# DATA CENTERS AND RELATED FACILITIES

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## 1.0 SCOPE

This data sheet identifies the hazards and provides property loss prevention recommendations for data centers and their critical systems and equipment.

### 1.1 Application

Related facilities covered in this data sheet include network control rooms, cryptocurrency and telecommunications (Voice Over Internet Protocol [VOIP]) facilities that use alternating current (AC) power.

See Appendix G for a case study on the cryptocurrency occupancy.

This data sheet does not cover the following:

- Telecommunication and broadcast facilities that use direct current (DC) power; refer to FM Property Loss Prevention Data Sheet 5-14, *Telecommunications.*
- Motor control centers and switchgear rooms; refer to FM Property Loss Prevention Data Sheet 5-19, *Switchgear and Circuit Breakers.*
- Industrial control system (ICS) instrumentation equipment rooms, control centers or process control rooms; refer to FM Property Loss Prevention Data Sheet 7-110, *Industrial Control Systems.*

### 1.2 Hazards

The main hazard associated with data centers and similar facilities is damage to sensitive electronic equipment caused by smoke, liquid from a variety of sources and natural hazard exposures.

Fire-related hazards include energized equipment and cabling, power supply areas (backup generator fuel systems and UPS batteries), and storage of spare cables (plastics) and other combustible materials. Fire involving energized equipment and cabling will grow slowly, release large amounts of smoke, and cannot be completely extinguished until the power is shut off.

Hazards to the functional operation of a data center include lack of power to data processing equipment support systems (e.g., HVAC).

### 1.3 Changes

**January 2026.** Full revision. The following changes were made:

A. Reorganized and streamlined guidance in all sections.

B. Revised guidance for Section 2.2.11, Earthquake, to reference Data Sheet 1-2, *Earthquakes,* and Data Sheet 2-8, *Earthquake Protection for Water-Based Fire Protection Systems*, as authoritative sources.

C. Added reference to Data Sheet 1-34, *Hail Damage*, for Section 2.2.12, Windstorm and Hail.

D. Revised Section 2.4.3.2.2, Water Mist Systems, to identify the availability of FM Approved water mist systems for the Hazard Category 2 (HC-2) and HC-3 classification.

E. Added guidance for Quantum computers in Section 2.3.1.5, Quantum Computers, and revised guidance in Section 3.2.2.

F. Revised liquid cooled equipment guidance in Section 2.5.2 as follows:

1. Direct chip
2. Rear door/heat exchanger
3. Immersion

G. Revised guidance or removed obsolete guidance in Section 2.6, Utilities and Support Systems, and in Section 3.5 as follows:

1. Power and utility cables
2. Electrical distribution system
3. Electrical utility

4. Emergency generator location and fuel supply

H. Deleted guidance for the use of portable fire extinguishers.

I. Revised ventilation guidance for the use of water mist systems in Section 2.4.3.2.2.

J. Revised Appendix A, Glossary of Terms, for inclusion of:

1. Battery Back-up Unit (BBU)
2. Cross-Zoned Detection
3. Energy Storage System
4. Non-Recycling Time Delay
5. Uninterruptible Power Supply (UPS)

K. The following content was removed, as it is no longer relevant or is included in the authoritative source Data Sheet:

1. Appendix D, Clean Agents

## 2.0 LOSS PREVENTION RECOMMENDATIONS

### 2.1 Introduction

The following information represents FM's loss prevention recommendations for new data centers and related facilities. Particular attention should be given to:

- Noncombustible construction materials
- Li-ion battery systems; Battery Back-up Units (BBU), Uninterruptible Power Supply (UPS) and Energy Storage Systems (ESS)
- Plenum-rated wires and cables, raceways and routing assemblies
- Non-fire-propagating, hot/cold aisle containment materials
- Redundancy of electrical systems
- Design of cooling systems
- Fire detection and suppression systems

Use FM Approved equipment, materials and services whenever they are applicable and available. For a list of products and services that are FM Approved, see the *Approval Guide*, an online resource of FM Approvals.

### 2.2 Construction and Location

#### 2.2.1 General

2.2.1.1 Construct data centers of noncombustible or FM Approved materials.

2.2.1.2 If plastic materials are used, ensure they are FM Approved to Standard 4882, *Class 1 Interior Wall and Ceiling Materials or Systems for Smoke Sensitive Occupancies.*

2.2.1.3 Protect data centers against external fire exposures in accordance with Data Sheet 1-20, *Protection Against Exterior Fire Exposure.*

2.2.1.3.1 Do not expose the air intake(s) of the building to combustible materials.

2.2.1.4 For high rise data centers, construct the building in accordance with Data Sheet 1-3, *High-Rise Buildings*.

2.2.1.4.1 For multi-story (non-high rise) data centers, construct the building in accordance with the appropriate sections of Data Sheet 1-3 for::

- Fire resistance of building elements
- Protection of openings in floors
- Protection of penetrations

2.2.1.5 Structurally connect containers for mobile/modular data center units when configured in a vertical array.

2.2.1.6 Do not route cooling or domestic liquid piping above areas containing critical/high-value equipment.

2.2.1.7 Provide supervision of the data center to prevent unauthorized access to the premises and assets in accordance with Data Sheet 9-1, *Supervision of Property*.

### 2.2.2 Doors and Windows

2.2.2.1 Minimize interior windows and doors to the data processing equipment room. For essential interior windows and doors, use tempered or wired glass for windows and minimum ¾-hour fire-rated doors.

2.2.2.2 If doors are held open intermittently or permanently, provide an electromechanical or electromagnetic holding mechanism interlocked to close the door on smoke detector actuation.

### 2.2.3 Floors

2.2.3.1 Construct floors, raised floors, and structural supporting members for raised floors of noncombustible materials.

### 2.2.4 Walls

2.2.4.1 Provide one-hour fire-rated interior walls and partitions in accordance with Data Sheet 1-21, *Fire Resistance of Building Assemblies*, for the following:

- Data processing equipment rooms
- Network/fiber optic rooms
- Tape cartridge storage rooms
- Emergency/standby power generation rooms

2.2.4.1.1 If multiple data processing equipment rooms are within the data center, provide two-hour fire-rated interior walls for compartmentation in accordance with Data Sheet 1-21, *Fire Resistance of Building Assemblies.*

2.2.4.2 Provide fire-rated interior walls, partitions and floors for power equipment rooms (standby generator and AC power) in accordance with Data Sheet 5-23, *Design and Protection for Emergency and Standby Power Systems*.

2.2.4.3 Have fire-rated interior walls built from the structural floor of the room to the structural floor above (or to the roof).

2.2.4.4 Use the limiting factors in Data Sheet 1-42, *MFL Limiting Factors*, to limit the maximum exposure from property loss and business interruption. Provide particular attention to these recommendations for data processing equipment rooms with high-value equipment (e.g., AI servers) or campus-style data center locations having multiple data center buildings on the premises.

### 2.2.5 Ceilings

2.2.5.1 Construct suspended ceilings of Class I materials. See Data Sheet 1-12, *Ceilings and Concealed Spaces.*

2.2.5.2 Limit the maximum height of ceilings in data centers to 30 ft (9 m). (See Section 2.4.3.3.1.1 and Section 3.3.3.1.2)

### 2.2.6 Penetrations

2.2.6.1 Seal openings in fire-rated floors and walls through which ducts, pipes, wires and cables pass using an FM Approved (Class Number 4990) or listed penetration seal with a fire-resistance rating equivalent to the rating of the wall or floor.

2.2.6.2 Provide a leakage-rated penetration seal with a maximum leak rate of 7 $ft^3/min/ft^2$ (2.1 $m^3/min/m^2$).

2.2.6.3 Seal openings in fire-rated floors and walls through which HVAC duct(s) pass with an FM Approved fire damper that has a fire-resistance rating equivalent to the rating of the wall or floor.

2.2.6.4 Provide smooth or protected electrical cable openings in floors (e.g., grommets, cable glands) to prevent damage to the cables.

### 2.2.7 Cables

2.2.7.1 Provide all grouped cables and cable trays (power and data) in accordance with Data Sheet 5-31, *Cable and Bus Bars*, in addition to the recommendations in this section.

2.2.7.2 Use communication and data cable (e.g., coaxial and fiber optic) and power cables that meet one of the following criteria:

A. FM Approved Class Number 3972; Group 1 or Group 1-4910

B. Plenum rated cable listed to Underwriters Laboratories (UL) Standard 910

C. Cable that has maximum flame spread distance of 5 ft (1.5 m) or less, tested in accordance with NFPA 262.

2.2.7.3 When communication, data and power cables cannot be provided in accordance with Section 2.2.7.2, provide protection for propagating and combustible materials in accordance with Section 2.4.3.1.

2.2.7.4 Separate power cables from communication/data cables by keeping the power cables in an independent cable tray/raceway or routing assembly.

### 2.2.8 Cable Raceways and Routing Assemblies

2.2.8.1 Use cable raceways and routing assemblies made of noncombustible materials.

2.2.8.2 When cable raceway and routing assemblies must be constructed of plastic, use one of the following:

A. FM Approvals 4910 specification-tested plastics listed in the Building Materials section of the *Approval Guide* (FM4910 plastics), or

B. Plenum-rated plastic raceways listed to Underwriters Laboratory (UL) Standard 2024.

2.2.8.3 Do not use cable raceways, routing assemblies or junction boxes constructed of polyvinyl chloride (PVC) material for power cables.

### 2.2.9 Hot and Cold Aisle Containment and Hot Collar Systems

2.2.9.1 Provide containment systems constructed of one of the following (listed in order of preference):

A. Noncombustible materials

B. FM Approved plastic containment panels listed as Class 4884, *Panels Used in Data Processing Center Hot and Cold Aisle Containment Systems*

2.2.9.2 Do not use polyvinyl chloride (PVC) materials for construction of the hot/cold aisle containment and hot collar systems.

### 2.2.10 Insulation

2.2.10.1 Provide building insulation and elastomeric materials installed on the building, beneath a raised floor and on floor supports in accordance with Data Sheet 1-57, *Plastics in Construction.*

2.2.10.2 Provide pipes and ducts using insulation with one of the following:

A. Noncombustible insulating materials (e.g., foil-wrapped fiberglass or mineral fiber wool)

B. FM Approved exterior pipe and duct insulation (Class 4924)

C. FM Approved insulation lined HVAC ducts (Class 4925)

#### 2.2.11 Earthquake

2.2.11.1 Design and protect the facilities location in FM 50-year through 500-year zones in accordance with Data Sheet 1-2, *Earthquakes.*

2.2.11.2 Provide seismic bracing and anchoring of all fire protection system components, piping, pumps, cylinder banks, etc., per Data Sheet 2-8, *Earthquake Protection for Water-Based Fire Protection Systems*.

#### 2.2.12 Windstorm and Hail

2.2.12.1 Design buildings, roof-mounted equipment, and ground-mounted equipment for wind forces in accordance with Data Sheet 1-28, *Wind Design*, and Data Sheet 1-29, *Roof Deck Securement and Above-Deck Roof Components*.

2.2.12.2 Design buildings, roof-mounted equipment and outdoor equipment against hail in accordance with Data Sheet 1-34, *Hail Damage*.

#### 2.2.13 Flood/Storm Water Runoff

2.2.13.1 Select a building site that is above the predicted 0.2% annual exceedance (500-year) flood elevation and includes 1 to 2 ft (0.3 to 0.6 m) of freeboard. Ensure the building site is at least 500 ft (152 m) from direct wave impacts and/or high flood-flow velocities (i.e., above 7 fps [2 m/s]). (See Data Sheet 1-40, *Flood*.)

2.2.13.2 Protect data centers, critical systems, and equipment at the facility and related facilities against storm water runoff in accordance with Data Sheet 1-40, *Flood*.

## 2.3 Occupancy

### 2.3.1 Data Processing Equipment Rooms

#### 2.3.1.1 General

2.3.1.1.1 Do not store packing materials or other combustibles (e.g., cardboard, plastic containers, etc.,) in the data processing equipment room or other critical areas (e.g., utility, UPS rooms, battery rooms, etc.,).

2.3.1.1 2 De-box equipment outside the data processing equipment rooms or other critical areas (e.g., utility, UPS rooms, etc.,).

2.3.1.1.3 Do not conduct physical destruction, secure wipe and/or degaussing of data storage devices (e.g., hard disk drives and solid-state drives) in the data processing equipment rooms.

#### 2.3.1.2 Data Processing Equipment Rooms (Above Floor)

2.3.1.2.1 Provide server enclosures (e.g., cabinets) and racks constructed of noncombustible materials. See Figure 2.3.1.2.1 for a typical server cabinet and rack arrangement.

2.3.1.2.2 Provide blanking plates constructed of one of the following (listed in order of preference) for empty server slots when used to route air flow in the equipment racks or hot/cold aisle containment system:

A. Noncombustible material

B. Plastic material listed to the FM Approval Standard Class 4884

*Fig. 2.3.1.2.1. Typical server cabinet and rack arrangement*

### 2.3.1.3 Data Processing Equipment Rooms (Below Floor)

2.3.1.3.1 Provide directional air baffle systems and piping insulation constructed of one of the following (listed in order of preference) when used to route air flow below the raised floor:

A. Noncombustible material

B. Plastic material listed to FM Approval Standard Class 4884

### 2.3.1.4 Li-ion Battery Back-up Units for Distributed Power Systems

2.3.1.4.1 Where Li-ion battery back-up units (BBU) are installed in a server rack as a distributed power system, the recommendations in this section are to be applied if the following conditions exist:

A. Maximum power capacity of 20 kWh per server rack as a distributed power configuration. (Refer to Section 3.2.1.1 for calculating power capacity.)

B. No more than two shelves containing BBU modules located together in the same area of the rack. (See Figure 2.3.1.4.1 for typical configuration.)

C. Aisle spacing between server rows is a minimum of 4 ft (1.2 m).

2.3.1.4.2 Consider server racks with distributed Li-ion battery back-up units (BBU) exceeding the maximum capacity of 20 kWh per rack as Energy Storage Systems (ESS). Follow the recommendations identified in Data Sheet 5-33, *Lithium-Ion Battery Energy Storage Systems.*

### 2.3.1.5 Quantum Computers

2.3.1.5.1 Arrange quantum computer equipment rooms in accordance with other sections of this data sheet.

2.3.1.5.2 Where multiple quantum computers utilize a common component(s), (e.g., gas delivery system for the cryogenic system), provide N+1 redundancy; and analyze the system for common points of failure.

See Section 3.2.2 for information on Quantum computers.

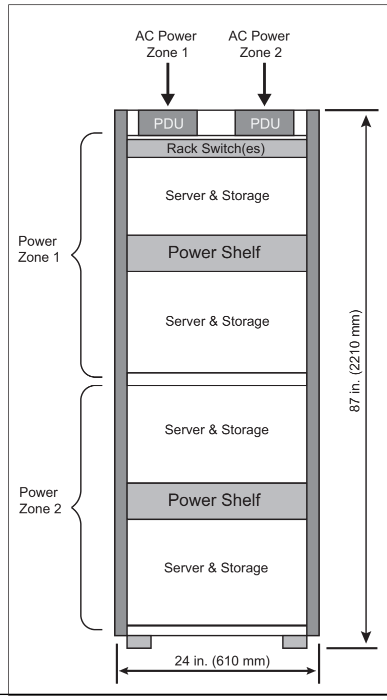



*Fig. 2.3.1.4.1. Typical configuration of battery back-up units in distributed power system*

**2.3.2. Automated Tape Cartridge Storage**

2.3.2.1 Do not locate automated tape cartridge storage units in the data processing equipment room.

2.3.2.2 Use tape cartridge units constructed of one of the following:

A. Noncombustible materials

B. Plastics that have been specification-tested to FM Approval Standard 4910. Specification-tested products are listed in the Building Material section of the *Approval Guide*.

## 2.4 Protection

### 2.4.1 General

Automatic, water-based fire protection (sprinklers or water mist) provides the highest level of protection based on reliability, maintenance, and its ability to protect various hazards as stand-alone protection.

Halocarbon and Inert Gas (Clean Agent) or Hybrid (Water and Inert Gas) fire protection may also provide adequate stand-alone protection, although limitations exist for its application.

2.4.1.1 The order of preference for water-based protection is:

A. Wet system

B. Non-interlocked preaction system

C. Single-interlocked preaction system

D. Double-interlocked preaction system

2.4.1.2 The type of water-based system provided (reference Table 2.4.1.2) should consider the impact of a time delay in water being applied to the fire and the ability to conduct maintenance. In particular, the time delay for a double-interlock, preaction system that requires both smoke detection and sprinkler/nozzle activation can negatively impact the control of the fire and potentially result in depletion of the water supply. In addition, the complexity of the preaction valve trim decreases the availability of the fire protection system.

*Table 2.4.1.2. Water-Based System Operation Sequence*

| *System Type* | *Detection Activation* | *Function* (Note 1) | *Sprinkler/Nozzle Activation* | *Supervision* (Note 2) |
|---|---|---|---|---|
| Wet | Not Applicable | N/A | Water discharges | Not Applicable |
| Non-interlocked preaction | Water fills piping | Or | Water fills piping and discharges | Yes |
| Single-interlocked preaction | Water fills piping | N/A | w/detection, water discharges | Yes |
| | | | w/o detection, no water in piping | |
| Double-interlocked preaction | Water does not fill piping; preaction control unit monitors system supervisory pressure | And | Piping fills with water only if detection and sprinkler/nozzle is activated | Yes |

Note 1. Action needed for system piping to fill with water.

Note 2. The system piping is pressurized with air or nitrogen or maintains a vacuum to supervise the integrity of the piping network. If the system piping or a sprinkler/nozzle is damaged, the supervisory pressure is reduced; and a low-air supervisory alarm is activated. Supervision is also one portion of the releasing operation for double-interlocked preaction systems.

2.4.1.3 When reducing equipment damage from an incipient fire to minimum possible levels is essential, or to facilitate a quicker return to service, provide an FM Approved halocarbon or inert gas (clean agent) or hybrid (water and inert gas) fire extinguishing system in addition to water-based protection.

2.4.1.4 Do not use aerosol generator fire extinguishing system units for the protection of the data center, related areas or electronic equipment.

2.4.1.5 Provide a hose stream allowance of 250 gpm (950 L/min).

2.4.1.6 Provide a water supply for a 60-minute duration.

### 2.4.2 Detection

#### 2.4.2.1 General Detection

2.4.2.1.1 Install fire detection per Data Sheet 5-48, *Automatic Fire Detection*, in conjunction with the following recommendations.

2.4.2.1.2 Use one of the following FM Approved VEWFD systems, appropriate for the characteristics of the occupancy (see Section 3.3.2):

A. Air aspirating

B. Intelligent high-sensitivity spot detection; photoelectric type

2.4.2.1.3 Limit forced cooling air ventilation to less than 5 ft/sec. (1.5 m/s) or 60 air changes per hour as measured per Section 3.5.2.3.

2.4.2.1.3.1 For air velocities greater than or equal to 5 ft/sec. (1.5 m/s) or 60 air changes per hour, interlock the ventilation system to reduce velocities to less than 5 ft/sec. (1.5 m/s) upon activation of a pre-alarm condition for the VEWFD system. (See Section 3.3.2.1.)

2.4.2.1.3.2 Conduct an acceptance test of the interlock(s) to confirm reduction of air velocities to less than 5 ft/sec (1.5 m/s) in the commissioning phase.

2.4.2.1.4 Provide minimum sensitivity settings above the ambient airborne levels and consider the impact of functional devices on the HVAC system (e.g., outside air economizers with or without dampers) for alert, pre-alarm and alarm conditions. (See Sections 3.3.2.2 and 3.3.2.3.)

2.4.2.1.5 Conduct smoke tests (see Appendix C) when the VEWFD system is installed to verify:

A. Smoke detectors are properly located with regard to air flow and velocity.

B. Ventilation and stratification within the protected area, including the impact of equipment and obstructions.

C. Proper detector settings (obscuration, sensitivity, etc.,).

2.4.2.1.6 Smoke detection systems below the raised floor space may be omitted under either of the following conditions:

A. Only FM Approved Group 1, Group 1-4910, or UL-listed plenum-rated cables are present.

B. VEWFD is provided at the air return for forced air re-circulated from below the raised floor into the room.

2.4.2.1.7 Do not install automatically operated smoke exhaust systems in the data processing equipment rooms.

2.4.2.1.7.1 Where automatic operation is required by local code, interlock the activation of the smoke exhaust system with the alarm for operation of the sprinkler or water mist system.

2.4.2.1.7.2 Do not activate the smoke exhaust system with the fire detection system.

2.4.2.1.8 Install the fire alarm control panel for fire detection annunciation in accordance with Data Sheet 5-40, *Fire Alarm Systems*.

2.4.2.1.9 When a fire extinguishing system is actuated by VEWFD, do the following:

A. Annunciate all alert, pre-alarm and alarm conditions to a constantly attended location.

B. Provide a local visual and/or audible alarm within the protected area.

C. Provide an alarm signal to the building fire alarm control panel area when any level (e.g., pre-alarm, actuation) of smoke detection signal is received from the smoke detection system.

2.4.2.1.10 Supervise fire alarms in accordance with Data Sheet 9-1, *Supervision of Property*, for a Class V or greater fire alarm service classification.

### 2.4.2.2 Air Aspirating Detection

2.4.2.2.1 Install VEWFD air sampling ports or remote sampling points in the return air, data processing equipment area, and below raised floors. (See Figure 2.4.2.2.1.)

2.4.2.2.2 Where localized detection is desired for critical business operations and/or in support of local manual power isolation, install VEWFD directly in equipment racks or cabinets.

2.4.2.2.3 Locate the air sampling port or remote sampling point at the return air inlet of each HVAC unit and/or at the interface of the exhaust air plenum. Each sampling port should cover an area no greater than 4 $ft^2$ (0.4 $m^2$) of the return opening. (See Section 3.3.2.)

2.4.2.2.4 Where a single level of detection is used (ceiling or below raised floor level), install an air sampling port or remote sampling point in an area no larger than 200 $ft^2$ (18.6 $m^2$). (See Figure 2.4.2.2.1.)

A. The air sampling port or remote sampling point does not need to be located in the center of the bay.

B. Do not locate air sampling ports or remote sampling points within 3 ft (0.9 m) of HVAC supply outlets, unless they are used to detect a failure originating within the HVAC unit (e.g., burning belt, bearing).

2.4.2.2.5 If two levels of detection are used (ceiling and below raised floor level), install an air sampling port or remote sampling point in an area no larger than 400 $ft^2$ (37.2 $m^2$) for both levels.

2.4.2.2.6 Provide two levels of detection where cable trays impede the flow of smoke to the ceiling.

A. Locate one level of detection below the cable trays and one level at the ceiling.

B. Stagger the air sampling ports or remote sampling points in an area no more than 200 $ft^2$ (18.6 $m^2$) between each level.

2.4.2.2.7 For air-sampling VEWFD, do not exceed a transport time of 60 seconds from the most remote port to the detection unit.

### 2.4.2.3 Intelligent High-Sensitivity Spot Smoke Detection

2.4.2.3.1 Install intelligent, high-sensitivity spot smoke detectors to monitor the return air.

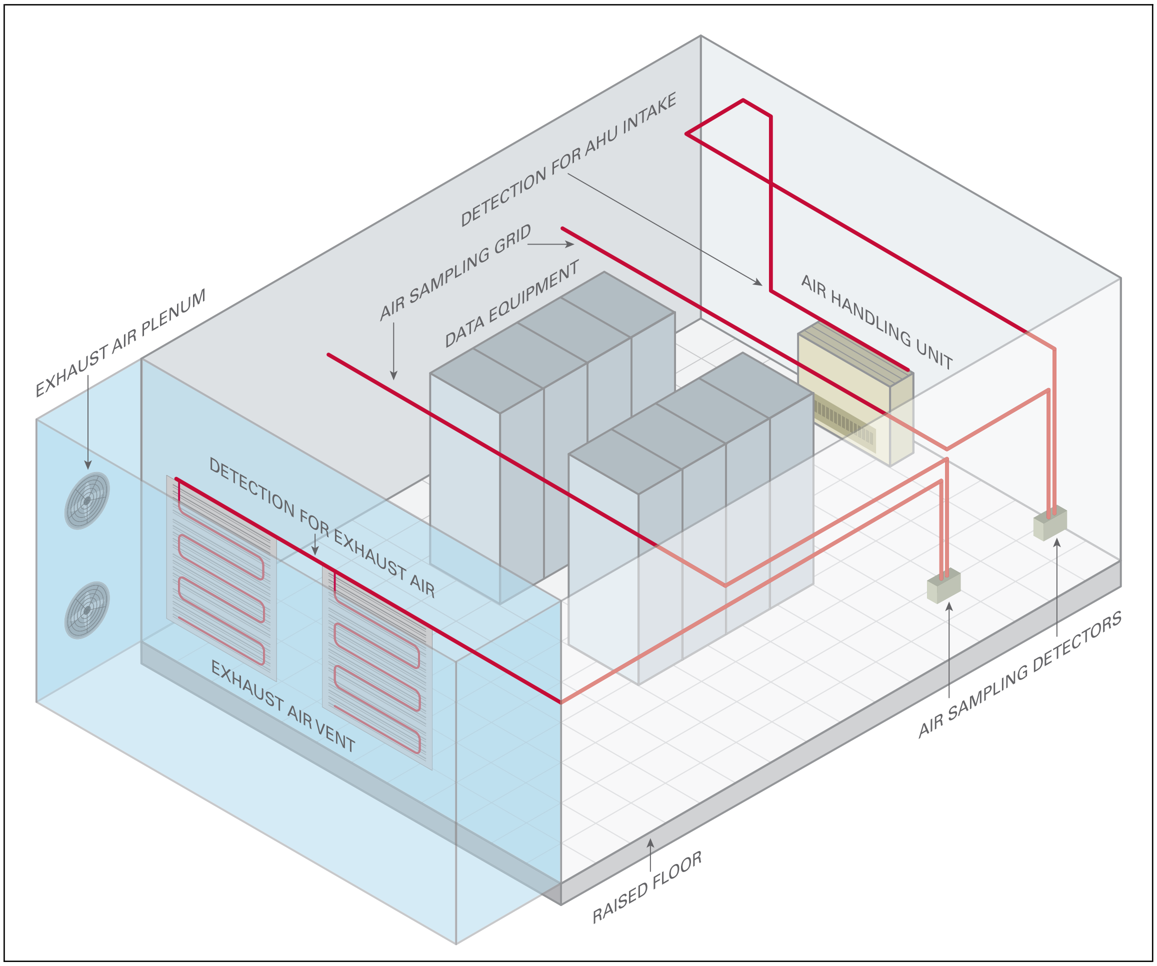



*Fig. 2.4.2.2.1. Very early warning fire detection (VEWFD); air-aspirating type*

A. Locate the spot detectors at the return air inlet of each HVAC unit and/or at the interface of the exhaust air plenum.

B. Locate the spot detectors so each covers an area no greater than 4 $ft^2$ (0.4 $m^2$) of the return opening.

2.4.2.3.2 Provide at least two intelligent, high-sensitivity spot smoke detectors in each protected space or zone for initiation of the protection system.

2.4.2.3.3 If an intelligent VEWFD spot-type smoke detector is used below a raised floor, ensure it is properly orientated as indicated in its FM Approval listing.

2.4.2.3.4 Install the intelligent high-sensitivity spot smoke detectors in accordance with the manufacturer's specification for spacing, based on the air movement (e.g., air changes per minute/hour in the protected space or zone).

### 2.4.3 Suppression

#### 2.4.3.1 Protection Options

##### 2.4.3.1.1 Data Center Above Floor

2.4.3.1.1.1 Use the flowchart in Figure 2.4.3.1.1.1 to determine which fire protection option can be provided to protect the data processing equipment room.

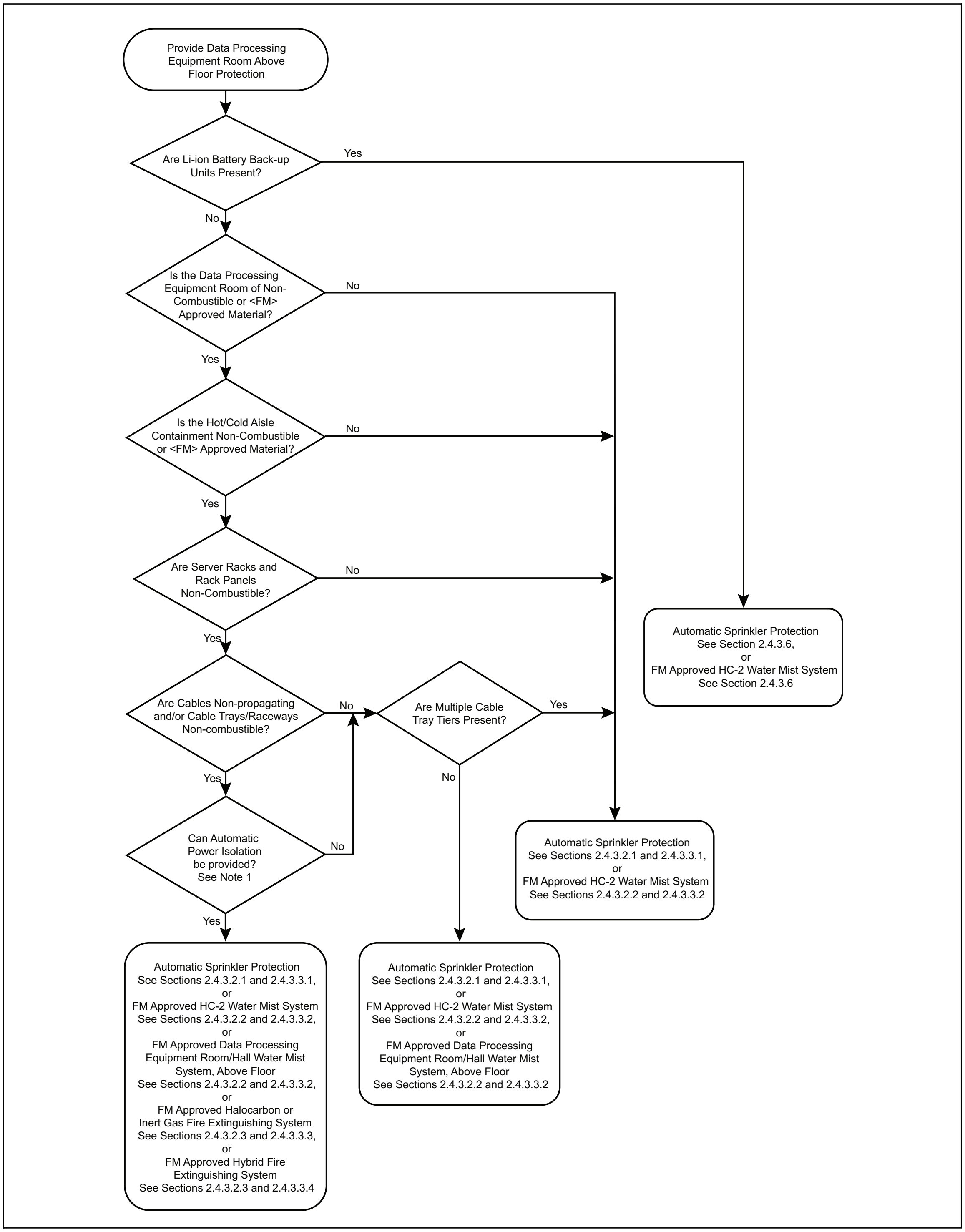



*Fig. 2.4.3.1.1.1. Flowchart to determine the above-floor protection option for the data processing equipment room*

**Notes for Fig. 2.4.3.1.1.1:**

**Note 1.** Automatic power isolation is preferred to prevent reignition and smoke recirculation (See Section 2.5.3.). Alternatively, a manual power isolation option can be considered if all conditions in Section 2.5.3.1.3 are met. When automatic or manual power isolation cannot be provided, use one of the alternative, water-based protection options outlined in this flowchart.

### 2.4.3.1.2 Raised Floor or Above-Ceiling Spaces Containing Combustibles (Concealed Spaces)

2.4.3.1.2.1 Use the flowchart in Figure 2.4.3.1.2.1 to determine which fire protection option can be provided to protect combustibles in concealed spaces (e.g., below the raised floor, above ceiling spaces or ceiling air plenum, in the data processing equipment room).

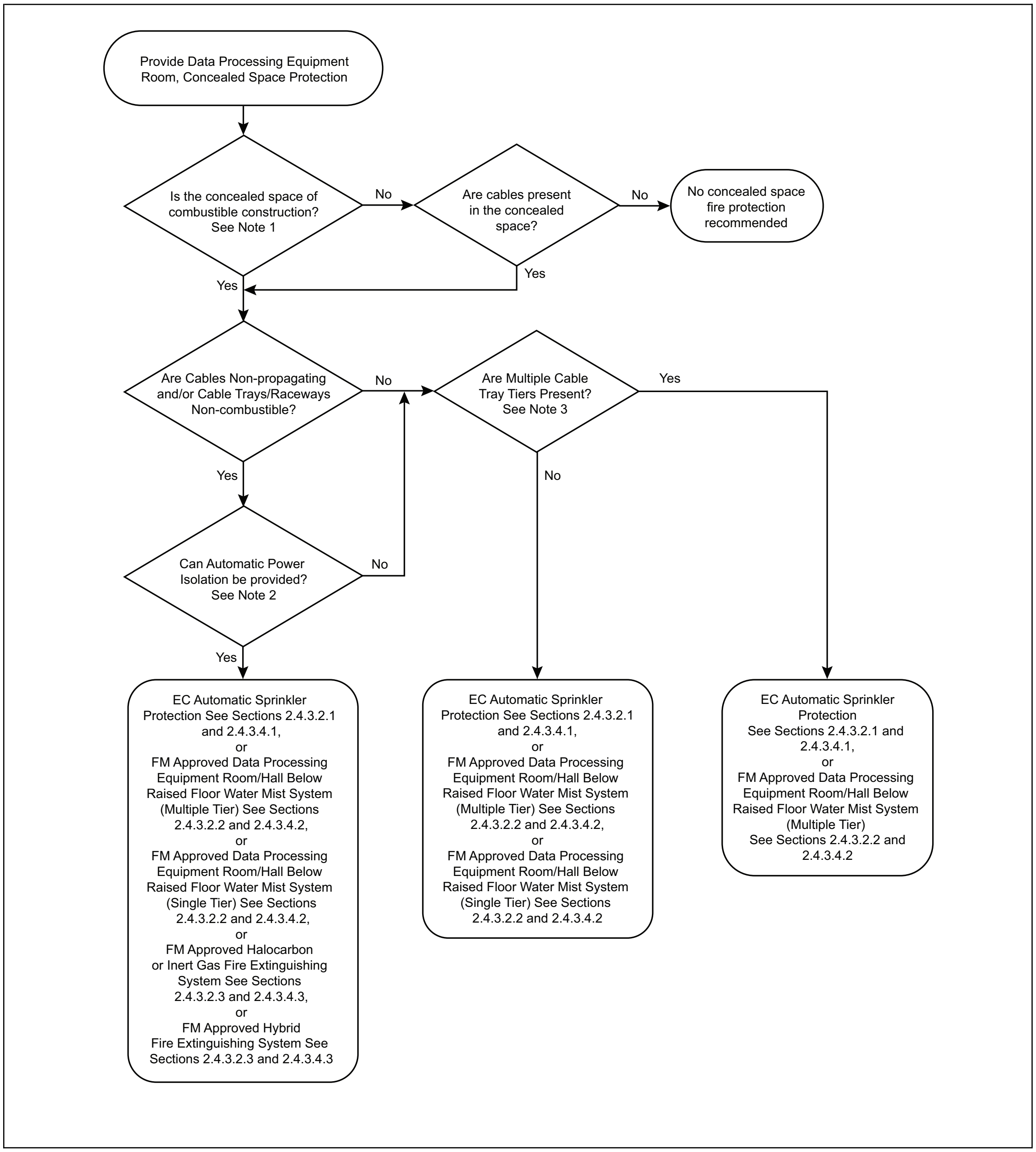



*Fig. 2.4.3.1.2.1. Flowchart for determining the protection option, below raised floors and above ceiling spaces, for the data processing equipment room*

**Notes for Fig. 2.4.3.1.2.1:**

**Note 1.** See Section 2.2.10.1 when combustible elastomeric materials and floor supports beneath a raised floor are to be provided.

**Note 2.** Automatic power isolation is preferred to prevent reignition and smoke recirculation (See Section 2.5.3.). Alternatively, a manual power isolation option can be considered if all conditions in Section 2.5.3.1.3 are met. When automatic or manual power isolation cannot be provided, use one of the alternative, water-based protection options outlined in this flowchart. .

**Note 3.** The number of allowable tiered cable trays for water mist systems is identified in the FM Approval Guide listing.

### 2.4.3.2 General

*2.4.3.2.1 Automatic Sprinklers*

2.4.3.2.1.1 Install sprinkler systems in accordance with Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*, the equipment manufacturer's manual and the recommendations in this section of Data Sheet 5-32.

2.4.3.2.1.1.1 Address obstructions (e.g., cable trays, electrical raceways, etc.) in accordance with Data Sheet 2-0.

2.4.3.2.1.2 Design preaction sprinkler systems in accordance with the following:

A. Install a dedicated preaction sprinkler system to protect the data center equipment rooms separately from other sprinkler systems.

B. When using a non-interlock or single-interlock preaction sprinkler system arrangement, base the sprinkler demand on a wet system.

C. In a double-interlock configuration, design the sprinkler system based on a dry system.

D. Provide a maximum water delivery time of 30 seconds for the operation of the single most remote sprinkler.

E. Provide a sectional valve and a 2 in. (50 mm) diameter test discharge line above (downstream from) the preaction valve to allow proper inspection, testing and maintenance in accordance with Data Sheet 2-81, *Fire Protection System Inspection, Testing and Maintenance.* (See Figure 2.4.4.2.1.2.E.)

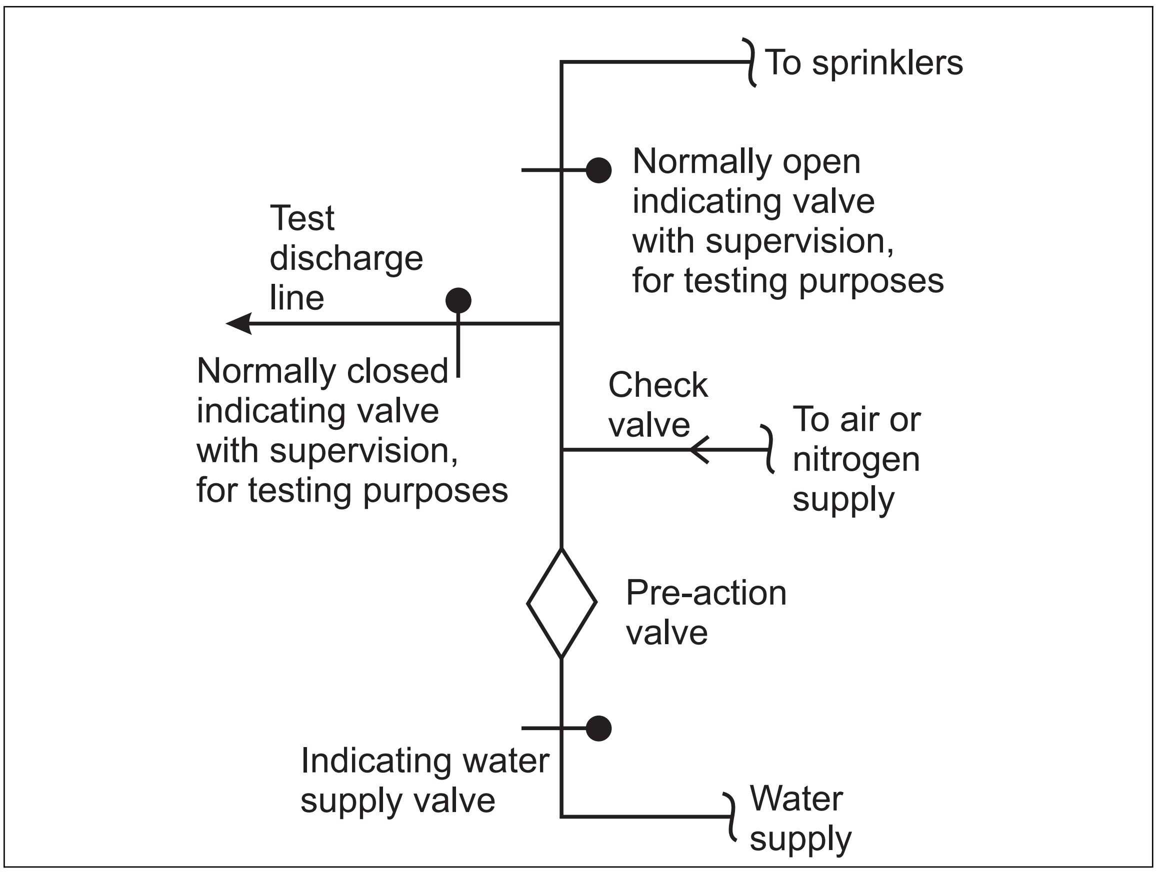



*Fig. 2.4.3.2.1.2.E. Schematic of preaction valve with test discharge line*

2.4.3.2.1.3 Actuate preaction sprinkler systems in accordance with Section 2.4.2.

2.4.3.2.1.3.1 Arrange the preaction valve to actuate upon the pre-alarm condition.

2.4.3.2.1.3.2 Do not use cross-zoned detection for activation of the preaction valve.

2.4.3.2.1.3.3 If both a preaction sprinkler system and halocarbon or inert gas (clean agent) fire extinguishing system are installed, provide two independent VEWFD smoke detection systems. The fire alarm threshold for the halocarbon or inert gas (clean agent) fire extinguishing system should be lower than that of the preaction, automatic sprinkler system.

*2.4.3.2.2 Water Mist System*

2.4.3.2.2.1 Install water mist systems in accordance with all applicable recommendations in Data Sheet 4-2, *Water Mist Systems*, the manufacturer's design, installation, operation and maintenance manual, and the recommendations in this section of Data Sheet 5-32.

2.4.3.2.2.2 Use one of the following automatic water mist systems for Data Processing Equipment Rooms/Halls:

A. FM Approved for "HC-2 or HC-3 Occupancies".

B. FM Approved for "Protection of Data Processing Equipment Rooms/Halls" if the following conditions are met:

- The maximum nominal upward velocity through perforated floor openings is 3.3 ft/sec. (1 m/s) or meets the provisions of the system's FM Approval listing.
- The maximum horizontal airflow is 4 ft/sec. (1.2 m/s) horizontal airflow or meets the provisions of the system's FM Approval listing.
- No overhead, multi-tiered, combustible cable raceways are present.
- No overhead, multi-tiered open cable trays of propagating cables are present.
- No Li-ion battery backup units (BBUs)or UPS systems are present.

2.4.3.2.2.3 Use an FM Approved automatic water mist system specifically listed for "Protection of Data Processing Equipment Rooms/Halls - Below-Floor Protection" to protect the area below a raised floor.

2.4.3.2.2.3.1 Use water mist systems to protect the area below a raised floor for the maximum number of tiered open trays of propagating cables designated in the FM Approval listing.

2.4.3.2.2.4 Design preaction automatic water mist systems in accordance with the following:

1. Section 2.4.3.2.1.2 for preaction automatic sprinkler systems

2. For an automatic water mist system FM Approved for "HC-2 Occupancies", increase the number of nozzles for the demand area as listed in the FM Approval Guide by 40%.

3. For an automatic water mist system FM Approved for "Protection of Data Processing Equipment Rooms/Halls", design the nozzle water demand area in accordance with the FM Approval listing and the manufacturer's Design, Installation, Operation and Maintenance manual.

2.4.3.2.2.5 Actuate preaction water mist systems in accordance with Section 2.4.2.

2.4.3.2.2.6 When a low-pressure water mist system is supplied by the building sprinkler system, install a separate water flow switch for the water mist system.

*2.4.3.2.3 Halocarbon and Inert Gas (Clean Agent) or Hybrid (Water and Inert Gas) Fire Extinguishing Systems*

2.4.3.2.3.1 Install systems in accordance with Data Sheet 4-9, Halocarbon and Inert Gas (Clean Agent) Fire Extinguishing Systems, or Data Sheet 4-6, Hybrid (Water and Inert Gas) Extinguishing System, as applicable, the manufacturer's design, installation and operation manual, and the recommendations in this section of Data Sheet 5-32.

2.4.3.2.3.1.1 Use FM Approved hybrid (water and inert gas) extinguishing systems for "Protection of Data Processing Equipment Rooms/Halls-Above-Floor Protection" if the following conditions are met:

- The maximum nominal upward velocity through perforated floor openings is 3.3 ft/sec. (1 m/s) or meets the provisions of the system's FM Approval listing.

- The maximum horizontal airflow is 4 ft/sec. (1.2 m/s) horizontal airflow or meets the provisions of the system's FM Approval listing.
- There are no Li-ion battery backup units (BBUs)or UPS systems.

2.4.3.2.3.2 Construct the physical building envelope in accordance with Section 2.2 to maintain the design concentration of clean extinguishing agent or hybrid media for whichever is the longer duration: 10 minutes, or until the affected equipment or components can be de-energized.

2.4.3.2.3.3 Actuate halocarbon and inert gas (clean agent) or hybrid (water and inert gas) fire extinguishing systems in accordance with Section 2.4.2.

2.4.3.2.3.3.1 Provide an FM Approved fire extinguishing system releasing device that is electrically compatible (voltage and current) with the halocarbon or inert gas (clean agent) fire extinguishing system or hybrid (water and inert gas) fire extinguishing system actuation device and that interfaces with the smoke detection and fire alarm systems.

2.4.3.2.3.4 When an FM Approved clean agent (halocarbon or inert gas) or hybrid (water and inert gas) fire extinguishing system is used to protect equipment hazards in the data processing equipment, provide:

A. Simultaneous halocarbon extinguishing system protection in both the data processing equipment room and below the raised floor. Use the same halocarbon extinguishing agent for both areas. (See Section 3.3.3.3.1.) Or

B. Inert gas or hybrid (water and inert gas) extinguishing system protection in either:

1. The data processing equipment room and below the raised floor, or
2. Only below the raised floor

2.4.3.2.3.5 Provide the proper clearance of the discharge nozzle(s) from the sidewall(s) of a hot/cold aisle containment system or other obstructions (e.g., cable trays) in accordance with the manufacturer's design, installation, and operation manual.

2.4.3.2.3.6 Arrange for the following to occur upon alarm for discharge of the halocarbon or inert gas (clean agent) or hybrid (inert gas and water) fire extinguishing system:

A. Shut down room/area HVAC systems (e.g., chillers) that:

1. Supply outside make-up air (external from protected room/area)
2. Only provides protection below the raised floor or above the ceiling space
3. Provide forced air distribution between multiple zones

B. Shut down localized equipment HVAC systems (e.g., CRAH and CRAC):

1. Supply outside make-up air (external from the protected equipment)
2. Cannot protect the volume of HVAC system ducts and components as part of the total hazard volume.

C. Automatically close fire and smoke dampers, as appropriate.

D. Power down data processing equipment, as appropriate (see Section 2.5.3).

E. Discharge the clean agent using a non-recycling time delay, (See Appendix A), with a time interval not exceeding 30 seconds.

2.4.3.2.3.7 Provide a permanently connected reserve of clean agent supply cylinder(s) for the halocarbon or inert gas (clean agent) fire extinguishing system in accordance with Data Sheet 4-9.

2.4.3.2.3.8 Provide permanently connected reserve of water and/or inert gas supply cylinder(s) for the hybrid (water and inert gas) fire extinguishing system in accordance with Data Sheet 4-6.

### 2.4.3.3 Data Processing Equipment Room (Above Floor)

*2.4.3.3.1 Automatic Sprinklers*

2.4.3.3.1.1 Design the automatic quick-response (QR) sprinkler protection with the following parameters:

A. Application density of 0.2 gpm/ft$^2$ (8 mm/min) over 2500 ft$^2$ (230 m$^2$) for wet pipe systems and 3500 ft$^2$ (330 m$^2$) for systems designed as dry pipe.

B. Nominal 135ºF (55ºC) temperature rating for wet pipe systems and nominal 165ºF (70ºC) for systems designed as dry pipe.

C. Maximum 30 ft (9 m) ceiling. (Refer to Section 3.3.3.1.2.)

D. Sprinkler deflector distance from ceiling:

1. Minimum: 1.75 in. (44 mm)

2. Maximum: 4 in. (100 mm)

E. Maximum spacing of 12 ft (3.6 m)

F. When elevated cable trays are present, provide a minimum pressure of 12 psi (0.8 bar) at the sprinkler or a maximum horizontal offset distance of 4 ft (1.2 m) from the sprinkler to the cable trays above the servers.

*2.4.3.3.2 Water Mist Systems*

2.4.3.3.2.1 Design water mist systems in accordance with all applicable recommendations in Data Sheet 4-2, *Water Mist Systems*, and the manufacturer's design, installation, operation, and maintenance manual.

*2.4.3.3.3 Halocarbon and Inert Gas (Clean Agent) Fire Extinguishing Systems*

2.4.3.3.3.1 Design halocarbon and inert gas (clean agent) fire extinguishing systems in accordance with all applicable recommendations in Data Sheet 4-9, *Halocarbon and Inert Gas (Clean Agent)*, the manufacturer's design, installation, operation, and maintenance manual, and the recommendations in this section of Data Sheet 5-32.

2.4.3.3.3.2 When magnetic hard disk drives (HDD) and storage systems are susceptible to disruption of performance by an excessive sound pressure level from the discharge of a clean agent fire extinguishing system, do the following:

A. For FM Approved inert gas fire extinguishing systems use a regulated pressure system to control flow and pressure from the discharge valve.

B. Use an FM Approved halocarbon or inert gas (clean agent) fire extinguishing system that has a noise reducing discharge nozzle listed as a component of the fire extinguishing system. Install the discharge nozzles as follows:

1. Determine the minimum radial distance based upon using the noise level or sound pressure level that can produce damage to the hard disk drive in conjunction with the sound pressure level of the discharge nozzle in the FM Approval listing.

2. Provide the discharge nozzle at a minimum radial distance from the hard disk drive for the discharge nozzle area of coverage and ceiling height. Provide this in accordance with the FM Approved manufacturer's design, installation, operation and maintenance (DIOM) manual or acoustic calculation method.

3. When the noise level or sound pressure level threshold for damaging the HDD is not available, use 100 dB in the calculation of the minimum radial nozzle distance.

4. For inert gas fire extinguishing systems, when possible, use discharge times from 60 seconds to 120 seconds.

C. When an FM Approved noise reducing discharge nozzle is not available as a component of the clean agent fire extinguishing system, install the clean agent fire extinguishing system as follows to decrease sound pressure levels:

1. Decrease the rate of flow of fire extinguishing system from the discharge nozzles used by increasing the number of nozzles for a reduced area of coverage per nozzle.

2. When possible, provide discharge nozzles at a minimum distance of 6.5 ft (2 m) for small orifice (3 - 8 mm) discharge nozzle(s) and 9.8 ft (3 m) for large orifice (15 - 20 mm) away from the server racks.

3. For inert gas systems, discharge times from 90 seconds to 120 seconds.

4. Provide the minimum nozzle pressure allowed by the FM Approval listing.

5. Ensure the noise pressure level of the peak nozzle pressure is below the allowable threshold of the HDD equipment. When the allowable noise level or sound pressure level threshold for the HDD is not available use 100 dB in the assessment.

D. Do not use pneumatic sirens as an alarm notification device.

*2.4.3.3.4 Hybrid (Water and Inert Gas) Extinguishing Systems*

2.4.3.3.4.1 Design hybrid extinguishing systems in accordance with all applicable recommendations in Data Sheet 4-6, *Hybrid (Water and Inert Gas) Extinguishing Systems*, and the manufacturer's design, installation, operation, and maintenance manual.

### 2.4.3.4 Raised Floor or Above-Ceiling Spaces Containing Combustibles (Concealed Spaces)

*2.4.3.4.1 Automatic Sprinklers*

2.4.3.4.1.1 Design the automatic extended coverage (EC) non-storage sprinkler protection with the following parameters:

A. Application density of 0.2 gpm/ft$^2$ (8 mm/min.) over 2500 ft$^2$ (230 m$^2$) for wet pipe systems and 3500 ft$^2$ (330 m$^2$) for systems designed as dry pipe.

B. Nominal 135ºF (70ºC) temperature rating for wet pipe systems and a nominal 165ºF (68ºC) for systems designed as dry pipe.

2.4.3.4.1.2 Provide a means of access in proximity to the detectors and sprinklers in the raised floor or above-ceiling space for inspection and maintenance.

*2.4.3.4.2 Water Mist Systems*

2.4.3.4.2.1 Design water mist systems in accordance with all applicable recommendations in Data Sheet 4-2, *Water Mist Systems*, and the manufacturer's design, installation, operation, and maintenance manual.

*2.4.3.4.3 Halocarbon and Inert Gas (Clean Agent) and Hybrid (Water and Inert Gas) Fire Extinguishing Systems*

2.4.3.4.3.1 Design halocarbon and inert gas (clean agent) and hybrid fire extinguishing systems in accordance with all the applicable recommendations in Data Sheet 4-9, *Halocarbon and Inert Gas (Clean Agent)*, or Data Sheet 4-6, *Hybrid (Water and Inert Gas) Extinguishing Systems,* and the associated manufacturer's design, installation, operation, and maintenance manual.

### 2.4.3.5 Hot/Cold Aisle Containment and Hot Collar Systems

*2.4.3.5.1 General*

2.4.3.5.1.1 If a solid containment ceiling is installed as a portion of the hot/cold aisle containment system, provide one of the following:

A. Adequate automatic fire protection (e.g., sprinklers, water mist, clean agent or hybrid) beneath the ceiling (designed per Section 2.4.3.2)

B. FM Approved (Class 4651) drop-out ceiling panels in conjunction with adequate automatic fire protection at ceiling level in the data processing equipment room. Install drop-out ceiling panels in accordance with Data Sheet 1-12, *Ceilings and Concealed Spaces,* and all of the following:

1. Use quick-response sprinklers or quick-response automatic water mist nozzles installed at ceiling level.

2. Limit the height of the drop-out ceiling panels above the floor to 15 ft (4.5 m).

3. Limit the distance between the drop-out ceiling panels and the sprinklers located above the ceiling to 20 ft (6.0 m).

4. Limit the distance between the drop-out ceiling panels and the automatic water mist nozzle located at ceiling level to the maximum ceiling height in the water mist system's FM Approval listing.

2.4.3.5.1.2 If containment curtains or other vertical partitions form part of the containment system or hot collar in such a way that the automatic fire protection at ceiling level can be obstructed, do one of the following:

A. Locate the partitions so they do not impede the discharge of the protection system for the contained area.

B. Provide additional discharge devices (e.g., automatic sprinklers, water mist nozzles, clean agent nozzles or hybrid nozzles) in the contained area.

2.4.3.5.1.3 Do not use the following containment devices as alternatives to providing sprinklers below the ceiling or within the containment system:

A. Containment panels mounted with fusible links

B. Automatic releases on curtains and panels

*2.4.3.5.2 Detection*

2.4.3.5.2.1 Arrange and install detection in the hot aisle containment system or hot collar in accordance with the manufacturer's design guide and/or application guide for this specific application.

2.4.3.5.2.2 If the data processing equipment room and exhaust/air return has been provided with an FM Approved VEWFD system (see Section 2.4.2), no detection is needed beneath a solid cold aisle containment ceiling.

*2.4.3.5.3 Sprinklers and Water Mist Systems*

2.4.3.5.3.1 When sprinkler protection is to be provided within the containment system design in accordance with Section 2.4.3.2.1.

2.4.3.5.3.2 When water mist protection is to be provided within the containment system design in accordance with Section 2.4.3.2.2.

2.4.3.5.3.3 If a grated ceiling is installed as part of the hot aisle containment system, provide a maximum spacing of 4 ft (1.2 m) between sprinklers or an automatic water mist nozzle at the ventilation ceiling and plenum interface. (See Figure 3.3.3.4.B.)

*2.4.3.5.4 Halocarbon and Inert Gas (Clean Agent) and Hybrid (Water and Inert Gas) Fire Extinguishing Systems*

2.4.3.5.4.1 If a halocarbon and inert gas (clean agent) or hybrid (inert gas and water) fire extinguishing system is installed for the containment system, provide the following:

A. A halocarbon and inert gas (clean agent) or hybrid (water and inert gas) fire extinguishing system designed in accordance with Section 2.4.3.2.3.

B. The clearance of the discharge nozzle(s) from the sidewall(s) of the containment system, provided in accordance with the fire extinguishing system manufacturer's design, installation and operation manual included with the FM Approval listing.

C. The proper design concentration within the volume of the containment system.

D. The proper design concentration surrounding the containment system(s).

### 2.4.3.6 Li-ion Battery Back-up Units for Distributed Power Systems

*2.4.3.6.1 General*

2.4.3.6.1.1 Provide vertical barriers in all server rack rows where Li-ion distributed power systems are used or expected to be used, regardless of the power capacity. Provide vertical barriers as follows (see Figure 2.4.3.6.1.1).

2.4.3.6.1.1.1 Locate vertical barriers after every third rack along the entire length of server rows.

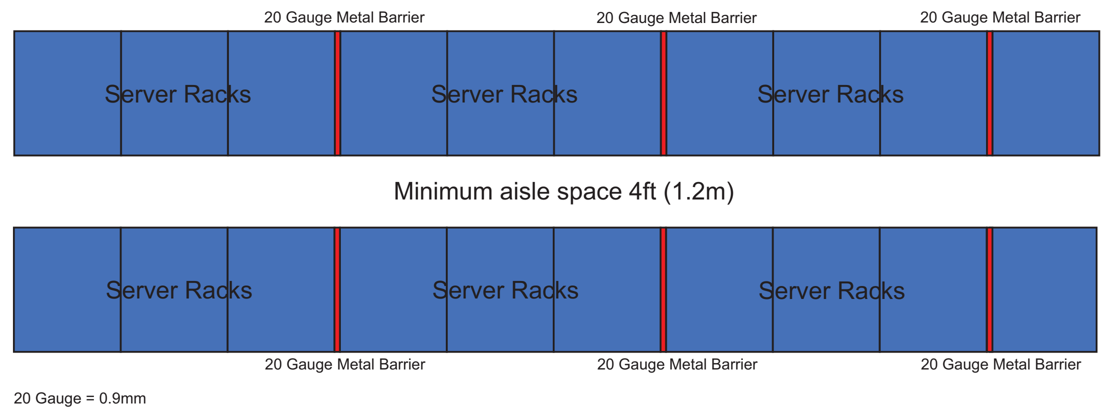



*Fig. 2.4.3.6.1.1. Vertical barrier location*

2.4.3.6.1.1.2 Use a minimum 20-gauge (0.9 mm) solid sheet metal for the vertical barriers on the side of every third rack to limit the fire spread.

2.4.3.6.1.1.3 Completely cover the side of the server rack with the barrier to fit the rack side profile.

2.4.3.6.1.1.4 Install the barrier in a way that will not reduce the effectiveness of the hot/cold aisle air flow cooling arrangement (i.e., kept to the side frame profile of the server racks).

*2.4.3.6.2 Automatic Sprinklers*

2.4.3.6.2.1 Design the automatic quick-response (QR) sprinkler protection in accordance with Sections 2.4.3.2.1 and 2.4.3.3.1.

*2.4.3.6.3 Water Mist*

2.4.3.6.3.1 Design the FM Approved automatic water mist systems with the following specifications:

A. Approved for protection of non-storage, Hazard Category (HC-2) occupancies.

B. Installed in accordance with Section 2.4.3.2.2.

*2.4.3.6.4 Halocarbon and Inert Gas (Clean Agent) and Hybrid (Water and Inert Gas) Fire Extinguishing Systems*

2.4.3.6.4.1 Do not use halocarbon or inert gas (clean agent) or hybrid (water and inert gas) fire extinguishing systems to provide protection for data processing equipment rooms with distributed Li-ion battery back-up units. (See Section 3.3.3.3.2)

### 2.4.3.7 Tape Cartridge Storage Units

*2.4.3.7.1 Detection*

2.4.3.7.1.1 When tape cartridges are constructed of combustible materials, provide an FM Approved very early warning fire detection (VEWFD) system within the cabinet in accordance with Section 2.4.2.

2.4.3.7.1.2 Interlock the VEWFD detection to de-energize the electrical service to the cabinet in accordance with Section 2.5.3.

*2.4.3.7.2 Automatic Sprinklers*

2.4.3.7.2.1 When sprinkler protection is provided within the tape cartridge storage unit, design in accordance with Section 2.4.3.2.1.

*2.4.3.7.3 Halocarbon and Inert Gas (Clean Agent)*

2.4.3.7.3.1 When a halocarbon and inert gas (clean agent) extinguishing system is needed within the tape cartridge storage unit, utilize an extended discharge in accordance with Section 2.4.3.2.3.

*2.4.3.8 Uninterrupted Power Supply (UPS) Rooms*

2.4.3.8.1 Protect UPS Rooms in accordance with Data Sheet 5-28, DC Battery Systems.

*2.4.3.9 Tape Cartridge Storage Rooms*

2.4.3.9.1 Provide automatic sprinkler protection in accordance with the recommendations for solid piled storage of unexpanded plastics in Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities.*

#### 2.4.3.10 Storage and Maintenance Areas

2.4.3.10.1 Protect storage areas in accordance with Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities.*

2.4.3.10.2 Protect storage areas with new or decommissioned Li-ion cells/modules/batteries in accordance with the applicable recommendations of Data Sheet 7-112, *Lithium-Ion Battery Manufacturing and Storage.*

## 2.5 Equipment and Processes

### 2.5.1 General

2.5.1.1 Provide proper grounding for equipment in accordance with Data Sheet 5-19, *Switchgear and Circuit Breakers*, Data Sheet 5-20, *Electrical Testing,* and the manufacturer's instructions.

### 2.5.2 Direct Chip, Rear Door/Heat Exchange and Immersion Cooling Systems

2.5.2.1 Use a non-ignitable liquid, non-flammable gas or non-ignitable liquid mixtures for cooling.

2.5.2.2 Provide identification of the cooling/heat transfer fluid being used.

2.5.2.3 Design the cooling systems (e.g., central distribution units (CDU) and pumps) with the following:

A. Primary and back-up power in accordance with Section 2.6

B. Sufficient redundancy to ensure continued operation in the event of equipment failure

C. Sufficient quantity, e.g., thermal mass, of cooling/heat transfer fluid to prevent burnout of server chips during transition from primary to back-up power upon loss of cooling

D. Functionality to conduct maintenance activities without disrupting the system

E. Where single manifolds are used, provide each system feed with isolation device(s) to ensure that leaks do not compromise the supply to other cooled services.

2.5.2.4 Provide the primary cooling piping systems (supplying cooling liquid to CDU's or heat exchangers within the racks) as follows:

A. FM Approved materials and components

B. Non-combustible piping materials (e.g., stainless-steel pipe)

2.5.2.5 Provide primary cooling system piping connections as follows:

A. Welded connections as the preferred arrangement

B. Where flexible connections are required, use non-combustible options such as braided steel hose.

2.5.2.5.1 Do not use interference type (e.g., push-fit) connections.

2.5.2.6 Use components (e.g., valves and piping) and materials, (e.g., elastomers and plastics), in direct contact with the cooling/heat transfer fluid that are verified to be compatible with the fluid at the minimum and maximum operating temperatures.

2.5.2.7 Use compatible materials in direct contact, provide protective coatings or insulate with non-conductive materials to avoid galvanic corrosion.

2.5.2.8 Design piping systems to withstand maximum system pressures, including sudden fluctuations (e.g., hydraulic shock).

2.5.2.9 Arrange all piping systems to isolate a leak to a single server or rack without compromising other connected supplies.

2.5.2.10 Route liquid systems and distribution piping to not expose sensitive equipment, e.g., UPS, server racks or electrical panels.

2.5.2.11 Locate piping below or along the exterior side of the room to minimize damage from potential leaks.

2.5.2.12 Where overhead cooling system pipes are used, do not position couplings, flanges or connections above sensitive equipment.

2.5.2.13 Provide non-combustible leak containment below liquid cooled systems and around potential leak points such as flanges and connections.

2.5.2.13.1 Design leak containment with sufficient capacity and drainage to remove the anticipated quantity of cooling liquid.

2.5.2.14 Provide addressable FM Approved leak detection that alarms to a constantly monitored system (e.g., Data Center Infrastructure Management [DCIM] and/or building management systems [BMS]) to allow for a prompt response to isolate the leak.

2.5.2.15 Annunciate alarms, e.g., temperature, flow, leak, etc., to a constantly attended location.

### 2.5.3 Power Isolation of Data Processing Equipment and HVAC Systems

#### 2.5.3.1 Power Isolation Method

2.5.3.1.1 Provide a power isolation method to achieve the following (separately or together):

A. De-energize all electrical power to the data processing equipment in the room or designated zone(s), except power to lighting, in the event of fire extinguishing system operation.

B. When appropriate, de-energize all dedicated heating, ventilation and air-conditioning (HVAC) systems serving the data processing equipment room or designated zone(s) in the event of fire extinguishing system and/or hybrid fire extinguishing system operation. See Section 3.4.2.2 for further guidance on the impact of power isolation to HVAC equipment.

C. Use a controlled depowering of the data processing equipment prior to isolation of the power source if abrupt power isolation will damage the data processing equipment.

2.5.3.1.2 Provide the appropriate power isolation method based on the type of fire protection installed and site conditions, per the criteria below. The goal is to achieve power isolation before the end of the fire protection agent duration.

A. For areas protected by a wet or preaction sprinkler system in accordance with the recommendations of Section 2.4.3.2.1, or a water mist system in accordance with the recommendations of Section 2.4.3.2.2, provide one of the following, listed in order of preference:

1. Automatic power isolation with controlled depowering initiated by any type of smoke detection or from the water flow alarm

2. Manual power isolation in accordance with Section 2.8.3

B. For areas protected by only a halocarbon or inert gas (clean agent) or hybrid (water and inert gas) fire extinguishing system, provide one of the following, listed in order of preference:

1. Automatic power isolation initiated by the alarm for the discharge of the fire extinguishing system per the following:

a. The controlled time-delay (soft switch) shutdown is completed in a maximum of 10 minutes.

b. The fire extinguishing system design concentration compensates for continuous forced-air distribution during the shutdown process (see Section 2.4.3.2.3).

c. The minimum design concentration to protect energized data processing equipment is maintained until the shutdown process is complete.

Contact the data processing equipment manufacturer for assistance with powering down data processing equipment and the appropriate initiating device to use for automatic power down.

2. Manual power isolation in accordance with Section 2.8.3 if all the conditions for manual power isolation listed in Section 2.5.3.1.3 are met.

2.5.3.1.3 If the need for business continuity of the data processing equipment prevents the use of automatic power isolation, a manual power isolation plan (per Section 2.8.3) is acceptable; if the plan can be relied on in all situations and has been evaluated as equivalent to automatic power isolation. All of the following conditions must exist in order to accept manual power isolation:

A. A VEWFD system is provided in all equipment rooms, according to the recommendations of Section 2.4.2.

B. VEWFD alarms are monitored at a constantly attended location, and alarms are immediately communicated to emergency responders. In addition, alarms may also be communicated to emergency responders via notifications to their mobile device.

C. Qualified and highly trained emergency responders are on site 24 hours per day and have knowledge of all power sources and the methods of isolating power to data center equipment. Responders should be authorized to execute the emergency power isolation plan as needed. Response should occur prior to the activation of fire protection systems or in a maximum of 10 minutes.

D. The data processing equipment room ceiling/roof, floor and walls (not including hot/cold aisle partitions) are of noncombustible construction in accordance with Sections 2.2.1, 2.2.3, 2.2.4 and 2.2.5.

E. Excellent human element programs are established and implemented:

1. Fire protection system impairments are well managed.

2. Ignition sources are controlled.

3. Maintenance, testing and inspection of fire protection and detection systems are regularly completed.

4. Penetrations to data processing equipment rooms are properly maintained.

5. Electrical maintenance, testing and inspection are regularly completed.

6. Housekeeping is excellent.

7. An emergency response plan is in place per Section 2.8.2.

F. The power isolation plan is:

1. Agreed upon by senior site management

2. Reviewed at least annually

3. Tested or drilled at least annually by all individuals involved in the plan

4. Agreed upon and communicated to the fire service

G. Measure the time to complete the manual power isolation at each annual test/drill. Confirm it can be completed within a maximum of 10 minutes after the fire detection alarm is received, including any required power-isolation authorization request procedures that might exist at the facility.

## 2.6 Utilities and Support Systems

### 2.6.1 General

2.6.1.1 Provide a level of redundancy (e.g., tier level) for utilities and support systems appropriate to the business model of the data center.

Refer to Section 3.5.1 for a list of various independent tier certifiers, as well as resources for determining the tier classification of each data center.

### 2.6.2 Electrical Utility

2.6.2.1 For new construction or when major additions are made, perform the following studies:

A. Short circuit study

B. Protection coordination study

C. Load-flow study

D. Stability study

E. System Reliability and redundancy study

2.6.2.2 For a critical location (see Appendix A), design the system with N+1 or greater redundancy to mitigate the downtime due to electrical system component(s) failure (see Section 3.6.2).

2.6.2.3 Provide adequate lightning protection and surge protection for each feed in accordance with Data Sheet 5-11, *Lightning and Surge Protection for Electrical Systems.*

### 2.6.3 Power and Utility Cables

Arrange power and utility equipment to prevent single-point fire exposures and maintain electrical redundancy in accordance with:

A. Section 2.2.7, Cables, in this data sheet and Data Sheet 5-31, *Cables and Bus Bars*

B. Data Sheet 5-4, *Transformers*

### 2.6.4 Emergency/Standby Power Generators

2.6.4.1 Provide sufficient on-site generation so that the data center operations will be unaffected by a loss of utility power.

2.6.4.2 Provide and protect emergency generators in accordance with Data Sheet 5-23, *Design and Protection for Emergency and Standby Power Systems*, and Data Sheet 13-26, *Internal Combustion Engines,* in addition to the recommendations in this section.

2.6.4.3 Locate the emergency generator in the following order of preference:

A. In a separate, purpose-built building with adequate protection

B. In the yard with adequate space separation to important buildings

C. At the ground-floor level in the data center

2.6.4.3.1 Do not locate emergency generators at roof level or in basement areas.

2.6.4.4 Provide one of the following fuel supplies for the generators, listed in order of preference:

A. A 24-hour fuel supply

B. A documented service interruption plan (SIP) that specifies the generators are to be refueled at a rate that allows their uninterrupted operation for 24 hours

2.6.4.4.1 Arrange the fuel supply in accordance with Data Sheet 7-88, *Outdoor Ignitable Liquid Storage Tanks*, as follows in order of preference:

A. Buried tanks

B. Outdoor aboveground tanks with the following:

1. Storage tanks accessed by piping only from the top

2. Protection against siphonic release

2.6.4.4.1.1 Do not locate diesel fuel tanks inside the data center, including the basement, or at roof level.

2.6.4.5 Provide noncombustible soundproofing materials when soundproofing materials are required.

### 2.6.5 Uninterruptible Power Supply (UPS)

2.6.5.1 Where battery UPS systems are provided, design, locate and install the system in accordance with Data Sheet 5-28, *DC Battery Systems.*

2.6.5.1.1 Where Li-ion battery UPSs are used, these are considered Energy Storage Systems (ESS). Follow the recommendations in accordance with Data Sheet 5-33, *Lithium-Ion Battery Energy Storage Systems.*

### 2.6.6 Heating, Ventilation and Air Conditioning (HVAC)

#### 2.6.6.1 General

2.6.6.1.1 Provide heating, ventilation and air-conditioning (HVAC) systems in accordance with Data Sheet 7-13, *Mechanical Refrigeration,* and the recommendations in this section.

2.6.6.1.2 For air-handling units (AHU), provide leak detection with alarm for water piping.

#### 2.6.6.2 Air Systems

2.6.6.2.1 Provide minimum N+1 online redundancy for HVAC components used to maintain the data processing equipment space environmental conditions (e.g., temperature, relative humidity) required for normal operations. These components can include fans, air handling units (AHU), computer room air-handling (CRAH) units, computer room air-conditioning (CRAC) units, chillers, cooling towers, pumps, controls, humidification system components, etc.

2.6.6.2.2 Provide air-handling equipment and air flow paths (e.g., AHUs, ducts) that are independent from those connected to other building spaces.

2.6.6.2.3 Provide a positive pressure of at least 0.05 in. (3 mm) water gauge in the data processing equipment rooms, relative to adjacent areas.

#### 2.6.6.3 Liquid Systems

2.6.6.3.1 Separate chilled water piping for equipment controlling the data processing equipment environment from chilled water piping serving the remainder of the building.

2.6.6.3.2 Connect dedicated data processing equipment space piping as close as possible to the chilled water source. Arrange in a loop with valves capable of dual feeding air handlers for critical applications in the event of a pipe failure.

#### 2.6.6.4 Controlling HVAC Systems

2.6.6.4.1 Provide controls to alarm upon high temperature or excessive temperature rate-of-change as follows:

A.High temperature: No more than 2°F or 2°C above the normal setpoint operating temperature of the lower of either:

1. the high data processing equipment temperature (as recommended by the OEM) measured at the equipment, or

2. the high space air temperature setpoint per the facility HVAC design.

B. Rate of temperature change: As a result of the study recommended in the loss-of-cooling equipment contingency plan (see Sections 2.8.5 and 2.8.7).

2.6.6.4.2 Provide audible and visual alarms in the vicinity of the equipment and at a constantly attended location.

2.6.6.4.3 Provide emergency power to HVAC systems (e.g., fans, CRAHs, chillers, cooling towers) for data processing equipment spaces.

2.6.6.4.4 Provide battery or an alternative power backup such as capacitors for HVAC controls.

#### 2.6.6.5 Monitoring HVAC Equipment

2.6.6.5.1 Monitor HVAC equipment to detect equipment fault conditions or failure and automatically initiate alarms, remedial actions and start redundant (N+1) equipment. At minimum, include the following:

A. Air handler supply duct airflow and temperature

B. Chilled water flow and temperature

C. Condenser water flow and temperature

D. Thermal storage systems

E. Evaporative cooling

F. Economizers

G. Refrigerant flow and temperature

H. Failure of electric power to this equipment

2.6.6.5.2 Monitor electrical power, data processing equipment controls, equipment rack temperatures, and data processing room temperature to detect abnormal conditions; and initiate alarms to mitigate data processing equipment space overheating. (See Section 2.8.3.)

#### 2.6.6.6 Filters

2.6.6.6.1 Provide heating, ventilation and air-conditioning (HVAC) filters that are listed to Underwriters Laboratories (UL) Standard 900 for fire performance.

#### 2.6.6.7 HVAC System Commissioning

2.6.6.7.1 Conduct testing to demonstrate the proper operability across the full range of functions for the HVAC equipment or controls, or the modification of existing HVAC equipment or controls. At minimum, include the following:

A. Automatic interlocks and controls associated with abnormal conditions or system malfunctions

B. Data processing equipment high-temperature alarms and actions

C. Data processing equipment room high-temperature and excessive rate of temperature rise alarms and actions

D. Automatic interlocks to reduce velocities to less than 5 ft/sec. (1.5 m/s), when provided.

## 2.7 Inspection, Testing, and Maintenance

### 2.7.1 General

2.7.1.1 Establish and implement data center utility and support system equipment inspection, testing and maintenance programs. See Data Sheet 9-0, *Asset Integrity,* for guidance on developing an asset integrity program.

### 2.7.2 Heating, Ventilation and Air Conditioning (HVAC)

2.7.2.1 Inspect, test, and maintain HVAC systems and controls for data processing equipment spaces in accordance with the applicable recommendations:

A. Equipment manufacturer’s guidelines

B. Data Sheet 7-13, *Mechanical Refrigeration*

C. Data Sheet 13-24, *Fans and Blowers, for fan guidance*

D. Data Sheet 1-6, *Cooling Towers*

2.7.2.1.1 When ventilation interlocks are provided to reduce air flow, test the interlocks between the fire protection and ventilation system on an annual basis.

2.7.2.2 Liquid Systems: Inspect, test, and maintain piping systems as part of the asset integrity program to verify piping integrity. See Data Sheet 1-24, *Protection Against Liquid Damage in Light-Hazard Occupancies,* for guidance on mitigating damage associated with a liquid release.

2.7.2.3 Drains: Develop a procedure for recording the regular inspection and cleaning of HVAC drains.

### 2.7.3 Equipment Direct Chip, Rear Door/Heat Exchange and Immersion Liquid Cooling

2.7.3.1 Inspect, test, and maintain piping systems as part of the asset integrity program to verify piping integrity and reduce the water damage exposure from a liquid release in accordance with Data Sheet 1-24, *Protection Against Liquid Damage in Light-Hazard Occupancies.*

2.7.3.1.1 Inspect liquid piping systems within data processing equipment rooms monthly to monitor for early indications of leaks, corrosion or impact damage.

2.7.3.1.1 Inspect up to the point of connection to CDUs or heat exchangers.

2.7.3.2 Conduct routine servicing, inspection and testing of critical components.

2.7.3.2.1 Provide maintenance in accordance with the manufacturers' guidance.

2.7.3.2.2 Monitor the liquid coolant quality for degradation to ensure the specifications remain in the design range for the cooling system.

2.7.3.3 Evaluate any findings and rectify in a timely manner.

### 2.7.4 Fire Protection

2.7.4.1 Inspect, test and maintain the fire protection system(s) in accordance with the applicable recommendations in Data Sheet 2-81, *Fire Protection System Inspection, Testing and Maintenance.*

2.7.4.2 Test the VEWFD system annually to verify proper operation in accordance with the applicable recommendations in Data Sheet 5-48, *Automatic Fire Detection.*

2.7.4.3 Inspect the integrity of the enclosure protected by a halocarbon or inert gas (clean agent) or hybrid (inert gas and water) fire extinguishing systems to determine if:

A. Changes have occurred that could affect volume, hazard or both.

B. Penetrations have occurred that could lead to extinguishing agent leakage.

2.7.4.3.1 If an administrative control program is used to document the enclosure integrity, inspect the enclosure every 36 months. If an administrative control program is not used, inspect at least once every 12 months.

2.7.4.3.2 Use a blower door fan unit to verify extinguishing agent concentration will be maintained if uncertainty exists about the integrity of the enclosure.

2.7.4.4 Test the interlocks between the fire protection and ventilation system on an annual basis. (See Section 2.7.2.)

### 2.7.5 Electrical Power Distribution

2.7.5.1 Inspect, test and maintain electrical equipment in accordance with Table 2.7.5.1.

*Table 2.7.5.1. Inspection, Testing and Maintenance - Electrical*

| *Equipment* | *Data Sheet* |
|---|---|
| Main electrical equipment and automatic transfer switch | Data Sheet 5-28, *DC Battery Systems*<br>Data Sheet 5-20, *Electrical Testing* |
| Switchgear and battery systems | Data Sheet 5-19, *Switchgear and Circuit Breakers* |
| Power distribution transformers | Data Sheet 5-4, *Transformers* |
| Emergency standby power systems | Data Sheet 5-23, *Design and Protection of Emergency and Standby Power Systems* |

## 2.8 Human Element

### 2.8.1 Business Continuity Plan

2.8.1.1 Develop a detailed written business continuity plan. Address the following in the plan:

- Executive management support
- Utilization/relocation of personnel
- Facilities and equipment, including:
    - Equipment contingency planning
    - Service interruption planning
    - Power isolation planning
- IT/telecom
    - Any hard disk drives susceptible to disruption of performance by sound pressure or noise
- Suppliers
- Clients
- Plan implementation and testing

2.8.1.2 Review the plan annually to ensure it is up to date and viable.

### 2.8.2 Emergency Response Plan

2.8.2.1 Establish an emergency response plan in accordance with Data Sheet 10-1, *Pre-Incident and Emergency Response Planning,* and the recommendations in this section.

2.8.2.2 Train emergency response personnel and provide authorization to do the following:

A. Conduct a controlled shutdown of electrical power at the ignition source as outlined in the power isolation plan (see Section 2.8.3).

B. Isolate leaking water used for cooling data processing equipment at the closest control valve. Use Data Sheet 1-24, *Protection Against Liquid Damage in Light-Hazard Occupancies*, as a resource to develop a plan and procedures.

2.8.2.3 Develop a pre-incident plan with the local fire service. At a minimum, include the following in the plan:

A. A tour of the facility

B. A description of the facilities and equipment

C. Any special hazards, such as Li-ion battery storage, diesel fuel, or other ignitable liquids, refrigerants, etc.

D. An overview of the fire protection system and location of key fire protection isolation valves, fire pumps and special protection systems

E. The power isolation plan implementation with consideration for ventilation systems that will remain on or be depowered

2.7.2.4 Provide a plan and means to ventilate the protected area from the discharge of either the halocarbon extinguishing agent, inert gas extinguishing agent, or hybrid media and byproducts of decomposition without contamination to other equipment and areas.

### 2.8.3 Power Isolation Plan

2.8.3.1 Develop a detailed power-isolation plan that includes formal procedures for de-energizing data and/or HVAC equipment to reduce damage, contamination from smoke, and prevent reignition.

2.8.3.1.1 Address the following in the power isolation plan:

A. When a manual power isolation plan is implemented, disconnect power to affected energized sources as locally as possible based on current conditions while still providing the ability to power down an entire room if necessary.

B. Initiate power isolation at the room level when the fire protection system(s) activate.

C. De-energize equipment prior to shutdown of HVAC and data processing equipment cooling systems to prevent equipment overheating.

D. Appropriate actions if initial mediation efforts are not successful and the data processing equipment space temperature continues to rise, including interrupting power to the data processing equipment (e.g., main power, emergency power, facility UPS, and equipment-based UPS).

2.8.3.2 At a minimum, include the following items in the power-isolation plan:

A. A description (for the ERT and fire service) of the data processing equipment and HVAC systems within the building and how they are powered and isolated or de-energized. Include all sources of power to the fire area (e.g., commercial power, batteries and generators)

B. The functions and/or zones of disconnect controls (e.g., switch/button, circuit breaker, switch gear) for powering down or de-energizing the data processing equipment and/or HVAC system in the data center

C. The location of the manual control(s), remote manual control(s) and disconnect control(s) for powering down the data processing equipment and/or HVAC system

D. The power sources to the equipment room (electrical panels, PDUs, etc.) showing the areas/equipment they control; so specific equipment can be quickly located and de-energized.

E. The data processing equipment or HVAC system associated with each zone, if multiple zones are used.

F. When to use the manual remote override disconnect control for de-energizing data processing equipment and/or HVAC system

G. The impact from the activation of individual data processing equipment power switches

H. Responders designated to perform the following tasks:

1. Isolate all sources of power, including commercial power, batteries and generators to the fire area.

2. Notify the fire service and site management authorized to implement the power isolation plan.

3. Meet fire service personnel.

4. Advise the fire service personnel of power sources, disconnect controls and depowering methods.

I. Posting the following information for the fire service inside the designated entrance:

1. Floor plans

2. Contact names and phone numbers of personnel responsible for the site

3. Location of emergency power disconnect controls

J. Pre-planning of the previous items with the fire service.

K. Procedures for emergency response team (ERT)and fire service drills.

2.8.3.5 Review and validate the power isolation plan annually or when significant changes occur to the data center.

2.8.3.6 Conduct tests, drills or walk-throughs of the power isolation procedures and methods at least annually with all individuals involved in the plan. (See Appendix D, Testing of Power Isolation Disconnect Control Systems)

### 2.8.4 Disaster Recovery Plan

2.8.4.1 Develop a detailed, written disaster recovery plan in accordance with Data Sheet 10-5, *Disaster Recovery Planning.*

2.8.4.2 Annually review and test the plan to ensure it is up to date and functional.

### 2.8.5 Equipment Contingency Plan

2.8.5.1 When utility and/or support system equipment breakdown results in an unplanned outage to key site processes and systems, develop and maintain a documented utilities and support system equipment contingency plan (ECP) per Data Sheet 9-0, *Asset Integrity.* See Appendix C of that data sheet for guidance on the process of developing and maintaining a viable equipment contingency plan. Also refer to sparing, rental and redundant equipment mitigation strategy guidance in that data sheet.

2.8.5.2 Include the following elements in the contingency planning process specific to data center equipment breakdown exposures, focusing on electrical and cooling system equipment. These elements can include repair, replacement, rental lead time options, used and/or surplus equipment, redundancy and sparing to minimize the downtime.

2.8.5.3 Consider the failure of an automatic transfer switch (ATS) or emergency/standby power systems and switchgear when evaluating equipment contingency plans.

2.8.5.4 For loss of cooling support equipment or electrical supplies, the overall objective of the ECP is to restore the equipment to operation. See Section 2.8.7 for guidance on operators and loss of cooling emergency operating procedures (EOPs).

### 2.8.6 Service Interruption Plan

2.8.6.1 When the loss of utility and/or support system services for a data center results in an unplanned outage to site processes and systems considered key to the continuity of operations, develop and maintain a documented, viable service interruption plan (SIP).

2.8.6.1.1 Develop the data center SIP by conducting a systematic, strategic assessment of data center utilities and support system services to identify, in advance, the impact of and response to loss of the services.

2.8.6.1.2 Consider recovery from damage to utilities and support system equipment and the loss of the process/equipment operating conditions and environment.

2.8.6.1.3 Consider the timeline for an orderly shutdown and isolation of equipment per the documented emergency operating procedures and the power isolation plan. Evaluate the state of the equipment, then restart and restore full operations per the documented standard operating procedures.

2.8.6.2 Evaluate the following elements in the SIP process specific to the utility system electrical services for the data center:

A. Electrical service (see Section 2.6)

1. System design/redundancy for critical electrical paths
    - a. Single points of failure
    - b. Critical load flexibility, continuity
    - c. Power isolation
2. Capabilities, viability of the emergency power system
    - a. Emergency or standby generators
    - b. UPS
    - c. Orderly shutdownd

d. Duration of operation

e. Fuel supply/replenishment for expected duration

B. Loss of cooling due to loss of electrical service (see Section 2.6.6)

1. System design/redundancy for critical cooling paths

### 2.8.7 Operators

2.8.7.1 Establish and implement an operator training program. Develop, maintain current, and implement documented standard operating procedures (SOPs) and emergency operating procedures (EOPs) in accordance with Data Sheet 10-8, Operators, and the recommendations in this section.

2.8.7.2 Define actions and provide instructions required for normal conditions (SOPs) to ensure operation within design limits and emergency/upset conditions (EOPs) due to the loss of electrical and cooling equipment.

2.8.7.3 Identify the process for the orderly shut-down of data processing equipment upon loss of cooling, or impending loss of cooling, before the temperature exceeds the facility's or manufacturer's guidelines, including warranty restrictions.

2.8.7.3.1 Consider sensors and alarms, and response capabilities of emergency personnel and operators in the EOP operations. Include the criticality of the data processing functions and an understanding of the time required to identify an equipment overheating situation, make decisions, and take actions to prevent data processing equipment damage.

2.8.7.4 Evaluate the following elements in the EOP process specific to equipment breakdown resulting in loss of cooling to data center processing equipment:

A. Data from the original equipment manufacturer's (OEM) literature for all critical data processing equipment components. Include warranty thresholds, recommended maximum short-term operating temperatures and automatic equipment shutdown interlocks provided by the OEM due to excess temperatures in all data processing equipment (power supplies, servers, data storage equipment, etc.).

B. Calculations by qualified design professionals involving the nature of the cooling equipment, the room and surroundings, and data processing equipment, to determine the expected room temperature rate of rise on loss of cooling, assuming continued operation of the data processing equipment.

C. The probable time to data processing equipment damage due to temperatures exceeding critical thresholds. Include at least the following inputs: data processing equipment individual heating characteristics, electrical power input to the data processing equipment room, data processing equipment space volume and height, normal data processing equipment space operating temperature, any partial cooling from the cooling equipment connected to standby power.

D. Using the information in A through C, develop (at a minimum) the following scenarios in the EOP at several levels of temperature threshold alarms with the mitigation actions to be taken at each level:

1. Short-term (~51 sec), medium-term (~51 min), and long-term (~72 hr) interruptions of utility power to the entire facility (See Section 2.8.6 for Service Interruption Planning.)

2. Breakdown of a single critical cooling system component, such as a chiller, chilled water pump, condenser water pump, cooling tower fan, air handler fan (e.g., bearing seize), cooling media control valve (e.g., failing closed), cooling system local and centralized control, variable speed drive, and electric power (e.g., circuit breaker) for any of the above equipment.

3. Additional breakdown scenarios as needed based on a review of the facility's unique design, arrangement and operation

E. The time necessary to provide sufficient cooling to the data processing equipment space following short-term power loss to the facility to avoid data processing equipment overheating damage. Include at least the following inputs: time to start standby power generators, cooling equipment connected to the standby power and time to start cooling equipment (e.g., controls, chillers, pumps, cooling towers, CRAH, etc.).

2.8.7.5 Implement the loss-of-cooling EOP using the following elements:

A. Training: Provide training to facility operations personnel and data processing equipment operations personnel.

B. Authority: Designate at least one operator per shift to have the authority to implement the EOP, including the data processing equipment power isolation plan (Section 2.8.3) if data processing equipment shutdown is needed to prevent damage.

C. Operation: Designate personnel on each shift to perform the steps in the loss of cooling equipment contingency plan.

D. Practice:

1. Recovering cooling to the data processing equipment, including starting emergency generators, shifting critical equipment operation to backup (N+1) components, restarting HVAC equipment (CRAH, chillers, pumps, cooling towers, controls, etc.)

2. The real-time decision path to identify situations in which cooling cannot be restored before the data processing equipment incurs critically high temperatures, resulting in shutdown of the data processing equipment.

3. The actions required to interrupt power to the data processing equipment in accordance with the power isolation plan to ensure the required timeframe is met.

2.8.7.6 Review and validate the SOPs and EOPs annually or when significant changes occur to the data center.

### 2.8.8 Facilities

#### 2.8.8.1 Housekeeping

2.8.1.1.1 Provide procedure(s) for regular housekeeping inspections with the following goals:

A. Potential ignition sources are controlled (e.g., smoking, hot work, temporary heaters, cooking equipment).

B. The accumulation of combustible materials is prevented.

C. Ordinary combustibles are not stored inside or behind control cabinets.

D. Necessary routine spare parts, manuals, etc. are kept in normally closed metal cabinets.

#### 2.8.8.2 Penetrations

2.8.8.2.1 Provide the following:

A. Develop procedure(s) to manage penetrations within the data center to control smoke and liquid damage and maintain the construction fire-resistance rating. At a minimum, include the following:

1. Location of the current or new penetration to be opened

2. Issuance of a permit for the opening of the penetration

3. Confirmation the work is completed, and the penetration is sealed or resealed

4. Removal and retention of the permit as a record of the work

5. Periodic audits of penetration locations to determine the procedure is being followed

B. Verify the integrity of penetration sealing on a minimum yearly basis.

C. Seal new penetrations identified from inspection or penetrations having compromised integrity in accordance with Section 2.2.6, Penetrations.

#### 2.8.8.3 Cables

2.8.1.3.1 Develop a Management of Change (MOC) policy to document the type/marking (e.g., plenum rated) of new communication and data cables (e.g., coaxial and fiber optic) and power cables that can be installed.

2.8.1.3.2 Remove abandoned or routine spare cables that are not in service and are not intended for future service.

#### 2.8.8.4 Hot Work Management

2.8.1.4.1 Develop a hot work management program in accordance with Data Sheet 10-3, Hot Work Management.

### 2.8.9 Security

2.8.9.1 Design buildings to prevent unauthorized access in accordance with Data Sheet 9-1, *Supervision of Property.*

2.8.9.2 Design buildings' security in accordance with Data Sheet 9-16, *Burglary and Theft,* and recommendations in this section.

2.8.9.2.1 Install an FM Approved Level 1 or better intrusion alarm system for data and record storage rooms, if these areas have emergency doors that exit outside the secure area.

2.8.9.2.2 Install an FM Approved Level 2 or better intrusion alarm system, if previous experience indicates this need.

2.8.9.2.3 Provide the alarm system with line supervision or a local alarm, and provide a response level that meets a response specification of FM-15.

# 3.0 SUPPORT FOR RECOMMENDATIONS

## 3.1 Construction and Location

### 3.1.1 General

Plastic materials, including those of fire-retardant composition, can produce large quantities of smoke that can damage data processing and other equipment.

### 3.1.2 Penetrations

The objective of sealing penetrations is to prevent smoke from a fire in adjacent spaces from entering the data processing equipment space, and to hold a halocarbon or inert gas (clean agent) concentration, if applicable.

Fire-resistance-rated penetration seals do not prevent the passage of smoke until the seal expands when exposed to heat from the fire. A penetration seal with a leakage rating will limit the passage of smoke before the seal is exposed to high temperatures. The UL 1479L-Rating leakage tests are conducted at ambient and at 400°F (204°C).

### 3.1.3 Cables

Power cables and junction boxes for power cables with chlorinated polyethylene or polyvinyl chloride (PVC) sheathing, insulation, or construction when involved in a fire or electrical fault could produce hydrochloric acid (HCL) gas at levels sufficient to produce smoke damage and corrosion to the data processing equipment and other equipment.

### 3.1.4 Hot/Cold Aisle Containment

Hot/cold aisle containment systems may introduce plastic combustibles into the room. The use of flexible plastics for containment is not recommended; because flexible plastics include plasticizers, which create more corrosive smoke when burned.

### 3.2 Occupancy

#### 3.2.1 Li-Ion Battery Backup Units in Data Processing Equipment Rooms

Data centers are moving towards battery back-up units (BBU) using Li-ion battery modules in data processing equipment rooms. Battery backup units (BBU's) are installed in data processing server racks to provide localized, uninterruptible power to the data processing equipment in the event of a main utility power failure and reduce peak power demand of the data center. BBUs are designed to be installed within a server rack in place of a server blade. Each company has their own proprietary technology, arrangement, specification, battery power, quantity and layout of the BBU's within the racks. See Figure 2.3.1.4.1 for example of a rack layout containing power shelves.

Each BBU module consists of a battery pack and a DC-DC converter. They are also equipped with a Battery Management System as well as electrical protection to manage battery and electrical faults. Most of today's BBUs use lithium-ion battery chemistry. Like other stationary batteries, BBU's require regular load testing to ensure they have sufficient capacity to perform their function.

Introducing Li-ion BBU's into a data center creates an ignition source within the data processing equipment room that did not previously exist. This additional ignition source has the potential to increase the frequency of fire losses in this occupancy. Therefore, tighter control of material flammability in the data hall (e.g., cables, cold/hot aisle separation panels, and other plastics and combustible materials on the computer servers and racks) is required. In addition, fire intensity and severity will be increased compared to that typically expected in data processing equipment rooms without distributed power systems. With multiple BBU's installed in server racks, the potential exists for continuous thermal runaway caused by overheating of adjacent BBU's. This situation has the potential to cause larger, more damaging fires with the added risk of reignition following a fire event.

##### 3.2.1.1 BBU Power Output

The output of individual BBU's should be available from the equipment operator and is usually reported as kWh for the overall unit.

Battery back-up units consist of a number of individual Li-ion cells. Cells are rated in Ampere hours (Ah) and Voltage (V). To determine the kWh output per cell the following formula should be used:

$$\frac{\text{Ah x V}}{\text{1000A}} = \text{kWh}$$

Once the kWh per cell is known, it should be multiplied by the number of cells in the module, giving the overall output per module.

The module output should then be multiplied by the number of modules per rack to determine the kWh per rack.

#### 3.2.2 Quantum Computers

Quantum computers are typically located at research establishments, universities and the research campuses of large technical organizations. Quantum computers are expensive (US$5-10 million per unit).

To operate, high vacuums and very low temperatures are needed to maintain stable operation of the quantum chip. Cryogenics are used to cool quantum computers to those low temperatures. Different methods are used to reach the desired low temperatures. Degree Kelvins are the standard for coldness measurements in cryogenics. Zero Kelvin is equal to absolute zero (-459.67˚F or -273.15˚C).

The quantum computer structure and equipment does not need to be located in a special environment, clean space, etc. However, once the vacuum and cryogenic chamber is lowered from the quantum computer to access the quantum chip, as in Figure 3.2.2, the internals are extremely delicate and susceptible to non-thermal damage from smoke.

**Quantum Computer Cooling**

Note that damage to the quantum computer does not occur with temperature change. However, functionality ceases with temperature fluctuations, creating errors in calculations; so, temperature control is critical to operation.

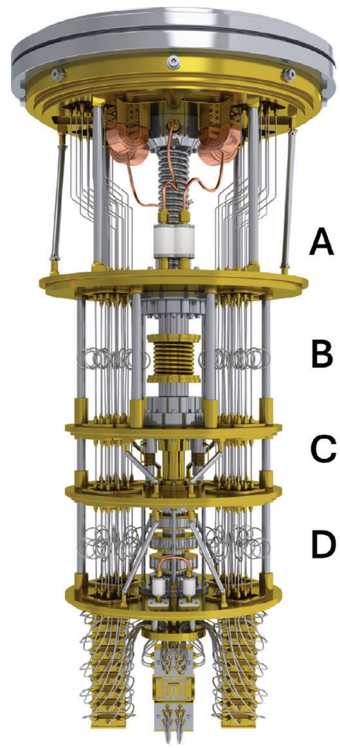



*Fig. 3.2.2. Internal component structure of vacuum and cryogenic chamber*

The loss of cooling to a quantum computer will not damage the quantum chip; however, it will not be able to operate and generate revenue.

Should multiple quantum computers be connected to an individual support system for vacuum, refrigeration or power, consider the impact to multiple quantum computers. Along with the quantum computer, large amounts of conventional computing power are needed to analyze and correct errors from the data generated. This conventional computing power will likely be located in data processing equipment rooms or data centers away from the quantum computers.

**Dilution Refrigeration (Typical Method)**

This method uses a mixture of Helium-3 and Helium-4 isotopes to cool the chip to temperatures as low as 10 millikelvin (10/1000th of a Kelvin) above absolute zero. Multistage systems precooled with nitrogen are used for this purpose. The quantum computer is arranged in a chandelier type structure, housed in a metal cylinder. The four stages in the structure get progressively colder, with the bottom stage connected to the quantum chip (Stage D). Stage A is the highest and warmest stage of the cooling system. This initial precooling may use standard refrigeration techniques. Stage B evaporative cooling uses liquid helium a few degrees above absolute zero. At Stage C actual dilution occurs when Helium-3 and -4 are mixed and circulated to draw away heat from the system. Finally at Stage D, qubits in the quantum chip are maintained at temperatures close to absolute zero.

The main components of the dilution refrigeration system, the still, heat exchangers, mixing chamber and mount/cold plate are all contained in the vacuum chamber of the quantum computer. The pulse tube cooler (PTC) is specific to a single computer. The gas delivery system is the system which could potentially create the single point of failure for multiple computers.

**Adiabatic Demagnetization Refrigeration**

Magnetic fields are used to cool paramagnetic materials. This cooling method can achieve temperatures to below 2 degrees Kelvin, which is suitable for certain types of quantum chips currently in development.

**Pulse Tube Refrigeration**

Mechanical cooling using pressure waves in a sealed gas circuit, effective for reaching temperatures of below 4 degrees Kelvin, is used in cryogen free systems.

**Laser Cooling**

Laser cooling is a technique that uses frequency and laser light intensity tuning to reduce the speed of the movement of atoms and other particles. This method can be used with certain types of qubit technology and is not widely used.

### 3.2.3 Tape Cartridge Storage

An automated tape library is a hardware device that contains multiple tape drives for reading and writing data, access ports for entering and removing tape cartridges, and a robotic device for mounting and dismounting the tape cartridges without human intervention. Tape cartridges are usually constructed of plastic and can be numerous within the tape library. When constructed of combustible material, they are a possible fuel source. The robotic devices are electrically powered and can be considered an ignition source. Hence, recommendations are provided for detection and suppression within the automated tape library equipment.

The virtual tape library (VTL) combines traditional tape backup methodology with disk technology to create backup and recovery features.

By backing up data to disks instead of tapes, VTL often increases performance of both backup and recovery operations. In some cases, the data stored on the VTL's disk array is exported to other media, such as physical tapes.

VTL disk storage is not designed to be removable. Since the disk storage is always connected to power and data sources, it is exposed to potential impact from data center interruptions.

## 3.3 Protection

### 3.3.1 General

#### 3.3.1.1 Aerosol Generator Fire Extinguishing System Units

Aerosol generator fire extinguishing system units are not clean agent systems as defined by Data Sheet 4-9, *Halocarbon and Inert Gas (Clean Agent) Fire Extinguishing Systems*, and do not provide reliable fire protection for a data center. Some products are thermally actuated, so they would not provide equipment protection in accordance with FM recommendations for this type of occupancy even if used with sprinkler protection.

Products that are listed by Underwriters Laboratories have specified limitations associated with the product category. In particular, they are intended for total flooding applications of normally unoccupied or uninhabitable spaces; and the potential effects of aerosol extinguishing agent discharge residue on sensitive equipment and other objects have not been investigated.

### 3.3.2 Detection

#### 3.3.2.1 General

Very early warning fire detection (VEWFD) systems detect smoldering or off-gassing, typically generated from an overheating condition or from low-energy fires. VEWFD systems detect incipient fires in critical areas before flame or even noticeable smoke develops. VEWFD may use aspirating (air-sampling detectors) or high-sensitivity, intelligent spot sensors/detectors. Detectors used to accomplish VEWFD are FM Approved to provide an alarm initiation at threshold levels more sensitive than conventional smoke detectors.

When evaluating the use of aspirating smoke detection versus intelligent high-sensitivity spot smoke detection, the specific requirements for the occupancy need to be considered, including the following:

- Progressive response notification
- Local identification of the event
- Type of fire protection system(s) provided

- Number of fire protection systems and/or zones provided

For aspirating smoke detectors and intelligent high sensitivity spot smoke detectors, multiple smoke annunciation thresholds can be used to perform a progressive response to a potential fire that minimizes business impact:

- Level 1 (Alert): Notify constantly attended location.
- Level 2 (Pre-Alarm/Action): Local alarm in protected area; initiate data transfer (re-route data to alternate data center equipment room or data center) and interlock reduced ventilation rate.
- Level 3 (Alarm/Fire): Initiate fire alarm to building fire alarm control panel and fire service, initiate suppression (or interlocked preaction sprinkler system or stage one on a double-interlock system).

In data processing equipment rooms with containment panels reaching to the ceiling level, a cross-zoned detection adds another interlock level due to isolation of the smoke. This configuration will lead to a “triple” interlock situation if applied to double interlock preaction systems.

Extending spot detectors or sampling ports downward into the flow path of the sheared air can mitigate issues with stagnant air pockets at the ceiling level. Also, providing individual, addressable sampling ports in specific server cabinet racks can identify event origin for critical equipment.

Environmental factors, such as humidity and dust, may require less-sensitive settings to avoid nuisance alarms. However, detection should not be desensitized to the point where the intent of very early warning fire detection is compromised. Obscuration levels may need to be different than suggested to achieve the intended function due to airflow, air velocity and type of HVAC system.

#### 3.3.2.2 Air Aspirating Detection

Typical minimum alert and pre-alarm settings for air-sampling systems are usually 0.2%/ft (0.7%/m) obscuration (effective sensitivity at each port). Alarm settings for air-sampling systems are usually 1.0%/ft (3.3%/m) obscuration (effective sensitivity at each port).

For air-sampling systems, these settings assume only one opening draws in smoke and the rest of the openings draw in clean air. The concentration at the alarm panel would be set at or less than the smoke concentration at one opening, divided by the number of openings.

For an alert setting of 0.2%/ft obscuration (effective sensitivity at each port) and 50 sampling openings, the panel setting would be equal to or less than 0.2%/ft divided by 50, or 0.004%/ft. If 20 openings were present, the panel setting would be equal to or less than 0.2%/ft divided by 20, or 0.01%/ft.

In metric units, for an alert setting of 0.7%/m obscuration (effective sensitivity at each port) and 50 openings, the panel setting would be equal to or less than 0.7%/m divided by 50, or 0.014%/m. If 20 openings were present, the panel setting would be equal to or less than 0.7%/m divided by 20, or 0.035%/m.

#### 3.3.2.3 Intelligent High-Sensitivity Spot Detection

For intelligent, high-sensitivity spot smoke detectors, the obscuration sensitivity levels can be programmed similar to an aspirating smoke detector. The control panel used with an intelligent, high-sensitivity spot smoke detector typically has fewer levels of notification with a reduced progressive response.

Typical minimum alert settings for intelligent high-sensitivity spot-type detectors are programmed to be 0.2%/ft (0.7%/m) obscuration. Alarm settings for high-sensitivity spot-type detection are programmed to be 1.0%/ft (3.3%/m) obscuration.

Ambient temperatures in a hot aisle could be in the range of 100°F (38°C) or more, which may be in excess of the allowable operating temperature for an FM Approved spot detector.

#### 3.3.2.4 Smoke Control Systems

Smoke management systems within a data center involve complex designs due to the variety of equipment, air-handling arrangements and the impact of smoke contamination on equipment. The effectiveness of these systems for minimizing damage to equipment is unknown.

### 3.3.3 Suppression

#### 3.3.3.1 General

*3.3.3.1.1 Protection Options*

The objective of automatic sprinkler and water mist systems in data centers is to control a fire and limit fire propagation to a small area beyond the region of ignition. If electrical power is not interrupted automatically, reignition of a fire from the continued delivery of electrical power is eliminated by the cooling effect of water. The power can be interrupted manually in a controlled sequence with coordination of fire extinguishment by the local fire service.

The objective of halocarbon or inert gas (clean agent) fire extinguishing systems in data centers is to limit the extent and severity of damage to data processing equipment, and reduce the associated business interruption to a much lower level than would result from automatic sprinkler or water mist system protection alone. Clean agent fire extinguishing systems are designed to maintain an adequate concentration of agent in the protected space for only a limited period of time (typically 10 minutes). This time reflects the practical limitations of constructing rooms to be as airtight as possible, which industry experience has shown to be exponentially more difficult with longer "hold times."

Once the extinguishing agent concentration is reduced below the required level, the fire will reignite any combustibles; if the ignition source has not been removed by shutting off power to the data processing equipment of fire origin. This concentration reduction occurs either by natural seepage of the extinguishing agent through cracks in the building over a short time, or when the doors are opened to admit emergency response team or fire service personnel. Therefore, power down must be accomplished within this timeframe to prevent reignition. If a clean agent fire extinguishing system is the only fire protection installed in the space (i.e., no sprinklers or water mist), and the energized data processing equipment is not powered down, an uncontrolled fire will result with fire propagation to the limit of combustibles.

Automatic sprinklers, water mist, hybrid, halocarbon and inert gas (clean agent) fire extinguishing systems each have positive and negative features as summarized in Table 3.3.3.1.1.

*Table 3.3.3.1.1. Comparison of Protection Features*

| *PROTECTION SYSTEM* | *POSITIVE FEATURES* | *NEGATIVE FEATURES* |
|---|---|---|
| Automatic sprinklers | * Occupancy & building protection<br>* Cost effective<br>*Reasonable maintenance | * Large fire needed to activate<br>* Premature activation water damage exposure<br>* Preaction system reduced reliability |
| Water mist | * Low quantity of water discharge<br>* Occupancy and building protection | * Large fire needed to activate<br>* Installation cost<br>* Restrictive applications (hazard category, ceiling height, etc.)<br>* Inspection & maintenance<br>* Complex system; reduced reliability |
| Halocarbon, hybrid or inert gas suppression | * Greatly limits damage<br>* Detector activated | * Protection for occupancy, not building<br>* Installation cost<br>* False discharge<br>* One shot discharge<br>* Room integrity<br>* Door fan test<br>* Inspection & maintenance<br>* Complex systems; reduced reliability<br>* Automatic power & HVAC shutdown may be required<br>* Not effective for combustible loading greater than light hazard.<br>* Halocarbon extinguishing agents need to be ventilated from the enclosure after a discharge due to the corrosive products of decomposition from exposure to the fire. |

*3.3.3.1.2 Suppression Criteria*

In general, the lower the room ceiling height, the more effective the fire protection systems. The limit of 30 ft (9.1m) on data center ceiling heights for sprinklers and water mist systems in the FM Approval listing is intended for the protection to activate promptly, thereby reducing fire, smoke, and water damage. The ceiling height limitation also constrains the room volume; such that the halocarbon, inert gas or hybrid extinguishing agent quantity and associated distribution piping remain practical.

### 3.3.3.2 Sprinklers and Water Mist Systems

No general design methodology exists for water mist systems. Fire control performance is not consistent between manufacturers of water mist systems. The characteristics of drop-size distribution, nozzle spacing, spray angle, installation parameters, etc. are determined from full-scale fire testing to replicate or represent a specific hazard application. Therefore, only an FM Approved water mist system listed for the specific hazard application or recommended in a Data Sheet as correlating to the hazard can provide acceptable protection.

*3.3.3.2.1 Data Center Equipment Room*

FM conducted a limited series of tests to evaluate the performance of sprinklers and water mist systems for the protection of vertical and horizontal cables. These cables were configured for use with servers and cable trays in a data processing equipment rooms with forced ventilation. The recommendation identified in Section 2.4.3.2.1.2 is based upon the results of this testing with the specific fire test hazard configuration.

*3.3.3.2.2 Below Raised Floor*

FM Approved water mist systems listed specifically for protection of cables below raised floors have two different design methods: (1) area of coverage and (2) local application. The area of coverage design uses a square nozzle spacing throughout the entire below-raised floor area, regardless of cable tray location. The local application design uses linear spacing and is intended to protect the specific length of cable tray. Either design can be used alone or in conjunction with the FM Approved “above-floor protection” design. The FM Approval listing for below raised-floor protection will designate the number of cable tray tiers for which it has been evaluated to adequately protect.

*3.3.3.2.3 UPS Rooms*

Water mist systems are not FM Approved for the protection of Li-ion battery UPS cabinets.

*3.3.3.2.4 Maximum Water Delivery Time Delay for Sprinklers and Water Mist Systems*

At existing locations, the water delivery time delay of the preaction automatic sprinkler or water mist system to the most remote sprinkler or nozzle (maximum 30 seconds) can be determined by either:

A. Testing to verify the water delivery time (if a remote test connection is provided)

B. Hydraulic calculations for water delivery time and confirmation that the installed sprinkler piping is in accordance with the hydraulic calculations

### 3.3.3.3 Halocarbon and Inert Gas (Clean Agent) and Hybrid (Water and Inert Gas) Fire Extinguishing Systems

*3.3.3.3.1 General*

If the halocarbon or inert gas extinguishing agent is designed to only discharge in the room with a raised floor or below the raised floor, a dilute agent concentration can develop; as the agent migrates to the unprotected space. This migration can result in insufficient agent concentration for fire extinguishment. If the agent is a halocarbon, decomposition of the extinguishing agent can occur (e.g., hydrogen fluoride), resulting in contamination of the data processing equipment.

Where a Level 2 pre-alarm will result in the pre-discharge alarm for the halocarbon or inert gas (clean agent) fire extinguishing system, operating procedures should specify that all nonessential personnel evacuate the area/room. This condition will prevent personnel exiting through a door after the fire extinguishing agent discharge has begun. Continuous opening of exit door(s) during or after the discharge will allow some of the extinguishing agent to escape, possibly causing the concentration in the protected area/room to drop below levels needed for fire extinguishment.

Labelling fire alarm pull stations and emergency power-down controls will help eliminate confusion during a fire emergency.

Halocarbons or inert gas (clean agents) discharged from the nozzle require a vaporization or separation distance, respectively. If the clean agent comes in contact with a surface (e.g., cable trays, containment system walls, obstructions) before it is vaporized, frosting can occur. This frosting will result in a delivered concentration less than the design concentration for protection of the room and/or enclosure. Discharging an inert gas too close to an object can cause significant damage to the equipment and reduce effectiveness of the extinguishing system.

*3.3.3.3.2 Battery Back-Up Units (BBUs)*

Halocarbon and inert gas (clean agent) and hybrid protection systems are not recommended for BBU applications for the following reasons:

A. Efficacy relative to the hazard: No evidence exists that gaseous protection is effective in extinguishing or controlling a fire involving Li-ion batteries. Halocarbon and inert gas (clean agent) protection systems may inert or interrupt the chemical reaction of the fire, but only for the duration of the hold time. The hold time is generally ten minutes—not long enough to fully extinguish a Li-ion battery fire or prevent thermal runaway from propagating to adjacent modules or racks.

B. Cooling: FM research has shown that cooling the surroundings is a critical factor to protecting the structure or surrounding occupancy; because currently, a Li-ion battery module fire cannot be extinguished with sprinklers. Gaseous protection systems do not provide cooling of the Li-ion batteries or the surrounding occupancy.

C. Limited Discharge: FM research has shown that Li-ion battery fires can reignite hours after the initial event is believed to be extinguished. As gaseous protection systems can only be discharged once, the subsequent reignition would occur in an unprotected occupancy.

*3.3.3.3.3 Sound Pressure Levels*

Very short discharge times (less than 60 seconds) should not be used with inert gas fire extinguishing systems if hard disk drives are susceptible to disruption of performance by sound pressure levels (e.g., noise) from the discharge. A minimum 30-second discharge time is part of the FM Approval listing, but should be avoided for this occupancy.

### 3.3.3.4 Hot/Cold Aisle Containment Systems

3.2.3.1 Hot/cold aisle containment presents challenges to fire protection in data processing centers due to:

- Shielding and obstruction of ceiling sprinklers or water mist nozzles
- Shielding and obstruction of smoke detection systems
- Failure of halocarbon or inert gas extinguishing agents to properly penetrate the equipment beneath the containment

Figures 3.3.3.4.A and 3.3.3.4.B provide conceptual views of typical hot and cold aisle containment systems with vertical air flow and typical sprinkler/nozzle placement. Figure 3.3.3.4.C provides a conceptual view of a hot collar containment system with vertical air flow and typical sprinkler/nozzle placement. Figure 3.3.3.4.D provides a conceptual view of hot and cold aisle containment systems for horizontal air flow with no raised floor.

Other containment configurations can be used to control the cooling of servers including the use of flexible plastic curtains.

Drop out ceiling tiles may be used to eliminate the need for localized sprinkler or water mist system protection within hot/cold aisle containment systems. When FM Approved (Class 6451) drop out plastic materials are not used, the thinnest flexible plastic curtain material should be used. This configuration may allow the aisle containment material to melt and fall into a fire sooner, allowing ceiling water discharge to reach the fire. Drop out of non-FM Approved materials during a fire event will likely be delayed and unreliable.

Engineered hot/cold aisle containment systems may leverage releasing device assemblies (fusible links, thermal mechanical links and mechanisms) to remove curtains and aisle containment materials used with containment systems during a fire. These systems should not be credited to operate as intended; as multiple factors (location of thermal element/fusible link, reliability of release mechanism, etc.) may impact the functionality of system during a fire event. The use of these devices increases the complexity of providing proper protection compared to additional sprinklers or clean agent nozzles.

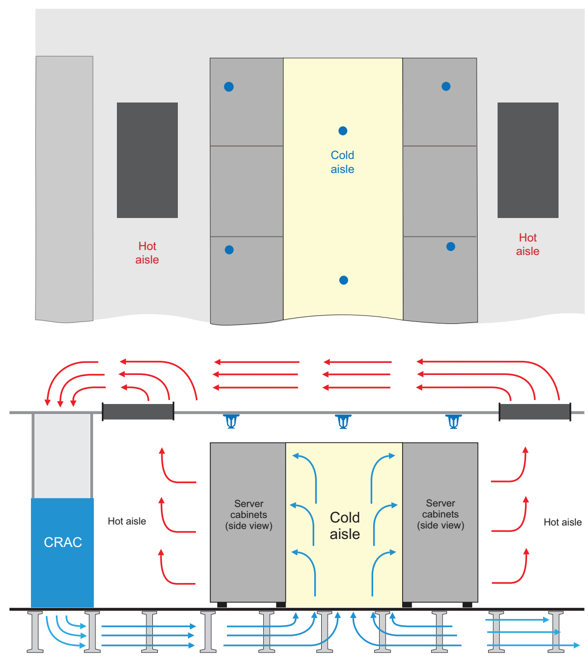



*Fig. 3.3.3.4.A. Conceptual view of cold aisle containment system (Note: Other containment configurations can be used to control the cooling of servers)*

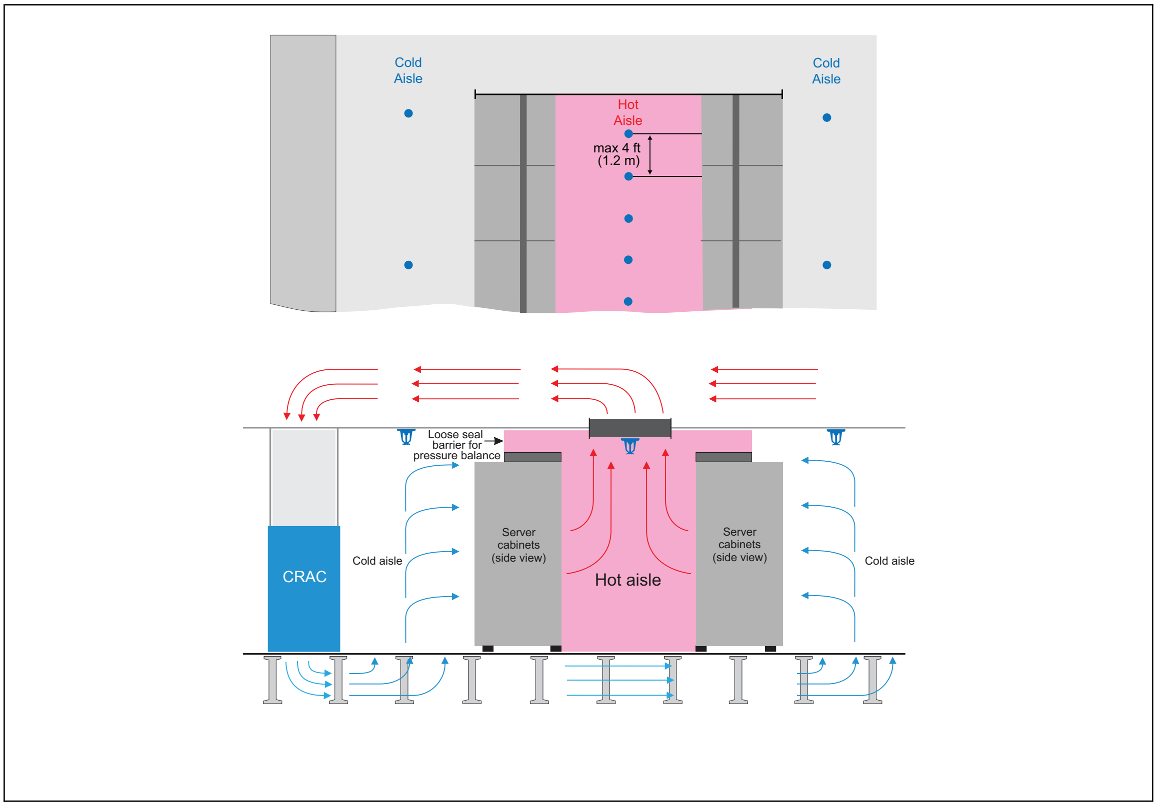



*Fig. 3.3.3.4.B. Conceptual view of hot aisle containment system*

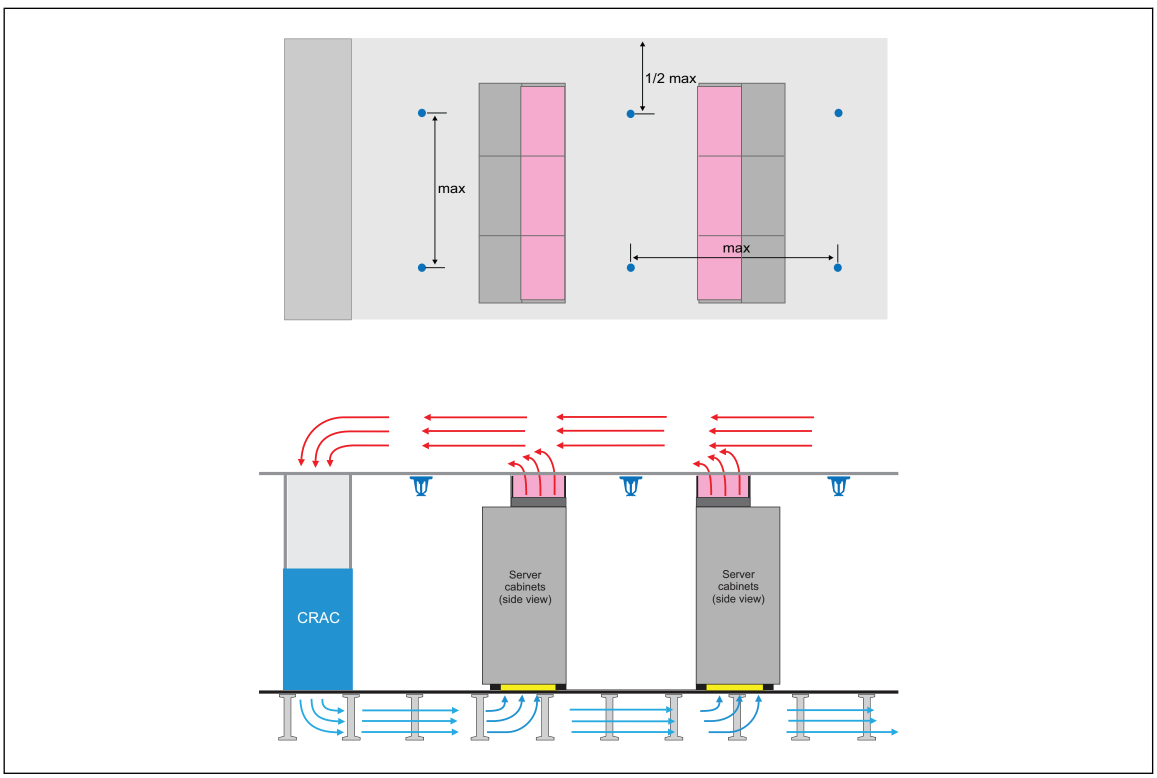



*Fig. 3.3.3.4.C. Conceptual view of hot collar containment system*

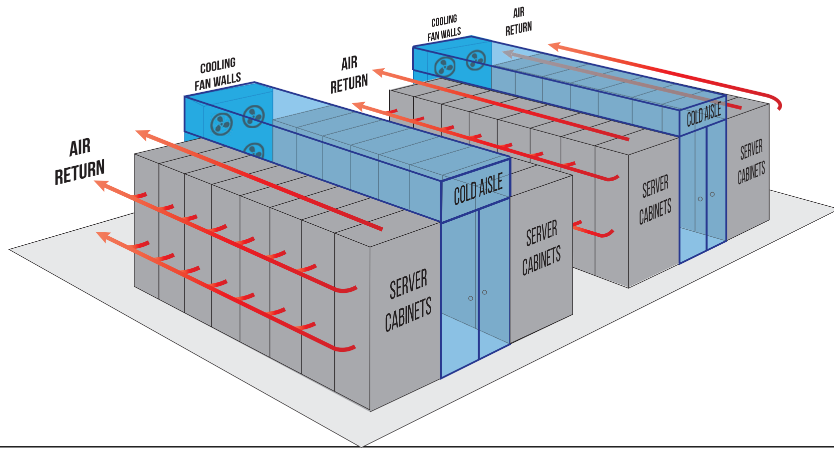



*Fig. 3.3.3.4.D. Conceptual view of hot/cold aisle with horizontal air flow without a raised floor*

Consider the type of air-handling unit (AHU) design for continuous distribution of the halocarbon or inert gas extinguishing agent to all areas of the containment aisles. The cooling air in a data processing equipment room is typically circulated in a closed loop from the air-handling unit to the equipment below the raised floor, into the return air ducts and back to the equipment. Some designs include single pass airflow, such that all cooling comes from the outside and exits the building without any recirculation. Some designs also include options for anything from single pass to total recirculation, depending on conditions.

### 3.4 Equipment and Processes

#### 3.4.1 Direct Chip, Rear Door/Heat Exchange and Immersion Liquid Cooling

Liquid cooling for rack servers (which includes direct-to-chip and immersion cooling) offers thermal efficiency and performance benefits, but also introduces a range of property loss prevention risks that need to be considered, including:

- Leaks from cooling fluids will cause damage to sensitive server equipment and other building and contents.
- Incompatible materials used for piping systems can lead to galvanic corrosion when poor cooling liquid quality or conductive cooling mixtures are present.
- Loss of cooling to server equipment from leaks or system component failures can cause rapid heating and result in damage/destruction to server components. In some cases, fire may result.

    o Thermal energy storage (TES) in a building-level cooling system is tied to a customer/suite-level liquid server cooling system. This system is basically a UPS for cooling. It provides thermal mass to bridge the time between the loss of utility power and when the backup generators turn on and restart the chillers.

- If fluids are ignitable, they could provide additional fuel for a fire and cause extensive damage.

#### 3.4.2 Power-Down of Data Processing Equipment and HVAC Systems

##### 3.4.2.1 General

The goals of the recommendations for power isolation of data processing equipment and HVAC systems are to remove the potential for reignition, improve the effectiveness of halocarbon or inert gas (clean agent) fire extinguishing systems and minimize the circulation of smoke to sensitive electronic equipment.

The installation of a power disconnect system to rapidly isolate power and HVAC supplies can seem contrary to the critical power/business continuity requirement of most data centers. However, an electrical fault is the most probable fire ignition source in a data center. To ensure adequate control of fire propagation, prevent reignition and allow emergency response personnel access, having a way to reliably isolate power is necessary.

Although a relatively high level of electrical fault protection exists throughout a data center via circuit breakers, fuses or other means, these cannot be relied upon to de-energize the faulty equipment and remove the ignition source. Some of the scenarios where electrical protection could fail to clear an electrical fault and remove the ignition source are included in Section 3.6.2.2.

The power isolation plan is intended to allow the local emergency response team (ERT) to respond to a small incident prior to automatic fire protection systems activating. If the plan cannot stop the event at the cabinet or row level, ensuring the ERT is prepared to isolate power to the room to minimize damage to the equipment and building is critical.

The purpose of a manual disconnect control is to preemptively initiate the de-energizing or “soft” power-down sequence of data processing equipment and/or the HVAC system before the automatic power-down.

#### 3.4.2.2 HVAC Systems

Power-down of the HVAC system(s) warrants the following considerations:

- HVAC power-down upon smoke detection may prevent heat and/or smoke from being drawn into data processing equipment.
- When make-up air is introduced to the data processing equipment room, it may cause the halocarbon or inert gas (clean agent) concentration to decrease below the concentration for fire extinguishment.
- HVAC power-down upon smoke detection may cause elevated ambient temperatures within the data center. Sustained elevated temperatures may cause damage to the data processing equipment. The possible damage may vary as a function of the exposure, data processing equipment design and materials of construction.

When coordinating isolation of power to data processing and HVAC equipment, consider the anticipated rate of rise for the data processing equipment room temperature if HVAC cooling is interrupted without removing power from the equipment cooled by those HVAC units. Cooling should continue for sufficient time to prevent the room temperature from rising above a level that would result in damage to data processing equipment or in warranty issues. Coordinate the shutdown of HVAC air handlers resulting from the performance goals of these power isolation guidelines with local code requirements (e.g., duct-mounted smoke detection at HVAC air-handler inlets or outlets).

A single disconnect control integrated to de-energize and interlock both data processing equipment and HVAC systems is preferred but is a condition of the previous considerations.

## 3.5 Utilities

### 3.5.1 General

Data centers and their customers place a high value on uptime.

For colocation data centers, these assurances of uptime are used to differentiate between providers and to attract customers. Being able to assure uptime is a competitive advantage.

Customers of data center companies and enterprise data centers also need uptime assurance to their own customers or regulators.

Because claims of uptime are important to data center companies and their customers, these claims need to be verified by independent certifiers.

The four key series of standards to which data centers design and certify the critical infrastructure are as follows:

1. The Uptime Institute, “Tier Standard: Topology”
2. ANSI/TIA-942, “Telecommunications Infrastructure Standard for Data Centers
3. EN 50600 Series, “Information technology – Data centre facilities and infrastructures”

4. ISO/IEC 22237 Series, “Information technology – Data centre facilities and infrastructures”

A list of independent certifiers is provided below:

- Uptime Institute, www.uptimeinstitute.com (certifiers for Uptime Institute Tiers)
- Enterprise Products Integration (EPI), www.epi-ap.com (certifier for ANSI/TIA-942 Ratings)
- Certifiers for EN 50600 and ISO/IEC 22237 Series
  - TüV SüD
  - TüV Nord
  - SGS Poland

### 3.5.2 Electrical Power Distribution

Due to their large power demand, as well as the need for an electrical supply with good power quality, data centers are typically supplied by medium-voltage, three-phase power from the utility.

The increasing power demand of data centers has also prompted more designs where power is delivered to the data center at the transmission level.

Onsite Power Generation (OSPG) is another developing trend where data centers develop their own power generation facilities to meet the power demands of the data center. This trend may also include direct wire connections to wind and solar farms owned by the data center client.

Battery Energy Storage Systems and rooftop PV Modules are also becoming increasingly common at data centers.

3.5.2.1 Figures 3.5.2.1.A and 3.5.2.1.B show the typical electrical power distribution for a data center. This drawing groups electrical equipment into different spaces (electrical space, IT space, mechanical space). These spaces are typically located in different parts of the facility: The IT space is the data center equipment room, and the electrical space is the substation and switch room. Cooling systems are usually located in the AHU or machinery room; however, cooling systems may also be located within the data center.

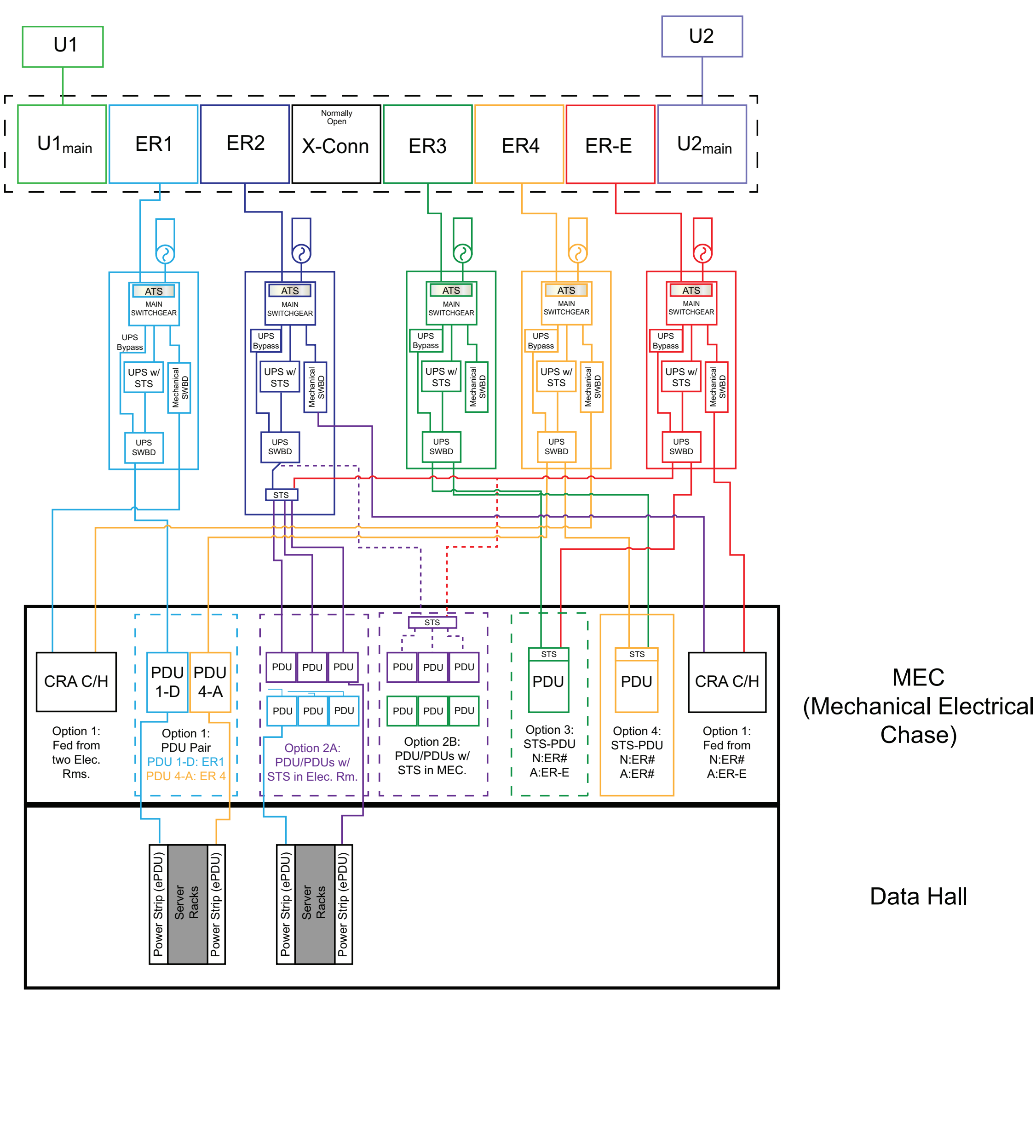


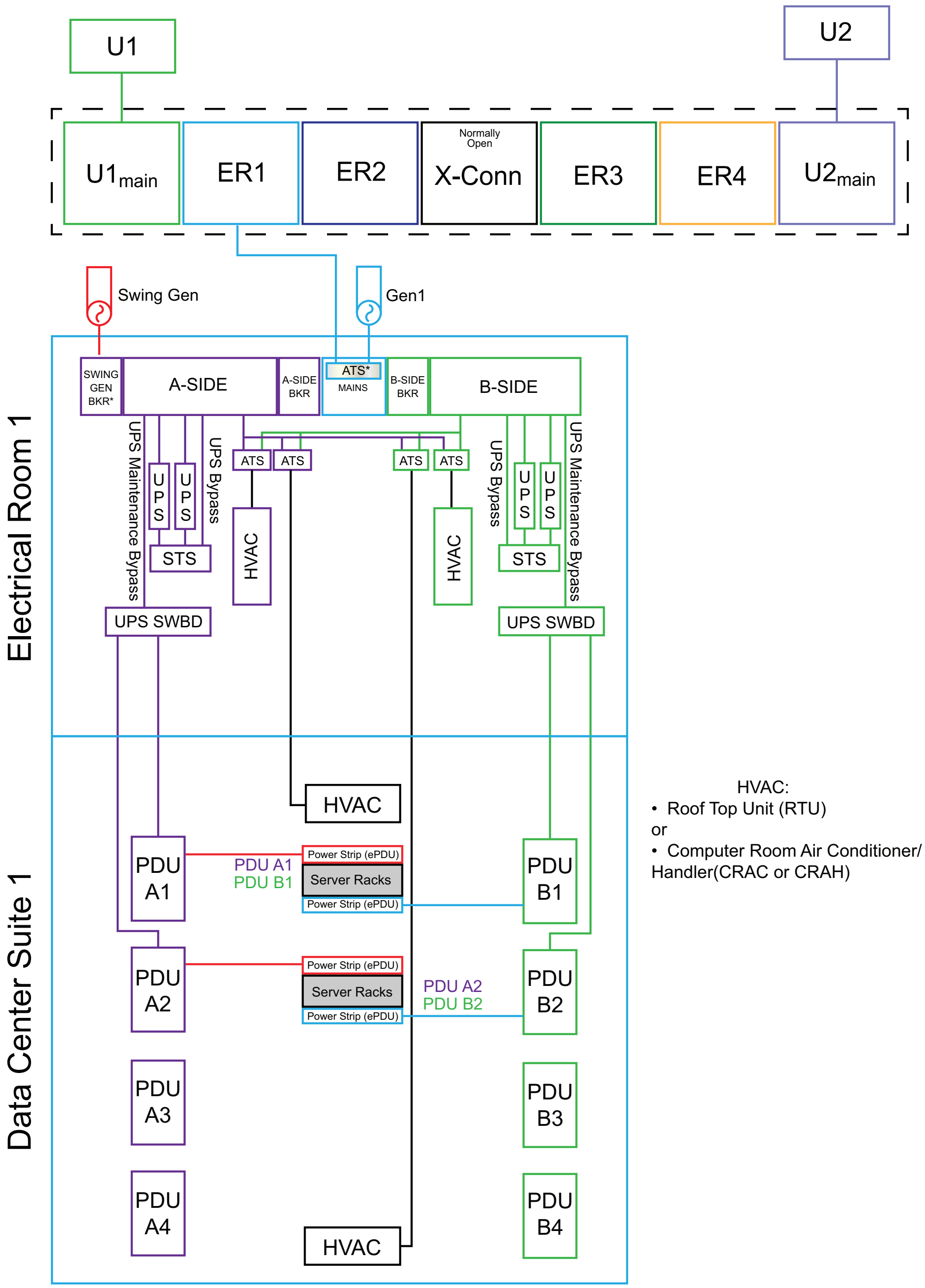

*Fig.3.5.2.1.A. Electrical power distribution for a data center (redundant distribution)*

IT equipment operates on single-phase, low-voltage power. The three-phase medium-voltage power is stepped down to a low voltage by a facility-owned transformer to feed low-voltage switchgear.

The low-voltage supply from the transformer is typically a four-wire system with a grounded neutral. The grounded neutral is important for electrical protection, as well as for power quality considerations.

Because maintaining a secure power supply for the data center is important, utility power to IT equipment is supplied through uninterruptible power supplies (UPS). These UPSs are fed from the low-voltage switchboard and distribute filtered, uninterruptible power to the data center through UPS switchgear. See Figure 3.5.2.1.C.

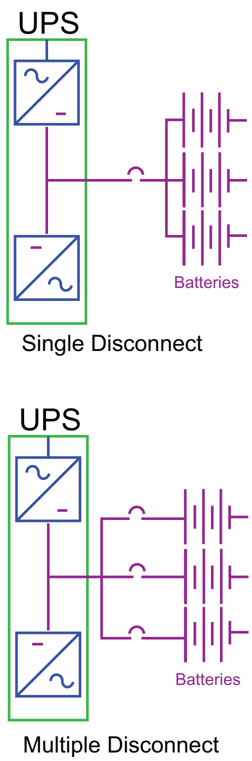
Typically, UPSs are of the static type, where utility power is used to charge batteries that take over when power is lost.




PDU Pair:
PDUs are organized in pairs such that a loss of a single side will not affect power continuity at the rack - dual corded

* The ATS function is typically accomplished using PLC control of the Main and Gen1 circuit breakers. Upon loss of normal power the load will transfer to Gen1. Should the load fail to transfer to Gen1 then the PLC will automatically shift the load to the Swing Gen. The Swing Gen typically provides back-up for multiple generators.

*Fig. 3.5.2.1.B. Electrical power distribution for a data center (PDU pairing)*




<u>UPSs</u>

UPSs can have different types of battery string disconnects.

- Single disconnect (older design)
- Individual disconnects for each string.
  - Individual battery disconnects allow maintenance and battery replacement to occur without having to take the UPS offline.

Not shown here are the input and output filter capacitors. These capacitors should be checked during the annual maintenance performed on the UPS.

*Fig. 3.5.2.1.C. Uninterruptible power system for a data center*

A stationary battery is used in the UPS systems. The UPS acts as a buffer against power interruptions, providing power to critical systems typically for 10-15 minutes while backup/emergency generators activate. Modern UPSs also play an important role in maintaining power quality to avoid loss of data and prevent damage to sensitive hardware due to voltage sags, surges, harmonics, flicker, frequency deviations and other power quality issues. UPS architecture can be centralized with batteries located inside dedicated battery rooms or electrical rooms. UPS battery architecture can also be de-centralized with UPS systems dedicated to each data hall. This modular approach allows for easy scalability. UPS systems can have configurations like 2N, and N+1 to enhance reliability. UPS battery chemistry can be lead-acid, nickel cadmium or Li-ion.

Because static UPSs have a limited power supply duration, most data centers will also have a standby diesel generator that supplies essential power to the data center for IT equipment and some lighting and cooling. This standby power may not be sufficient to run the full electrical load for auxiliary operations (e.g., offices, conference rooms) in the data center.

Some data centers may use dynamic UPSs. These are driven by a diesel generator and have a longer power supply duration. Depending on the capacity of the dynamic UPS, having a separate emergency diesel generator may not be necessary.

With the use of Artificial Intelligence (AI), power quality and ability to respond to instantaneous load changes has increased. This increase is due to the nature of processing AI data that requires UPSs to act as power conditioners. As such, this condition may increase battery cycling, which in turn could negatively impact battery life.

In addition to IT equipment, the low-voltage switchgear in the electrical space also supplies other equipment, such as the data center cooling and lighting systems. Cooling systems that have a large power demand may be fed directly from the medium-voltage switchboard.

Within the IT space, typical arrangements for supplying the racks are shown in Figures 3.5.2.1.A and 3.5.2.1.B:

A. A power distribution unit (PDU) feeding a remote power panel (RPP). The PDU typically consists of a main input circuit breaker, a transformer, panelboards, surge arrestors, output power cables, and metering and control modules. The RPP is similar to the PDU but has no transformer; it has an input circuit breaker and panelboards with metering and control modules that distribute power to the racks. The PDU and RPP are equipment cabinets that sit on the raised floor in the data center.

B. A plug-in busduct. The busduct has a feed unit connecting the bus to the upstream switchboard with plug in units directly feeding each rack. The busduct can be located overhead or under the raised floor. Metering and control functions are provided in the feed unit. When power reaches the equipment racks, a rack power distribution unit (rPDU) distributes the power to individual equipment. The rPDU is essentially a power strip into which individual IT equipment is plugged.

#### 3.5.2.2 Electrical Protection for the Data Center

3.5.2.2.1 Data centers have several layers of electrical protection. These are described below, starting at the rack and working backward toward the utility supply:

A. The power supply for individual IT equipment is fitted with over-temperature, overload and short-circuit protection. This protection is primarily designed to protect the individual IT equipment from damage if a problem occurs with the power supply.

B. Rack power distribution units (rPDUs) are similar to power strips used in office and residential buildings and typically do not have any protection. Sometimes, over-temperature and overload protection is provided at the power strip.

C. Remote power panels (RPPs) have overload and short-circuit protection for each of the feeders to the rPDUs. This protection is provided at the branch circuit breakers and main circuit breaker of the RPP.

D. PDUs have overload and short-circuit protection for each of the feeders to the RPPs. Ground fault protection may also be provided at this level. If the PDU contains transformers, over-temperature and overload protection will be supplied for the transformer. This protection is available at the branch circuit breakers and main circuit breaker of the PDU.

E. The UPS distribution switchboard has overload and short-circuit protection for each of the feeders to the PDUs. Ground fault protection may also be provided at this level. In addition, protection is provided for the battery charger, inverter and rectifier.

F. The low-voltage switchboard has overload, short-circuit and ground fault protection for every feeder. This protection is provided at the main incoming LV breaker, as well as at each of the branch circuit breakers.

G. The medium voltage switchboard has overload, short-circuit and ground fault protection. Transformer protection for the MV/LV transformer is also provided. Transformer protection is provided at the circuit breakers for the utility and transformer feeders. Control and tripping power for these circuit breakers may be present. This level of electrical protection ensures that when electrical faults occur within the data center or the electrical distribution system, protection will detect and remove the electrical fault by de-energizing the equipment where the fault occurred.

3.5.2.2.2 Although a relatively high level of electrical protection exists throughout a data center, scenarios exist for which this electrical protection may not be able to detect an electrical fault. In these situations, the faulty equipment will not be de-energized; so, the ignition source will not be removed. These scenarios include:

A. Series arcing. Series arcing occurs when a break in the conductor or a loose connection results in a discontinuity in the circuit. If the discontinuity or break is not large enough, current will still flow across the break as an arc. Series arcing is limited to less than the load current. As a result, it will not be detected by over-current protection.

B. High-resistance parallel arcing. The other type of arcing is parallel arcing, where the insulation between energized conductors or between a conductor and ground is compromised; and current is allowed to flow as an arc. The fault current that flows during this type of arcing is very high, and short circuit protection is designed to detect and remove this type of electrical fault. However, under some circumstances where the arc resistance is high, the fault current may not be large enough to activate short circuit protection.

C. Loose electrical connections. Loose electrical connections can lead to overheating. This overheating will not be detected as an overload if the load current does not increase. Loose electrical connections are also a source of series arcing. Series arcing cannot be detected by conventional electrical protection.

D. Circuit breaker failure. Circuit breakers are mechanical devices and can fail to operate. Circuit breakers also have a limited fault-interrupting rating and may fail to properly interrupt a fault that exceeds their rating. These types of faults may also weld the contacts of circuit breakers, preventing them from opening.

E. Incorrect or faulty grounding. Grounding is critical to ensure the correct operation and detection of electrical protection. Incorrect or faulty grounding can lead to malfunctioning electrical protection or faults that cannot be detected by electrical protection.

#### 3.5.2.3 Heating, Ventilation, and Air Conditioning (HVAC)

Computational Fluid Dynamics (CFD) modeling or equivalent design technologies can be used to determine the ventilation air velocity to ascertain if an interlock is needed for operation of the automatic sprinkler or water mist system. Limit the forced cooling air ventilation velocity upon smoke detection to less than 5 ft/sec. (1.5 m/s) upon activation of the pre-alarm condition.

In the commissioning of the data processing equipment room, consider the following in terms of measuring the maximum air velocities:

A. Horizontal velocity along the length of the aisle at heights within 4-10 in. (0.1-0.25 m) of the ceiling in proximity to automatic sprinkler nozzles and detection points

B. Multiple locations along the length of the server rack aisle

C. Horizontal velocity should not be measured near fan walls (as these velocities are expected to be higher) and should be measured no further than at the leading edge of the server racks from the fan wall.

## 3.6 Loss History

### 3.6.1 Losses by Peril

A recent 15-year study of FM data center losses was reviewed. Details are provided in Table 3.6.1-1.

*Table 3.6.1-1. Losses by Engineering Peril*

| *Peril* | *Percentage by Loss Cost* | *Percentage by Frequency* |
|---|---|---|
| Fire | 42.3% | 10.9% |
| Escaped Liquids Damage | 10.0% | 13.6% |
| Sprinkler Leakage | 9.3% | 5.9% |
| Electrical Breakdown | 7.2% | 8.6% |
| Temperature Change | 6.4% | 5.7% |
| Wind and Hail | 6.1% | 10.2% |
| Water – Liquid Damage | 4.6% | 4.8% |
| Mechanical Breakdown | 3.6% | 2.0% |
| Service Interruption | 2.3% | 3.6% |
| Surface Water | 1.6% | 1.6% |
| Transportation | 1.1% | 5.7% |
| Miscellaneous | 0.9% | 5.2% |
| Flood | 0.8% | 3.4% |
| Riot/Civil Commotion | 0.7% | 0.7% |
| Impact | 0.4% | 3.2% |
| Wind | 0.4% | 1.4% |
| Lightning | 0.4% | 2.7% |
| Other | 1.7% | 10.7% |
| **Total** | 100.0% | 100.0% |

### 3.6.2 Illustrative Losses

#### 3.6.2.1 Fire in Data Storage Equipment

A fire of unspecified electrical origin occurred in a 1.2 terabyte memory array in a computer room at a data processing and telephone switching center. Fire damaged the plastic cases of approximately 10 hard drive disks. Smoke and soot damage occurred to nearby computer and telephone equipment, and to the interior of the 8,000 $ft^2$ (740 $m^2$) computer room. The fire was extinguished with nine portable Halon units. Neither sprinklers nor a fixed gaseous suppression system were provided. Computer operations were restored within 12 hours.

#### 3.6.2.2 UPS Battery Fire Causes Significant Nonthermal Damage

A loose connection between an uninterrupted power supply (UPS) and a cable was the possible cause of a fire at a computer center. Other possible causes were a rectifier drying up the liquid in the battery, or a room temperature that may have been too high because of a faulty air conditioner. Heavy black smoke from the fire damaged all 500 computers in the same basement area as the UPS batteries. The time required to retrieve and reconstruct lost data and to reconfigure replacement computers was eight days.

#### 3.6.2.3 Chill Water Leak Causes Equipment and Facility Damage

A coupling on the chill water piping under the raised flooring on the third floor separated, allowing chill water under pressure to spray under the flooring, wetting cables in the area. The chill water ran down to the second and first floors through unprotected cable openings between floors. The chill water wetted server racks in the data processing room on the second floor and data control consoles on the first-floor mainframe operations control room. Water damage occurred to suspended ceiling tiles, carpeting and computer equipment storage on both the first and second floors.

#### 3.6.2.4 Rain Water Enters Building and Damages Servers

A capacitor in one of the eleven computer room air conditioning (CRAC) units overheated, resulting in smoke in the 9,000 $ft^2$ (836 $m^2$) data center. The inert gas fire extinguishing system discharged, and the resulting sound pressure level (e.g., noise) impacted the hard drives of the server data storage systems.

The hard drives contain a magnetized head that writes data. Due to vibrations from the sound waves, the read-write heads were knocked off track, either bouncing on the surface of the disks or knocking into the wall of the hard drives. The heads and disks are not designed to be touched. When this happens, a “headcrash” results and causes damage to the disks, making data unreadable.

## 4.0 REFERENCES

### 4.1 FM

Data Sheet 1-2, *Earthquakes*
Data Sheet 1-3, *High-Rise Buildings*
Data Sheet 1-6, *Cooling Towers*
Data Sheet 1-12, *Ceiling and Concealed Spaces*
Data Sheet 1-20, *Protection Against Exterior Fire Exposure*
Data Sheet 1-28, *Wind Design*
Data Sheet 1-24, *Protection Against Liquid Damage in Light-Hazard Occupancies*
Data Sheet 1-40, *Flood*
Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*
Data Sheet 2-8, *Earthquake Protection for Water-Based Fire Protection Systems*
Data Sheet 2-81, *Fire Protection System Inspection, Testing and Maintenance*
Data Sheet 3-0R, *Hydraulics of Fire Protection Systems*
Data Sheet 3-7, *Fire Protection Pumps*
Data Sheet 3-26, *Fire Protection Water Demand for Nonstorage Sprinklered Properties*
Data Sheet 4-2, *Water Mist Systems*
Data Sheet 4-9, *Halocarbon or Inert Gas (Clean Agent) Fire Extinguishing Systems*
Data Sheet 5-4, *Transformers*
Data Sheet 5-11, *Lightning and Surge Protection for Electrical Systems*
Data Sheet 5-14, *Telecommunications*

Data Sheet 5-19, *Switchgear and Circuit Breakers*
Data Sheet 5-20, *Electrical Testing*
Data Sheet 5-23, *Design and Protection for Emergency and Standby Power Systems*
Data Sheet 5-25, *High Voltage Direct Current Converter Stations*
Data Sheet 5-28, *DC Battery Systems*
Data Sheet 5-31, *Cables and Bus Bars*
Data Sheet 5-40, *Fire Alarm Systems*
Data Sheet 5-48, *Automatic Fire Detection*
Data Sheet 7-13, *Mechanical Refrigeration*
Data Sheet 7-88, *Outdoor Ignitable Liquid Storage Tanks*
Data Sheet 7-110, *Industrial Control Systems*
Data Sheet 9-0, *Asset Integrity*
Data Sheet 9-1, *Supervision of Property*
Data Sheet 9-16, *Burglary and Theft*
Data Sheet 9-13, *Evaluation of Flood Exposure*
Data Sheet 9-17, *Protection Against Arson and Other Incendiary Fires*
Data Sheet 10-1, *Pre-Incident and Emergency Response Planning*
Data Sheet 10-5, *Disaster Recovery Planning*
Data Sheet 10-8, *Operators*
Data Sheet 13-3, *Steam Turbines*
Data Sheet 13-10, *Land-Based Wind Turbines and Farms*
Data Sheet 13-17, *Gas Turbines*
Data Sheet 13-26, *Internal Combustion Engines*

Thumuluru, S., Ditch, B., Chatterjee, P. and Chaos, M. *Experimental Data for Model Validation of Smoke Transport in Data Centers.* FM Research Technical Report. September 2014.

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#### 4.1.1 FM Approvals

Class Number 3972, *Examination Standard for Cable Fire Propagation*
Class Number 4882, *Examination Standard for Class 1 Interior Wall and Ceiling Materials or Systems for Smoke Sensitive Occupancies*
Class Number 4884, *Examination Standard for Panels Used in Data Processing Center Hot and Cold Aisle Containment Systems*
Class Number 4910, *Examination Standard for Cleanroom Materials Flammability Test Protocol*
Class Number 4924, *Examination Standard for Pipe and Duct Insulation*
Class Number 4925, *Examination Standard for Fabric Ducts and Insulation Lined HVAC Ducts*
Class Number 4955, *Examination Standard for Flammability of Absorbent Battery Acid Spill Containment Pillows*
Class Number 5420, *Examination Standard for Carbon Dioxide Extinguishing Systems*
Class Number 5560, *Examination Standard for Examination Standard for Water Mist Systems*
Class Number 5580, *Examination Standard for Hybrid (Water and Inert Gas) Fire Extinguishing Systems*
Class Number 5600, *Examination Standard for Clean Agent Fire Extinguishing Systems*

### 4.2 Other Standards

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Underwriters Laboratories (UL). *UL Standard for Safety for Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables used in Spaces Transporting Environmental Air*. UL 910 (Withdrawn 2001).

Underwriters Laboratories (UL). *Test Methods for Determining the Combustibility of Characteristics of Plastics Used in Semi-Conductor Tool Construction*. UL 2360, 2023.

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Underwriters Laboratories (UL). *Information Technology Equipment - Safety - Part 21: Remote Power Feeding*. UL 60950-21, 2022.

## APPENDIX A GLOSSARY OF TERMS

**Aisle:** The distance of floor across from two rows of server racks or cabinets, typically 4 ft (1.2 m). See also cold aisle, hot aisle and hot/cold aisle containment.

**Automated tape library (ATL):** An enclosed storage and retrieval system that moves recorded electronic data (e.g., plastic cassettes) between storage and server equipment.

**Air-aspirating detection:** See “Very early warning fire detection (VEWFD).”

**Availability:** The degree to which a system, subsystem or equipment is in a operable state when it is requested for use at any random time.

**Battery Back-up Unit (BBU):** A stationary battery (less than 20 kWh) with a battery management system used to provide localized uninterruptible back-up power directly integrated at the server level to maintain power and/or to avoid loss of data and damage to sensitive hardware due to voltage sags, surges, harmonics, flicker, frequency deviations and other power quality issues.

**Business continuity:** A strategic approach to business as a whole, involving the development of a response to safeguard the entire business by managing the impact of a disruption to achieve the company's business objectives for survival, regardless of the cause of the disruption. By implication, the development of the BCP requires a much deeper understanding of the business, the criteria for business survival, the continuity strategies available, and the resources necessary to implement the continuity response.

**Building automation system:** A centralized building automatic control system, usually controlling at least the HVAC but that may also control lighting, security, safety, electric power, fire alarm, or any other building system. Also known as a building management system (BMS).

**Cabinet:** Device for holding data center equipment, most commonly used to hold multiple servers. Also called a rack.

**Cold aisle:** The aisle in front of the airflow intakes on the server racks where HVAC cooling airflow is controlled.

**Co-location:** Rental to third parties of disk space, provision of web-hosting services on a server, or segmented areas with individual tenants that control their own equipment.

**Cloud computing:** A model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

**Computer room air conditioner (CRAC):** An air handler that uses refrigerant and an internal compressor dedicated to providing cooling air to the data processing equipment space. Cooling the air in the data processing equipment room is accomplished by airflow over evaporation cooling coils where the refrigerant is being directly expanded.

**Computer room air handler (CRAH):** An air handler dedicated to providing cooling air to the data processing equipment space that uses chilled water cooling coils within the unit. Central cooling equipment (e.g., chiller) is located in separate mechanical rooms.

**Critical location:** A facility for which systems, processes or other elements that are essential for a company or organization to operate successfully. If a system or process fails or is unavailable, it can result in risks to human safety, significant financial or reputational damage, or a serious disruption to the organization's core functions and objectives. Examples include hospital power systems, emergency dispatch centers, or a company's core financial data.

**Cross-zoned detection:** A technique involving the use of two different methods of fire detection with each assigned to a separate zone/circuit (first or second detection inputs) to initiate the alarm response. This can include a "counting-zone" since the control logic involves the counting the number of detectors in alarm. This can only be accomplished with an intelligent fire alarm system using an addressable fire alarm control panel.

**Data center:** A facility used to house data processing equipment and associated components, such as telecommunications and storage systems. It generally includes redundant or backup power supplies, redundant data communications connections, environmental controls (e.g., HVAC, fire suppression) and security devices.

**Data processing equipment room:** A room mostly occupied with data processing equipment such as servers, tape cartridge storage, printers, etc.

**Disaster recovery:** Activities necessary to respond to an incident at a location to restore normal operations after a major disaster or specific scenario. DRPs are therefore written to establish the necessary actions to take during and immediately after an anticipated event to expedite the resumption of normal operations.

**Disconnect control:** A device that controls the interface of the disconnecting means of power by a pathway, relay, or equivalent method.

**Double-interlock preaction system:** A sprinkler system that is located downstream of a preaction valve and is equipped with closed-type sprinklers. The preaction valve is arranged to open only after the actuation of both a sprinkler and a detection system that is supervising the area being protected by the preaction sprinkler system. Most double-interlock sprinkler systems have either an electric or a pneumatic means of accomplishing these two activating conditions.

**Emergency Power Off (EPO):** See Manual Disconnect Control.

**Energy Storage System (LIB-ESS): [Data Sheet 5-33]** Any system through which electrical energy can be stored and reused when needed. Energy capacity is typically greater than 20 kWh.

**High-rise building:** Any building with an occupied floor located more than 75 ft (23 m) above the lowest level of fire service vehicle access with the exception of:

- Airport traffic control towers
- Open parking garages
- Amusement park structures
- Bleachers
- Grandstands
- Stadiums
- Special industrial buildings (ex. BLRB)
- Buildings with high hazard occupancies

**Hot aisle:** The aisle at the rear of the server racks into which air is directed after being heated by passing through the data processing equipment for return to the HVAC equipment.

**Hot/cold aisle containment:** Physical barriers provided in the immediate vicinity of air-cooled server racks that separate hot air exhausted from the data processing equipment from the cooler supply air into the equipment racks. Containment is typically provided above and at both ends of a hot or cold aisle, in whole or in part.

**Hot air collar:** An assembly used to duct heated exhaust air from an enclosure(s), cabinet(s,) or rack(s) of the data processing equipment to the return air path of the HVAC system.

**Input/output (I/O) room:** The room where the electronic hardware is wired to interface from the control room with the field/process devices. Discrete I/O devices have switches for inputs and relay outputs (e.g., operate solenoid valves or pump motors). Analog I/O devices have process variable inputs, and variable controller outputs.

**Intelligent high-sensitivity spot detection:** See “Very early warning fire detection (VEWFD).”

**Listed:** Listed by a reputable testing laboratory according to a widely recognized testing standard adopted by model building codes.

**Manual disconnect control:** A means to preemptively initiate the de-energizing or “soft” power-down sequence of data processing equipment and/or the HVAC system.

**Mobile/modular data center:** An enclosed construction unit or prefabricated container (e.g., ISO shipping container) containing data processing equipment (e.g., servers, storage, networking, software management) and/or supporting utility systems (e.g. power, power conditioning, HVAC) intended to be configured on a modular basis either as a standalone unit or several units combined in an array to provide data center functions.

**N+1:** Need plus one, a redundancy concept where operational capacity is met by one or more components or systems, plus one additional component or system adequate to enable continued operations in the event of a failure of one component or system in the base configuration.

**Network Control room:** A room serving as an operations center where a facility, service, or equipment can be remotely monitored by electronic equipment and controlled by personnel. The network control room is used in network, command and control, and other control application operations.

**Network/fiber optic room:** A space that supports cabling to areas outside the data processing equipment room. The network/fiber room is normally located outside the data processing equipment room but, if necessary, can be combined with a main distribution area, intermediate distribution area or horizontal distribution area. The network/fiber room may also be referenced as the telecommunications room.

**Non-interlock preaction system:** A sprinkler system that is located downstream of a preaction valve and is equipped with closed-type sprinklers. The preaction valve is arranged to open upon either the operation of a sprinkler or the actuation of a detection system that is supervising the area being protected by the preaction sprinkler system.

**Nonpropagating or Group 1 cable:**

1. Cable with a fire propagation index (FPI) of less than 10 when tested in the FM fire propagation apparatus.

2. Cable that, when tested in accordance with the FM 3972 Vertical Tray Test, does not have flame spread more than 5 ft (1.5 m) beyond the 60 kW fire exposure.

3. Cable that has passed UL 910 or NFPA 262 tests.

**Non-recycling time delay:** An electronic device that allows personnel to evacuate the space within a discrete time period before the discharge is initiated and the time period cannot be reset once initiated.

**Plenum-rated cable:** Considered non-fire propagating and equivalent to FM Approved Group 1 cable.

**Preaction sprinkler system:** A sprinkler system that is located downstream of a preaction valve and is equipped with closed-type sprinklers (i.e., sprinklers equipped with a thermal sensing element and an orifice cap).

**Preaction valve:** An automatic water control valve, typically installed on a sprinkler system riser, specifically designed to hold back water from passing through it until certain conditions have been met, such as activation of a detection system supervising the area protected by the preaction sprinkler system or by pressure drop downstream of the valve. It is connected upstream of a preaction sprinkler system.

**Process control room:** A cutoff and/or isolated room in which personnel are available 24/7 to operate a process from a central or remote location. The process control room is typically integrated with an input/output room and/or cable spreading room to control the function of equipment. Process control is extensively used in industry and commonly enables mass production of continuous processes such as, paper, pharmaceuticals, chemicals, and electric power as well as other industrial processes, such as supervisory control and data acquisition (SCADA) systems. Process control rooms/technical spaces may be unattended and operated remotely.

**Propagating cable:**

1. Cable with a fire propagation index (FPI) of more than 10 when tested in the FM fire propagation apparatus.

2. Cable that, when tested in accordance with the FM 3972 Vertical Tray Test, has a flame spread greater than 5 ft (1.5 m) beyond the 60 kW fire exposure.

3. Cable that has not been tested or has not passed UL 910 or NFPA 262 tests.

**Proportional-integral-derivative (PID) controller:** A control loop feedback mechanism controller commonly used in industrial control systems. A PID controller continuously calculates an error value as the difference between a desired setpoint and a measured process variable and applies a correction based on proportional, integral, and derivative terms, (sometimes denoted P, I, and D respectively) which give their name to the controller type.

**Quantum Computer:** A quantum computer is a machine that uses the properties of quantum physics to store data and perform computations. The basic unit of memory is a quantum bit or qubit. Qubits are made using physical systems, such as the spin it an electron or the orientation of a photon. Qubits can represent numerous combinations of binary bits (1 and 0) simultaneously at the same time for potential outcomes.

**Raceway:** An enclosed channel of metal or nonmetallic materials designed for holding wires, cables or bus bars.

**Rack:** Device for holding data center equipment, most commonly used to hold multiple servers. Also called a cabinet.

**Routing assembly:** A single channel or connected multiple channels, as well as associated fittings, forming a structure system that is used to support, route, and protect wires and cables.

**Row:** A group of server racks or cabinets contiguously joined together.

**Server:** Data processing equipment that serves information to computers that connect to it. When users connect to a server, they can access programs, files, and other information from the server. Common servers are web servers, mail servers, and LAN servers.

**Server farm:** A collection of computer servers usually maintained by an enterprise to accomplish server needs far beyond the capability of one machine. Server farms often have backup servers that can take over the function of primary servers in the event of a primary server failure. Server farms are typically co-located with the network switches and/or routers that enable communication between the different parts of the cluster and the users of the cluster. The computers, routers, power supplies, and related electronics are typically mounted on racks in a server room or data center.

**Single-interlock preaction system:** A sprinkler system that is located downstream of a preaction valve and is equipped with closed-type sprinklers. The preaction valve is arranged to open upon the actuation of a detection system that is supervising the area being protected by the preaction sprinkler system.

**Soft power-down:** A disconnect control that triggers a sequence of data processing equipment commands followed by de-energizing such that an orderly power-down is necessary to minimize data processing equipment damage.

**Tape library:** In data storage, a tape library is a collection of magnetic tape cartridges and tape drives. An automated tape library is a hardware device that contains multiple tape drives for reading and writing data, access ports for entering and removing tapes and a robotic device for mounting and dismounting the tape cartridges without human intervention.

**Thermal runaway:** Rapid heating of data processing equipment above critical operating temperatures, which may cause short-term data processing equipment damage due to loss of cooling to the data processing equipment space. Possible causes include loss of power to portions of or the entire facility, loss of power to critical HVAC cooling components, and failure of individual HVAC components.

**Uninterruptible Power Supply (UPS):** A device or system that provides quality and continuity of power through the use of a stored energy device (e.g., stationary battery) as the backup power source for a period of time when the normal power is incapable of performing acceptably and transitioning to another emergency source of power. The UPS stationary battery chemistry can be lead-acid, nickel cadmium or li-ion with an energy capacity typically greater than 20 kWh.

**Unoccupiable enclosure or space:** An enclosure or space that has dimensions and physical characteristics such that it cannot be entered by a person.

**Valve-regulated lead acid batteries (VRLA):** Batteries designed to minimize gas emissions and eliminate electrolyte maintenance by recombination of internally generated oxygen and hydrogen to conserve water. A resealable valve is intended to vent gases not recombined, hence the term ″valve-regulated.” The electrolyte in a VRLA cell is ″immobilized″ by the use of a highly porous fibrous mat between the plates or by the use of a gelling agent to thicken the electrolyte.

**Very early warning fire detection (VEWFD):** These detectors maybe photo-electric spot-type or air-sampling type detection systems. Spot detectors using xenon or laser light detection chambers can be considered VEWFD detectors. VEWFD detectors are an order of magnitude more sensitive than conventional smoke detectors. These detectors can be set to alert at smoke obscuration levels below 0.02 percent per foot (0.06 percent per meter) and an alarm condition at a smoke obscuration level below 1.0 percent per foot (3.1 percent per meter). Conventional smoke detectors alarm at 1 to 3 percent per foot (3.3 to 9.8 percent per meter).

**Water Delivery Delay:** The time in which water travels from the opening of a preaction system alarm check valve to the most remote sprinkler or inspector’s test connection.

**Zone:** A distinct area, created by a physical barrier or division of open space, from the total area of a data processing equipment room that is segmented into dedicated power and/or HVAC systems for the data processing equipment.

## APPENDIX B DOCUMENT REVISION HISTORY

The purpose of this appendix is to capture the changes that were made to this document each time it was published. Please note that section numbers refer specifically to those in the version published on the date shown (i.e., the section numbers are not always the same from version to version).

**January 2026.** Full revision. The following changes were made:

A. Reorganized and streamlined guidance in all sections.

B. Revised guidance for Section 2.2.11, Earthquake, to reference Data Sheet 1-2, *Earthquakes,* and Data Sheet 2-8, *Earthquake Protection for Water-Based Fire Protection Systems*, as authoritative sources.

C. Added reference to Data Sheet 1-34, *Hail Damage*, for Section 2.2.12, Windstorm and Hail.

D. Revised Section 2.4.3.2.2, Water Mist Systems, to identify the availability of FM Approved water mist systems for the Hazard Category 2 (HC-2) and HC-3 classification.

E. Added guidance for Quantum computers in Section 2.3.1.5, Quantum Computers, and revised guidance in Section 3.2.2.

F. Revised liquid cooled equipment guidance in Section 2.5.2 as follows:

1. Direct chip
2. Rear door/heat exchanger
3. Immersion

G. Revised guidance or removed obsolete guidance in Section 2.6, Utilities and Support Systems, and in Section 3.5 as follows:

1. Power and utility cables
2. Electrical distribution system
3. Electrical utility
4. Emergency generator location and fuel supply

H. Deleted guidance for the use of portable fire extinguishers.

I. Revised ventilation guidance for the use of water mist systems in Section 2.4.3.2.2.

J. Revised Appendix A, Glossary of Terms, for inclusion of:

1. Battery Back-up Unit (BBU)
2. Cross-Zoned Detection
3. Energy Storage System
4. Non-Recycling Time Delay
5. Uninterruptible Power Supply (UPS)

K. The following content was removed, as it is no longer relevant or is included in the authoritative source Data Sheet:

1. Appendix D, Clean Agents

**April 2025.** Interim revision. The following changes were made:

A. Revised Section 2.2.11, Windstorm, to remove the reference to FM Data Sheet 1-8, *Antenna Towers and Signs*, as this data sheet was made obsolete, effective April 2025. Applicable recommendations were moved to FM Data Sheet 1-28, *Wind Design*. Section 2.2.11.2 was updated to include this reference.

B. Revised the following sections that reference FM Data Sheet 1-45, *Air Conditioning and Ventilating Systems*, as this data sheet was made obsolete, effective April 2025:

- 2.3.5.3, *Heating, Ventilation and Air Conditioning (HVAC)*
- 2.3.5.3.6, *Smoke Management Systems*
- 2.6.1, *Heating Ventilating and Air Conditioning (HVAC)*
- 4.0, *References*

**October 2024.** Interim revision. The following changes were made:

A. Modified the current recommendations to identify data centers should not use polyvinyl chloride (PVC) construction materials (Section 2.2.1).

B. Added new Appendix E, *Testing of Power Isolation Disconnect Control Systems*, which provides an overview of the integrated system with by-pass that allows for testing the depowering of electrical equipment in the data processing equipment room.

**January 2024.** Interim revision. The following changes were made:

A. Modified the scope of Operating Standard 5-32 to identify the exclusion of industrial control instrumentation equipment rooms. Those property loss prevention recommendations are covered in Data Sheet 7-110, *Industrial Control Systems*.

B. Simplified the current protection recommendations for the various hazards in a data processing equipment room to a standard protection criterion.

C. Formatted Section 2.0, Loss Prevention Recommendations to realign active and passive protection of equipment and processes used in a data center to the different hazard areas within the occupancy.

D. Revised Hot and Cold Aisle Containment figures to identify sprinkler and nozzle locations.

E. Added the following terms to Appendix A, Glossary of Terms:

- Aisle
- Cabinet
- Row
- Water Delivery Delay

**July 2023.** Interim Revision. Made editorial change to Table D-2 of Class C design concentration for FK-5-1-12. Revised the minimum design concentration percentage to include the proper safety factor based upon the Class A minimum extinguishment concentration.

**January 2023.** Interim revision. The following changes were made:

A. Updated recommendations in Section 2.4.4 to allow equipment using Li-ion batteries in distributed power systems of data processing equipment to be protected with automatic water mist systems.

B. Made editorial updates to figures in Section 2.8.1, Electrical Distribution System and Section 3.4.1, Electrical Power Distribution.

**July 2022.** Interim revision. The following significant changes were made:

A. Added recommendations for the protection of equipment using Li-ion batteries in the following:

1. Battery back-up units for distributed power systems of data processing equipment

2. Uninterruptable power supplies (UPS) (refer to Data Sheet 5-28, *DC Power Systems*)
3. Energy storage systems (reference to Data Sheet 5-33, *Lithium-Ion Battery Energy Storage Systems*)

B. Modified guidance in Section 2.2, Construction and Location:

1. For multi-story data centers to be in accordance with specific sections of Data Sheet 1-3, *High Rise Buildings*
2. To address leakage of liquids (Section 2.2.1.6) in accordance with Data Sheet 1-24, *Protection Against Liquid Damage*
3. To provide preventing unauthorized access to a data center in accordance with Data Sheet 9-1, *Supervision of Property*

C. Added recommendations to address the impact high velocity and horizontal airflow for the cooling of data processing equipment has on the actuation and operation of sprinklers, water mist system nozzles, and smoke detection (Section 2.4.3).

D. Updated guidance on the proper application of wet, single, and double interlock sprinkler and water mist system configurations (Sections 2.4.7.1 and 2.4.7.2, respectively).

E. Updated recommendation and support guidance for oxygen reduction systems (Sections 2.4.1.7 and 3.2.1B) to conform with Data Sheet 4-13, *Oxygen Reduction Systems*.

F. Updated recommendations in Section 2.4.7.3.7 for the proper placement of FM Approved clean agent fire extinguishing system discharge nozzles based on the listing to provide sound pressure level values to hard disk drives that are susceptible to damage.

G. Updated guidance in Section 2.5.2, Hot/Cold Containment and Hot Collar Systems, to address inclusion of FM Approved panels to the FM Approval Class 4884 Standard.

H. Added general guidance for “Quantum” computers in equipment and processes (Sections 2.5.1 and 3.3.1, respectively).

I. Added guidance for B&M equipment with the specialized recommendations for their application in data centers and related facilities (Section 2.8, Utilities and Support Systems).

J. Updated recommendations for automatic power isolation in Section 2.8.2, Power Isolation of Data Processing Equipment and HVAC Systems.

**October 2021.** Interim revision. Removed the recommendation on battery design, installation, inspection, testing, and maintenance in this document. Replaced recommendations with reference to Data Sheet 5-28, *DC Battery Systems*.

**July 2020.** Interim revision. Added equipment contingency planning and service interruption planning guidance.

**April 2020.** Interim Revision. Clarifications were made in the following section:

1. A new general recommendation (Section 2.4.5) for local alarms to be annunciated at a constantly attended location to be consistent with recommendations to allow for implementation of a Power Isolation Plan.

**October 2019.** Interim Revision. The following changes were made:

A. Transferred Recommendations associated with process control rooms to OS/DS 7-110, Industrial Control Systems.

**January 2018.** Interim revision. The following changes were made:

A. Added alternative method to anchoring of equipment for securement to earthquake.

**April 2017.** The following changes were made:

1. Revised the scope of this data sheet to identify when recommendations apply to telecommunication facilities using Voice over Internet Protocol (VoIP) equipment and other related occupancies that have data processing equipment rooms/halls.

2. Added new recommendations to Section 2.2.1, General, for the proper location of HVAC equipment in data processing equipment rooms.

3. Revised recommendations in Section 2.2.10, Earthquake, to align with the recommendations in Data Sheet 1-2, *Earthquakes.*

4. Revised recommendations in Section 2.2.12, Flood/Storm Water Runoff, to align with the recommendations in Data Sheet 1-40, *Flood.*

5. Revised the recommendation in Section 2.3, Occupancy, as follows:

   a. Removed the allowance of two pallet loads of in-process storage in the data processing equipment room based on the 2014 Engineering Support Project.

   b. Added recommendation for storage to be in accordance with Data Sheet 8-9, *Storage of Class 1,2,3,4 and Plastic Commodities.*

6. Added recommendation in Section 2.4.5.7 for the use of portable smoke detection.

7. Revised recommendations in Section 2.4.6.1, Automatic Sprinklers, to include the following based on the 2014 Engineering Support Project:

   a. Removed recommendation for double-interlocked sprinklers.

   b. Added recommendation for minimum pressure of sprinklers protecting elevated hazards.

8. Revised recommendations in Section 2.4.6.2, Water Mist Systems, based on the 2014 Risk Service Project.

9. Added new recommendations to Section 2.4.6.3, Clean Agent Fire Extinguishing Systems, to address the impact of noise (from discharge) on hard drives.

10. Revised the recommendation in Section 2.5.1.1, Equipment, on blanking plate materials of construction.

11. Added new recommendation to Section 2.5.2.2 on materials that can be used for solid ceilings in hot/cold aisle containment systems.

12. Revised the recommendations in Section 2.5.2.4, Sprinkler Protection for Hot/Cold Aisle Protection, based on the 2014 Engineering Support Project.

13. Added Section 2.7.2 Power Isolation Plan.

14. Revised the recommendations in Section 2.7.5, Security, to align with Data Sheet 9-1, *Supervision of Property.*

15. Added Section 2.7.7 Loss of Cooling Emergency Response Plan.

16. Revised Section 2.8.2, Power-Down of Data Processing Equipment and HVAC Systems. Changed terminology from “power-down” to “power isolation.”

17. Added new recommendations to Section 2.8.5, Heating, Ventilation, and Air Conditioning Systems, to address loss of cooling.

18. Added information to Section 3.1.3, Cables, to support the recommendation of not using power cables with chlorinated polyethylene or polyvinyl chloride (PVC) sheathing or insulation.

19. Added information to Section 3.2.4.10, Portable Detection, to support the recommendation for the usage of portable smoke detection.

20. Added new information to Section 3.2.5.3.7 regarding clean agent fire extinguishing systems to address the impact of noise (from discharge) on hard drives.

21. Revised Section 3.4.1, Electrical Power Distribution, to provide more information on the types of power supplies used in data centers.

22. Added Section 3.4.2, Electrical Protection for the Data Center, to provide more information on the types of passive protection used for power supplies in data centers.

23. Revised Section 3.4.4, Power-Down of Data Processing Equipment and HVAC Systems. Changed terminology from “power-down” to “power isolation.”

24. Added the following terms to Appendix A, Glossary of Terms:

- Availability
- Building automation system
- Computer room air conditioner (CRAC)
- Computer Room air handler (CRAH)
- Listed
- Network/fiber optic room
- Proportionalintegralderivate (PID) controller
- Thermal runaway

25. Made editorial changes throughout the data sheet to clarify the intent of the recommendations.

**July 2012.** This data sheet has been completely rewritten. Major changes include the following:

1. Changed the title from *Electronic Data Processing Systems* to *Data Centers and Related Facilities*.

2. Added hot/cold aisle containment systems and protection recommendations.

3. Added the recommendation for the protection of foam insulation beneath raised floors in the data processing equipment room.

4. Added guidance on using clean agent fire extinguishing systems and water mist systems.

5. Added protection recommendations for modular data centers.

6. Added protection recommendations for process control rooms, control rooms, and diagnostic equipment. Recommendations in the specific sections for process control rooms, control rooms, and diagnostic equipment when identified will supersede those for data centers.

7. Added recommendations for redundancy of certain critical utility systems: heating, ventilation and air conditioning (HVAC) systems, chillers, and ventilation.

8. Updated the section on automatic power-down to include powering down and de-energizing data processing equipment and HVAC systems.

9. Deleted the recommendation for automatic smoke control and removal systems.

**May 2005.** The revisions are based on a change in Data Sheet 5-31, *Cables and Bus Bars*. The change combines FM Approved Group 2 and Group 3 cable along with cables that have not been tested by FM and considers these as cables that can ‘‘propagate’’ fire. ‘‘Nonpropagating’’ cable does not require protection. Nonpropagating cable is either (a) FM Approved Group 1, (b) UL-910 plenum rated or (c) cable with a maximum flame spread distance of 5 ft (1.5 m) when tested in accordance with NFPA 262, *Standard Method of Test for Flame Travel and Smoke of Wires and Cables for use in Air Handling Spaces.*

**January 2005.** Reference to the future use of Halon 1301 and 1211 systems for protection of computer and computer related equipment has been replaced with a recommendation for the use of clean agent systems installed in accordance with Data Sheet 4-9, *Clean Agent Fire Extinguishing Systems*.

**September 2004.** Recommendation 2.4.2.1.2 was modified to allow the use of light hazard water mist systems FM Approved for open area protection.

**September 2002.** Recommendation for protection of subfloor areas of the computer room has been revised to include the use of FM Approved Clean Agent fire extinguishing systems and water mist systems.

**January 2001.** The document has been reorganized to provide a consistent format.

**September 2000.** The document has been reorganized to provide a consistent format.

**May 1999.** The recommendation for grounding of computer systems was revised. Also, guidance for fire protection of Group 2 cables that are randomly laid (unbundled across the floor) was modified.

**June 1993.** Data Sheet 5-32 has been completely rewritten.

## APPENDIX C PERFORMANCE TEST PROCEDURES FOR VEWFD SYSTEMS

Performance tests for VEWFD systems are intended to simulate the small amounts of smoke that would be created in the early stages of a fire in a data processing equipment room. If an actual fire were to produce the amounts of smoke produced by these tests, data center companies would want to be alerted by the fire alarm system. The tests represent a good balance between the desire to use smoke sources that are representative of the types of fires that have occurred in data processing equipment rooms and the desire to minimize the introduction of smoke that can cause damage to operating data processing equipment in the area/room.

An engineering survey of the area to be protected is a useful resource to locate smoke detectors or sampling ports. Factors such as air flow, proximity to air handling system diffusers, and other physical features of the installation need to be taken into account.

### C.1. Objectives

Performance tests are intended to meet the general objectives listed below:

A. The tests are intended to be repeatable. A consistent quantity, temperature, and color of smoke are produced each time the test is performed.

B. The test equipment can be quickly set up in actual data center facilities.

C. Testing is intended to prevent or minimize the potential for smoke damage to data processing equipment in the room (little or no corrosive products of combustion should be produced).

### C.2. Heated Wire Test

This test uses an electrically overloaded PVC-coated wire to simulate the early stages of a fire. Although a PVC wire is used, hydrogen chloride vapor is unlikely to be produced in quantities significant enough to be of concern, due to the relatively low temperatures reached. If the current is applied for a longer time, or if the wire sample is shorter than stated, small quantities of hydrogen chloride can be generated. In either event, a clearly perceptible odor that should dissipate in a short time is produced by the test. Table C.2 describes two heated wire tests.

*Table C.2. Heated-Wire Test Parameters*

| *Parameter* | *Modified BS 6266 Test: 1 m Wires in Parallel* | *North American Wire Test* |
|---|---|---|
| Wire Specs | Wire is very flexible due to stranded construction and highly plasticized insulation. | A single strand of 22 AWG copper wire, insulated with PVC to a radial thickness of 1.1 mm (0.041 in.). This wire is stiffer than the BSI wire due to the single-strand construction and the minimally plasticized PVC insulation. |
| Smoke Characterization | More visible smoke than the 2 m test or the single wire 1 m test but still very light smoke. Due to the higher temperature in the wires, a small amount of HCI vapor will be produced. | More visible smoke than the BSI wire tests but still very light. A minor amount of HCI is produced but for a shorter duration than the BSI wires tests. |
| Test Period | 60 seconds | 30 seconds |
| Electrical Load | Constant voltage -6.0 volts dc, current varies from 0 to 30 amperes during the test due to changing resistance in the wire. | Constant current of 28 amperes. Voltage varies from 0 to 18 volts dc during test due to changing resistance in the wire. |
| Pass/Fail Criteria | ″Alert″ or ″pre-alarm″ signal within 120 seconds of the end of the period. | |

A. Test Apparatus

The test apparatus consists of the following:

1. Wire. Table C.2 lists options for wire selection and test parameters for the users to select. Test wire should be cut cleanly to the length specified in Table C.2.

2. Wire Mounting. The wire should be arranged by placing it on a noncombustible, nonconductive board, or suspending it on a noncombustible, nonconductive support. The wire should be arranged so that there are no kinks or crossovers where localized higher temperature heating can occur.

3. Power Supply and Leads. A regulated dc power supply should be capable of supplying a current of 0 to 30 amperes at 0 to 18 volts dc (i.e., Kenwood Model XL6524E-D). The lead wires between the power supply and the test wire (s) should be 10AWG, 3.25 m (10.66 ft) long to avoid unacceptable voltage drop.

4. Stop Watch. A stop watch or clock accurate to 1 second should be used.

B. Test Procedure

1. The test should be performed in the room in which the detection system is installed, with all normal ventilation fans (e.g., fans internal to equipment, room ventilation fans) operating. Testing should also be performed with the fans turned off to simulate the potential for fan cycling and/or a power failure. This does not preclude testing required by NFPA 72.

2. Detector Programming. The detector alarm sensitivity setting (i.e., pre-alarm or alarm) used during the test should be identical to those used during normal operation of the detection system. Alarm verification or time delay features should be disabled during the test to permit the detector response to be annunciated immediately upon activation.

This testing is intended to verify that the detectors or sensor will ″see″ smoke in sufficient concentrations to reach the specified alarm levels.

Because the test produces a small amount of smoke for a brief period of time (i.e., a puff of smoke), the use of the alarm verification or time delay features would likely result in the detector or sensor not reaching the specified alarm levels. In a ″real world″ fire, the smoke would continue to be produced as the fire grows, permitting the detector or sensor to reach alarm. If these features are disabled during the testing, they should be enabled at the conclusion of the testing before leaving the room.

3. Test Locations. Test locations should be selected by considering the airflow patterns in the room and choosing challenging locations for the tests (i.e., both low airflow and high airflow can be challenging). If possible, the locations and elevations of the test apparatus should be varied to simulate the range of possible fire locations in the room. Locations where the smoke will be drawn directly into the data processing equipment cooling ports or fans should be avoided. Locations where the smoke will be entrained into the air exhausting from an equipment cabinet are acceptable.

4. Preparation. The test wire should be prepared by carefully removing not more than 0.6 in. (12 mm) of the insulation from each end. The wire should be mounted on the insulating material so that there are no kinks or crossovers in the wire.

5. Setting. The power supply should be set to supply either a constant voltage or constant current as shown in Table C.2.

6. Connection. The ends of the test wire(s) should be connected to the power supply leads.

7. Test. When all other preparations are complete, the power supply should be switched on for a period shown in Table C.2. After the appropriate current application time, the power supply should be turned off, and the test results should be observed and recorded. To avoid burns, the wire should not be touched during the test, or for 3 minutes after turning the power supply off. If the wire is located close to HVAC registers or equipment exhaust ports, the airflow can cool the wire and result in inadequate production of smoke. In this event, either the apparatus should be repositioned or the wire should be shielded from the airflow.

8. Test Sequence. The test should be repeated at least three times for each HVAC condition, with the test apparatus placed in a different location in the room each time. If possible, the elevation of the test apparatus should be varied.

9. Pass/Fail Criteria. The pass or fail criteria for the VEWFD system should be as indicated in Table C.2.

## APPENDIX D TESTING OF POWER ISOLATION DISCONNECT CONTROL SYSTEMS

**Power Isolation Disconnect Control Systems** A key process of data processing equipment rooms is power isolation and the ability to test this function. Simply put, upon command as triggered by a manual disconnect control (e.g. Emergency Power Off [EPO] button), fire/smoke event or another emergency situation, the power isolation disconnect control system de-energizes equipment in the impacted area either automatically or manually.

**Purpose and Function of the Power Isolation Disconnect Control System is as follows:**

- Remove as much electricity as possible from impacted area to minimize the risk of electrocution to emergency personnel as they arrive on site.
- Depowering HVAC systems in a fire event may help reduce the propagation of fire from combustible materials.
- Isolating the power from critical loads prior to water (sprinkler and water mist systems) flow may maintain the operability of this equipment, thus saving the cost of replacement.

**Power Isolation Disconnect Control System design must take into account:**

A. All critical spaces, power sources, electrical distribution, back-up and cooling equipment.

B. Incorporate all input triggers, such as manual disconnect controls, e.g. EPO buttons, at egress doors and Fire Alarm calls.

C. Ensure capability of testing the power isolation disconnect control system on a regular basis. To accomplish this objective, a power isolation disconnect control panel (reference Darwell Integrated Technology Inc, TripMaster EPO Control) is typically required.

D. Provide appropriate training for all personnel associated with the critical spaces.

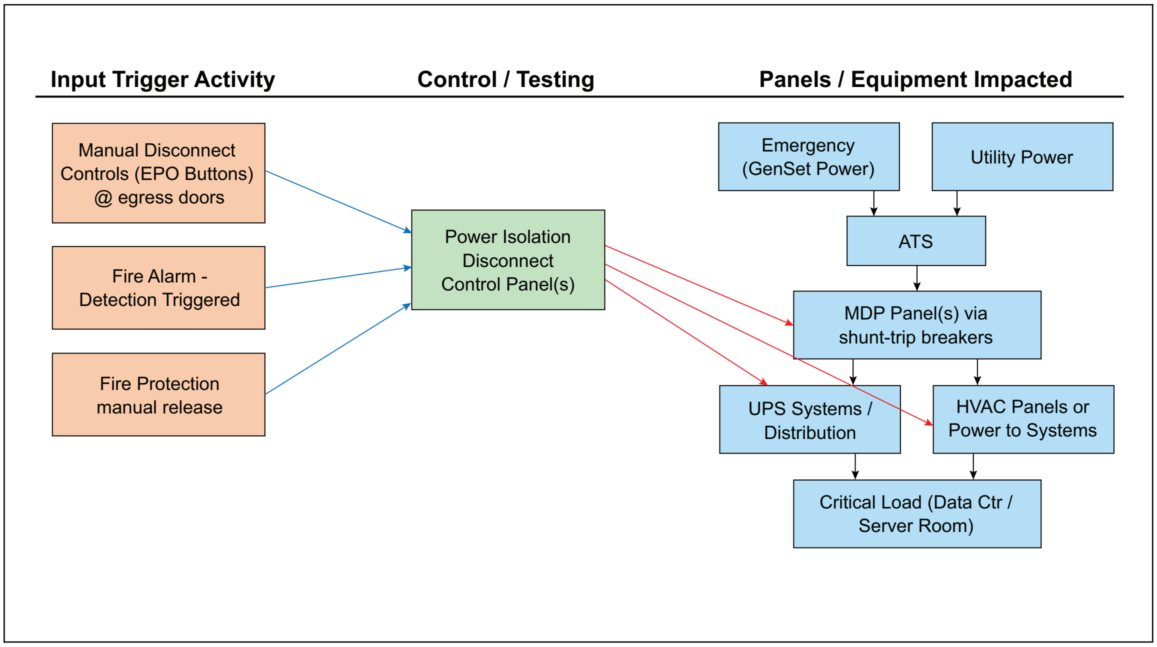


*Fig. D.1. Basic power isolation disconnect control system framework*

**Notes:**

1. Input triggers will vary based on the data processing equipment room. Every environment is recommended to have a power isolation disconnect control system, either automatic or manual, for depowering of equipment. Manual disconnect controls (e.g. EPO button) may or may not be located at every egress. The fire protection and/or fire alarm will be site specific for the triggering the power isolation disconnect system control panel.

2. The impacted electrical panels will require shunt trip breakers that will shut down power at change of state. Every UPS needs a direct shut-down to take out the battery power as well. Depowering the HVAC equipment directly can be done in lieu of shunt-trip breakers in most cases.

3. The Power Isolation Disconnect Control Panel (reference Darwell Integrated Technology Inc, TripMaster EPO Control):

   a. Receives the trigger inputs and sends the output change of states to the panels and equipment to shut-down power.

   b. The control panel can be placed in ‘Test Mode’ which will indicate that a trigger event has occurred but will not send the output signals for power isolation.

   c. This provides critical load protection from an accidental shut-down event when work or cleaning is being performed in that space.

   d. This allows testing of signals to the fire protection system without negative impact on the operation of the data processing equipment room.

   e. This allows testing of input triggers, detection to assure the call for power off is active.

   f. Testing the outputs needs to be scheduled by the specific site equipment.

**Site Variations that impact the Power Isolation Disconnect Control System Design:**

1. An environment that has separate A/B UPS Rooms may choose to have separate manual disconnect control systems in each room. A trigger event would depower the panels and equipment in that specific space. Power distribution downline from panels in this space would be depowered as well.

2. The power isolation disconnect control system panel will have outputs that take down both A and B Rooms, hence all the power in the data processing equipment room.

**Long-term Considerations following Power Isolation Disconnect Control System Installation:**

- Any and all power sources, electrical distribution, back-up and cooling equipment added within the data processing equipment room must be incorporated into the existing power isolation disconnect control system.
- Any modification of the fire alarm and/or fire protection in the data processing equipment room must be incorporated into and tested through the existing power isolation disconnect control System.
- Power Isolation Disconnect Control System testing shall become a vital part of equipment and electrical systems testing.
- Provide appropriate training for all personnel associated with the data processing equipment room following installation and on a periodic basis. A new employee training protocol should include the Power Isolation Disconnect Control System if employee is in the data processing equipment room(s).

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