

## Comparison of fire extinguishing systems

# Fire extinguishing systems using 3M™ Novec™ 1230 Fire Protection Fluid vs. inert gas extinguishing systems

This paper refers to the protection of high-value industrial goods in enclosed areas.

In evaluating both extinguishing systems, the key criteria used are:

- 1 Performance and speed of extinguishing
- 2 Safety of people
- 3 The total cost of ownership
- 4 Sustainability and environmental regulations

## Basic principles of combustion:

Any interruption of the combustion process is described as extinguishing. In the course of extinguishing, one or several preconditions for combustion are eliminated:

▶ **Extinguishing through cooling (withdrawal of heat)**

Heat is withdrawn from the combustion process and bound in the extinguishing agent. This leads to the combustion temperature being lowered. If it falls below a minimum level, combustion ceases.

▶ **Extinguishing by means of damping down (reducing the proportion of oxygen in the surrounding air)**

Most fires are extinguished if the concentration of oxygen in the air falls below 15%, e.g. using inert gas extinguishing systems.

▶ **Extinguishing through withdrawal of the combustible material**

Withdrawal of the combustible material at source will extinguish all fires.

▶ **Extinguishing by catalytic effect**

This process is based on disrupting the combustion process. The extinguishing agent binds intermediate products together or the extinguishing agent combines with intermediary products.

## 1 Performance and speed of extinguishing

Extinguishing systems which use **3M™ Novec™ 1230 Fire Protection Fluid** provide highly effective means of fighting fires in the phase when they first break out. The fire is extinguished approximately 40 seconds after the automatic fire recognition signal is triggered. The flooding time is limited to 10 seconds, and the fire is totally extinguished in a maximum of 30 seconds.<sup>1</sup>

For each type of extinguishing system, it is critical that the requirements stipulated by the system specifier are always met throughout the protected area. Any subsequent structural alterations could reduce the system safety and efficacy, as extinguishing agents could escape from the area to be protected in the event of being triggered.

In order to avoid fires re-igniting, a holding time of at least 10 minutes is usually set. Concentration of the agent which is effective for extinguishing must usually be maintained during this holding time. Any interventions by fire departments, trained personnel or any other actions such as switching off energy (if the source of ignition = energy), must be undertaken so as to avoid any re-ignition occurring within the holding time.

**Novec 1230 fluid** performs its full extinguishing effect even while being operated with circulating air (air conditioning technology) if a closed system is involved, i.e., if no fresh air is introduced into the room. In the case of a fire occurring, therefore, the circulating air must not be switched off. Any existing air circulation may actually improve distribution of the extinguishing agent in the room.

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In the event of an inert gas extinguishing system being used, the pre-warning time amounts to a minimum of 30 seconds and the system discharge time 60 to 120 seconds. The actual extinguishing of the fire takes a maximum of 30 seconds (approximately) if compliance with the standard/certification directives is required. Overall, the duration of time from the discovery of the fire to it being completely extinguished amounts to approximately 2 to 3 minutes, considerably longer than with the use of a fire extinguishing system featuring **3M™ Novec™ 1230 Fire Protection Fluid**. This longer extinguishing interval can lead to significantly increased fire damage and increased downtime of IT systems.

## 2 Safety of people

Novec 1230 fluid has the highest margin of safety amongst clean extinguishing agents, with a high safety margin between its normal use concentrations (5.6% vol, Higher Class A) and the No Observable Adverse Effect Level (NOAEL) at 10%, resulting in a relative safety margin of 78%. Use of **Novec 1230 fluid** therefore provides a large relative margin of safety for operating personnel in occupied spaces. Even if this concentration increases at a future stage due to construction work, for example due to the integration of further server racks in the room to be protected (whereby the net air volume decreases and therefore the concentration of the extinguishing increases), no risk arises for the personnel present.

Due to the inherent dangers of fire and smoke, as a requirement, people should leave the room before an extinguishing system is activated if at all possible. In the event of accidents during evacuation, or in the event of a false system discharge, people can occasionally be left behind in the danger zone. In this situation, **Novec 1230 fluid** provides safe protection for workers.

When a fire with an open flame is extinguished, decomposition products are generally created, mainly by the combustible materials (fuels). These can include substances with high levels

of toxicity such as carbon monoxide and gases released from plastics. Likewise, fluorinated synthetic extinguishing agents decompose if they reach flame temperatures (> 600 °C), forming HF acid. This acid can never exist as a 'stand-alone' in a fire situation, but only as part of a mixture of decomposition products generated from the combustible materials and the extinguishing agent.

During the suppression of a fire with an **inert gas extinguishing agent**, these toxic reaction and decomposition products also come into existence, even if not by means of the extinguishing agent. Users may wish to consider the impact that the additional time taken for reduction of oxygen in the extinguishing phase using **inert gas systems** has on this generation of hazardous substances (plus eventual compounds generated due to incomplete combustion at low O<sub>2</sub> level<sup>2</sup>).

As previously mentioned, when extinguishing with a fire protection system using **Novec 1230 fluid**, the concentration of extinguishing agent in the room remains low. Providing the design and installation complies with the standards, fire protection systems using **Novec 1230 fluid** extinguish fires quickly in their incipient stage before an open fire has broken out, or in other words, in an interval of time in which the power of the fire is still very low. This eliminates the creation of decomposition products in a quantity that could be harmful to people or equipment.

This is why the very fast-acting extinguishing effect of **Novec 1230 fluid** represents a significant advantage regarding the safety of people, as, in overall terms, the dangerous gases caused by the fire can hardly come into existence.

When **inert gas is used as an extinguishing agent**, the extinguishing effect is caused by the removal of oxygen in the danger zone. People who are unable to evacuate and are exposed to inert gas system discharge could face a higher risk of hypoxia with symptoms highlighted in Table 2. The design concentration of inert gas systems in EN-15004 is 45.2%, leading to remaining oxygen levels of 11.3%.

2 Effects of exposure to single or multiple combinations of the predominant toxic gases and low oxygen atmospheres produced in 'http://www.sciencedirect.com/science/article/pii/S0272059087900467'

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**Table 1: Design Concentrations of Clean Agents (EN-15004-2, Table 3)**

Agent	Quantity in kg acc. EN 15004	Cylinder size	Working pressure	Cylinder no	Design in vol%	Total gas amount flooded in m <sup>3</sup>	Oxygen level before flooding	Remaining oxygen after flooding	Similar to altitude of
3M™ Novec™ 1230 Fire Protection Fluid	825.3	180l	50	4	5.60%	58.46	20.90%	19.80	500m
HFC-227ea	677.3	180l	50	4	8.50%	88.98	20.90%	19.10	700m
IG-541	867.6	80l	300	27	45.7%	648.0	20.90%	11.30	5000m
IG-100	700.8	80l	300	29	45.2%	696.0	20.90%	11.50	4900m
IG-55	846.9	80l	300	27	45.2%	648.0	20.90%	11.50	4900m
IG-01	1124.6	80l	300	28	49.2%	672.0	20.90%	10.60	5400m

Source: 'Hazards of Inert Gases and Oxygen Depletion' IGC Document 44/09/E, European Industrial Gases Association

**Table 2: Asphyxia – Effect of O<sub>2</sub> Concentration (from NL/77 Campaign against Asphyxiation)**

O <sub>2</sub> (Vol %)	Effects and symptoms
18–21	<b>No discernible symptoms</b> can be detected by the individual. A risk assessment must be undertaken to understand the causes and determine whether it is safe to continue working.
11–18	Reduction of physical and intellectual performance <b>without the sufferer being aware</b> .
8–11	Possibility of fainting within a few minutes without prior warning. <b>Risk of death below 11%</b> .
6–8	Fainting occurs after a short time. <b>Resuscitation possible</b> if carried out immediately
0–6	Fainting almost immediate. <b>Brain damage</b> , even if rescued.

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**3 Total cost of ownership**

Installing an extinguishing system using **3M™ Novec™ 1230 Fire Protection Fluid** requires a one-off investment, aside from the annual inspection costs. Accidental system discharges are extremely rare according to extinguishing systems manufacturers, meaning that extinguishing agent costs are also a one-off investment. Follow-up costs are at a reasonable level (rechargeable batteries and rubber hoses have to be changed at regular intervals, while the extinguishing agent containers have to be subjected to regular monitoring). **Novec 1230 fluid** is stored as a liquid rather than a gas, and fire extinguishing systems using **Novec 1230 fluid** typically require 80% less space compared to an inert gas system. This can lead to valuable real estate savings over the lifetime of the system.

Installing an **inert gas extinguishing system** also requires a one-off investment, aside from the annual inspection costs. In the case of smaller protective areas, the costs of procurement are usually higher than with the use of extinguishing systems using **Novec 1230 fluid**. This is due to additional construction costs associated with over-pressurisation (e.g. installation of venting), plus creation of a reserve system to negate

delays in recharging the system in the event of discharge. The increase in number of cylinders not only has an impact on real-estate costs (significantly more cylinders are required due to the fact that inert gas can only be stored at a gas, mainly under very high pressure), but also on overall system weight, requiring reinforcing of flooring in some cases.

As **inert gas** is essentially a 'natural gas', the extinguishing agent itself is considerably cheaper than **Novec 1230 fluid** on a simple unit cost comparison. However, it is important to consider the entire cost of system ownership to make a balanced decision on the choice of agent.

**4 Sustainability and environmental regulations**

**Novec 1230 fluid** has a strong environmental profile, with zero ozone depletion potential and a global warming potential of less than 1 due to a five-day atmospheric lifetime. It is not subject to the European F Gas Regulation or any other International Directive or Regulation.

**Inert gas extinguishing systems** have a neutral impact on the environment as natural resources are used as the extinguishing media.

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## Summary

- 1 Overall, considering pre-warning, flooding and extinguishing time, extinguishing fires using inert gas takes up to three minutes. Systems using **3M™ Novec™ 1230 Fire Protection Fluid** extinguish fires in considerably less time.
- 2 In addition to other reaction and decomposition products, (including ones which form due to the combustible materials, e.g. carbon monoxide, de-gasing from plastics), a small quantity of HF acid is formed when extinguishing with synthetic extinguishing agents, solely as part of the mix of the fuel decomposition products. Due to the rapid extinguishing effect, this is of such a small amount, however, that it poses minimal hazard to people.
- 3 When **inert gas** is used as an extinguishing agent, consideration should be given to the formation of additional toxic harmful substances created due to the longer time to extinguish, and the incomplete combustion in this process. No products of decomposition are created by the extinguishing agent itself.
- 4 **Inert gas extinguishing** reduces the concentration of oxygen in the protected space. The safety of workers is at risk due to the acute danger of hypoxia.
- 5 **Novec 1230 fluid** has a very high margin of safety for people. It extinguishes by means of its cooling effect and not by suppressing oxygen.
- 6 On a simple unit cost comparison, the **inert gas** extinguishing agent alone is lower priced.
- 7 As **inert gas** is stored in a gaseous condition, considerably more cylinders, and therefore more storage floor space, is required compared to **Novec 1230 fluid** stored in a liquid condition.
- 8 **Inert gas** is stored at pressures up to 300 bar (**Novec 1230 fluid** in contrast at only 25 bar up to 70 bar). For this reason, the inert gas extinguishing system requires higher dimensioned components in order to ensure the safety of the system.
- 9 **Novec 1230 fluid** and **inert gas** are both considered to be sustainable solutions, and are not subject to any regulations or phase-down programmes.

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