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SERIES K: PROTECTION AGAINST INTERFERENCE

ITU-T K.20, K.21, K.45, K.82 – Additional criteria to protect telecommunication cabling during a power cross event

ITU-T K-series Recommendations – Supplement 3

Supplement 3 to ITU-T K-series Recommendations

ITU-T K.20, K.21, K.45, K.82 – Additional criteria to protect telecommunication cabling during a power cross event

Summary

Supplement to the ITU-T K-series Recommendations provides criteria that enable the implementation of power cross protection for telecommunication cabling connected to equipment compliant with ITU-T K.20, ITU-T K.21 and ITU-T K.45.

This supplement aims to:

- Provide current-time limitations to protect telecommunication cabling from fusing and wire insulation damage.
- Explain the evolution of physical wiring simulators and their drawbacks.
- Provide designers with the tools to extrapolate the supplement current-time limitations data to larger and smaller conductor sizes.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T K Suppl. 3	2015-10-23	5	11.1002/1000/12686

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

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ITU-T K.20, K.21, K.45, K.82 – Additional criteria to protect telecommunication cabling during a power cross event

1 Introduction

ITU-T equipment Recommendations [b-ITU-T K.20], [b-ITU-T K.21] and [b-ITU-T K.45] have power cross tests with prospective currents ranging from 0.23 A to 23 A. These power cross tests do not include an assessment of equipment feed cable heating. This Supplement provides information on the equipment overcurrent protector operate values to comprehend wiring current limitations.

Appendix I describes the tools and references a designer may use to define the overcurrent protector maximum time-current characteristic for specific wiring types. Appendix II covers the evolution of North American wiring simulators.

2 Wire current-time capability

Figure 1 shows a typical wire current-time characteristic. The current capability for short durations is governed by an adiabatic i^2t limitation, which results in the downward sloping portion current line. At longer durations (d.c.) a steady-state condition occurs resulting in a horizontal portion of the current line. This sort of curve is typically used to define the operate values of a single element fuse.

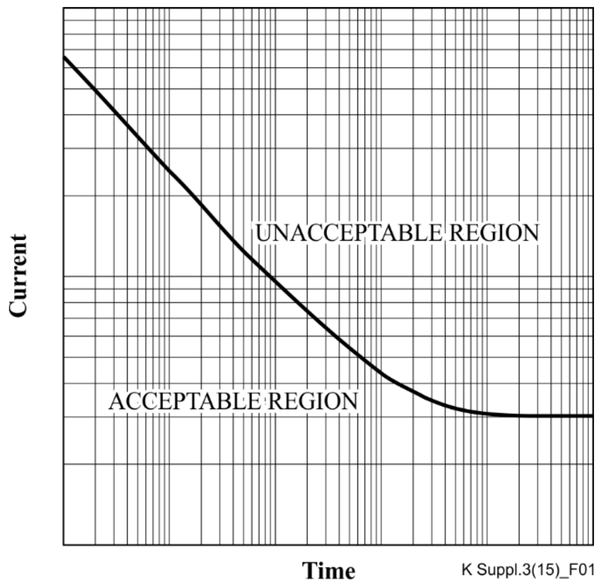

Figure 1 – Typical wire current-time curve

A current-time curve such as that in Figure 1 might be for wire conductor fusing or the onset of the wire insulation damage, or some intermediate condition. The performance requirement for the equipment overcurrent protector would be to operate in the acceptable area of the figure over the range of expected power cross current levels.

North America equipment standards have for many years included wiring simulators during a power fault event. These wiring simulators were developed to be part of a power fault test and are used as indicators of whether wiring would be damaged in an actual power fault event. Because of the country of origin of the wiring simulators, most of the data is referenced to American Wire Gauge (AWG) wire sizing. To relate the AWG to metric sizing, metric diameter equivalents are given in this supplement. For telecommunication cabling, for a given AWG, n, the wire diameter d mm can be calculated from:

$$d = 0.127 * 96^{(36-n)/39}$$

3 Wire current-time limits

3.1 Insulation damage

Figure 2 shows the limit curves for 0.4 mm and 0.2 mm diameter copper wire based on the [b-P-32-382] i^2t values and the [b-IEC 60950] equivalent DC values from Table I1 in Appendix I.

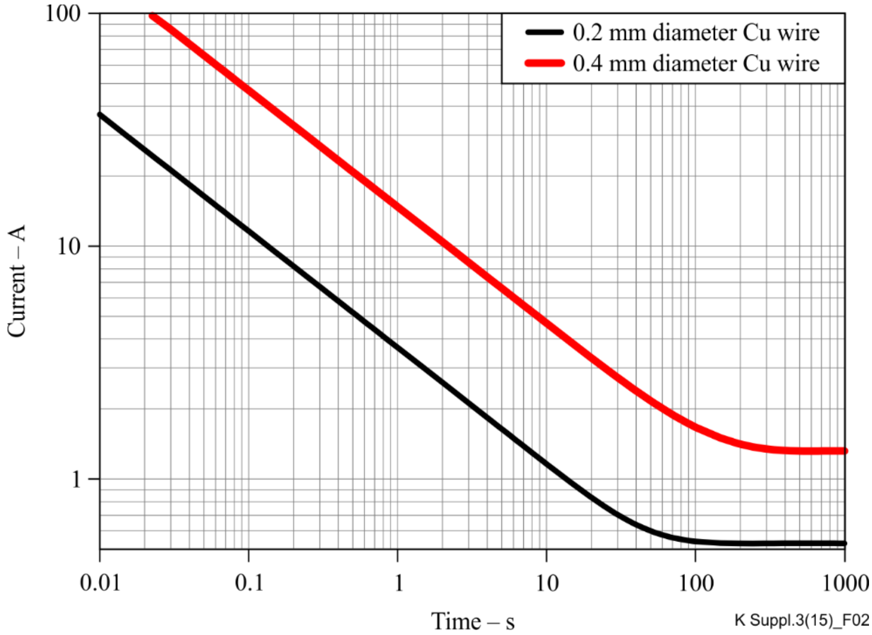

Figure 2 – Insulation damage limit current-time curve for 0.2 mm and 0.4 mm copper wire

In the steady state, long-term condition, the maximum allowed current for 0.4 mm diameter copper wire is 1.3 A and 0.2 mm wire is 0.53 A based on [b-IEC 60950] and [b-IEC 62368]. The ITU-T equipment Recommendations [b-ITU-T K.20], [b-ITU-T K.21] and [b-ITU-T K.45] power cross generator will only apply a maximum prospective current of 23 A.

3.2 North American wiring simulation

As shown in Appendix II, the wiring simulator used depends on the standard being complied with. Furthermore, the simulator that can be used may be a current-time curve, a physical simulation or both. A physical simulation can be a specified fuse or a length of AWG wire. None of the physical simulations are precision indicators, hence the move towards current-time templates. Any "universal" simulator curve should add a safety margin to cover the possible use of physical simulators. The biggest variability occurs in the steady state region [b-Lindquist].

The most popular wiring simulation fuse is the MDL-2. Here "2" indicates that the rated current is 2 A. In US standards, the MDL-2 fuse must conduct 1.1*2 = 2.2 A for four hours [b-Lindquist]. Figure 3 shows the published MDL-2 curve adjusted down to 2.2 A from the typical 2.6 A at 1000 s.

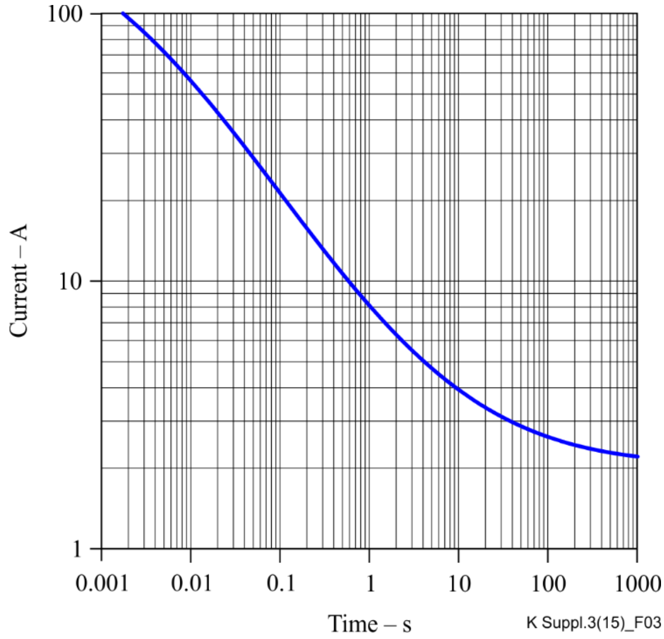

Figure 3 – MDL-2 limit current-time curve (derated to 85% of its typical value)

Points to note here are:

– The Figure 3 MDL-2 curve (derated to 85% of its typical value) falls below the 0.4 mm Figure 2 insulation damage curve for times less than 10 s. Conversely, for times greater than 20 s, the Figure 3 curve allows more current than the Figure 2 curve.

– The Figure 3 curve has a variable i^2t. At 0.01 s i^2t is 13 A^2s, 0.1s is 45 A^2s and 1 s is 65 A^2s.

Appendix I

Wire equations and data

I.1 Introduction

This appendix describes the tools and references that a designer may use to define the overcurrent protector maximum time-current characteristic for specific wiring types. Historical information on the [b-Preece] and [b-Stauffacher] referenced equations given in [b-Adams *et al*].

I.2 DC

The Preece equation [b-Preece] is used to predict the DC fusing current of wires in free air:

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

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, AWG 32 has a diameter of 0.2019 mm, making I = 80*0.2019^1.5 = 7.3 A. There have been other values of multiplier and power reported see [b-Babrauskas *et al*].

In practice, a more desirable limitation is the prevention of wire insulation damage rather than wire fusing. One reference often used is section 3.16 of [b-MIL-STD-975], Wire and Cable Derating Criteria. Figure I.1 plots the 3.16 table data for wire diameters of 0.2 mm to 2 mm. The table data is for an ambient temperature 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.

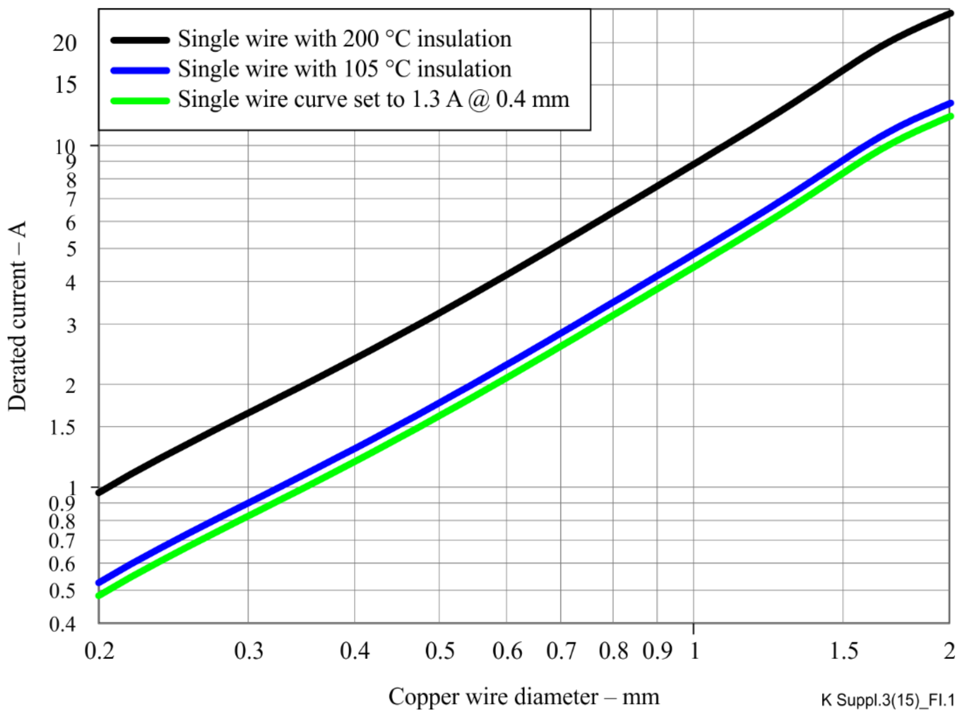

Figure I.1 – MIL-STD-975 derated current versus wire diameter

The green line in Figure I.1 is the MIL-STD-975 current curve set to 1.3 A for a wire diameter of 0.4 mm, the value specified in [b-IEC 60950-1] and [b-IEC 62368-1] safety standards.

I.3 Transient current

The Onderdonk equation referenced by [b-Stauffacher] is for adiabatic conditions and is used to predict the I^2t for a given wire temperature change for periods up to about 1 s. The I^2t value is dependent on the fourth power of the conductor diameter, *d*. The metric version of the equation is shown below:

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

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 temperature of 30 °C and the copper melting temperature of 1083 °C, the equation becomes:

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

The [b-P-32-382] standard uses the Onderdonk equation to predict the maximum wire I^2t value for no insulation damage by using the insulation damage temperature to ambient temperature difference. For PVC insulation the insulation I^2t is about 15% of the wire fusing I^2t. The reduction factor can rise to about 30% for 250 °C cable insulation.

I.4 Results

Underwriters Laboratories Inc. produced the document *An Investigation of the Use of 16 and 18 AWG Conductors for Power Branch Circuits in Industrial Machinery Applications* for the NFPA79 Small Wire Working Group [b-UL E4273]. Clause Thermal Withstand Ratings for Insulated Conductors covers equations from [b-P-32-382] (Onderdonk for no insulation damage), research conducted by [b-Middendorf] (50% insulation voltage loss), data from [b-Soares] (lug tightness lost) and the Onderdonk [b-Stauffacher] wire melting point equation.

With reference to 26 AWG wire melting I^2t [b-Stauffacher] the other condition factors were 14% P-32-382, 37% Middendorf and 29% Soares.

Table I.1 lists the [b-UL E4273] wire electrical parameters for 18 AWG to 32 AWG with PVC insulation.

Table I.1 [b-UL E4273] – Parameters for 18 to 32 AWG

Wire AWG	Dia (mm)	Preece DC Fusing (A)	Onderdonk transient melting i^2t (A^2s)	Onderdonk Preece knee (s)	Middendorf (50% insulation voltage loss) i^2t (A^2s)	ICEA standard P-32-382 i^2t (A^2s)	IEC DC Figure I.1 (A)
18	1.0237	82.7	64787	9.1	23971	8881	4.99
19	0.9116	69.5	40745	8.1	15076	5588	4.19
20	0.8118	58.4	25625	7.2	9481	3516	3.53
21	0.7229	49.1	16116	6.4	5963	2212	2.98
22	0.6438	41.2	10135	5.7	3750	1392	2.51
23	0.5733	34.7	6374	5.1	2358	876	2.13
24	0.5106	29.1	4009	4.6	1483	551	1.81
25	0.4547	24.5	2521	4.1	933	347	1.54
26	0.4049	20.6	1586	3.6	587	218	1.32
27	0.3606	17.3	997	3.2	369	137	1.14
28	0.3211	14.5	627	2.9	232	86.3	0.98
29	0.2859	12.2	394	2.6	146	54.3	0.85
30	0.2546	10.3	248	2.3	92	34.2	0.73
31	0.2268	8.61	156	2.0	58	21.5	0.63
32	0.2019	7.24	98	1.8	36	13.5	0.53

Common AWG sizes have these values [b-UL E4273]:

– 26 AWG: 0.4049 mm diameter, 20.6 A DC fusing current, 1586 A^2s melting I^2t, 587 A^2s insulation damage I^2t, 218 A^2s no insulation damage I^2t and IEC DC 1.32 A.

– 28 AWG: 0.3211 mm diameter, 14.5 A DC fusing current, 627 A^2s melting I^2t, 232 A^2s insulation damage I^2t, 86.3 A^2s no insulation damage I^2t and IEC DC 0.98 A.

– 32 AWG: 0.2019 mm diameter, 7.24 A DC fusing current, 2.2 A DC no insulation damage, 98 A^2s melting I^2t, 36 A^2s insulation damage I^2t, 13.5 A^2s no insulation damage I^2t and IEC DC 0.53 A.

Appendix II

Evolution of North American wiring simulators

II.1 Power fault sources

According to US standards, to prevent wire damage, a wiring network of traditional (0.1 mm diameter X 4 ≈ 32 AWG (0.2 mm),) phosphor bronze tinsel conductor telephone line cord feeding two pieces of terminal equipment should have its maximum current limited to:

– 2.2 A (long duration),

– 7 A for 5 s, and

– I^2t = 100 A^2s for short durations.

A single wire of 26 AWG (0.4 mm diameter) has limits of:

– 5 A (long duration), and

– I^2t = 1200 A^2s for short durations.

The maximum applied power fault stress levels are:

1) 600 Vrms, 40 Arms for 1.5 s: [b-UL 60950-1] resulting from a high voltage power line contact to a telephone shielded cable (I^2t = 2400 A^2s)

   or

   425/600 Vrms, 40 Arms for 1.5 s: [b-GR-1089-CORE] resulting from a high voltage power line contact to a telephone shielded cable (I^2t = 2400 A^2s)

2) 600 Vrms, 7 Arms for 5 s: [b-UL 60950-1] Power induction or from a ground potential rise after a power line fault to a multi-grounded neutral conductor (I^2t = 245 A^2s).

   or

   425/600 Vrms, 30 Arms for 5 s: [b-GR-1089-CORE] resulting from power induction (I^2t = 4500 A^2s)

3) 600 Vrms, 2.2 Arms steady state: [b-UL 60950-1] Induced currents from a power line fault to resistive earth.

   or

   425/600 Vrms, 2.2 Arms steady state: [b-GR-1089-CORE] resulting from current induction.

4) 120 Vrms, 25 Arms steady state: Mains power line crossed with a telephone line.

In [b-GR-1089-CORE], if the expected primary protector is a carbon block, a 600 Vrms test level is used, and for a gas discharge tube (GDT) primary protector a test level of 425 V rms is used – it is not an AC distribution supply voltage. Where contact with commercial building power might occur, [b-GR-1089-CORE] specifies item 4 is also run at 277 Vrms, 25 Arms.

Steady state conditions are assumed to occur with test times of 900 s and 1800 s depending on the standard.

The limit current-time conditions have been variously defined as current-time values, current-time templates (graphs), bare AWG wire and a fuse type. The last two are grossly inaccurate as these physical simulations are not precision gauges. The advent of large memory depth digital waveform recorders has allowed the data collection for use with current-time values or current-time templates (graphs).

II.2 General

The [b-TIA/EIA-571] standard was the original derivation of wiring maximum current values and the power fault test values. The recommended I^2t wiring value was increased from 45 A^2s to 100 A^2s in the subsequent [b-TIA/EIA-571A]. The I^2t wiring simulators of [b-TIA/EIA-571] were a Bussmann MDQ 1-6/10 fuse or a 32 AWG wire. [b-TIA/EIA-571A] used a Bussmann MDL-2 fuse or a 32 AWG wire.

The "Review of wiring simulator implementation" correspondence in the Telecommunications Industry Association, TR41.7.5 committee in 2003 examined the possible replacement of MDL-2 and MDQ 1-6/10 fuses by non-invasive current measurement for wiring simulation. The proposals were accepted and are used in the UL Outline of Investigation document [b-UL 2564].

Clauses II.3 through II.7 discuss the common US standards having power fault condition testing.

II.3 ANSI/TIA/EIA-571 and ANSI/TIA/EIA-571A wiring simulator documents

This clause traces the development of the requirements and the simulations through US TIA standards [b-TIA/EIA-571] and [b-TIA/EIA-571A]. All statements were true at the time, but may not cover more modern equipment.

The TIA was not involved in safety requirements and so the overvoltage tests went over to UL and became part of UL1459. The original rationales for the sneak current requirements were provided in [b-TIA/EIA-571] Annex B (Informative) Rationale for telephone line overvoltage tests (4.3.2.3).

II.3.1 Sources of power fault overvoltage

a) Contact with multi-grounded neutral primary power line, 4 kV to about 150 kV.

b) Induction from primary power line fault current.

c) Ground potential rise from primary power line fault current flowing to ground.

d) Contact with secondary power line, 120 V.

II.3.2 Analysis of limiting overvoltage conditions

Longitudinal voltage (L-type) of up to 600 V rms can occur inside wiring that is protected with 3-mil carbon blocks. Asymmetrical operation of the carbon blocks can result in metallic voltages (M-type) of 200 to 600 V rms (60 Hz).

Five conditions of overvoltage apply to terminal equipment:

1) An I^2t of 2400 A^2s can result from power line contact to a telephone shielded cable. A test condition of 40 amperes for 1.5 seconds was chosen to give this I^2t. I^2t is directly related to heating in adiabatic processes.

2) Up to 7 A for 5 s can result from induction or from a ground potential rise after a power line fault to a multi-grounded neutral conductor.

3) Induced currents of up to 2.2 A, steady state, can result from a power line fault to resistive earth, wherein the fault current is not sufficient to cause the power line breakers to trip. Equipment must be evaluated over the range of possible currents.

4) Induced voltages may be low enough not to activate voltage limiting devices. Equipment must be evaluated over the range of possible voltages.

5) A 120 V power line crossed with a telephone line can deliver up to 25 A to the telephone wiring, limited by the wiring impedance.

Maximum induction voltages occur when a telephone cable is run in joint use with power lines. Certain digital systems (such as an ISDN S/T interface) impose system limitations that limit the cable length to 1000 meters or less. With such a short range, induced voltages are limited to less than 60 V and conditions 3 and 4 above are not considered.

Contact conditions can occur on any telephone cable that is run with power cables, including short lines within a campus environment. Therefore, contact conditions 1, 2 and 5 above apply for all exposed telephone cables.

II.3.3 Performance of telecommunication user premises equipment

Traditional telephone equipment, which has proven safe in years of use for millions of installations, is not hazardous when subjected to the above overvoltage conditions because of the following equipment parameters:

1) The traditional telephone is the 500-type made of flammability class HB material. An electromechanical 500-type set as manufactured in the 1970s is damaged by a 2.2 A current, but the damage is confined to a protective metal can inside the set. The telephone's speech network has an impedance of 50 ohms above 1 A, and fuses open at $I^2t=40$, thereby protecting the telephone line cord by limiting fault current. The tip and ring conductors are also isolated from ground so that longitudinal voltages cause no damage. Some telephone systems with grounding conductors have used heat coils (a type of fuse) on the telephone lines to protect the building wiring.
2) The traditional telephone line cord was made of phosphor bronze tinsel conductor. Tinsel cord softens at 2.2 A (long duration), at 7 A for 5 s, and at $I^2t=400$ for short durations, but the conductors do not melt through the jacket at these current levels.
3) Modular jacks can withstand 2.5 A (long duration) and $I^2t=400$ (short durations) before the jack material (early model jacks) begins to melt. Leaded jacks use 26 AWG stranded wire for the leads.
4) Riser cable (26 AWG min., solid wire, the smallest gauge in use for premises wiring) can withstand 5 A (long duration) and $I^2t=1200$ (short durations). At $I^2t=2400$ the conductors will melt their insulation but will not fuse open. (Note that the $I^2t=2400$ value is not in [b-TIA/EIA-571]) A 26 AWG cable longer than about 100 feet is self-protecting due to current limiting provided by its wire resistance.

Modems built to computer industry standards have traditionally used fire resistant enclosure materials to provide safety.

II.3.4 Current-time template of clause II.3.3 items

Figure II.1 plots the four current-time curves for telecommunication user premises equipment items 1) to 4). These levels are withstand values or values which do not create a safety hazard for the item. A current limiter's maximum current-time values could exceed an item's values by some amount before a safety hazard occurs.

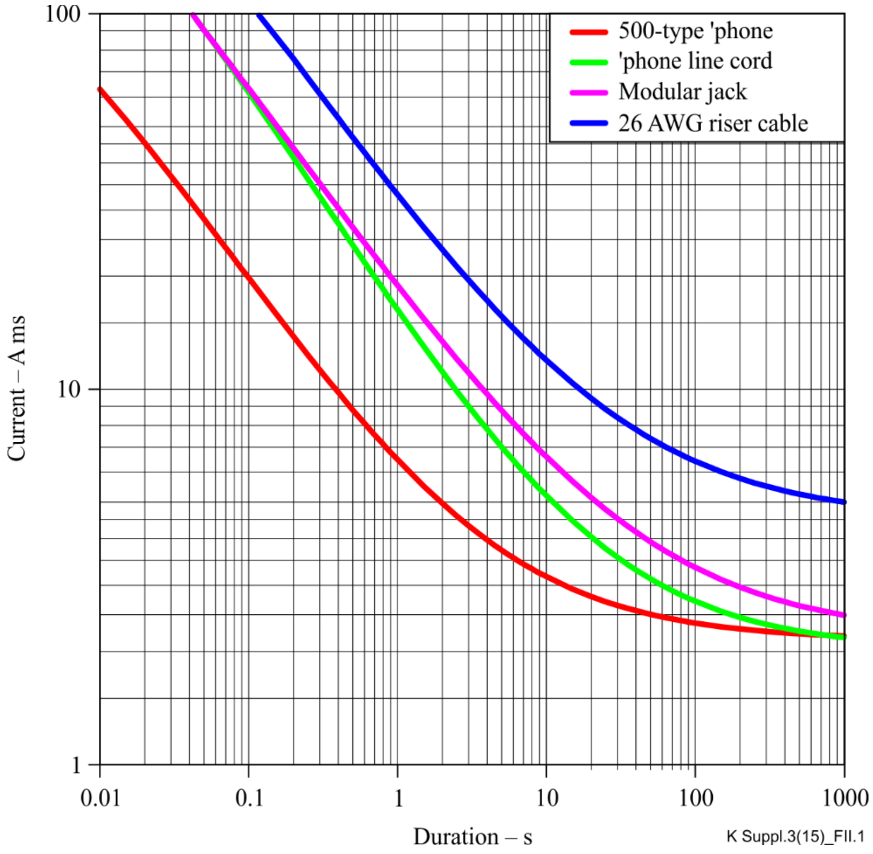

Figure II.1 – Telecommunication user premises equipment current-time curves

II.3.5 Multiple sets

The telephone line may be connected to several telephone stations (branches). Current in the main line (unbranched) must be limited to $I^2t=400$ to protect the line cord. [b-EIA/TIA-571] has "network interface jack" instead of "line cord" and adds the sentence "For compatibility with present installations, all telephones need to limit current in a manner similar to the 500-type sets ($I^2t=40$).".

A common installation has a telephone set and an answering machine, each of which can terminate the network in a low impedance after an overvoltage event. If each branch were fused for $I^2t=400$, the main line feed could see a much higher current. Assuming fault current is evenly distributed to the branches, each branch (i.e., the telephone and answering machine) needs to limit short duration current to $I^2t=400/n^2$, where n is the number of branches.

[b-EIA/TIA-571] assumes three branches and so ends up with a value of $I^2t=400/3^2= 45\ A^2s$ (see Figure II.2 a). In 1999, specification EIA/TIA-571b changed the wiring simulator i^2t parameter. Based on the cord feeding two, not three, pieces of terminal equipment. This meant that each piece of terminal equipment now had an i^2t limit of $400/2^2 = 100\ A^2s$ (see Figure II.2 b). To meet the increased i^2t value, the fuse was changed from the (dual element) Bussmann MDQ 1-6/10 to the (single element) Bussmann MDL-2. But the published MDL-2 fusing characteristic is a poor match to the wiring simulator parameters, being some 20% to 30% different, even before considering the individual fuse variability.

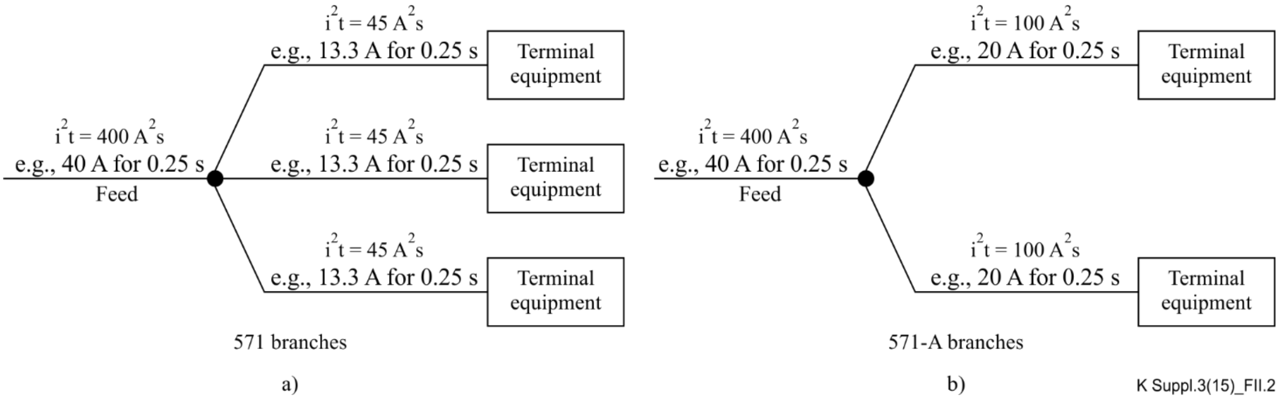

Figure II.2 – a) Wiring and equipment limit i^2t values for the [b-EIA/TIA-571] three-branch circuit
b) The [b-EIA/TIA-571A] two-branch circuit

II.3.6 Discussion of clause II.3.5 values

From [b-EIA/TIA-571] to [b-EIA/TIA-571A] the I^2t changed from 45 to 100 based on whether three [b-EIA/TIA-571] or two [b-EIA/TIA-571A] parallel lines are considered. One is probably looking at stacked disasters here, as with modern thryristor-type voltage limiters one piece of terminal equipment is liable to hog the current. This means that the equipment short term I^2t limit could be raised from 45 A^2s or 100 A^2s to 400 A^2s.

II.3.7 Wiring simulation

A composite model of a telephone line cord has a limiting current-time characteristic that is determined by the following:

1) Long duration current limit is just over 2.2 A.
2) The current limit is just over 7 A at a 5-s duration.
3) Short duration (adiabatic) current-time characteristic is about I^2t=100 A^2s. (For reasons given in clause II.3.5, [b-EIA/TIA-571] has a value of I^2t=45 A^2s).

Characteristics 1) and 2) are easily tested. To provide an indication of whether telephone wiring would be damaged during a short duration fault, a fuse that opens at I^2t=100 is desirable for testing purposes. If such a fuse is blown open during testing, the telephone line cord would be damaged. A fuse that meets these parameters is the Bussmann MDL-2. ([b-EIA/TIA-571] has a different fuse with 45 A^2s and states "A fuse that meets these parameters is the Bussmann MDQ 1-6/10 (formally MDX-type))

It is not necessary to use a fuse; the wiring model could be used to evaluate test results obtained with a current probe. Also, 32 AWG copper wire has a suitable fusing characteristic to be used as an indicator.

Not all telephone line cords use tinsel wire. When 26 AWG stranded wire (the same wire gauge as riser cable) is used, equipment does not need to limit I^2t to 100 because the line cord is considered sufficiently robust.

II.3.8 Discussion of clause II.3.7 values and fuses

The difference between [b-EIA/TIA-571] and [b-EIA/TIA-571A] is an I^2t of 45 A^2s and 100 A^2s. This I^2t difference drove the fuse change from the Bussmann MDQ 1-6/10 to the Bussmann MDL-2 for the [b-EIA/TIA-571A]. How well these fuses met the original intents of [b-EIA/TIA-571] and [b-EIA/TIA-571A] can be judged from Figure II.3. Figure II.3 shows the published typical fuse curves together with lines for 100 A^2s and 45 A^2s and points for 7 A @ 5 s and 2.2 A @ 900 s.

These fuses and the 32 AWG copper wire were intended for testing I^2t (clause II.3.6). Onderdonk's equation for 32 AWG wire i^2t gives a fusing value of 98 A^2s, making 32 AWG wire suitable for indicating 100 A^2s has been exceeded. Because the wiring simulator formulation is for a wiring network and not for a single wire, 32 AWG wire is unsuitable as a gauge for periods after the 40 A, 1.5 s I^2t test. For example the calculated 32 AWG Preece fusing current is 7 A, whereas an indication of currents exceeding 2.2 A is required.

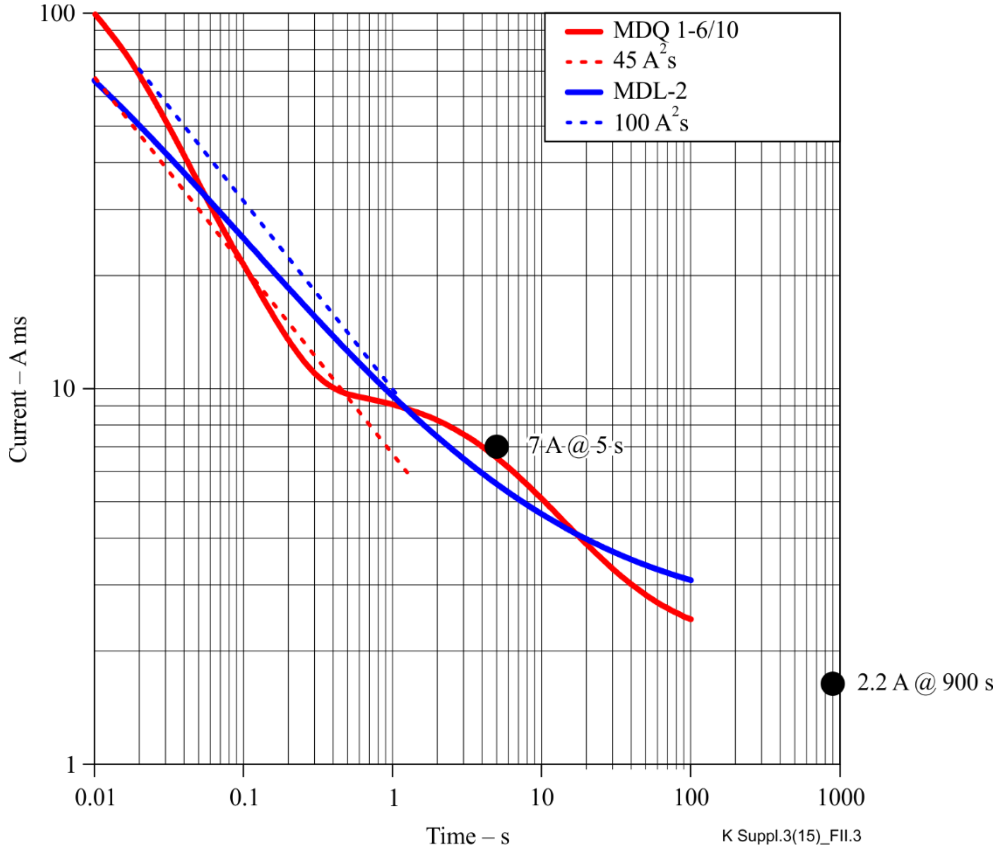

Figure II.3 – Typical fuse characteristics and clause II.3.6 values

Compared to the defined values, the Bussmann MDL-2 fuse is typically 35% low in I^2t current, 20% low at 5 s and 20% high at 900 s. Once fuse tolerance is taken into account, there are even greater inaccuracies in the fuse operating current values.

Figure II.4 plots the current-time curve for the clause II.3.6 wiring simulator composite model of a telephone line cord. The composite values are described as "just over 2.2 A", "just over 7 A at a 5 s duration" and "about I^2t=100". This tolerance is compassed in the thick plot line, which uses the following value variations:

- Long duration current limit is 2.2 A −0, +10%.
- The current limit is 7 A −0, +10% at a 5 s duration.
- Short duration (adiabatic) current-time characteristic has an I^2t=100 A^2s, −5%, +5%

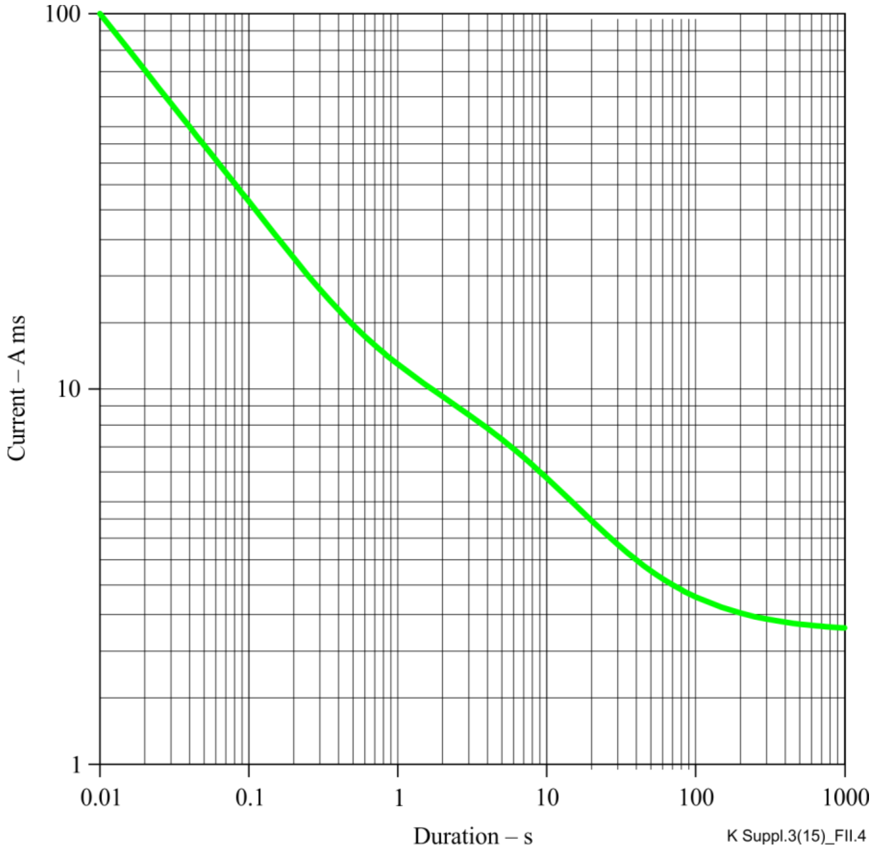

Figure II.4 – Clause II.3.6 wiring simulator (composite model) current-time curve

[b-EIA/TIA-571A] states that the MDL-2 fuse is "A fuse that meets these parameters". However, plotting the Bussmann data sheet curve and the limit values of 120 s maximum and 5 s minimum @ 4 A, shows the fuse typically operates before the clause II.3.6 wiring simulator up to durations of 30 s and operates after for durations greater than 50 s (see Figure II.5). The maximum limit value of 120 s @ 4 A greatly exceeds the 3.1.6 wiring simulator limit value of 30 s. The minimum limit value of 5 s @ 4 A is much shorter than the B3.6 wiring simulator limit value of 30 s. The MDL-2 is an unregulated reference gauge with a large tolerance. Modern digital oscilloscopes allow accurate evaluations of current limiter current-time values without the type of errors introduced by using an MDL-2 fuse as the reference gauge.

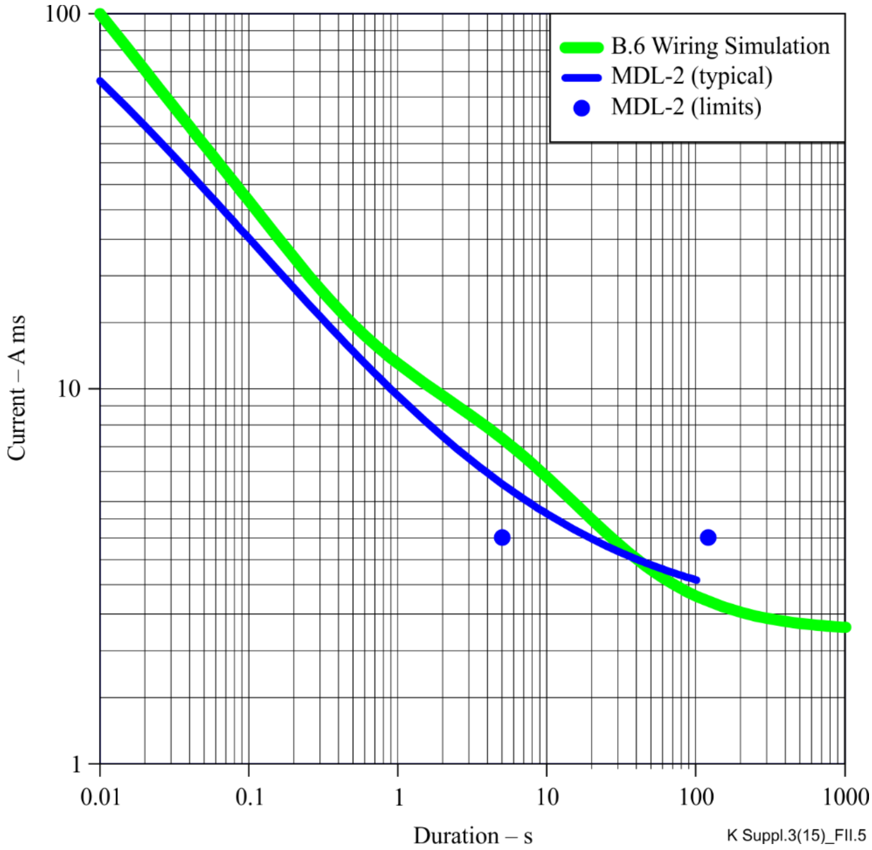

Figure II.5 – Clause II.3.6 wiring simulator and MDL-2 current-time curves

II.4 UL 1459-1998

This standard adopted the EIA/TIA-571 values (45 A^2s) and covered three different equipment types. It added a current-time template Figure II.6.

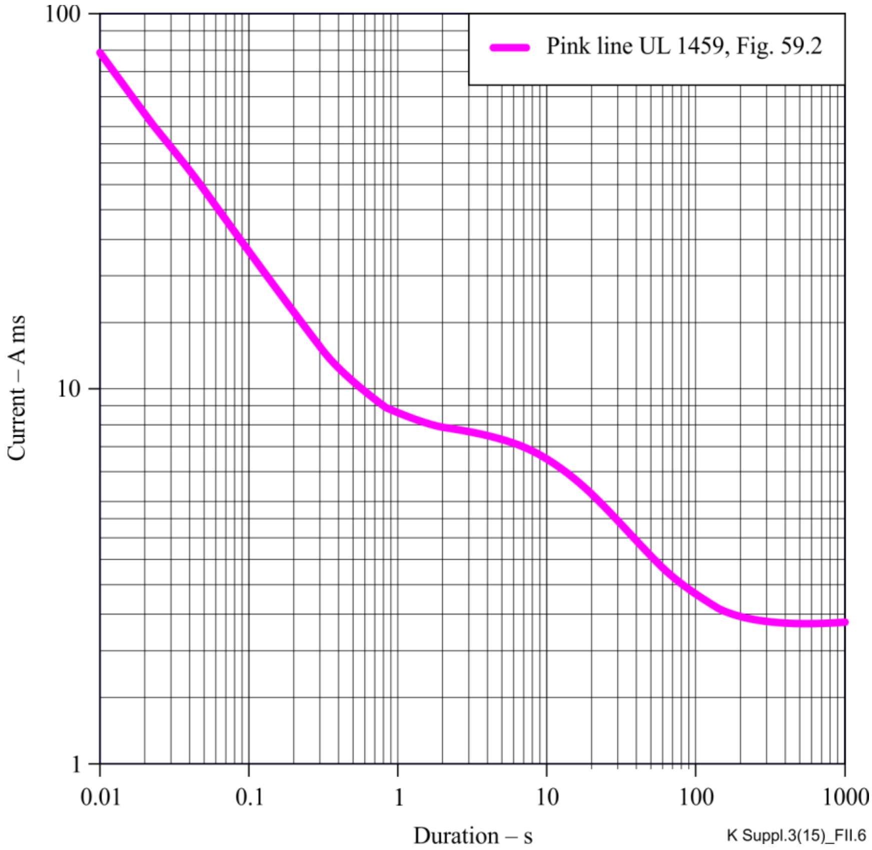

Figure II.6 – Acceptable current limiter current-time limits from [b-UL 1459]

II.5 UL 60950-1

[b-UL 60950-1], Annex NAC, Power line crosses, was born out of [b-UL 1549], but modified to the EIA/TIA-571A I^2t values. Annex NAC is a simplified version of the UL 1459 material. Annex NAC states:

A wiring simulator shall be used in test conditions 1 (600 Vrms, 40 Arms for 1.5 s) and 5 (120 Vrms, 25 Arms for 30 min), where:

– a minimum 26 AWG telecommunications line cord is not provided; or

– minimum 26 AWG wiring is not specified for field-wired telecommunications equipment.

The wiring simulator shall be:

– a 50 mm length of 0.2 mm (No. 32 AWG) bare or enamelled solid copper wire;

– a fuse having a time-current characteristic comparable to a 0.2 mm wire [Bussman Mfg. Co. Type MDL-2 A fuse or equivalent]; or

– for test condition 1 only, a current probe consisting of a 300 mm length of at least 0.5 mm (No. 24 AWG) copper wire to determine the I^2t imposed on the connecting wiring.

Compliance is determined by the 50 mm length of wire or the fuse not interrupting current during the test, or by the current probe measurement indicating an I^2t less than 100 A^2s.

Tests conditions are:

- Test condition 1: 600 V, 40 A, applied for 1.5 s
- Test condition 2: 600 V, 7 A, applied for 5 s.
- Test condition 3: 600 V, 2.2 A, applied per test duration.

- Test condition 4: A voltage whose peak value is below the overvoltage protector conduction voltage, at a current value does not result in an open circuit condition or exceed 2.2 A applied per test duration.
- Test condition 5: 120 V, 25 A, applied per test duration.

II.5.1 NAC.2.3 Wiring simulator discussion

For test 1, the <100 A^2s condition, three wiring simulator approaches could be used. The 32 AWG wire has a melting i^2t of 95 A^2s and the measured current is not to exceed a value of 100 A^2s. The Bussmann Mfg. Co. Type MDL-2 A fuse curve in Figure II.3 shows that fusing will typically occur at or below 100 A^2s.

The Bussmann Mfg. Co. Type MDL-2 A fuse is not really a good match to the other TIA-571A parameters (Figure II.3) of 7 A for 5 s and 2.2 A for 30 min and it will inherently have a large variation fuse to fuse. This is why testing often involves the use of many fuses to find the one that gives equipment passing. A typical Bussmann Mfg. Co. Type MDL-2 A fuse will operate 2.7 A, rather than the required 2.2 A – hardly a precision gauge!

In test 5 a 50 mm length of 0.2 mm (No. 32 AWG) bare or enamelled solid copper wire is not suitable for gauge as typically a 32 AWG wire has a DC fusing current of 7.2 A, way too high for the 2.2 A fusing requirement.

II.6 GR-1089-CORE, Issue 6

This document covers equipment at central office, outside plant equipment and customer premises. As a result there are several requirements for the maximum wire currents. For second level power fault tests [b-GR-1089-CORE] changed earlier issue test levels and given several options see clause II.1. The original 600 Vrms, 60 Arms for 5 s test has been split into a 425 Vrms, 40 Arms for 1.5 s test and a 425 Vrms, 30 Arms for 5 s test.

II.6.1 Stub links and block cable

Fuse links of 24 AWG and 26 AWG stub cable are considered to precede the primary protection. In certain cases 20 AWG "block wire" is used. The primary is expected to support the following current-time values without hazard to allow current interruption, see Table II.2.

Table II.2 – GR-1089-CORE stub cable values

Short-circuit current per conductor of a twisted-pair	Current flow time (s)		I^2t value (A^2s)	
	24 AWG	26 AWG	24 AWG	26 AWG
30	900	900	–	–
60	3	0.5	10800	1800
120	0.6	0.12	8640	1728
350	0.04	0.014	4900	1715
Onderdonk equation			3862	1528

While the applied I^2t values are reasonable for 26 AWG wire, the 24 AWG I^2t values are excessive for 60 A and 120 A.

II.6.2 Customer premises and OSP facilities equipment fusing coordination tests

These equipment port test requirements are intended to prevent excessive current to flow under power fault conditions and coordinate with premises-type wiring (including telephone modular cords) or 26 AWG wiring.

II.6.3 26 AWG or coarser wiring

For 26 AWG or coarser wiring the wiring simulator is a 30-cm (1-foot) section of 26 AWG copper wire covered in cheesecloth. As a result of testing the wire shall neither fuse nor the cheesecloth suffer damage.

II.6.4 Customer premises wiring

For customer premises wiring described there are two options: wiring simulator fuse failure or predefined current-time values being exceeded.

II.6.5 Wiring simulator fuse

GR-1089-CORE allows the use of a Bussmann Type MDQ 1-6/10A fuse or Type MDL 2.0A fuse for the wiring simulator. The performance and limitations of these are covered in clause II.3.8.

II.6.6 Current-time values

For the current-time limits graph, the published Bussmann Type MDL 2.0A fuse curve was modified to raise the long-term current from 2.7 A to 3 A to give Figure II.7.

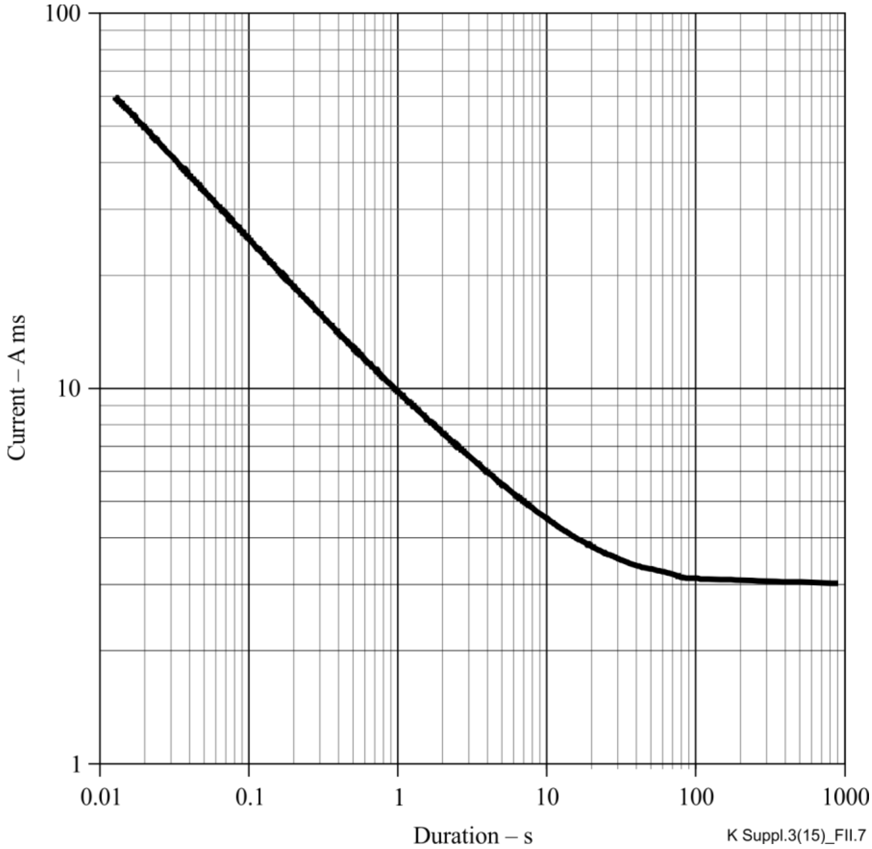

Figure II.7 – Limit current-time values for customer premises wiring

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