COMMUNICATIONS INTEGRATORS INC.

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TEMPERATURE CONSIDERATIONS FOR CII 24-CABLE TRUNK BUNDLES IN FMC

Q: Will the CII solution of running 24 trunk cables within FMC cause or contribute to excessive heat build-up on low voltage cables running PoE?

A: No. In fact it may help to improve heat dissipation for low voltage cables running PoE.

Table 1 below shows System Specifications for Type 1 PoE and Type 2 PoE Plus systems. The table shows maximum operating current of 350 mA per pair for Type 1 PoE and 600 mA for Type 2 PoE Plus.

Figure 1 below shows the TIA developed profiles of temperature rise vs. applied current per pair for category 5e, 6, and 6A cables configured in 100-cable bundles.

Figure 2 below shows the results of temperature rise testing conducted by Siemon on their Cat 5e, Cat 6, Cat 6A UTP, Cat 6A UTP slim profile, Cat 6A F/UTP, & Cat 7 S/FTP, also configured in 100-cable bundles.

Figure 1 shows that within a Cat 5e UTP 100-cable bundle (worst case), temperature rise at the maximum DC cable current of 600 mA for Type 2 PoE Plus is 7.2° C, providing some headroom beneath the TIA recommended 10° C maximum temperature rise. (TIA recommends no more than a 10° C temperature rise on the low voltage cables to minimize insertion loss that is induced by heat.) This 100-cable bundle is configured first as a 6-around-1 bundle, then the bundle size incrementally grows to an 18-around-1 bundle, to a 36-around- 1 bundle, to a 60-around-1 bundle, to a 90-around-1 bundle, and, finally, to a 100-around-1 bundle, ending up with a bundle 5 to 6 cables deep as shown in the photos below.


6-around-1 bundle


18-around-1 bundle


100-around-1 bundle

Photos taken from Siemon's White Paper IEEE 802.3at PoE Plus Operating Efficiency

This 100-around-1 bundle is providing a significant amount of thermal insulation which will retain the generated heat within the cable bundle, much more so will the CII 24-cable bundle, which has only 2 or 3 layers of thermoplastic cable insulation.

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Further to this, the Flexible Metal Conduit that encases the CII 24-cable bundle will tend to facilitate heat dissipation, while the multiple layers of thermoplastic insulation of the 100-cable bundle tends to hold in and retain the heat generated by PoE.

In Siemon's White Paper IEEE 802.3at PoE Plus Operating Efficiency, they state, "Since metal has a higher conductivity than thermoplastic jacketing materials, a thermal model can be used to predict that screened and fully-shielded cables have better heat dissipation than UTP cables. Siemon's data substantiates the model and clearly demonstrates that screened cables exhibit better heat dissipation than UTP cables and fully-screened cables have the best heat dissipation properties of all copper twisted-pair media types." See Figure 2 below.

It would follow then that a 24-cable bundle fully encased within high conductivity Flexible Metal Conduit would in the same way dissipate heat much more effectively than large trunk cable bundles having only multiple layers of thermoplastic insulation that will serve to hold in the PoE generated heat. Therefore, rather than causing or contributing to excessive heat build-up, the fully sheathed CII trunk cables would tend to facilitate superior heat dissipation when compared to conventional methods of running PoE trunk cables.

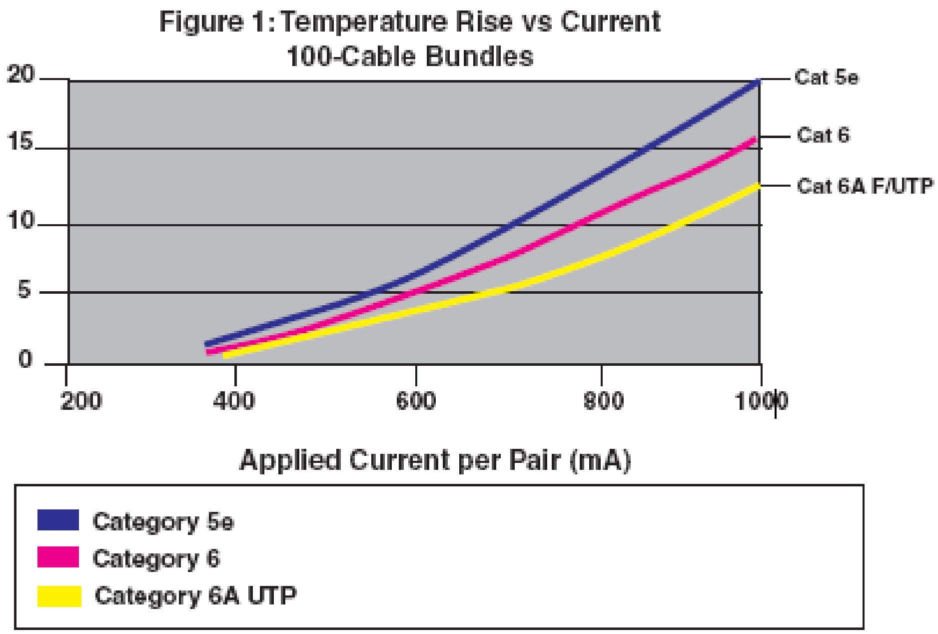
An excerpt from the White Paper IEEE 802.3at PoE Plus Operating Efficiency, published by the Siemon company, from which the bulk of this data comes, follows:

Table 1: Overview of PoE and PoE Plus System Specifications

	Type 1 - PoE	Type 2 PoE Plus
Minimum Category of Cabling	Category 3/Class C	Category 5/Class D:1995 with DC loop resistance < 25Ω
Maximum Power Available to the PD	13 W	25.5 W
Minimum Power at the PSE Output	15.4 W	30 W
Allowed PSE Output Voltage	44 - 57 VDC	50 - 57 V
Nominal PSE Output Voltage	48 VDC	53 VDC
Maximum DC Cable Current	350 mA per pair	600 mA per pair
Maximum Ambient Operating Temperature	60° C	50° C
Installation Constraints	None	Maximum 5kW delivered power per cable bundle

POE Plus Challenges:

The development of PoE Plus requirements brought to light a significant new challenge in the specification of power delivery over structured cabling. For the first time, due to the higher power delivered by Type 2 PSE devices, IEEE needed to understand the temperature rise within the cabling caused by applied currents and subsequently specify the PoE Plus application operating environment in such a way as to ensure that proper cabling system transmission performance is maintained. In order to move forward, IEEE enlisted the assistance of the TIA and ISO cabling standards development bodies to characterize the current carrying capacity of various categories of twisted-pair cables.



After extensive study and significant data collection, TIA was able to develop profiles of temperature rise versus applied current per pair for category 5e, 6, and 6A cables configured in 100-cable bundles as shown in **Figure 1**. Interestingly, these profiles were created primarily based upon analysis of the performance of unshielded twisted-pair (UTP) cables. They were later corroborated by data submitted to the ISO committee. As expected, since category 5e cables have the smallest conductor diameter, they also have the worst heat dissipation performance and exhibit the greatest temperature rise due to applied current. Note that category 5 cables were excluded from the study since category 5 cabling is no longer recommended by TIA for new installations. IEEE adopted the baseline profile for category 5e cables as representative of the worst-case current carrying capacity for cables supporting the PoE Plus application.

Additional TIA guidance recommended that a maximum temperature increase of 10°C, up to an absolute maximum temperature of 60°C, would be an acceptable operating environment for cabling supporting PoE Plus applied current levels. In consideration of this input, IEEE chose to reduce the maximum temperature for Type 2 operation to 50°C, which eliminated the need for complicated power de-rating at elevated temperatures. Next, IEEE had to identify a maximum DC cable current that would not create a temperature rise in excess of 10°C. An analysis of the worst case category 5e current carrying capacity profile led IEEE PoE Plus system specifiers to target 600 mA as the maximum DC cable current for Type 2 devices, which, according to the TIA profile, results in a 7.2°C rise in cable temperature. Although this temperature rise is less than the maximum 10°C value recommended, it provides valuable system headroom that helps to offset additional increases in insertion loss due to elevated temperatures and minimize the risk of premature aging of the jacketing materials. Operating margin against excessive temperature rise is especially critical because this condition cannot be ascertained in the field.

Siemon Labs investigated the current-carrying capacity of riser (CMR) and plenum (CMP) category 6A F/UTP and category 7A S/FTP cables, in addition to the new slim-profile category 6A UTP cables. Test cables were arranged in accordance with the TIA 100-bundle cable configuration and the worst case temperature rise for each media type was profiled. Reference category 6A UTP measurements were collected and used to normalize Siemon data to the TIA category 6A data. The resulting heat dissipation profiles are shown in **Figure 2**. The current carrying capacity of category 7 cables is expected to be equivalent to category 7A cables since their physical construction is so similar. The worst case temperature rise for each media type with 600 mA applied current is shown in **Figure 3**.

Figure 2: Temperature Rise vs Current
100-Cable Bundles

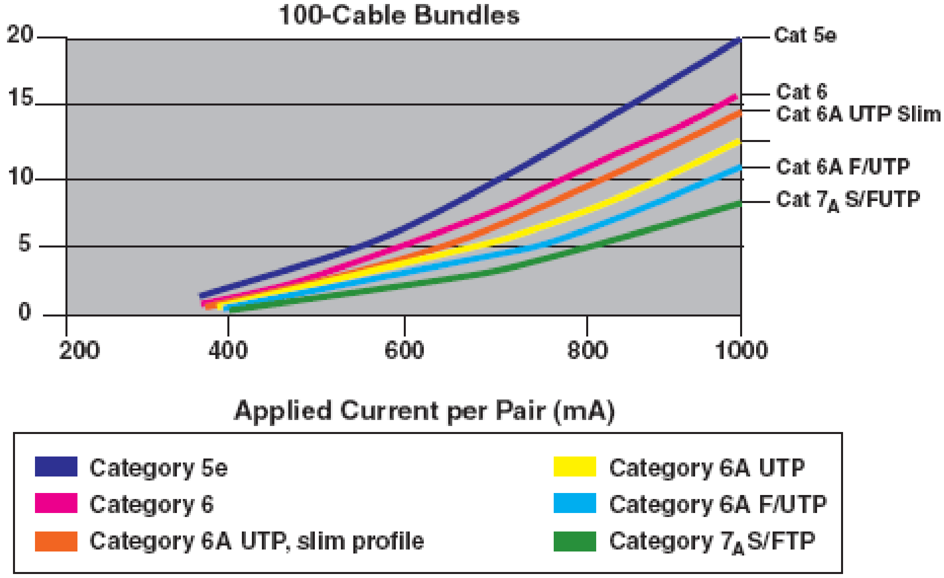
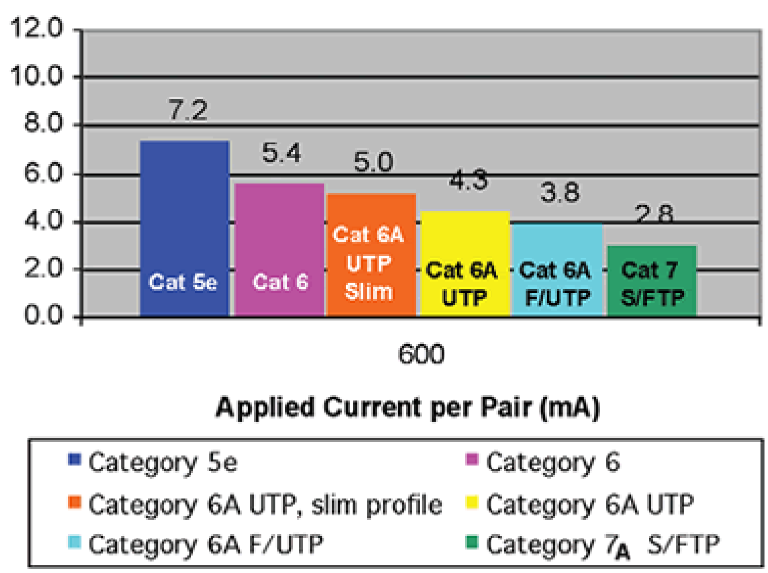


Figure 3: Worst Case Temperature Rise at
600 mA



Overview of the Siemon 100-Bundle Temperature Rise Versus APPLIED CURRENT Test Configuration:

1. Beginning with a core consisting of a 1.2 meter length of cable, layers of 1.2 meter long cable lengths were carefully applied around the core to create a symmetrical 6- around-1 bundle.

2. The bundle layer was secured with electrical tape and a temperature-sensing thermocouple was embedded into the surface of the cable jacket.

3. Additional 1.2 meter cable lengths were applied, taped, and embedded with thermocouples to grow the bundle size incrementally from an 18-around-1 bundle, to a 36-around- 1 bundle, to a 60-around-1 bundle, to a 90-around-1 bundle, and, finally, to a 100-around-1 bundle.

4. The finished 100-around-1 bundle was suspended in air at a minimum distance of 0.3 m from any object in all directions. The ends of the bundle were covered with insulating foam to eliminate heat dissipation from the ends of the bundle, thereby ensuring worst case heat build-up. Test leads from a continuous current power supply were attached to all 4-pairs in the cable bundle.

5. The current on the power supply was set to 720 mA for each pair, for a total of applied current of 2.88 A. Initial sample temperatures were measured and recorded for each bundle layer. Temperature readings were collected at hourly intervals from each thermocouple. Final temperature readings were collected after the bundle had stabilized for 4 hours. As expected, the highest temperature rise was recorded at the thermocouple closest to the core of the bundle. The thermal resistance of the cable bundle was determined from the measurements, and a heat dissipation profile, including performance at 600 mA, was derived.

6. Measurement accuracy is approximated to be +/- 1ºC.