Property Risk Consulting Guidelines

XL Risk Consulting

A Publication of AXA XL Risk Consulting

PRC.17.10

INFORMATION TECHNOLOGY

INTRODUCTION

Information Technology (IT) in various forms has become critical for personal and business operations. In today's world its evident electronic information development, analysis and storage is the heart of a successful operation. Because of this factor, its crucial the information is secure, readily available and manageable whether it is located on a local, corporate or contracted system or even on "the cloud". Interruption, corruption or loss of electronic information could potentially halt operations resulting in sizable business interruptions. Due to the dependability on IT systems, components of this vast field should be analyzed for adequate protection and business continuity. This includes, but not limited to, the first entry points (desktop computers, portable devices, smart phone, etc.), to the LANs, to the full-scale data centers, which are capable of processing and storing information at an ever-growing rate.

Business interruption losses associated with Information Technology Equipment (ITE) could potentially exceed the property losses tied to the actual equipment. In order to determine the appropriate means of reducing the possibility of ignition and an ensuing fire, we must first understand the effects of such an occurrence.

Heat

ITE and storage media are unusually vulnerable to heat damage. Permanent damage can begin at temperatures as low as 125°F (52°C). About 150°F (66°C), loss of information is likely to occur. When temperatures are elevated above 200°F (93°C) serious distortion and failure of equipment will take place. Between 300°F (149°C) and 500°F (260°C), irrevocable damage will occur. Finally, between 650°F (343°C) and 750°F (399°C), plastics within equipment could degrade, melt to a flammable liquid, resulting in an expanding fire load that would spread to adjacent equipment. If not adequately controlled, the rate of burn could develop elevated temperatures resulting in radiant heat damage outside the immediate fire area.

Smoke

Smoke particles deposited on terminals and circuit boards can lead to erratic equipment behavior. While the condition may be correctable, the necessary cleaning can involve considerable downtime.

Corrosive Fume Contamination

Along with particulate matter, fire or electrical heating can produce corrosive gases. Of special concern are the large quantities of hydrogen chloride gas evolved during the breakdown of PVC insulation. Combining with moisture in the surrounding air and from the combustion process, this gas becomes hydrochloric acid, a strongly corrosive agent which attacks terminals, solder circuitry and electronic components.

Water

Experience indicates that the extent of damage to or degree of downtime of ITE from exposure to water is not as serious as originally contemplated. Older generation computers used high voltage circuitry and were highly susceptible to water damage because of thermal shock to vacuum tubes. Modern equipment is solid-state type and are not prone to destruction by water. In addition, the major electrical components are well shielded from direct water impingement.

Accidental discharge from a sprinkler system has a lower occurrence than from other sources of water within the ITE area. These consist of cooling water, drinking water and drainage lines. An accidental discharge from a fire protection sprinkler system is quite rare. The current industry standard is 1 in 16,000,000 sprinkler heads will accidentally discharge due to manufacturer’s defect.

Sprinklers can limit the spread of fire from the piece of equipment where the fire originated to noninvolved equipment amazingly well. Significant fire damage can be expected to the piece of equipment where the fire originated. Where a total loss to a piece of equipment cannot be tolerated a supplementary gaseous extinguishing system may be needed. The need for supplementary gaseous agent protection depends on the vulnerability to major property damage or extensive downtime.

On occasions where electronic equipment has been subjected to smoke or corrosive fume contamination, effective cleaning of affected parts has been accomplished by use of a water based cleaner, followed by prompt air drying. This has prevented or reduced permanent damage to equipment or its components.

High business interruption potentials create the greatest need for providing property protection. In itself, the destruction of a critical IT system represents a sizable monetary loss, but even more serious financial consequences may accrue from its abrupt unavailability. This resultant loss of services may be offset by preplanning for a hot or cold site or a cloud-based service. Here, success hinges upon having made prior arrangements for the emergency situations, having tested the arrangement to ensure it will work, and, most important, having available the needed system and applications as well as preceding generations of recorded data. However, a real crisis occurs when:

- The equipment destroyed is unique.
- Similar units are remote or unavailable because of full time commitments.
- A natural catastrophe effects multiple user contracted to use the same site.
- Security will not permit processing of confidential data at an outside location.
- The equipment directly controls an industrial process, e.g., chemical plant, or major piece of production equipment.

OPERATIONS

Information Technology Equipment (ITE) Architecture Overview

Information Technology Equipment (ITE) may be in a dedicated space, an entire building or a group of buildings. ITE consists of data processing equipment, associated components and supporting infrastructure including mechanical, electrical and telecommunication systems. Depending on the scale of the operation, the system may have its own dedicated network controls and security room.

ITE includes servers, mainframes, computers, storage systems, switches and routers. Associated components supporting the ITE includes power and data cable networks, UPS units, server racks and supporting mechanical and electrical infrastructure, with determined redundancy.

In most cases ITE will be in protected fire-rated compartments, separated from the other occupancy supporting infrastructure. At most, cooling equipment will be housed in the same fire compartment as the ITE room. Each supporting infrastructure of mechanical and electrical systems is, likewise, located within fire-rated compartment similar with other types of occupancy risks.

In some cases, magnetic tapes and/or automatic retrieval systems are used to store and handle data. With the advancements in ITE, data is more likely to be stored in high-capacity media that should be located outside the ITE area. Limited exceptions may be considered based on the scale of the operation and/or the business interruption potential.

ITE is typically installed in racks within a dedicated climate-controlled room. As the number of racks within a single room increase, so does the concern with temperature and humidity. In order to reduce these factors, forced air movement through the racks is a method that is typically implemented. To maximize energy and cooling efficiency, aisle containment systems may be used. The physical containment that is typically used extends from the top of the racks to the ceiling, between the racks and at the ends of the rows. In order to maintain minimal combustible loading in the dedicated room the containment material should be approved for this specific application. In addition, special attention should be given when utilizing aisle containment to insure proper fixed fire protection and detection coverage.

ITE and support equipment areas are typically unoccupied, except during service or maintenance. In most dedicated ITE areas, the control and/or security stations are continuously monitored. Network topology both physical (nodes connects with a network) and logical (data flow) are not meant to be covered in this PRC Guideline.

ITE configuration, infrastructure and quality can be of a variety of combinations depending on requirements. Standards for certifying ITE facilities and infrastructure define such requirements as well as analysis the business risk so that the acceptable level of overall availability of the ITE can be determined. This can be determined by its rating or tiers of selected standards as well as in-house/corporate design guidelines.

Standards for application and certification for data centers are mainly:

- American Standard ANSI/TIA 942, Telecommunication Infrastructure for Data Center
- Series of European Standards EN 50600, Information Technology - Data Centre Facilities and Infrastructures
- Series of ISO/IEC TS 22237-1 to 7 – Data Center Facilities and Infrastructure - Parts 1 to 7
- Singapore Standards (SS) 507 Business Continuity and Disaster Recovery
- Uptime Institute, Data Center Standard (providing Tier Certification based on its own standard)

These standards present tier classifications used to describe the site-level infrastructure topology required to sustain operations, and not the characteristics of individual systems or subsystems. It is generally split into the following:

- *Tier/Class/Rating 1:* Basic Site Infrastructure (99.671% Guaranteed Availability)
- *Tier/Class/Rating 2:* Site Infrastructure with Redundancy in Components (99.741% Guaranteed Availability)
- *Tier/Class/Rating 3:* Concurrently Maintainable Site Infrastructure (99.982% Guaranteed Availability)
- *Tier/Class/Rating 4:* Fault Tolerant Site Infrastructure (99.995% Guaranteed Availability)

A comparison amongst the 3 recognized standards in terms of power, cooling, and telecom requirements can be found in Appendix A.

ITE Area Configurations

ITE areas may be configured in one of the following ways:

- **Hyperscale (or Enterprise Hyperscale):** A facility owned and operated by the company it supports. They offer robust, scalable applications and storage portfolio of services to individuals or businesses. Hyperscale computing is necessary for cloud and big data storage. It is at least 10,000 ft² (1,000 m²) in size and usually has a minimum of 5,000 servers linked with an ultra-high speed, high fiber count network. Noticeable difference from Enterprise to Hyperscale is the high fiber count utilized across the network.

- **Colocation:** One data center owner selling space, power and cooling to multiple enterprise. Interconnections are large drivers for businesses. Colocation data centers offer interconnections to SaaS. This enables businesses to scale and grow their business with minimum complexity at a low cost. Colocation companies may offer technical guidance for companies that don't know what they require or want the hassle to source and deliver it. A colocation data center can house more than one if not thousands of individual customers. Individual customers could possibly lease as little as space as needed. This could be less than a partial rack.
- **Wholesale Colocation:** Like the colocation standards, except the interconnection may not be a requirement. These facilities are used by hyperscale or large companies to hold their IT infrastructure.
- **Enterprise:** Sometimes, and often incorrectly used interchangeably with Hyperscale data centers, the enterprise facility is defined more by its purpose and ownership than by its size and capacity. The enterprise may be located on or off premises for connectivity, power and security purposes.
- **Telecom:** A facility which is owned and operated by a telecommunications or service provider company. Some telecom companies run the data center within a data center.
- **Edge:** Tend to be operated by colocation service providers, built for versatility and speed. Distinct by its location and connectivity, these are typically positioned in growing markets or on the outskirts of existing networks. The edge allows companies to deliver content and services to local users with minimal latency. Early indications show Edge data centers will support IoT, autonomous vehicles and move content closer to users, with 5G networks supporting much higher data transport requirements.
- **Modular:** Modular data centers (MDCs) are prefabricated units, rated at 1,000 volts or less, consisting of an outer enclosure housing multiple racks or cabinets of ITE and possibly support equipment.

BUILDINGS AND UTILITIES

Exposures

When designing or evaluating a specific location, Nat Cat (natural catastrophe) and outside exposures should be identified, and the appropriate precautions should apply. This may include, but not limited to the following:

Windstorm: Design buildings, roof and ground mounted equipment to resist maximum anticipated wind forces in accordance with local building design standards[1] and/or account agreeable standards.

If a critical ITE operation is in a tornado prone area, consider tornado resistant construction. Select a location that is not vulnerable to damage resulting from the collapse of structures, such as masts, towers, and metal stacks. Avoid windows in exterior walls. Windblown debris could damage the windows resulting in interior rain and debris damage to the equipment and building. On lower floors, exterior windows also constitute a weak point in security against external sabotage.

Flooding: Avoid locations that are susceptible to flooding from either natural or man-made sources. Basements or locations partially below grade are undesirable because of reliance on sump pumps or other mechanical methods for drainage. Do not locate structures housing ITE areas over, under or in proximity of domestic, production or fire protection water mains.

In multistory or multiple occupancy buildings, protect the ITE areas against the entrance of water by watertight ceilings and seals between walls, floors, and ceilings. Exercise particular care in establishing watertight seals around penetrations. When raised floor areas are present, provide appropriate drain for the below the raised floor. The drainage system should be designed to prevent backflow into the area. Where cooling or other water lines are present, water leak sensors should be present and monitored by the BMS and/or an appropriate alarm service.

Earthquake: In areas of known earthquake activity, design earthquake-resistant structures for housing ITE that result in minimal interior damage. Also, conduct an earthquake risk assessment by a consulting firm specializing in seismic design and evaluation.

Provide seismic bracing and/or anchoring for the followings:

- Water-based sprinkler protection systems
- Clean-agent fire protection systems
- Data processing equipment
- Raised floor systems
- Supporting systems such as HVAC, plumbing, power supply, etc.

Outside Exposures: Protect building(s) housing ITE and support equipment against external exposures with the appropriate detachment and/or protection. Refer to PRC.2.0.5, *Protection of Buildings from Exterior Fire Exposures*, for further details. It should be noted to that air supplies may be a concern in regions with possible forest or field fires or industrial operations in the area. With this in mind and other possible exposures, locate fresh-air intakes for air-handling systems so that possible entrance of smoke, debris and noxious and/or corrosive fumes will not be a concern or capable of be adequately monitored and managed.

Construction Features

When designing and/or evaluation the construction of an ITE area and the building envelope, the following areas should be considered:

- The supporting structure, roofing system, exterior & interior wall composition and wall, ceiling and floor coverings.
- Fixtures used in climate control systems including ducts, aisle containment and air collars.
- Materials of utility supports such as insulation of chilled water pipes and cables especially when routed within, below, above and/or in proximity of the ITE area.

Materials used or installed should be non-combustible. Examples of non-combustible materials are metal, concrete, masonry, gypsum board, rockwool and glass. Plastic materials including fire treated or fire retardant should not be permitted for the room structure.

If plastics are present within the ITE area they should meet FM Approval 4910, *Cleanroom Materials Flammability Test Protocol*. However, plastics will be acceptable if the product meets one of the following:

- FM 4882 Standard, Class 1 Interior Wall and Celling Materials or Systems for Smoke Sensitive Occupancies
- A maximum flame spread index of 50 and smoke development of maximum 450 in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*.
- Small scale tests such as BS/DIN EN 13501-1 for aisle containment materials may be considered (with notification and approval from respective Account Consultant) when test results meet the requirements of ASTM E84. Where these wall systems are considered or encountered, refer to PRC.2.0.2, *Expanded Plastics in Building Construction*, for additional guidance.

When piping and ductwork requires insulation, only non-combustible material should be used. Supporting documentation should be provided from the material manufacturer and should include test results from a nationally recognized testing laboratory.

The cable raceways and routing assemblies should be non-combustible or listed per UL 2024, UL *Standard for Safety Cable Routing Assemblies and Communications Raceways*.

Physical Separation and Cutoffs

ITE areas should not be located above, below or adjacent to areas or other structures where hazardous processes are located unless accepted property protective features are provided. Below grade/basement locations should be avoided as water ingress and flood potentials are higher.

Provide at least 1-hr fire rated full height (from structure floor to structure ceiling above) interior partitions, ceilings and floors for the ITE area, network rooms, UPS rooms. Doors to the area should consist of automatic closing and latching fire resistive doors with a minimum ¾ hr fire rating.

To support the fire resistive rating ensure the following:

- Keep all doors closed and latch when not in use. Doors to ITE and support areas are usually designed to be secured and closed for security purposes. However, when it is necessary to hold doors open, use electromechanical or electromagnetic devices, interlocked with the associated fire alarm system. Design devices to automatically close the door upon activation of an “alarm”. If electromagnetic devices are used, confirm the magnetic field will not interfere with or damage operations or media.
- Seal all cable and pipe penetrations through fire rated partitions, floors and ceilings with listed equivalent wall rated material.
- Seal openings in fire rated partitions through which HVAC duct(s) pass, with listed automatic closing fire dampers of fire resistance rating of ¾ hrs.
- When new construction or modifications are in progress, install temporary listed fire-stop penetration seals (such as fire pillows or cushions) for protection when work is stopped at night and during weekends.
- Fill in the ridges of corrugated roof decking with an appropriate fireproofing material where decking passes over the walls of the enclosure. Tape and plaster all wall board joints during construction, particularly at surface intersections.

Subdivide sizable ITE areas, wherever possible, to limit the exposure to fire, smoke, heat, and corrosive fumes from a single incident. Extend this division from subfloor to the floor above or to underside of the roof.

Where vaults or storage rooms open into the ITE area, provide a secondary means of access for firefighting purposes so that the ITE area is not exposed to the release of heat, smoke, and fumes during such operations.

Utility Supporting Systems

Utility supporting systems for ITE areas typically include the power supply distribution, HVAC, data transmission, security, and surveillance systems.

The electrical systems may include such features as transformers, transfer switching stations, circuit breakers, generators, UPSs, PDUs, RPPS, cabling, etc. In order to maintain continuous and uninterrupted operations, these features may be required for a high-quality and reliable power supply. With added equipment, comes added exposures. In order to reduce potential losses, adequate protection features, precautions, SOPs, maintenance and testing programs should be inclusive and well established. According to a study by NFPA, electrical distribution equipment such as cables is the major cause of fires in electronic equipment areas.

The cooling systems are critical for the operation of an ITE area. The CRAC and CRAH systems are make up the majority of the cooling systems for ITE areas. Further details on these systems can be found in the “Types of Cooling Techniques”. As the equipment data handling capability increases due to technology improvement, the equipment power consumption requirement increases such that cooling water or liquid is directly piped to the data processing equipment. This increases the likelihood of liquid damage to sensitive electronic equipment in the data hallway.

Power System Considerations

The operations of the ITE area are highly dependent on the integrated design and operations of mechanical and electrical systems. The interruption of power to any system could result in significant interruption of operations or data processing or transmission. As a result, it's common to find redundancy throughout the systems at various levels. This redundancy factory method is typically expressed by N+X, where X is the redundancy factor of N. For example, a N+1 design indicates the N is equipped with at least one independent backup component.

Power Distribution Design

Power distribution design for the traditional larger ITE area consist switchgears delivering power to the PDUs. The power supply is then distributed to the RPPs which then deliver power to the racks via “whips’ (power cabling) routed below the raised flooring.

The following are some of the main challenges with the traditional design:

- Valuable floor space occupied by electrical distribution equipment
- Below floor cabling becoming congested
- Disruption of airflow used for cooling
- Removal of abandoned or unused cables
- Identification of circuits
- Lack of flexibility or adaptability
- Modifications are typically complex and time consuming

Power management solutions for modern ITE area has evolved to be both flexible and easily adaptable to changing requirements. The systems are typically designed for scalability for change and growth. The initial investment provides long-term cost savings for the owner.

Modern power management solutions typically include:

- Separate overhead power and data busway systems
- Intelligent PDUs
- Power management software

Cabling

All cabling should conform with NFPA 70, National Electrical Code.

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

- FM Approved Group 1.
- UL Standard 910 listed plenum rated cable.
- Cable that has a maximum flame spread distance of 5 ft (1.5 m) or less when tested in accordance with NFPA 262, *Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces*.
- Low smoke halogen free cables complying with EN 50267 and EN 50268 standards when outside North America.

Data cables and power cables should be kept separate. NFPA 70 Article 645.5.D.2 indicates that the branch circuit supply conductors to receptacles shall be permitted under a raised floor if they are in rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, electrical metallic tubing, metal wireway, surface metal raceway with metal cover, flexible metal conduit, liquid tight flexible metal conduit, Type MI cable, Type MC cable or Type AC cable. Interconnection wiring, on the other hand, may be as determined by the component manufacturer. If the underfloor space has no exposed combustible surfaces, all wiring is listed, is of the type specified above and fire propagation is improbable, a fire protection system in the underfloor space may be waived and only an approved detection system be provided.

Use cable raceways and routing assemblies made of non-combustible materials. When cable raceway and routing assemblies must be constructed of plastic, plenum-rated plastic raceways listed to UL Standard 2024, *Standard for Cable Routing Assemblies and Communications Raceways*, should be employed. Do not use cable raceways, routing assemblies or junction boxes constructed of PVC material for power cables.

Do not use plastic grids or reflectors on lighting fixtures. Glass diffusers are preferred on lighting fixtures.

Pay special attention to power surge and lightning protection to prevent nuisance shutdowns and damage to equipment. Also, brownout and blackout potential should be reviewed, and contingency plans prepared and periodically updated. Protect sensitive electronic equipment against voltage fluctuations that routinely occur due to transients, power outages, electrical disturbances, and noise on the circuit. These problems can be intercepted and controlled using such devices, as surge suppressers, filters, voltage regulators, isolation transformers, power conditioners, motor generator systems or by UPSs. For further guidance on lightning and surge control, see PRC.5.2.1 and PRC.5.2.2. Electrical maintenance is essential to the continuous operation of the ITE. Refer to NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*.

Where immediate ITE shutdown can be tolerated, locate prominently marked EPO controls at main exits for this purpose. These EPOs should control all power to the ITE. Guard the EPOs against accidental tripping by using controls of the pull-type operation rather than push-button or toggle-type. If this is not possible then, remote means should be available and acceptable SOPs should be implemented.

Power Cables Considerations

Due to a potential ignition source, power cables located in the ITE area should be insulated and listed and/or approved for such applications.

Traditionally, the halogen-free conduits have been specified as to prevent the generation of toxic gases; however, this should not be confused with properties associated with flame retardant or low smoke. It is still considered combustible if exposed to an ignition source.

In recent years, LSZH cables have been the preferred cabling in many occupancies including ITE environments due to their low smoke and toxicity characteristics. The LSZH insulation and jacketing conduits are used extensively for the power, data, and instrumentation cables.

As a general guideline for cable installation in the European ITE areas, it is recommended LSZH cables be installed in compliance with EN 50267 and EN 50268 Standards.

Protection for Arc Flash

Arc flash refers to occurrence when an electrical short circuit current flows through the air. This occurrence is characterized by a large release of energy that generates light, sound, shockwave and heat. The arc flash can be caused by dust particles in the air, moisture condensation or corrosion on the electrical or mechanical components, material failure or human factors including faulty installation, poor maintenance practice etc.

Arc flash creates a tremendous amount of rapid energy with temperatures possibly reaching 35,000°F (19,427°C). This is hotter than the sun’s surface.

Mitigation measures reduce the potential for arc flashing, the Electrical Maintenance Program should include thermographic infrared surveys, connection torqueing and switch/relay integrity testing of the electrical systems. All work on the components should be carried out by qualified and trained personnel.

Air Conditioning

Design and construct air conditioning systems for proper load and redundancy, where needed. Install air conditioning systems in accordance with NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, and as follows:

- ITE areas and media storage vaults should preferably have their own independent air conditioning systems.
- Otherwise, isolate air conditioning systems from all other areas and equip ducts with automatic fire dampers at points of penetration through fire rated separations.
- Locate air intakes as far as possible from sources of flame, smoke, and noxious, radioactive or corrosive fumes.
- Air-handling units, ductwork, insulation, liners and other associated components should be of non-combustible material
- System filters should be non-combustible or UL900 Class 1 listed.
- If above ceiling spaces are used as an air conditioning plenum, it should be void of combustibles.

Air Conditioning Techniques

Air conditioning accounts for approximately 35% of the energy consumption in the IT operation. Since equipment generates significant heat and typically running 24/7, the air conditioning systems are considered critical to the operation. The Computer Room Air Conditioner (CRAC) (see Figure 1) and Computer Room Air Handler (CRAH) systems (see Figure 2) are the most commonly used methods in modern ITE environments. These and other technologies are continuously evolving to increase efficiency and reduce carbon footprint.

CRAC vs. CRAH: CRAC units remove the heat by forcing warm air over the cooling coils filled with refrigerant while CRAH units utilize water in the coil as a heat sink and require more equipment in the operating process.

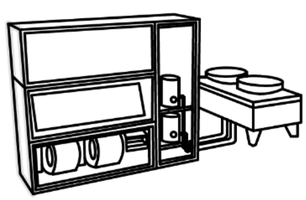

Figure 1: CRAC

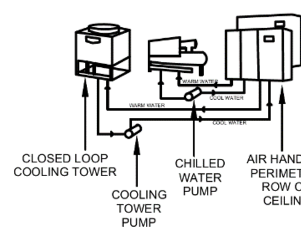

Figure 2: CRAH

CRAC/CRAH Air Handlers: These units may be located within or outside the ITE area and employ three main components consisting of air filters, cooling coils and fans. These components should be non-combustible. In most cases air filters do not meet this standard; therefore, should comply with ANSI/UL 900, *Standard for Air Filter Units* (see Figure 3). Additional features, including humidity controls may be employed to control static electricity.

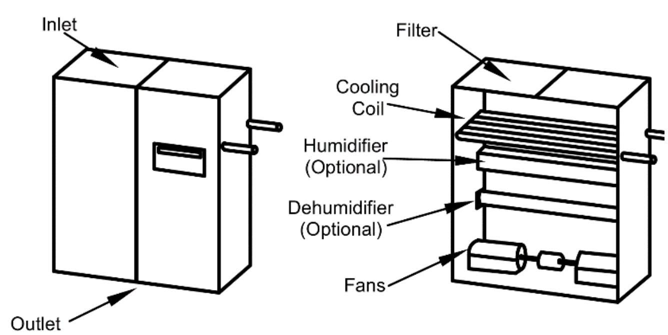

Figure 3: Air Handlers

Free Cooling: This cooling concept (see Figure 4) is becoming popular with large purpose-built data centers. It is an alternative to the traditional air conditioning method which uses ambient air without refrigeration plant needed. Ambient air enters the building via louvres on one side of the building. The sucked in air will then be filtered, cooled, and humidified by evaporative coolers. The cold air will enter the ITE area into an aisle containment configuration. Hot air will be drawn out of the area by fans via another set of ducts connected to the other side of the building. There are some limitations to this system since it can only be used in certain regions where the ambient conditions are met.

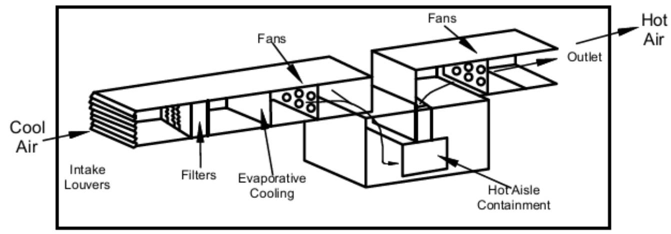

Figure 4: Free Cooling

Heat Wheels/Heat Exchangers: This cooling method (see Figure 5) is less commonly seen in the market. The installation is similar to the free cooling method mentioned above. Since fresh air can contain dust, moisture, particles, etc. which can deteriorate the ITE electrical circuits, this installation is capable of cooling the air without the need of introducing fresh air into the building. For this cooling method to work efficiently, the filters and evaporative cooling used in the ducts of the free cooling system are replaced by heat wheels/heat exchangers which allows thermal energy to be transferred from one stream to another.

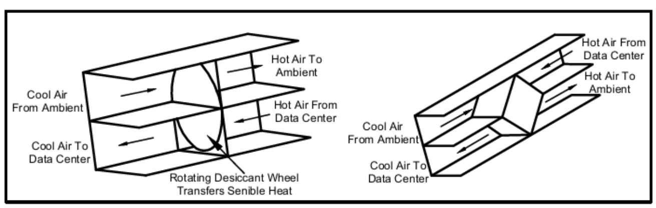

Figure 5: Heat Wheels/Heat Exchangers

Liquid immersion cooling is one of the latest cooling methods used in this industry. Components are completely submerged in the heatsink liquid (ex. Dielectric fluid, mineral oil, water, etc.) for cooling. This concept is believed to reduce energy consumption by more than 70% and provides higher cooling capacity without any know component performance degradation. The technology is also believed to reduce the carbon footprint by significant eliminating most of the required air conditioning equipment. Since air flow through the racks is not an issue with the technology, the floor space is greatly reduced. If immersion cooling is utilized than hazard analysis associated with the cooling method should be a performed.

Cooling efficiency is often a challenge for the ITE area. This is typically managed by the BMS and can drastically improved by:

- Controlling the volume and temperature of the air flow
- Sealing unwanted voids in the air flow path with listed materials
- Maintaining clean UL 900 energy efficient filters
- Employ energy efficient Electronically Commutated (EC) fans

ITE Area Arrangements

In the raised floor ITE areas, the air handling units are typically positioned on top the raised floor and supported raised floor structure. Conditioned cooled air from the air handling units is directed below the raised floor, upward through perforated floor tiles typically positioned in from of the server racks, through the racks and back to the air handling units via air circulation below the fixed ceiling, through above ceiling air plenums, or non-combustible duct work. In smaller and older IT areas a traditional cooling system (see Figure 6) combines hot and cold air mix. This design requires significant energy to environment's condition.

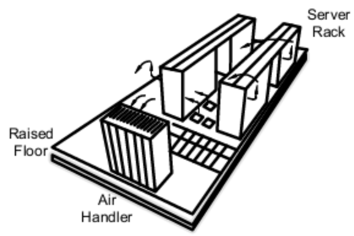

Figure 6: Traditional Cooling System

In order to increase efficiency, containment walls or hot collars may be installed separating the cold from hot aisles (see Figures 7 & 8). (Note: Elements of containment should be in accordance with "Construction Features" section of this PRC Guideline.)

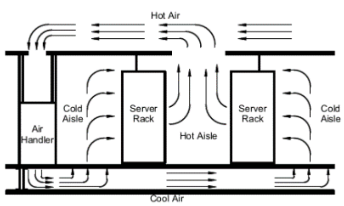

Figure 7: Hot Aisle Containment

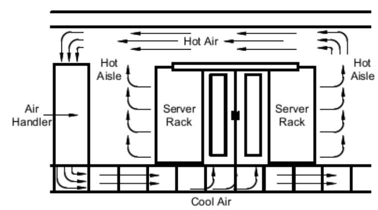

Figure 8: Cold Aisle Containment

Advancements in controlling cooling efficiency and utilization of the ITE area have introduced the concept of non-raised floor ITE areas (see Figures 9). This not only eliminated the hassle of accessibility to below floor utilities and cabling but positions the air handlers outside the normally secured operating envelope. Aisle containment features will typical be found in this type of IT area.

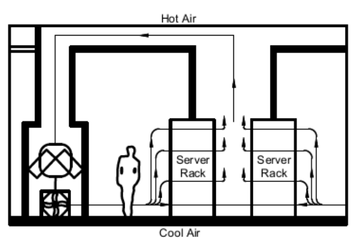

Figure 9: Non-Raised Floor IT Area

Type of Data Transmission To/From the Site and Within the ITE area

There are two main data transmission network technologies used in most ITE environments: fixed-line network and mobile/wireless network.

- **Fixed-line networks** primarily utilized copper and fiber optic cables for transmission of data. This technology may require the assistance of IP addresses, DNS servers, amplifier, cell towers, routers, etc.
- **Mobile/wireless networks** are used when end users are connected to the network via wireless transmission technologies. Signals are transmitted via satellite or antenna. Mobile networks consist of 2G, 3G, 4G, and now 5G. It is reported that 4G networks are approximately 5 times more energy efficient than 3G, and 50 times more efficient than 2G. The energy and emission impacts of the new 5G technology is still uncertain at this time. The 5G antenna currently consumes approximately 3 times more electricity than a 4G antenna.

However, the new power-saving features could narrow the differences down to approximately 25%. Network infrastructure specialists indicated that 5G networks could be 10-20 times more energy efficient than 4G networks in the future. Therefore, the market is shifting away from 2G/3G networks to 4G/5G networks.

Building Management Systems

The building management system should monitor the following within the ITE areas:

- Fire alarms (could also be monitored at an acceptable monitoring station)
- Features of the HVAC equipment including:
    - System efficiency
    - Air supply flow and temperature
    - Cooling media flow and temperature
    - Smoke Detection
- Room temperature and humidity
- Abnormal ITE operating temperature
- Fluid leakage in and/or below liquid-cooled components in the ITE area
- Leakage below liquid cooled air-handling units
- Hydrogen detection above the UPS if tested levels deem necessary
- At least two of the following features when the BBU/UPS consists of VRLA batteries:
    - Battery temperature
    - Battery voltage
    - Float current
    - Conductance
- Lithium Ion (Li-Ion) BBU/UPS systems are relatively new to the ITE industry and offer several advantages over the VRLA batteries including quicker installation, smaller occupied area, less maintenance, greater power and longer life to name a few. Li-Ion BBU/UPSs may be centralized or within the individual server racks. With all of the advantages associated with Li-ion, some inherent hazards, including but not limited to thermal runaway and release danger gases. In order to reduce the potential hazards, a combination of active and passive controls inaugurated in the BMS.

Typically, the Li-Ion BBUs are delivered from the manufacturer with a 30% charge. If damage or short circuiting should occur, the chemicals inside the BBU begin to heat up, which causes further degradation of the separator. The battery can eventually hit temperatures exceeding 1,000° F. At that point the flammable electrolyte can ignite or even explode when exposed to the oxygen in the air.

When the BBUs are not in operation the following should apply:

- BBUs should be located in a storage area with an automatic sprinkler designed density of 0.30 gpm/ft².
- All BBUs not in use should be stored in acceptable hazardous substance cabinets and UL listed and/or FM Approved.
- When the BBUs are outside of acceptable hazardous substance cabinets and not in operation, they should be in acceptable sealed Li-ion battery containers.
- BBUs should not be stored in the ITE area.
- SOP should be specific on handling and transport of the BBUs.

  The current edition of NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems*, and our PRC Guidelines should be referenced for specific features as well as other standards when employing Li-ion technology.

Power isolation of the ITE and HVAC systems minimizes the potential for reignition and circulation of smoke to sensitive electronic equipment on site. When the fire suppression system operates, the electrical service to the ITE and supporting air-handling systems should automatically deenergized. If this is not feasible, then the site should be equipped with 24/7 personnel fully trained and capable of adhering to strict and appropriate SOPs in the event of an emergency situation.

PROCESS EQUIPMENT

There are various degrees of ITE areas, including but not limited to, ITE closets, to a server rooms, to data centers. All may be capable of storing, processing and distributing data with varying degrees of capacity and support infrastructure. The area normally has a separate and independent HVAC system and may also employee a raised floor. Small closets may house as few as one server composite and data centers may house several thousand racks.

In the traditional ITE room the racks will be lined up in rows and the cooling system will not have a designed flow path. The cold air from the cooling system will combined with the hot air generated from the server racks. This requires a significant degree of energy to maintain an optimum operating temperature and humidity.

Newer ITE rooms employ the aisle containment configuration. Within this type of room, a HVAC method deployed in the occupied area of an air-cooled ITE area utilizing physical separation of hot exhaust air from cooler intake air between equipment cabinets, rows of ITE, or associated power and cooling infrastructure; containment is typically above and at both ends of a hot aisle or a cold aisle, in whole or part. Aisle Containment Systems separate the cool supply air from the warm exhaust air. This concept optimizes the energy efficiency, which result lower operating expenses.

In all ITE area the occupancy should be restrict to operational ITE equipment. Combustible storage including but not limited to files, manuals, paper supplies and idle cabling and equipment should not be present in the ITE area. If the materials are deemed necessary, they should be stored in closed metal cabinets.

The ITE area should not be exposes by or located directly above, below or adjacent to boilers and/or compressor rooms, hot water tanks, pressure vessels, and operations involving ignitable liquids or hazards materials.

Do not expose ITE areas to storage or process areas with explosion potential. If computers control a process with explosion potential, isolate them from the hazard by an explosion-resistant structure.

Pipes containing any liquids or gases should not be routed through or adjacent to ITE areas. When an adjacent property has an explosive hazard, reduce the exposure by positioning the ITE areas on the opposite side of the occupied building.

LOSS PREVENTION AND CONTROL

Pre-Emergency Planning

Refer to PRC.1.7.0, *Pre-Emergency Planning*, for the structure and details when developing such a plan. Pre-emergency plan must be site-specific. Corporate-level rolled-out plans need to be customized at site specific level as each facility is unique and encompasses a variety of site-specific hazards and potentials for emergency incidents. No matter how extensive and thorough loss prevention programs and procedures, management must ensure that each facility is prepared to deal with any internal or external event that can lead to an emergency at the facility. An emergency is an event that requires immediate response to limit the threat to property, the environment and business operations.

Depending on the specific ITE occupancy, level of local ownership and employees on-site, the pre-emergency plan should consist of a comprehensive document owned and maintained by local management. This responsibility may often be transferred to a third party which owns, operates and/or manages the site. In such cases, all associate programs should be critiqued for accuracy and inclusion.

Policy statement is expected to be a corporate directive. The emergency coordinator and possibly committee should customize the plan and report directly to facility management. The role of an emergency coordinator is multi-faceted and resides with one that has knowledge of the site and its operations, including security. Support for this role may be shared with various colleagues in the respective fields.

Hazard identification and evaluations should be specific to the features that are present, including, but not limited to the ITE area and infrastructure. This may include natural disasters, outside infiltration, social/political exposures, etc.

The data processing, transfer and storage dependencies are critical when evaluating ITE systems. This could range from a moot facture in a well-designed system to catastrophic event for a stand-alone platform. Understanding of each system is a critical factor for developing and implementing the appropriate plans and procedures.

When developing a comprehensive pre-emergency plan, include detailed procedures for the following possible events:

Fire/Smoke/Thermal/Water:

- Activation of smoke/heat detection alarm (including all areas: room, below raised floor, above ceiling, air handler, etc.)
- Observed fire or smoke
- Report of fire in another section of building or adjacent area
- Operation of sprinkler system or special extinguishing system

Utility:

- Abrupt loss of electrical power
- Malfunction or loss of air conditioning equipment (Including air contamination)
- Cooling, drainage, domestic and production water mitigation

Natural Catastrophes:

- Floods, earthquake, tornado, hurricane, snow, hail rain, artic freeze, etc.

Social/Political:

- Terrorism, civil disorders, labor unrest, events which could influence or reduce workforce.

The goal of the procedures should be to avoid and/or reduce the loss potential which could not only result in property damage but could have substantial business interruption.

The recovery procedure plans, depending on the event, should be executed at the onset of the event. NFPA 75, *Standard for the Fire Protection of Information Technology Equipment*, Annex B details actions that should be followed within the first 24 hrs of an event in order to reduce the potential electronic components and magnetic media damage. Primary damage to electronic components is caused by smoke that contains corrosive chloride and sulfur combustion by-products. Smoke exposure during a fire for a relatively short period of time does little immediate damage. However, the particulate residue left after the smoke had dissipated contains the active by-product that will corrode metal contact surfaces in the presence of moisture and oxygen. The ultimate objective in restoration is the removal of contaminant as soon as possible and systematically. Maintaining 40-50 percent relative humidity will generally prevent an acceleration of corrosive activity. Equipment, even when totally submerged in water, can be restored. Whenever water is introduced to the components, it is most important to immediately turn off all electrical power to the equipment. When possible, water or moisture abatement can be performed by a qualitied party.

As with all plans, success is based on the commitment from management, implementation, review, and testing. These elements assist in the reduction of property loss potential and business interruption. Plans should be reviewed at least annually; however, depending on the extend of the developed plan, more frequent reviews and tests may be required. Updates to the plan should be made as the building, occupancy and/or business changes.

FIRE PROTECTION

NFPA 75 should be the primary basis for requirements for protection. The following fire protection sections addresses AXA XL Risk Consulting's interruptions, concerns and guidelines when designing and/or evaluating ITE areas.

Fixed automatic fire protection should be provided in all ITE and support areas and throughout the occupied building. Fire protection controls and system monitoring annunciators should be readily available and located outside the protecting area. There are various means of properly protecting the ITE area from fire exposure, this may include automatic sprinklers, clean agent, water-mist or a combination.

Automatic Sprinkler Protection

In most situations the ITE area automatic sprinkler system should be designed and installed based on an Ordinary Hazard Group I occupancy as addressed in NFPA 13, *Standard for the Installation of Sprinkler Systems*. The system may be a wet pipe or pre-action sprinkler system. For pre-action systems, incorporate single-interlock activation utilizing fixed photoelectric smoke detection or air sampling. The sprinkler protection, detectors or sampling pots should be located throughout the ITE area and positioned based on the manufacturer's listing or approval. Where possible, interlock equipment and mechanical power to de-energize prior to the introduction of sprinkler water-flow. If there is a valid reason not to include this feature, then an acceptable documented and implemented SOP should be developed addressing the de-energizing actions that should be taken upon activation of sprinkler water-flow.

Clean Agent Extinguishing System

Where water supplies for automatic sprinkler protection is a challenge or the loss potential is high, a gaseous clean agent may be used in accordance with NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, and PRC.13.6.1, *Clean Agent Systems*. The system should incorporate single-interlock activation utilizing fixed photoelectric smoke detection or air sampling. The detectors or sampling pots should be located throughout the ITE area and positioned based on the manufacturer's listing or approval. Where possible, interlock equipment and mechanical power to de-energize prior to the introduction of agent. If there is a valid reason not to include this feature, then an acceptable documented and implemented standard operation procedure should be developed addressing the de-energizing actions that should be taken upon activation of clean agent system.

The systems should be designed with a connected reserve supply arranged to put the second quantity of agent in the automatic mode by operation of a main/reserve switch. Locate the main/reserve switch where it will be accessible during an emergency. Do not operate important production equipment without the fire protection in service. A third set of containers can be kept on premises if the containers cannot be serviced within 24 hrs. Although they need not be connected to the protection system, they must be inspected, tested and maintained. Containers of halocarbon-based clean agent must be conditioned for a period of time before being filled to their final weight and pressure, rendering on-site filling ineffective.

Provide a plan and means to ventilate the protected area from the discharge of the clean agent and corrosive decomposition products without contamination to other equipment and areas.

It should be noted that clean agent systems must hold a minimum design concentration at the end of a 10 min. soak period after discharge. Where operation of HVAC systems would exhaust the clean agent supply, the HVAC systems should be interlocked to shut down when the clean agent system is actuated. When smoke venting systems are used, interlock the systems to be inoperable until the end of the 10 min. soak period.

Although not as common as clean agent extinguishing systems, water-mist systems may be considered. Activation design should be similar to the clean agent system and equipped with reservoir supplies.

Automatic Sprinkler Protection/Clean Agent Extinguishing System Combination

There are occasions where a sprinkler/clean agent combination is warranted. In order to determine such an occasion a fire risk analysis should be performed. The following factors should be considered during the process to evaluate the potential property damage and business interruption:

- Fire threat of the installation to occupants or exposed property
- Business loss from loss of processing or data
- Business loss from equipment replacement
- Regulatory impact
- Client or potential client reputation
- Redundant offsite processing

Protection & Detection for Areas of Concern Outside the ITE Area

Appropriate fixed automatic fire protection should be provided below raised floors when cables are present and above the ceiling when utilized as a return air plenum.

Protection below non-combustible raised floors may be omitted if only UL-listed plenum-rated cables are present or if an air sampling fire detection system is provided at the return inlet for the below floor air-handler.

Extinguishers

Equip the IT area with Class BC extinguishers using halogenated agents or carbon dioxide, and Class A pressurized clear-water extinguishers in sufficient numbers so that at least one of both types is within the appropriate travel distance based on NFPA 10, *Standard for Portable Fire Extinguishers*. Provide one extinguisher of each type at the main entrance to the room. Signage should be cleanly displayed adjacent to each extinguisher indicating the type of fire for which it is intended. Dry chemical extinguishers should not be used in ITE areas.

To avoid confusion during an emergency, clean agent Class ABC extinguisher may be used in lieu of the Class A and Class BC extinguishers.

Hose Connections

Provide manual hose connections throughout the facility.

Smoke Venting

Install an engineered smoke management system in accordance with NFPA 92, *Standard for Smoke Control Systems*, to provide the following:

- Normal air release when a suppression agent is used
- Air movement to cleanse suppression agent from the enclosure
- Smoke venting for fire-fighting access
- Pressurization to exclude infiltration of smoke from an exterior fire
- Adequate make-up air

Provide emergency mechanical ventilation to exhaust smoke and corrosive fumes to the atmosphere. Base the fan capacity on the ratio of 3 cfm/ft^2 (0.9 m^3/min/m^2) of floor area in the ITE area and 4 cfm/ft^2 (1.2 m^3/min/m^2) of floor area in magnetic media vaults.

Careful consideration must be given to the probable paths smoke and fumes will take and efforts must be made to minimize contaminant exposure. Avoid fan arrangements that will spread contaminants through equipment. Hydrogen chloride generated by burning cable and wiring insulation is a major concern, particularly when underfloor spaces are present. Emergency exhaust from underfloor areas will tend to pull smoke and corrosive fumes away from equipment and will make it easier to remove floor panels without smoke and fumes billowing upwards.

Activation of smoke exhaust fans or automatic cycling of the air conditioning system to a nonrecirculating, full exhaust mode should take place upon actuation of any smoke or POC detector in the ITE area or underfloor space. If a gaseous extinguishing system is used, interlock the ventilation to be inoperable until the end of the “soak period.”

Vital Records and Media Protection

Vital records (e.g., paper records and electronic storage media) should be stored in a standard records vault or in listed or approved records protection equipment. The records storage vault should be equipped with the appropriate automatic fire protection and smoke detection systems. Records protection storage units should appropriate listed and approved and carry a 2-hr fire resistive rating. The unit should also be located outside the ITE area and not subject to damage or exposing hazards.

Use a remote location with security and protection comparable to the primary location for storage of duplicate system, application programs, and preceding generations of magnetic media. This back-up process is frequency completed automatically via data transmission and in cycles as short as real-time input. The shorter the cycle time, the least potential for business interruption. In those situations where physical media is utilized for back-up, daily records should be sent to a secured storage area on-site and a complete system update should be performed weekly and held at a secured remote location.

Surveillance

Since early detection and prompt response from personnel are vital in avoiding serious damage to electronic equipment, the following supervisory service combination is recommended.

- A constantly attended fully addressable fire alarm system including, but not limited to, sprinkler water-flow and early warning smoke detection.
- Provide standard, recorded, hourly guard service during periods when the ITE area and/or adjacent areas may be unoccupied, or provide an acceptable fully addressable central station signaling system.
- Water leak sensors should be provided below all liquid cooled and cooling equipment in and around the ITE area and monitored by a continuously attended signaling system.

Further upgrading of surveillance may be warranted when the total value or importance to operations is significant.

Security

Use a secure access system at entrances to the property, buildings and floors to verify employees and visitors.

ITE areas and critical operations should remain secured with access granted to qualitied individuals.

REFERENCES

1 ASCE 7 - Minimum Design Loads for Buildings and Structures, American Society of Civil Engineers, Reston, VA.

AS/NZS 1170.2 – Structural Design Actions Part 2: Wind Actions, Standards Australia, Sydney, Australia.

EN 1991-1-4 - Eurocode 1: Actions On Structures - Part 1-4: Wind Actions, European Committee For Standardization, Brussels, Belgium.

NBCC - National Building Code of Canada, National Research Council of Canada, Ottawa, Canada.

GB50009 - China National Standard, China Architecture and Building Press, Baiwanzhuang, Beijing, China.

CP-2004 - Code of Practice of Wind Effects, Building Department Hong Kong

IS875 (Part 3) - Indian Standard Code of Practice, Bureau of Indian Standards, New Delhi, India.

SNI-03-1727 - Standard National Indonesia, Indonesia

REFERENCES (CONT'D)

AIJ-RLB - Recommendations For Loads On Buildings, Architectural Institute of Japan, Tokyo, Japan.

KGG – KBC 2005 -Korean Government Guidelines of Korean Building Code, Korea

MS1553 -Code of Practice of Wind Loading, Malaysia Standard, Malaysia

NSCP - National Structural Code of the Philippines, Association of Structural Engineers of the Philippines, Manila, Philippines.

EIT-1018-46 Wind Loading Code for Building Design, Engineering Institute of Thailand.

TCVN2737 – Loads and Actions Norn for Design, Vietnam

INFORMATION TECHNOLOGY GLOSSARY

BBU Battery Backup Unit

BMS Building Management System, also Battery Management System

CRAC Computer Room Air Conditioner. Like the air conditioner at your house. It has a direct expansion (DX) refrigeration cycle built into the unit.

CRAH Computer Room Air Handling. A CRAH unit works exactly like a chilled water air handling unit.

DNS Domain Name System

EPO Emergency Power Off

HVAC Heating, Ventilation & Air Conditioning

IP Internet Protocol

IT Information Technology

ITE Information Technology Equipment. Equipment used to generate, process and store data.

LAN Local Area Networks

LSF Low Smoke and Fume. This refers to cable jacketing and insulation made with materials that emit a small amount of black smoke and toxic halogens; however, it is well within the levels of cable standards. They are not 100% halogen-free and are also not flame retardant.

LSZH Low Smoke Zero Halogen. This refers to cable jacketing and insulation made with materials that produce low or limited smoke and toxic halogens when exposure to fire.

MDC Modular Data Center

PDU Power Distribution Unit. A multiple-output device which distribute electric power to the server and/or network equipment.

POC Products of Combustion

PVC Polyvinyl chloride

RPP Remote Power Panel

SaaS Software as a Service

SOP Standard Operation Procedure

UPS Uninterruptible Power Supply. A device that provides the required power if there is a loss or reduction of the primary power supply.

VRLA Valve-Regulated Lead Acid

INFORMATION TECHNOLOGY TABLES

ITE ARCHITECTURE OVERVIEW

	Standard			
	EN 50600 / ISO/IEC TS 22237	TIA 942	SS 507	UpTime
Conformity	Class: 1-4	Rated: 1-4	Pass/Fail	Tier: I-IV
Certification	Available	Available	Available	Available
Scope of Topology	Electrical Mechanical Distribution Architectural Telecom Site Location Safety-Security Efficiency	Electrical Mechanical Distribution Architectural Telecom Site Location Safety-Security Efficiency	Electrical Mechanical Distribution Architectural Telecom Site Location Safety-Security	Tier Standard Electrical Mechanical Distribution OS Standard Other Element
Auditor	Not applicable	Multiple organizations available	Multiple organizations available	UpTime Institute only

INFRASTRUCTURE TIER STANDARDS

Power

	Tier/Class/Rating			
Standard	1	2	3	4
EN 50600 / ISO/IEC TS 22237	Supply: Single source Distribution: Single path	Supply: Redundant source (single path to primary distribution equipment) Distribution: Single path (redundancy of components)	Supply: Redundant source (multiple paths to primary distribution equipment) Distribution: Redundant path Compartmentalisation of redundant elements.	Supply: Multiple source (multiple paths to primary distribution equipment) Distribution: Redundant path (fault tolerant except during maintenance via redundancy of components) Compartmentalisation of redundant elements.
TIA 942	UPS: N arrangement Generator: No redundancy	UPS: N+1 arrangement equipment level (single path) Generator: No redundancy	System allows concurrent maintenance. Generator: N+1	Fault Tolerant Generator: 2N
Uptime Institute	No redundancy	N+1 redundancy on some components.	Concurrently Maintainable (1 active and 1 passive power path in backbone and 2 simultaneously active paths to critical equipment from UPS)	Fault Tolerant. Compartmentalisation of redundant elements.

Cooling

Standard	Tier/Class/Rating 1	2	3	4
EN 50600 / ISO/IEC TS 22237	Single system	Single system with redundant devices	Multi path concurrent repair/operate solution. Compartmentalisation of redundant elements.	Multi path concurrent repair/operate and fault tolerant solution. Fault Tolerant. Compartmentalisation of redundant elements.
TIA 942	No redundancy	N+1 redundancy for mechanical equipment. Loss of electrical supply path or water supply (where applicable) could lead to a loss of cooling.	N+1 redundancy for mechanical equipment to allow for concurrent maintainability. Temporary loss of electrical power or interruption of water supply (where applicable) will not cause a loss of cooling but may cause temperature to elevate within operational range of critical equipment. The switchover from N to +1 may be performed manually.	N+1 redundancy for mechanical equipment to allow for fault tolerance. Extended loss of supply path of power or piping (where applicable) will not cause loss of cooling outside operational range of critical equipment. The switch over from N to +1 should be fully automated.
Uptime Institute	No redundancy	N+1 redundancy on some components.	Concurrently Maintainable.	Fault Tolerant. Compartmentalisation of redundant elements.

Telecoms

Standard	Tier/Class/Rating 1	2	3	4
EN 50600 / ISO/IEC TS 22237	Single path using direct connections.	Single path using fixed infrastructure with redundancy on the ENI (External Network Interface).	Multi-path using fixed infrastructure with redundancy on the ENI (External Network Interface).	Multi-path using fixed infrastructure with diverse pathways and redundant distribution areas with redundancy on the ENI (External Network Interface).
TIA 942	Cabling, racks, cabinets, & pathways meet TIA specifications.	(Requirements in Rating 1 Included) Diversely routed access provider entrances and maintenance holes with minimum 20m separation.	(Requirements in Rating 2 Included) Redundant access provider services - multiple access providers, central offices, access provider rights-of-way, redundant entrance room, redundant backbone cabling and pathways.	(Requirements in Rating 3 Included) Redundant main distribution areas (if present), redundant intermediate distribution area, redundant horizontal cabling and pathways.
Uptime Institute	Not Part of the Standard	Not Part of the Standard	Not Part of the Standard	Not Part of the Standard

Tier Requirements

	Tier 1	Tier 2	Tier 3	Tier 4
Active Capacity Components to Support the IT Load	N	N+1	N+1	N After any failure
Distributiuon Paths	1	1	1 Active and 1 Alternative	2 Simultaneously Active
Concurrently Mainaintable	No	No	Yes	Yes
Fault Tollerance	No	No	No	Yes
Compartmentation	No	No	No	Yes
Continuous Cooling	No	No	No	Yes