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Information, Analysis and Insights for Manufacturers, Fire Fighters and Senior Fire and Safety Professionals

Special Report

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Produced in partnership with Dafo Fomtec AB

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Mike Ward, Managing Director of the Association for Specialist Fire Protection, reflects on 50 years of the organisation advancing competence, clarity and collaboration across the built environment

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Special Report

Fluorine-Free Foam

IFSJ presents a Special Report on Fluorine-Free Foam, with exclusive insights from Dafo Fomtec AB

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Editor's Introduction
Fluorine-Free Foam

Welcome to this Special Report on Fluorine-Free Firefighting Foam, produced by International Fire and Safety Journal in partnership with Dafo Fomtec AB.

Fluorine-free foam is now a central focus for fire protection specialists as organisations replace stocks of PFAS-based agents with new formulations that meet both environmental and performance requirements. The change is driven by binding regulation and growing evidence of PFAS contamination in groundwater and human tissue. Authorities in Europe, North America and Asia have confirmed phase-out schedules, while manufacturers and operators are implementing the practical steps needed to transition. What began as a policy target has become a defined technical process that reaches from laboratory testing to field application.

Performance and consistency

The principle is simple: remove the persistent fluorinated compounds that gave AFFF its vapour-sealing ability and replace them with biodegradable chemistries that achieve the same control of flammable liquid fires. Achieving that balance has required detailed work on viscosity, stability and compatibility with legacy hardware. Current formulations blend hydrocarbon surfactants with stabilisers and polymers that strengthen bubble walls and extend burn-back resistance. Each new agent is tested for flow consistency, heat tolerance and system performance to ensure it meets established Class B standards.

"The insights in this report present a clear view of where fluorine-free foam stands today."

This report brings together contributions from Dafo Fomtec AB, whose research has played a central role in this field. Founder and CEO John Ottesen discusses how polymer hydration affects storage stability and proportioning accuracy. His insight highlights the operational risks that arise when moisture interacts with polymer chains inside concentrate tanks. R&D specialist Magnus Johnsson outlines the testing process that links formulation design to controlled fuel fires, where each variable—nozzle type, application rate and drainage time—is verified through repeat trials. Their perspectives connect research with operational readiness, showing how modern foam chemistry is defined by proven performance rather than substitution by approximation.

The Editor's Product section features Fomtec's Enviro MIL, developed for defence and airport response units and certified to MIL-PRF-32725(2) and U.S. Navy Type 3 standards. Testing under live fuel conditions confirms its durability, extinguishing speed and suitability for long-term storage in fixed or mobile systems.

Fluorine-free foam marks a clear direction for professional firefighting. It unites environmental compliance with dependable suppression capability, providing users with confidence that system performance can advance without carrying forward the liabilities of earlier formulations. Together, the insights in this report present a clear view of where fluorine-free foam stands today: scientifically advanced, operationally proven, and aligned with the global move toward safer, sustainable fire protection. ■

Market Analysis

Chemistry in transition

The firefighting foam industry is entering a decisive period of PFAS replacement, research and regulatory enforcement across multiple sectors

The fluorine-free firefighting market is accelerating as governments, manufacturers and end users respond to new regulation and growing awareness of per- and polyfluoroalkyl substances (PFAS) risks. Investment is increasing across aviation, industrial and municipal sectors, with the shift away from Aqueous Film Forming Foam (AFFF) reshaping procurement and product development.

Market overview

According to Astute Analytica, the global firefighting foam market was valued at US $990.3 million in 2024 and is forecast to reach US $1.38 billion by 2033, reflecting a compound annual

growth rate of 3.78 percent. The report attributes this growth to environmental regulation, equipment replacement cycles and the uptake of fluorine-free alternatives.

Legislation and awareness

Recognition of the risks posed by PFAS continues to rise. Legislative bodies are phasing out PFAS foams, with the European Union targeting roughly 470 tonnes of PFAS emissions each year from firefighting activities. The EU formally adopted its restriction on PFAS in foam on 3 October 2025, introducing a phased schedule of use bans counted from entry into force and setting a maximum limit of 1 mg/L PFAS content in foam concentrates used after those deadlines. Civil aviation has five years to comply.

In the United States, the Department of Defense has requested more than US $850 million for fiscal year 2025 to remove, dispose of and replace AFFF stocks. Broader PFAS remediation and foam transition costs are expected to exceed US $2 billion over time. The US military's large-scale phase-out is seen as a major catalyst for market change.

Global impact

Asia-Pacific remains the largest regional market, holding about 36 percent of global share in 2024. Within the region, China accounted for more than 30 percent of market revenue, while India's fire-protection systems market is projected to grow by US $1.81 billion between 2024 and 2029. In the Middle East, the UAE's "1 Billion Readiness" campaign aims to train one billion people worldwide in fire safety from 2025 to 2027, reflecting wider cultural and economic interest in prevention and preparedness.

> "Broader PFAS remediation and foam transition costs are expected to exceed US $2 billion over time."

Aviation investment

Aviation has become a priority sector in the fluorine-free transition. The US Federal Aviation Administration has established a US $350 million grant programme to support approximately 500 eligible airports as they switch to PFAS-free foams. Around US $30 million of this funding is reserved for Aircraft Rescue and Firefighting (ARFF) vehicles that cannot be retrofitted. New ARFF vehicles typically cost US $1 million or more, highlighting the scale of investment required for full replacement.

Industrial and risk sectors

Industrial sectors such as oil, petrochemical and chemical manufacturing continue to account for the majority of foam use. In the European Union, these applications represent roughly 59 percent of PFAS-foam consumption. Rising incident rates are reinforcing the shift toward safer alternatives: publicly reported fires at waste and recycling facilities in the US and Canada rose 15 percent in 2024, from 373 to 430 incidents, according to Fire Rover. In South Korea, the National Fire Agency recorded 678 lithium-ion battery fires between 2020 and 2024. Automatic suppression systems have been shown by the NFPA to reduce average property loss per reported home fire by about 55 percent, underscoring the value of effective extinguishing media.

A measured transition

The move to fluorine-free foam is now the defining development in fire protection. Regulatory deadlines are established, funding has been assigned, and production capacity is increasing to meet confirmed demand. The change is no longer theoretical or pilot-based; it is operational and progressing across aviation, industrial, maritime and public-sector firefighting.

Ongoing research is refining foam chemistry to maintain performance on Class B and flammable-liquid fires. Manufacturers are improving compatibility with existing proportioning and delivery systems, while fire authorities are updating procurement standards to align with environmental legislation. These actions are shaping a stable supply chain and a clearer basis for technical evaluation. ■

John Ottesen, Founder and CEO at Dafo Fomtec AB, discusses developing a high performance SFFF without partially hydrated natural polymers

The POLYMER problem

Knowledge Partner

Across many sites the practical work of replacing PFAS-based foams has begun, with attention turning to whether alternatives can deliver recognised fire test performance while fitting into existing proportioning and storage arrangements. That focus has brought polymer choice to the fore because it strongly influences drainage, heat resistance, viscosity and long-term behaviour in service.

Fluorine based foams such as FP, AFFF, FFFP and their alcohol resistant derivatives are being phased out due to the persistence of PFAS chemicals and the health and environmental impact of certain identified members of the PFAS group. Attention has shifted toward synthetic fluorine-free foams (SFFF) as we look to replace the PFAS foams with alternatives offering similar firefighting performance. These foams also promise environmental safety, but as we strive for equivalency in

> "Adjustments to polymer type and concentration have offered incremental improvements, but none have solved the fundamental hydration problem."

performance many of them introduce a different kind of risk: reliance on polymer chemistry and specifically partially hydrated natural polymers.

Polymers in firefighting foam

The use of natural polymers in firefighting foams is not a new technology, having first emerged in the 1970's with the early alcohol resistant foams. Standard hydrocarbon foams such as FP, AFFF and FFFP when applied to a water miscible fuel such as acetone or IPA are not able to retain a foam blanket. Foam chemists found that the addition of natural polymers into the foam concentrate allowed a polymeric layer to drop out and form a barrier between the foam bubbles and the water miscible fuels.

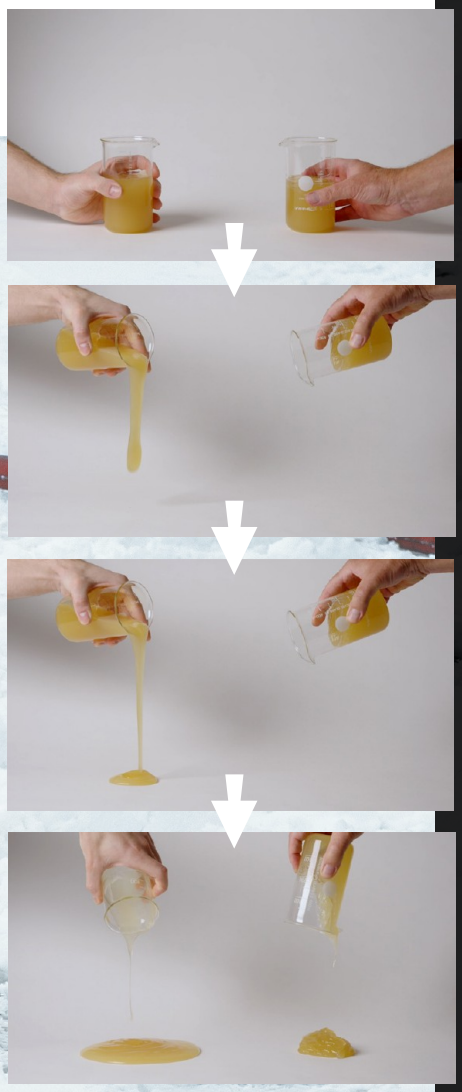
These polymers had additional benefits to the performance of the firefighting foam as they produced slower draining foams and the stronger bubble structure often led to improved heat resistance. These performance enhancing features led to Alcohol Resistant foams becoming almost universally adopted as the foam agent of choice for emergency response firefighting on large fires in the high hazard industries on hydrocarbon fuel fires since the 1990's.

From the early 1970's into the 2010's manufacturers experimented with different polymers and quantities in their foam concentrates as they wrestled with fundamental issues:

- The addition of polymers increased the viscosity of the foam concentrate
- Maintaining these polymers in solution or suspension through the life of the foam concentrate, also talked about as the stability of the foam

The question of viscosity can be discussed as an engineering issue because if you know the viscosity then the equipment and system can be designed accordingly to handle the foam concentrate, with proportioning and pumping selected to suit the measured rheology. Of course, the viscosity and the shear rates must be known and remain constant for those assumptions to hold.

Stability on the other hand is something that every foam manufacturer has faced at some point in time, whether due to a batch issue, raw materials out of specification or incorrect quantities in the batch, or due to storage and climatic conditions with their clients, and when stability issues occurred what was ▸



typically seen was separation of the foam concentrate with the polymers either sinking or floating separated from the surfactant mixture.

Over 30 plus years of manufacturing these products the manufacturers have been able to determine the best combination of polymers and quantities to achieve the optimal balance of viscosity, fire performance and achieve a safe window of stability for the concentrate. For Fomtec this involves adding our polymer combination up to around 1% by volume in our top performing 3 x 3 products.

SFFFs and polymers

With the demise of PFAS containing foams, Fomtec, along with the other foam manufacturers has had to develop new formulations accepting that like the early pure protein foams we are now entirely reliant on the blanket integrity for our extinguishing and burnback security. Fomtec returned to natural polymers to improve performance by creating slow draining bubbles with good heat resistance. The formulation approach remains in that increased polymers leads to a more viscous foam concentrate and potential stability issues with the concentrate.

With the transition to fluorine free foams more emphasis on viscosity was inevitable due to capabilities of existing equipment and this desire to have the combination of fire performance and a lower viscosity has seen a number of manufacturers formulating with partially hydrated polymers, or what we at Fomtec like to call hidden gum. While effective in the lab and the fire test house, this approach introduces vulnerabilities that can compromise firefighting performance in the field.

The partially hydrated polymer challenge

Water sensitivity and storage instability

Polymers are also highly sensitive to moisture during storage. In humid environments or when water ingress occurs in foam storage tanks, partly hydrated polymers will hydrate if they come into contact with water. This causes them to swell and increase the viscosity of the concentrate. This can occur as lumps or more generally an increase in viscosity that can lead to system malfunction. The risks include:

- Blocked pumps and nozzles, reducing delivery capacity
- Unpredictable viscosity, disrupting proportioning accuracy
- Batch-to-batch performance variability, leading to performance variability

System-level risks in fire protection

In applications such as aviation hangars, petrochemical terminals, offshore installations and chemical processing plants it is difficult to observe polymer behaviour inside fixed systems during transition projects. Concentrate pipelines can be complex and impossible to inspect, so confirming that all cleaning water is removed before filling new concentrate can be very challenging, and even a small amount of retained moisture can influence the behaviour of a partly hydrated polymer once the system is back in service.

> **"The addition of polymers increased the viscosity of the foam concentrate."**

How competitors still depend on polymers

Most foam manufacturers continue to rely on partially hydrated polymers as the foundation of their SFFF performance. This dependency creates a balancing act between the need for lower stable viscosity and the risk of hydration variability. It is a matter of creating a finely balanced formulation where the partly hydrated polymers are restricted from developing viscosity, and this finely balanced formulation can be very sensitive to ambient conditions leading to instability. Adjustments to polymer type and concentration have offered incremental improvements, but none have solved the fundamental hydration problem.

This means that across the industry many partially hydrated polymer-based foams still face the dual risks of instability and viscosity changes in real world use.

Dafo Fomtec AB continues to follow a fully hydrated path

Fomtec has always used formulations based on fully hydrated polymers and thus raising the bar making it more challenging to achieve the highest ratings in some fire performance standards, specifically with burnback performance with saltwater. Now, through proprietary formulation

technology, Fomtec has launched a new generation of Enviro high performance foam agents based on fully hydrated natural polymers. This is an evolution through 15 years of research and development in the Enviro Program and more than 3500 fire tests.

No loss of performance

The most remarkable aspect of this innovation is that Fomtec's fully hydrated polymer foams perform at the highest level without compromise.

Internationally certified: independent testing shows that Fomtec's foams meet or exceed EN 1568, ICAO and UL162 requirements for extinguishment and burn-back resistance.

Stable storage life: with fully hydrated polymers, with no polymers to hydrate or degrade, concentrates remain consistent.

Reliable system delivery: no lumps, gels or clogging means foam systems work as designed in real emergencies.

Water-quality independence: performance is consistent across different types of water supplies.

This combination of established chemistry and proven fire performance sets Fomtec apart from every other foam manufacturer globally.

> **"Most foam manufacturers continue to rely on partially hydrated polymers as the foundation of their SFFF performance."**

Regulatory and environmental context

The timing of this breakthrough is significant. Across Europe,

North America and Asia-Pacific, regulations are tightening on both PFAS chemicals and the performance standards for their replacements. Users are under pressure to:

- Phase out PFAS based foams
- Ensure environmental compatibility of alternatives
- Maintain or improve performance levels required by regulators and insurers

Fomtec's fully hydrated polymer technology directly addresses these concerns, providing an environmentally sustainable solution with stable performance, which aligns with what regulators, insurers and fire brigades require.

Why it matters

Fire brigades, airports, oil and gas operators and industrial sites need confidence that their foam will perform as specified, proportion within tolerance and store without unwanted change. By removing the dependency on partially hydrated polymers, Fomtec avoids the hydration-driven variability that can change viscosity and delivery in service, supporting a predictable transition from PFAS based agents to SFFF in existing equipment. ■

Magnus Johnsson, R&D Specialist at Fomtec, details the move from C8 to C6 and SFFF foams for regulatory and operational progress

Evolving *formulations*

The move from long-chain C8 foams through C6 formulations and now into synthetic fluorine free foams (SFFF) has reshaped the firefighting sector. Meeting the performance requirements of UL, ICAO, military and other test regimes has required extensive development and live fire testing on varied fuels. At Fomtec, this is a hands-on process, with Research & Development staff directly engaged in large-scale fire trials.

"I can't imagine how I could do my lab work effectively if I was not involved with the fire testing."

Working alongside Fomtec's chemists on the formulation and evaluation of new foam concentrates, Magnus Johnsson has played a central role in bridging laboratory research with real-world fire testing. In this interview, he discusses his experience in product development, the challenges of meeting diverse certification requirements and the key focus areas driving current foam research.

How would you describe the journey from C8 foams to C6 and now to SFFF and what has it meant for your work in R&D?

C8 to C6 was billed a "small change" of a fluorosurfactant, but in reality it involved reformulation of all our PFAS-containing foam agents and recertification. Reformulating the higher-performing foams such as the UL/FM sprinkler foams or the US DOD Mil Spec was more involved than we thought it would be.

Moving to SFFF was something we started back in 2011, some five years before the move from C8 to C6 needed to be completed. This SFFF journey was, and continues to be, a rollercoaster ride, as we are pretty much starting with a clean piece of paper with the formulations.

What defines C8, C6 and SFFF formulations and why has the sector evolved through these stages?

In very basic terms, the 8 and the 6 relate to the number of carbon atoms in the chains of the fluorochemicals that are used within the foam concentrate. SFFF is the acronym for Synthetic Fluorine Free Foam and is the term adopted

by NFPA, UL, FM and Fomtec to cover a foam concentrate with "no intentionally added PFAS."

The driving force for the journey through these phases is environmental concerns from the family of chemicals called PFAS. PFAS are a large group of man-made chemicals where ongoing research indicates that they are extremely persistent, and some are also toxic and bioaccumulative.

What insights do you gain from taking part in live fire testing as both developer and firefighter?

Everything we do in the laboratory has to be validated in the fire tests, and I can't imagine how I could do my lab work effectively if I was not involved with the fire testing. Some test standards such as UL topside or Mil Spec require active firefighting and have pass/fail criteria based on extinguishing times. Being the lead firefighter for product development to these standards is essential.

This is even more important with the development of SFFFs, as they can extinguish as quickly as a PFAS-based foam, but different techniques are required.

"We realised that there are likely many chemicals being stored that we just don't have the fire data on and so we spend some two years developing an estimation tool."

How do UL and MIL-SPEC test standards differ and why must performance be assessed under each?

It has to be accepted that the authorities setting the fire performance standards and the associated test protocols do so as they believe that they are the most appropriate for their application. Comparison between a product's performance to one standard against another is rarely possible, and as we move to SFFF formulations I would suggest that this comparison is even more difficult.

Variables include the size and shape of the test pan, the fuels, the nozzle, the flow rates and application times. Then we have different preburn periods and foam application times, as well as the criteria for pass or fail. For example, the UL test pan is rectangular and 50 ft^2, whereas the Mil Spec pan is circular and 28 ft^2, and the test fuels are heptane for UL and gasoline and Jet A for Mil Spec.

How do you see foam technology evolving and where do you expect to see the most progress?

I have to believe that SFFFs will go the way of AR-AFFFs, and we will start to see better-performing low-viscosity products. At Fomtec, we have already launched our IMO-approved Enviro SEA range, for the ARFF mission the Enviro AIR, and to meet the needs of the US DOD, our Enviro MIL. ■

Editor's Product

Built for defence and environmental duty

Fomtec's Enviro MIL has achieved US Navy Type 3 certification, offering ARFF and defence users a fluorine-free solution with verified extinguishing performance and proven durability

Fomtec® Enviro MIL is a fluorine-free foam concentrate developed for high-risk firefighting environments where performance and environmental compliance are both critical. Designed without fluorosurfactants or fluoropolymers, Enviro MIL supports the transition away from PFAS-based foams while maintaining effectiveness in challenging operational scenarios. Its certification and tested performance make it suitable for both Aircraft Rescue and Fire Fighting (ARFF) and land-based military operations.

Certification and compliance

Enviro MIL has achieved MIL-PRF-32725(2) approval and was granted U.S. Navy Type 3 certification in April 2025. This listing on the Qualified Products List (QPL-32725) provides assurance that Enviro MIL has met the U.S. Department of Defence's stringent requirements for firefighting foams. For ARFF services, this certification demonstrates that the product is not only safe for use in aviation environments but also meets internationally recognised military standards for reliability and performance.

Performance in fire scenarios

Enviro MIL has been extensively evaluated against hydrocarbon fuel fires, including jet fuel (Jet A) and gasoline, the most common risks in ARFF and military facilities. Tests confirm rapid knockdown, effective extinguishment, and resistance to burnback, ensuring operational safety during fuel-related incidents.

In standard nozzle testing, Enviro MIL delivered an expansion ratio of 8:1 with an 8-minute drainage time. Under MIL-specification nozzle testing, expansion exceeded 7:1, with drainage times exceeding 11 minutes, resulting in a durable foam blanket.

Environmental responsibility

Enviro MIL's fluorine-free formulation eliminates PFAS from firefighting operations, a growing requirement for both civil aviation authorities and defence organisations. The product is readily biodegradable and meets the environmental performance requirements outlined in MIL-PRF-32725(2). While more sustainable than legacy foams, safe handling and disposal practices are still recommended to minimise environmental impact in the event of spills.

Shelf life and stability

Stored in original packaging under recommended conditions, Enviro MIL offers a shelf life of more than 10 years in temperate climates. Routine inspection is advised to maintain readiness, particularly for critical ARFF vehicles and military installations where reliability cannot be compromised.

By combining operational effectiveness with environmental responsibility, Enviro MIL supports both sectors in maintaining high standards of safety while addressing the global transition away from PFAS-based foams. ■

Find out more

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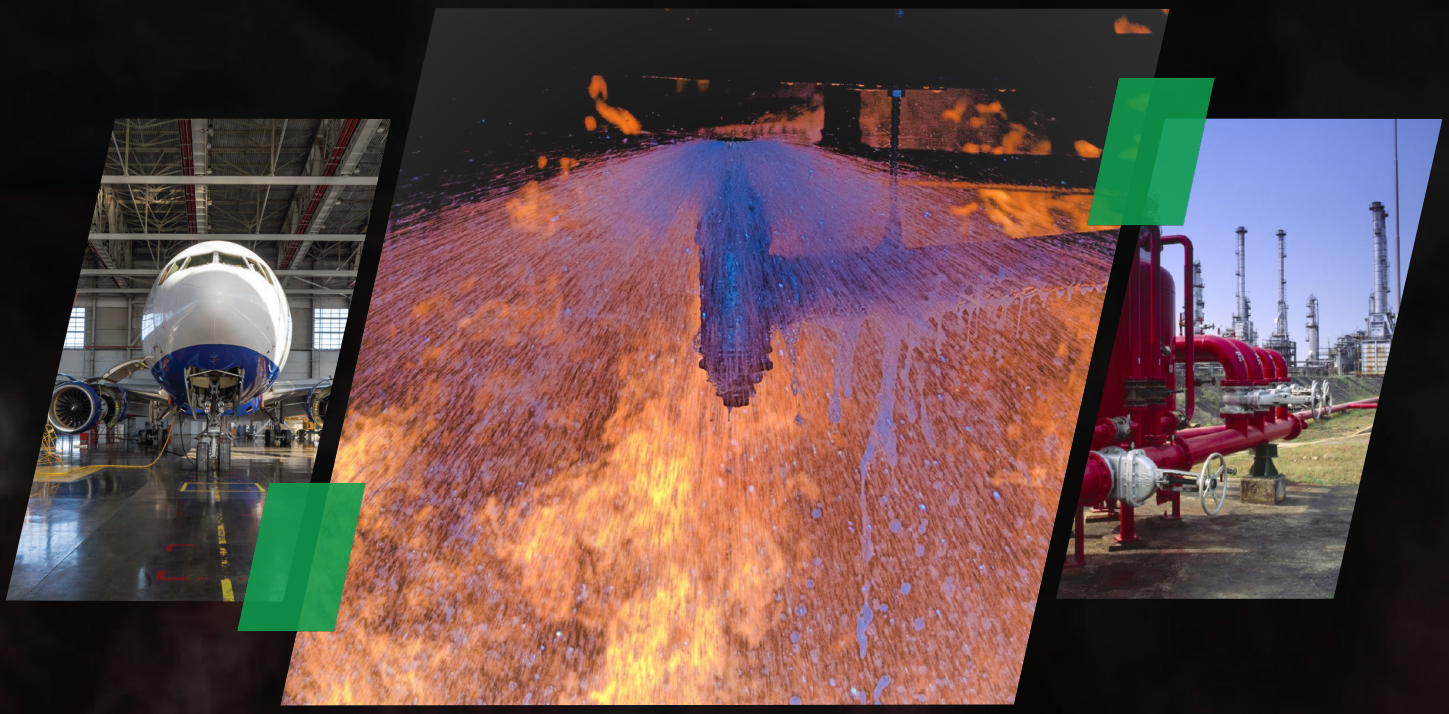

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