The Protection of Data Centres

Economic and Environmental Consideration of the Alternative Technologies Available

Mr A Elder and Dr T R Nichols, CPhys MIFireE

Johnson Controls

CONTENTS

Introduction 4
Risk Assessment 4
System Suitability 4
Sprinkler Systems 5
Water Mist Systems 5
Gas Extinguishing Systems 6
Detection 7
Hypoxic Systems 9
Cost/Benefit Analysis 9
Summary 10

INTRODUCTION

Data centres are provided with fire suppression and detection measures to protect critical data and help minimise business interruption. At least part of the protection may be provided by a gas extinguishing or water sprinkler/water mist systems. The consideration of a particular type of system has historically been determined by specialist consultants, who in turn have been influenced by manufacturers and their own experience. Regular builders and owners of data centres have often implemented their own measures, some of which have been imported from other countries, particularly the US. This article provides a brief summary of the alternative technologies and compares the relative merits, costs and environmental influences. Whilst this paper focusses primarily on the suppression systems, a suitable fire detection and alarm system within a data centre is also very important and usually requires a comprehensive range of measures. Systems are usually interconnected to the main building system, where the data centre is part of a larger building complex.

RISK ASSESSMENT

The type of fire detection and protection system used in a data centre should be determined from a suitable risk assessment. It is outside the scope of this paper to detail such an assessment but the following items should be considered :-

- Which areas are to be protected? It is likely that more than one form of fire protection system is required.
- What are the loss criteria? Any system operated by heat detection or thermal bulbs will be slower to respond than one operated by smoke. Failure to detect a fire early could result in greater fire damage.
- In the data centre processing hall - is every cabinet critical; or is it mainly infrastructure that needs to be preserved?
- What is the effect of water on sensitive electronic components (particularly those that cannot be powered down upon discharge?
- Gas extinguishing systems activated by sensitive detection systems will operate quickly, often before a fire develops from smouldering; extinguishing the fire and providing opportunity for cost effective repairs with minimal disruption to business. Upon eventual discharge of water based systems, equipment will require replacement due to fire, smoke exposure and some water damage.

SYSTEM SUITABILITY

Once the risk assessment has been completed, then a review of fire protection methods can be carried out. Some of the criteria detailed below, may influence the type of fire protection that would be offered. Key questions that can arise over the differing types of fire protection methods include:-

- Storage space
- Installation cost
- Maintenance cost
- Other infrastructure costs, e.g. water supply, pipe sizes, requirements for venting/extract
- Reinstatement/refilling procedure/costs after an event
- Insurers requirements
- Environmental considerations

SPRINKLER SYSTEMS

Many buildings housing data centres have some form of sprinkler protection. Sprinklers provide a well proven, prescriptive form of protection, covered by thorough standards and in many countries, third party certification of both product and installation companies. Sprinklers are essentially nozzles held closed with a frangible bulb that acts as a heat detection device. When sufficient heat has been generated, the bulb ruptures opening the nozzle.

Sprinkler systems are designed as wet or dry (pre-action), dependent on the design criteria for the risk, and likelihood of freezing. The nozzles are fixed to a pipe network that is fed by a central water supply. The size of the pipe work, pump set and amount of water storage is determined by the design criteria known as hazard classification. Under the EN12845 standard, an ordinary hazard 1 requires a system capable of flowing water over a protected area of 72m^2. An insurer's minimum expectation for data centres would be ordinary hazard, so requiring 5mm/min over 216m^2 and maybe higher due to airflow and the presence of hot/cold aisle containment arrangements. Since typically a sprinkler covers 12m^2, under EN12845 this is equivalent to a minimum of 6 nozzles operating dependent on the final layout. FM requirements for data centres are more onerous and have been recently classified as HC-2 with over three times the design area and 60% higher water density (at 8mm over 230m^2) than currently applied in Europe.

Sprinklers can provide protection throughout the building; their performance in fire scenarios is well proven, but the response time is relatively slow, since heat is the activating mechanism. The use of standard response frangible bulb elements in the sprinkler heads protects against unwanted activation sometimes encountered with fast response frangible bulbs in the event of heat spikes sometimes encountered in data centres. The water generated per sprinkler is also significant so the consequential damage can be considerable if delicate or costly equipment is to be protected. It is for this reason that data halls that are sprinkler protected are based on the pre-action type, whereby the pipe work is normally dry and only fills with water when a primary detection system has been activated. The activation of the sprinkler(s) will still only occur with heat, and whilst generally only one or two sprinklers will be activated, the design quantity is much greater. Recent testing by FM on both Johnson Controls ULF water mist and sprinklers have resulted in FM Global changing their data sheet 5-32 to reflect the increase in hazard classification. Their results were presented at the NFPA conference in June 2015.

Sprinklers do not provide three dimensional protection and will not penetrate cabinets, and as such are generally designed for fire control, property protection purposes and life safety systems.

WATER MIST SYSTEM

Water mist is a relatively new technology that has been developed for marine applications and extended into land-based use. Water mist is based on using a lower quantity of water than sprinklers, but in a finer droplet form. Essentially it uses a different application technology to achieve this. Water mist is commercially available in two forms – low pressure systems operating at less than 15 bars, and high pressure systems that typically operate at 70 bars upwards. The water density required is dependent on the type of fire and the application. For example, very hot fires (Class B and Class F) can be extinguished with very small quantities of water (water density below 0.8 mm/m^2). For Class A or deep seated fires, extinguishing cannot necessarily be achieved but the tested performance must be equal or better than the equivalent sprinkler design. With a water density between 1.6mm/m^2 to 2.1mm/m^2, this is generally much less than the equivalent sprinkler system.

Since less water is used, the comparative collateral damage and clean-up is lower. Additionally infrastructure such as water storage tanks, pump sets and pipe sizes are smaller than the sprinkler system equivalent.

Water mist is the only practical alternative to carbon dioxide for the protection of diesel generators as it can be applied locally. However, since the application is very much manufacturer dependent and until recently the technology had been beset with virtually no standards (by its nature it is not possible to have a prescriptive standard for all systems), it is essential that the chosen product has evidence of fit for purpose testing, or third party accreditation. Beside the current standards: European Technical Specification TS EN 14972, NFPA 750 and BS 8489, there is now a test protocol that has been released by FM Global. This protocol is specifically for data centres, now classed as HC-2, and covers fire tests and component approval to cover scenarios including ventilated areas; propagating cable fires; hot/cold aisle arrangements; under-floor and pre-action systems. At a minimum any water mist system supplied should have this approval.

Water mist, like sprinklers is not designed to penetrate cabinets but will prevent fire from spreading outside it. The advantage may be a speedier reinstatement of the system after activation along with minimal clean-up compared with sprinklers.

GAS EXTINGUISHING SYSTEMS

In the protection of actual data halls, the aforementioned technologies of sprinklers/water mist are only designed for the control of a fire (although extinguishing may be achieved). Gas extinguishing systems are actuated via smoke detection so are much more rapid in deployment, with a total discharge time between 10 seconds and 2 minutes depending on the gas used and design criteria. Gas systems are clean agents, i.e. do not create a residue on discharge. The gas is stored in steel containers that are located adjacent the risk, or remotely, again dependent on the gas type and availability of storage space. Often reserve containers are installed in case of discharge so that business downtime is not affected. Since gas discharges rapidly and increases pressure in the protected enclosure, pressure relief dampers are required to safely vent the pressure.

Gas systems are normally one of two types; halocarbon or inert. Halocarbon agents systems are liquefied gases super-pressurised with dry nitrogen to discharge as a gas in 10 seconds. Commonly used halocarbon agents include FK-5-1-12 (known as Novec 1230) or HFC-227ea (known as FM200). Extinguishing is achieved by chemical cooling and inhibition of the flame. Design concentrations that vary according to the design standard and the type of agent are between 4.5% and 8.5% by volume. HFC's have been identified as global warming gases covered by the fluorinated greenhouse gases (F Gas) regulations. Novec 1230 (offered in the SAPPHIRE system) is a fluoroketone with a negligible global warming potential and is exempt from these regulations. It comes with a 20 year manufacturer's warranty (only Johnson Controls warrants the system as well as the agent) against any future restriction of use. Often but not exclusively the systems are modular, i.e. are contained in single containers, with individual pipe networks, and are often located immediately adjacent or within the risk.

Recent introduction of 42 bar Novec systems from Johnson Controls have increased their design flexibility permitting systems to be more easily designed to protect multi-hazard facilities and using longer pipe runs than hitherto possible.

Inert gas systems consist of pressurised inert gas typically at 150, 200 or 300 bar and normally stored in 80 litre or 140 litre containers. The extinguishing mechanism is through the reduction of oxygen to less than 15% by volume. There are two types of system – constant flow, such as the Johnson Controls iFLOW system that use lower grade pipe and reduces pressure relief requirements; and older orifice technology where the pressure is reduced to 60 bar before entering the pipe work.

Discharge time is typically between 60 and 120 seconds, with the longer discharge times reducing the free vent area required for pressure relief. Inert gas systems are often configured to protect multiple areas with sufficient containers to protect the largest enclosure and directional valves to direct the gas into the appropriate hazard area. Directional valves can be fed by individual pipe work from the container bank or from a high pressure extended manifold that extends throughout the protected building. Where fewer containers are required from the total maximum, different actuation circuits and non-return valves are used in the pneumatic actuation circuit or simpler more flexible binary systems can be used. Inert gas system containers can be located remote from the hazard areas.

Halocarbon and inert gas systems are covered by the EN15004 series of standards.

Containers are required to be hydrostatically tested periodically in some jurisdictions, which in Europe is 10 years.

Refill costs of systems are influenced by the cost of the agent and the labour required to handle the containers.

DETECTION

A notable trend within the IT industry is to significantly increase computing power without increasing usable floor space within the datacentre. The use of increasingly powerful computer servers results in greater power density and increased power dissipation. As this process proceeds more heat is generated, which increases potential ignition sources, heightening the possibility of a fire developing.

It has become accepted practice that critical facilities require a highly sensitive smoke detection system, such as Johnson Controls Triple Sensing Technology. This is a combined optical smoke, carbon monoxide and heat detector which provides reliable early fire detection and false alarm immunity. An additional unique function also allows the detection of poisonous gas (CO) leaks.

By digitally transmitting the smoke, heat and gas data from the Triple Sensing Technology to powerful fire algorithms located in the control panel, the relationship and values between each medium will quickly confirm or reject individual events as being a real fire or a false alarm.

The Triple Sensing Technology can operate in single or multi-mode with the parameters for each individual element set at commissioning, in line with the application environment.

Following along with the above mentioned increased computing power in the modern datacentre is the requirement for energy conservation or efficiency. The two issues can be opposed from one another in most cases. To focus the cooling where it is needed most (on the server) modern datacentre's have begun using various physical containment methods where the hot air and cold air are kept separated and directed around the equipment in an appropriate fashion.

The modern datacentre is no longer a single large space – rather it is a series of “data halls” which segregate the hot exhaust air and the cold supply air to focus the cooling where it is required most – on the servers. It is important to note that in retro-fit applications care must be taken to insure that any containment methods do not interfere with the detection or suppression equipment which could hinder their effectiveness.

Within these modern datacentres, where high airflow is present due to high levels of mechanical cooling required an Aspirated Smoke Detection (ASD) system such as VESDA may be preferred. Aspirated detection systems operate by constantly sampling the air from multiple points throughout the enclosure or protected space and return this sampled air to a central detector which analyses the air for products of combustion.

These systems are not totally dependent on thermal energy to transport smoke to the detector, but do require the use of a number of sample pipes connected to the detector, with appropriately spaced holes, to be laid out above or below a ceiling in parallel runs, some metres apart. Ultimately smoke laden air is drawn into the pipework through the holes and onwards to a sensitive smoke detector, using the negative pressure of an aspirator (air pump).

Ultimately, it is the type of smoke generated within a data centre and the dynamics of the airflow which guide the fire engineer to design the best fire detection system for that environment based on spot detectors or air sampling, with detection of smoke being the a critical part of the solution.

An additional detection challenge in the modern data centre is the standby power room – as with most modern day processes many modern data centres are “24/7” style facilities with no tolerance for process shut down. To counter the effects of AC power loss issues from the local power supplier modern data centres utilize diesel powered standby generators and / or large arrays of DC batteries to keep the computer servers powered in cases where the AC power has been lost.

These battery rooms present a significant hazard requiring protection as batteries give off hydrogen gas during the life of the battery. Should the gas build up a potentially explosive condition can be present within the space to detect this situation hydrogen gas detection is used within the battery room to alert the operator. There are numerous types of spot type and aspirated type gas detection products which can fit the need.

HYPOXIC SYSTEMS

Hypoxic systems are relatively new but have some advantages and disadvantages, in the protection of applications such as archives, museums, etc. Hypoxic systems work by injecting oxygen reduced air into the hazard so that the ambient air is maintained typically at 15%. In such systems, a fire cannot start, and so they are often referred to as fire prevention systems.

At sea level, 14.5% to 15% oxygen content is equivalent in human physiology to being at around 2,500m altitude, or in a commercial aeroplane. With very rare exceptions this level is safe for use in occupied areas – in fact, more than 5 million people live at altitudes with the same or less equivalent oxygen. The hypoxic air is produced by forcing compressed air through a membrane that separates the nitrogen and oxygen molecules. The oxygen reduced air is then injected to the risk. Consideration needs to be made of inward air leakage, and any risk where this is below 3% can usually be protected. Open doors can normally be accommodated but through drafts should be avoided. Areas subject to occupation can be fed with a continuous stream of hypoxic air to provide some degree of air change.

Systems normally are designed to be fire safe (below 16%) within 48 hours, and normally operate on a duty cycle of 50% to 70%. Potentially this large volume of 'safe' air acts as a reservoir and continues to provide protection, usually for hours dependent on leakage. Hypoxic systems operate 24/7 and a fire cannot start and can cover multiple areas at the same time, thereby avoiding the protection downtime that is usual following the activation of the previously mentioned systems. There is no cost of refill, and no business interruption during this process.

There is no need for pressure relief or extensive pipe networks (the hypoxic air can be injected into a central duct, CRAC unit, or through room injection points), so the installation time is minimal as is the plant space required. However, costs for compressors and membranes that form the heart of the system are high for larger units required, and there is the on-going running costs of compressors (up to 200kW +). The principle factor that prohibits their use however, is that of leakage. If leakage is not contained, the system will be very large and may be very uneconomical to run, or may not work at all. Even the most efficient systems will need continuous power of at least 55% of the compressor rating and more normally nearer 80%.

Data centres are often positively pressurised and hypoxic systems can't deal with this level of leakage and on this basis are not generally recommended as being a practical solution.

COST / BENEFIT ANALYSIS

The size and complexity of the risk often helps in the determination of the particular solution. Both small and large hazards may be protected with gaseous systems and the specifics of the particular data centre, may influence which technology is selected. Water mist is applicable for local application & total flood hazards and in lieu of sprinklers where collateral damage is a concern, space savings are required or pipe runs clash with other services. Water mist can be more cost effective too, dependent again on the size, and complexity, particularly with regard to civil works required e.g. tank houses, or the break tanks. By and large, where water mist is selected, because of approvals and cost, for data centres, low pressure Johnson Controls ULF is a preferred option where this technology has been deemed suitable, in comparison with competing high pressure solutions.

Insurers should be consulted when the type of fire protection system is being considered.

SUMMARY

This white paper summarises the practical combined experiences of the authors over 60 years including throughout the halon changeover. It does not cover all aspects, but reflects on experiences in actual discharge scenarios, costs, expert witness work and complex installation projects. On personal recommendations based on cost, reliability and environmental impact then the optimum solution for data centres would be a sprinkler system to protect the building and gaseous systems to protect the data halls and peripheral UPS and battery rooms and water mist to protect the DRUPS (AquaMist ULF or AquaMist FOG). Water mist may be extended into other areas, providing it is installed in accordance with the limitations of test for the specific application.

ABOUT THE AUTHORS:

Alan Elder is Industry Fellow - Engineered Systems for Johnson Controls. He is the UK Principal Expert to ISO, Chairman of various technical committees, including British Standards FSH18/6, Fire Industry Association - Working Group Gases, EUROFEU Fixed Extinguishing Installations Section and a member of several CEN TC191 technical committees.

Dr Tim Nichols is Sales Director Water Mist for Johnson Controls. He is an author of a book on Fire Extinguishing Systems; working group member of FIA water mist, member on the FIA Extinguishing Council, and BSI FSH/18/06 and TC 191/WG6/TG3. He is a member of the IFE; Institute of Physics; and has written several papers on fire engineering and undertaken expert witness work.

Johnson Controls is a world leader in the development, approval and manufacture of all types of gaseous, water mist, water sprinkler and foam systems, and can therefore offer solutions based on the most appropriate technology for the protected hazard.

About Johnson Controls' Building Technologies and Solutions

Johnson Controls' Building Technologies & Solutions is making the world safer, smarter and more sustainable – one building at a time. Our technology portfolio integrates every aspect of a building – whether security systems, energy management, fire suppression or HVACR – to ensure that we exceed customer expectations at all times. We operate in more than 150 countries through our unmatched network of branches and distribution channels, helping building owners, operators, engineers and contractors enhance the full lifecycle of any facility. Our arsenal of brands includes some of the most trusted names in the industry, such as Tyco®, YORK®, Metasys®, Ruskin®, Frick®, PENN®, Sabroe®, Simplex® and Grinnell®.

For more information, visit www.johnsoncontrols.com or follow @JCI_Buildings on Twitter.

Johnson Controls
Tyco Park, Grimshaw Lane
Newton Heath
Manchester, M40 2WL
Tel. +44 (0)161 259 4000
www.tfppemea.com

