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TrueEdge™ NEMA Type 4 Low-Profile IDF Thermal Solutions

INTRODUCTION

Network enclosures house and secure electronic network equipment such as switches, routers, gateways, and power supplies. These enclosures are deployed in a wide array of environments and conditions and must provide an appropriate level of protection for the sensitive equipment inside. Appropriate temperature regulation for the network system is a key component to avoiding overheating equipment and potential failure. This application guide defines thermal management solutions and key design considerations to mitigate thermal factors for the Panduit TrueEdge™ NEMA Type 4 Low- Profile Industrial Distribution Frame (IDF) Enclosures.

The TrueEdge™ NEMA Type 4 Low-Profile IDF is a fully sealed network enclosure that carries strict Type 4/12 and IP66 ratings to prevent ingress of dust, water, spray and other environmental hazards. While protecting the equipment in harsh or extreme environments, the air inside is completely enclosed, increasing the need for careful thermal management considerations. Installing the enclosure in an environment with a high ambient temperature further increases the need to consider cooling options for any enclosure.

This application guide reviews key design considerations for thermal management solutions to mitigate thermal factors for Panduit Low-Profile IDF Enclosures. The solutions presented in this guide are based on maintaining the internal temperature of the enclosure below the maximum operating temperature requirements of typical enterprise equipment with margin (35°C for servers, 40°C for UPS, and 45°C for switches). The guide discusses the capabilities of the various thermal management solutions and provides guidelines for recommended solutions.

SOLUTIONS

The air in an enclosure is affected by the heat load (power used) of the active equipment, the size of the enclosure, the thermal resistance between the chassis of the active equipment and the air, the construction material of the enclosure and the air temperature surrounding the outside of the enclosure. Several cooling techniques are discussed from the simplest to the more complex, to include passive and active cooling solutions. The TrueEdge equipment rail adjustments support the equipment at the ideal height for proper air flow inside the enclosure. Additional rails can be purchased to mount equipment of various heights. The configuration and the total expected heat load of the equipment can determine the minimum cooling needs for each application. Panduit utilizes practical testing of these cooling techniques with actual equipment under workloads. Heat loads are calculated for various ambient temperatures and correlated with test data.

INFORMATION GATHERING

The following information about the enclosure and the equipment it will house (the “system”) is essential to properly select a thermal solution. This information is generally available from the equipment vendor data sheets, specifications, instruction manuals, deployment guides, etc. See pages 5 and 6, System Examples for sample calculations.

1. **Maximum Ambient Air Temperature -** This is the maximum expected air temperature that will surround the exterior of the enclosure.
2. **Maximum Desired Internal Enclosure Temperature -** The equipment with the lowest maximum operating temperature limit will dictate the maximum allowable internal temperature for the enclosure. Check this temperature limit for every device and include high altitude adjustments where necessary. The graphs below assume 35°C for servers, 40°C for uninterruptible power supplies (UPS), and 45°C for switches. Adjust calculations accordingly if the equipment’s operating limits differ from the assumptions.
3. **The Internal Heat Load -** This is the sum of the power consumed by the equipment mounted inside the enclosure. Include heat considerations from secondary power supplies (i.e., PoE, below). Calculate internal heat loads based on all devices at their maximum output.
4. **Enclosure Dimensions -** The height, width, and depth, inch (mm).
5. **Enclosure Material -** The solutions below are for enclosures constructed from steel. The type of steel e.g., stainless, or mild will have a minimum impact on these calculations.
6. **Indoor or Outdoor -** The calculations in Figure 1 apply only to an enclosure not exposed to direct sunlight.

Switches

For network switches, 100% of the switching power is dissipated as heat inside the enclosure. Use the switching power consumption rating for 100% of traffic listed in most datasheets. Some network switch manufacturers may report the total heat dissipation in BTU/h. This must be converted to watts (1 BTU/h = 0.293W). Note that listed heat dissipation in the equipment datasheet may exclude heat from secondary PoE power supplies.

Power over Ethernet (PoE)

When calculating heat created by PoE devices *outside* the enclosure, include 15% of the total PoE power provided by the switches. For typical enterprise applications, PoE devices (security cameras, LED lighting, etc.) dissipate at least 85% of their heat at the device location (away from the enclosure). Power supply inefficiencies, cabling, and connectors are a significant portion of the internal heat load of the enclosure.

For PoE devices *inside* the enclosure, assume 100% of the PoE power for that device is dissipated as heat inside the enclosure. Calculations may include either the total available PoE power of the switch (worst case) or the total expected installed power consumption of all connected PoE devices (expected case) based on preference.

Servers

To calculate the heat dissipation of a server, assume all the power consumed by the server is dissipated as heat inside the enclosure. When the power consumption of the server is unknown, assume 75% of the power supply rating will be consumed and converted to heat. Be sure to account for the redundancy configuration (i.e., 2+0 or 1+1) when the server contains multiple power supplies.

UPS

It is also necessary to account for the heat generated by an uninterruptable power supply (UPS). A UPS typically operates at a reduced efficiency when operating in “battery mode” (versus “normal mode” or “line mode”). Battery mode efficiencies are typically the worst case and may not be reported in the manufacturer’s datasheet. For a typical UPS running in battery mode, assume the UPS heat output is equivalent to 15% of the total power *consumed* by all devices connected to the UPS.

THERMAL MANAGEMENT GUIDE

EQUIPMENT CONFIGURATION

The positions of equipment, cabling, and accessories within the enclosure have a major impact on the airflow within the enclosure. Improper setup may elevate equipment temperatures above acceptable levels. Follow the guidelines below to ensure sufficient cooling is achieved.

1. If required, remove the right gland plate and mount an nVent CR23 air conditioner or equivalent.
2. Mount all heat-generating equipment in the lowest possible position to prevent hot air recirculation inside the enclosure.
3. Use additional e-rail kits (i.e., WME6RAIL) when various size equipment is installed to ensure all heat-generating equipment is mounted in the lowest possible position or at a maximum height of 6 in. (152mm) from the bottom of the equipment's hot air outlet to the bottom of the enclosure. Place taller equipment, such as servers, behind the shorter equipment to prevent blockage of circulated air.
4. Avoid mounting servers with high heat output in the front rack unit or the rear two rack units. The ideal location for high heat generating equipment is centered in the rack. Reserve the outer rack units for PDUs or cable pathways.
5. Connect the air conditioner to UPS battery power whenever equipment is connected to any battery backup power.
6. Carefully arrange and secure power cabling to avoid obstructing the equipment outlets.
7. Carefully arrange and secure data cabling to avoid obstructing the air conditioner inlets.

PASSIVE NATURAL CONVECTION COOLING (SEALED ENCLOSURE) FUNDAMENTALS

During normal operation, the active equipment dissipates heat which increases the air temperature inside the enclosure. The internal heat transfers to the exterior of the enclosure through convection, conduction, and radiation. A minor amount of the heat is transferred directly to the enclosure from the active device through conduction since the equipment is in contact with the equipment mounting rails. Heat flows from high temperature to low temperatures. So, the air temperature inside the enclosure will increase until it exceeds the temperature outside of the enclosure. After a period (typical < 48 hours under continuous operation) a steady state temperature is reached inside the enclosure. This internal air temperature must be at or below the operating temperature specified for the components installed inside the enclosure. Hot air is more buoyant and will rise towards the top of the enclosure creating a temperature gradient inside the enclosure. The bottom area of the enclosure will be near the outside ambient temperature, and the top area can be 10°C to 20°C higher than the bottom of the enclosure.

CLOSED LOOP COOLING SYSTEM (AC UNIT)

When it becomes necessary to have a lower internal temperature than the ambient temperature around the enclosure, an air conditioner (AC unit) is required. The AC unit will result in an increase in the average heat dissipation of the enclosure and therefore it may allow more equipment to be deployed. The enclosure is designed with openings on the right side to fit an nVent CR23 AC unit or equivalent. There is no need to add additional venting to the enclosure. The air conditioner is a sealed system. Refer to AC specifications to understand NEMA and IP rating implications.

Recommendations for closed-loop AC systems.

1. Remove the vertical equipment rails and the gland plate on the right side of the enclosure.
2. Read the instruction manual available from the vendor for the AC Unit or equivalent.
3. Follow vendor recommendations for minimum clearances around the exterior of the AC unit.
4. Reinstall the right vertical equipment rails after the air conditioner is installed.
5. Follow the equipment guide below when mounting devices in the enclosure.

COOLING REQUIREMENTS FOR THE 6RU TrueEdge™ NEMA TYPE 4 LOW-PROFILE IDF

Figure 1 in this section illustrates the allowable ambient temperature outside an enclosure vs. a heat load for various recommended cooling solutions. These calculations apply to the 6RU TrueEdge NEMA Type 4 Low-Profile enclosure.

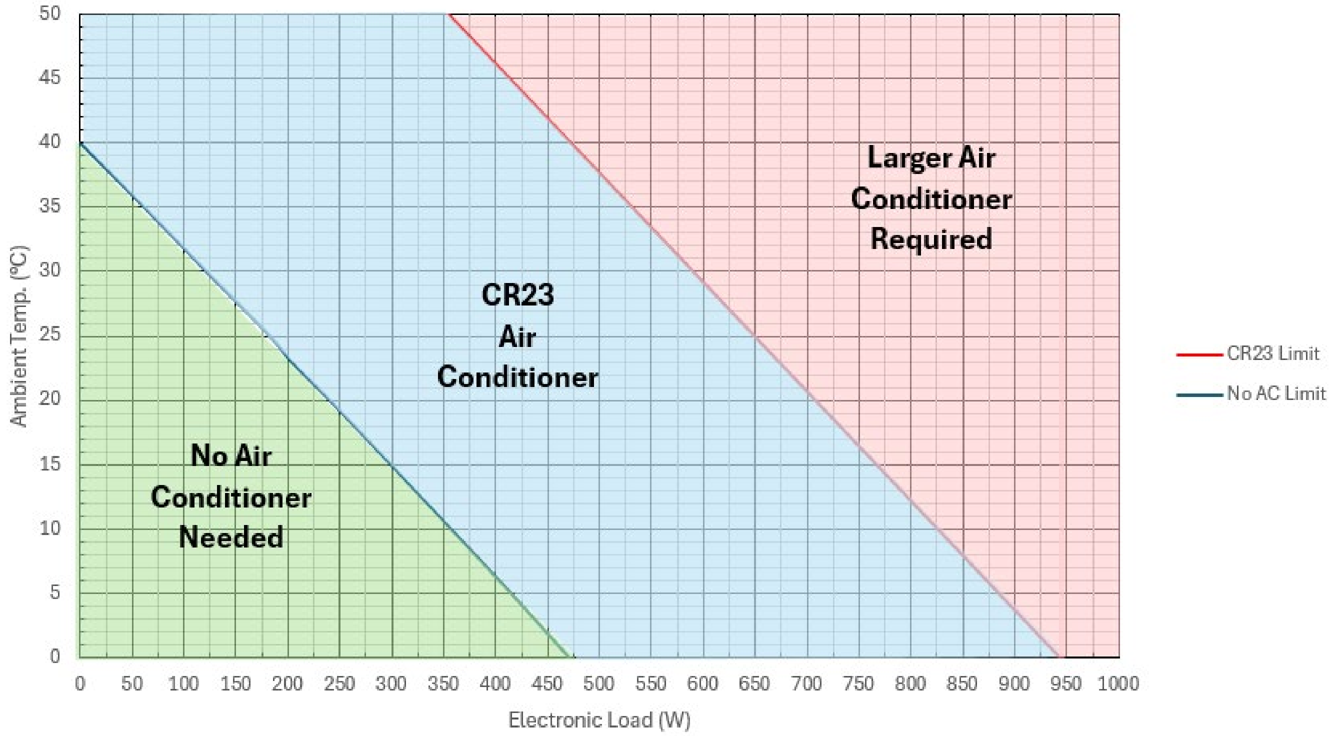

Figure 1: Electronic Load vs. Ambient Temperature

Notes:

If the application falls on the border between two cooling zones, choose the cooling option with the higher capacity.

These recommendations are for typical front-to-back breathing equipment. Any side-to-side breathing equipment or equipment with atypical hot air outlets will require additional cooling considerations to maintain acceptable temperatures.

When operating at a high elevation or if the equipment’s maximum operating temperature is lower than the standard assumptions, increase the expected ambient temperature to accommodate.

SYSTEM EXAMPLES

EXAMPLE 1

Two switches, each having a power consumption rating of 127.7W at 100% traffic, and 48 PoE+ (30W) ports. All ports are expected to draw full PoE power.

The PoE power consumption per switch is 30W multiplied by 48 ports.
30W x 48 ports = 1440W PoE Power Consumed per Switch

The PoE heat output per switch is 15% of the PoE Power (216W).
1440W x 0.15 = 216W PoE Heat Dissipation per switch

The combined heat output per switch is the switching power added to the PoE heat output (343.7W).
216W + 127.7W = 343.7W Heat Dissipation per Switch

The total system heat output is 343.7W multiplied by the number of switches.
343.7W x 2.0 = 687.4W Total System Heat Dissipation

EXAMPLE 2

One switch with a listed total heat output of 395.5 BTU/h and with a secondary 840W PoE Power supply. All PoE power to be utilized. One server with a known power consumption of 1052.4W at maximum workload. A UPS is connected with enough capacity to power the switch, server, and all PoE devices.

The heat output of the switch must be converted to watts by multiplying by 0.293.
395.5 BTU/h x 0.293W = 115.9W Switching Heat dissipation

The PoE heat output of the switch is 15% of the available PoE power.
840W x 0.15 = 126W PoE Heat Dissipation

The total heat output of the switch is the PoE heat output added to the switching power.
115.9W + 126W = 241.9W Total Switch Heat Dissipation

The total heat output of the equipment is the switch heat output added to the server power.
241.9W + 1052.4W = 1294.3W Equipment Heat Dissipation

The total power ***consumed*** by the equipment is switching power plus the total available PoE power plus the server power.
115.9W + 840W + 1052.4W = 2008.3W Total Equipment Power Consumption

The heat load of the UPS is 15% of the total equipment power consumption.
2008.3W x 0.15 = 301.2W UPS Heat Dissipation

Total heat dissipated inside the enclosure is the equipment heat dissipation plus the UPS heat dissipation.
1294.3W + 301.2W = 1595.5W Total System Heat Dissipation with UPS in battery mode

EXAMPLE 3

One server with two 1600W power supplies in 1+1 full redundant mode, unknown consumption at full load.

The total available power for this redundancy configuration is the power rating for only one power supply (1600W) since it is fully redundant. The maximum expected heat load is 75% of this available power.
1600W x 0.75 = 1200W Total Internal Heat Load

EXAMPLE 4

Two servers, each with two 1100W power supplies in 2+0 non-redundant mode, unknown consumption at full load.

The total available power for each server is the combined power of two power supplies since they are in non-redundant mode.

1100W x 2 = 2200W Available Power per Server

The maximum expected heat load is 75% of the available power multiplied by two servers.

2200*W* x 0.75 x 2 = 3300*W Total System Heat Dissipation*