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Power over Ethernet

Requirements and Limitations due to the Cabling System

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- Code Requirements and Approvals
- the meaning of Cable Rating in NEC and UL 444/CSA 22.2 No. 214 (and any other code)
- Requirements to meet the IS 11801 Standard and the TIA Premises Cabling Standard
- IEC Cable Requirements:
  - Attenuation as a function of temperature
  - Internal heat generation due to current
- IEC RJ-45 Connector Requirement
  - Repetitive un-plugging of a live load circuit

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The codes consider three critical Temperatures for cable rating:

Conductor surface temperature

Insulation or jacket surface temperature

Ambient temperature

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Background and History :

- the rating temperature is all to often confounded with ambient temperature, especially in the user base
- the reason for this is a past oversight of all standard organizations. The currents were so low, that in fact the temperature difference, rating temperature minus ambient temperature, was so small that it fell into the temperature range of measurement accuracy – so nobody cared !!!
- but, most of the deployed cables are RATED to 60^{o}C conductor surface temperature !!!

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NEC Code (2005) Article 310-10 NEC (2005):

“Temperature limitations of conductors: No conductor shall be used in such a manner that its operating temperature exceeds that designated for the type of insulated conductor involved. In no case shall conductors be associated together in such a way, with respect to type of circuit, the wiring method employed, or the number of conductors, that the limiting temperature of any conductor is exceeded.”

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NEC Code (2005) Article 310-15 NEC (2005):

“Ampacity for conductors rated 0 – 2000 Volts”: Gives a formula to calculate the maximum allowed current under “Engineering Supervision”, taking into account the influence of skin effect and proximity effect.

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To cope with the NEC and CEC code, UL444/CSA 22.2 No. 214 rates data grade cables according the temperature the insulation / jacketing material can sustain, going from 60°C to 250°C

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According to NEC and CEC code data cables are Class CL2 or CL3 power-limited cables. NEC has no power limits in article 800 for communication cables, but they are understood to be within the Class CL3 limits. Premises Cables are rated 60 ºC (few are 75 ºC). That means a maximum of 60 ºC or 75 ºC conductor surface temperature.

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The attenuation increase of the cables over temperature is already standardized in IEC 61156 – 5 and – 6 and the corresponding test method will be included in IEC 61156 – 1. In North America the test method is already included in ASTM D – 4566 - 2005.

Limits will be set – if it is not yet already done – by ICEA (Insulated Cable Engineers Association)

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The attenuation increase has to be considered as having an integral impact over the length of the installed cable due to longitudinally varying temperatures. There are no major problems to be expected, as the attenuation improved substantially over the last couple of years.

This does not alleviate the problem of overheating due to current loading over the rated temperature due to bundling

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Impact of the Current loading

The current yields a temperature increase of the conductor. The heat generated inside a cable containing insulated conductors is dissipated into the environment (here assumed to have infinite boundaries) by conduction, convection and radiation through the insulation and the jacket.

This can be calculated.

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The conductor surface temperature for different cable configurations has been calculated under lenient conditions, i.e. a uniform heat dissipation throughout the cable bundle has been assumed. The current has then been reduced for the center cable or cables by 75 % per surrounding cable layer (also lenient)

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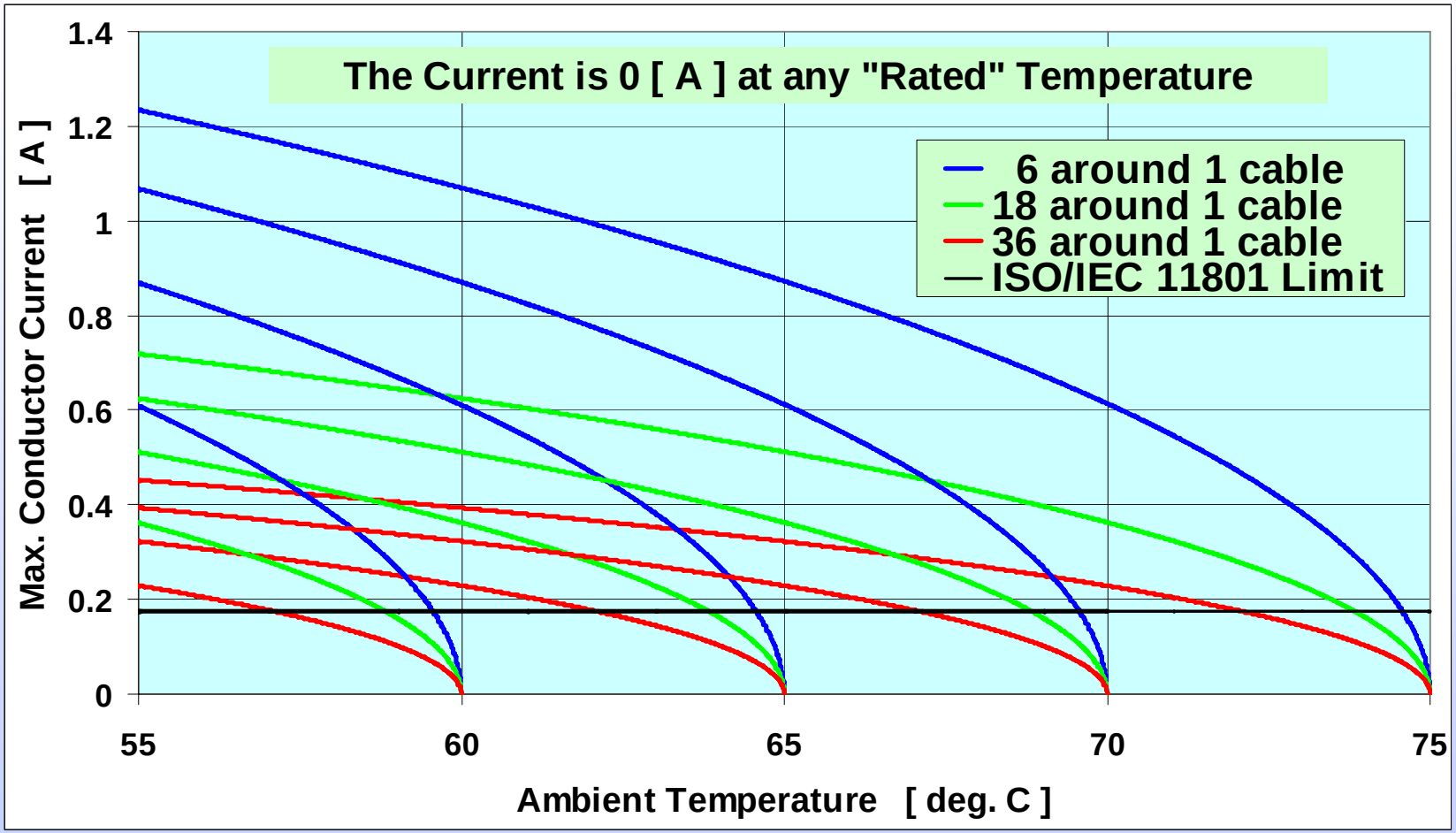

Maximum conductor current as a function of the ambient temperature for different cable configurations under assumption of different “rating” temperatures

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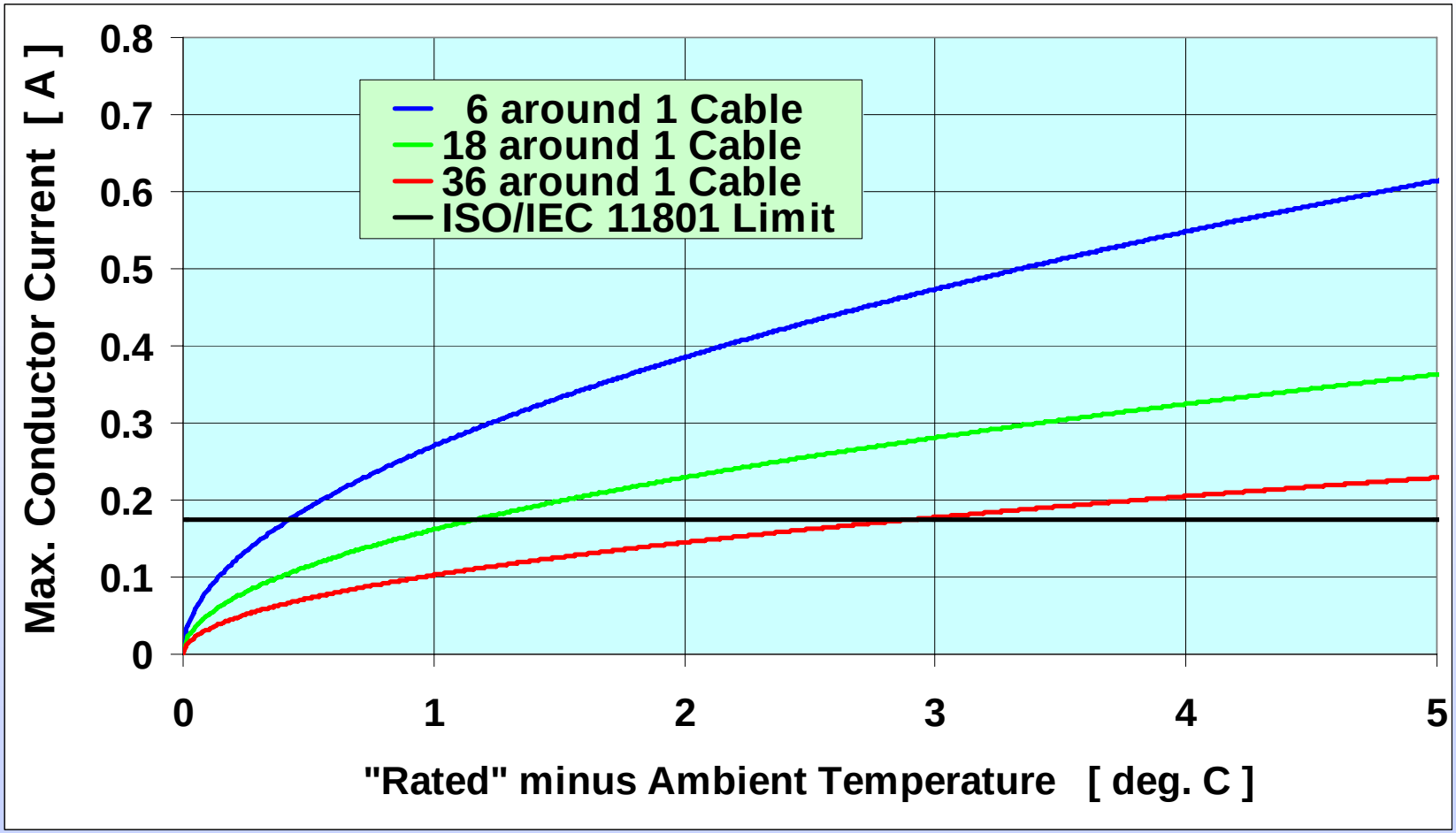

Maximum conductor current as a function of the difference of “rated” and ambient temperature

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At least for the 18 around 1 and 36 around 1 cable configuration the temperature deviation between ambient and rated temperatures are greater than 1 ºC. Hence, it cannot be argued anymore that the difference falls within the measurement accuracy. Furthermore it has to be reiterated that the calculations yield very lenient results, and it has to be anticipated that the real conductor surface temperatures in the center cable are higher.

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As a Result :

- the Cables for the Power over the Ethernet have to have a higher Temperature Rating than 60 °C.
  The next higher Class has a Rating of 75 °C.
- PoE, even at the actual Current Specification Limit of ISO/IEC 11801 cannot be legally deployed over the installed Base, without having 75 °C rated Cables already in Place.

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The Cables close to the Equipment Rooms, and inside the Equipment Rooms are frequently tightly bundled in Numbers vastly exceeding those considered here.

Therefore it has to be re-iterated that the here presented Results are based on extremely lenient Conditions.

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Cables for the Power over the Ethernet are not specifically covered by any code article. However, the existing installed base can legally not be used for this application.

A higher temperature rating is mandatory for such cables

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However, the Cable Performance of the installed Base is not the only limiting Factor to be seriously considered.
The Connectors themselves represent another Hurdle, especially upon (plugging**) and un-plugging under Load.**
IEC SC 48B, responsible for the Standardization of the RJ-45 Connectors considers towards this Purpose the following Load Circuit Schematics:

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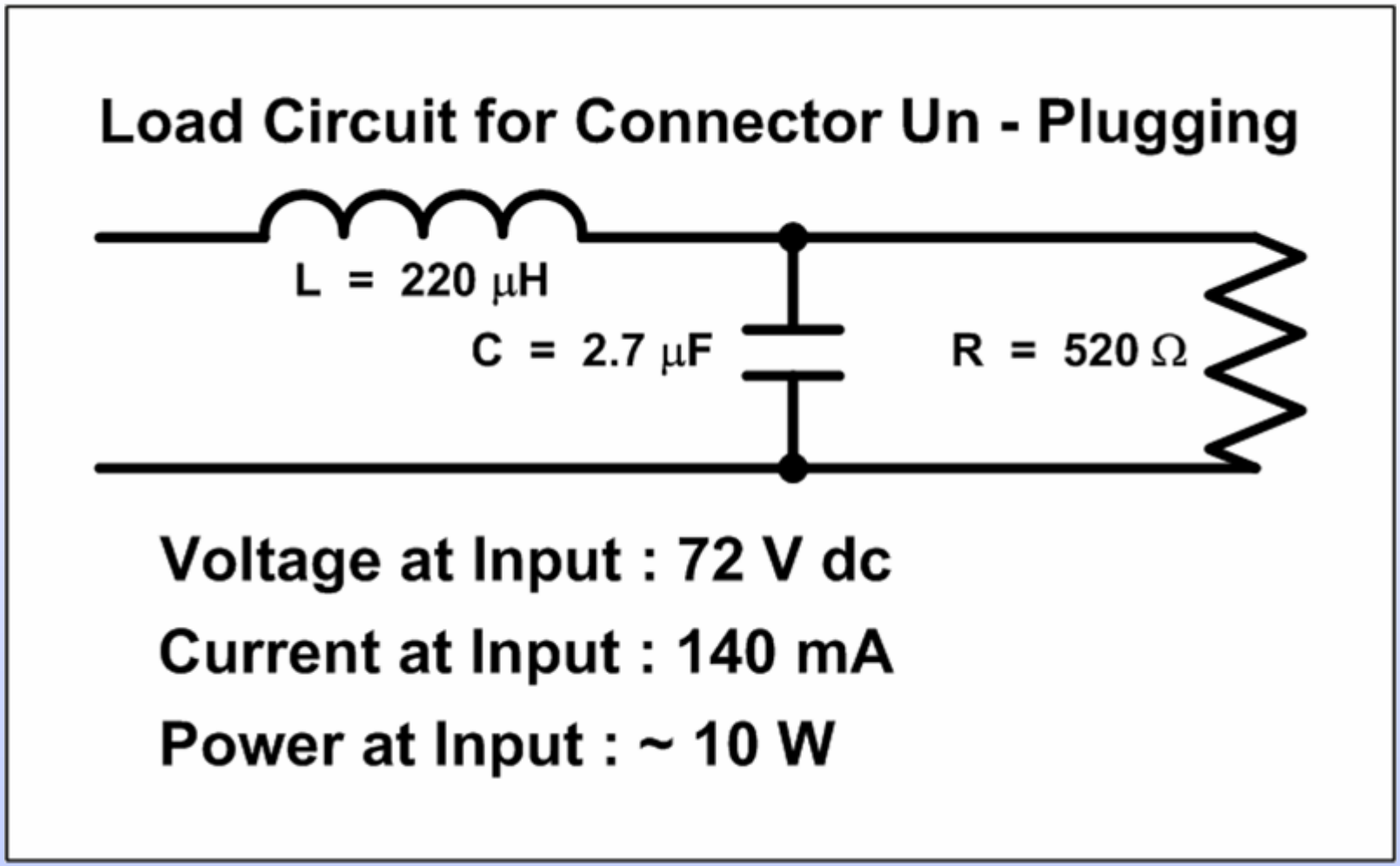

Load Circuit Schematics for Contact testing upon Un- plugging, as proposed in IEC SC 48B (RLC values not yet finalized !)

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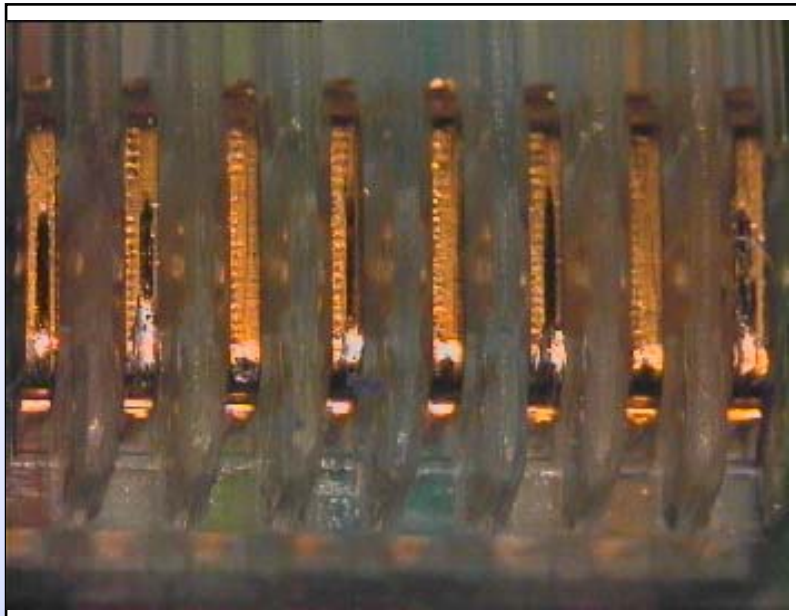
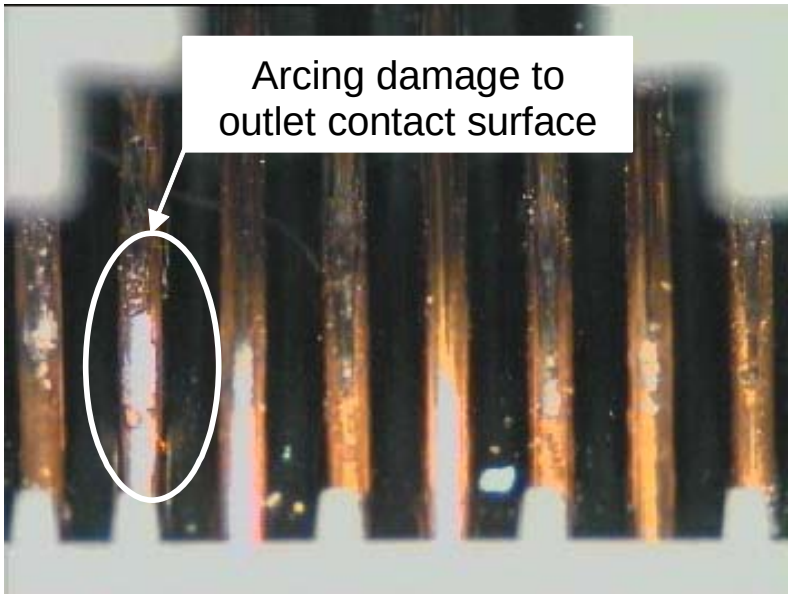


Test Plug after 750 cycles with no power applied



Test Outlet after 750 cycles with 31 Watts applied

Note: Plugging under load has a minor impact on contact deterioration. The un-plugging is the main culprit !

Pictures supplied graciously by the Siemon Company

Deterioration of the gold plated contact surface due to plugging and un-plugging under load

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Conclusion:

- Deployment on installed base is legally in most cases impossible
- Cables with a temperature rating of 75 °C have to be used
- Extreme care has to be taken with respect to the connectivity
- Eventually a more resistant connector may have to be selected