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Fire Safety in the Printing Industry: The Curious Case of the Missing Literature

ABSTRACT

Printing facilities have significant fire and explosion hazards, i.e., combustible paper and toner dust, flammable inks and cleaning solvents, ignition sources from electrical equipment, and static electricity generated during high-speed printing processes. Despite these hazards, the extent of peer-reviewed fire research dedicated to the printing industry remains unclear. This study addresses this gap through a PRISMA-guided systematic review of the academic literature, supplemented by a structured review of key grey literature sources. The academic search was conducted across Scopus, IEEE Xplore, and ScienceDirect for publications in the past 10 years. A total of 314 articles were identified, of which only 4 met the eligibility criteria, and only 1 directly investigated fire or explosion hazards in a printing-adjacent facility. To complement the limited academic evidence, the grey literature review examined widely adopted technical guidance, including FM Global Data Sheets 7-96 (Printing Plants), 3-26 (Fire Protection for Nonstorage Occupancies) and the UK Health and Safety Executive (HSE) guidance on Fire and Explosion Risks in Printing. The findings reveal that the fire-safety knowledge base for the printing industry exists predominantly within technical standards, insurer guidance, and regulatory documents rather than peer-reviewed publications. This work highlights a critical research gap and identifies priorities for future fire research to strengthen the scientific evidence base supporting fire-safety design and risk management in printing facilities.

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KEY WORDS
Fire safety in printing, printing industry, printing plant, fire protection

1. Introduction

Printing industry in many of its forms is at a significant risk when it comes to the fire and explosion hazards. The reason is mainly the fact that the printing plants combine some of the ingredients that the fire safety engineers tend to be wary of the most: large volumes of flammable liquids and large quantities of finely divided combustible solids, often in the same room as heat sources and static-generating machinery.

Pre-press operations, ignitable liquids, printing press operations, drying, storage and waste are where most common major hazards occur. In pre-press, depending on the printing technique there is often a use of paper, film and other photographic chemicals that aid in the process of printing plate creation. Again, depending on the printing technique printing presses are made out of rubber or plastic and coated with different solutions. Volatile organic compounds (VOC) or chemicals responsible for the vapor emission, the use of hydraulic systems, ignition sources that can happen due to the static or other electrical equipment and high combustible loading are some of the hazards during the printing press operations. Liquids such as different inks and dyes, and Ferric Chloride solution for plate making together with different adhesives are the ones commonly pointed out as high-risk substances during the press process. Similar risk can be found during the drying processes due to the high temperatures, lack of residue cleaning in dryer exhausts and vapor release.

Finally, storage facilities that are in relation to the printing facilities pose as a fire hazard as well (Logic, 2021).

In the context of the flammable and combustible liquids solvent-based inks, cleaning solvents (toluene, xylene, hexane, isopropyl alcohol, acetone, methyl ethyl ketone, ethyl acetate, glycol ethers, kerosene), fountain solutions, and blanket washes are used heavily in gravure, flexographic, and offset printing. Many of the printing operations can involve flammable materials, for example: coatings, inks, and cleaning solvents. These materials together with low flashpoint chemicals and suspended paper dust and spray powder can create significant fire and explosion risks. Gravure printing in particular normally uses solvent-based inks classified as Class 1A flammable liquids under NFPA 30 (Logic, 2021; YassamineEbadat, 2023).

Another risk that can be found in printing processes is in relation to the combustible dust. Paper dust, powder coatings, and starch accumulations are a recurring explosion hazard. Dust accumulations in paper and printing operations can lead to increased fire and explosion possibilities. In (Sun et al., 2026) researchers specifically modeled the risk in relation to VOCs and paper dust. In their research, it was pointed out that higher concentrations of paper powder combined with VOCs significantly enhance flame brightness, combustion intensity, heat release rate, and flame duration. The same paper reported two incidents: in 2008, solvent gasoline vapor at a printing factory in Changchun exploded when ignited by a spark, killing two and injuring two, and in 2025 a color printing factory fire in Fuzhou ignited paper and other flammable materials, causing four deaths and significant economic damage. Static-related incidents have also occurred. In 2011 explosion in the Netherlands was traced to a static discharge occurring during the manufacture of a flammable solvent-based ink. Beyond static discharge, conventional ignition sources common to industrial settings such as faulty wiring, overheating equipment, and heat-generating dryers and curing units are also present in printing environments. Drying and UV-curing systems in particular have been linked to solvent vapor accumulation and localized paper ignition (YassamineEbadat, 2023).

Considering the possible fire hazard in the printing processes, this paper aims to conduct the literature review across different scientific data basses and possess two questions:

RQ1: To what extent is the scientific literature in the past ten years dealing with the topic of fire safety in printing industry?

RQ2: Can so-called “gray literature” supplement the scientific literature?

Together with the introduction and conclusion, this paper consists of the following sections: section 2 describes the methodology of the literature review, showcasing it through the PRISMA diagram, section 3 briefly discusses the results, while the discussion with the answers to the research questions is in the section 4.

2. Methods

In order to answer research questions, a two-stage methodology combining a PRISMA-guided systematic review of peer-reviewed academic literature together with a review of grey literature was employed. The systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021). Given the anticipated scarcity of printing-specific academic research, the review was supplemented by a targeted grey literature review of technical standards, insurer loss-prevention guidance, and regulatory documentation, recognized sources of applied fire-safety knowledge in industries where formal research output is limited.

A systematic search of the academic literature was conducted across three databases: Scopus, IEEE Xplore, and ScienceDirect. These databases were selected to capture engineering, fire-safety science, and applied industrial-safety literature across both technical and multidisciplinary indexing platforms. Searches were limited to articles and journal papers published in English within an open-access model over the preceding ten years.

Search terms combined core hazard concepts (e.g., "fire safety," "fire protection," "fire risk," "fire hazard," "combustible dust," "dust explosion," "explosion protection") with industry- and process-specific terms (e.g., "print*," "printing plant," "printing industry," "printing press," "flexograph*," "gravure," "lithograph*," "letterpress," "screen printing") using Boolean operators. Exclusion terms ("3D print*," "additive manufactur*," "rapid prototyping," "printed circuit board*," "PCB") were applied at the search-string level in Scopus and IEEE Xplore to filter out unrelated additive-manufacturing and electronics literature returned by keyword overlap. Because ScienceDirect's advanced search interface could not accommodate the full combined query, three narrower sub-searches were run and their results pooled.

2.1. Eligibility Criteria and Screening

Records identified through the database searches were screened by title and abstract against predefined eligibility criteria. Studies were eligible for inclusion if they:

14. were published as a peer-reviewed journal article in English, in an open-access outlet, within the ten-year search window, and

15. directly addressed fire or explosion hazards, risk factors, or mitigation measures relevant to printing operations, printing-adjacent facilities, or printing materials.

Studies were excluded if the hazard or process described was unrelated to printing (e.g., general electrical fire detection, construction site firefighting equipment, mining, media/broadcast "printing" in the journalistic sense) or if the printing-related term matched only incidentally to an unrelated topic (e.g., "printed circuits" or a stray keyword tag).

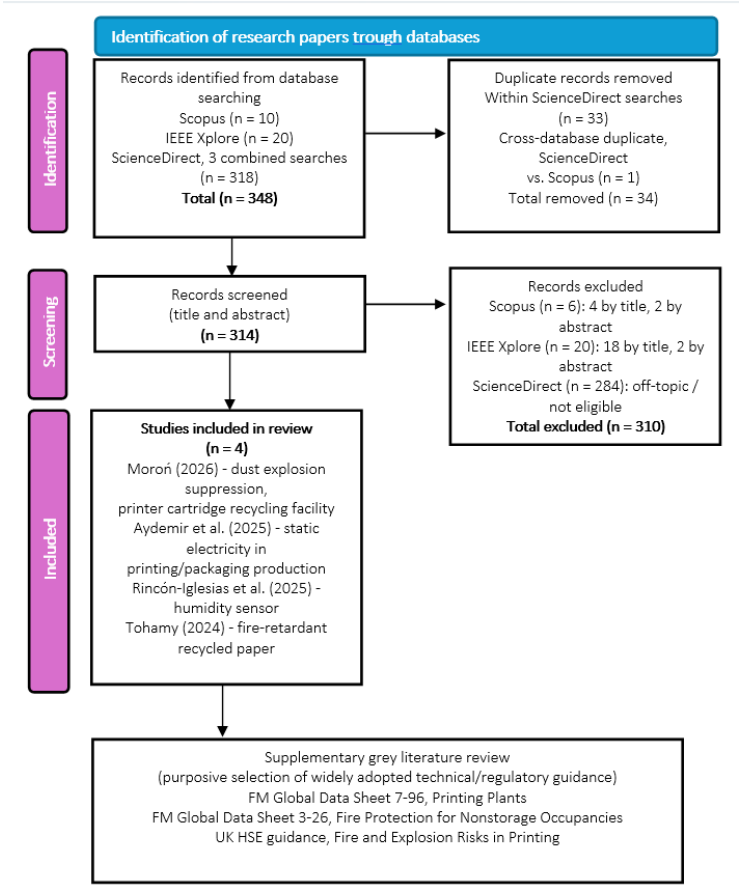
The combined search across the three databases returned 348 raw records (Scopus, n = 10; IEEE Xplore, n = 20; ScienceDirect, n = 318 across three combined sub-searches). Thirty-four duplicate records were removed: 33 internal duplicates arising from the overlap between ScienceDirect's three sub-searches, and one cross-database duplicate in which a ScienceDirect result independently matched a record already retrieved through Scopus. This yielded 314 unique records for title/abstract screening. Of these, 310 were excluded.

1. 6 from Scopus (4 by title, 2 by abstract),
2. 20 from IEEE Xplore (18 by title, 2 by abstract), and
3. 284 from ScienceDirect as off-topic or ineligible

This selection left four studies that met the full eligibility criteria. Of these four, one (Moroń, 2026) directly investigated a fire or explosion hazard within a printing-adjacent facility; the remaining three addressed materials or phenomena relevant to printing (static electricity generation, fire-retardant paper composites, a printed sensor referencing fire-safety applications) without directly studying hazard mechanisms at a printing facility itself. Included papers (Tohamy, 2024; Aydemir et al., 2025; Rincón-Iglesias et al., 2025; Moroń, 2026) together with the gray literature (Fire and Explosion Risks in Printing- HSE, n.d.; FM Global, 2019, 2023, 2026) will be looked over in this paper. This screening process is summarized in a PRISMA flow diagram shown in Figure 1.

2.2. Data Extraction and Synthesis

For each of the four included academic studies, data extracted included the hazard mechanism addressed, the printing process or material system studied, study methodology, and key findings relevant to fire or explosion risk. For grey literature sources, extracted content focused on hazard classifications, prescribed engineering and administrative controls, and occupancy- or process-specific protection recommendations.



» **Figure 1:** *PRISMA with the literature review details*

2.3. Limitations of the Review Approach

The systematic search was limited to three databases and a ten-year window, which may have excluded older foundational studies or literature indexed exclusively elsewhere. ScienceDirect's search interface constraints required splitting the query into three sub-searches, introducing a higher internal duplicate rate (33 of 318 raw records) than the single-query searches used in Scopus and IEEE Xplore; this is a methodological artifact of the platform. The grey literature review was purposive rather than exhaustive, focused on the most widely adopted guidance documents rather than a comprehensive survey of all available industry publications. The marked disparity between the volume of grey literature guidance and the paucity of peer-reviewed academic validation (four included studies, only one directly on-topic) is itself a central finding of this review and is examined further in the Discussion.

3. Results

The systematic search identified 348 raw records across Scopus (n = 10), IEEE Xplore (n = 20), and ScienceDirect (n = 318, pooled from three combined sub-searches). After removing 34 duplicate records, 33 arising from overlap between the ScienceDirect sub-searches and one cross-database duplicate shared between ScienceDirect and Scopus, 314 unique records remained for title/abstract screening. Screening excluded 310 records (Scopus, n = 6; IEEE Xplore, n = 20; ScienceDirect, n = 284), leaving four studies that met the full eligibility criteria, approximately 1.3% of the initial pooled record set. The PRISMA flow diagram (Figure 1) summarizes this process.

Notably, IEEE Xplore contributed zero included studies despite returning 20 records; all were excluded at the title (n = 18) or abstract (n = 2) stage, primarily because the search terms matched unrelated topics such as general electrical fire detection, firefighting equipment inspection, or incidental keyword overlaps (e.g., "printed circuits," a stray "Printing" tag on a forest-fire UAV study). This suggests limited direct engagement with printing-industry fire safety within the venues indexed by IEEE Xplore.

Of the four included studies, only one (Moroń, 2026) directly investigated a fire or explosion hazard within a printing-adjacent facility. This study examined dust explosion risk from toner powder in a laser-printer-cartridge recycling installation, combining hazard-zone identification with laboratory-scale and full-scale on-site testing, and demonstrated that continuous dosing of inert dust achieved greater than 90% explosion suppression.

The remaining three included studies addressed hazards or materials relevant to the printing sector without directly studying a printing facility's fire or explosion risk:

(Aydemir et al., 2025), reviewed the causes, effects, and mitigation of static electricity across printing and packaging production processes, including its role in fire risk, though the study is framed as a broad process and quality-control review rather than a facility-level hazard investigation.

(Tohamy, 2024), developed a fire-retardant composite paper (carbon nanotube/gelatin-enhanced recycled printed paper) and characterized its flame-retardancy properties, addressing material-level fire resistance rather than facility hazard management.

(Rincón-Iglesias et al., 2025), developed an inkjet-printed humidity sensor and noted potential fire-safety monitoring applications, but did not investigate fire or explosion hazards arising from the printing process itself.

3.1. Findings from the Grey Literature Review

In contrast to the sparse academic record, the grey literature review identified substantial, well-established technical guidance addressing fire and explosion hazards in printing facilities.

Printing operations present a distinctive risk profile that spans two normally separate regulatory domains: process fire/explosion safety and occupational chemical exposure.

FM Global's general nonstorage occupancy standard (FM Global, 2019) establishes hazard categories HC-1 to HC-3 based on combustible loading, and explicitly nominates "printing plants" as an HC-3 example under manufacturing occupancies, alongside "coating and printing" operations (FM Global, 2019). This baseline classification is significant because it frames printing as a heavier-than-typical industrial hazard even before ignitable liquids or in-process storage are considered. Indeed, the printing plants data sheet (FM Global, 2023) directly cross-references (FM Global, 2019), recommending that press rooms with little or no in-process storage be protected as HC-3 occupancies under that standard, while rooms with excess ignitable liquid, paste ink, or roll-stock storage escalate to occupancy-specific standards such as ignitable liquid storage or Class 1 to 4 and plastic commodity protection.

Across both FM Global sheets, ignitable liquids emerge as the central fire hazard rather than an incidental one. (FM Global, 2023) catalogues inks, solvents, blanket wash, hydraulic fluid, press lubrication fluid, and heat transfer fluid as ignitable liquids intrinsic to the press itself, and distinguishes low flash point (<200°F/93°C)

from high flash point paste ink liquids (≥200°F/93°C) because this threshold determines whether automatic sprinklers alone are adequate or whether special suppression (typically local-application CO_2) is required. This is reinforced structurally: staging, storage, and mixing of these liquids beyond quantities in (FM Global, 2023) defer to the dedicated ignitable liquid operations standard (FM Global, 2026), which governs containment, drainage, piping, and dispensing-station design.

A recurring theme in (FM Global, 2023) is that printing presses are architecturally resistant to conventional ceiling-level sprinkler protection because catwalks, enclosures, mezzanines, and archways shield the fire source from above (FM Global, 2023). The data sheet's support section states plainly that ceiling sprinklers alone will not adequately protect most printing presses, and that protecting a press is fundamentally a two-part problem: routing water near concealed spaces, and ensuring it is positioned to actually intercept the fire.

4. Discussion

Following the literature review, it became obvious that the scientific literature in the past 10 years is lacking with the field specific empirical and experimental research. It is not to say that this kind of research specific to the printing industry is not being done, rather that it is more often than not tightly tied to the specific printing techniques. Such situation is expected, especially since different printing techniques require completely different approaches in building, electrical power, organization and materials requirement. It does not aid this particular case that the printing industry in itself is immensely multidisciplinary, so it is expected that the researchers from different fields write about different aspects of the printing industry.

RQ 1 set the inquiry “to what extent is the scientific literature in the past ten years dealing with the topic of fire safety in printing industry?” The answer is: very limited, and almost entirely indirect. Across three major databases (Scopus, IEEE Xplore, ScienceDirect) covering engineering, applied science, and multidisciplinary research, a search spanning the full ten-year window returned 348 raw records, reducing to 314 unique records after deduplication. Of these, only four studies (1.3%) met eligibility criteria, and of those four, only one study directly investigated a fire or explosion hazard within a printing or printing-adjacent facility (Moroń, 2026).

RQ 2, on the other hand, has a positive answer. This literature review suggests that the gray literature supplements the academic literature, and even substitutes for it in this domain. It can be concluded following the gray literature review is that it builds upon a wide, multidisciplinary field of printing and fire safety and provides readers with condensed information and guidelines.

5. Conclusions

This paper went through the currently available academic literature with the goal to asses the current state of the research interest in the field. The research query that combined core hazard concepts (e.g., "fire safety," "fire protection," "fire risk," "fire hazard," "combustible dust," "dust explosion," "explosion protection") with industry- and process-specific terms (e.g., "print*," "printing plant," "printing industry," "printing press," "flexograph*," "gravure," "lithograph*," "letterpress," "screen printing") using Boolean operators and exclusion terms ("3D print*," "additive manufactur*," "rapid prototyping," "printed circuit board*," "PCB") showed 348 raw records, reducing to 314 unique records after deduplication. Of these, only four studies (1.3%) met eligibility criteria, and of those four, only one study directly investigated a fire or explosion hazard within a printing or printing-adjacent facility. Those papers were analyzed together with selected gray literature, and it can be concluded that the grey literature search returned substantive, actively maintained, sector-specific guidance, capable of summarizing multidisciplinary finds across multiple scientific fields.

This is not to say that the gray literature is ought to replace the academic one, but rather it should be motivation for stronger cooperation between the researchers across academic disciplines.

6. References

Aydemir, C., Altay, B.N. and Steingraeber, J.K. (2025) 'Static electricity in printing and packaging production processes: Causes, effects, and solutions', *The International Journal of Advanced Manufacturing Technology*, 139(7–8), pp. 4199–4210. DOI: 10.1007/s00170-025-16084-8

Health and Safety Executive. (no date) *Fire and explosion risks in printing*. Available from: https://www.hse.gov.uk/printing/fire-explosion.htm [Accessed 15 September 2026].

FM Global. (2019) Data Sheet 3-26: *Fire Protection for Nonstorage Occupancies. FM Property Loss Prevention Data Sheets*. Available from: https://www.fm.com/FMAApi/data/ApprovalStandardsDownload?isGated=-false&itemId=%7B4881E43C-2D4D-4C8A-AC86-B5D-0DA8A973D%7D [Accessed 10 September 2026].

FM Global. (2023) Data Sheet 7-96: *Printing Plants. FM Property Loss Prevention Data Sheets*. Available from: https://www.fm.com/FMAApi/data/ApprovalStandardsDownload?isGated=true&itemId=%-7B404A9285-8C35-4C14-872B-A0C83ABB-2F1C%7D [Accessed 02 August 2026].

FM Global. (2026) Data Sheet 7-32: *Ignitable Liquid Operations. FM Property Loss Prevention Data Sheets*. Available from: https://www.fm.com/FMAApi/data/ApprovalStandardsDownload?itemId=%7B0E226C82-CA57-47C4-8ECB-E384AA589D34%7D [Accessed 10 September 2026].

Logic, R. (2021) *Fire Protection at Printing Plants*. Risk Logic. Available from: https://risklogic.com/fire-protection-at-printing-plants [Accessed 10 September 2026].

Moroń, W. (2026) 'The explosion suppression effects of added limestone dust on minimizing the risk of dust explosions in the printer cartridge recycling installation', *Journal of Loss Prevention in the Process Industries*, 100, 105875. DOI: 10.1016/j.jlp.2025.105875

Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., McGuinness, L.A., Stewart, L.A., Thomas, J., Tricco, A.C., Welch, V.A., Whiting, P. and Moher, D. (2021) 'The PRISMA 2020 statement: An updated guideline for reporting systematic reviews', *BMJ*, 372, n71. DOI: 10.1136/bmj.n71

Rincón-Iglesias, M., Krebsbach, P., Correia, D.M., Mendes-Felipe, C., Lanceros-Méndez, S. and Hernandez-Sosa, G. (2025) 'Sustainable Fully Inkjet-Printed Humidity Sensor Based on Ionic Liquid and Hydroxypropyl Cellulose', *ACS Applied Materials & Interfaces*, 17(22), pp. 32680–32690. DOI: 10.1021/acsami.5c00505

Sun, S., Xing, C., Pang, L., Hu, Y., Wang, H. and He, C. (2026) 'Study on the Effects of VOCs Concentration on the Explosion Characteristics of Paper Powder', Fire, 9(1), 34. DOI: 10.3390/fire9010034

Tohamy, H.-A.S. (2024) 'Greener, Safer Packaging: Carbon Nanotubes/Gelatin-Enhanced Recycled Paper for Fire Retardation with DFT Calculations', Journal of Renewable Materials, 12(12), pp. 1963–1983. DOI: 10.32604/jrm.2024.054977

YassamineEbadat. (2023) *Shocking: Printing, Solvents & Thin Films. Stonehouse Process Safety*. Available from: https://stonehousesafety.com/shocking-printing-solvents-thin-films/ [Accessed 03 September 2026].



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