FIRE PROTECTION IN DATA CENTERS: WHAT IS THE MOST SUITABLE SOLUTION?
1. Scope

The aim of this white paper is to give basic information to non-specialists that need to evaluate the fire suppression system that is most suitable for their constraints. This evaluation was conducted based on the practices and experiences made by installers or EPC contractors.

This white paper lists the main fire suppression systems used for fire protection of data centers, comparing respective technologies and pointing out possible limitations, restrictions of use and assets or disadvantages of these fire protection solutions.

2. Introduction

Today data centers are one of the main components of modern technologies, communication infrastructures, as well as world exchanges and businesses. Therefore, the need to protect data center equipment against intrusion and destruction is becoming not only more and more important but rather indispensable.

According to studies, the global data center IP traffic is expected to more than triple by 2020, from 4.7 zettabytes of data per year to over 15.3 zetta-bytes per year. (1) International Data Corporation (IDC) forecasted that the total number of data centers of all types will reach 8.6 million worldwide by the end of 2017.

On the another hand, space dedicated to data centers globally will reach nearly 2 billion square feet by 2018, up from just over 1.8 billion square feet in 2013 (3). And construction spending on data centers is expected to grow at more than 12 percent per year until 2020 (4).

In 2016, the average total cost was estimated to $740,357 (USD) per down-time incident (2) which represents $8,851 per minute of lost revenue and unproductive employees. The protection of data centers from downtime and service outages is an essential requirement for both businesses and consumers.
3. Fire hazard in data centers

Fires are perhaps the least predictable cause of data center outages but at the same time they are the greatest potential hazard to the health and safety of employees. Fire protection for modern data centers is complex because the overall protection program needs to be based on the level of acceptable risk for the data centers and yet needs to meet the rigors of reliability and business continuity goals. The main goals and objectives for the protection of data centers are primarily to secure life safety, to ensure the protection of property and finally to guarantee business continuity.

Therefore, it is imperative to develop a comprehensive protection program (which will be explained under NFPA 75) to address expected fire risks, rather than simply meeting simple local codes and regulations. This initiative provides a robust approach to meet these goals and objectives.

The 3 major design and infrastructure standards developed for the data center industry are ranked as follows:

- Uptime which has little or no literature on guidelines for fire safety. - ANSI/BICSI 002-2014 which requires that the fire protection program complies to NFPA standards.
- TIA-942 which also requires the fire protection program to comply to NFPA standards.

In addition, the UL white paper emphasizes that the requirements of the NFPA 75 on fire protection of data centers need to be met. (5)
4. Possible extinguishing systems

The NFPA 75 Standard for Fire Protection of Information Technology Equipment outlines a comprehensive approach analyzing risks when protecting data centers from fire.

It states that:

- Information technology equipment rooms and information technology equipment areas located in a building equipped with sprinklers shall have an automatic sprinkler system. The automatic sprinkler system protecting information technology equipment areas should be connected separately from the other sprinkler system.
- Information technology equipment rooms and information technology equipment areas located in a building not equipped with a sprinkler shall have an automatic sprinkler system, a gaseous clean agent extinguishing system or both.
- Where there is critical need to protect data in process, reduce damage of equipment, and facilitate the return to service, consideration shall be given to the use of a gaseous agent inside units or total flooding systems in information technology areas equipped with or without sprinklers.

Considering the information and facts mentioned above, a sprinkler system and/or a pre-action sprinkler system or a total flooding gaseous clean agent system is needed for the protection of information technology equipment areas. The pre-action sprinkler system/total flooding gaseous clean agent system would always be activated first. The sprinkler system rather serves as a secondary system.
4.1. Pre-action sprinkler system:

Sprinkler systems suppress fires with water and prevent a fire spread. According to NFPA 13, usually, a water supply of 30 minutes at a normal flow rate of 25 gallons per minute is required, i.e. that at least 750 gallons of water would dump on the equipment. Sprinklers are actuated by a thermal sensor when its temperature reaches 60°C or above.

Use in data centers:

- The high actuation temperature of sprinklers results to a long activation time of the system making it possible for the fire to spread quickly and leading to irreversible damages to the equipment.
- Water is therefore not a suitable extinguishing agent for electronical or electrical equipment (electrical conductivity).
- Water does not completely flood the space and cannot reach certain areas such as inside an enclosure or a cabinet.
- The costs for cleaning and water damage of the equipment (from about 750 gallons of water) need to be added to the outage cost caused by the fire itself.
- Installation cost level: very economic
4.2. Water mist system:

A water mist system uses the same method as traditional sprinklers but combines water with high pressure gas to create a very fine water steam. The small water droplets allow the water mist system to control, suppress or extinguish a fire by cooling both, the flame and surrounding gases by evaporation, displacing oxygen by evaporation, attenuating radiant heat by small droplets. This system can be considered as a mix of a sprinkler system and an inert gas system as it uses water to control the fire (it requires 3 times less water than a classic sprinkler system) and gas to displace oxygen.

Use in data centers:

- Although it is operating with a lesser amount of water upon activation, it could still be crashing the electronic equipment of the facilities with 240 gallons of water at its best.
- It performs well on large energetic fires, but has shown poor performance on small fires.
- It does not fully flood an area, and as a result it is not suitable for the suppression of hidden or obstructed fires, such as in an in-cabinet or in-rack fire. - Cleaning costs and water damage of the equipment (from 240 gallons water) would inevitable be a concern.
- Installation cost level: economic
4.3. Inert gas systems:

Inert gas systems suppress fire with the natural gases found in the air we breathe. They are called “total-flooding systems” because of their capacity to reach hidden spaces. It smothers a fire by displacing the oxygen in the protection zone to a level below which fire cannot burn.

It is cleaner and safer to use naturally-occurring inert gases to suppress fire rather than water or man-made chemicals, particularly in environments with sensitive electronic equipment or delicate assets.

Use in data centers:

- Suffocates a fire within seconds without collateral damage
- Prevents reignition for up to 20 minutes
- It fully floods a space (extinguishment of hidden or obstructed fires, such as in-cabinet or in-rack fires)
- No residue from the agent, no cleaning needed
- Safe for humans
- Safe for equipment (No damages created by the agent)
- Safe for environment
- Continuity of service (no downtime for clean-up or reconditioning) - Bigger pressure relief vents are needed (Because of fast discharge of inert gas) - Installation cost level: medium

Results:

The pre-action sprinkler system or water mist system for the data centers are not suitable solutions for the fire protection of data centers because of the high quantity of water dumping on the electronic equipment in the facilities in the event of activation.

These systems are more suitable for the protection of buildings rather than critical equipment. Furthermore, the downtime, the clean-up needed after the actuation and the physical collateral damages generated by these systems are not at all compatible with the level of the risks acceptable for the data centers. They clearly do not meet the rigors of reliability and business continuity goals expected in this sector.

Inert gas, the logical choice:

- No residues, nothing to clean up
- No chemical reaction
- No toxic reactions
- Safe for humans
- Safe for equipment (no damages created by the agent) - Safe for the environment
Restrictions for the use of inert gas systems in data centers

Envirogen™ gas systems seem to be the most suitable systems to data centers applications, however, they showed some limits due to unsuspected sources in the past. The white paper issued by Siemens in 2012 (6) described the potential damages to hard disk drives during the discharge of inert gas systems. After a test of battery in which they simulated the inert gas discharge conditions one by one, they isolated two different potential sources of damage: overpressure and high noise levels generated during an inert gas discharge.

Laboratory tests finally exonerated the overpressure factor and pointed out the high noise level was the origin of this damage. They also showed that a noise level over 105 dB could significantly reduce the hard disk drives performance and even temporary crash them at a noise level above 115 dB.

A more recent study conducted in 2017 by the prestigious Michigan Technological University (7), analyzed the performance of hard disk drives in high noise environments and highlighted a significant performance reduction of about 50% in writing and reading process caused by a sound pressure level above 110 dB. The study also demonstrated that the sound pressure level, as a single parameter, cannot be considered as dangerous for hard disc drives. It highlighted that the combination of sound pressure level together with frequency is the relevant parameter to consider for the prevention of a crash of HDD’s in data centers.

Fig.1 shown below represents the critical sound pressure level at frequencies from 500 Hz to 10 000 Hz where the HDD’s panel experiences performance reduction of 50%.

It is important to consider the 110 dB value as maximum sound pressure level acceptable on HDD’s to ensure their integrity and the safety of the data during a fire suppression system discharge.

**Figure 1**

![Critical Sound Pressure Level for HDD at frequencies from 500 Hz to 10 000 Hz](image_url)

<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
<th>Sound Pressure Level at which HDD performance was reduced by approx. 50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.50</td>
<td>80.0 dB</td>
</tr>
<tr>
<td>0.63</td>
<td>90.0 dB</td>
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<td>190.0 dB</td>
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<tr>
<td>10.00</td>
<td>200.0 dB</td>
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</table>
To solve this problem, Brigit Systems has developed the Envirogen™ Fire Suppression System with a sound reduction nozzle.

Envirogen™ is a complete fire suppression system that harnesses nature itself to fight fires and prevent damage. Using naturally-occurring inert gases to suppress fire, rather than water or man-made chemicals, is cleaner and safer particularly in environments with sensitive electronic equipment or delicate assets.

In addition, the Envirogen™ pressure regulator technology is extremely useful for an application in data centers as it modulates the discharge pressure to a constant 40-60 bar dynamic pressure delivering the design concentration within 60 to 120 seconds but with significant advantages:

- Greater safety: Prevents explosive force of discharge
- Saves time and reduces costs considerably: Enables the use of low pressure manifolds & pipeworks at a lower cost and an easy installation.
- It reduces the difficulty and the cost of location/fitting pressure vents in the protected space.
- Contributes to keep the hard drive integrity: Using an Envirogen™ pressure regulator results in a noise reduction up to 5 dB.

The Envirogen™ system together with its pressure-regulated technology, combined with the special design of the Envirogen™ Silent Nozzle is the perfect fire suppression system solution for the protection of data centers.

Envirogen™ Silent Nozzle is an extinguishing nozzle made for Envirogen™ systems. The nozzle has a specific design and is surrounded by 2 external filters allowing a significant noise reduction during a system discharge.

- The following fig. 2 compares the critical sound power level exposed by the Michigan Technological University with the sound pressure generated from a standard nozzle and the Envirogen™ silent nozzles (The same most common orifice Ø was used for both nozzle, sound measurement performed by Metravib, third party laboratory).

**Figure 2**

<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
<th>Envirogen™ Silent Nozzle</th>
<th>Standard Inert Gas Nozzle</th>
<th>Critical Sound Pressure Level where 50% of HDD experience significant performance reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.50</td>
<td>70</td>
<td>90</td>
<td>110</td>
</tr>
<tr>
<td>0.63</td>
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<tr>
<td>10.00</td>
<td>200</td>
<td>280</td>
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</table>
In addition, the Envirogen™ Silent Nozzle has been tested by GTA (Technische Akustik GmbH), which is specialized in technical acoustic measurements. It was proven to reduce sound pressure level down to 90 dB (fig. 3).

The measurement was done according to the International Standard ISO 3744:2010: “Acoustics -- Determination of sound power levels and sound energy levels of noise sources using sound pressure -- Engineering methods for an essentially free field over a reflecting plane.”

Figure 3

Envirogen™ Silent Nozzle reduces the sounds below the danger level
Gas discharge over time

Discharge with standard nozzle with sound above danger level
Gas discharge over time
Sound is not the only important parameter. It is also important to consider the behavior of the Oxygen ($O_2$) level reduction. However, reducing the noise generated by an inert gas discharge is not the only aspect for the fire suppression with inert gas in data centers. The innovative Envirogen™ technology allows to perfectly combine the noise reduction required to preserve the hard disks and to achieve the extinguishing efficiency needed to protect the data against fire loss.

The unique design of the Envirogen™ Silent Nozzle allows a diffusion of the extinguishing agent on the side and the bottom of the nozzle due to the radial and axial flow resulting in a more efficient extinguishment than with other competitive solutions for the protection of sensitive equipment.

As demonstrated in fig. 4 and 5, we observe a similar distribution efficiency to the ceiling, center and bottom of the room with the standard as well as the Envirogen™ Silent Nozzle (the same orifice was used for both tests).

**Figure 4**

![Graphs showing oxygen distribution in the room with standard nozzle and Envirogen™ silent nozzle](image)

- Oxygen distribution in the room with standard nozzle
- Oxygen distribution in the room with Envirogen™ silent nozzle

- Nozzle pressure
- Cyl pressure
- $O_2$ ceiling
- $O_2$ mid height

$O_2$ ceilings covered by $O_2$ mid height curve
5. Conclusion

Data centers play a major role in today’s business activities and in an unfortunate event of a fire, the three pillars (1- life safety, 2- property protection, 3- business continuity) for the fire protection of critical equipment must be achieved.

Data centers are nowadays an increasing growth factor for all economies. Therefore, outages generated by a fire or an unsuitable fire extinguishing system could have inconceivable consequences for businesses that absolutely need to maintain constant access to their data.

Finding the most suitable fire protection solution for data centers is therefore indispensable. Due to different analyzes, the complete Envirogen™ fire suppression system together with its pressure regulator and the Envirogen™ Silent Nozzle represent the safest, most efficient and cost-effective choice as fire suppression system for data centers.

Abbreviations:

- EPC: Engineering, procurement, and construction
- dB: decibel
- SPL: Sound Pressure Level
- HDD: Hard Drive Disk
- kHz: kilohertz

Definitions:

Sound Pressure Level (SPL): SPL is actually a ratio of the absolute, Sound Pressure and a reference level (usually the Threshold of Hearing, or the lowest intensity sound that can be heard by most people). SPL is measured in decibels (dB).
Envirogen™ is associated with the Brigit Group of Companies with over 20 year of experience within the Fire Protection Industry