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

IN THIS ISSUE



# ANOTHER STEP IN ELECTRICAL SAFETY

*By Bill Mairs*

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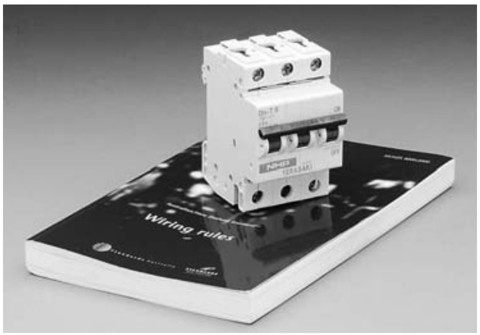
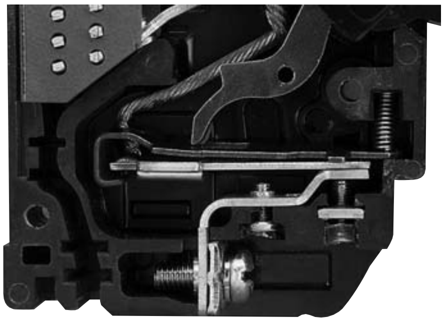
*NHP Electrical Engineering Pty Ltd*



The new Wiring Rules AS/NZS 3000:2000 include changes to improve electrical safety. During short circuits, it is possible for exposed conductive parts of an installation to rise to a voltage which could cause severe shock to anybody in contact with them. The new rules require the design of the electrical installation to be such that this type of risk is kept to a minimum. In addition, domestic installations now require earth leakage protection on both lighting and power circuits. To ensure the new safety requirements are complied with, an improved understanding of the characteristics of the circuit protective devices and potential fault currents is required for those responsible for the installation.

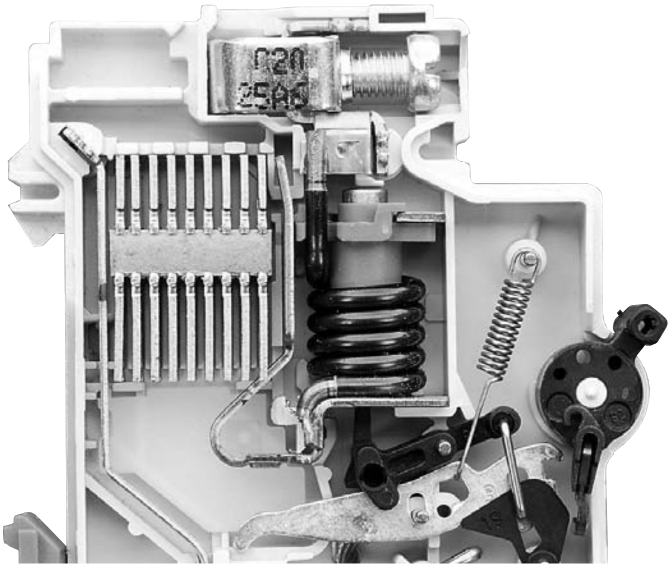
## The Miniature Circuit Breaker (MCB)

The MCB has long replaced the rewireable fuse for the protection of low current (<100 A) circuits. The MCB offers easy resetting after a fault and until the introduction of the 2000 edition of the Wiring Rules, was selected simply to match the cable rating. Very few people have been aware that different characteristics have been available and the new Wiring Rules now require an understanding of the differences. The problem is further complicated by the existence of two standards for MCBs in Australia. The old AS3111 is still applicable until 2007. In the meantime it runs concurrently with AS/NZS4898. These standards have different requirements for the time/current characteristics of the circuit breakers.



***Typical magnetic trip. AS3111 style***

While most MCBs use a directly heated bimetal (the bimetal carries the current) the older or what can be generally called the AS3111 breakers, have a simple clapper type magnetic trip. MCBs to AS/NZS4898 typically have a solenoid arrangement and for each current rating the number of turns is



*Typical magnetic coil. AS/NZS4898 style*

different. The magnetic trip of the AS3111 breakers was more to allow the MCB to interrupt short circuit levels than provide a feature for the protected circuits. The standard has no specific test requirements for the performance of the magnetic trip. For the AS/NZS4898 breakers, the magnetic trip is assessed and the breaker characterised by the pick up point of the magnetic trip. This gives rise to three types B, C and D with mean instantaneous operating points of 4, 7.5 and 12.5 times rated current respectively (*See Diagram A*). For the Australian market, the C curve has been the common rating with very little application for B and D curves.

## Why have different curves

In most applications, even with the new requirements the C curve is the best characteristic to use. It will provide adequate circuit protection with little nuisance tripping. With some loads such as air conditioners and welders there can be large inrush currents that will cause tripping of the circuit breaker. This can often be resolved by fitting a D curve breaker with the higher magnetic trip. The new Wiring Rules have introduced concepts that now require a B curve breaker to be fitted in some circuits to ensure that under short circuit conditions the magnetic trip level has been reached.

For AS3111 style breakers there is no choice of performance characteristics. If there is a problem with tripping time; compliance may require larger cables or reduced length of the cable run.

## The problem

The Multiple Earth Neutral (MEN) wiring system as used in Australia, is intended to ensure exposed conductive parts of an installation are maintained at the same potential as earth. In the case of the normal 415 V supply the MEN system also prevents any live conductors from being higher than 240 V above earth. Under short circuit conditions the situation can change because

*Typical MCB trip characteristics to AS/NZ4898*

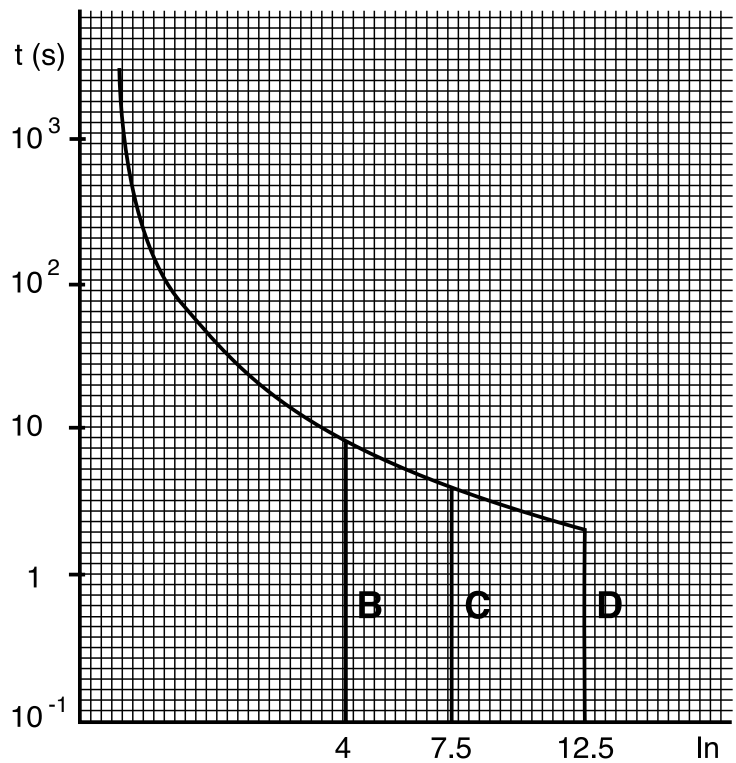



*Diagram A.*

## Maximum circuit length when volt drop and touch voltages are considered

| Conductor Size | | Cable Rating | | | Circuit-breaker types (AS/NZS 4898) Din Style | | | (AS 3111) | (AS 2005.21.2) |
|---|---|---|---|---|---|---|---|---|---|
| Active | Earth | AS/NZS 3008.1.1 (Table 9, Col.4) Unenclosed, Touching | AS/NZS 3008.1.1 (Table 9, Col.10) Partially insulated | Protective Device Rating | Type B | Type C | Type D | Terasaki SAFE-T | Fuses |
| mm sq | mm sq | A | A | A | Maximum circuit length, Lmax., m | | | | |
| 1 | 1 | 14 | 10 | 6 | 39 (170) | 39 (91) | 39 (55) | 39 | 39 (204) |
| 1 | 1 | 14 | 10 | 10 | 23 (102) | 23 (55) | 23 (33) | 23 (36) | 23 (114) ● |
| 1.5 | 1.5 | 18 | 13 | 10 | 37 (153) | 37 (82) | 37 (49) | 37 (53) | 37 (170) |
| 1.5 | 1.5 | 18 | 13 | 16 | 23 (96) | 23 (51) | 23 (31) | 23 (28) | 23 (82) ● |
| 2.5 | 2.5 | 26 | 18 | 16 | 42 (160) | 42 (85) | 42 (51) | 42 (46) | 42 (136) |
| 2.5 | 2.5 | 26 | 18 | 20 | 34 (128) | 34 (68) | 34 (41) | 34 (36) | 34 (93) ● |
| 2.5 | 2.5 | 26 | 18 | 25 | 27 (128) | 27 (67) | 27 (40) | 27 (37) | ◆ |
| 4 | 2.5 | 34 | 24 | 25 | 43 (126) | 43 (67) | 40 | 36 | 43 (90) ● |
| 4 | 2.5 | 34 | 24 | 32 | 34 (98) | 34 (52) | 31 | 28 | ◆ |
| 6 | 2.5 | 44 | 31 | 40 | 40 (90) | 40 (48) | 29 | 30 | ◆ |
| 10 | 4 | 60 | 43 | 50 | 54 (117) | 54 (62) | 37 | 42 | 54 (73) ● |
| 16 | 6 | 80 | 57 | 63 | 68 (142) | 68 (76) | 45 | 51 | 68 (85) ● |
| 16 | 6 | 80 | 57 | 80 | 54 (112) | 54 (59) | 36 | 36 | ◆ |
| 25 | 6 | 105 | 79 | 80 | 84 (124) | 66 | 40 | 40 | 66 ● |
| 25 | 6 | 105 | 79 | 100 | 68 (99) | 53 | 32 | 32 | ◆ |
| 35 | 10 | 130 | 92 | 100 | 93 (159) | 85 | 51 | 51 | 47 ● |
| 35 | 10 | 130 | 92 | 125 | 74 (127) | 68 | 41 | | ◆ |
| 50 | 16 | 160 | 110 | 125 | 99 (198) | 99 (106) | 63 | | 90 ● |

◆ Fuses of this rating cannot be used for cables of type Unenclosed, Touching or Partially Insulated.
● Fuses of this rating cannot be used for cables of type Partially Insulated.
Length limited by voltage drop of 5%. Single phase circuit. Load = protective device rating. At half load length may be doubled.
**Note:** Values within brackets are the lengths when only short circuit conditions are considered. (See B5.1 of AS3000:2000)
All figures are based on a nominal voltage of 230V.

*Table1. Maximum circuit length when volt drop and touch voltages are considered*

of the impedance of the earth conductors. Exposed parts can reach voltages approaching the normal phase to earth voltage. ***(See diagram B )***

## The risk

If a person is in contact with say, the frame of an electrical device when it develops an internal fault to earth, they can be exposed to a significant voltage between the point they are standing on and the device frame. The voltage they are actually exposed to will depend on quite a few factors. The risk however is real and is greatest when an operator of an electrical device is required to grasp it. The Wiring Rules consider that provided the exposure time of this voltage is less than 0.4 seconds, then the risk to a person in contact with exposed conductive parts is minimal.

## Fault calculation

To access the clearance time under fault conditions the prospective fault current must be determined by measurement or, calculation. It is the prospective current that will flow when the end of the cable being protected is connected to the protective earth conductor that is of concern. With long cable runs this prospective current can be found to be comparatively low. It should be remembered however that the first problem with long cable runs is the possibility of excessive voltage drop, and cables should be selected first for current rating, then checked for voltage drop before determining the fault prospective.

The Wiring Rules give guidance as to the calculation of fault currents and provides Table B5.1 for a quick guide to maximum circuit lengths for typical active/earth wire combinations. It should be noted that the lengths quoted for Type B circuit breakers and fuses for cables up to 16 mm cannot be achieved because of excessive volt drop. Care should also be taken to check the cable rating for the intended mounting or enclosure. In particular the cable rating must be multiplied by 0.9 when using a fuse. The above table 1 shows the results when volt drop and installation method are considered. It also includes a column for Terasaki Safe-T circuit breakers.

## Earth leakage

For a circuit protected by a 30 mA earth leakage device, the clearance time of 0.4 seconds is easily achieved and it is not necessary to consider prospective currents or operating characteristics of the circuit over current protection. Any current flow to earth above 30 mA will cause virtually instantaneous tripping and comply with the wiring rules 0.4 second requirement.

While earth leakage devices with higher trip levels (300 mA being typical) are used in other countries to address the problems of touch voltages, they have so far had little acceptance in Australia. The higher trip level is however much more suited for protecting the whole of an installation, and it is less prone to the nuisance tripping that can arise with 30 mA devices. Trip levels above 30 mA do not provide adequate protection against shock when direct contact is made with a live conductor, as current flow in the region between 30 and 300 mA is where most electrical fatalities will arise.

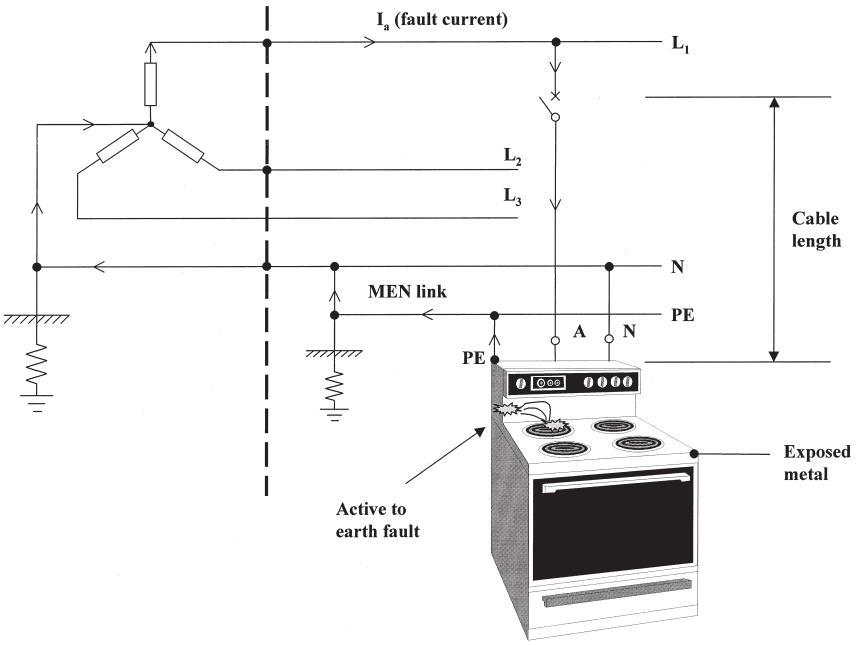



*Diagram B.*
*- Faults to earth can cause a risk of shock*

## Protection against short circuit

The Wiring Rules are now more specific in the need to limit the temperature rise of conductors during a short circuit. The normal MCCB, MCB and HRC fuse will meet the requirements and will prevent damage to conductors. In the case of the more robust air circuit breakers, it is possible to a set time delay at short circuit current levels. If this is done the temperature rise of the conductor must be checked for the time delay selected at the fault current prospective of the circuit in question. The required calculation can be found in clause 2.4.4.3 of the Wiring Rules.

## Conclusion

Australia is following what has been accepted in many countries for some time. The changes mentioned above address what is a flaw in the MEN system of earthing. That is under short circuit conditions temporary exposure to harmful voltages is possible. This risk can be overcome by ensuring the circuit is tripped in less than 0.4 seconds. This can be achieved by normal over current protective devices if cable runs are not excessive. If earth leakage protection is installed the requirement is easily met. While the number of instances where this has caused a problem may not be very high, the risk is still there and the solution is fairly simple.

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