NHP

TECHNICAL NEWS

Issue 7

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Quarterly Newsletter of Australia's leading supplier of low-voltage motor control and switchgear.

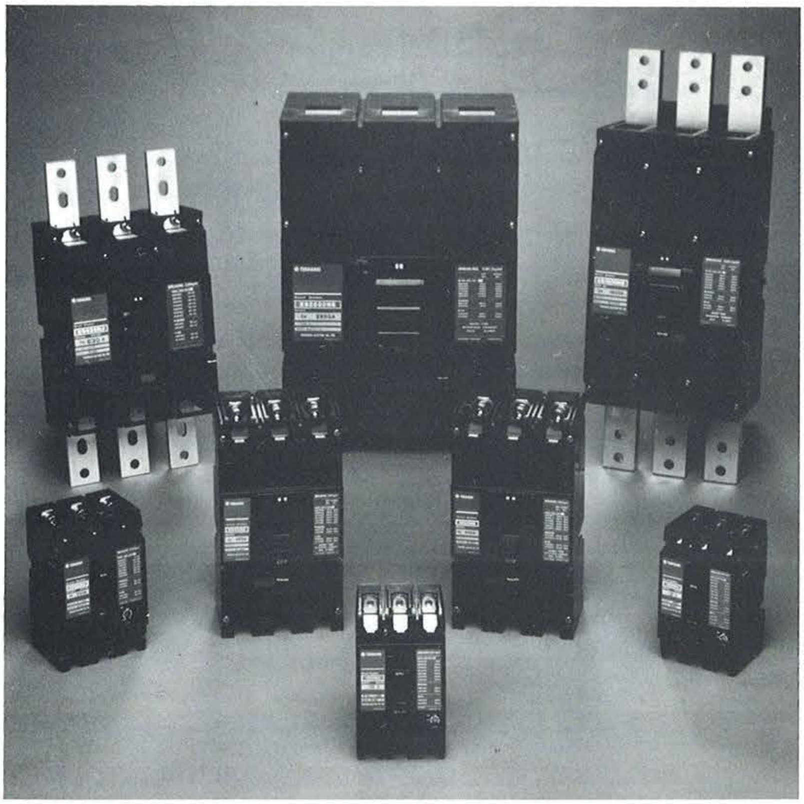
QUICK GUIDE TO FAULT LEVELS

The Wiring Rules require that protective devices shall be capable of interrupting any over-current up to and including the prospective short circuit current at the point where the protective devices are installed. To provide equipment with lower ratings can create a danger but to provide ratings much higher than that required can be a waste of money.

The calculation method described in this publication is intended to provide a quick and simple means of determining the approximate fault level.

The point of supply

At the point of supply two fault levels can exist. The first is the actual fault level determined mainly by the impedance of the distribution transformer supplying the installation.



Calculating the actual fault level can lower the cost of components.

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The second is that declared by the supply authority. This level may be higher than the actual as it may allow for flexibility in the future. Changes to the distribution transformer or its location will not cause an upgrading of the installation if it has already been designed for worst case conditions.

To calculate the fault level at the terminals of the distribution transformer, it is generally sufficiently accurate to consider only the transformer impedance. The HV supply usually has a far greater capacity and can supply a transformer shorted on its output with little drop (5% is a typical figure) in voltage.

Neglecting the impedance of the HV supply makes the calculation very simple if the transformer impedance is known. Typical values are listed in **Table 1**.

The calculation for maximum fault current is ;

$$I_{sc} = \frac{kVA \times 100}{\sqrt{3} \times V_s \times Z\%}$$

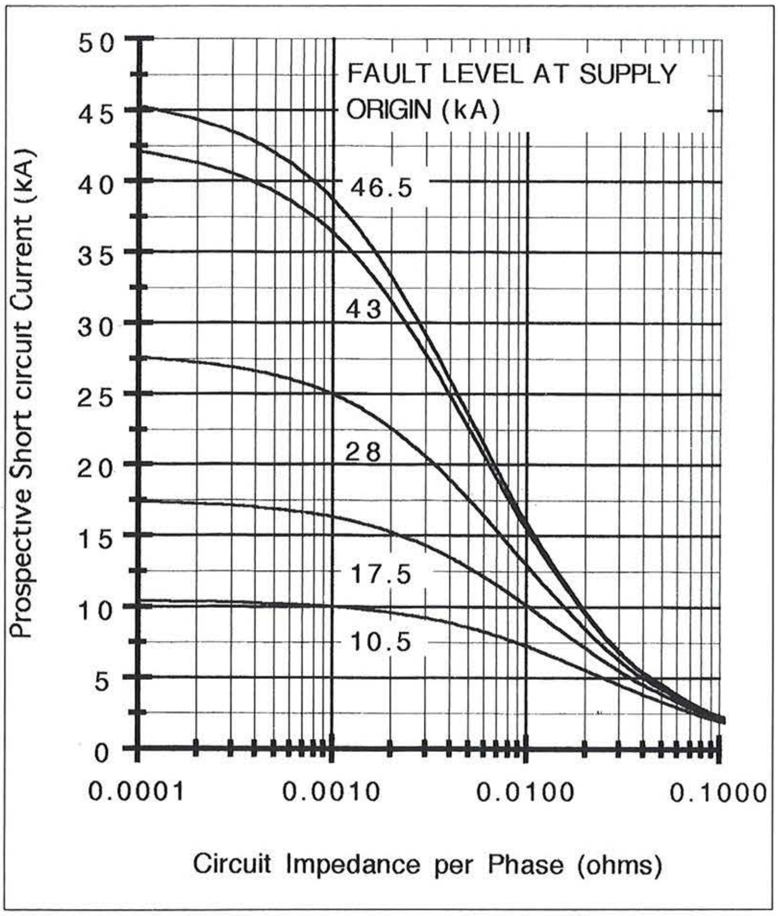
e.g. For a 500 kVA transformer with 4% impedance and 415 volt secondary

$$I_{sc} = \frac{500 \times 100}{\sqrt{3} \times 415 \times 4}$$
$$= 17.4\ kA$$

Table 1

Transformer kVA	X Ω	R Ω	Z Ω	Impedance %	Fault prospective kA
250	0.0120	0.0200	0.0230	3.3	10.5
500	0.0052	0.0120	0.0137	4.0	17.5
1000	0.0026	0.0081	0.0086	5.0	28.0
1500	0.0015	0.0053	0.0056	5.0	43.0
2000	0.0012	0.0050	0.0052	6.0	46.5

Figure 1



Reducing factors

The fault level at the transformer terminals may not represent the actual fault level at the switchboard. The impedance of the connecting busbar or cables may make a significant reduction.

In **Figure 1** the effect of additional circuit impedance on the prospective short circuit level of the transformer can be determined.

The calculation of the exact circuit impedance is not always simple as it is dependant on the resistance and reactance of the conductors. The reactance is determined by the conductor shape and spacing.

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As a reasonable guide to cable impedance **Table 2** can be used. The table assumes the cables to be laid flat and touching.

For small cables the impedance is determined mainly by the resistance but as the size increases the reactance becomes the major factor.

In **Table 3** typical values for busbar systems are given.
It is interesting to note that the impedance of busbars is higher than for cables as the larger phase spacings produce higher reactance values.

To use these tables, multiply the "impedance per metre" Z by the conductor length. The reduced fault level can then be determined from Figure 1.

Note:- This method only gives an approximate result. To determine fault levels more accurately the total circuit resistance and reactance need to be determined and applied in the following formula to determine the total impedance;

$$Z \text{ total} = \sqrt{R_{tot}^2 + X_{tot}^2}$$

Table 2

Cable Size mm²	X Ω/m	R (at 45 °C) Ω/m	Z Ω/m
4	0.000155	0.004960	0.004962
6	0.000146	0.003320	0.003323
10	0.000137	0.001960	0.001965
16	0.000129	0.001240	0.001247
25	0.000120	0.000725	0.000735
35	0.000116	0.000564	0.000576
50	0.000114	0.000416	0.000431
70	0.000109	0.000289	0.000309
95	0.000107	0.000215	0.000240
120	0.000104	0.000166	0.000196
150	0.000104	0.000136	0.000171
185	0.000103	0.000109	0.000150
240	0.000102	0.000084	0.000132
300	0.000101	0.000068	0.000122
400	0.000100	0.000055	0.000114
500	0.000099	0.000046	0.000109

Table 3

Bar Width (6.3 mm thick) mm	Phase Centres mm	X Ω/m 1 Bar	2 Bars
40	150	0.00017	0.00015
	200	0.00019	0.00017
50	150	0.00015	0.00013
	200	0.00018	0.00016
63	150	0.00014	0.00012
	200	0.00016	0.00015
80	150	0.00014	0.00014
	200	0.00016	0.00016
100	150	0.00013	0.00013
	200	0.00015	0.00015
125	150	0.00012	0.00011
	200	0.00014	0.00013
160	150	0.00010	0.00010
	200	0.00012	0.00012

Note: *With the above phase centres the bar resistance is much smaller than the reactance.*

For cable calculations please ask for your free copy of the NHP Short Circuit Calculation Nomogram available from any NHP office.

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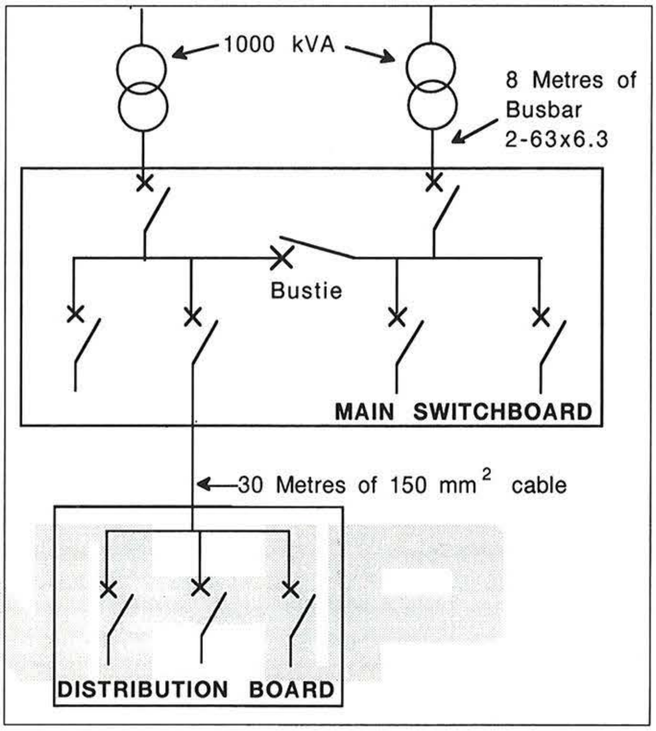
Typical installation

The diagram in **Figure 2** shows a typical installation being fed by two 1000 kVA transformers. The main switchboard is divided into two sections and is provided with a bustie to allow power to be fed to the installation from one transformer in the event of a failure of the other supply. It is important to note the effect that operating with the bustie closed has on the fault prospective seen by the outgoing devices.

In this example it can be seen that even with 50 kA at the main switchboard, equipment capable of handling 23 kA is all that is required at the distribution board.

Figure 2



Short circuit calculations

	Bustie open	Bustie closed
Transformer fault level	28 kA	28 kA
Impedance of busbar	0.001Ω	0.001Ω
Fault level at main switchboard	25 kA	50 kA
Impedance of cable	0.0042Ω	0.0042Ω
Fault level at distribution board	17 Ka	23kA

Editorial content: - Please address all enquiries to 'The Editor - 'NHP Technical News' PO Box 199, Richmond Victoria 3121.

NHP Electrical Engineering Products Pty Ltd A.C.N. 004 304 812
Internet http://www.nhp.com.au
MELBOURNE
43-67 River Street,
Richmond, Vic. 3121
Phone: (03) 9429 2999
Fax (03) 9429 1075
SYDNEY
30-34 Day Street North,
Silverwater, N.S.W. 2128
Phone: (02) 9748 3444
Fax: (02) 9648 4353
BRISBANE
25 Turbo Drive,
Coorparoo, Qld. 4151
Phone: (07) 3891 6008
Fax: (07) 3891 6139
ADELAIDE
50 Croydon Road,
Keswick, S.A. 5035
Phone: (08) 8297 9055
Fax: (08) 8371 0962
PERTH
38 Belmont Ave.,
Rivervale, W.A. 6103
Phone: (08) 9277 1777
Fax: (08) 9277 1700
NEWCASTLE
575 Maitland Road,
Mayfield West, N.S.W. 2304
Phone: (02) 4960 2220
Fax: (02) 4960 2203
TOWNSVILLE
62 Leyland Street,
Garbutt, Qld. 4814
Phone: (07) 4779 0700
Fax: (07) 4775 1457
ROCKHAMPTON
208 Denison Street,
Rockhampton, Qld. 4700
Phone: (07) 4927 2277
Fax: (07) 4922 2947
TOOWOOMBA
Cnr Carroll St. & Struan Crt.,
Toowoomba, Qld. 4350
Phone: (07) 4634 4799
Fax: (07) 4633 1796
CAIRNS
14/128 Lyons Street,
Bungalow, Qld. 4870
Phone: (07) 4035 6888
Fax: (07) 4035 6999
DARWIN
3 Steele Street,
Winnellie, N.T. 0820
Phone: (08) 8947 2666
Fax: (08) 8947 2049
Agents:
HOBART
199 Harrington Street,
Hobart, Tas. 7000
Phone: (03) 6234 9299
Fax: (03) 6231 1693
LAUNCESTON
59 Garfield Street,
Launceston, Tas. 7250
Phone: (03) 6344 8811
Fax: (03) 6344 4069
BURNIE
6 Wellington Street,
Burnie, Tas. 7320
Phone: (03) 6432 2588
Fax: (03) 6432 2580