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SAFETY & SECURITY

Fight Data Center Fires Using Good Old H_2O

Nitrogen-charged, dry-pipe or preaction, water-based systems provide adequate fire protection in data centers

UII report 16

Fight Data Center Fires Using Good Old H_2O

Data center operators have long had a deep-seated aversion to fire. Rightfully so, as a fire anywhere in a data center can cripple operations and even destroy the entire building and all its contents. As a result, most commercial buildings include water-based sprinkler systems to extinguish fires before they cause too much damage.

In some applications, facility owners will employ a clean agent fire suppression system to avoid water damage to irreplaceable or invaluable items, such as art, rare artifacts, or extremely expensive equipment and merchandise. For many years, the clean agent of choice was Halon, but it has largely been replaced for environmental reasons by inert gas and halocarbon systems (see the sidebar Types of Clean Agent Suppression Systems).

Uptime Institute Research Take

- Uptime Institute recommends the use of nitrogen-charged, dry pipe or preaction fire suppression systems in data center spaces
- Uptime Institute advises that clean agent fire suppression systems are unnecessary in data centers, except in rare instances, such as supercomputing facilities
- Inadvertent discharges of fire suppression systems are three times more likely than fire, meaning a facility is more likely to be affected by the operation of a clean agent system than by fire
- Inadvertent discharges of inert gas systems, a type of clean agent, have been shown to damage IT disk drives
- Clean agent systems generally increase data center costs, particularly when used as a supplemental or secondary system for marketing reasons
- Low-pressure halocarbon systems are the preferred alternative when clean agent suppression is required for commercial or marketing reasons

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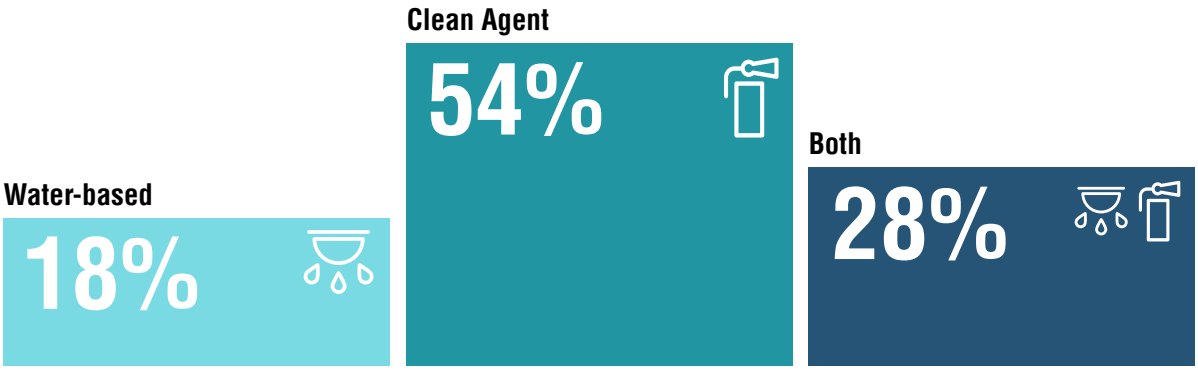
According to the 2017 Uptime Institute Data Center Survey, more than half (54%) of all data center facilities rely solely on a clean agent system, with another 28% having both a clean agent system and a water-based system. Uptime Institute concludes that in most cases having two fire suppression systems is an unnecessary precaution that may even increase risk, depending on which clean agent is used and how the systems are deployed.

While only 18% of survey respondents rely solely on a water-based system, Uptime Institute believes that a nitrogen-charged, dry-pipe or preaction, water-based solution is the most appropriate fire suppression system in most properly maintained data centers.

What kind of fire suppression systems do you deploy in your primary data center?

Uptime Institute 2017 Data Center Survey, n=577



With the possible exception of supercomputing facilities, the equipment in a data center, and even the building itself, are not as valuable as the data and not priceless or irreplaceable, even in the event of a total loss. More troubling, Uptime Institute finds that inert gas fire suppression systems that are inadvertently discharged during testing or maintenance have actually damaged mechanical hard drives, increasing overall risk to the data center, even when there is no fire. This is a completely unnecessary risk, as accidental discharges of fire suppression systems happen three times as often as data center fires, according to the 2017 survey.

Lee Kaiser, chair of NFPA 75 (National Fire Protection Association 75 Standard for the Fire Protection of Information Technology Equipment), estimates that there about two fires per month in the U.S. that result in a suppression system discharge. He wrote, “About 10 percent of the time it (the fire) is in the IT equipment, but manufacturers have made great

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strides in making equipment more resistive to causing fires. A little more than a third of the time the ignition source is the power distribution equipment—either inside the IT room or outside in a power or battery room. Uninterruptible power supplies are a frequent source of small fires and smoke events. The remaining causes are less common and can include foreign objects in the data center, human error, or even arson." Fires that originate in data halls are generally not serious. Of course, those that originate outside the data hall can be quite serious and must be met and controlled by appropriate fire suppression systems.

As a result, Uptime Institute recommends that data center operators develop a robust disaster recovery or business resiliency plan to protect any data that is considered irreplaceable and use nitrogen-charged, dry-pipe or preaction, water systems to suppress any fires that might occur in the data center. These systems offer equal or superior fire protection against the types of fires that originate in data halls and eliminate risk of server damage due to inadvertent discharge.

For these systems to be effective, data center operators must be vigilant about removing flammables from the data halls and white spaces (including under raised floors). Flammables, including packing materials and unauthorized storage, can be the source of a data center fire or provide fuel so that electrical fires, which tend to be self-extinguishing, can spread. Removing flammables from these areas will prevent fires that originate in the data center from spreading. Efforts to keep data center spaces free of flammables should be incorporated in the facility's standard operating procedures.

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Uptime Institute believes that marketing competition among colocation and hosting providers created momentum for the use of clean agent suppression in data centers. These providers promote their facilities as safer because they include a clean agent fire suppression system; however, one Uptime Institute Network member recently reported "notable disk drive damage to its customers' hard drives" after an accidental discharge of an inert gas fire suppression system. Uptime Institute has documented at least two other similar incidents (see 'About this report' below), with media reporting many other incidents. This risk appears exclusive to inert gas systems because they are stored and operate at higher pressures than other clean agent systems.

Some consultants can be blamed for the misapplication of clean agent fire suppression systems in data centers. One major design/build firm offers clean agent fire suppression as an option in what it calls its highest reliability (Level 8-10) facility designs. It offers only water-based suppression in Level 1-7 designs. This option almost certainly adds to the cost of the design, construction, and operation of the data center without reducing the fire risk.

About this report

In assembling this report and making this recommendation, Uptime Institute informally surveyed Uptime Institute Network members, searched its AIRs database, and pursued media reports to add to findings from the 2017 Uptime Institute Data Center Survey. This research confirmed that that accidental activation of inert gas fire suppression systems has resulted in incidents in dozens of facilities, some of which led to downtime or disk damage.

In a previous paper, Uptime Institute reported that the AIRs database included 54 incidents involving inert gas fire suppression systems. Of these reported incidents, 15 involved accidental discharge, with two downtime reports. However, many of the incidents took place in support areas, with no possibility of server damage.

Many of the incidents examined by Uptime Institute are not sufficiently detailed to identify the type of clean agent system in use. However, when the reports included sufficient details to identify the fire suppression system, it was always an inert gas system. This finding is in line with industry reports and supports 3M's (the manufacturer of Novec 1230) claim that lower-pressure halocarbon systems have never been blamed for disk drive damage.

Uptime Institute notes that clean agent systems have value in some applications but notes that data center operators must balance this value against the cost premium and the fact that very few data center fires originate in server rooms. Only 11% of respondents to Uptime Institute's 2017 data center survey have ever experienced a fire anywhere in a data center.

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Types of fire suppression systems

To understand the risk to data centers, it is important to understand the differences between the major types of fire suppression agents and systems, which are water-based, inert gas, and halocarbon systems, including hydrofluorocarbon (HFC) and fluoroketone types.

Type of Clean Agent Suppression System

Clean agents used for fire suppression include the following well-known products and tradenames. Some of these products may be available under other tradenames from different vendors.

Halocarbons

Hydrofluorocarbons (HFC)

- HFC-227ea (FM-200)
- HFC-125 (FE-25)
- HFC-23 (FE-13)

Fluoroketones

- FK-5-1-12 (Novec 1230)[1]

[1]Stored as liquid

According to 3M, Novec 1230 belongs to a family of chemicals called halocarbons, which also includes HFCs and fluoroketones and is a halon replacement and hydrofluorocarbon (HFC) alternative. Novec 1230 has a global warming potential (GWP) of less than one while the HFCs have a GWP of more than 3000. Novec 1230 fluid has the highest margin of safety for human occupancy among clean agents, including inert gas.

Inert Gases

- IG-55 (Argonite)
- IG-541 (Inergen)
- IG-100 (Nitrogen)
- IG-01 (Argon)

Source: NFPA 2001, 2015 from International Fire Protection, an industry vendor

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Most water-based fire systems distribute water via sprinkler heads, which are located throughout a room, facility, or building. The preaction and dry-pipe systems commonly used in data centers incorporate sprinkler heads that include a tin plug that melts at a specified temperature and a pressurized segment of dry pipe that excludes water from entering the data hall until the pressure is released. If there is a fire in one area, the sprinkler heads open only where the temperature exceeds the melting point of the plug, which releases the pressure, allowing the valve to open. In the event of a fire, the plugs restrict water damage to the areas nearest the fire. Because fires that originate in data centers are usually electric—and self-extinguishing and limited in scope—preaction and dry-pipe systems can suppress fire without causing undue damage elsewhere. When there is no fire, even during testing and maintenance, the plug keeps the equipment safe from water damage.

Uptime Institute recognizes the danger of corrosion from water entering pipes above the data center floor during testing, which is why our recommendation includes the use of nitrogen to pressurize the system to prevent microbial growth.

Halocarbons and inert gases (the most common types of clean agents) were developed as alternatives to Halon 1301 (a trade name for bromotrifluoromethane), which is being phased out worldwide because of its effect on the ozone layer. Its potential negative health impact on humans has caused others to voluntarily eliminate its use before existing stocks are completely eliminated. However, modifying a Halon system to use a modern clean agent is expensive and so Halon is still used in some fire suppression systems.

Like Halon 1301, both inert gas and halocarbon clean agents leave no residue, so cleanup is not required after a discharge. Because clean agents form no corrosive or abrasive residues, they are suitable for use on delicate or expensive assets (e.g. books, paintings, and cultural heritage items) that would be destroyed by other fire suppression systems. The clean agents are non-corrosive and non-conductive and do not damage electric and electronic circuits, even under full load operation, according to one major vendor of fire suppression systems.

For non-IT purposes, inert gas and halocarbon systems perform approximately equally well. However, unlike water-based systems, both halocarbon and inert gas system flood the entire data hall or room affected by the fire and not just a few racks or enclosures. The clean agent must remain in the room long enough to ensure that the fire does not re-flash and to provide adequate time for emergency forces to respond. There can be no single-rack or limited response to a small fire.

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As a result, recharging clean agent systems can be quite expensive, depending on which clean agent is used and how much is discharged. In one recent incident, a manufacturing/quality control issue with system triggers in an unfinished space caused a single 900-pound tank of FE 25 to discharge, which would have cost the facility owner almost $25,000 to refill (For purposes of scale, the 4200 square foot data room would be covered by 2200 pounds of gas).

Most of the new clean agents are not toxic at their typical design levels and can be use in areas that might be occupied by people. When coupled with an early detection system, inert gases and halocarbons both thoroughly flood a protected area, rapidly extinguishing even hard to reach fires, including inside a cabinet or beneath a raised floor. The clean agent systems are applicable to Class A, B, and C fires.

Pressurized systems can damage servers

Halocarbon systems are stored as compressed liquefied gases and pressurized to 25 or 40 bar with nitrogen, with the exception of FE-13, which is a liquid stored at lower pressures. Inert gas agents are supplied in high-pressure gas cylinders, typically pressurized to 200 or 300 bars (4400 psi), so they must be handled very carefully. According to reports, peak clean agent pressures can be great enough to damage infrastructure such as walls, if the spaces are not designed correctly, including proper venting.

Inert gas and halofluorocarbon (HFC) systems extinguish fires in completely different ways. Upon activating to a fire, smoke, or other sensor signal, a high-pressure inert gas system releases enough gas so that the oxygen content drops to less than 14.3%, with the normal objective being 12.5%, which starves the fire of oxygen. The low-pressure halocarbons such as HFC-227ea, HFC-125, and FK-5-1-12 can extinguish fires through heat absorption because they have very high heat capacities.

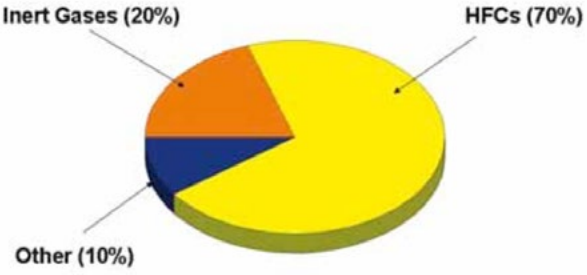

Figure 1. *Worldwide Clean Agent Market* Chemours, Spring 2011

According to the US chemical company Chemours, 70% of the clean agent systems deployed in 2011 in all facilities were HFC systems, with inert gas systems accounting

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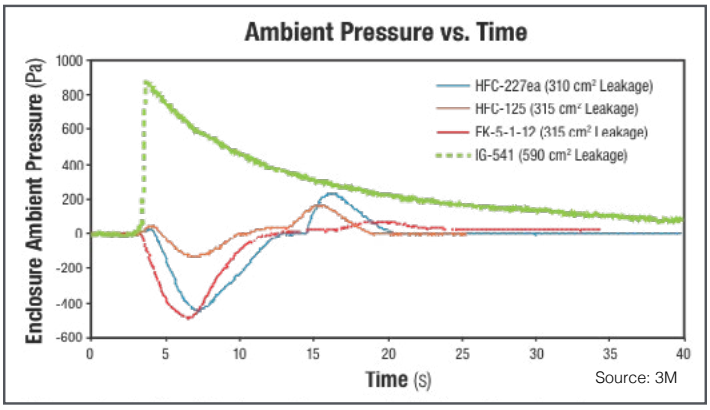
for 20% of the worldwide market at that time. Anecdotally, the use of inert gas systems in data centers is somewhat more common in Europe, where many of the high-profile failures due to inadvertent discharge have occurred, because of somewhat better environmental characteristics and lower operating costs, despite their higher initial cost. Inert gas systems also require less storage space than HFC clean agents.



Ambient enclosure pressures for various clean agent system discharges.

The release of high-pressure inert gases into enclosed data halls and white spaces in data centers, has been blamed for damaging IT hard disk drives (HDDs). Writing in Data Economy, Bart Goeman, Business Development Manager EMEA, 3M, (https://data-economy.com/data-centre-downtime-hidden-costs-fire-suppression/) explained, "Not all clean agents behave the same, and there are differences in the volume of gas used, the duration of discharge, the pressure at which they operate, and the noise they make upon discharge." These differences make inert gases the likely culprit for disk damage caused when fire suppression systems have been activated, either by actual fire, human error, malfunction, or false alarm caused by dust.

Goeman wrote, "High decibel levels at specific frequencies cause vibration in HDD spindles and actuator axes, which lead read/write elements to misalign and fail. The latest generation of HDDs cannot tolerate in excess of 12 nanometers (0.00000045 in.) of misalignment. As HDDs become more advanced, with more densely packed components, the likelihood is that there will be even more sensitivity to noise-induced failure."

He added, "While further research is required, so far there are no reported instances of halocarbon clean agents discharge leading to HDD damage. This is thought to be because halocarbons are typically discharged at lower nozzle pressures and in a much shorter time compared to inert gas systems, meaning less noise is produced and thus reducing the risk of vibration within HDDs."

In one incident in the fall of 2017, the accidental discharge of an inert gas fire suppression system during testing damaged the mechanical servers in a mission-critical banking facility in Eastern Europe, with the data center going off-line for several days. In another incident,

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an inadvertent discharge of an inert gas fire suppression system caused outages that led stock trading to be suspended in several Scandinavian countries. The Uptime Institute AIRs database includes at least two other similar incidents that led to data center downtime.

Uptime Institute has been unable to find an instance where inadvertent discharge of a low-pressure halocarbon systems damaged disk drives. This despite the fact that HFCs are 3.5 times more common than inert gas systems across all industries.

Mechanical server manufacturers are aware of the problems relating to the release of inert gas, with most believing that a combination of sound and pressure jar the read-write mechanisms of mechanical servers out of line. Sound from current systems have been measured as high as 120 decibels (dB), including alarm, during system activation.

One end user who recently experienced an outage caused by the inadvertent discharge of an inert gas fire suppression system reported that drive manufacturers are asking for noise limits as low as 90 dB two meters from the disk (about 6.5 feet), although others have asked for 100 dB at the nozzle. These limits are intended to minimize server damage. One fire system suppression vendor doubts the effectiveness of this approach, especially in heterogeneous facilities, as it says that no two server types respond to the same combination of sound and pressure, so that decibel restrictions can only limit the damage caused by the discharge of an inert gas system.

This means that even in instances where a clean agent system might be required or preferred, the use of inert gas systems should be avoided.

Conclusion

In previous research, Uptime Institute has reported that data center fires are relatively rare and are usually caused by inappropriate human activity in the data center (white spaces) or by electrical failures, which tend to be self-extinguishing. Other fires spread to the data center from other spaces. At these times, the need for an effective and functioning fire suppression system is obvious, and the system must provide life safety and protect expensive gear and mission-critical data. However, inert gas fire suppression systems can damage a facility and its servers, posing a risk to operations when inadvertently activated during testing and maintenance.

These considerations mean that the choice and design of a fire suppression system must meet the business needs and fire threats the facility is likely to face. Water-based systems,

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for example, will destroy sensitive IT gear when activated. In general, however, the loss of IT gear in a fire is acceptable to insurance companies and local authorities having jurisdiction (AHJs), which view equipment as replaceable as long as the system saves lives and preserves the building. In some instances, the insurance companies may require the use of a water-based system. Data center operators may not share this view, having invested millions of dollars in facilities and equipment and with incalculable investments in the data.

According to one major vendor of both types of fire suppression systems, clean agent systems better protect IT equipment because they do not damage electric and electronic circuits, even under full load operation. In addition, these gas systems can suppress deep-seated fires, including those inside a cabinet or beneath a raised floor. Pre-action systems, which also remove the presence of water from the data center floor except when activated, are another alternative.

Inert gas and HFC clean agents extinguish fires very differently. Inert gas systems display oxygen in a room, thus starving a fire of fuel. Halocarbon agents remove heat from the fire, which also extinguishes the fire. For non-IT purposes, the two approaches perform approximately equally well.

Clean agent fire suppression systems require that a room be well sealed. This is required so that the agent can disperse into the room and does not escape through any openings within the room. The agent must remain in the room long enough to ensure that the fire does not re-flash and to provide adequate time for emergency forces to respond. Venting may be required for halocarbons. It is necessary that a calculation be performed to determine the size of the vent. Inert gas systems must be vented to relieve the pressure that is created by a system discharge.

The use of a highly pressurized system in a data center environment introduces additional operational risk. A damaged valve head can propel a tank through a solid wall or kill or maim operations personnel standing in its path (https://www.youtube.com/watch?v=TZCLFY0wb7k).

In summary, Uptime Institute believes the limited risk of a fire originating in a data center hall makes nitrogen-charged, preaction or dry-pipe, water-based fire suppression systems preferable for most data center operators. The market also includes a number of clean agent suppression systems that are appropriate to protect priceless or irreplaceable equipment or to meet certain other business requirements.

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