Inert gas nitrogen – the effective and benign extinguishing agent

Unlike most extinguishing agents, inert gas nitrogen (N_2) does not cause collateral damage, nor does it have any negative environmental side effects. It is a clean, safe, effective, and fast acting choice for hardware protection.

In the past decades, many synthetic extinguishing agents were introduced because of their effectiveness and ability to act fast and without noticeable collateral damage. Most of them were soon removed from the market due to harmful side effects on climate, health, and environment. The most recent example concerns the application of so-called PFAS based agents. In February 2023, five Member States of the EU proposed a full ban on the use of PFAS. In September 2023, ExxFire submitted a formal response to the EU proposal for a full ban on PFAS. In short, ExxFire points out that the application of PFAS based extinguishing agents can easily be avoided by using inert gases such as N_2. With a very few exceptions, inert gases are proven to be just as effective and fast acting as their PFAS based counterparts.

Although extinguishing methods have been around for many centuries, it was not until the first decades of the twentieth century that fire suppression systems developed to more sophisticated levels, aiming for more effectiveness and limited collateral damage to objects and people. Solutions based on water and powders – usually potassium-based salts – were gradually replaced by alternatives such as synthetic gases based on carbon, bromine and fluor. These so-called halons were first used during World War II in fire extinguishers for aircraft and tanks. In the mid-1960s, halon gases were widely introduced as an effective gaseous fire suppression agent for use around highly valuable materials in places such as museums, mainframe rooms, and telecommunication switching centers. Halons were also widely used in the maritime industries, in the engine rooms of ships, and in the transport industry in vehicles. Its efficiency as a fire extinguishing agent has also led it to be the predominant choice of fire extinguishing agent on commercial aircrafts. However, during the 1970s and 1980s, harmful side effects gradually became apparent. Most significant, the ozone depletion effect caused by halons and similar chlorofluorocarbons was demonstrated and this resulted in a ban in most countries since January 1, 1994, as part of the Montreal Protocol on ozone depleting substances.

Alternative solutions for halons were soon developed. Successful examples were synthetic gases deemed less harmful than halons. In particular, substance HFK 227ea, commercially known as FM200, was considered a good alternative for fire suppression applications. This fluor carbon-based gas was demonstrated to be a very effective extinguishing agent with little collateral damage, no ozone depletion effect and acceptable risks regarding safety and health. However, despite its beneficial characteristics compared to halons, HFK 227ea was demonstrated to cause harmful side effects. Like most HFKs and similar gases (sometimes referred to a F-gases) HFK 227ea was proven to be a very powerful greenhouse gas. With a greenhouse potential of over 3,000 kg of CO_2 equivalent per kg HFK-227ea, the agent significantly contributes to global warming even at relatively low emissions resulting from extinguishing events and unintended causes such as false alarms and leakage. In 2014, the European Parliament and European Council announced measures that should result in a two-third reduction of F-gas emissions in 2030. European Directive 517/2014 imposes strict restrictions on the use of HFK-227ea and a full phase out is expected.

More recently, alternative extinguishing agent FK-5-1-12 was introduced. Like halons and HFK 227ea, the active ingredient is a synthetic gas based on carbon and halogens, in this case fluorine. It is claimed that this agent has low impact on climate and environment. Also, it is claimed that FK-5-1-12 has superior properties concerning safety, health and extinguishing effectiveness. However, it now becomes gradually clear that these claims may not hold. FK-5-1-12 is a synthetic compound fully qualifying as a so-called PFAS, a large family of synthetic substances, known as per- and polyfluoroalkyl substances. In the past few years, more and more adversary effects of PFASs have been revealed and their persistence ("forever chemicals") is considered highly problematic. Noteworthy is a proposal for a full ban on PFASs in the EU. Even though a derogation on PFAS containing extinguishing agents is considered, the urgency of reduction is clearly demonstrated.

The need for restricting the use of FK-5-1-12 systems as soon as possible is their hazardous characteristics. For example, FK-5-1-12 is known to be converted in the atmosphere by a photolytic pathway.

End products include hydrogen fluoride (HF) and trifluoroacetic acid (TFA). TFA is a persistent and mobile pollutant. Its multiple adverse effects warrant restrictions on any source, including FK-5-1-12.

Different from the synthetic products described above – halons, HFK227ea and FK-5-1-12 – inert gases such as nitrogen and argon as inert are not toxic and do not show any adversary effect on ozone layer or climate. An exception to this is inert gas CO_2, which shows acute toxicity and contributes to global warming.

Nitrogen is demonstrated to provide an effective extinguishing agent. It is as clean and acts as fast as its hazardous synthetic equivalents, without the undesired side effects.

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What is a clean agent?

A typical clean fire suppressing system consists of one or more cylinders containing a gas (used to suppress the fire) and an auxiliary system that detects the fire and releases the gas. The term 'clean' indicates that the system can extinguish the fire without causing damage to the objects to be protected, unlike aerosols, foam or water. In this particular context, the qualification "clean" does not refer to the impact on the environment and health.

For this discussion two key clean fire suppressing systems can be differentiated: those that use PFAS-agents and those that use inert gases.

ExxFire notes that many companies offering clean fire suppressing systems offer both PFAS systems and inert gas systems. As a result, the potential proponents of inert gas systems have an interest in also keeping PFAS systems on the market. This makes it difficult for regulators and other industry players to obtain clear information about the (im)possibilities of restricting certain PFAS systems.

The other type of clean fire suppressing systems uses inert gases ('inert gas systems') as an extinguishing agent, such as nitrogen (N_2) and argon (Ar) and their mixtures. These inert gas systems are based on the principle of reducing the oxygen concentration by displacement until it reaches a level where combustion is no longer supported, and an (incipient) fire is extinguished. Each system is designed to decrease oxygen to a specific level. When discharged, inert gas is quickly and uniformly distributed within the enclosure. According to ExxFire analysis, inert gasses already form two-thirds of today's total market.

ExxFire's system is a special type of inert gas system: a nitrogen generator. Instead of storing the nitrogen in a cylinder under pressure, its sealed steel cylinders contain solid propellant that produces gaseous nitrogen and a solid residue after a chemical reaction. The gaseous nitrogen is generated at the moment an incipient fire is detected by smoke detectors, thermal wires or other instruments. After suppressing the fire, the residue inside the system mainly consists of sodium, sand and some auxiliary components.

The gaseous nitrogen is released to displace oxygen and, as a result, suppress the (incipient) fire. All solid products remain inside the casing before, during and after activation. The technology was originally developed by the Netherlands Organisation for Applied Scientific Research (TNO) for the use in satellites. ExxFire's technology is certified by the Centre National de Prévention et de Protection (CNPP) and the US Environmental Protection Agency (EPA). Like all other inert gas systems, ExxFire systems do not apply or emit any PFAS.

PFAS Impact

During the lifetime of a PFAS system of typically 10 years, approximately 30% of the PFAS gases will be released into the environment – since each year approximately 2% of the installed capacity is used to suppress a fire, for a false alarm or for testing. Additionally, all PFAS systems experience leakage of PFAS gases throughout their lifecycle. The remaining 70% of PFAS is ultimately processed as waste, during which again leakage to the environment can be expected. As long as PFAS systems are installed, PFAS emissions will continue. The environmental impact will be significant.

The most commonly used gas in PFAS systems is FK-5-1-12, for which the patent has expired in 2020. Already we are seeing new 'generic' producers entering the market, mainly from Asia. This makes it harder to keep control of the exact composition and purity of the PFAS gases entering the EU market. Harmful contaminations, including PFAS other than FK-5-1-12, are known to be present and aggravate environmental concerns.

Asphyxiation

It is noted that the use of nitrogen as a fire suppressant can reduce oxygen levels to 10-12 percent, which can cause a potential asphyxiation hazard. However, this is only relevant in the case of *room protection* since object protection – by definition – assumes absence of people.

Keep in mind that for other extinguishing agents, asphyxiation hazard is present as well.

Input ExxFire for EU Consultation

In September 2023, ExxFire submitted a formal response to the EU proposal for a full ban on PFAS. In short, ExxFire points out that the application of PFAS based extinguishing agents can easily be avoided by using inert gases such as N_2. With a very few exceptions, inert gases are proven to be just as effective and fast acting as their PFAS based counterparts. As a result, a long term or even unlimited derogation period is not at all necessary.

More information on the proposed ban can be found on:
https://echa.europa.eu/nl/hot-topics/perfluoroalkyl-chemicals-pfas

and

https://echa.europa.eu/nl/restrictions-under-consideration/-/substance-rev/72301/term

ExxFire's input can be found on:
https://echa.europa.eu/nl/comments-submitted-to-date-on-restriction-report-on-pfas

On this page, refer to Table 104, response 8885

Further reading:
https://www.rivm.nl/en/pfas