Department of Transport and Main Roads

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Manual

Traffic and Road Use Management
Volume 4 – Intelligent Transport Systems and Electrical Technology

Part 8: Electrical Verification Requirements for New or Altered Roadside Installations

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1 Introduction

This requirements specification sets the minimum requirements for electrical testing and verification documentation. The target audiences for this document are Electrical Contractors and departmental Electrical Inspectors involved in the electrical testing of new low voltage electrical installations for road lighting, traffic signals and ITS applications.

A Contractor who installs electrical equipment or an electrical installation for the department is obliged by the Electrical Safety Act to ensure that the way the electrical equipment or installation is installed, and the processes followed for installing the electrical equipment, when installed, is electrically safe.

Consequently, the Contractor is obliged to sufficiently test and examine the electrical equipment or installation to ensure it is electrically safe.

As a minimum, the department requires that tests include the mandatory tests detailed in AS/NZS 3000 and AS/NZS 3017.

> This revision of TRUM Volume 4 Part 8 references AS/NZS 3000:2018 and AS/NZS 3017:2022, which have been significantly revised from the previous versions of 2007 and 2003 respectively.
>
> The EFLI table has been revised to include values for ELV operation.
>
> Revision to the Electrical Certificate of Test includes 15-minute average running load of an installation.

This requirements specification provides details on specific test requirements and the manner by which test results must be presented as part of handover documentation.

2 Referenced documents

Table 2 – Referenced documents

Reference	Title
AS/NZS 3000	*Electrical installations* (known as the Australian / New Zealand Wiring Rules)
AS/NZS 3008.1.1	*Electrical installations – Selection of cables Part 1.1: Cables for alternating voltages up to and including 0.6/1 kV – Typical Australian installation conditions*
AS/NZS 3017	*Electrical installations – Verification by inspection and testing*
AS/NZS 4836	*Safe working on or near low-voltage electrical installations and equipment*
AS 60269.1	*Low-voltage fuses General requirements*
AS 61010.1	*Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General requirements*
IEC60127	*Miniature Fuses* (International Electrotechnical Commission)
MRTS256	*Power Cables*
TRUM Vol. 4 Part 3	*Electrical Design Manual for Roadside Devices*
-	*Electrical Safety Act* 2002 (Queensland)
-	Electrical Safety Regulation 2013 (Queensland)

3 Testing documentation

This section details the requirements for testing documentation produced prior to and after electrical testing.

3.1 Testing Plan

Electrical installations which comply with Part 2 of AS/NZS 3000 shall be tested in accordance with procedures detailed in AS/NZS 3017.

Any part of an electrical installation which achieves compliance by specific design and installation (Section 1.9.4 of AS/NZS 3000 and AS/NZS 3008) shall have detailed electrical test procedures developed to supplement or replace the requirements of AS/NZS 3017 and AS/NZS 4836. In this case, the test procedures developed shall be of the same or more detailed than the test described in AS/NZS 3017 and shall cover testing to verify the installation prior to putting it into service, as well as periodic verification or in-service testing. Test procedures for an electrical installation designed in accordance with Section 1.9.4 of AS/NZS 3000 shall be submitted to the Administrator 28 days prior to the planned date of testing on site. Prior to handover of maintenance responsibility to the Principal, the Contractor shall provide training to the Principal's nominated maintenance provider specifically to explain project specific requirements for periodic in service electrical testing.

3.2 Electrical Certificate of Test (CoT)

The Contractor shall record the results of all tests required by AS/NZS 3000 Part 2. This means filling out each column in Part 8 – *Electrical Certificate of Test* (CoT) provided as an annexure to this document, unless expressly agreed otherwise by Transport and Main Roads (except for the RCD trip time which is only required for circuits with RCD protection). Mandatory information to be recorded includes test data and details of the instruments used in the format shown in CoT annexed to this document. In order to assist the Contractor to complete the required information, each field in the CoT form is explained below in Section 4.

The CoT form shall contain all information captured in typed format rather than handwritten.

4 Information required in Certificate of Test

4.1 Test instruments

All test equipment shall comply with the relevant requirements of AS 61010.1 and suitable for its intended purpose and be inspected regularly, particularly after extended periods of storage, to ensure that it remains operational and safe and internal batteries are adequately charged.

Table 4.1 lists test equipment and associated category requirements as defined in Section 6.7.4 of AS 61010.1. Category voltage requirements will depend on measurements being taken, either phase to neutral or phase to phase. Probes need to be selected accordingly.

Table 4.1 - Test instruments

Test	Equipment	Comments	Minimum Category
Earth continuity	Ohmmeter (multimeter)	Capable of measuring DC resistance to minimum resolution 0.01 Ohms (can be a multimeter)	III
Insulation resistance	Insultation resistance tester. (If working live, use current clamp)	Meter to be rated to test voltage 1000V. Unit to have accuracy of +/- 5%	III
Polarity	Ohmmeter (multimeter)	Capable of measuring DC resistance to minimum resolution 0.01 Ohms (can be a multimeter)	III
Earth Fault Loop Impedance	Loop Impedance tester	Capable of measuring under load. High current 'trip' type meter (draws greater than 4A in EFLI test)	III
Infrared thermal imaging	Thermal imager	Minimum resolution 0.1 C Minimum scale 25-110 C	-
Verification of RCD	RCD tester	Testing of an RCD is carried out to ensure that the RCD operates and disconnects the designated circuit as required	III

Before commencing any of the tests in Section 4.4 below, the Contractor must ensure that all tools and electrical equipment are selected, serviced, and calibrated properly, and all details including type, serial number and the latest calibration date must be clearly shown in the CoT.

4.2 Installation data

The information contained under "Installation data" pertains to the types of circuits, electrical equipment, wiring and switchgear for the entire installation. This information forms an essential part of the test certificate and also serves as an inventory of the electrical installation for future reference.

4.2.1 Circuit number and Phase

The circuit number and phase shall be as displayed in the as-constructed design drawing and documentation. If no drawing is available, a complete sketch of the installation from the point of supply to each circuit termination must be provided.

4.2.2 Circuit designation

The circuit designation describes whether the circuit is a Consumer mains, Submains or a final subcircuit. Refer to AS/NZS 3000 for the exact definition of these terms.

4.2.3 Circuit Load

The circuit Load in Amperes must be recorded. For the Consumer mains this is simply the maximum demand, and for the submains it is the load in each circuit.

4.2.4 Type of wiring

Refers to the cable characteristics such as insulation, sheathing, conductor type, number of cores and CSA (Cross-Sectional Area). The permissible characteristics are defined in TRUM Vol. 4 Part 3 and MRTS256.

4.2.5 Number of points served

This refers to the number of equipment attached at the end of the circuit.

4.2.6 Maximum permitted disconnect time

This is typically either 0.4s or 5s.

4.2.7 Overcurrent Protective device type and rating

A protective device is either a fuse, a Type B MCB, Type C MCB, Type D MCB, RCD or RCBO, each with their relevant rating in kA, A and mA (for RCDs).

4.3 Visual Inspection

Visual inspection is to be completed to ensure that there are no local hazards prior to completing the prescribed tests.

All visual inspection shall be conducted in accordance with Section 2 of AS/NZS 3017. The contractor must consider all items in the check list in Section 2.2 of AS/NZS 3017. A tick (✔) under the visual inspection item of the CoT is interpreted as an affirmation by the Contractor that all items in the checklist were considered and, as a result, the relevant requirements of AS/NZS 3000 are satisfied.

4.3.1 Labelling

The visual inspection must also ensure that all equipment, including switchgear, cables and terminals in the installation are clearly labelled to assist in subsequent periodic verification.

4.4 Test results

4.4.1 Continuity of the earthing system

The earth continuity test shall meet the requirements of AS/NZS 3000 and shall be tested in accordance with the procedures outlined in Clause 4.4 of AS/NZS 3017. The resistance of the main earthing conductor, the protective earthing conductor, and equipotential bonding conductors (in ohms) shall be recorded. The contractor shall record whether the protective earth exceeds the 0.5Ω, then earth is deemed insufficient and ensure the project manager has been notified.

4.4.2 Insulation resistance

The insulation resistance test shall meet the requirements of AS/NZS 3000 and be tested in accordance with the procedures outlined in Clause 4.5 of AS/NZS 3017.

For Mains & Sub Mains the insulation resistance (in Mega-ohms) between Phase conductors, Phase-to-Neutral, Phase-to-Earth, and Neutral-to-Earth shall be recorded.

For final Sub Circuits the insulation resistance (in Mega-ohms) between Phase-to-Earth, and Neutral-to-Earth shall be recorded.

For traffic signal multicore cables the insulation resistance (in Mega-ohms) between Active Cores-to-Earth and Neutral-to-Earth shall be measured. For each run, the Neutral-to-Earth and the Active-to-Earth resistance shall be recorded.

4.4.3 Polarity

The polarity test is intended to ensure that no shock hazard results from the incorrect connection of active, neutral, and earthing conductors and shall be tested in accordance with the procedures outlined in Clause 4.6 of AS/NZS 3017.

4.4.4 Verification of FLI/EFLI (fault-loop impedance / earth fault-loop impedance)

The fault-loop impedance of a circuit is measured as per certificate of test, if a fault of negligible impedance occurs between an active conductor and a protective neutral / earthing conductor or an exposed conductive part, sufficient current will flow in the fault-loop to cause a protective device to operate within a specified disconnection time.

The reference temperature for measuring the FLI/EFLI shall be recorded in the provided space in accordance with the principles outlined in Section 4.4.4.1 below.

The FLI/EFLI shall be measured in accordance with the procedures outlined in Clause 4.8 of AS/NZS 3017, at the following locations:

- At the termination of the Consumers mains
  - MSB main switch
  - Traffic Signal controllers
  - ITS cabinets
- At the furthest termination point of each circuit
  - poles (lighting and signals)
  - mast arms (ITS pole)

  Note: For ELV circuits, the DC resistance of the fault loop may be used to represent FLI (phase to neutral) and / EFLI (phase to earth). Both FLI and EFLI shall be captured on all Traffic Signal installations.

4.4.4.1 Selection of EFLI testing temperature

It is the responsibility of the Contractor to select the appropriate reference temperature for evaluating the EFLI (Earth Fault Loop Impedance) of the new installation.

For most installations where there is a much lower amount of current flowing relative to the current carrying capacity, a conductor temperature of 20°C can be assumed. This can be considered a worst case scenario.

The EFLI values shown in AS/NZS 3017 and AS/NZS 3000 are based on a conductor temperature of 75°C and should only be used when the conductor is operating at maximum permissible current, assuming this is the maximum temperature for the insulation.

The temperature quoted in the design documentation on which the installation is based, can only be used as a reference temperature if it can be proven that it is equivalent to the operating conductor temperature as installed.

Notwithstanding the above general guidelines, the Contractor shall use thermal imaging or equivalent means in order to verify or select the appropriate temperature.

Depending on the selected temperature, the EFLI table to be used shall be in accordance with Section 5 below. The Contractors Registered Professional Engineer Queensland (RPEQ) Electrical shall determine suitable alternative EFLI values where required, taking into account the specific site geometry and ambient conditions.

Note: The values recorded for the EFLI shall be interpreted in conjunction with the values recorded in Section 4.2.6 for disconnect time, Section 4.2.7 for upstream protective device and the impedances for selected temperatures as specified in Section 5.

4.4.5 Operation of RCDs

Where applicable, testing of an RCD is carried out to ensure that the RCD operates and disconnects the designated circuit. The value to be recorded is the tripping time in milliseconds (ms).

A number of traffic controllers are equipped with a RCD protected socket outlet, which is designed for ancillary electrical equipment. In general, RCDs are installed in accordance with the requirements of the TRUM Vol 4 Part 3.

Note: An RCD shall not be installed in any of the circuits used to drive the traffic signals.

A visual inspection is required to make sure these RCD protected socket outlets are not subject to any operation of traffic signals. A tripping time test of the integrated RCD is required using the RCD tester in accordance with the procedures outlined in Section 3.7 of AS/NZS 3017, to confirm tripping time does not exceed 300ms. The use of the integral test button is not acceptable.

5 Maximum values of EFLI (Zs) at 230 V a.c. and 42 V a.c. for selected temperatures

Table 5 shows EFLI values for protective devices for selected temperatures (20, 25, 45 and 75 degrees C). The tables are obtained from the recorded AS/NZS 3000 values at 75°C as follows:

First, the EFLI values for temperature 20°C are obtained as follows:

$$R_{20} = \frac{R_{75}}{1 + \alpha(75 - 20)}$$

Where:

R_{20} is impedance at 20°C, in ohms R_{75} is impedance at 75°C, in ohms

α = 0.00393, is the temperature coefficient of resistivity of copper at 20°C, in °C^{-1}

Having obtained the values for EFLI at 20°C, the EFLI for any other temperature Θ (> 20°C) is obtained as follows:

$$R_\theta = R_{20}[1 + \alpha(\theta - 20)]$$

The Extra Low Voltage (ELV) EFLI values for the 2A and 5A fuses commonly used in traffic signal controllers (see Section 5.1) were obtained from controlled testing under laboratory conditions applying a voltage of 39V so that at the rated ELV of 42V these values are conservative. Other ELV EFLI values for protective devices rated 6A onwards were extrapolated from existing EFLI values at 230V.

Table 5 - Maximum EFLI values for selected protective devices and temperatures

MAXIMUM VALUES OF EFLI @ 20° C								
Protective device rating (A)	LV (230 V a.c)					LV (160 V a.c)	ELV (42 V a.c)	
	Circuit-breakers (0.4s)			Fuses		Fuses	Fuses	
	Type B	Type C	Type D	0.4s	5s	0.4s	0.4s	5s
2	23.640	12.608	7.565	26.214	33.351	16.881	4.05	6.24
5	9.456	5.043	3.026	12.466	15.006	7.795	1.89	2.99
6	7.880	4.203	2.522	9.456	12.605	6.578	1.62	2.15
8	5.910	3.152	1.891	7.565	9.954	5.263	1.28	1.69
10	4.728	2.522	1.513	5.254	7.565	3.659	0.90	1.29
16	2.955	1.576	0.946	2.524	4.111	1.776	0.44	0.70
20	2.364	1.261	0.756	1.719	2.952	1.201	0.30	0.50
25	1.891	1.009	0.605	1.349	2.228	0.913	0.22	0.38
32	1.478	0.788	0.473	1.053	1.801	0.740	0.18	0.30
40	1.182	0.630	0.378	0.789	1.349	0.576	0.14	0.22
50	0.946	0.504	0.303	0.592	1.053	0.411	0.10	0.18
63	0.750	0.400	0.240	0.452	0.773	0.312	0.08	0.12
80	0.591	0.315	0.189	0.312	0.559	0.214	0.05	0.10
100	0.473	0.252	0.151	0.222	0.395	0.156	0.04	0.07
125	0.378	0.202	0.121	0.173	0.354	0.123	0.03	0.06
160	0.296	0.158	0.095	0.132	0.247	0.091	0.02	0.04
200	0.236	0.126	0.076	0.107	0.189	0.074	0.02	0.03

MAXIMUM VALUES OF EFLI @ 25° C								
Protective device rating (A)	LV (230 V a.c)					LV (160 V a.c)	ELV (42 V a.c)	
	Circuit-breakers (0.4s)			Fuses		Fuses	Fuses	
	Type B	Type C	Type D	0.4s	5s	0.4s	0.4s	5s
2	24.105	12.856	7.714	26.729	34.006	17.213	4.13	6.36
5	9.642	5.142	3.085	12.711	15.301	7.948	1.93	3.05
6	8.035	4.285	2.571	9.642	12.853	6.707	1.65	2.20
8	6.026	3.214	1.928	7.714	10.149	5.366	1.31	1.72
10	4.821	2.571	1.543	5.358	7.714	3.731	0.91	1.32
16	3.013	1.607	0.964	2.574	4.192	1.811	0.44	0.71
20	2.410	1.286	0.771	1.752	3.010	1.224	0.30	0.51
25	1.928	1.028	0.617	1.375	2.272	0.931	0.23	0.39
32	1.507	0.803	0.482	1.073	1.836	0.755	0.18	0.31
40	1.205	0.643	0.386	0.805	1.375	0.587	0.14	0.23
50	0.964	0.514	0.309	0.604	1.073	0.419	0.10	0.18
63	0.765	0.408	0.245	0.461	0.788	0.319	0.08	0.13
80	0.603	0.321	0.193	0.319	0.570	0.218	0.05	0.10
100	0.482	0.257	0.154	0.226	0.402	0.159	0.04	0.07
125	0.386	0.206	0.123	0.176	0.361	0.126	0.03	0.06
160	0.301	0.161	0.096	0.134	0.252	0.093	0.02	0.04
200	0.241	0.129	0.077	0.109	0.193	0.075	0.02	0.03

MAXIMUM VALUES OF EFLI at (@ 45° C								
Protective device rating (A)	LV (230 V a.c)					LV (160 V a.c)	ELV (42 V a.c)	
	Circuit-breakers (0.4s)			Fuses		Fuses	Fuses	
	Type B	Type C	Type D	0.4s	5s	0.4s	0.4s	5s
2	25.963	13.847	8.308	28.789	36.628	18.540	4.45	6.85
5	10.385	5.539	3.323	13.690	16.481	8.561	2.08	3.29
6	8.654	4.616	2.769	10.385	13.844	7.224	1.78	2.37
8	6.491	3.462	2.077	8.308	10.931	5.780	1.41	1.85
10	5.193	2.769	1.662	5.771	8.308	4.019	0.98	1.42
16	3.245	1.731	1.039	2.772	4.515	1.951	0.48	0.77
20	2.596	1.385	0.831	1.887	3.242	1.318	0.33	0.55
25	2.077	1.108	0.665	1.481	2.447	1.002	0.24	0.42
32	1.623	0.865	0.519	1.156	1.978	0.813	0.20	0.33
40	1.298	0.692	0.415	0.867	1.481	0.632	0.15	0.24
50	1.039	0.554	0.332	0.650	1.156	0.452	0.11	0.20
63	0.824	0.440	0.264	0.497	0.849	0.343	0.08	0.14
80	0.649	0.346	0.208	0.343	0.614	0.235	0.06	0.11
100	0.519	0.277	0.166	0.244	0.433	0.172	0.04	0.08
125	0.415	0.222	0.133	0.190	0.388	0.135	0.03	0.06
160	0.325	0.173	0.104	0.144	0.271	0.100	0.02	0.05
200	0.260	0.138	0.083	0.117	0.208	0.081	0.02	0.03

MAXIMUM VALUES OF EFLI @ 75° C								
Protective device rating (A)	LV (230 V a.c)					LV (160 V a.c)	ELV (42 V a.c)	
	Circuit-breakers (0.4s)			Fuses		Fuses	Fuses	
	Type B	Type C	Type D	0.4s	5s	0.4s	0.4s	5s
2	28.750	15.333	9.200	31.880	40.560	20.530	4.93	7.59
5	11.500	6.133	3.680	15.160	18.250	9.480	2.30	3.64
6	9.583	5.111	3.067	11.500	15.330	8.000	1.97	2.62
8	7.188	3.833	2.300	9.200	12.105	6.400	1.56	2.05
10	5.750	3.067	1.840	6.390	9.200	4.450	1.09	1.57
16	3.594	1.917	1.150	3.070	5.000	2.160	0.53	0.85
20	2.875	1.533	0.920	2.090	3.590	1.460	0.36	0.61
25	2.300	1.227	0.736	1.640	2.710	1.110	0.27	0.46
32	1.797	0.958	0.575	1.280	2.190	0.900	0.22	0.37
40	1.438	0.767	0.460	0.960	1.640	0.700	0.17	0.27
50	1.150	0.613	0.368	0.720	1.280	0.500	0.12	0.22
63	0.913	0.487	0.292	0.550	0.940	0.380	0.09	0.15
80	0.719	0.383	0.230	0.380	0.680	0.260	0.07	0.12
100	0.575	0.307	0.184	0.270	0.480	0.190	0.05	0.09
125	0.460	0.245	0.147	0.210	0.430	0.150	0.04	0.07
160	0.359	0.192	0.115	0.160	0.300	0.111	0.03	0.05
200	0.288	0.153	0.092	0.130	0.230	0.090	0.02	0.03

Note: The EFLI for 2A, 5A and 8A circuit breakers are calculated using the mean tripping currents specified in AS/NZS 3000. 160 V a.c. has been included specifically for LV traffic signal controllers dimming applications.

5.1 Maximum EFLI values for fast-acting 2A, 5A and 8A fuses used in TSC

In new traffic signal controllers (TSC), the lamp switching circuit for each signal group aspect is protected by a **slow-acting** 2A or **fast-acting** 5A fuse cartridge readily replaceable from the front of the logic module. Older TSCs might have fast-acting fuse rated 8A.

The most commonly used fuses are Bussman® and Littelfuse®.

Slow-Acting fuse

- LITTEL 215 series (5 mm x 20 mm)
- BUSSMAN S505 series (5 mm x 20 mm)

Fast-Acting fuse

- LITTEL 216 series (5 mm x 20 mm)
- BUSSMAN S501 series (5 mm x 20 mm)

The EFLI values shown in Table 5 are based on values obtained from the fuse datasheets, testing, and recording the worst case.

The Time-current curves for Bussman® and Littelfuse® showing the disconnection currents at 0.4s and 5s are shown in Figure 5.1a and Figure 5.1b respectively.

For ELV circuits as per Table 5, 5s disconnection time is appropriate. 0.4s disconnection time has also been included for reference or if required in specific aquatic / marine settings.

Note: In Table 5, the 2A, 5A and 8A fast-acting fuses are in accordance with IEC60127, whereas the rest of the fuses are to AS 60269.1.

Figure 5.1a - Time-current curve for Bussman Fuse

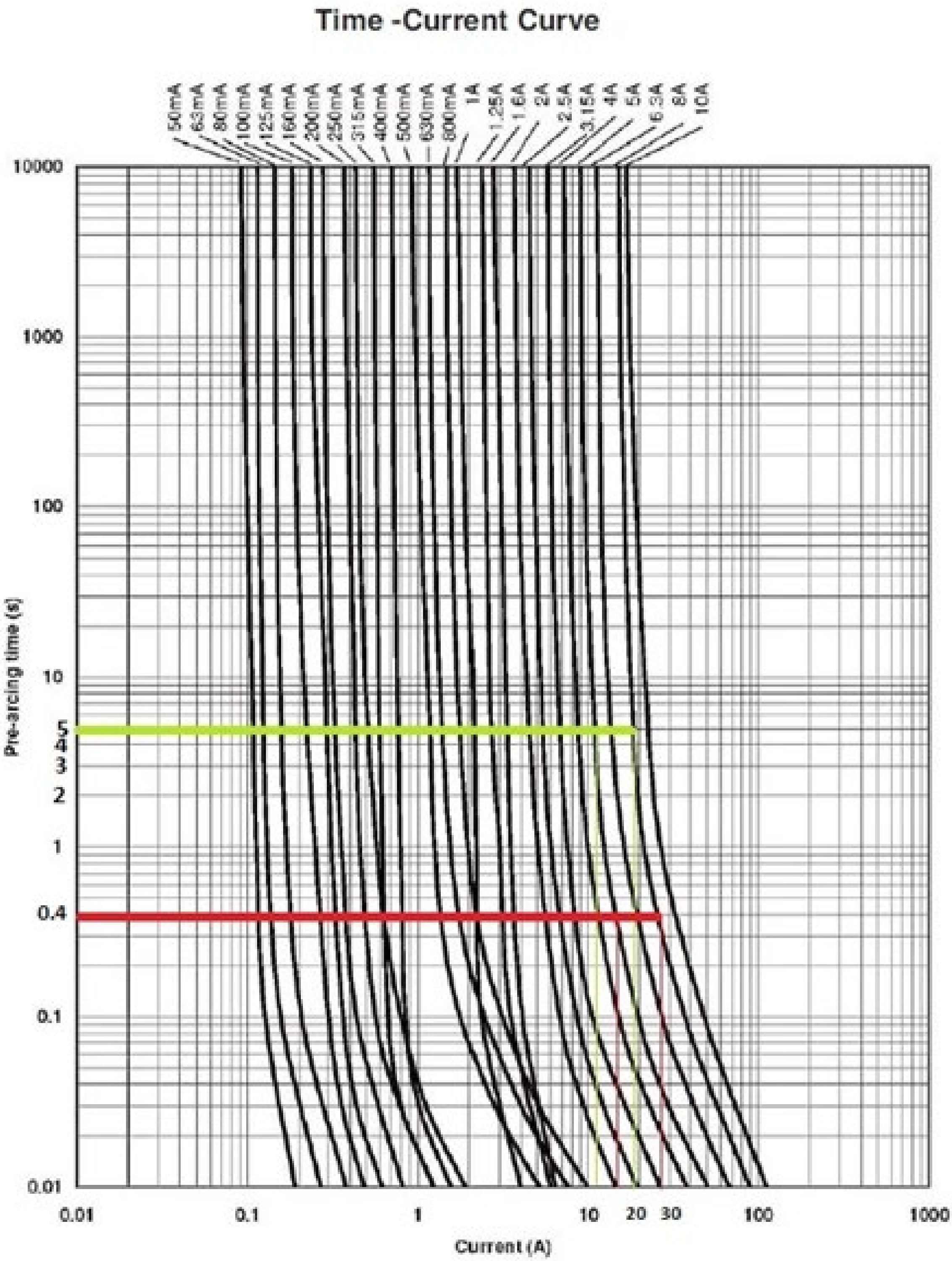

Figure 5.1b - Time-current curve for Littelfuse