: Proceedings of the 5th CCPS Latin American Conference on Process Safety (LACPS 2013). <https://doi.org/10.1007/s43938-025-00083-y>.
- Myers, T.J., 2008. Reducing aluminum dust explosion hazards: case study of dust inerting in an aluminum buffing operation. *J. Hazard Mater.* 159 (1), 72–80. <https://doi.org/10.1016/j.jhazmat.2008.02.106>.
- Myers, T., Ibarreta, A., 2009. Investigation of the Jahn Foundry and CTA Acoustics dust explosions: similarities and differences. *J. Loss Prev. Process. Ind.* 22 (6), 740–745. <https://doi.org/10.1016/j.jlp.2009.08.016>.
- Myers, T., Ibarreta, A., O'Hern, S., 2016. Mitigating fire and explosion hazards of metal powders: update on changing consensus standards. In: *Advances in Powder Metallurgy and Particulate Materials 2016: Proceedings of the 2016 International Conference on Powder Metallurgy and Particulate Materials*. <https://doi.org/10.1016/j.mprp.2016.01.073>.
- National Fire Protection Association (NFPA), 2019. NFPA 652: Standard on the Fundamentals of Combustible Dust. NFPA. Retrieved from: <https://link.nfpa.org/publications/652/2019>.
- National Fire Protection Association (NFPA), 2023. NFPA 68: Standard on Explosion Protection by Deflagration Venting. NFPA. Retrieved from: <https://link.nfpa.org/publications/68/2023/>.
- National Fire Protection Association (NFPA), 2025. NFPA 660: Standard for Combustible Dusts and Particulate Solids. NFPA. Retrieved: <https://www.nfpa.org/codes-and-standards/nfpa-660-standard-development/660>.
- New coal dust filter with two-stage separation, 2004. *Aufbereitungs-Technik/Mineral Processing*.
- Nixon, C.L., 1998. Explosion protection methods for the power generation industry. Evaluating the hazard and reviewing explosion protection methods. Fenwal Safety Systems (US). Retrieved from: <https://www.osti.gov/biblio/20013506>.
- Novak, N., Trajkovski, A., Kalin, M., Majdić, F., 2023. Degradation of hydraulic system due to wear particles or medium test dust. *Appl. Sci.* 13 (13), 7777. <https://doi.org/10.3390/app13137777>.
- Occupational Safety and Health Administration. Air contaminants, 29 C.F.R. § 1910.1000. Electronic Code of Federal Regulations. Retrieved from: <https://www.ecfr.gov/current/title-29/part-1910/section-1910.1000>.
- Pahasup-anan, T., Kreetachai, T., Ruengphrathuengsuka, W., Wongcharee, S., Usahanunth, N., Imman, S., Suwannahong, K., 2021. Dust explosion risk assessment of extruded food production process by fault tree analysis. *ACS Chemical Health & Safety* 29 (1), 91–97. <https://doi.org/10.1021/acs.chas.1c00036>.
- Pang, L., Liu, J., 2024. Research on the explosion vent external composite disaster induced by dust explosion inside the dust collector. *J. Loss Prev. Process. Ind.* 91, 105376. <https://doi.org/10.1016/j.jlp.2024.105376>.
- Pang, L., Cao, J., Xiao, Q., Yang, K., Shi, L., 2022. Explosion propagation in a dust removal pipeline under dust collector explosion. *J. Loss Prev. Process. Ind.* 74, 104662. <https://doi.org/10.1016/j.jlp.2021.104662>.
- Pang, L., Jin, X., Li, G., Li, T., Jin, L., Lv, P., 2024. The influence of pipeline deposited dust on the explosion propagation of dust collector. *Powder Technol.* 434, 119341. <https://doi.org/10.1016/j.powtec.2023.119341>.
- Park, C.S., Kim, C.O., 2018. Risk assessment of explosion of mixed dust generated in semiconductor manufacturing. *Trans. Korean Inst. Electr. Eng.* 67 (3), 474–478.
- Peng, Z., Kessissoglou, N.J., Cox, M., 2005. A study of the effect of contaminant particles in lubricants using wear debris and vibration condition monitoring techniques. *Wear* 258 (11–12), 1651–1662. <https://doi.org/10.1016/j.wear.2004.11.020>.
- Pinna, F., Stochino, F., 2025. Nonlinear SDOF model for dynamic response and fragility analysis of steel plates under blast loads. *Eur. J. Environ. Civil Eng.* 1–24. <https://doi.org/10.1080/19648189.2025.2508209>.
- Pinna, F., Zucca, M., Simoncelli, M., Stochino, F., 2025a. Explosion venting in dust collectors: a critical review of standards for reduced pressure and reaction force duration. *J. Loss Prev. Process. Ind.*, 105670 <https://doi.org/10.1016/j.jlp.2025.105670>.
- Pinna, F., Zucca, M., Simoncelli, M., Stochino, F., 2025b. A new logarithmic congestion model for vent sizing and reduced pressure prediction in baghouse dust collectors. *J. Loss Prev. Process. Ind.*, 105829.
- Pranckutė, R., 2021. Web of Science (WoS) and Scopus: the titans of bibliographic information in today's academic world. *Publications* 9 (1), 12. <https://doi.org/10.3390/publications9010012>.
- Prugh, R., 2018. Combustible-Dust flash fires: Flame-Resistant clothing. In: 2018 Spring Meeting and 14th Global Congress on Process Safety. AIChE.
- Radandt, S., 1984. Explosionsdruckentlastung an Langgestreckten Runden Silos, vol. 494. VDI-Berichte, pp. 185–197.
- Reinauer, T.V., 1979. Guidelines in application of explosion vents. *J. Air Pollut. Control Assoc.* 29 (3), 295–298.
- Rockwell, S.R., Petrow, D., Hanks, C., Curran, E., 2017. Development of a mobile medium-scale dispersed dust flame-effects testing apparatus. In: *Proceedings of the 10th. U.S. National Combustion Meeting*.
- Russo, P., De Rosa, A., Mazzaro, M., 2017. Silo explosion from smoldering combustion: a case study. *Can. J. Chem. Eng.* 95 (9), 1721–1729. <https://doi.org/10.1002/cjce.22815>.
- Saccone, M., Stochino, F., Zucca, M., Simoncelli, M., 2025. Longitudinal shear behaviour in Recycled aggregate Concrete Composite Slabs: a state-of-the-art review. *J. Build. Eng.*, 114002 <https://doi.org/10.1016/j.jobte.2025.114002>.
- Sama, G., Pistis, M., Giorgio, I., Eremeyev, V.A., Spagnuolo, M., 2025. New Hinge design for fibrous metamaterial enables filament 3D printing. *Mech. Res. Commun.*, 104452.
- Schaefer, H.G., 1991. Characteristics and applications of brown coal dust. Safety measurements at workplace and in the environment. *Eigenschaften und Verwendung von Braunkohlenstaub. Sicherheitsmassnahmen fuer Arbeitsplatz und Umwelt. Staub, Reinhaltung der Luft*(Germany, FR) 51 (4).
- Scheppe, P., Faißt, U., 2025. Impact of explosion isolation measures on the reduced explosion overpressure in vented vessels. *Chemical Engineering Transactions* 116, 655–660. <https://doi.org/10.3303/CET25116110>.
- Schreier, G., 2012. Selecting fume collectors for welding applications. *Welding Journal* 91 (12), 73–76.
- Simon, X., Bémer, D., Chazelet, S., Thomas, D., Régnier, R., 2010. Consequences of high transitory airflows generated by segmented pulse-jet cleaning of dust collector filter bags. *Powder Technol.* 201 (1), 37–48. <https://doi.org/10.1016/j.powtec.2010.02.036>.
- Siwek, R., 1994. New revised VDI guideline 3673 "Pressure release of dust explosions". *Process Saf. Prog.* 13 (4), 190–201. <https://doi.org/10.1002/prs.680130404>.
- Siwek, R., 1999. Facility safety special. Prevention is better: explosion protection in filter facilities. *Chem. Tech. (Hiedelb.)* 28 (7), 28–30.
- Smyth, S., Cox, B., Hetrick, T., Ogle, R., 2019. Lessons learned from a milling explosion. *J. Loss Prev. Process. Ind.* 62, 103928. <https://doi.org/10.1016/j.jlp.2019.103928>.
- Specialty conference on, 1978. *The User and Fabric Filtration Equipment* 3, 1978.
- Srinath, S.R., Kauffman, C.W., Nicholls, J.A., Sichel, M., 1987. Secondary Dust Explosions. ASTM Special Technical Publication. <https://doi.org/10.1520/STP281688>.
- Strasser, W., Strasser, A., 2018. Challenging paradigms by optimizing combustible dust separator. *J. Fluid Eng.* 140 (7), 071301. <https://doi.org/10.1115/1.4039234>.
- Sun, S., Mao, T., Lv, P., Pang, L., 2022. Dust explosion risk assessment for dry dust collector based on AHP-fuzzy comprehensive evaluation. *Processes* 10 (12), 2616. <https://doi.org/10.3390/pr10122616>.
- Svensson, A., 2010. Careful handling of hazardous cargos. *Bulk. Solids Handl.* 30 (5), 256–257.
- Tagali, A., 1992. Cleaning of exhaust air and waste gas with wet scrubbers. *Chem. Tech. (Hiedelb.)* 21 (4), 119–124.
- Tascón, A., Ramírez-Gómez, Á., Aguado, P.J., 2016. Dust explosions in an experimental test silo: influence of length/diameter ratio on vent area sizes. *Biosyst. Eng.* 148, 18–33. <https://doi.org/10.1016/j.biosystemseng.2016.04.014>.
- Taveau, J., 2012. Secondary dust explosions: how to prevent them or mitigate their effects? *Process Saf. Prog.* 31 (1), 36–50. <https://doi.org/10.1002/prs.10478>.
- Taveau, J., 2017. Dust explosion propagation and isolation. *J. Loss Prev. Process. Ind.* 48, 320–330. <https://doi.org/10.1016/j.jlp.2017.04.019>.
- Taveau, J., Hochgreb, S., Lemkowitz, S., Roekaerts, D., 2018. Explosion hazards of aluminum finishing operations. *J. Loss Prev. Process. Ind.* 51, 84–93. <https://doi.org/10.1016/j.jlp.2017.11.011>.
- Thomas, D., 1984. *Disposal of grain dust*. In: *National Conference Publication. Institution of Engineers, Australia*. ISBN 978-0-85825-241-7.
- Thomas, M., Peters, Sawvel, Russell A., Park, Jae Hong, Anthony, T. Renée, 2015. Evaluation of a shaker dust collector for use in a recirculating ventilation system. *J. Occup. Environ. Hyg.* 12 (9), D201–D210. <https://doi.org/10.1080/15459624.2015.1043056>.
- Ural, E.A., 2001. A simplified development of a unified dust explosion vent sizing formula. *Process Saf. Prog.* 20 (2), 136–144. <https://doi.org/10.1002/prs.680200211>.
- U.S. Chemical Safety and Hazard Investigation Board, 2023. *Fatal Combustible Dust Explosions at Didion Milling Inc. Investigation Report No. 2017-07-1-WD*.
- U.S. Department of Labor, 2020. *Occupational Safety and Health Administration. OSHA Technical Manual (OTM), Section IV: Chapter 6—Combustible Dusts (Directive No. TED-01-00-015)*.
- Valiulis, J.V., Tamanini, F., Zalosh, R.G., 1999. Experiments on the propagation of vented dust explosions to connected equipment. *Process Saf. Prog.* 18 (2), 99–106. <https://doi.org/10.1002/prs.680180209>.
- Van Eck, N.J., Waltman, L., 2016. *Vosviewer Manual*.
- Verein Deutscher Ingenieure (VDI), 2002. VDI 3673 Blatt 1: Druckentlastung von Staubexplosionen. Retrieved from: <https://www.vdi.de/en/home/vdi-standards/details/vdi-3673-blatt-1-pressure-venting-of-dust-explosions>.
- Vidlická, M., Balog, K., Chudová, A.D., 2022. Explosion suppression of combustible polymer dust in the fabric filter. *Int. J. Environ. Sci.* 8 (2), 1–13.
- Wang, B., Xu, K., Wang, Y., Parker, T., Wang, Q., 2020. Using soybean isoflavone to prevent hydrogen production reaction of aluminium dust and water in wet dust removal systems. *J. Loss Prev. Process. Ind.* 67, 104233. <https://doi.org/10.1016/j.jlp.2020.104233>.
- Yuan, Z., Khakzad, N., Khan, F., Amyotte, P., 2015. Dust explosions: a threat to the process industries. *Process Saf. Environ. Prot.* 98, 57–71. <https://doi.org/10.1016/j.psep.2015.06.008>.
- Zalosh, R., 2007. New dust explosion venting design requirements for turbulent operating conditions. *J. Loss Prev. Process. Ind.* 20 (4-6), 530–535. <https://doi.org/10.1016/j.jlp.2007.04.038>.
- Zalosh, R., 2015. Dust collector explosions: a quantitative hazard evaluation method. *J. Loss Prev. Process. Ind.* 36, 258–265. <https://doi.org/10.1016/j.jlp.2015.03.011>.
- Zalosh, R., Grosseil, S., Kahn, R., Sliva, D., 2005. Dust Explosion Scenarios and Case Histories in the CCPS Guidelines for Safe Handling of Powders and Bulk Solids. American Institute of Chemical Engineers. <https://doi.org/10.1016/j.jlp.2015.03.011>.
- Zbasnik, G., Tice, G.A., Dilla, T.A., Gese, R.A., Henderson, J.R., 1985. Coal dust control and explosion mitigation. In: *Proceedings of Coal Technology: International Coal Utilization Conference and Exhibition*.

Zhao, X., Zhang, Y., 2023. Analysis of the tribological and dynamic performance of textured bearings under contaminated conditions. *Tribol. Int.* 187, 108732. <https://doi.org/10.1016/j.triboint.2023.108732>.

Zhong, S., & Deng, X. Modeling of coal dust explosions in a long duct. *SAFETY SCIENCE AND TECHNOLOGY.*, 706-715.

Zhou, F.B., Li, J.L., Li, S.H., Wang, F., 2017. Experimental investigation and application of dry-type filtering dust collection technology in fully mechanized excavation face. *J. China Coal Soc.* (3). <https://doi.org/10.13225/j.cnki.jccs.2016.1150>.