# GUIDE TO CIRCUIT BREAKER STANDARDS

BS EN 60898: 1991

BS EN 60947-2: 1996

The Electrical Installation Equipment Manufacturers' Association

# INTRODUCTION TO EIEMA AND IT'S LOW VOLTAGE CIRCUIT BREAKER DIVISION

The Electrical Installation Equipment Manufacturers' Association, is an autonomous, incorporated Association of British manufacturers of electrical installation equipment. The Association's roots date back to 1915 as a product section of BEAMA The Federation of British Electrotechnical and Allied Manufacturers' Associations.

EIEMA's Low Voltage Circuit Breaker Division consists of major UK manufacturing companies in this field and has its own officers, technical and other committees, all operating under the guidance and authority of the EIEMA Board of Management supported by specialist central services for guidance on European Single Market, Quality Assurance, Legal and Health & Safety matters.

Active participation in the work of numerous national, international and regional standards committees has provided the background and support to ensure safety and performance for the design, development and manufacture of its members' products. The result is quality equipment of the highest standard throughout each division of the Association.

*This publication is available at £10.00 plus postage and packing*

# LOW VOLTAGE CIRCUIT BREAKERS CHANGES IN STANDARDS

## Harmonisation

In an ideal world, the compatibility of manufactured goods across a wide geographical area can remove barriers to trade and can result in an efficiency of scale due to increased manufacturing volumes which in turn can reduce costs. In the electrical industry, appropriate standardisation could mean common supply networks and products; and in low-voltage circuit breaker applications can result in:

- ability to use compatible equipment;
- no need to adapt or modify such products;
- fewer limitations on the source of supply.

To this end considerable progress has already been made by the national standards committees of over 40 nations who are co-operating to formulate world standards which provide a consensus of international opinion on electrical supply and harmonisation.

## World Standards

Participating countries comprise the International Electrotechnical Commission (IEC).

Most of these participating countries already have their own national standards which may differ from elements of the IEC Standards. However when a need for harmonisation is identified, documents produced by the IEC may, where appropriate, form the basis for future national standards.

## European Standards

Within Europe harmonisation of electrical products is controlled by CENELEC (Comite Europeenne de Normalisation Electrotechnique) which produces, appropriate European standards based on the work of the IEC once a need has been identified and agreed.

CENELEC is made up of the 18 national standards committees of the EC (European Community), and EFTA (European Free Trade Association). Whilst a European Standard can be a direct replica of an IEC standard, discussions within CENELEC may result in the formulation of a standard which includes commonly agreed variations.

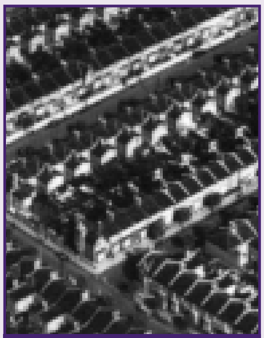
Two types of European Standard exist: the European Norm (prefixed EN-) and the Harmonised Document (prefixed HD-) where EN- qualifies the adoption of the standard by all member countries *without* deviation; and HD- qualifies that the standard has been adopted *subject to national deviations*.

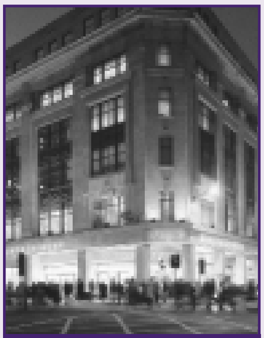
In general the first two numbers after the EN- or HD- prefix indicates the presence or otherwise of an IEC Standard: 60 in the case of the former, 50 in the case of the latter.

## United Kingdom Standards

Adoption of the European Standard within the EC is mandatory. In the UK such standards are further endorsed with the additional 'BS' prefix, for example: BS EN 60898, the British Standard for circuit breakers for overcurrent protection for household and similar installations.

BS EN 60898
(EN 60898,
IEC 60898)


HOUSEHOLD


RETAIL


MACHINERY

Relates to Low Voltage Circuit Breakers for use in household and similar installations. In the UK traditionally known as miniature circuit breakers (MCB's).

BS EN 60947-2
(EN 60947-2,
IEC 60947-2)


INDUSTRIAL

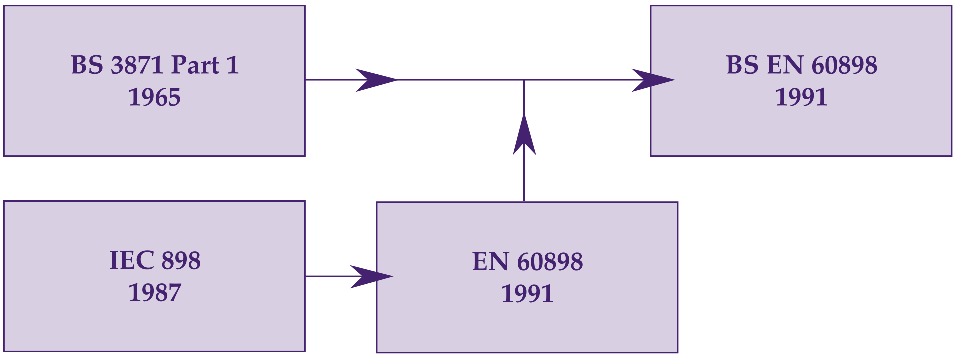

CITY

Relates to Low Voltage Circuit Breakers for use in industrial and similar installations. In the UK traditionally known as moulded case circuit breakers (MCCB's ) and also air circuit breakers (ACB's).

*From 1 January 1997, all IEC publications have the number 60000 added to the old number, e.g: IEC 898 has been renumbered as IEC 60898. For a period of time during the change over from one numbering system to the other, publications may contain identities from both systems.*

The guide also shows the timing for the introduction of the new standards and withdrawal of existing standards.

# LOW VOLTAGE CIRCUIT BREAKERS FOR USE IN HOUSE-HOLD AND SIMILAR INSTALLATIONS




## BS EN 60898 (EN 60898, IEC 60898)

It can be seen from the diagram above that up to 1987 no IEC Standard existed for miniature circuit breakers which, in the UK, have been manufactured since 1965 to BS 3871, under the title 'Miniature Air Circuit Breakers for a.c. circuits.'

The introduction in 1987 of IEC 898, under the title 'Circuit Breakers for Overcurrent Protection for Household and Similar Installations', formed the basis for acceptance of the European Standard EN 60898; which was published in the UK in 1991, as BS EN 60898. BS 3871 Part 1 was withdrawn on the 1st July 1994.

**Products which complied with BS3871 Part 1 before 1st July 1994, as shown by the manufacturer or by certification, were allowed to apply for production until 30th June 1999. Since this date all products must comply with BS EN 60898**

There are considerable differences between the BS 3871 and BS EN 60898 standards and reference must be made to the standards for full details.

Worthy of mention here and of interest to the specifier/installation designer are:

### Preferred Values of Current

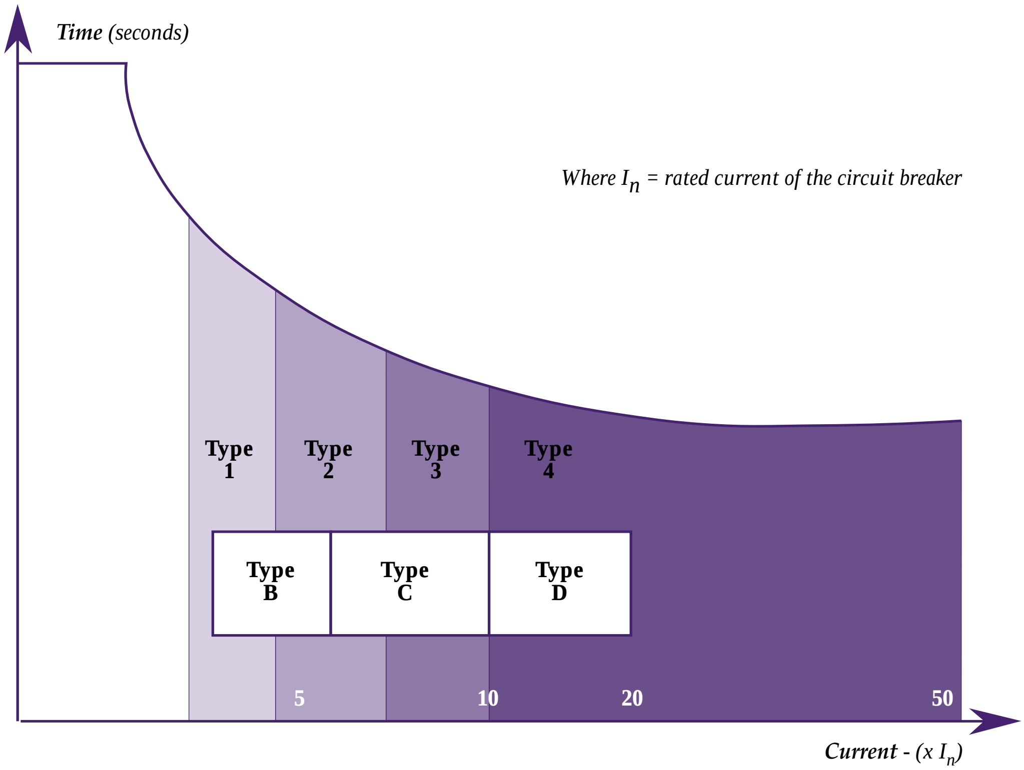
The Imperial current ratings have been totally superseded by the Renard series which have been increased to include 125A.

The new values are 6, 10, 13, 16, 20, 25, 32, 40, 50, 63, 80, 100 and 125A.

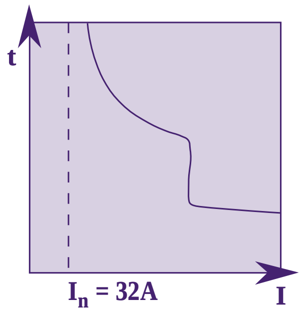
The inclusion of 125A rated circuit breakers recognises the increasing cur:ent demand in final circuits and the requirement for suitable protection devices, compatible in physical size with circuit breakers, and capable of being installed in the same standard distribution boards.

## BS 3871, BS EN 60898

# TIME/CURRENT CHARACTERISTICS




The Types I to 4 are omitted from the new standard which requires new instantaneous tripping characteristics:




| BS 3871 (OLD) | |
|---|---|
| Type 1 | 2.7 to 4.0$I_n$ |
| Type 2 | 4.0 to 7.0$I_n$ |
| Type 3 | 7.0 to 10.0$I_n$ |
| Type 4 | 10.0 to 50.0$I_n$ |

| BS EN 60898 (NEW) | |
|---|---|
| Type B | 3 to 5$I_n$ |
| Type C | 5 to 10$I_n$ |
| Type D | 10 to 20$I_n$ |

Note: *IEC 898 permits the upper limit for type D to extend to 50 x $I_n$.*

There is no Type A instantaneous tripping characteristic to avoid confusion with the A abbreviation for amperes.

The application of the new tripping characteristics should pose no problems to circuit designers in that:

**Type 1/Type B** are ideally suitable for domestic and commercial installations having little or no switching surges.

**Types 2 and 3/Type C** are best suited to general use in commercial/industrial installations where the use of fluorescent lighting, small motors etc. can be produce switching surges which would operate a Type I / Type B circuit breaker.

**Type 3/Type C** circuit breakers may be necessary in instances of highly inductive circuits, for example, banks of fluorescent lighting.

**Type 4/Type D** are particularly suited to the protection of equipment such as transformers, some fluorescent lighting, X-Ray machines, industrial welding equipment and similar applications where abnormally high inrush currents are experienced.

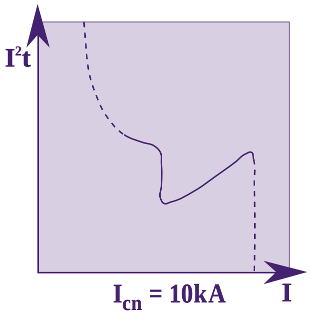
BS 7671:1992 Requirements for Electrical installations (16th Edition of the IEE Wiring Regulations) specifically identifies Types 1, 2 & 3, Types B, C & D. Lower earth fault loop impedances (Zs) are generally necessary for Type 4 to achieve the operating times required by Regulation 413-02-08. (Maximum Zs is calculated using the formula in the regulations and the characteristics of the circuit breaker).

Where the requirement cannot be achieved, use of circuit breakers as overcurrent protective devices is not precluded, but the use of residual current devices (RCDs) to provide protection against indirect earth fault conditions is implied.

Establishment of the value of the earth fault loop impedance (Zs) at the design stage of the installation will determine which type of circuit breaker should be used.

Table 41B2 of the Wiring Regulations gives the same maximum loop impedances for Types 3 and C since their maximum instantaneous operating current coincides at 10 times rated current. The Table also quotes the same maximum values for either 0.4 second or 5 seconds disconnection times.

## RATED SHORT-CIRCUIT CAPACITY ($I_{cn}$)



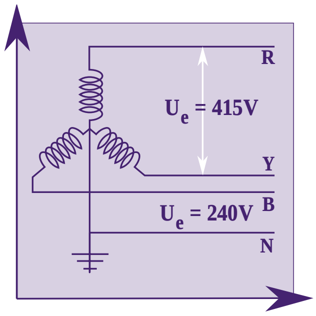

In BS EN 60898 the ‘M’ category ratings for short-circuit capacities disappear. The manufacturer must, however, declare the short-circuit capacity of the products at specified power factors of test circuit. Higher short-circuit capacities up to 25kA are recognised with the following values of $I_{cn}$:

| BS 3871 | |
|---|---|
| **M1** | 1000A |
| **M1.5** | 1500A |
| **M3** | 3000A |
| **M4.5** | 4500A |
| **M6** | 6000A |
| **M9** | 9000A |

| BS EN 60898 ($I_{cn}$) | |
|---|---|
| **1500** | 1500A |
| **3000** | 3000A |
| **6000** | 6000A |
| **10000** | 10000A |
| **15000** | 15000A |
| **25000** | 25000A |

# NEW STANDARD TERMINOLOGY

$U_e$




### $U_e$ Rated Operational Voltage

The nominal voltage of the system should not exceed $U_e$

*e.g. Single Pole $U_e$ 240/415V*

*Three Pole $U_e$ = 415V*

*In IEC Publication 38 the voltage values of 230v and 230/400v have been standardised. These values should progressively replace the values of 240v, 220/380v and 240/415v.*

$U_i$

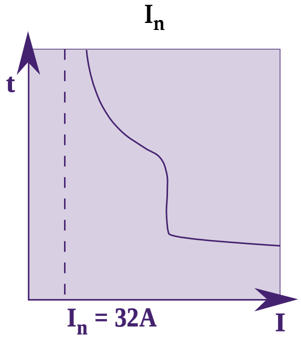
$U_i$ = 500V
Tested @
2000V ac 50Hz

### $U_i$ Rated Insulation Voltage

The voltage on which the dielectric properties are based using tests at high voltage and mains frequency

*Unless otherwise stated the rated insulation voltage is the value of the maximum rated voltage of the circuit breaker. In no case shall the maximum rated voltage exceed the rated insulation voltage.*

$I_n$

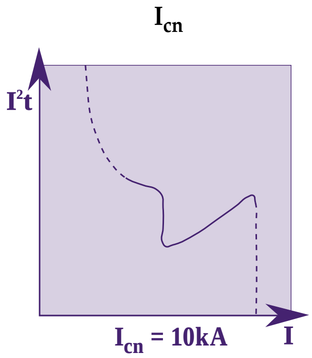



### $I_n$ Rated Current

The current which the circuit breaker will carry continuously under specified conditions and on which the time/current characteristics are based.

Unless otherwise stated $I_n$ is based on a reference ambient temperature of 30 degrees centigrade.

*e.g. $I_n$ = 32A Trip Type C marked 'C32'.*

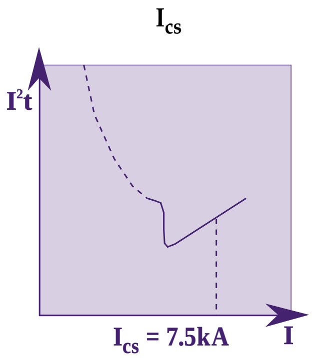



**$I_{cn}$ Rated Short Circuit Capacity**

The calculated prospective fault current at the incoming terminals of the circuit breaker should not exceed $I_{cn}$.

*e.g. $I_{cn}$ = 10kA marked* $\boxed{10000}$

*Exception: Using back up protection as specified by the manufacturer.*




**$I_{cs}$ Service Short Circuit Breaking Capacity**

[Not marked on the circuit breaker]

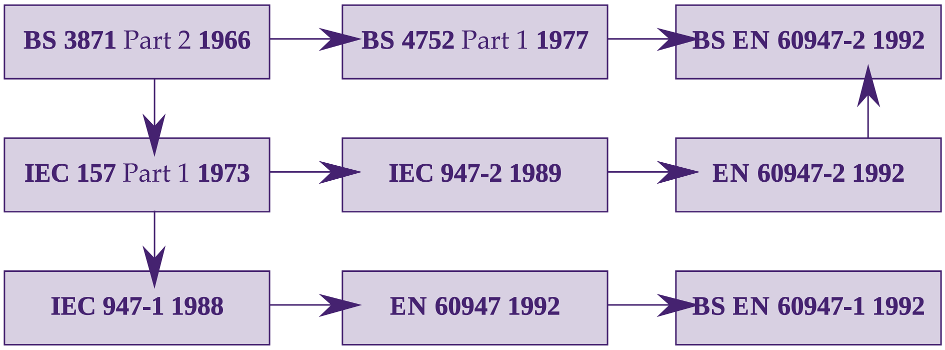
The maximum level of fault current operation after which further service is assured without loss of performance.

Ratio between service short-circuit capacity ($I_{cs}$) and rated short-circuit capacity ($I_{cn}$) – (factor k).

| $I_{cn}$ | k |
|---|---|
| ≤ 6000 A | 1 |
| > 6000 A | 0.75* |
| > 10000 A | 0.5** |

* *Minimum value of $I_{cs}$: 6000 A*
** *Minimum value of $I_{cs}$: 7500 A*

# LOW VOLTAGE CIRCUIT BREAKERS FOR USE IN INDUSTRIAL AND SIMILAR INSTALLATIONS




## BS EN 60947 -2 (EN 60947 -2, IEC 60947-2)

To fully understand the scope of IEC 60947-2, one must refer back to the origins of circuit breaker standards.

The original standard in the UK was BS 3871 Part 2 1966, which was followed by the evolution of IEC 157 Part 1 1973. This was incorporated as BS 4752 in 1977.

During the 1980's the concept of the 947 series of standards evolved. This for the first time would bring all products relating to low voltage switchgear and control gear under one generic standard. *Refer to note on page 4.*

| | |
|---|---|
| **IEC 947** | Specification for low voltage switchgear and control gear. |
| **IEC 947-1** | General Rules. |
| **IEC 947-2** | Circuit Breakers. |
| **IEC 947-3** | Switches, disconnectors, switch disconnectors and fused combination units. |
| **IEC 947-4** | Contactors and motor starters. |
| **IEC 947-5-1** | Control circuit devices - electromechanical. |
| **IEC 947-5-2** | Proximity switches. |
| **IEC 947-6** | Multiple function switching devices. |
| **IEC 947-7** | Ancillary equipment. |

In 1989 the International standard for air circuit breakers IEC 157 was superseded by IEC 947-2. This was adopted as the European norm EN 60947-2 in March 1991. This was published in the UK as British Standard BS EN 60947-2 in May 1992 with the withdrawal of the dual standard IEC 157/BS 4752 in September 1992.

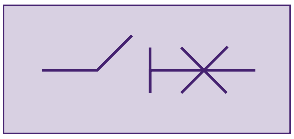
Products which complied with the relevant national standard before 30th September 1992, as shown by the manufacturer or by certification, were allowed to apply for production until September 1997. Since this date all products must comply with EN 60947-2.

This standard for circuit breakers introduces additional stringent testing procedures to emphasis the reliability in service of conforming products.

There are considerable differences between BS 4752 and BS EN 60947-2 and reference must be made to the standards for full details.

Worthy of mention here and of interest to the specifier/installation designer are:

## ISOLATION



The suitability of circuit breakers for use as isolators has been a contentious issue for some time. BS 4752 stated that its views on isolation were under review.

BS EN 60947-2 is more precise in its requirements for circuit breakers suitable for isolation by defining tests to which such units must comply. If the criteria for such tests are met the product must, if intended use as an isolator display the symbol illustrated

## CATEGORIES

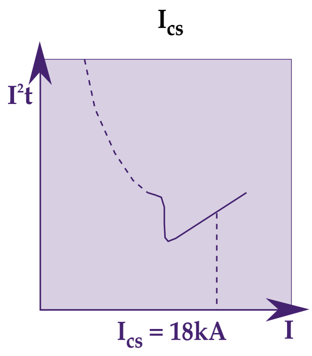
This subject constitutes the major change between the BS 4752 and BS EN 60947-2 standards. BS EN 60947-2 recognises a different classification system in categories A and B.

**Category A** designates circuit breakers not specifically intended for selectivity with devices on the load side. In other words circuit breakers will discriminate only up to certain fault levels, above which discrimination with devices on the load side cannot be guaranteed.

**Category B** designates circuit breakers specifically intended for selectivity with devices on the load side. Such circuit breakers will incorporate some form of time delay.

# SHORT CIRCUIT BREAKING CAPACITIES

BS EN 60947-2 Recognises both a rated service ($I_{cs}$) and a rated ultimate ($I_{cu}$) short circuit breaking capacity for both category A and category B circuit breakers.




**Rated Service Breaking Capacity ($I_{cs}$)**

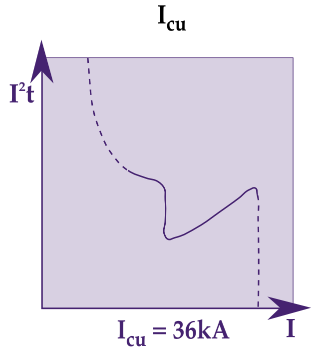
In order to define the value of $I_{cs}$ the circuit breakers under test must be subjected to a test sequence of:

$I_{cs}$ = o - t - co - t - co

*where*

*o = opening operation under fault conditions.*
*t = time interval before re-closing (not more than 3 mins)*
*c = closing operation on to a fault.*

After this test sequence, dielectric, terminal temperature and overcurrent tests are applied. The circuit breaker must meet certain test parameters to ensure that the circuit breaker has not deteriorated in performance and can, in fact, be put back into service.




**Rated Ultimate Breaking Capacity ($I_{cu}$)**

$I_{cu}$ = o - t - co

*where*

*o = opening operation under fault conditions.*
*t = time interval before re-closing (not more than 3 mins)*
*c = closing operation on to a fault.*

After this test sequence, dielectric and overcurrent tests are applied.

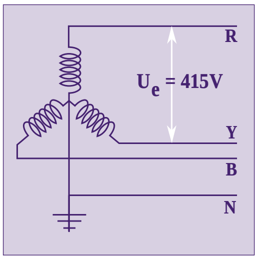
**Application of Breaking Capacities**

The rated service breaking capacity ($I_{cs}$) applies to short circuit faults that could occur in practice; whereas the ultimate short circuit capacity ($I_{cu}$) is the maximum theoretical. fault value of the installation at the point of connection.

The standard defines the ratio between $I_{cs}$ and $I_{cu}$. $I_{cs}$ will be shown as either 25, 50, 75 or 100% of its $I_{cu}$ value, for category A and 50, 75 or 100% of $I_{cu}$ for category B.

Thus a circuit breaker can remain in service after interrupting short circuit up to its rated value of $I_{cs}$. Where two or more faults occur between the $I_{cs}$ and $I_{cu}$ values, the continued operation of the circuit breaker must be verified.

**$U_e$**




### $U_e$ Rated Operational Voltage

The nominal line-to-line voltage of the system should not exceed $U_e$

*In IEC Publication 38 the voltage values of 230v and 230/400v have been standardised. These values should progressively replace the values of 240v, 220/380v and 240/415v.*

**$U_i$**

$U_i$ = 660V
Tested @
2500V ac 50Hz

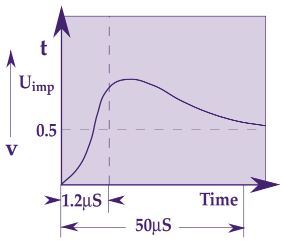
### $U_i$ Rated Insulation Voltage

The voltage on which the dielectric properties have conventionally been based using tests at high voltage and mains frequency.

It is intended to replace this value with $U_{imp}$.

*Unless otherwise stated the rated insulation voltage is the value of the maximum rated voltage of the circuit breaker. In no case shall the maximum rated voltage exceed the rated insulation voltage.*

**$U_{imp}$**

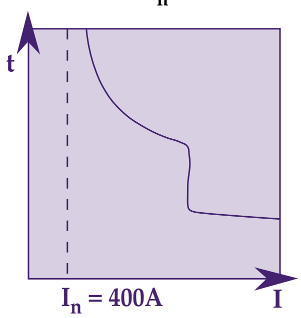



### $I_{imp}$ Rated Impulse Withstand Voltage

The voltage on which clearance distances are based. The value of transient peak voltage the circuit breaker can withstand from switching surges or lighting strikes imposed on the supply.

*e.g. $U_{imp}$ = 8kV, Tested @ 8kV peak with 1.2/50$_{\mu s}$ impulse wave.*

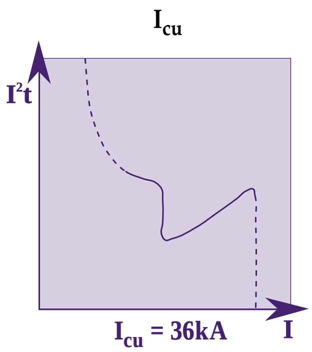
**$I_n$**




### $I_n$ Rated Current

The current which the circuit breaker will carry continuously under specified conditions and on which the time/current characteristics are based.

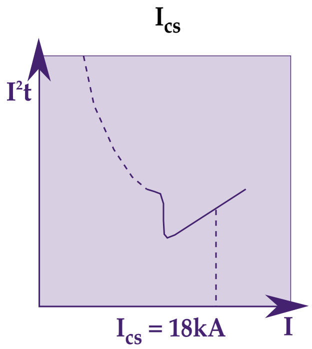
Unless otherwise stated $I_n$ is based on a reference ambient temperature of 30 degrees centigrade.




### $I_{cu}$ Rated Ultimate Short Circuit Breaking Capacity

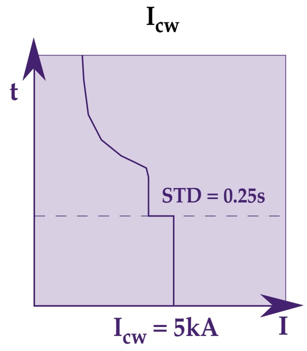
The calculated prospective fault current at the incoming terminals of the circuit breaker should not exceed $I_{cu}$.

Exception: Using back up protection as specified by the manufacturer.




### $I_{cs}$ Rated Service Short Circuit Breaking Capacity

The maximum level of fault current operation after which further service is assured without loss of performance.




### $I_{cw}$ Rated Short-Time Withstand Current

Circuit breakers of Utililisation Category B have a short-time delay allowing time graded selectivity between circuit breakers in series.

$I_{cw}$ is the current the circuit breaker will withstand for the maximum short-time delay time. Preferred times are 0.05, 0.1, 0.25, 0.5 and 1.0 second.

# MEMBERSHIP

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# GUIDE TO CIRCUIT BREAKER STANDARDS

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