R&M
Convincing cabling solutions

Future proof PoE installations

ontwerp & installatie adviezen

Robert Post
Reichle & De-Massari

Robert.post@rdm.com

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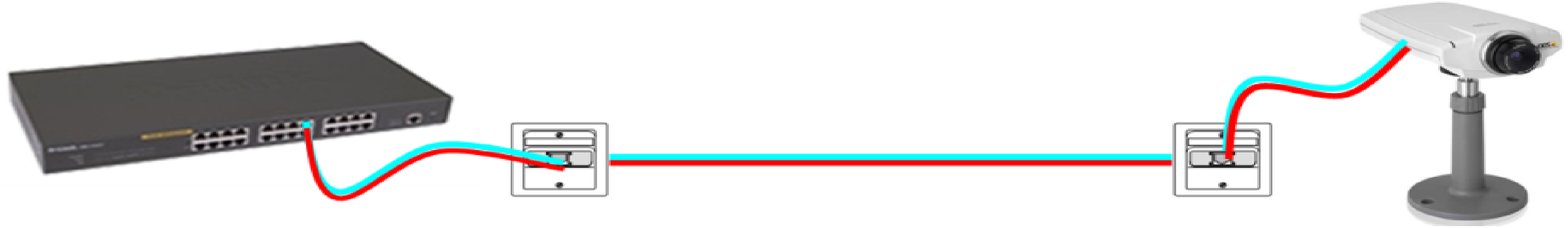
FHI INDUSTRIËLE AUTOMATISERING

Introduction

- Every IT device connected to the data network needs a power source
- The idea came up to provide the power with the data → remote powering
- 2003 IEEE defined «Power over Ethernet» using (50V +/- 12%) to provide power in the Switch (Endspan insertion) or in a separate power injector (Midspan insertion)
- Since then, PoE is a big trend in building automation and IoT for ever more power



PoE

IEEE 802.3af (2003):
Power over Ethernet **(PoE)** = 15W/13W

IEEE 802.3at (2009):
PoE Plus **(PoEP)** = 26W/22W

Propriety Cisco:

*Universal PoE **(UPoE)** = 60W/54W*

***HDBase-T:** (Home entertainment)*

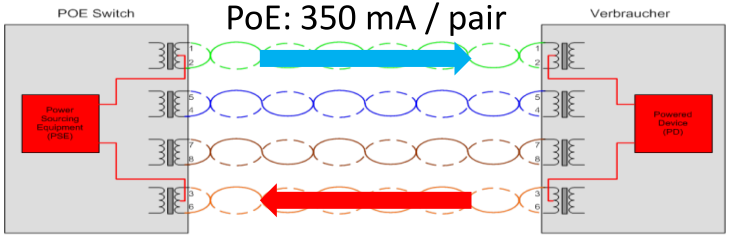
*Power over HDBase-T **(POH)** = 100W*

<u>In progress:</u>

IEEE 802.3bt:
4 Pair PoE **(4PPoE)** > 55W/49W

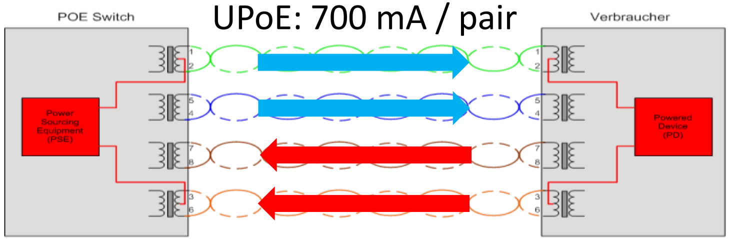
Investigations for 100W ongoing

PoE: 350 mA / pair



PoEP: 600 mA / pair

POH: 880 mA / pair
UPoE: 700 mA / pair

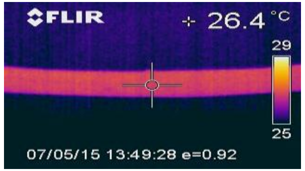


4PPoE: 650mA – 1100mA / pair

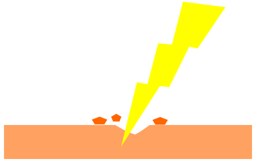
Effects of remote powering on cabling

2 different effects are considered relevant in the discussion of remote powering:

- Cable heating due to current flow in the wires
  - Transmission performance change under increased temperature
  - Life expectancy of the cable may decrease due to higher temperature



- RJ45 contact stress due to un-mating under load
  - Degradation of contact quality can negatively affect transmission reliability
  - Continuous power flow needs reliable low resistance connections



Cable heating

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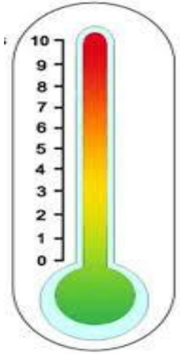
Standardization in progress

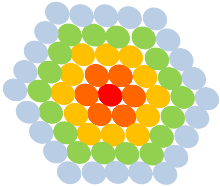
- Current flowing in cable generates heat → the temperature in the cable rises
- Higher currents → higher temperature rise
- Thinner wire diameter → higher temperature rise
- More cables bundled together → higher temperature rise
- Environmental conditions and cable construction have an influence on temperature rise



Standardization committees are working on the problem in different projects (ISO/IEC SC25: TR 29125, Cenelec TC215: EN50174-99-1)

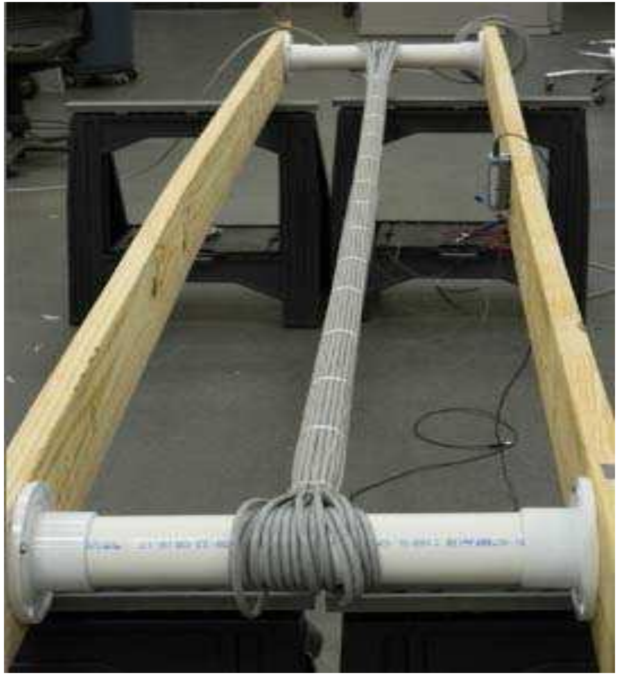
Modelling seems stable, but coefficients still for further study

Standardization model



- All cables in the bundle carry remote power
- Cables are bundled together to compact, near round shape*
- Cable must be several meters long in uniform environmental condition
- Same type of cables are used within the bundle

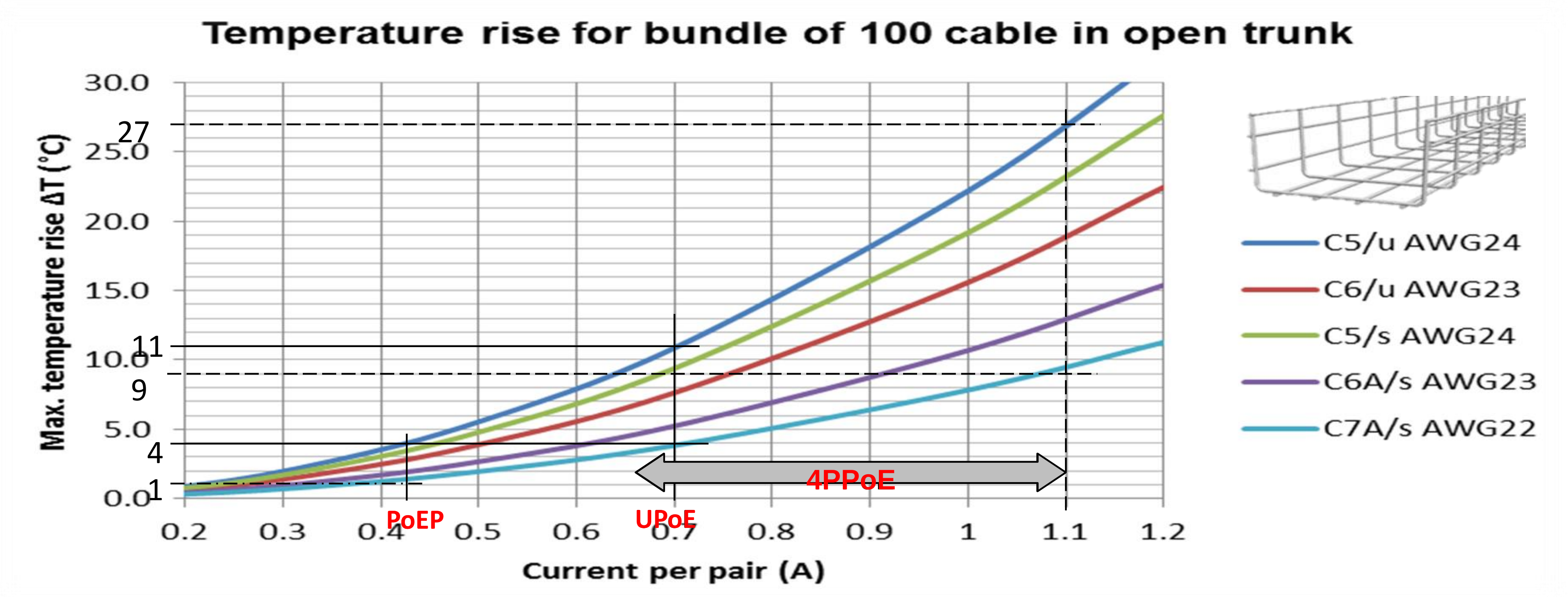
*Whether cables are placed perfectly in parallel or more randomly distributed has little influence on temperature increase



Test rig according to prTR50174-99-1

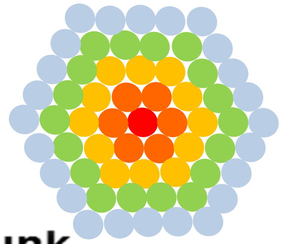
Cable heating

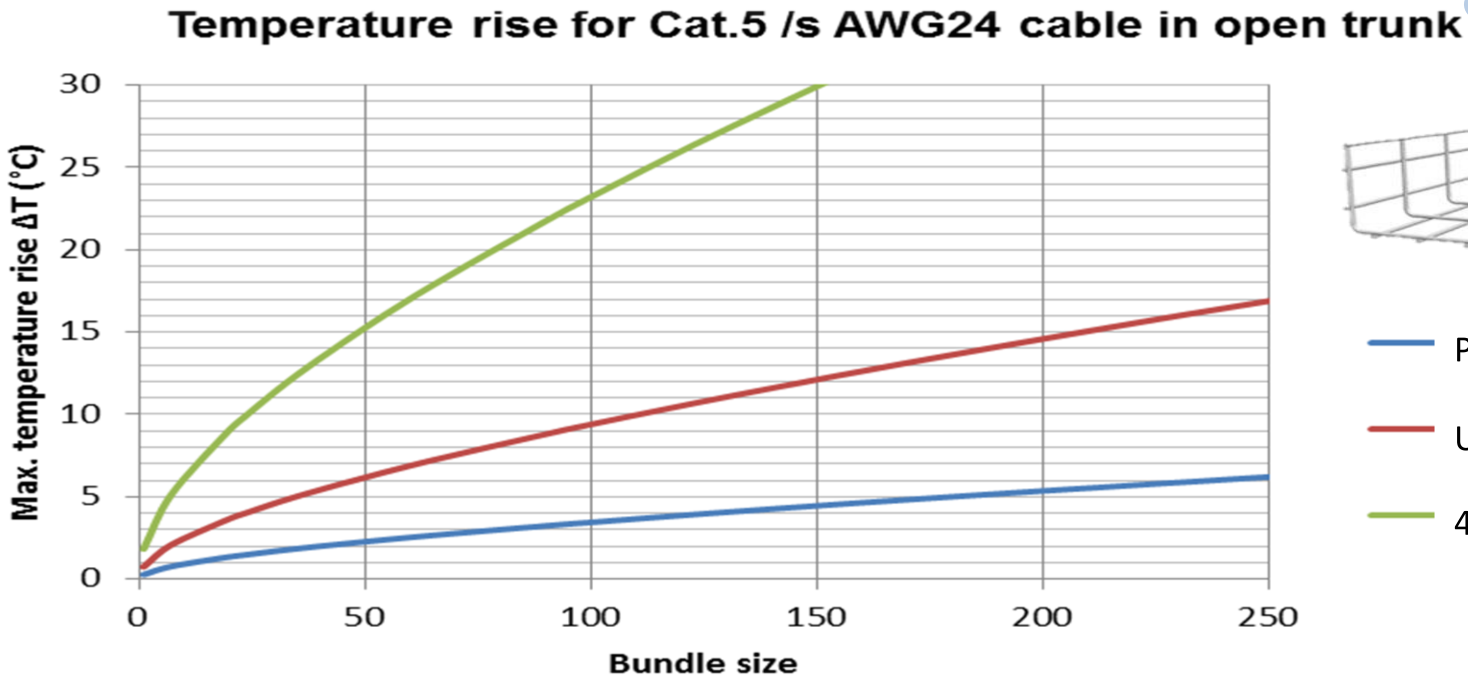
Temperature rise due to current

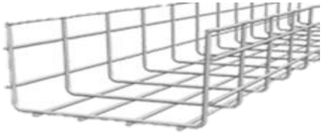


Cable heating

Temperature rise due to bundle size

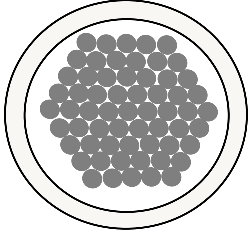


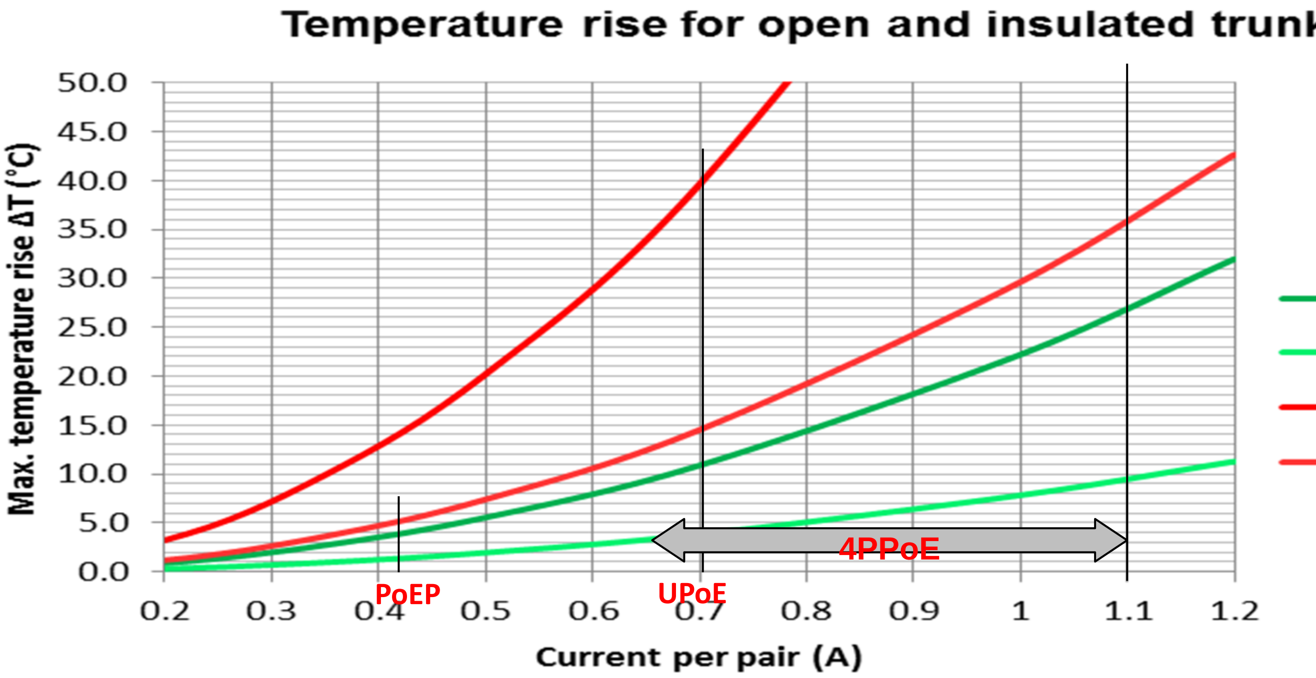




Cable heating

Temperature rise due to bundle environment





Strategies to deal with cable heating

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- Max. cable temperature must be observed
  - Most cables are designed for 60°C max. (check with supplier) → warranty!
  - Local regulations for health and safety may apply

- Change of cable properties have to be considered
  - Higher temperature creates higher link attenuation
  - Link length may have to be reduced to accommodate attenuation increase

Model	Figure	Implementation equation		
		Class D	Class E and E_A	Class F and F_A
Interconnect - TO	12a	$H = 109 - FX$	$H = 107 - 3^{a} - FX$	$H = 107 - 2^{a} - FX$
Cross-connect - TO	12b	$H = 107 - FX$	$H = 106 - 3^{a} - FX$	$H = 106 - 3^{a} - FX$
Interconnect - CP -TO	12c	$H = 107 - FX - CY$	$H = 106 - 3^{a} - FX - CY$	$H = 106 - 3^{a} - FX - CY$
Cross-connect - CP - TO	12d	$H = 105 - FX - CY$	$H = 105 - 3^{a} - FX - CY$	$H = 105 - 3^{a} - FX - CY$

H the maximum length of the fixed horizontal cable (m)
F combined length of patch cords/jumpers, equipment and work area cords (m)
C the length of the CP cable (m)
X the ratio of cord cable insertion loss (dB/m) to fixed horizontal cable insertion loss (dB/m)
Y the ratio of CP cable insertion loss (dB/m) to fixed horizontal cable insertion loss (dB/m)

NOTE For operating temperatures above 20 °C, H should be reduced by 0,2 % per °C for screened cables; 0,4 % per °C (20 °C to 40 °C) and 0,6 % per °C (>40 °C to 60 °C) for unscreened cables.

[a] This length reduction is to provide an allocated margin to accommodate insertion loss deviation.

At operating temperatures above 20°C, the maximum link length H must be reduced as follows:
Shielded cabling: 0,2% per °C
Unshielded cabling: 0,4% from > 20°C – 40°C
0,6% from > 40°C – 60°C per degree

PL length calculator for remote powering

Delivered current per wire = ½ current per pair

No. of wires carrying current (both ways)

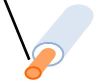
Current: 0.35 A   Wires: 4

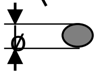
Cable type	Electrical Channel length (Standard)	Attenuation reserve of cable for app. Class	Installation cable diameter (mm)	Cable resistance (Ω/100m)	Combined patch cords length (m)	Patch cord factor	Theoretical max. PL length (m)	Ambient temperature (°C)	Cable bundle coefficent	Bundle thickness (mm)	Bundle width (mm)	Bundel size equivalent	Temp. increase inside bundle (°C)	Bundle environment coefficent	Temp. Increase of bundle (°C)	Total temp. (ambient + increase) (°C)	Attenuation faktor (% pro °C)	Max. PL length * (m)	Max.ambient temp. for 60°C copper temp. (°C)
Cat5e/u (AWG24)	109	1.00	5	9.5	10	1.2	97.0	30	5.00	50	100	136	2.52	0.40	8.4	41	0.4	89	49
Cat6/u (AWG23)	109	1.05	6	7.5	10	1.5	99.5	30	5.00	50	100	95	1.39	0.40	4.6	36	0.4	93	54
Cat6A/u (AWG23)	109	1.10	7.2	9.5	10	1.5	104.9	30	5.00	50	100	82	1.52	0.40	4.5	36	0.4	98	54
Cat5e/s (AWG24)	109	1.00	5	9.5	10	1.5	94.0	30	3.00	50	100	136	1.51	0.40	8.4	40	0.2	90	50
Cat6A/s; Cat7/s (AWG23)	109	1.10	7.5	7.5	10	1.5	104.9	30	2.50	50	100	57	0.42	0.40	2.9	33	0.2	102	57
Cat7A/s (AWG22)	109	1.15	8.5	6	10	1.5	110.4	30	2.50	50	100	53	0.31	0.40	1.9	32	0.2	108	58

PL calculation according to standard

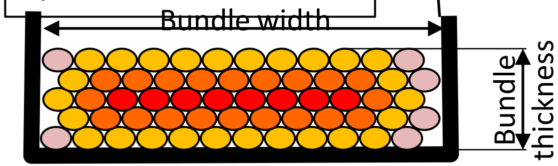
Class D:	109m
Class E_A:	104m
Class F_A:	105m

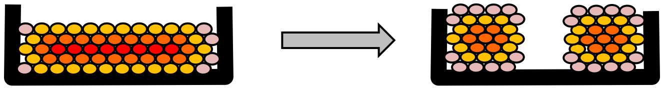
Cat.6_A / Cat.5e:	110%
Cat.7_A / Cat.5e:	115%
Cat.7_A / Cat.6_A:	105%



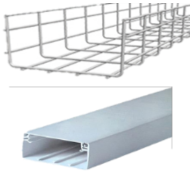


To be standardized:
U/UTP: 5.0
F/UTP: 3.0
S/FTP: 2.5

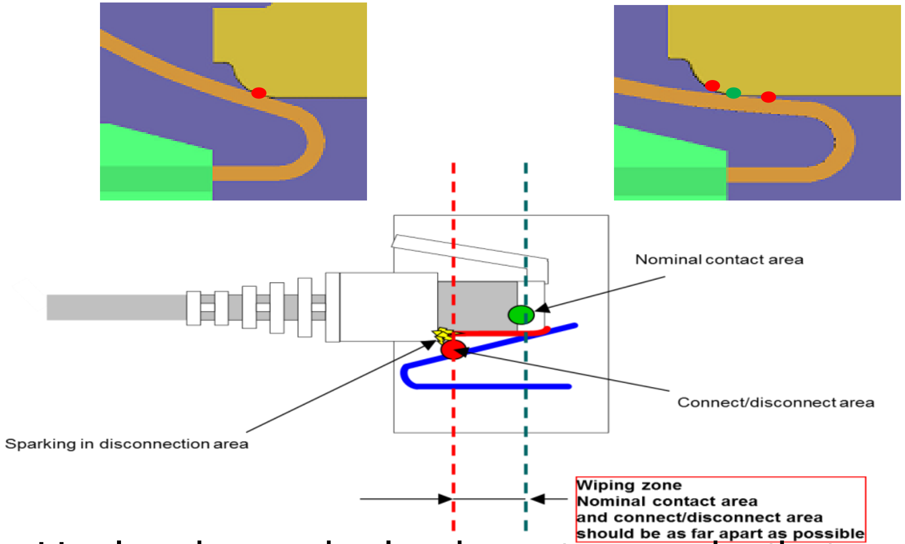


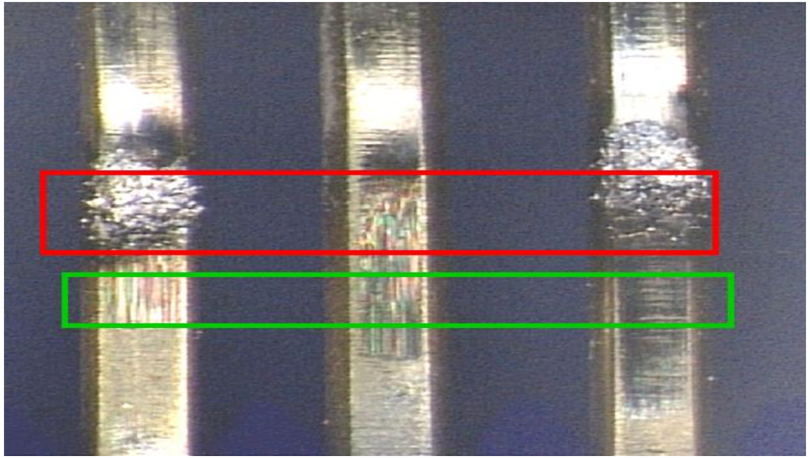


To be standardized:
Open Pathway: 0.2
Closed Trunk: 0.4
Insulated Trunk: 1.0



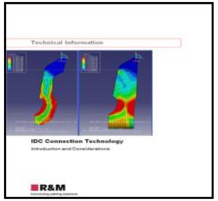
Effects on connectivity: contact stress

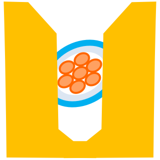


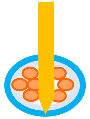


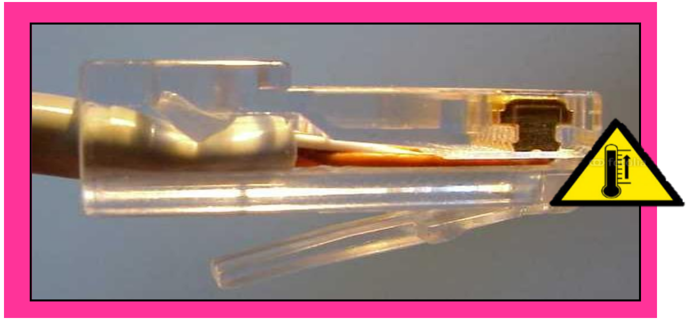
- Unplugging under load creates sparks that can destroy the contacts
- The higher the transmitted power the higher the destruction
- Whether a RJ45 jack is affected depends on mechanical construction

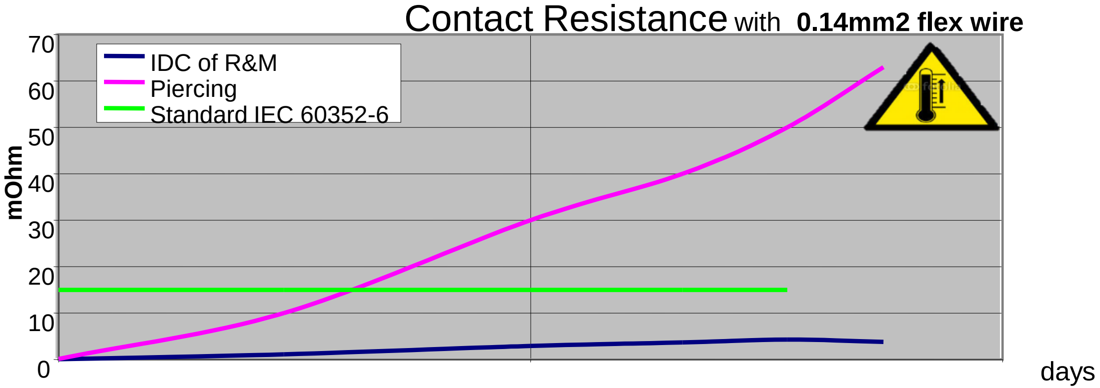
Reliable Connectivity

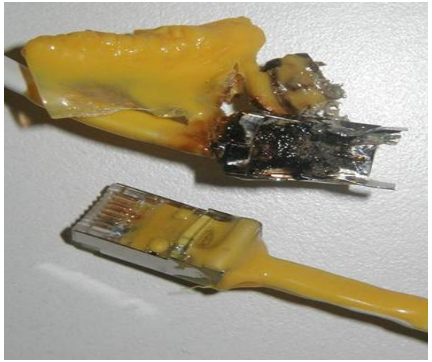












Message of today

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- To ensure proper operation of remote power over data cabling the attenuation budged has to be managed according to the expected temperatures
- Large cable bundles should be avoided,
  Multiple, separated smaller bundles are better than one big one.
- Heat accumulation in cable pathways should be avoided and air flow should be assured as much as possible
- Shielded cabling allows for longer cable runs than unshielded cabling
- Bigger copper diameter cables allow for longer cable runs (-1 AWG class)
- Observe maximum temperature (60°C) even when attenuation is ok
- Connectors should be selected to allow reliable power transmission over the intended life time of the cabling (select design with long wiping zone)
- IDC connections have better long term reliability than piercing techniques

Thank you!

For further information

R&M, Robert Post
Forehand, Richard Vermeulen