Criteria to Protect Telecommunication Cabling During a Power Cross Event

PEG CONFERENCE

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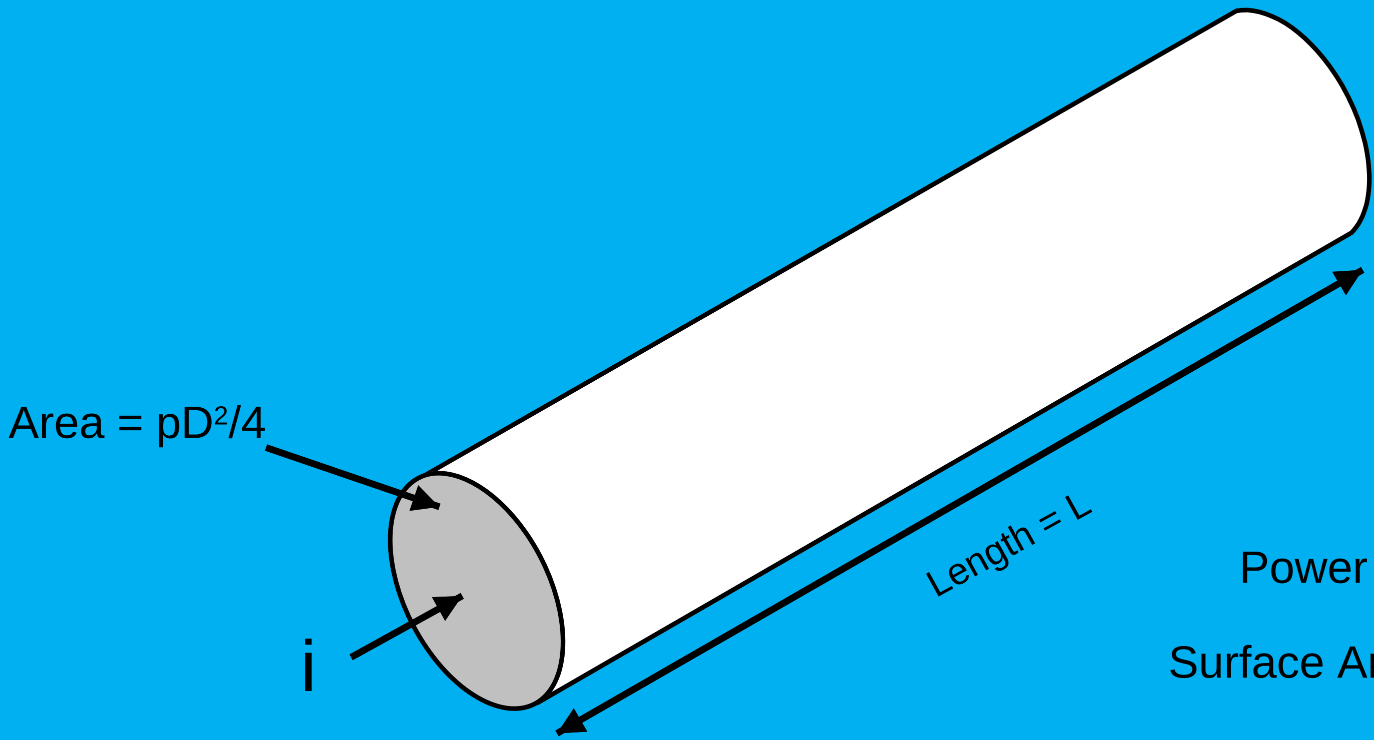
Rational for this work

- North American standards, UL 60950-1 and GR-1089-CORE, test for power fault wiring damage.
- International standards, IEC and ITU-T, don't test for power fault wiring damage.
- This work created ITU-T Supplement 3 (2015): *ITU-T K.20, K.21, K.45 and K.82 – Additional criteria to protect telecommunication cabling during a power cross event*

Just a piece of wire



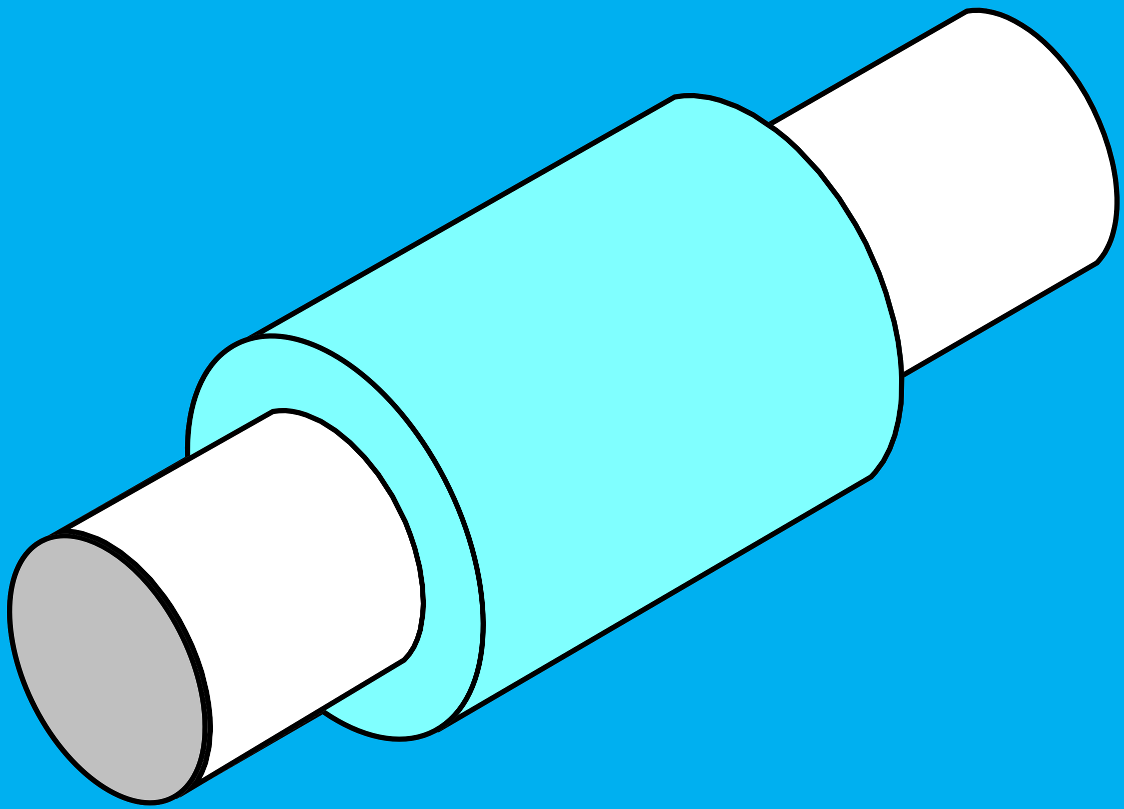
$R = r\,L/(pD^2/4)$

Power Loss = $P = i^2R$

Surface Area = $SA = pDL$

Surface power density = $P/SA = 4i^2r/(p^2D^3)$

Insulation damage sets temperature limit



DC fusing current of wires in free air (Preece)

$$I = A * d^{1.5}$$

Where *I* is the wire fusing current, *d* is the wire diameter and *A* is a constant, dependent of units system and the wire material. For a copper wire of diameter of *d* mm, the equation becomes:

$$I = 80 * d^{1.5}$$

For example, 32 AWG has a diameter of 0.2019 mm, making $I = 80 * 0.2019^{1.5}$ = 7.3 A.

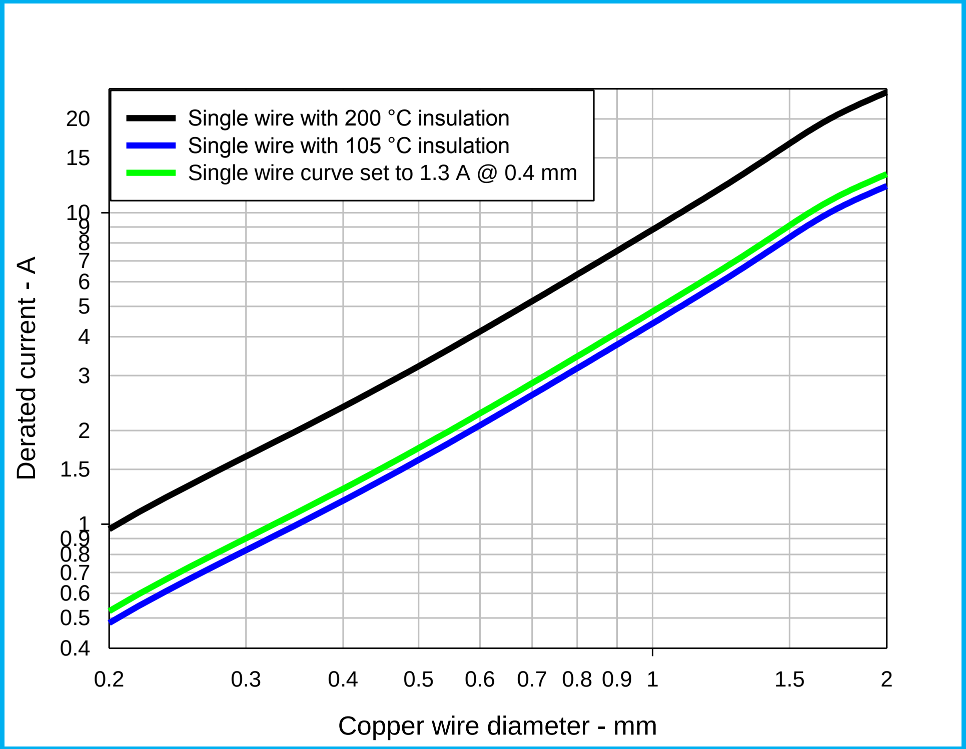
Preece W. H., *On the Heating Effects of Electric Currents*, Proc. Royal Society 36, 464 - 471 (1883). No. II, 43, 280 - 295 (1887). No. III, 44, 109 - 111 (1888).
(Retrieved 2015-09 from www.ultracad.com/articles/reprints/preece.zip)

DC Insulation damage current

- MIL-STD-975 section 3.16 Wire and Cable Derating Criteria gives maximum currents for an ambient of 70 °C and various insulator maximum temperatures (Teflon at 200 °C down to types of PVC at 105 °C).
- For cable bunches, a derating factor of (28-N)/27 should be applied, where N is the number of conductors. The derating factor is taken as a constant value once the bundle exceeds fifteen conductors.

MIL-STD-975M NASA, Standard Electrical, Electronic and Electromechnical (EEE) Parts List, 5 August 1994

DC levels to avoid insulation damage



MIL-STD-975 derated current versus wire diameter

Adiabatic (thermal capacity) conditions Onderdonk equation

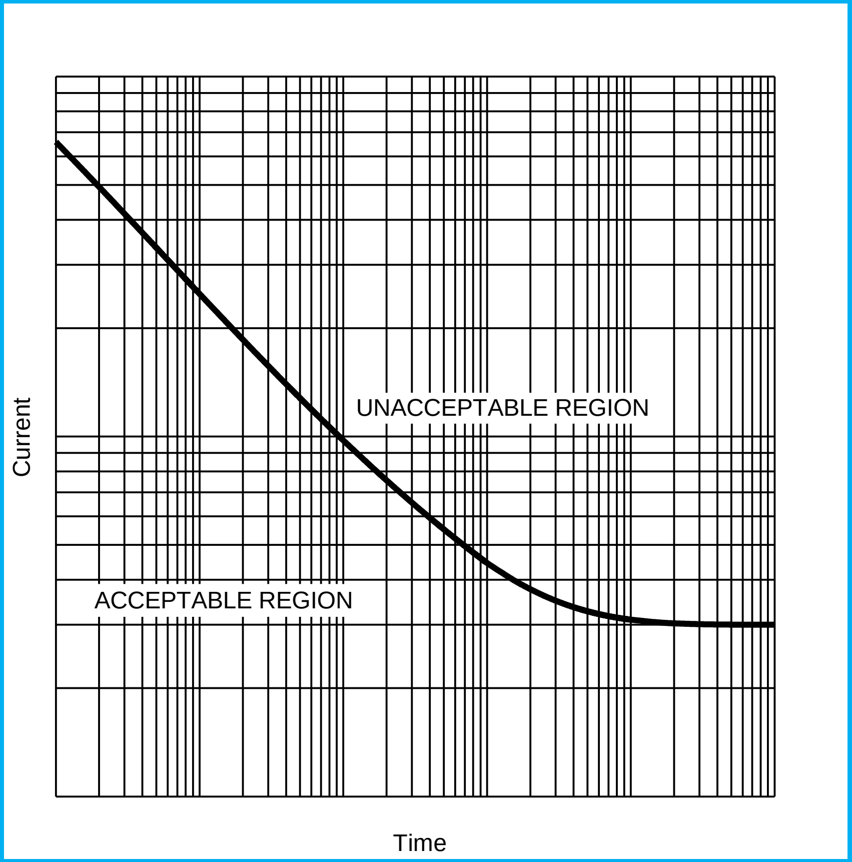
$$I^2 t = 7.28 * 10^4 * d^4 * LOG\left(\frac{\Delta T}{274} + 1\right)$$

Where
I (A) is the wire current,
d (mm) is the wire diameter,
t (s) is the current flow time, and
ΔT is the temperature difference (°C) between the wire and ambient.
For an ambient of 30 °C and the copper melting temperature of 1083 °C, the equation becomes:

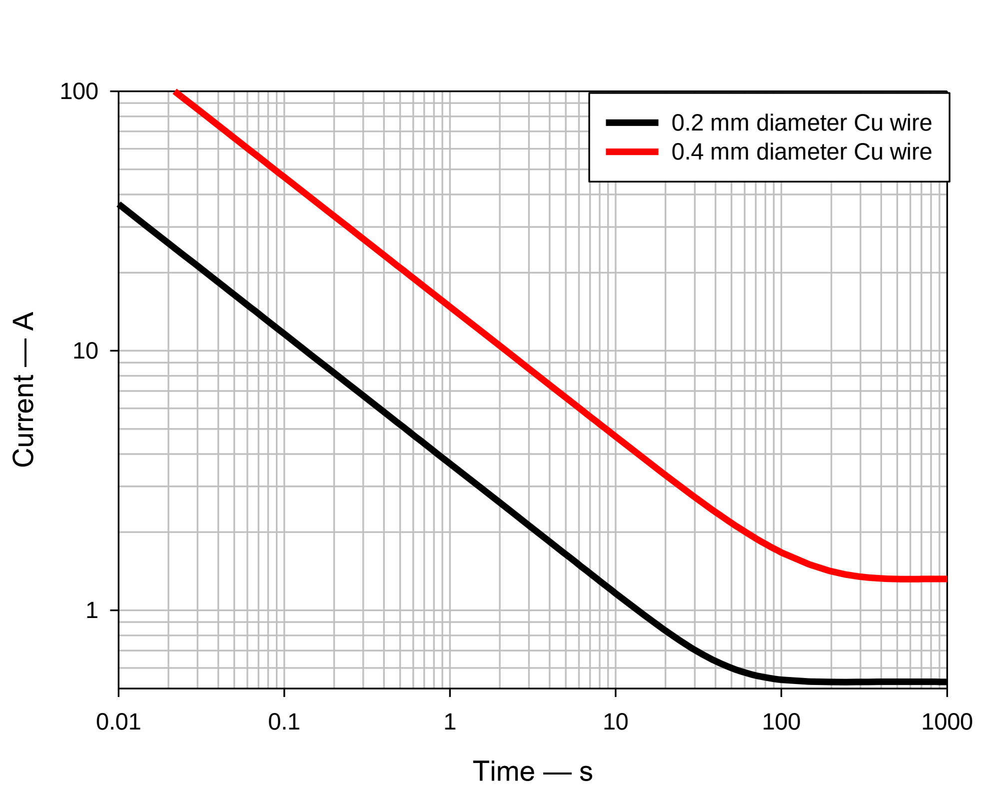
$$I^2 t = 5 * 10^4 * d^4$$

Adam J. & Brooks D., In Search for Preece and Onderdonk, 2015 (retrieved 2015-09 http://www.ultracad.com/articles/preece.pdf)
ANSI/ICEA PUBLICATION P-32-382-2007, Short circuit characteristics of insulated cables

Typical wire current-time curve



Insulation damage limit current-time curve for 0.2 mm and 0.4 mm copper wire



Based on the P-32-382 i^2t values and the IEC 60950 equivalent DC values from Table I1 in Appendix I.

Parameters for 18 to 32 AWG

Wire AWG	Dia (mm)	Preece DC Fusing (A)	Onderdonk transient melting i^2t (A^2s)	ICEA standard P-32-382 i^2t (A^2s)	IEC 60950-1 DC Figure I.1 (A)
18	1.0237	82.7	64787	8881	4.99
19	0.9116	69.5	40745	5588	4.19
20	0.8118	58.4	25625	3516	3.53
21	0.7229	49.1	16116	2212	2.98
22	0.6438	41.2	10135	1392	2.51
23	0.5733	34.7	6374	876	2.13
24	0.5106	29.1	4009	551	1.81
25	0.4547	24.5	2521	347	1.54
26	0.4049	20.6	1586	218	1.32
27	0.3606	17.3	997	137	1.14
28	0.3211	14.5	627	86.3	0.98
29	0.2859	12.2	394	54.3	0.85
30	0.2546	10.3	248	34.2	0.73
31	0.2268	8.61	156	21.5	0.63
32	0.2019	7.24	98	13.5	0.53

Evolution of North American wiring simulators

- ANSI/TIA/EIA-571 and ANSI/TIA/EIA-571A
- UL 1459-1998
- UL 60950-1
- GR-1089-CORE, Issue 6
- Stub links and block cable

Protection Engineers Group

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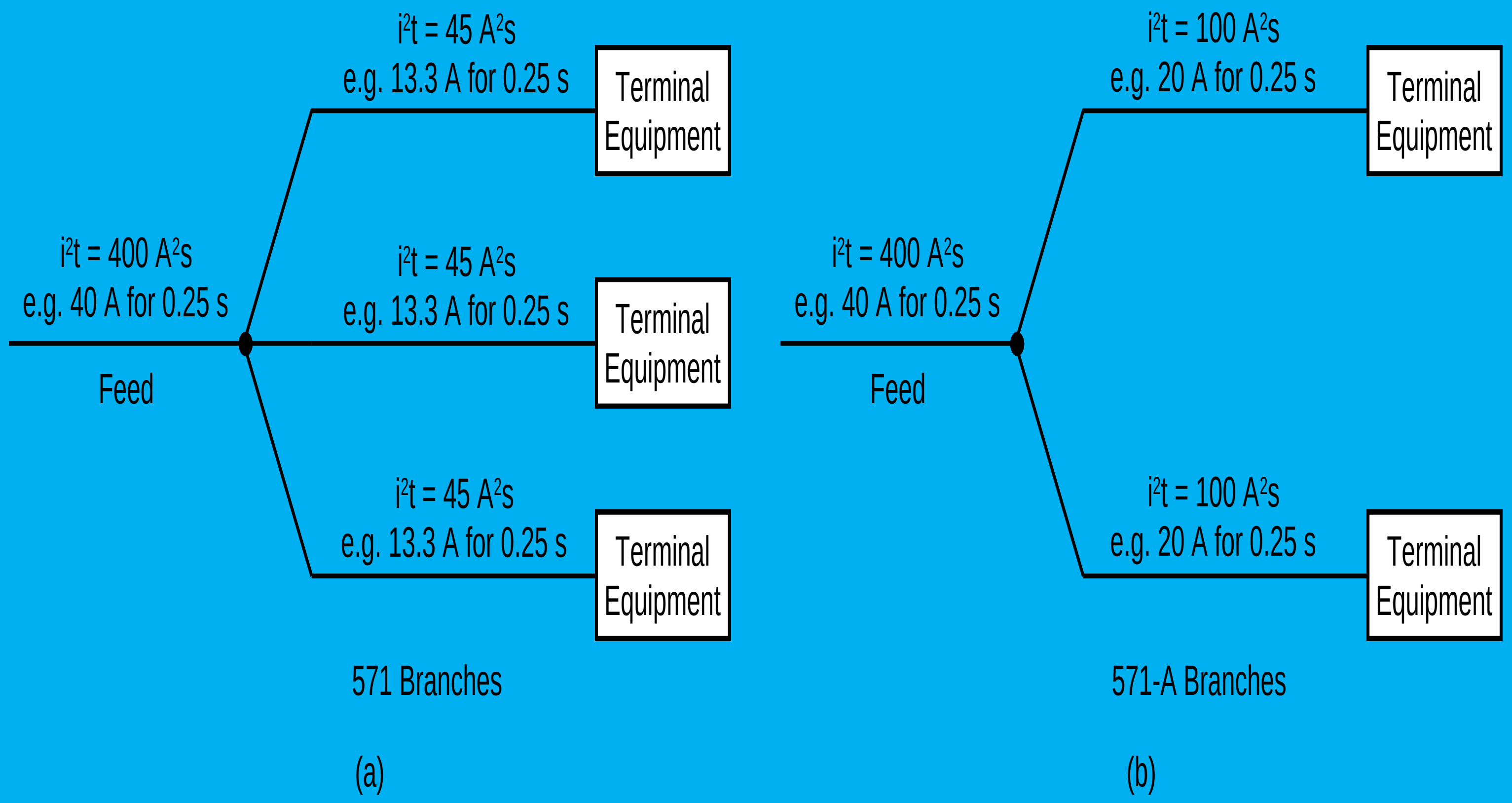
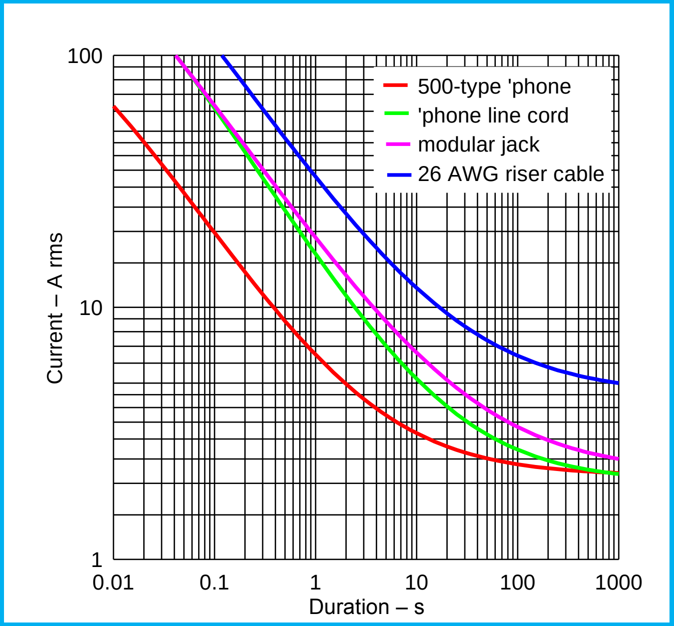
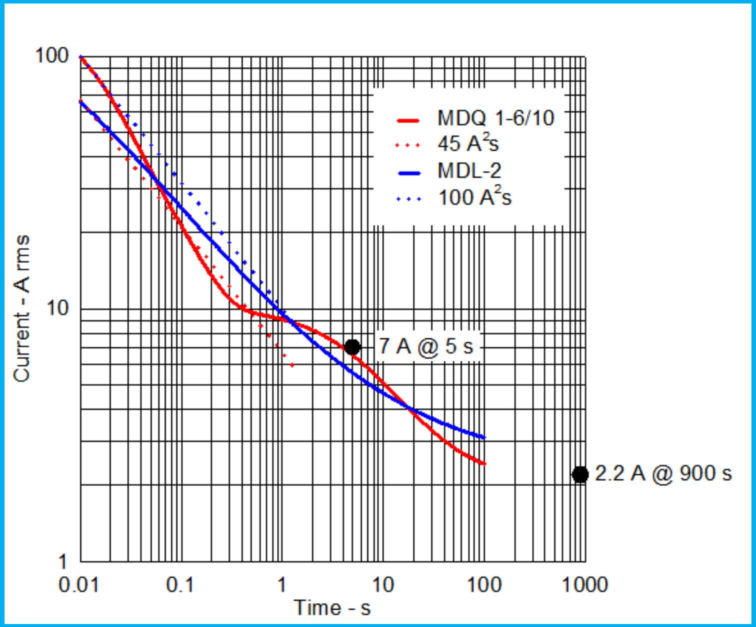
EIA-571(A), 1992 (1999), Telecommunications User Premises Equipment Environmental Considerations – current division

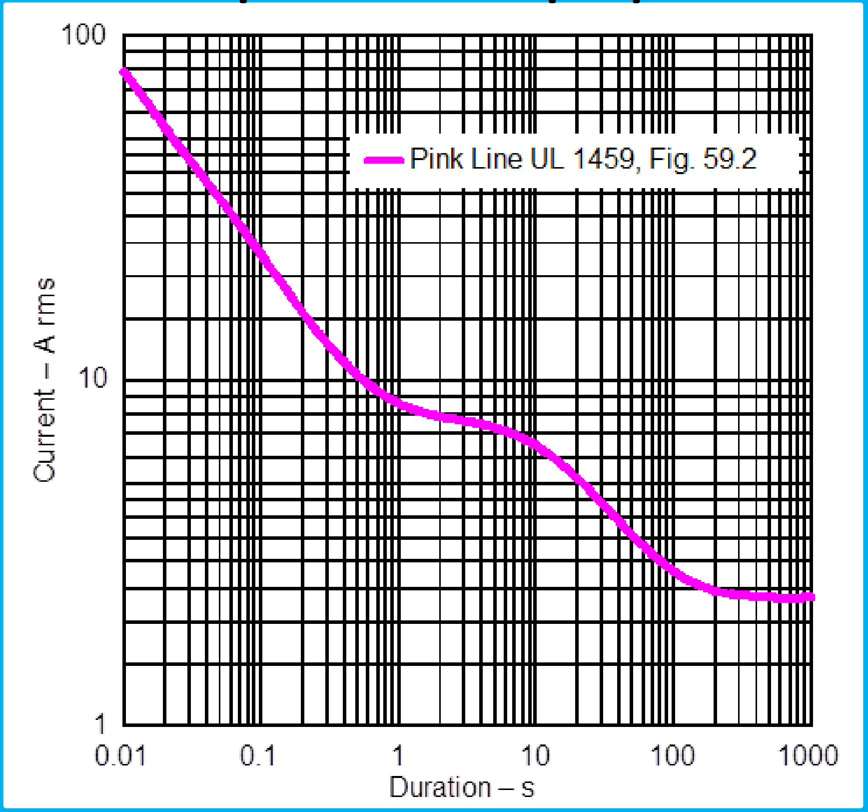


EIA-571(A), 1992 (1999), Telecommunications User Premises Equipment Environmental Considerations – I-t curves



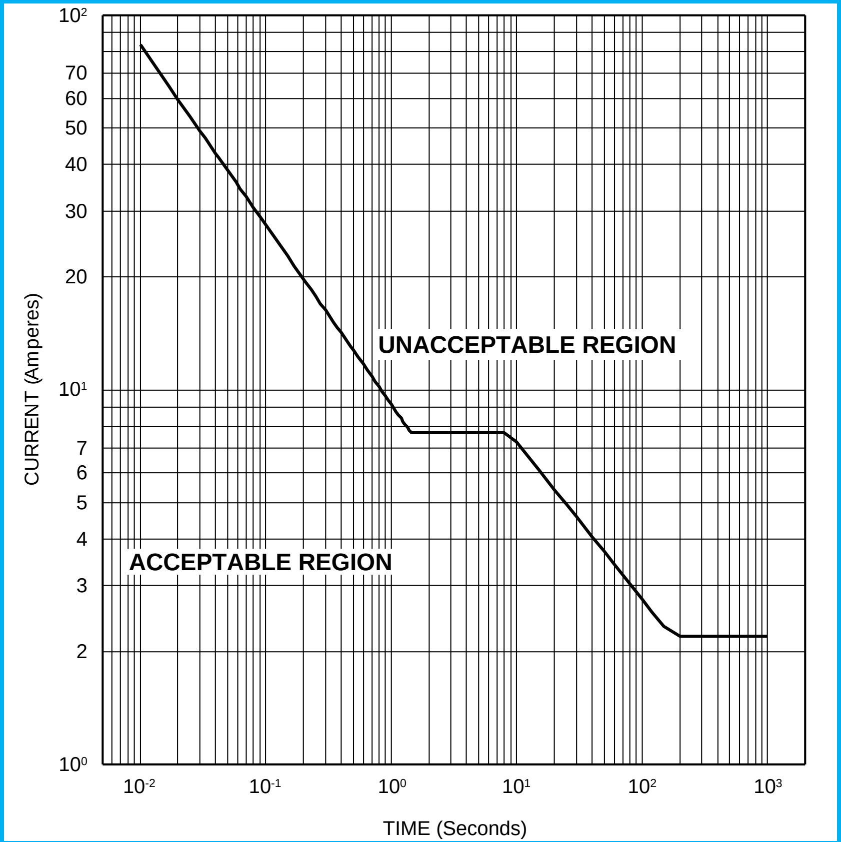


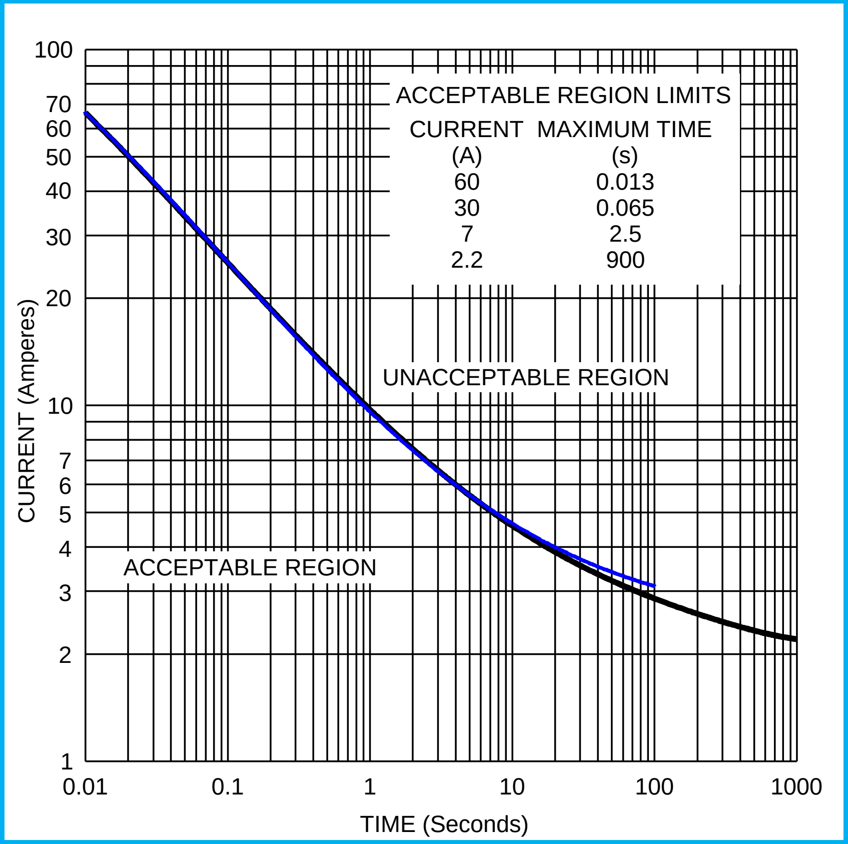
UL 1459 (1995): UL standard for safety - telephone equipment



UL 60950-1: Information Technology Equipment - Safety - Part 1: General Requirements used an MDL-2 fuse

GR-1089-CORE, Issue 6, 2011, Electromagnetic Compatibility and Electrical Safety - Generic Criteria for Network Telecommunications Equipment





Stub links and block cable

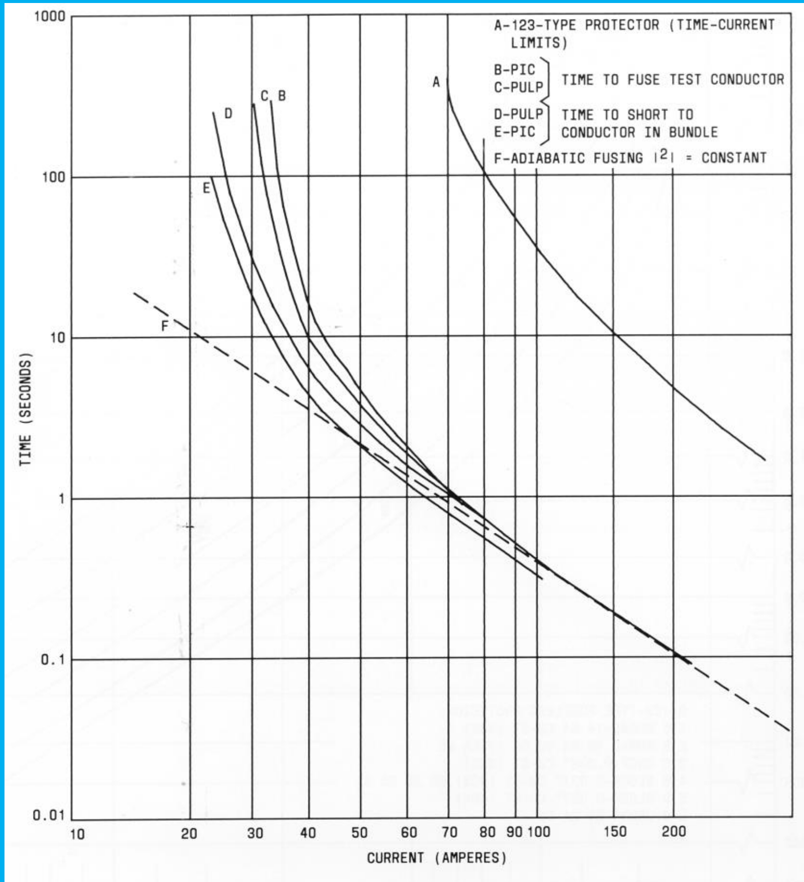


Fig. 15.30—Protective Characteristics of 24-Gauge Copper Cable and the Safe Time-Current Capability of 123-Type Fuseless Protector

Closing Remarks

- All simulations are based on an i^2t limitation for adiabatic times and a fixed current value for thermal equilibrium times.
- The derivation of Norther American simulation curves are based on testing.
- Simulation curves based on insulation temperature rise are more conservative. Example, 26 AWG has a North American fixed current limit of 2.2 A, but in IEC safety standards it is 1.3 A.