UL, the NEC & Power Over LAN Cable

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Contents

Making the world a safer place

Our goal is to help get safer products to the marketplace

Our independence and objectivity give UL a credible voice on safety

Who are we?

A mission focused on making the world a safer place

Who are we?

More than 100 years of expertise focused on product safety and compliance

Who are we?

Respected worldwide for
our technical expertise

Who are we?

Rigorous follow-up and market surveillance aimed at getting safer products to market

Who are we?

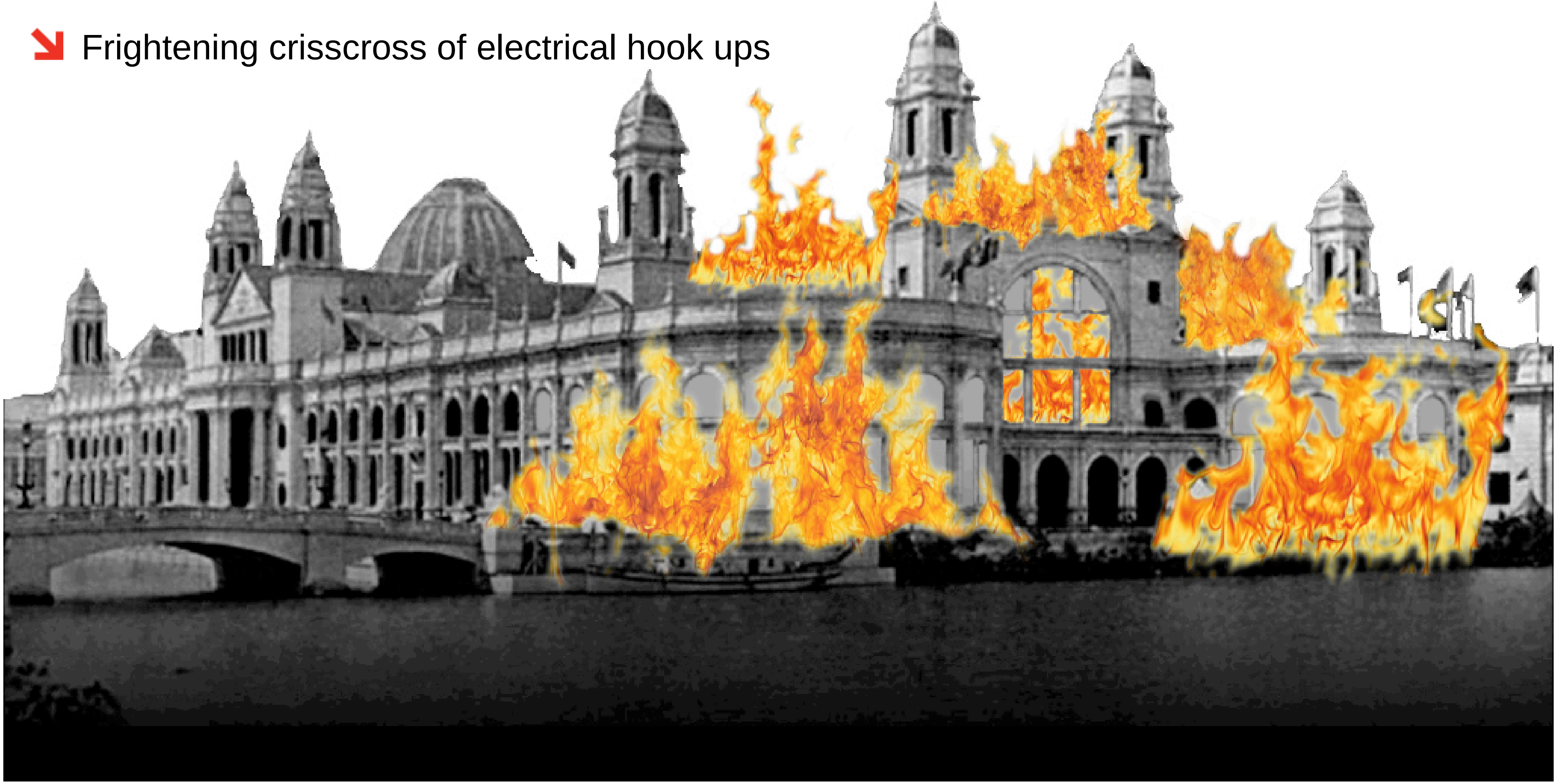
Support for regulators, retailers, insurers and consumers in the supply chain

Our history

- UL's rich heritage and more than 100 years of experience provide a strong foundation for our future

The Palace of Electricity, 1893 World's Fair

- Massive flammable façade
- Frightening crisscross of electrical hook ups



The Palace of Electricity, 1893 World’s Fair

The Palace of Electricity, 1893 World's Fair

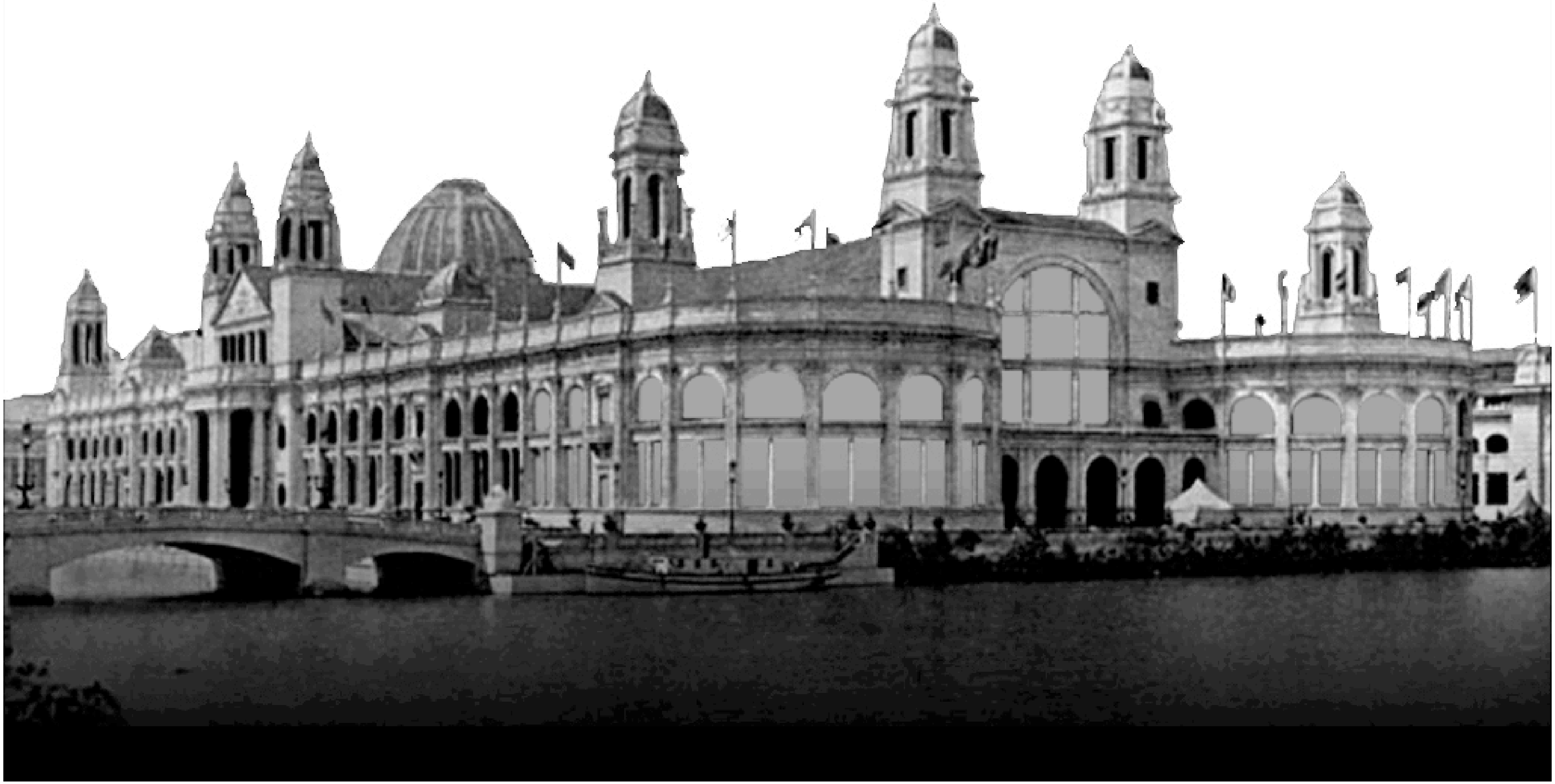
William Henry Merrill

The Palace of Electricity, 1893 World's Fair

- The exhibition became a huge success

The Palace of Electricity, 1893 World's Fair

- The markets for electricity and the products controlling fire were ready to take off



After our founding, our role continued to evolve

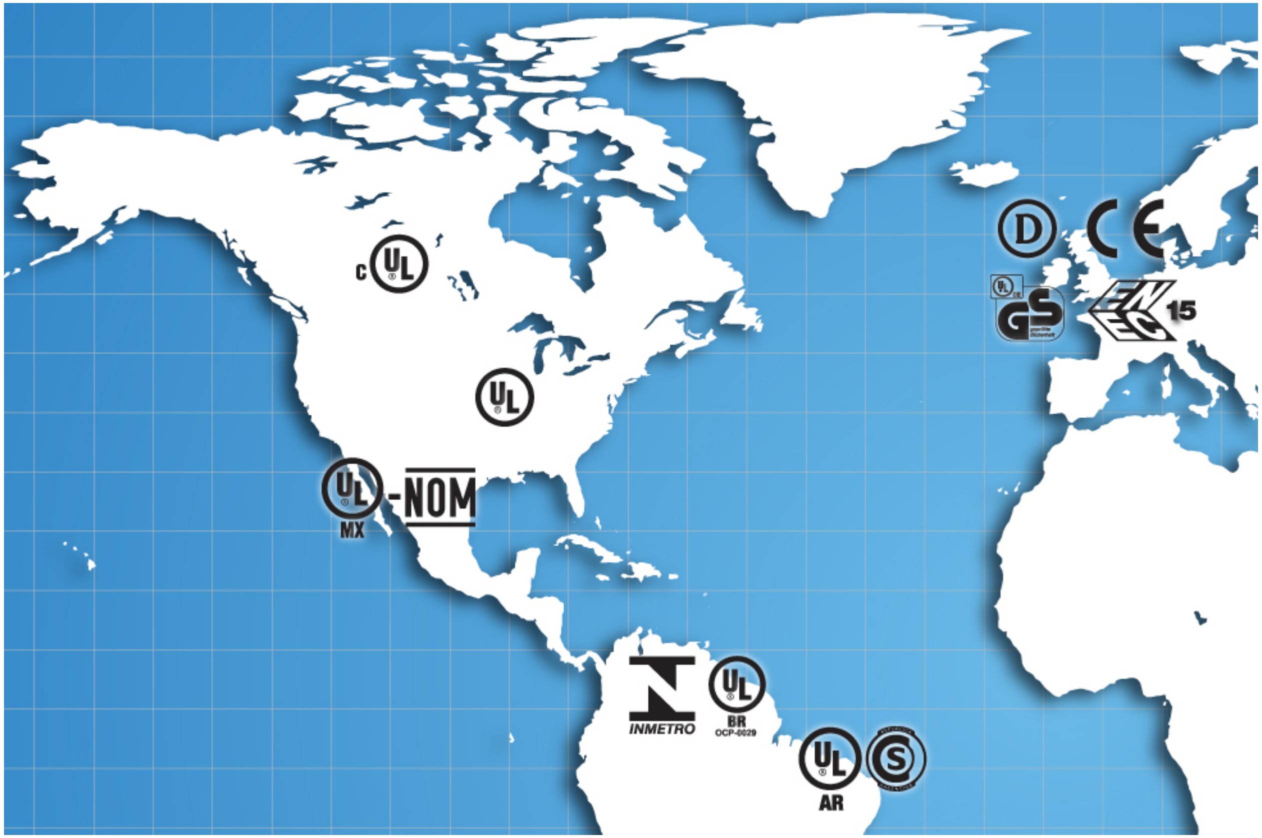
- Initially, we helped the marketplace gain confidence in the safety of the developing electrical system
- This confidence in the “new” technology drove demand for products

Building a safety system

- UL led development of the North American safety system by developing standards, building a two-part certification model and aiding model code development

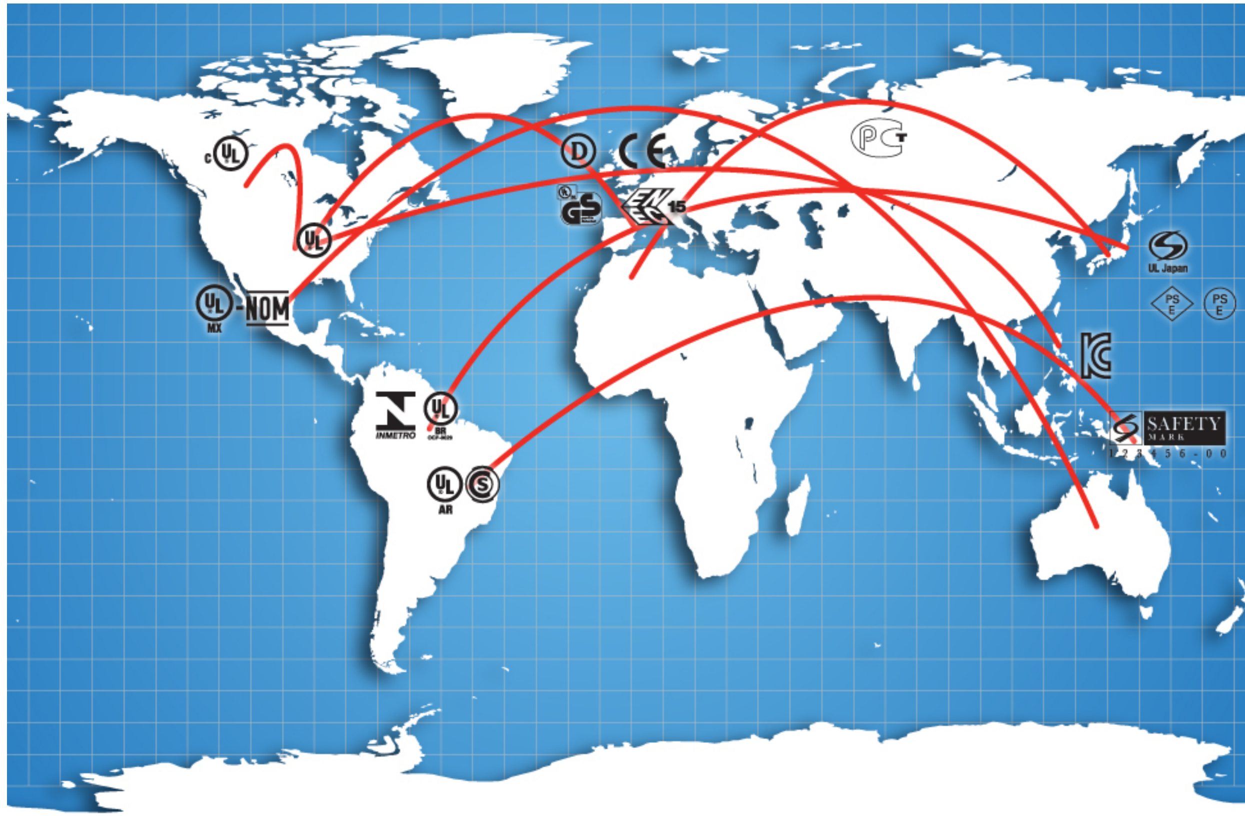
Moving beyond North America

- As new technologies enter the market, UL is expanding to meet manufacturer and supply chain demands



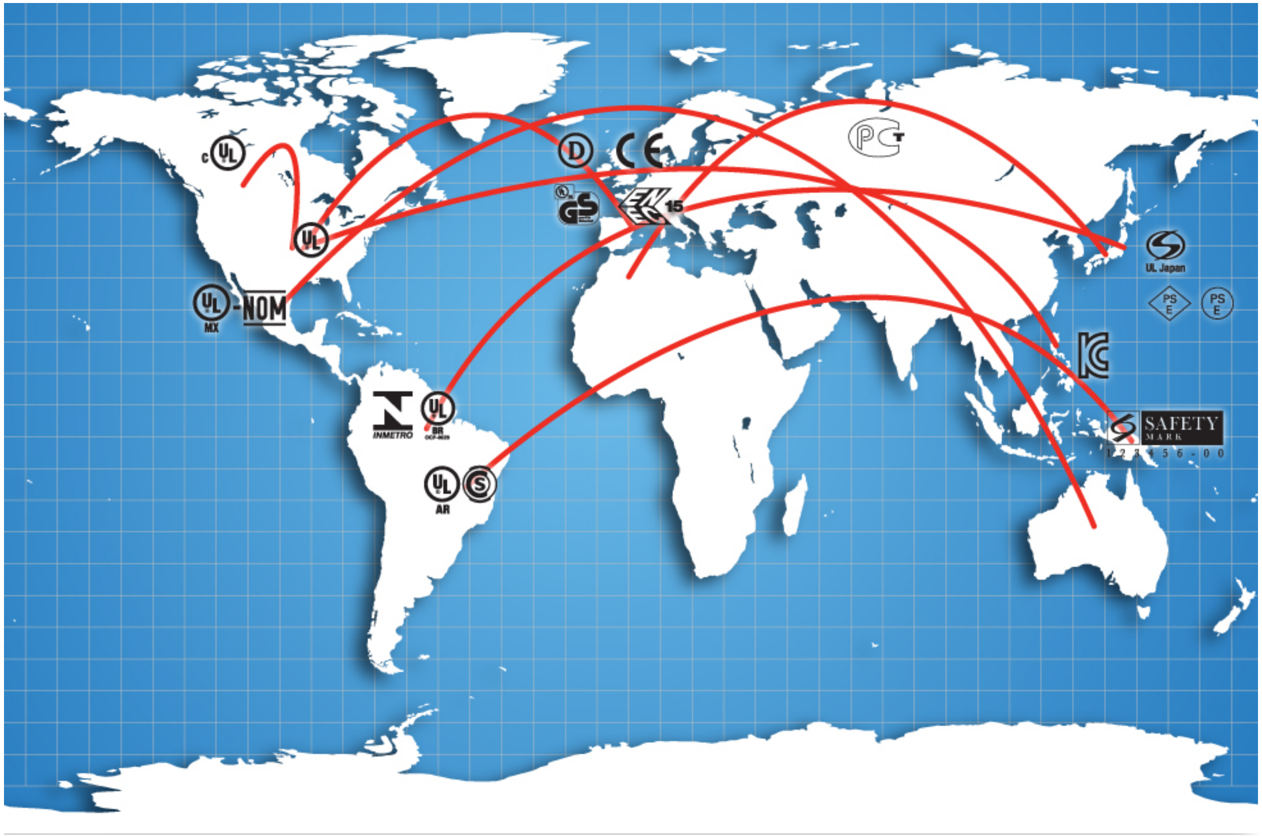
A global UL

- Our experience provides a distinct advantage in helping customers navigate the challenges and opportunities of a global marketplace



UL’s role in today’s global marketplace

- Facilitate access to global markets
- Maintain a level playing field
- Help manufacturers get safer products to market
- Help the supply chain gain access to those safer products



A view to the future

UL's independent, objective assessments will continue to provide peace of mind and confidence in new technologies entering today's marketplace

22 BILLION UL MARKS APPEAR ON PRODUCTS ANNUALLY

OVER **1 BILLION** CONSUMERS GLOBALLY WERE REACHED BY UL WITH SAFETY MESSAGES

97,237 PRODUCT EVALUATIONS CONDUCTED BY UL

1,507 CURRENT STANDARDS FOR SAFETY PUBLISHED BY THE UL FAMILY OF COMPANIES

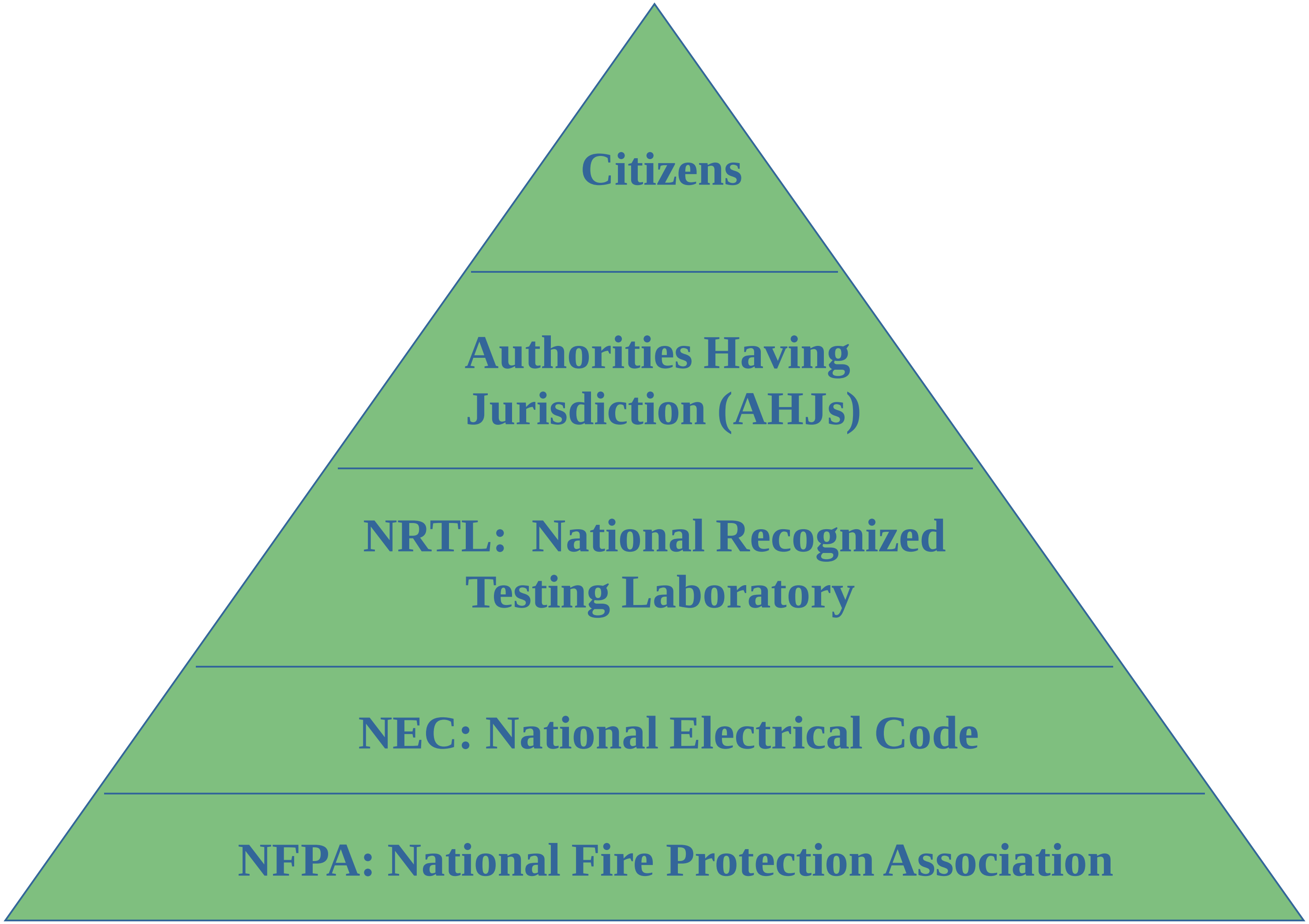
159 FACILITIES IN THE UL FAMILY OF COMPANIES

10,842 EMPLOYEES IN THE UL FAMILY OF COMPANIES

113 COUNTRIES WHERE UL CUSTOMERS ARE LOCATED

Introduction to the National Electrical Code (NEC)

Safety in the US



National Electrical Code

- Practical Safeguarding. “The purpose of this code is the practical safeguarding of persons and property from hazards arising from the use of electricity.”

- “This code covers the installation of electric conductors, electric equipment, signaling and communications conductors and equipment, and fiber optic cables and raceways for the following…”

Why is the NEC Important?

- Defines some construction requirements
- Defines installations permitted and not permitted
- Used by Authorities having Jurisdiction (AHJ’s) to inspect installations
- Since AHJ’s have discretion in what code they use and how they interpret the code, it is important to know where your products will be installed.

NEC Revisions – Important Dates

Process Step	Date
Post final first draft report	July 17, 2015
Public comment closing date for paper submittals and other submittals that do not use the submission tool	August 21, 2015
Public comment closing date if using the submission tool (e-PC)	September 25, 2015
Second draft meeting (San Diego)	November 2-14, 2015
Posting of second draft and panel ballot	January 4, 2016
Final date for receipt of second draft ballots	January 15, 2016

Fact-Finding Investigations

DEFINITION:

FACT-FINDING REPORT (INVESTIGATION)
A formal record of an investigation of the features and properties of a product, assembly or system undertaken by UL for the purpose of providing an Applicant with a means for seeking amendment of a nationally recognized installation code or Standard toward which UL's work is oriented.

Fact-Finding Investigations

- Developing facts, information and data
- Issuing a Report for use by the Applicant seeking amendment of a nationally recognized installation code or standard (i.e., NEC)
- Issuance of the Report does not constitute an endorsement of the proposed amendment addressed
- In no way implies listing or other recognition of the product by UL

A Matter of Safety

- The NEC has the responsibility to ensure that communications cables are used and installed within their maximum voltage and temperature ratings in a manner that protect people and property from hazards.

- As this is an application area of high growth with increasing power demands, SPI submitted proposals to the NEC to enable the safe implementation of powering over communications cables by addressing well documented overheating problems as power levels increase.

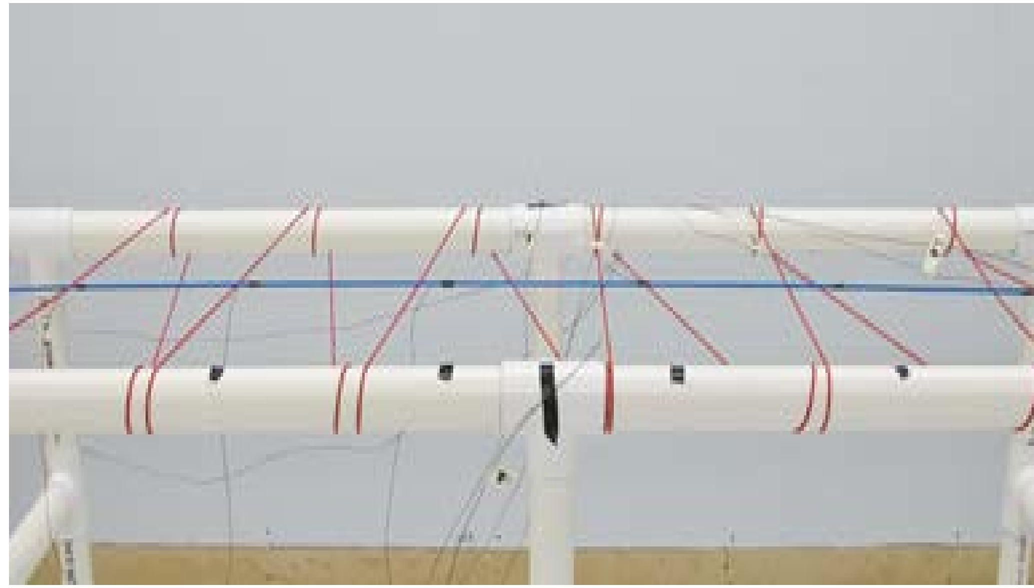
- SPI and project members have sponsored a fact finding investigation at UL to gather data for the development of comments related to the first revisions to the NEC for the safe implementation of powering over communications cables.

- This fact finding investigation is still on-going and not yet complete. Final observations and conclusions have not yet been made. Due to the high level of industry interest, SPI has authorized UL to provide this interim information.

Scope of the Fact-Finding Investigation

- Investigate the effects of higher levels of power applied over communications cables under typical installation practices permitted by the NEC
- Determination and evaluation of realistic worse-case conditions
- Gather data for the development of comments related to the first revisions to the NEC including:
  - Conductor Ampacities
  - Bundle Sizes
  - Installation Practices
- Mitigate safety concerns
- Focus on power (volts, watts, amps), not applications
- Test protocol consistent with other similar studies
- Develop data from testing

Test Fixture



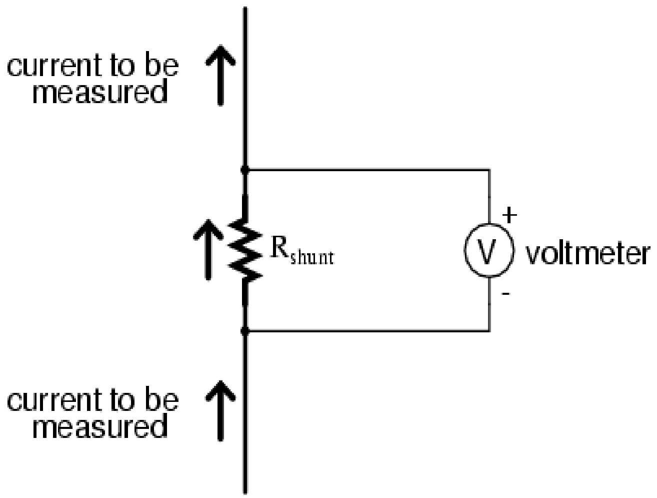
Parachute cord was used to support the cable bundles to minimize any heat-sinking effects.

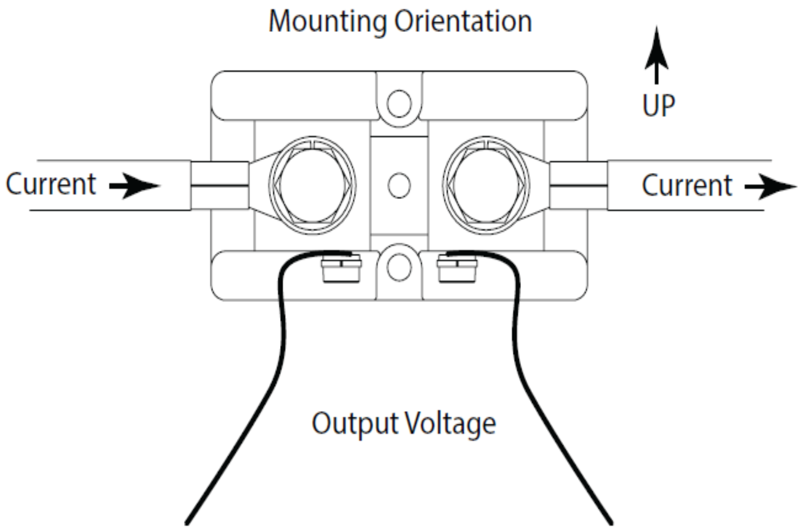
2” schedule 40 PVC pipe

Data Acquisition

Measuring Current

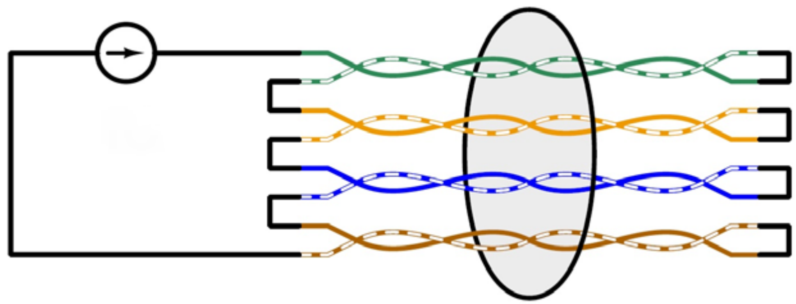
Current measurements were made by measuring the voltage across a calibrated precision shunt resistor with data acquisition units.



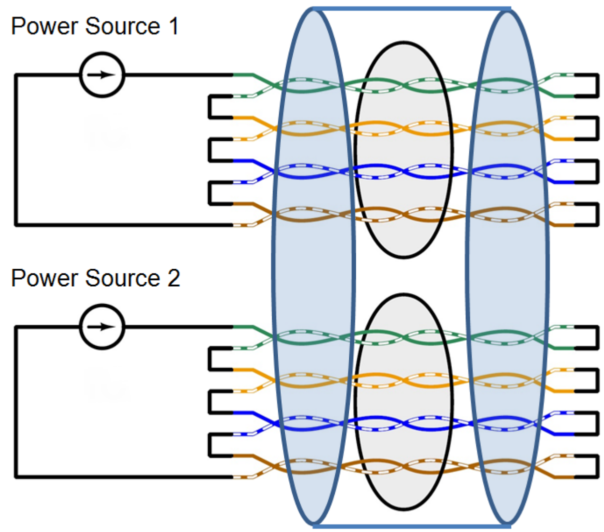


Wiring Diagrams

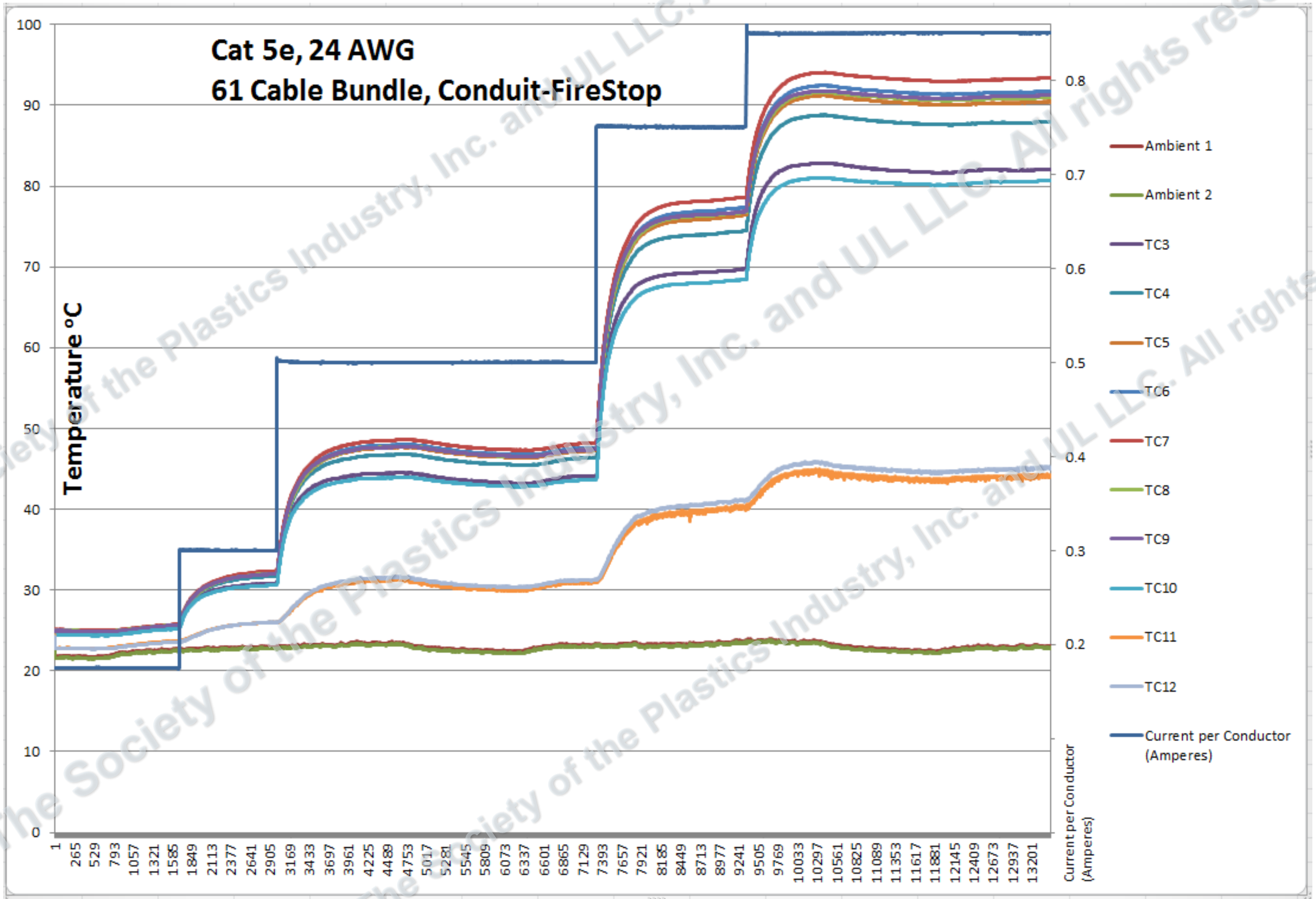
Single Power Supply



Multiple Power Supplies

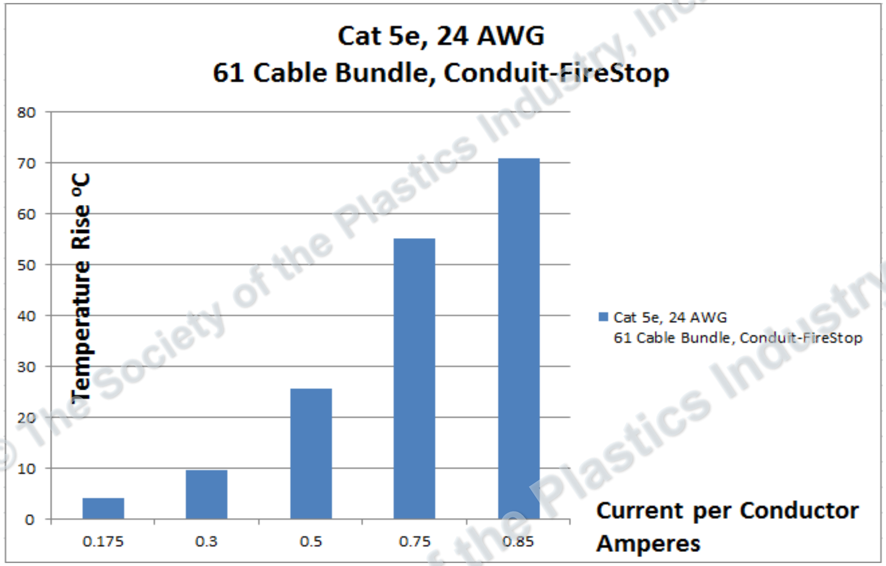


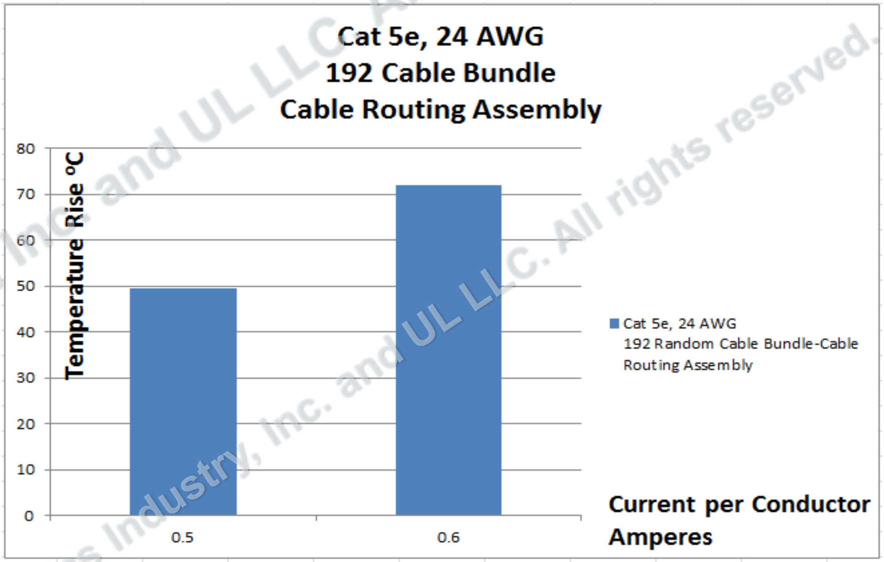
Thermal Response to Current



Current

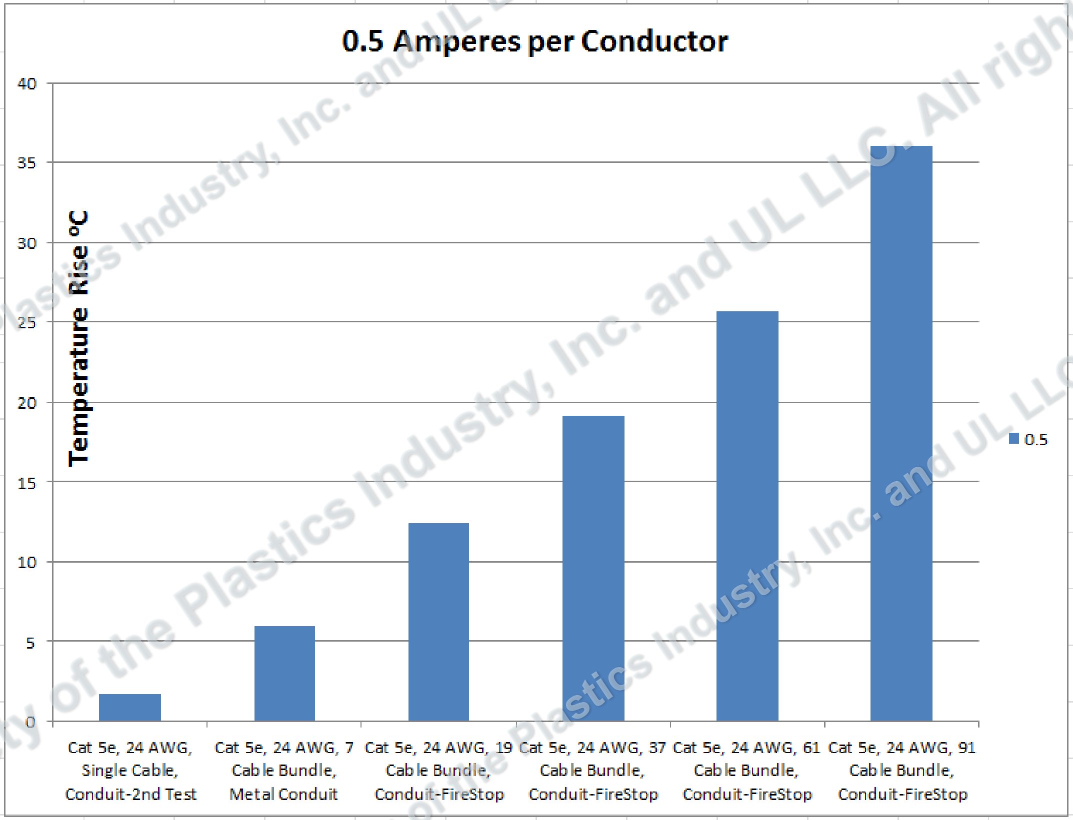
Very small increases in conductor current resulted in large increases in measured temperatures.





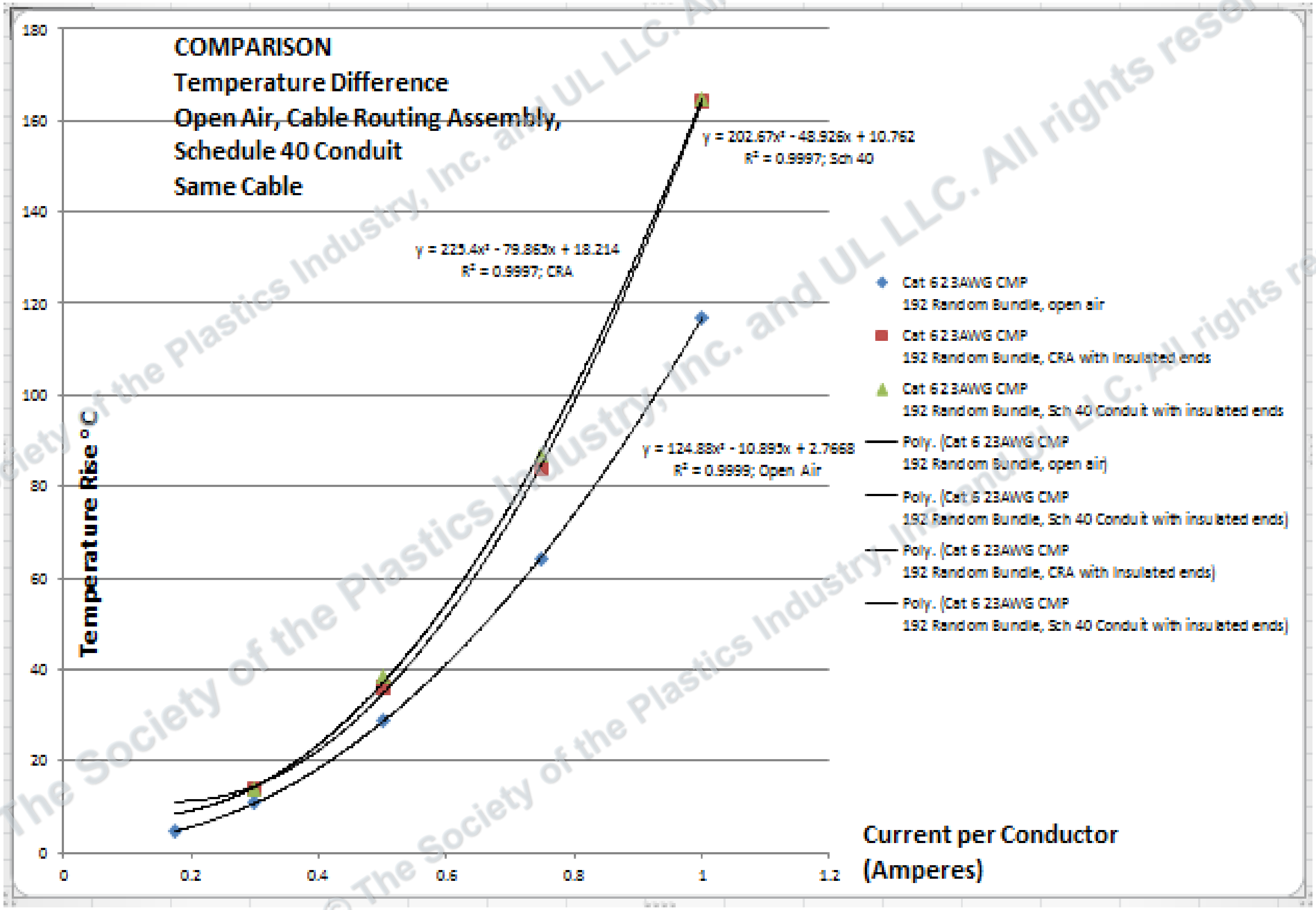
Bundle Size

Increasing the number of cables in a bundle resulted in increases in the measured temperatures



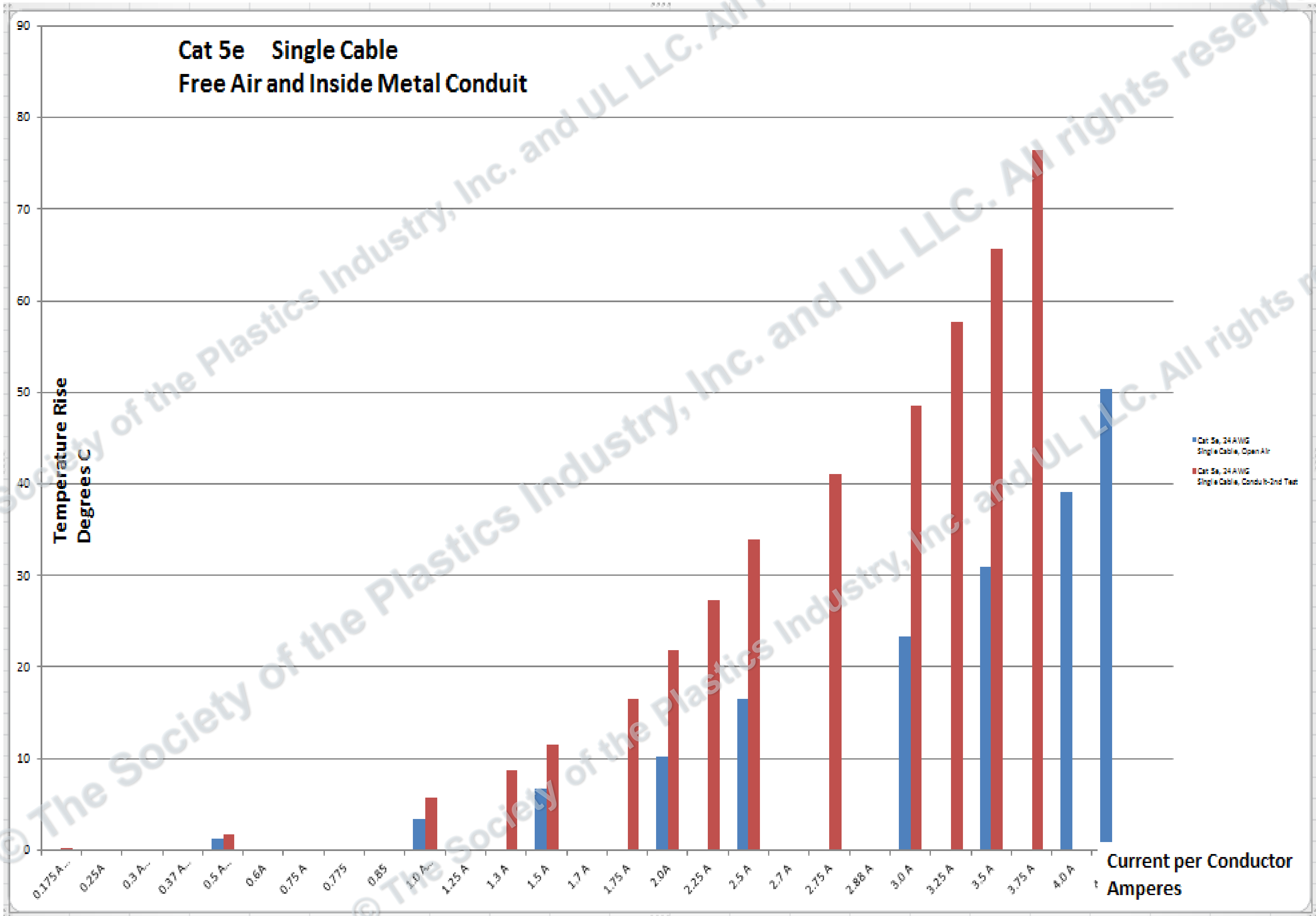
Installation Methods

Various methods of installation were tested



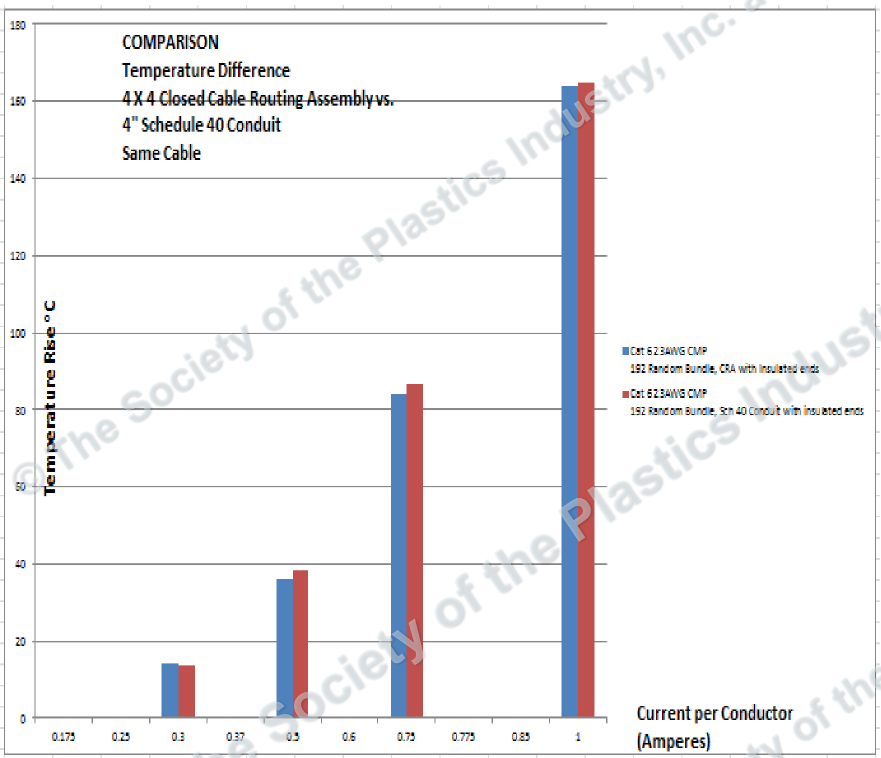
Enclosing Cables

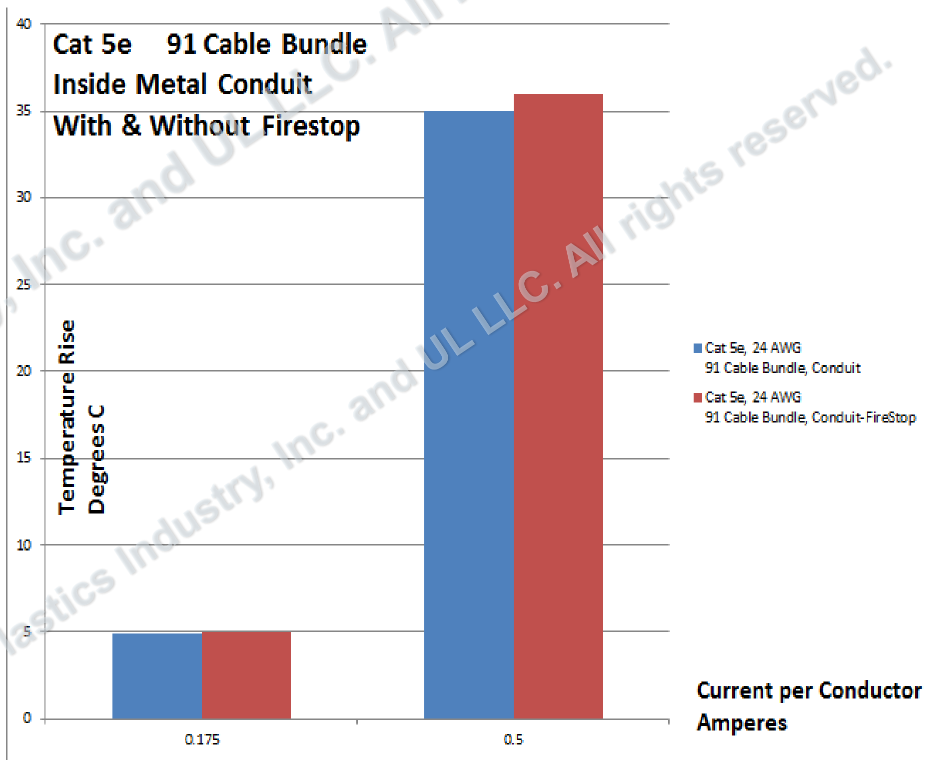
Enclosing cables results in higher measured temperatures



Enclosing Cables

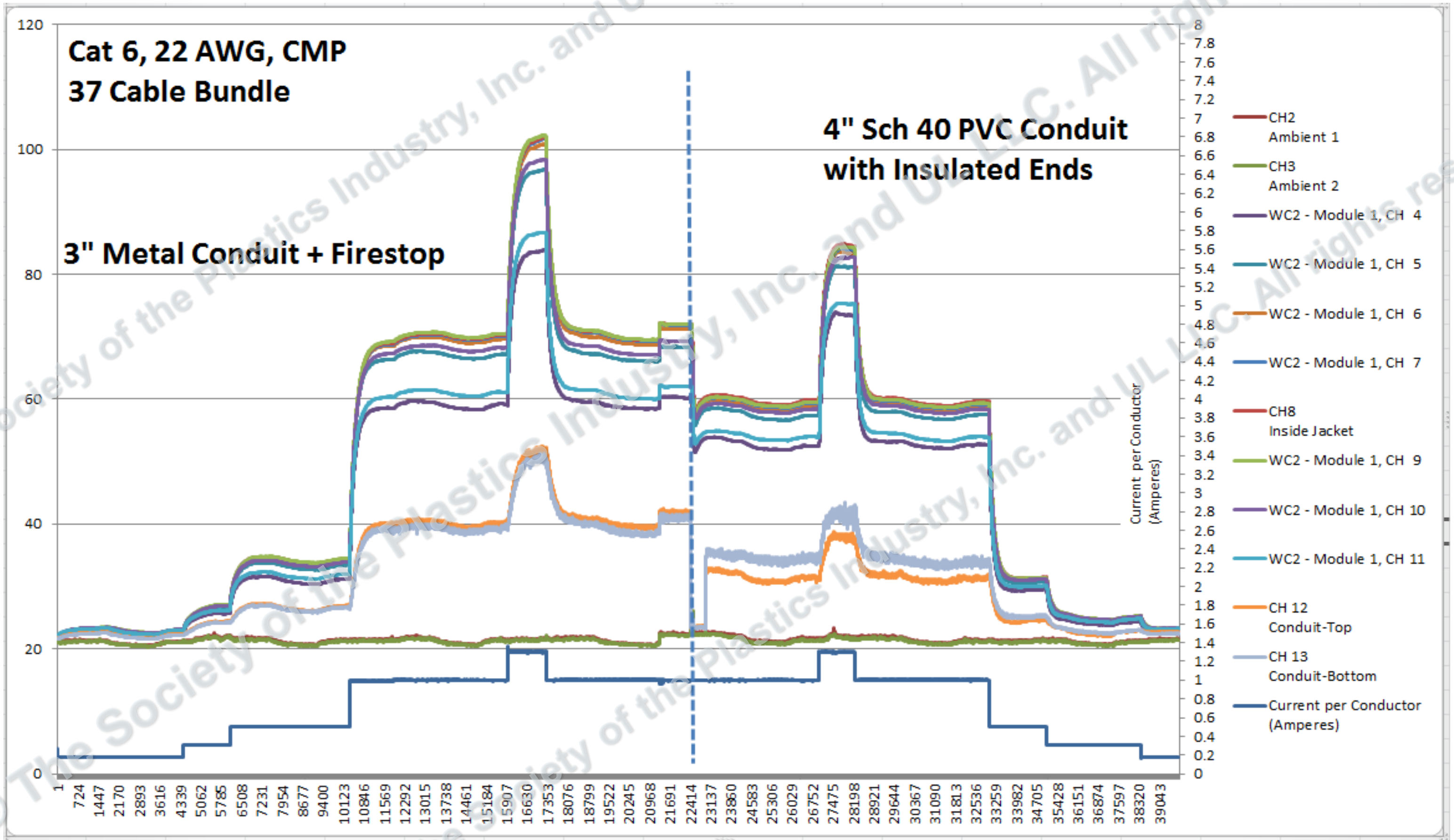
Different methods of enclosing the cables sometimes resulted in small differences in measured temperatures



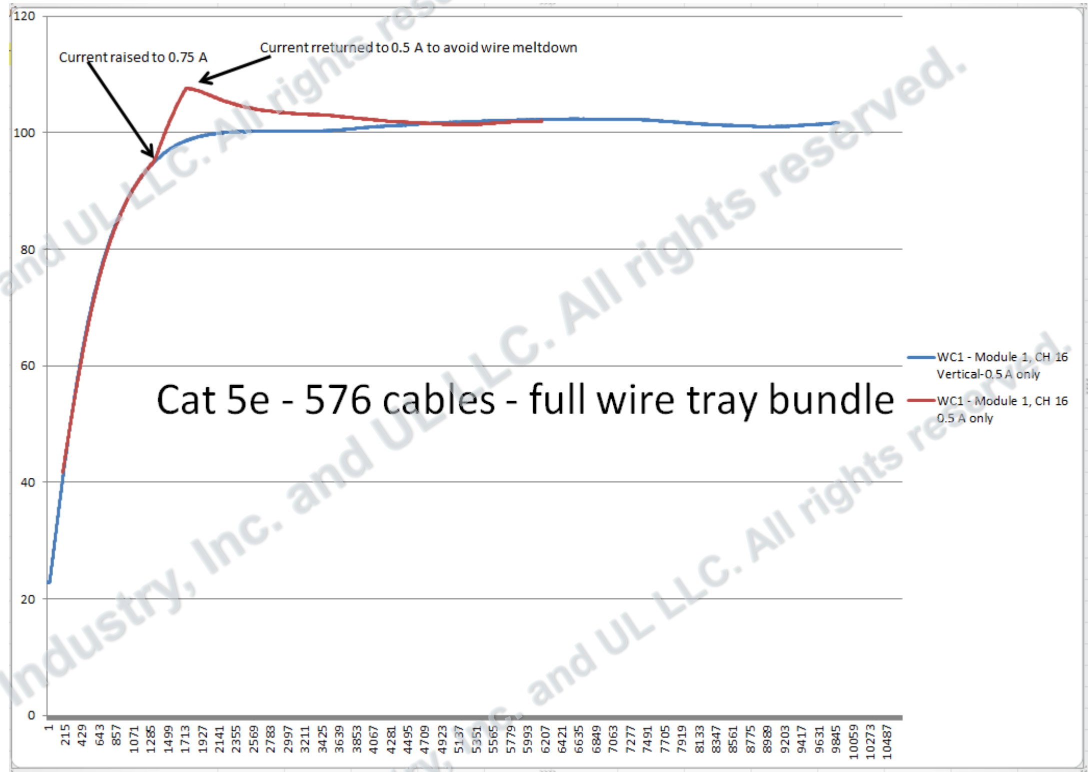


Enclosing Cables

Different methods of enclosing the cables sometimes resulted in significant differences in measured temperatures



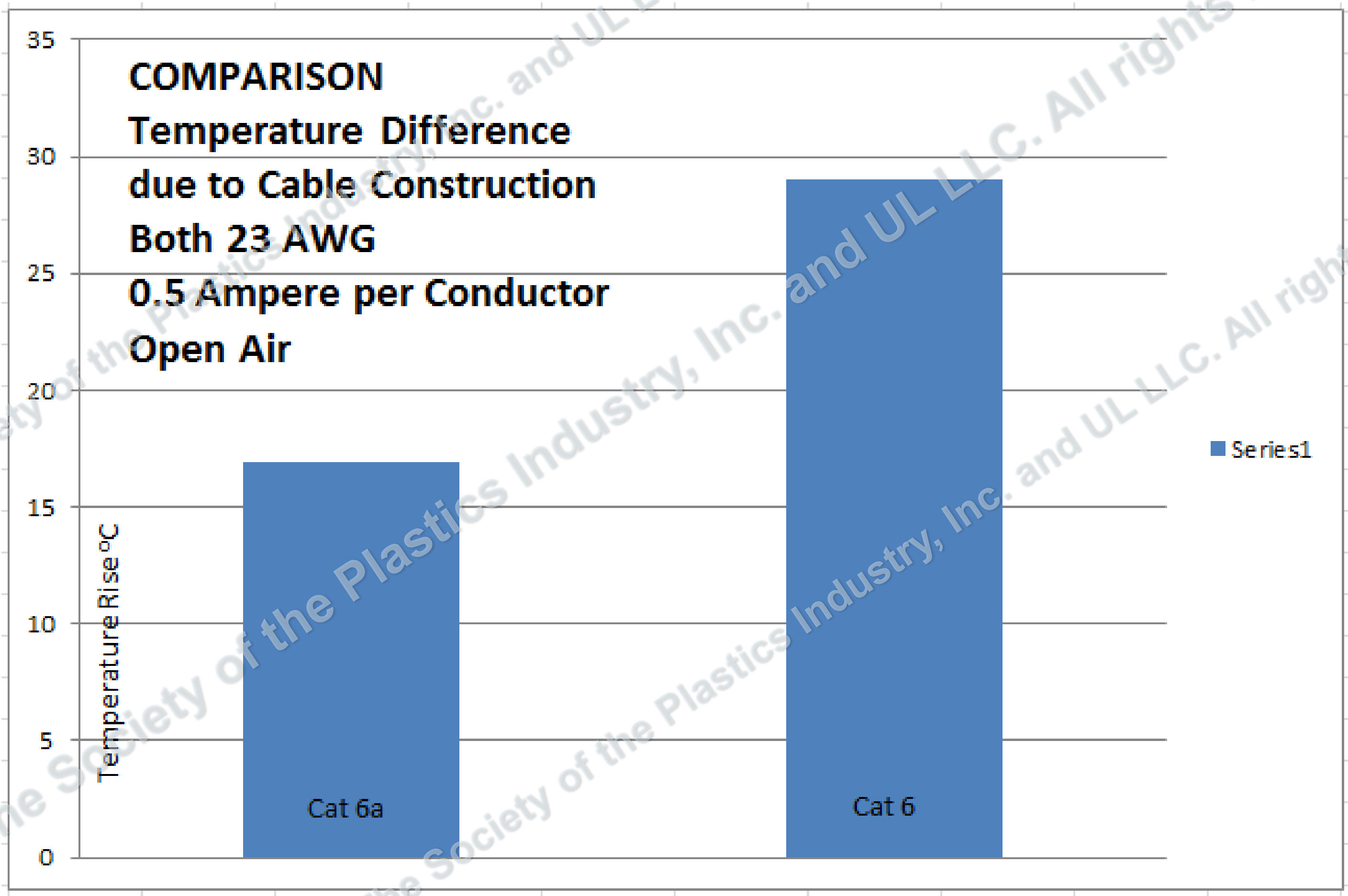
Cable Orientation



Cable orientation made little difference in large bundles

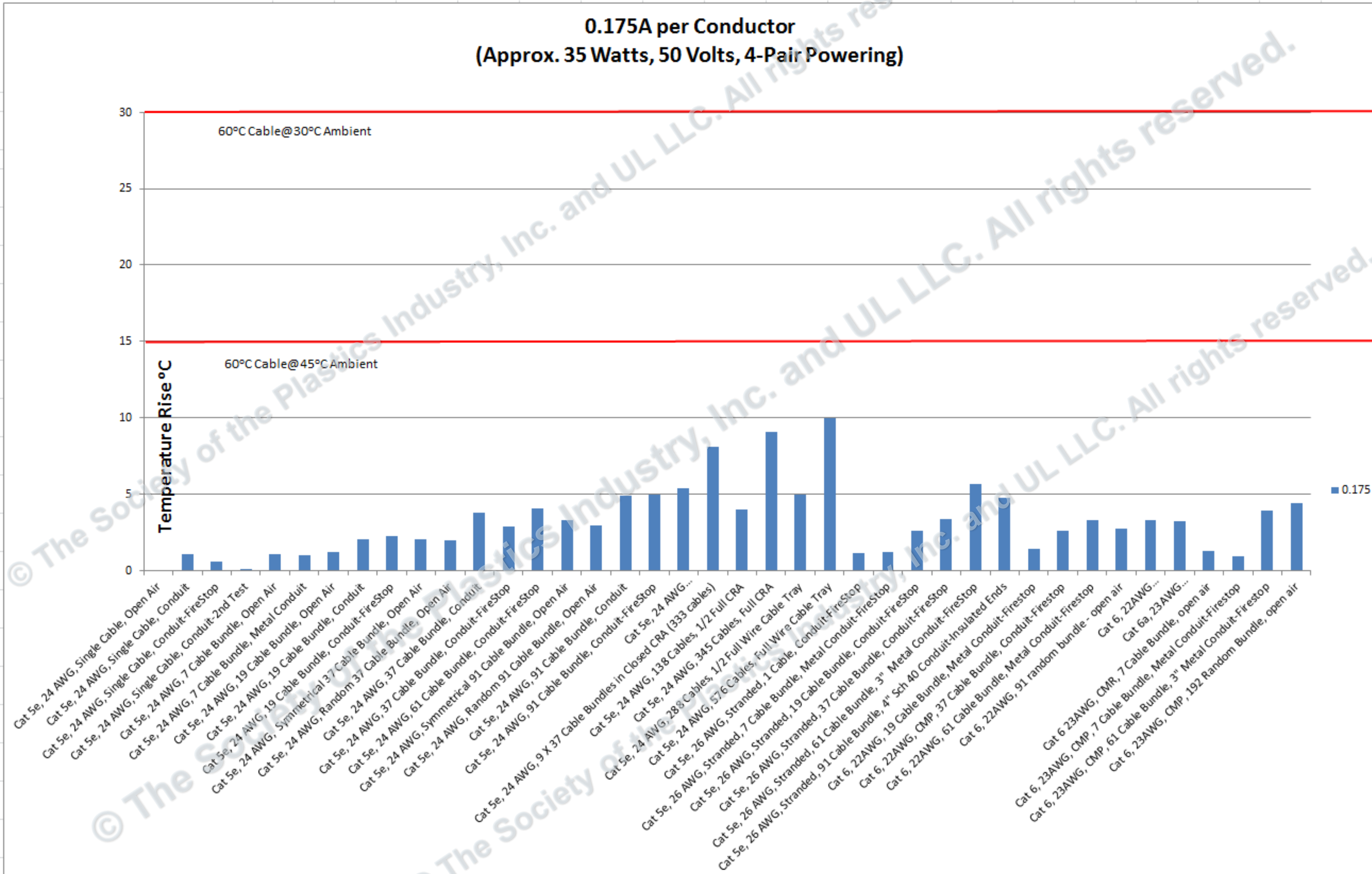
Cable Comparisons

Different cable constructions can make a big difference



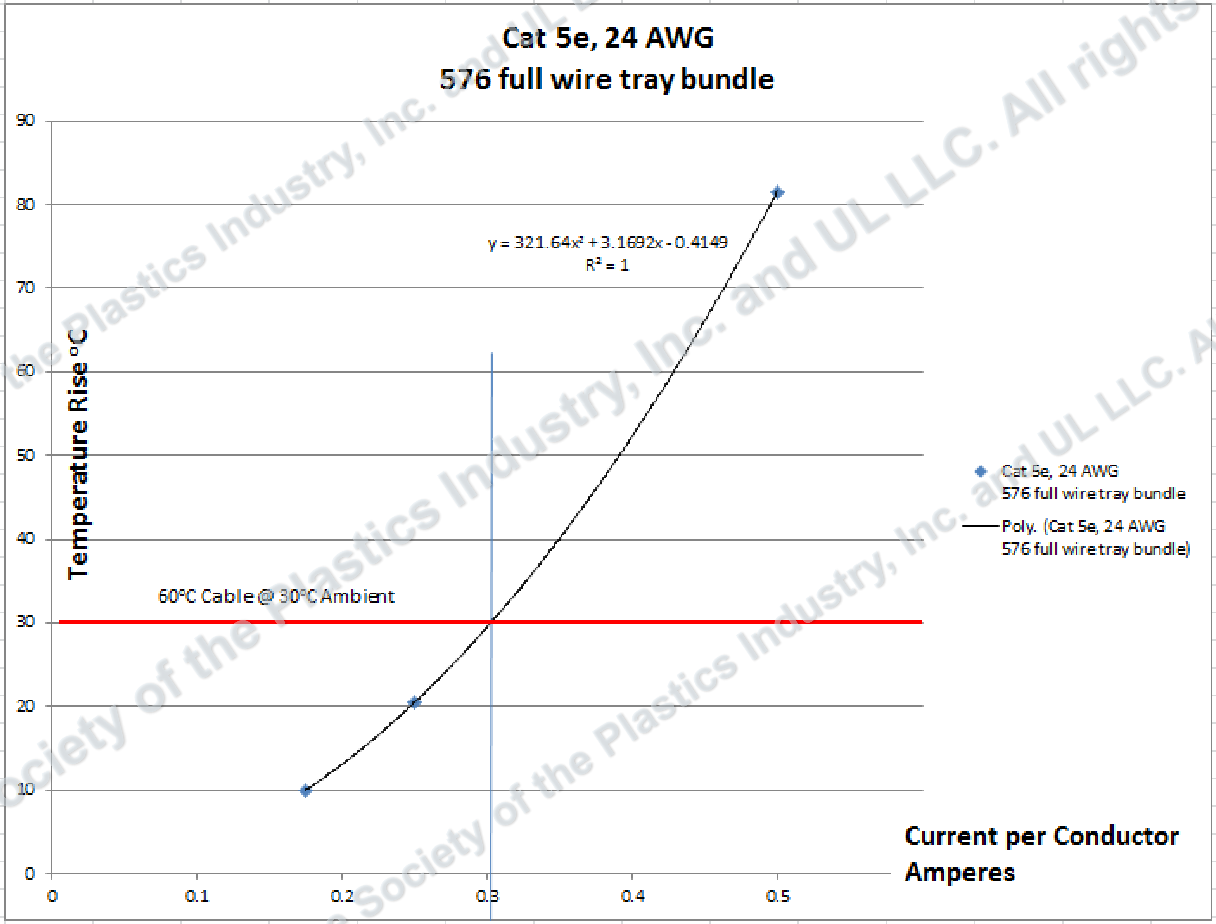
Some More Observations and Data

The data shows that overheating does not occur at 35 watts



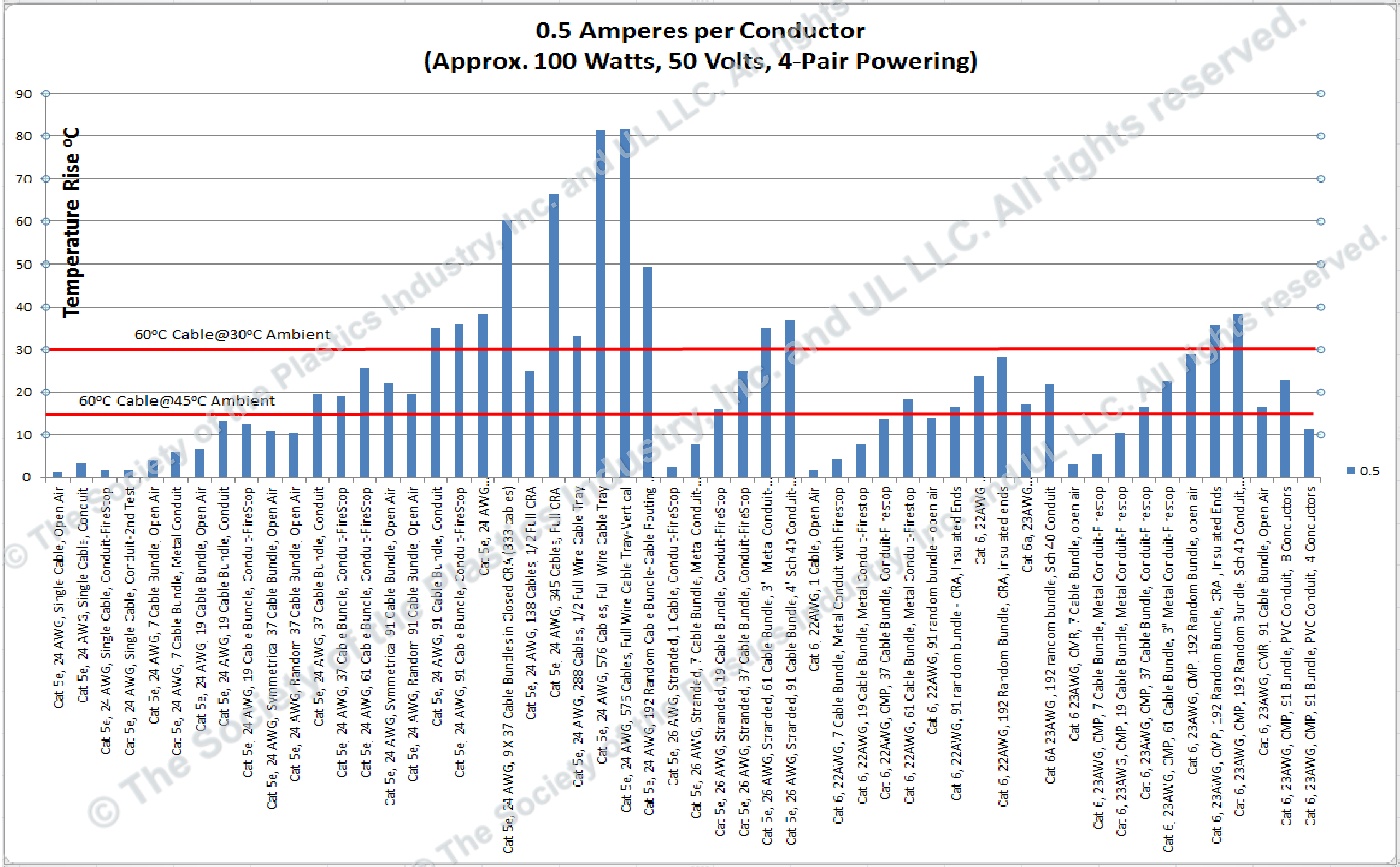
The data shows that overheating does not occur at 60 watts even under extreme bundling conditions

0.3 Ampere per Conductor
(Approx. 60 Watts, 50 Volts, 4-Pair Powering)

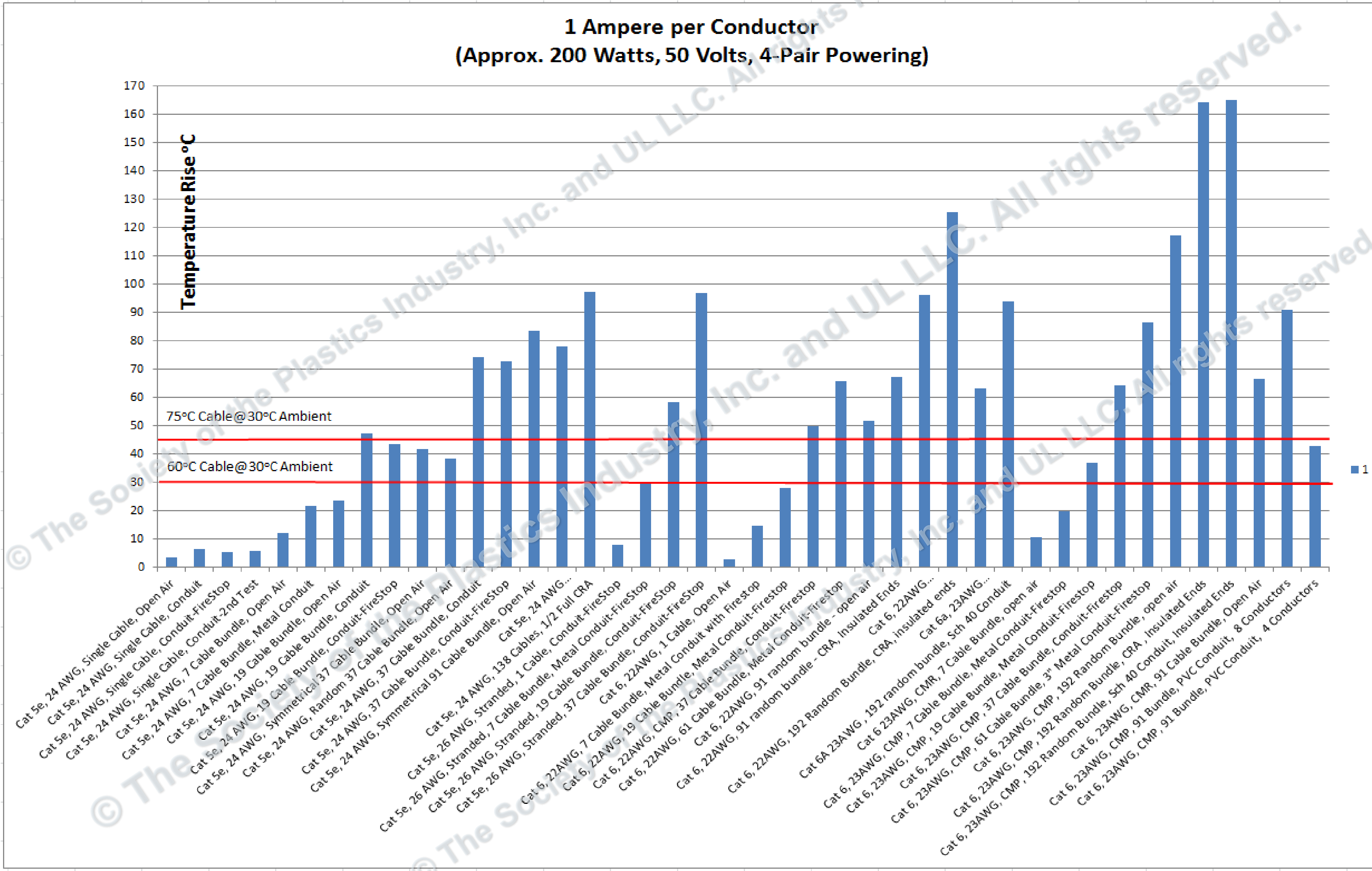


$y = 321.64x^2 + 3.1692x - 0.4149$; For $y = 30$ (°C), $x = 0.303$ Amperes

The data shows that under many installation conditions overheating occurs at 100 watts



The data shows that under a significant number of installation conditions overheating occurs at 200 watts



What is the Concern?

NEC Table 11 (B)

Existing Class 2 Power & Current Limitations

Table 11(B) Class 2 and Class 3 Direct-Current Power Source Limitations

Power Source		Inherently Limited Power Source (Overcurrent Protection Not Required)					Not Inherently Limited Power Source (Overcurrent Protection Required)			
		Class 2				Class 3	Class 2		Class 3	
Source voltage V_{max} (volts) (see Note 1)		0 through 20*	Over 20 and through 30*	Over 30 and through 60*	Over 60 and through 150	Over 60 and through 100	0 through 20*	Over 20 and through 60*	Over 60 and through 100	Over 100 and through 150
Power limitations VA_{max} (volt-amperes) (see Note 1)		—	—	—	—	—	250 (see Note 3)	250	250	N.A.
Current limitations I_{max} (amperes) (see Note 1)		8.0	8.0	$150/V_{max}$	0.005	$150/V_{max}$	$1000/V_{max}$	$1000/V_{max}$	$1000/V_{max}$	1.0
Maximum overcurrent protection (amperes)		—	—	—	—	—	5.0	$100/V_{max}$	$100/V_{max}$	1.0
Power source maximum nameplate rating	VA (volt-amperes)	$5.0 \times V_{max}$	100	100	$0.005\times V_{max}$	100	$5.0 \times V_{max}$	100	100	100
	Current (amperes)	5.0	$100/V_{max}$	$100/V_{max}$	0.005	$100/V_{max}$	5.0	$100/V_{max}$	$100/V_{max}$	$100/V_{max}$

- The permitted current per conductor far exceeds the 1 A used for the data in the previous slide (i.e. 100/30 = 3.33 amperes)
- Not referenced in Chapter 8
- A new table limiting ampacities was proposed

Possible Solutions

First Revision NEC Table

Table 840.160(A) Communications Conductor Ampacity Based on Copper Conductors at Ambient Temperature of 30°C (86°F), Conductor Temperature 60°C (140°F)

Conductor Size (AWG)	Ampacity of Each Conductor in a Single 4-Pair Multipair Communications Cable Installed Separated from All Other Cables	Ampacity of Each Conductor in a Multipair Communications Cable when More Than One Cable Is Installed Together or the Multipair Cable Is Larger Than 4 Pairs
26	0.8	0.4
24	1.3	0.6
23	2	1
22	3.1	1.5

Informational Note: The conductor size of existing communications cable, including "category X" type cables, can be as small as 26 AWG.

Proposed Revised NEC Table

Table 840.160(C), Ampacities of Each Conductor (in Amperes) in a 4-Pair Communications Cable, Based on Copper Conductors at Ambient Temperature of 30°C (86° F) with all Conductors in All Cables Carrying Current, 60°C (140°F), 75°C (167°F) and 90°C (194°F) Rated Cables																					
AWG	Number of 4-Pair Cables in a Bundle																				
	1			2-7			8-19			20-37			38-61			62-91			92-192		
	Temperature Rating			Temperature Rating			Temperature Rating			Temperature Rating			Temperature Rating			Temperature Rating			Temperature Rating		
	60°C	75°C	90°C	60°C	75°C	90°C	60°C	75°C	90°C	60°C	75°C	90°C	60°C	75°C	90°C	60°C	75°C	90°C	60°C	75°C	90°C
26	1.0	1.0	1.0	1.0	1.0	1.0	0.7	0.8	1.0	0.5	0.6	0.7	0.4	0.5	0.6	0.4	0.5	0.6	NA	NA	NA
24	2.0	2.0	2.0	1.0	1.4	1.6	0.8	1.0	1.1	0.6	0.7	0.9	0.5	0.6	0.7	0.4	0.5	0.6	0.3	0.4	0.5
23	2.5	2.5	2.5	1.2	1.5	1.7	0.8	1.1	1.2	0.6	0.8	0.9	0.5	0.7	0.8	0.5	0.7	0.8	0.4	0.5	0.6
22	3.0	3.0	3.0	1.4	1.8	2.1	1.0	1.2	1.4	0.7	0.9	1.1	0.6	0.8	0.9	0.6	0.8	0.9	0.5	0.6	0.7

Note 1: For bundle sizes over 192 cables, or for conductor sizes smaller than 26 AWG, ampacities shall be permitted to be determined by qualified personnel under engineering supervision.

Note 2: Where only half of the conductors in each cable are carrying current, the values in the table shall be permitted to be increased by a factor of 1.4.

Informational Note: The conductor sizes of communications cable in wide-spread use are typically 22 – 26 AWG.

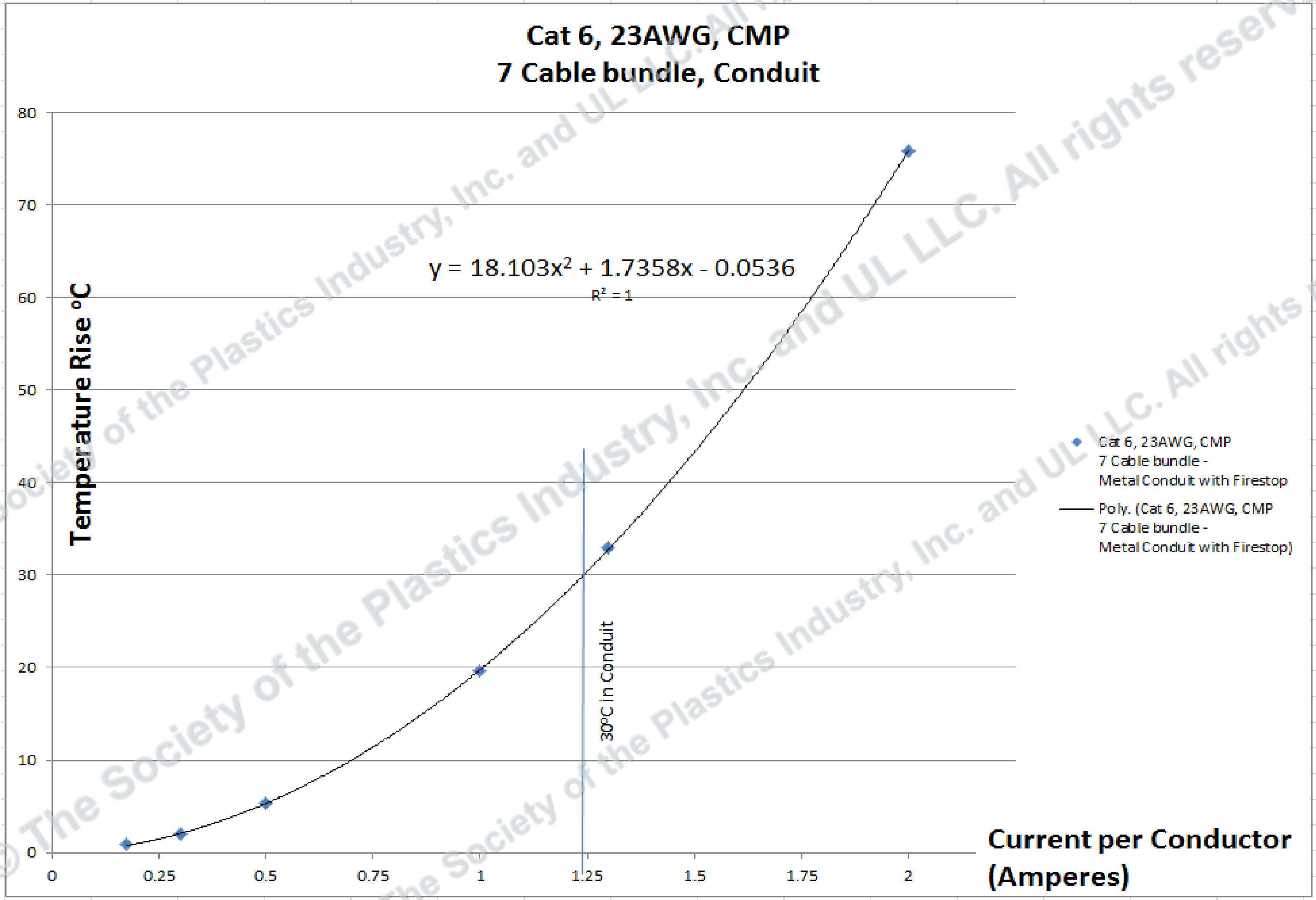
Proposed Revised NEC Table

- Proposed text will make it clear that already installed and newly installed traditional cables are permitted to be used for powering in compliance with the ampacity table. This was always the intent of the panel and stated in the existing first revision text:

"(C) Installations of New Cables. New cables installed for carrying both communications and power, where the maximum adjusted ampacity of conductors exceed the values in Table 840.160(A), shall be Type CMP-LP, CMR-LP or CM-LP, as applicable."

Proposed Revised NEC Table

Data used to determine values for the NEC Table



Proposed Revised NEC Table

Data used to determine values for the NEC Table

Cat 6, 23AWG Amperes for 30 Degree C Rise								
(60°C Cable @ 30°C Ambient)								
Bundle Size		1	7	19	37	61	91	192
Best-fit Formula (Enclosed) Target: y = 30			30.0272997	30.0148235	30.0383938	30.0468984	30.076393	30.0537397
Amperes (Enclosed);	x=		1.242	0.893	0.674	0.582	0.59	0.452
Cat 6, 23AWG Amperes for 45 Degree C Rise								
(75°C Cable @ 30°C Ambient)								
Bundle Size		1	7	19	37	61	91	192
Best-fit Formula (Enclosed) Target: y = 45			45.0366358	45.0184231	45.0810645	45.0902936	45.0683725	44.9865667
Amperes (Enclosed);	x=		1.531	1.105	0.834	0.718	0.718	0.549
Cat 6, 23AWG Amperes for 60 Degree C Rise								
(90°C Cable @ 30°C Ambient)								
Bundle Size		1	7	19	37	61	91	192
Best-fit Formula (Enclosed) Target: y = 60			60.0632094	60.0313281	60.0459766	59.9957489	59.9776302	59.9662773
Amperes (Enclosed);	x=		1.775	1.284	0.968	0.831	0.823	0.628

Proposed Revised NEC Table

Data used to determine values for the NEC Table

30°C Temperature Rise (60°C Cable Rating @30°C Ambient)							
Conductor Size (AWG)	Number of 4-Pair Cables in a Bundle						
	1	2-7	8 -19	20 - 37	38 - 61	62-91	92 - 192
26	1.98	1.001	0.707	0.549	0.460	0.449	NA
24	2.209	1.187	0.813	0.634	0.546	0.455	0.398
23		1.242	0.893	0.674	0.582	0.590	0.452
22		1.499	1.04	0.765	0.663	0.68	0.527

45°C Temperature Rise (75°C Cable Rating @30°C Ambient)							
Conductor Size (AWG)	Number of 4-Pair Cables in a Bundle						
	1	2-7	8 -19	20 - 37	38 - 61	62-91	92 - 192
26	2.424	1.227	0.874	0.677	0.572	0.554	NA
24	2.732	1.461	1.009	0.782	0.674	0.561	0.478
23		1.531	1.105	0.834	0.718	0.718	0.549
22	3	1.857	1.284	0.952	0.822	0.826	0.631

Proposed Revised NEC Table

Derivation of 1.4 factor for ½ the number of conductors energized in a Cable

$P_8 = P_4$ = Power per cable (assume same for both)
I_8 = Current for each conductor with 8 conductors energized
I_4 = Current for each conductor with 4 conductors energized
R = DC Resistance of each conductor (assume same for both)

$P = I^2 \times R$

For 8 conductors energized: $P_8 = I_8^2 \times R \times 8$ (8 conductors)

For 4 conductors energized: $P_4 = I_4^2 \times R \times 4$ (4 conductors)
or
$I_4 = \mathrm{SQRT}\ (P_4/(R \times 4))$

Since the power is assumed to be the same, the formula for 8 conductor power, P8, can be substituted for P4 to get a formula for I_4:

$I_4 = \mathrm{SQRT}\ (P_8/(R \times 4)) = \mathrm{SQRT}\ ((I_8^2 \times R \times 8)/(R \times 4)) = \mathrm{SQRT}\ (I_8^2 \times 2)$

Proposed Revised NEC Table

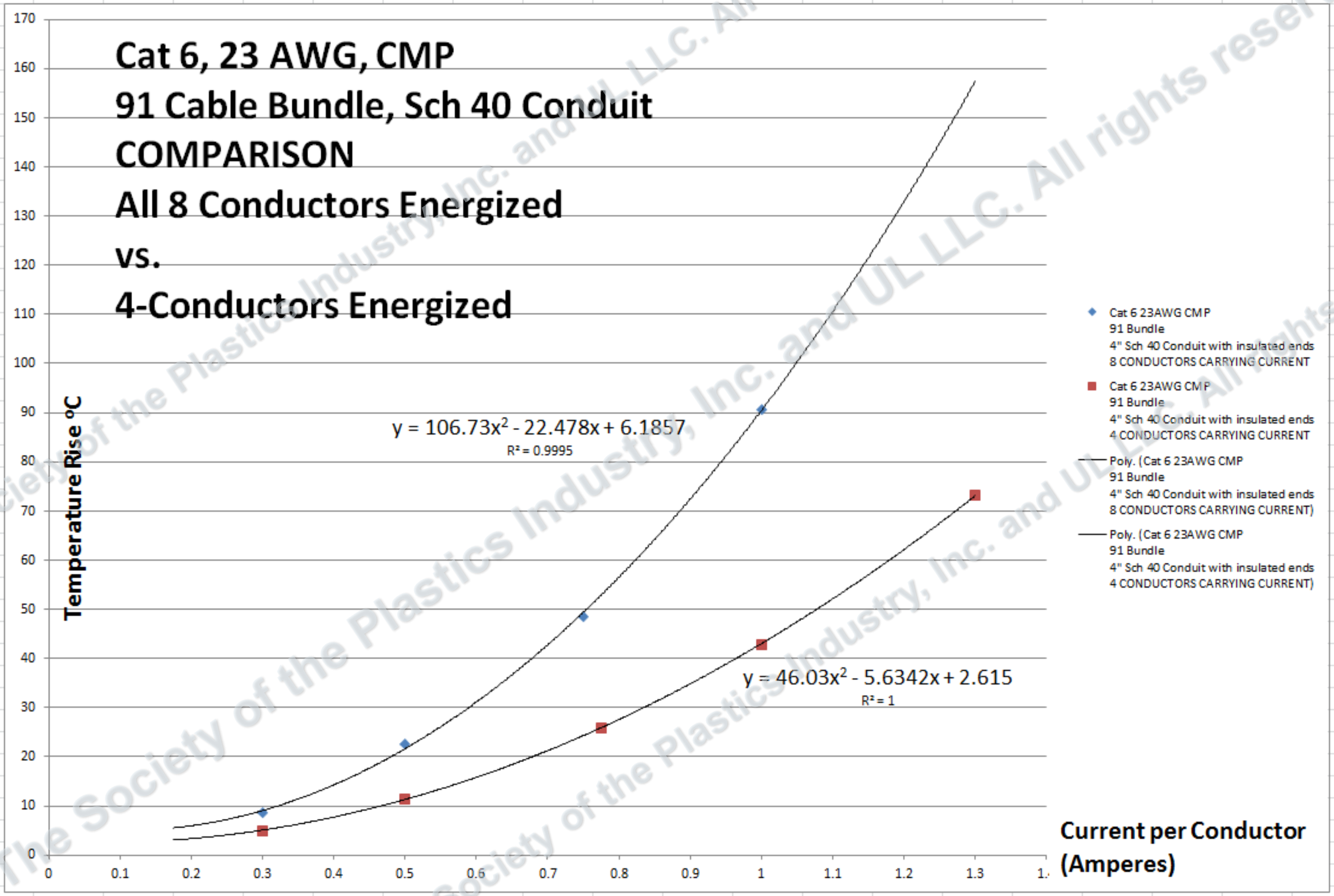
Derivation of 1.4 factor for ½ the number of conductors energized in a Cable

Calculating I_4 for a number of different I_8 currents we get the following along with a “factor” for each.

I_8	I_4	Factor (Factor = I_4 / I_8)
3	4.2426	1.4142
2	2.8284	1.4142
1.3	1.8385	1.4142
.6	.8485	1.4142
.3	.4243	1.4142

Proposed Revised NEC Table

Data to Support the 1.4 factor for ½ the number of conductors energized



Proposed Revised NEC Table

Data to Support the 1.4 factor for ½ the number of conductors energized

Up-Rating for 4 conductors carrying current							
TARGET TEMP	20	30	40	50	60	70	80
Amperes for a temperature 8 conductors, 61 cables	0.481	0.59	0.678	0.755	0.823	0.886	0.944
Amperes for a temperature 4 conductors, 61 cables	0.679	0.835	0.965	1.078	1.18	1.273	1.36
Temperature for a current, 8 conductors, 61 cables	20.0669415	30.076393	40.0076893	50.0535783	59.9776302	70.0528151	80.0774133
Temperature for a current, 4 conductors, 61 cables	20.0110954	30.0037098	40.0422838	50.0320589	60.058816	70.0356133	80.089576
Factor ($I_{8\text{-cond}}$ X Factor = $I_{4\text{-cond}}$)	1.41164241	1.41525424	1.42330383	1.42781457	1.43377886	1.43679458	1.44067797

“-LP” Cable

NEC First Revision

The first revision text for the changes to the NEC included the provision for the optional use of “-LP” cables

“(C) Installations of New Cables. New cables installed for carrying both communications and power, where the maximum adjusted ampacity of conductors exceed the values in Table 840.160(A), shall be Type CMP-LP, CMR-LP or CM-LP, as applicable.”

“-LP” Cable

Data shows that cable heating can be managed via:

- Increased AWG size
- Cable design Variations
- Material selection
- Installation Practices

“-LP” Cable

- Permits taking advantage of cable design and construction innovations
- An <u>alternative</u> to the proposed ampacity table
- An additional, <u>optional</u> rating that may be added to traditional cables like “CM”, “CMR”, “CMP”
- <u>Not required</u> for new or legacy installations
- <u>Not a mandatory</u> replacement for existing LAN cable installations
- Intended to provide <u>another choice</u> for new installations or upgrades

UL Certification Requirement Decision (CRD) – LP cable Listing requirements

- **Test Configuration:** 192-cable bundle in Sch 40 PVC conduit (conduit sized based on overall diameter of bundle).
- **Test Setup:** All conductors carrying LP rating current (connected in series).
- **Requirement:**. The temperatures measured on the insulation and jacket of the cables shall not exceed the temperature rating of the cable. Temperatures are corrected to an ambient of 45°C.
- **Applicable Cable Types:** Communications cables, i.e. CMP, CMR, CMG and CM.
- **Optional Cable Marking:** LP(XX) where XX is 0.5, 0.6, 0.7, 0.8, 0.9 or 1.0. The XX in the LP rating represents the maximum per conductor current.
- **Example Surface Marking:**

  "Type CMP-LP (0.8) (UL) 22 AWG 75°C"

THANK YOU

Questions?

Thanks to our Presenters

Steven A. Galan

Randy Ivans

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