Fire Suppression Systems

for

IT Comms and Data Centre

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Paul Kennedy

Chartered Institution of Building Services Engineers
27th November 2014
TYPICAL DATA CENTRE LAYOUT
DATA CENTRE FIRE RISKS
CHOOSING THE CORRECT SOLUTION
DESIGN CODES AND STANDARDS
FIRE TRIANGLE
DETECTION SYSTEMS
GAS SUPPRESSION SYSTEMS
WATER BASED SYSTEMS
SYSTEM INSPECTION AND MAINTENANCE
Q&A
COOLING SYSTEM CONFIGURATIONS

HOT & COLD AIR CONTAINMENT SYSTEMS

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Fire protection for modern data centres is complex, the protection strategy needs to be based on the level of acceptable risk for the data centre user.

A comprehensive protection program should be developed to address expected fire risks, rather than simply meeting local codes and regulations.

**Expected Fire Risks**

- Digital Equipment
- Wire and Cable Containment
- HVAC Equipment
- Raised Floors or Suspended Ceilings
- Other Combustibles (Packaging)

Lower Risk ➔ Higher Risk
CHOOSING THE CORRECT SOLUTION

The following conditions should be met for the purpose of designing a fire protection solution for a Data Centre.

a) identify the presence of a fire
b) communicate to the occupants and authorities
c) contain the fire and extinguish it if possible

Prior to selection, the design engineer must assess potential hazards...

a) Will the data centre have raised floors?
b) Will the data centre have suspended ceilings?
c) Will it have high ceilings?
d) Will personnel occupy the area?
e) Will detectors be obstructed in any way?
f) Will discharge devices be obstructed in any way?
g) What cause & effect strategy should be introduced?
h) How long will it take for local authorities to attend?
# CODES AND STANDARDS – GENERAL

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<td>8.1 General</td>
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<td>8.2 Environmental</td>
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<td>9.0 Safety</td>
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</tr>
<tr>
<td>9.1 General</td>
<td>11</td>
</tr>
<tr>
<td>9.2 Safety</td>
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<tr>
<td>10.0 Summary</td>
<td>11</td>
</tr>
</tbody>
</table>
Fire Protection for electronic equipment installations – Code of Practice

BS 6266:2011
NFPA® 13
Standard for the Installation of Sprinkler Systems
2013 Edition

LPC Rules for Automatic Sprinkler Installations 2009
Incorporating BS EN 12845

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How Standards Differ to Conventional Systems

Most Sprinkler Heads are approved to a specific risk classification and to the same K-Factor, pressure, spacing etc. Therefore the sprinkler design standards (EN 12845, NFPA 13, FM, CEA 4001 etc.) describe where and when you use these pre-approved components. Sprinkler standards advise on how to size the piping, where supports are to be located, the types of materials (carbon/galvanised steel) and so on...

This is not the case with Watermist Systems...

Each system has its own design parameters, set down by the manufacturer, which must be adhered to in order for the system to function. Fire tests are needed for the various applications/hazard classification and verified by a 3rd party.

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FIRE TRIANGLE

For a fire to survive it requires the presence of three elements.

Remove any one of the three to suppress a fire.

Inert gas systems will lower the oxygen level.

Traditional sprinkler systems will lower the temperature.

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DETECTION AND GAS SUPPRESSION SYSTEMS
DETECTION SYSTEMS

POINT DETECTION VERSUS AIR SAMPLING

POINT DETECTION

BS6266 RECOMMENDS A MIXTURE OF IONISATION AND OPTICAL DETECTORS TYPES AT 15 m² COVERAGE PER DETECTOR FOR AIR VELOCITIES < 4 METERS PER SECOND

AIR SAMPLING

PRIMARY DETECTION IE. MONITORING RETURN AIR FLOWS TO AIR HANDLING UNITS PROVIDES EARLY WARNING
DETECTION SYSTEMS

POINT DETECTION VERSUS AIR SAMPLING

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GAS SUPPRESSION SYSTEMS

FIRE CLASSIFICATION

<table>
<thead>
<tr>
<th>EMEA</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Solid</td>
<td>Solid</td>
</tr>
<tr>
<td>Materials*</td>
<td>Materials</td>
</tr>
<tr>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Flammable</td>
<td>Flammable</td>
</tr>
<tr>
<td>Liquids</td>
<td>Liquids</td>
</tr>
<tr>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Gases</td>
<td>Electric</td>
</tr>
<tr>
<td>D</td>
<td>Metal</td>
</tr>
<tr>
<td>E</td>
<td>Grease /</td>
</tr>
<tr>
<td>F</td>
<td>Cooking Oil</td>
</tr>
</tbody>
</table>

- Clean Agents are effective on class A, B and C fires.
GAS SUPPRESSION SYSTEMS

APPLICATIONS

The application for these systems are high value risks, namely:

- Computer Rooms
- Data Centres
- Vital machinery
- EDP Areas
- Communications Rooms

- These are Business Critical Facilities and if affected by fire, could result in major business disruption.

- A greater attention to Fire Engineering is required. Hazard Analysis is vital.

- Correct assessment of the risk is important.

- We need long-term fire protection solutions which are people and property friendly.
GAS SUPPRESSION SYSTEMS

TYPES OF GAS SUPPRESSION SYSTEMS

INERT GAS SUPPRESSION SYSTEMS

- Inergen IG541
- Argonite IG55
- Nitrogen IG100
- Argon IG01
- Carbon Dixoide CO₂

CHEMICAL GAS SUPPRESSION SYSTEMS

- Novec 1230
- FM200
GAS SUPPRESSION SYSTEMS

HOW DO GAS SUPPRESSION SYSTEMS WORK?

- NATURALLY OCCURRING INERT GASES SUCH AS INERGEN AND ARGONITE EXTINGUISH FIRE BY REDUCING OXYGEN

- CHEMICAL GASES SUCH AS FM200 AND NOVEC EXTINGUISH FIRE BY HEAT ABSORPTION AND CHEMICAL MEANS

- THEY INTERRUPT THE COMBUSTION PROCESS

- CLEAN, DRY, FAST – MINIMAL DAMAGE AND DOWNTIME
TOTAL FLOODING

- Gas is discharged into the protected space to develop a specific concentration uniformly throughout the entire space.

- 3-dimensional penetration.

- Agent must remain in area for up to 10 mins (or more)
GAS SUPPRESSION SYSTEMS

THE CHOICES

Chemical

OR

Natural
GAS SUPPRESSION SYSTEMS

CHEMICAL SYSTEMS – FM200

- Introduced in the early 90s
- Non Toxic - safe for people
- Discharges within 10s
- Zero Ozone Depletion Potential
- Atmospheric lifetime 36 years
- Global Warming Potential = 3300
- Monitored under Kyoto Protokol
GAS SUPPRESSION SYSTEMS

CHEMICAL SYSTEMS – NOVEC 1230

- Introduced in 2001
- Discharges within 10 seconds
- Clean – leaves no residue
- Non toxic – safe for people
- Zero Ozone Depletion Potential
- Atmospheric Lifetime 5 days
- Global Warming Potential = 1
- Good safety factor
- 25 and 42 Bar System available
<table>
<thead>
<tr>
<th>System</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>INERGEN</td>
<td>IG51</td>
<td>These systems employ natural gases such as nitrogen, argon and carbon dioxide or a blend of these gases.</td>
</tr>
<tr>
<td>ARGONITE</td>
<td>IG55</td>
<td>50% N2, 50% AR</td>
</tr>
<tr>
<td>NITROGEN</td>
<td>IG100</td>
<td>INERGEN</td>
</tr>
<tr>
<td>ARGON</td>
<td>IG01</td>
<td>52% N2, 40% AR and 8% CO2</td>
</tr>
<tr>
<td>CARBON DIOXIDE</td>
<td>CO₂</td>
<td>ARGONITE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50% N2, 50% AR</td>
</tr>
</tbody>
</table>
GAS SUPPRESSION SYSTEMS

DESIGN STANDARDS

- EN 15004-1:2008  FIXED FIRE FIGHTING SYSTEMS
- ISO14520-1 : 2006  GASEOUS FIRE EXTINGUISHING SYSTEMS
- BS7273-1:2006  ELECTRICAL ACTUATION OF FIRE SUPPRESSION
- NFPA 2001  CLEAN AGENT FIRE EXTINGUISHING SYSTEMS
- BS6266:2011  FIRE PROTECTION FOR ELECTRONIC EQUIPMENT INSTALLATIONS
- IS3218:2013  FIRE DETECTION AND ALARM SYSTEMS
GAS SUPPRESSION SYSTEMS

TYPICAL MECHANICAL LAYOUT

- Storage Containers
- Pipework
- Discharge Nozzles
Dedicated Chemical Agent Systems require numerous cylinders and can take up valuable floor space.
INERGEN Central Bank fully utilises valuable floor space.

Gas Discharge Zone

Directional Valves

Central Bank stored up to 100 metres away from risk area.
GAS SUPPRESSION SYSTEMS

OVERCOMING VOLUME RESTRICTIONS

Risk A
20 cylinders

Risk B
15 cylinders

Risk C
12 cylinders

Risk D
18 cylinders

20 cylinder central bank

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INERGEN gas discharge creates a mixture of 60% normal air mixed with 40% INERGEN gas.
GAS SUPPRESSION SYSTEMS

TYPICAL INERGEN SYSTEM

<table>
<thead>
<tr>
<th>%</th>
<th>22</th>
<th>18</th>
<th>16</th>
<th>14</th>
<th>12</th>
<th>10</th>
<th>8</th>
<th>6</th>
<th>4</th>
<th>2</th>
<th>0</th>
</tr>
</thead>
</table>

Safety Margin

Fire dies from start of discharge
And is extinguished within 60 seconds

12.5%
INERGEN/Oxygen Atmosphere

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When gaseous fire suppression is discharged into a protected area, the initial concentration meets the design requirements throughout the room. However, the gas dissipates from the room through vents, through gaps around doors, windows and ceiling tiles, etc.
As the gas leaks from the room, the effective layer drops.

Above this, the concentration is less than the amount required to extinguish the fire.
Heavy chemical gases leak quickly.

As the interface layer drops below the top of the protected equipment, the equipment becomes exposed to oxygen levels which can support combustion and could risk re-ignition.

GAS SUPPRESSION SYSTEMS

TYPICAL CHEMICAL SYSTEM
GAS SUPPRESSION SYSTEMS

TYPICAL INERT SYSTEM

INERGEN gas leaks out VERY SLOWLY because it has a similar density to air.

When INERGEN puts a fire out, it stays out.
IS PRESSURE VENTING REQUIRED?

All Gas Suppression Systems create pressure and require pressure relief.
GAS SUPPRESSION SYSTEMS

FAN TESTING – (ROOM PRESSURISATION & DE-PRESSURISATION)

Variable speed
Fan and screen

Air in and out

Fan unit

Digital manometer

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GAS SUPPRESSION SYSTEMS

FAN TESTING – (ROOM PRESSURISATION & DE-PRESSURISATION)

Fan testing – used to determine size of vents (if required) to prevent overpressure during discharge.

Pressure build up due to volume of gas entering the enclosure.

Overpressure vent
FAN TESTING – (SUPERIOR HOLDING TIMES)

- Less enclosure integrity required
- Fire fighting concentrations maintained when integrity is breached
- INERGEN density as close to natural air as possible

<table>
<thead>
<tr>
<th>Agent</th>
<th>Density</th>
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<tbody>
<tr>
<td>Inergen</td>
<td>1.29 Kg/m³</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>1.42 Kg/m³</td>
</tr>
<tr>
<td>NAF SIII @ 8.6%</td>
<td>1.43 Kg/m³</td>
</tr>
<tr>
<td>FM200 @ 7%</td>
<td>1.70 Kg/m³</td>
</tr>
<tr>
<td>Air on its Own</td>
<td>1.20 Kg/m³</td>
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</table>
# GAS SUPPRESSION SYSTEMS

## PRO’s AND CON’s

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<tr>
<th>Feature</th>
<th>Chemical</th>
<th>Natural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrosive/toxic products</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Visual obscurcation</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Sudden temperature drop</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Critical design concentrations</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>High cost of refill</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Global Warming effect*</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Tested on Humans</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Cylinder storage consideration</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Room leakage factor</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Pressure Relief Venting</td>
<td>yes (P+N)</td>
<td>yes (P)</td>
</tr>
<tr>
<td>Dedicated Extract System</td>
<td>yes</td>
<td>not essential</td>
</tr>
</tbody>
</table>
GAS SUPPRESSION SYSTEMS

DECOMPOSITION PRODUCTS

Unlike Chemical gases that react with a fire to create corrosive HF decomposition products

INERGEN does NOT create corrosive HF decomposition products
GAS SUPPRESSION SYSTEMS

LEGISLATION

- Halon 1301/1211 - BANNED. Mandatory removal December 2003
- HCFCs (NAF S-111) - EC ban from 1995
- HFCs (FM-200) - BANNED Denmark, Sweden and Switzerland. Restricted in U.K. and Ireland. Limited emissions on HFCs (no testing)
- DETR statement HFC’s “Not A Sustainable Technology In The Long term”
- EU HFC Leakage Monitoring – F Gas
EN15004 Recommends…

Every 3 Months : Electrical Detection Systems

Every 6 Months : Mechanical Systems

Every 12 Months : Room Integrity Tests

Every 10 Years : Cylinder Pressure Testing
WATER BASED SYSTEMS
WATER BASED SUPPRESSION SYSTEMS

TYPES OF WATER BASED SUPPRESSION SYSTEMS

CONVENTIONAL SPRINKLER SYSTEMS

- Wet Type Sprinkler Systems
- Dry Type Sprinkler Systems

PREACTION SPRINKLER SYSTEMS

- Non Interlock Preaction System
- Single Intelock Preaction System
- Double Interlock Preaction System

WATER MIST SYSTEMS

- High Pressure Water Mist Systems
PRE-ACTION SPRINKLER SYSTEMS

DEFINITION AND TYPES OF PRE-ACTION SYSTEMS

NFPA 13 § 3.4.10* Preaction Sprinkler System

... A sprinkler system employing automatic sprinklers that are attached to a piping system that contains air that might or might not be under pressure, with a supplemental detection system installed in the same areas as the sprinklers...

Piping is wet from pump unit up to the section valve, all pipe work down stream of the section valve is dry and system integrity is monitored by air.

Operating Pressure = 5 – 10 bar
PRE-ACTION SPRINKLER SYSTEMS

DEFINITION AND TYPES OF PRE-ACTION SYSTEMS

NON INTERLOCK PREACTION SYSTEM

A detector operating first will cause water to flow into the sprinkler piping in readiness for the operation of a sprinkler. However, whenever a sprinkler head operates first, this system will respond as a dry pipe system with water flow from the sprinkler system.

SINGLE INTERLOCK PREACTION SYSTEM

A detector operating first will cause water to flow into the sprinkler piping in readiness for the operation of a sprinkler. When a sprinkler head operates first, an alarm will be sounded however the sprinkler piping will not be flooded until a detector operates.

DOUBLE INTERLOCK PREACTION SYSTEM

Both a detector and a sprinkler head must operate before the system piping is flooded and water discharged onto the source of the fire.
# PRE-ACTION SPRINKLER SYSTEMS

## Definition and Types of Pre-Action Systems

<table>
<thead>
<tr>
<th></th>
<th>Non Interlock</th>
<th>Single Interlock</th>
<th>Double Interlock</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>System Flooding</strong></td>
<td>![Image]</td>
<td>![Image]</td>
<td>X</td>
</tr>
<tr>
<td><strong>System Discharge</strong></td>
<td>![Image]</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
</tbody>
</table>
PRE-ACTION SPRINKLER SYSTEMS

MAJOR COMPONENTS OF PRE-ACTION SYSTEMS

- Fire Alarm Panel
- Pump Unit Control Panel
- Compressor
- Pre-action Valve
- Pre-action Valve
- Pump
- Tank
- Smoke Detector
- IR/UV Detector
- Nozzle
HIGH PRESSURE WATER MIST SYSTEMS

DEFINITION OF WATER MIST SYSTEMS

NFPA 750: A water spray for which the 99% of the flow-weighted cumulative volumetric distribution of water droplets, Dv0.99, is less than 1000 μm at the minimum design operating pressure and is measured in a plane 1M from the nozzle.

1000 μm = 1.0 mm, AFIS System = 10 – 150 μm (0.01 – 0.15 mm)

1.0 mm diameter = 2 m² / litre
0.01 mm diameter = 200 m² / Litre

Operating Pressure = up to 100 bar
SIGNIFICANCE OF DROPLET SIZE

The smaller the droplet…

- Greater Surface Area
- Evaporate Quicker
- Remain Airborne Longer

As a consequence…

- Reduces Radiant Heat
- Improved Smoke Scrubbing
- Smaller Footprint
HIGH PRESSURE WATER MIST SYSTEMS

HOW DO WATER MIST SYSTEMS WORK

3 Main Physical Effects

Evaporation Cooling
- ~ 330 kJ to heat 1 liter from 20°C to 100°C
- ~ 2260 kJ to convert 1 litre to steam
- Energy absorption cools both flames and plume

Oxygen Displacement
- ~ 1600:1 volumetric expansion
- Steam generation aids lowering oxygen concentration

Radiation Blocking
- Prevents the fuels from volatizing and burning
- Reduces fire growth (inhibiting fire spread)

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HIGH PRESSURE WATER MIST SYSTEMS

WHY SUCH HIGH PRESSURES

Momentum / Kinetic Energy…

➢ Smaller droplets require a higher Kinetic Energy to penetrate the fire plume to get to the source of the fire…
Full-scale model of the actual Iliad Data Center (25 m², 5 m high)
HIGH PRESSURE WATER MIST SYSTEMS

MAJOR COMPONENTS OF WATER MIST SYSTEMS

- FIRE ALARM PANEL
- PRE-ACTION VALVE
- SMOK DETECTOR
- IR/UV DETECTOR
- NOZZLE
- PUMP UNIT CONTROL PANEL
- COMPRESSOR
- PRE-ACTION VALVE
- PUMP
- TANK

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## COMPARISON OF SYSTEMS

### SAMPLE DATA CENTRE PROJECT

Floor Area = 1,000 m²  
Height = 3.0 m  
Volume = 3,000 m³

<table>
<thead>
<tr>
<th></th>
<th>Sprinkler</th>
<th>HPWM</th>
<th>Inert Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard Classification</td>
<td>HC 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area of Operation (m²)</td>
<td>140</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head / Nozzle Pressure (bar)</td>
<td>0.5</td>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td>Head / Nozzle K-Factor</td>
<td>80</td>
<td>2.75</td>
<td>n/a</td>
</tr>
<tr>
<td>Design Density (mm/min)</td>
<td>4</td>
<td></td>
<td>n/a</td>
</tr>
<tr>
<td>No. Heads / Nozzles Operating in AMAO</td>
<td>12</td>
<td></td>
<td>All</td>
</tr>
<tr>
<td>Water Supply Duration (min.)</td>
<td>60</td>
<td></td>
<td>n/a</td>
</tr>
<tr>
<td>Water / Gas Volume (m³)</td>
<td>42*</td>
<td>14*</td>
<td>1,840</td>
</tr>
<tr>
<td>Tank / Cylinder footprint (m)</td>
<td>5.0 x 4.5**</td>
<td>3.0 x 2.5**</td>
<td>6.0 x 1.5</td>
</tr>
<tr>
<td>Pump footprint (m)**</td>
<td>9.0 x 5.0</td>
<td></td>
<td>n/a</td>
</tr>
</tbody>
</table>

* = Excludes Hydrants & Hose Reels  
** = Assumes 2.0 Meters High  
*** = Assumes Primary and Secondary Pump