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TECHNICAL NEWS

INDUSTRIAL SWITCHGEAR & AUTOMATION SPECIALISTS

NHP

CABLE CONSIDERATIONS

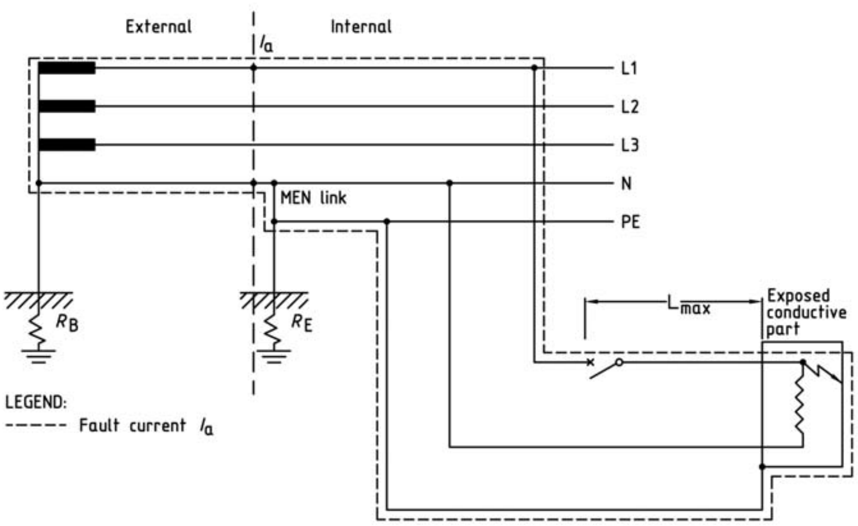
By Application Engineering, Sydney.

Size Matters:

The size (csa) and the length of a cable run have important implications to the proper overall design of an electrical installation. From the aspects of voltage drop, the I^2T (thermal ability) of the cable in association with the protective device and the fault loop impedance, all play critical and interrelated parts in the assessments by the electrical contractor and his suppliers.

Fault Loop Impedance:

Clearing a short circuit to earth requires a fault current high enough to cause the protective device to operate quickly. AS/NZS 3000:2000 (Clause 1.7.4.3.3) requires that the 'characteristics of the protective devices and the earthing system impedance shall be such that ... automatic disconnection of the supply will occur within the specified time.' This is to afford adequate protection of people when 'exposed conductive parts ... become live under fault conditions (indirect contact).'



FEATURES:

- Size matters
- Fault loop impedance
- Selection of MCBs
- Thermal stress I^2T
- Voltage drop

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The conditions are met when the impedance of the fault loop multiplied by the current causing the protective device to operate within prescribed times is equal to or less than the nominal voltage (230 V) to earth.

The electrical contractor will perform earth fault loop impedance tests to ensure that the path taken by an earth fault current is low enough to allow sufficient fault current to flow and to operate the protective device within the required times. These disconnection times shall not exceed:

a) 0.4 sec for, basically, final sub-circuits that supply socket outlets, not exceeding 63 A, hand held equipment and portable equipment intended for manual movement during use.

b) 5 sec for other circuits including submains and final sub-circuits supplying fixed equipment.

The *Wiring Rules* gives guidance as to the maximum length of specific conductors with the following equation:

$L_{max} = 0.8U_o \times S_{ph} \times Spe/ I_a \times 0.0225 (S_{ph} + S_{pe})$

Where

L = max. length in metres

U_o = nominal phase voltage (230 V)

S_{ph} S_{pe} = csa of active and protective earthing conductors

I_a = trip current setting for the instantaneous operation of the circuit breaker (if 0.4 sec)

Selection of MCBs with consideration of fault loop impedance:

Maximum circuit lengths (L_{max}) for different conductors and protective devices

Conductor size (mm^2)		Protective Device Rating (Amps)	Maximum circuit length, Lmax	Circuit Breakers				Fuses
				Din-T			Safe T	
Active	Earth			'B' curve	'C' curve	'D' curve		
1	1	6		170	91	55	37	204
1	1	10		102	55	33	30	114
1.5	1.5	10		153	82	49	45	170
1.5	1.5	16		96	51	31	21	82
2.5	2.5	16		160	85	51	35	136
2.5	2.5	20		128	68	41	29	93
4	2.5	25		126	67	40	28	90
4	2.5	32		98	52	31	21	70
6	2.5	40		90	48	29	24	60
10	4	50		117	62	37	38	73
16	6	63		142	76	45	46	85
16	6	80		112	59	36	36	59
25	6	80		124	66	40	40	66
25	6	100		99	53	32	32	47
35	10	100		159	85	51	51	75
35	10	125		127	68	41	NA	58
50	16	125		198	106	63	NA	90

Based on and expanded from Table B5.1, AS/NZS 3000:2000

If MCCBs are being considered for sub-mains or final sub-circuits to fixed equipment then a maximum disconnection time of 5 sec is applicable.

Examples:

	XS125NJ125	XS250NJ160	XS 250NJ250
Phase conductor = (mm^2)	70	70	90
Earth Conductor = (mm^2)	16	16	25
MCCB amps =	125	160	250
Amps at 5 sec =	750	1280	2000
Lmax. = (meters)	132	83	80

With TemBreak 2, the thermal magnetic MCCBs will have adjustable magnetic elements, 6 - 12 times, thus allowing for relatively long cable runs. The table below shows an example of the electronic (fixed characteristics) version.

MCCB S250CE	Curve 1	Curve 2	Curve 3	Curve 4	Curve 5	Curve 6	Curve 7
Phase Conductor = (mm^2)	70	70	70	70	70	70	70
Earth conductor = (mm^2)	25	25	25	25	25	25	25
MCCB amps =	250	250	250	250	250	250	250
Amps at 5 sec. =	625	625	1000	1500	1875	2500	2500
L max. (metres) =	241	241	150	100	80	60	60

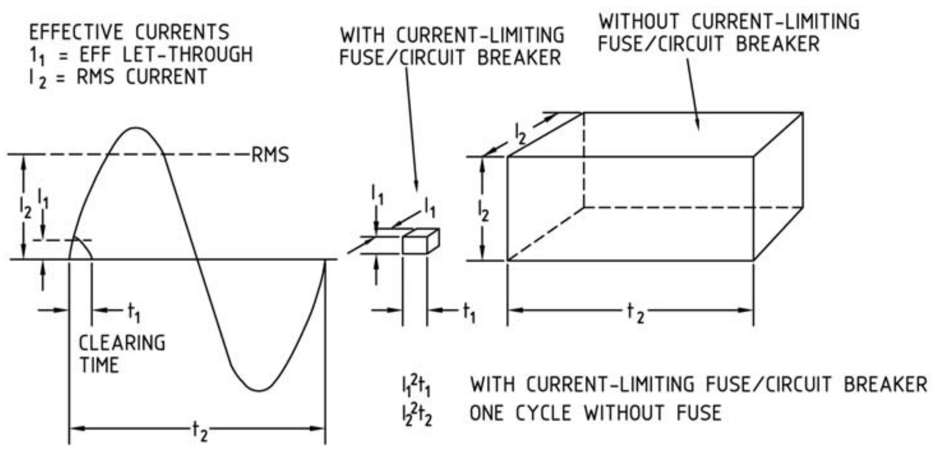
Thermal Stress: I^2T

$S^2 K^2 = I^2T$

Therefore, if the *K* factor is known the S or csa of the cable can be determined.

To consider the affects of short circuits on cables reference can be made to AS/NZS 3008.1.1:1998 for the values of *K* for the determination of permissible short circuit currents. Basically the *K* factor is dependent on the initial temperature and the final temperature of the cable and its insulation. E.g. bare copper, *K* = 170 whereas for PVC V75, K is usually = 111 and this value should be used if specific details are not known.

Graphical representation of I^2T



If one is considering busbars for a 50 kA switchboard with a short time rating of 1 sec, then the minimum is

$$S = \sqrt{\frac{I^2T}{K^2}} = 295\ mm^2$$

This translates to, say, 50 x 6.3 copper bar as the minimum size that can be used.

However, when one is considering current limiting devices such as MCCBs, MCBs and fuses it is necessary to check the I^2T characteristic.

Examples: With XS125NJ/32 @ 20 kA the I^2T let through = 0.44 x 10^6 amp^2 sec.

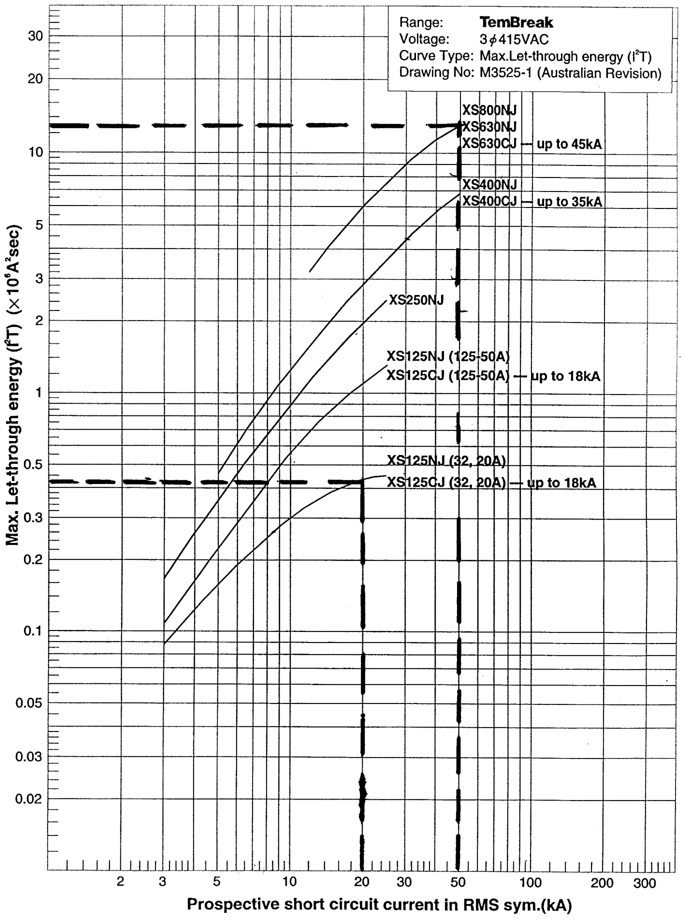
$$\therefore \; S = \sqrt{\frac{0.44 \times 10^6}{111^2}}$$

= 6 mm^2 (nominally 40 A), ∴ Satisfactory.

Whereas, an XS800NJ/800 @ 50 kA lets through 13.5 x 10^6 amp^2 sec.

$$S = \sqrt{\frac{13.5 \times 10^6}{111^2}} = 35 \text{ mm}^2$$

(nominally 110 A), ∴ One should select the conductor based on the load current required.



Fuses, on the other hand, have constant I^2T values and these are usually given as two figures; 'pre-arcing' and 'total' at particular voltages.

Fuse Type	Pre-arc I^2T	Total I^2T @ 240 V	Total I^2T @ 415 V
NTC32	375	845	1500

For example: a 32 A standard industrial fuse at 415 V will have a pre-arcing of 375 amp^2 sec and a total of 1500 amp^2 sec. Here, the minimum cable size would be;

$$\therefore \quad S = \sqrt{\frac{1500}{111^2}} = 0.4 \text{ mm}^2.$$

Again the circuit current rating would be the deciding factor.

Nevertheless, this example serves to illustrate the excellent current limiting and energy limitation aspects of HRC fuses.

Voltage Drop:

The size of 'every current carrying conductor shall be such that the voltage drop between the point of supply and any point in the installation shall not exceed 5%'. The electrical contractor will determine the voltage drops for the specific installation.

The voltage drop can be determined from

- the milli-volt per ampere metre; Vd = L x I x Vc/1000 or
- the circuit impedance; Vs = IZc or
- the load power factor or
- specific charts or computer programmes.

Example: With a 6 mm^2 cable carrying 32 A @ 45 °C, what is the maximum length of run?

From the table Vc = 5.86

∴ L = 20.75 (5 % of 415 V) x 1000/32 x 5.86 = 110 M.

TABLE 41

THREE-PHASE VOLTAGE DROP AT 50 Hz OF SINGLE-CORE INSULATED AND SHEATHED COPPER CONDUCTORS, LAID FLAT TOUCHING OR IN A WIRING ENCLOSURE

Conductor size	Three-phase voltage drop at 50 Hz, mV/A.m									
	Conductor temperature, °C									
	45		60		75		90		110	
mm^2	Max.	0.8 p.f.	Max.	0.8 p.f.	Max.	0.8 p.f.	Max.	0.8 p.f.	Max.	0.8 p.f.
1	40.3	—	42.5	—	44.7	—	46.8	—	49.7	—
1.5	25.9	—	27.3	—	28.6	—	30.0	—	31.9	—
2.5	14.1	—	14.9	—	15.6	—	16.4	—	17.4	—
4	8.77	—	9.24	—	9.71	—	10.2	—	10.8	—
6	5.86	—	6.18	—	6.49	—	6.81	—	7.23	—
10	3.49	—	3.68	—	3.86	—	4.05	—	4.30	—
16	2.20	—	2.32	—	2.43	—	2.55	—	2.71	—
25	1.40	—	1.47	—	1.55	—	1.62	—	1.72	—
35	1.02	—	1.07	—	1.12	—	1.18	—	1.25	—
50	0.763	—	0.801	—	0.840	—	0.878	—	0.929	—
70	0.545	—	0.571	—	0.597	—	0.623	—	0.657	—
95	0.413	—	0.431	—	0.449	—	0.467	—	0.491	—
120	0.345	—	0.358	—	0.371	—	0.385	—	0.403	—
150	0.299	0.299	0.309	—	0.319	—	0.330	—	0.344	—
185	0.262	0.261	0.270	0.269	0.277	0.277	0.285	0.285	0.296	0.296
240	0.230	0.224	0.235	0.230	0.240	0.236	0.245	0.242	0.252	0.250
300	0.212	0.201	0.215	0.206	0.219	0.211	0.222	0.215	0.227	0.222
400	0.198	0.181	0.200	0.185	0.202	0.189	0.205	0.192	0.208	0.197
500	0.188	0.166	0.190	0.169	0.191	0.172	0.193	0.174	0.195	0.178
630	0.179	0.153	0.180	0.155	0.181	0.157	0.182	0.159	0.184	0.162

Replicated from AS/NZS 3008.1-1:1998

Consequently, we should not ignore the rather mundane aspects of circuit cabling and its sizing. If a particular circuit protective device is specified, then due consideration of the circuit details should be undertaken before alternatives are proposed. The relative merits of fault loop impedance, thermal stress (the Joule equivalent) and the circuit voltage drop should always be part of CABLE CONSIDERATIONS!

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