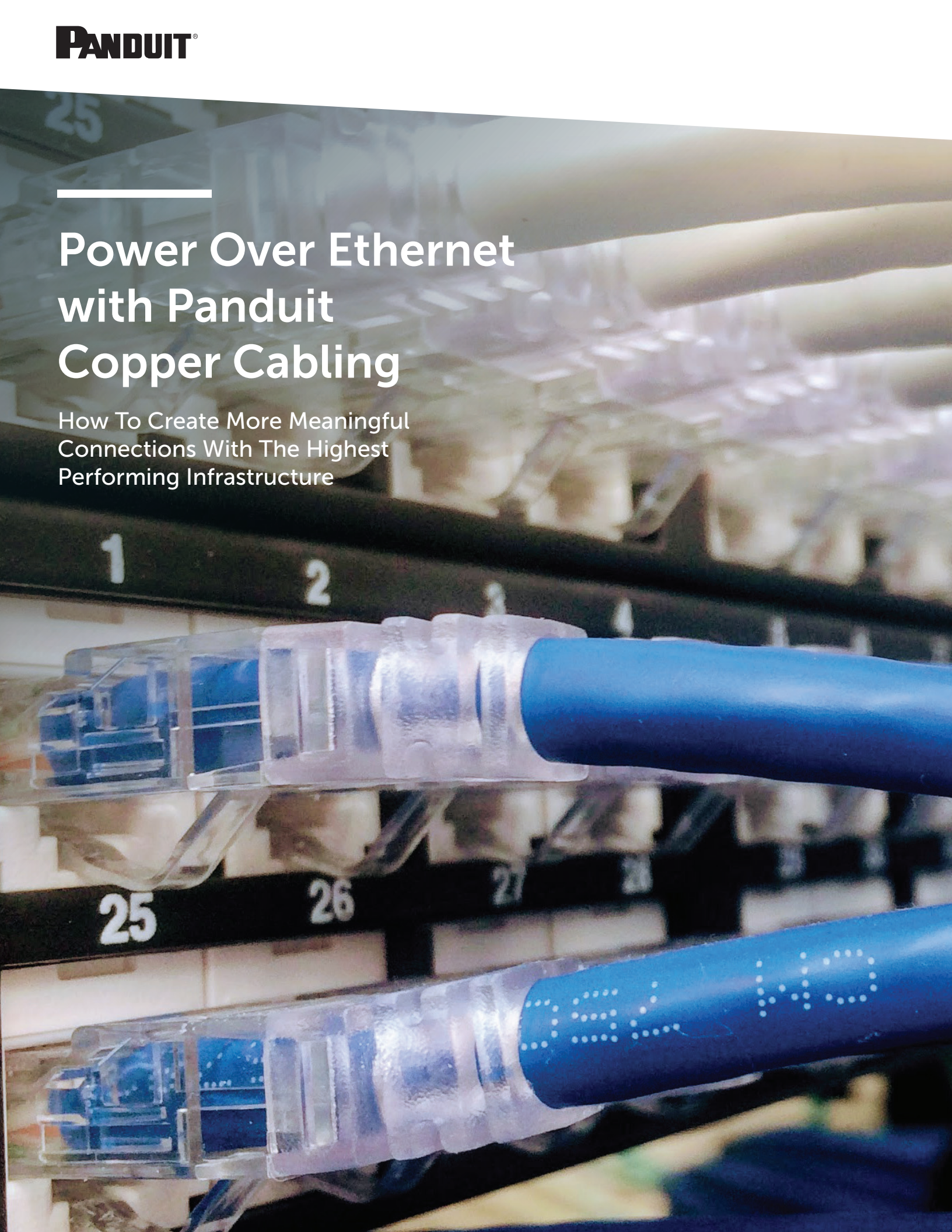

Power Over Ethernet with Panduit Copper Cabling

How To Create More Meaningful
Connections With The Highest
Performing Infrastructure



Introduction

Increasing usage of Power over Ethernet (PoE) represents one of the most meaningful impacts to enterprise network infrastructure in recent history. This technology reduces installation costs and time by allowing power and data onto a single twisted-pair cable, installed by a single low-voltage contractor and eliminating the need for a separate electrical cable to each device.

As the ubiquitous nature of Ethernet has grown, an increasing number of items are being networked together. These new applications, such as digital signage, next generation wireless access points, nurse call systems, and video conferencing systems, have power needs beyond PoE+ standards. The industry has recognized this need and has begun to develop next generation PoE equipment that will supply 51 to 71 watts.

This document provides information and guidance on installing Panduit cabling and connectivity with both the existing PoE+ and the new higher power PoE standards.

Cable Standards and Power over Ethernet

It is important to understand that the cables and connectors, by themselves, can handle the current and power levels associated with delivering PoE. The concerns with running PoE in cables has to do with heat and temperature rise that occurs when the cables are bundled, and the concern with connectors is arcing that occurs when a plug is removed from a connector with live PoE. Concerns with these factors are:

- Some temperature rise will increase cable insertion loss and may create bit errors for your application
- Extreme temperature increase past the recommended cable operating range can create long term damage to the cable
- Arcing can damage plug and jack contacts, and make transmission through them impossible

A number of standards are in place today that govern the delivery of Power over Ethernet. These are outlined below.

General Copper Cabling Standard: ANSI/TIA-568.2-D

All copper cable installations should follow the guidance of ANSI/TIA-568.2-D, the Balanced Twisted-Pair Telecommunications Cabling and Components Standard. The 2018 update to the standard added 28 AWG patch cords and modular plug terminated links as compliant components in the channel.

Power over Ethernet: IEEE 802.3bt

The primary standard that references the delivery of Power over Ethernet is IEEE 802.3. First introduced in 2003 in version 802.3af, the standard has gone through several iterations in the past 15+ years, with each revision essentially doubling the amount of power that can be delivered. The latest version, IEEE 802.3bt, introduces Type 3 (up to 51 W) and Type 4 (up to 71 W) PoE, now using all four pairs of wires for both power and data transmission (referred to as PoE++ or 4PPoE). The bt version was approved in October 2018. Table 1 shows the versions of 802.3 and how it has changed over the years, and the power and current that can be provided.

Type	Standards	Maximum Current	Number of Energized Parts	Power at Device	Standard Ratified
PoE	IEEE 802.3af (802.3at Type 1)	350 mA	2	13 W	2003
PoE+	IEEE 802.3at Type 2	600mA	2	25.5 W	2009
PoE++	IEEE 802.3bt Type 3	600mA	4	51 W	2018
	IEEE 802.3bt Type 4	960mA		71 W	
Not PoE standards based	Cisco UPOE	600mA	4	60 W	Exists today – no official ratification
	HDBaseT (www.hdbaset.org)	1000mA		71 W	

Table 1: Power over Ethernet Existing and Future Standards

Temperature Rise Guidance from TIA TSB-184-A

The Telecommunications Industry Association (TIA) TSB-184-A is a technical service bulletin that provides guidance for installing cables that run PoE, PoE+ and PoE++. PoE was the original Power over Ethernet standard, with currents up to 350 mA on 2 pairs of twisted pair cable. PoE+ increased the current to 600 mA, also on 2 pairs. The recently approved PoE++ standard boosts that level even further, up to 960 mA, now over 4 pairs (see Table 1). TSB-184-A recommends that a bundle of cables should not exceed a 15°C temperature rise within the center of the bundle. This temperature rise depends upon:

- Size of bundle
- Current running through the wire pairs and number of energized pairs
- Cable wire gauge and construction

In September of 2018, TIA published ANSI/TIA-568.2-D. This document formally recognized 28 AWG patch cords as being standards compliant. Therefore, to supplement TIA-TSB-184-A, TIA is working on an addendum, TSB-184-A-1, to provide guidelines for the use of 28 AWG patch cords for power delivery.

This TSB will show that 28 AWG is safe for use with all PoE standards, provided that the bundle size is smaller. Once TSB-184-A-1 is published, this document will be updated to include further guidance on using 28 AWG patch cords with Power over Ethernet.

Arcing Test Method Standards: IEC 60512-9-3 and IEC 60512-99-001

An electrical arc (spark) naturally occurs most times when removing a plug from a jack with PoE running. The arc poses no danger to the user, and it is often difficult to notice. However, it can damage the points on the jack and plug contacts where it occurs. Connectors must be designed so the location damaged by the arc is not where the plug and jack mate. IEC test methods IEC 60512-9-3 and IEC 60512-99-001 address this particular issue.

Electrical arcs with Panduit Connectivity

All Panduit plugs and jacks are designed to pass the test methods of IEC 60512-9-3 and IEC 60512-99-001 to ensure that when arcing occurs, it will not damage the critical plug and jack mating point. Figure 1 highlights arcing on a Panduit connector showing how it occurs at a location (red) that does not affect the plug and jack mating location (green). It also shows the damage to the contacts on Panduit products is minimal. More information on PoE and Panduit Connectors can be found in the Technical Brief: [Effect of Next Generation 100 W Power over Ethernet on RJ45 Connectivity](#).

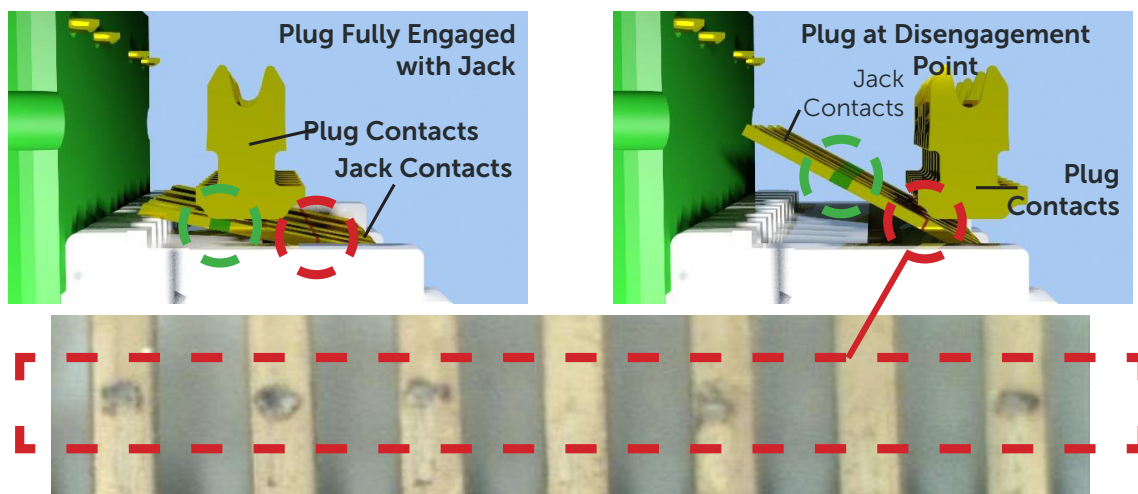


Figure 1: Minor arcing (red) does not occur in Panduit jack mating region (green). Non-Panduit jacks may see such damage in the critical mating area.

The 2017 National Electric Code and PoE

In North America, the 2017 revision of the National Electric Code pulled the highest levels of PoE into the scope of the NEC. While the code will not impact the majority of PoE installations, it did create some significant changes for the structured cabling industry, namely the introduction of Limited Power (LP) cables, and ampacity tables to regulate cable bundle sizes. The code only impacts Type 4 PoE++, or power levels above 60 W at the power source. Since most PoE installations are Type 3 and below, most applications will not fall into the scope of the new requirements.

Limited Power is a new UL certification that applies to communications cables permanently installed in the United States, which are being used in PoE applications. Cables that carry UL's LP designation have been evaluated to carry the marked current under installation scenarios without exceeding the temperature rating of the cable. When LP cables are used, cable bundle sizes are not restricted. In Type 4 PoE applications, if LP-rated cables are not used, then cables must be bundled in accordance with an ampacity table.

More information on the NEC, including the ampacity table that determines bundle sizes, can be found in our Technical Brief: [Impact of 2017 National Electric Code on Power over Ethernet Cabling](#).

International Cabling Guidelines for PoE++: ISO/IEC TS 29125 and CENELEC TR 50174-99-1

ISO/IEC TS 29125 and CENELEC TR 50174-99-1 are both European standards that define requirements for remote powering via communications cabling. These standards address things like cable bundling to limit heat rise and mating and un-mating of copper connectors under power load.

Maximum PoE Power Unlikely to Increase Beyond 100 W

It is unlikely that future PoE standards will be developed to exceed the 71 W allowed by the new PoE++ standard for many years. Next generation PoE standards have traditionally come to market within 6- to 8-year time frames, with double the power of the previous standard (see table 1). These standards are done in response to market needs. For a new standard to be developed, it will require a pervasive market need for about 200 W, as well as have a large installed base of cabling to run it. For PoE beyond 100 W, this installed base does not exist because much of today's cabling will not support 200 W. 200 W will require next generation cabling with a higher operating temperature and improved thermal performance beyond typical Category 5e and 6. Therefore, PoE beyond 100 W is at least 10 to 15 years away.

Panduit Cabling Overview

Panduit is the industry leader in traditional standard gauge cables as well as small diameter solutions that have a length limitation below 100 meters. These small diameter solutions use wire gauges such as 26 or 28AWG in order to give customers the smallest diameter cables possible to allow for better cable management, improved air flow, and increased capacity in existing wire trays. With recent standards changes, 28 AWG patch cords are now part of a standards-compliant solution. The summary is shown in Figure 2.

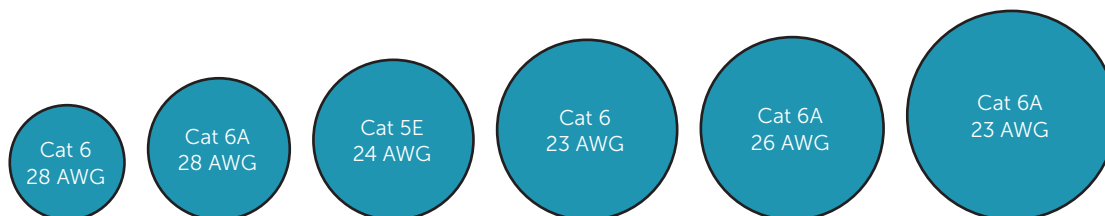


Figure 2: Panduit Patch Cord Overview

PoE Temperature Rise Testing Results

Panduit has done extensive testing across our entire cable line in order to provide guidance with TSB-184-A. These tests studied our diverse selection of cables and measured the temperature rise in varying bundle sizes having a variety of currents applied. An example of the testing done with 48 and 100 cable bundles is shown in Figure 3. Similar testing was done with bundle sizes of 61 and 24 cable bundles. 100 cables was chosen as the maximum bundles size as that was the maximum recommendation given in TSB-184-A.

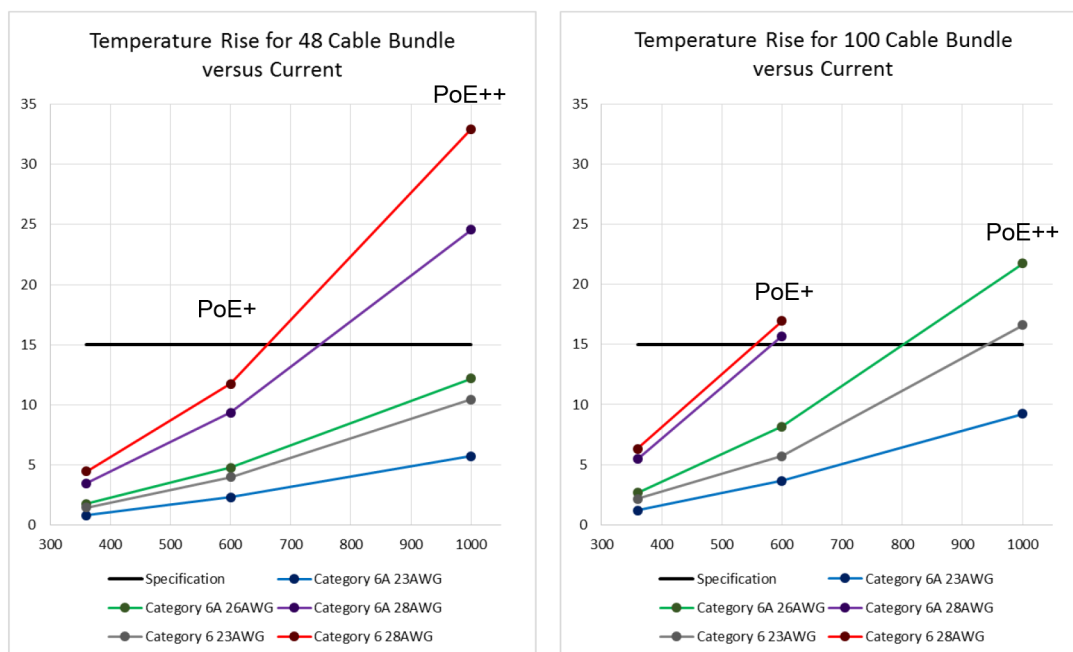


Figure 3: Bundle Temperature Rise over Time for 48 and 100 Cable Bundles

Constant Current vs. Constant Power

In 2018, a team of researchers from Panduit, Cisco, and Philips Lighting undertook PoE testing to measure heat rise in copper cabling that was running PoE, in a real-world, worst-case scenario. In the testing, power and data were transmitted over 192 cables of varying lengths, with temperature rise measured at the center of the 192-cable bundle. The laboratory setup utilized 29,000 feet of cable with varying lengths of cable to represent a typical Enterprise cabling length distribution. The power at the source was then modified to ensure that the power at the end device was held constant. To ensure the quality of transmission during the testing, a bit error rate generator transported data across the cabling.

This enhanced test method produced more accurate results because it considered the ‘constant power’ nature of PoE. The testing focused on constant current vs. constant power. Some of today’s standards have been developed based on constant current models – delivering the same worst-case level of current through the channel, regardless of channel length. A constant power model reflects the IEEE 802.3bt standard, which limits powered devices to a maximum wattage, regardless of the cable length. The implication of constant power is that with shorter channels, less power and current is delivered from the source (due to lower power losses over the channel), than in constant current models. The results were summed up in two high-level findings:

- Real world worst-case PoE deployment scenarios have lower temperature rise than the previous worst-case models
- PoE cable bundles can be larger than current standards recommend

The testing provided validated proof that will guide best practices for PoE installation going forward. The testing organizations mutually agreed that the constant power methodology should be the method standards bodies refer to in generating best practices. However, it is unknown if the standards will ever officially adopt the change in methodology.



Conclusion

The recommendations for maximum bundle size are given below in Table 2

Cable Type	PoE / PoE + Maximum Bundle Size (2-pair, up to 600mA)	PoE++/HDBaseT Maximum Bundle Size (4-pair, up to 960 mA)
Cat 6 28 AWG	48	24
Cat 6A 28 AWG	48	24
Cat 5E 24 AWG	Tested up to 100 cables	61
Cat 6 23 AWG	Tested up to 100 cables	72
Cat 6A 26 AWG	Tested up to 100 cables	48
Cat 6A 23 AWG	Tested up to 100 cables	Tested up to 100 cables

Table 2: Recommended maximum bundle size for a given Panduit cable type to limit temperature rise to 15 degrees or less. This is only focused on limiting the temperature rise and does not factor into the 2017 National Electric Code.

The Importance of Cable Operating Temperature Rating

There is a simple equation to understand when deciding on a bundle size and cable type:

$$\text{Cable Temperature Rating} \geq \text{Ambient Temperature} + \text{Bundle Cable Temperature Rise}$$

Therefore, one must be aware of the ambient temperature of where the cable is being installed, what the expected cable temperature rise is for whatever cable type or bundle size is being used, and what the maximum cable operating temperature is. It should be noted that many Panduit cables allow for a cable operating temperature of 75°C, which is higher than the typical industry average of 60°C (all Panduit Category 6A Vari-MaTriX cables are rated up to 75°C or 90°C). This gives more flexibility to the ambient temperature environment where they can be deployed.

Deploying for PoE

Panduit recommends having a diversity of power delivery to have both redundant power sources, and to ensure there is room for future data and future power needs. This means:

- Running at least two Category 6A cables to each powered device
- Each run of Category 6A cable comes from a different zone distribution area

Panduit recommends running at least two Category 6A cables for two different purposes. The first purpose is to have redundancy and possible link aggregation (if the device allows). In the case with link aggregation, some access points have two data ports. Therefore, two one gigabit data ports could have up to two gigabits with port aggregation.

The second (and more common) purpose is due to future expansion. Often as wireless rates increase, the number of access points and density of the access points needs to increase. By having cable already installed in the ceiling, it is very simple to move around and add the additional access points. The simplest and most cost effective time to run cables to a given location is when the walls are not yet installed.

Recommendation

Not all PoE cabling and infrastructure is the same, and quality will make a meaningful difference to the performance of a network and its longevity.

Panduit recommends all new installations use Category 6A due to the fact it supports the highest data rate of 10GBASE-T, and has no bundle size limitations with any current or future Power over Ethernet application. If different cable types are used for PoE other than Category 6A, follow the guidelines in this document to reduce bundle size to allow the use of smaller gauge cables. These bundles can be grouped together so the total number of cables being routed remains the same.

For each PoE device deployed, Panduit recommends running two cables to that device.



For more information, visit us at

www.panduit.com

Contact Customer Service by email: cs@panduit.com
or by phone: 800.777.3300

PANDUIT US/CANADA
Phone: 800.777.3300

PANDUIT EUROPE LTD.
London, UK
cs-emea@panduit.com
Phone: 44.20.8601.7200

PANDUIT SINGAPORE PTE. LTD.
Republic of Singapore
cs-ap@panduit.com
Phone: 65.6305.7575

PANDUIT JAPAN
Tokyo, Japan
cs-japan@panduit.com
Phone: 81.3.6863.6000

PANDUIT LATIN AMERICA
Guadalajara, Mexico
cs-la@panduit.com
Phone: 52.33.3777.6000

PANDUIT AUSTRALIA PTY. LTD.
Victoria, Australia
cs-aus@panduit.com
Phone: 61.3.9794.9020