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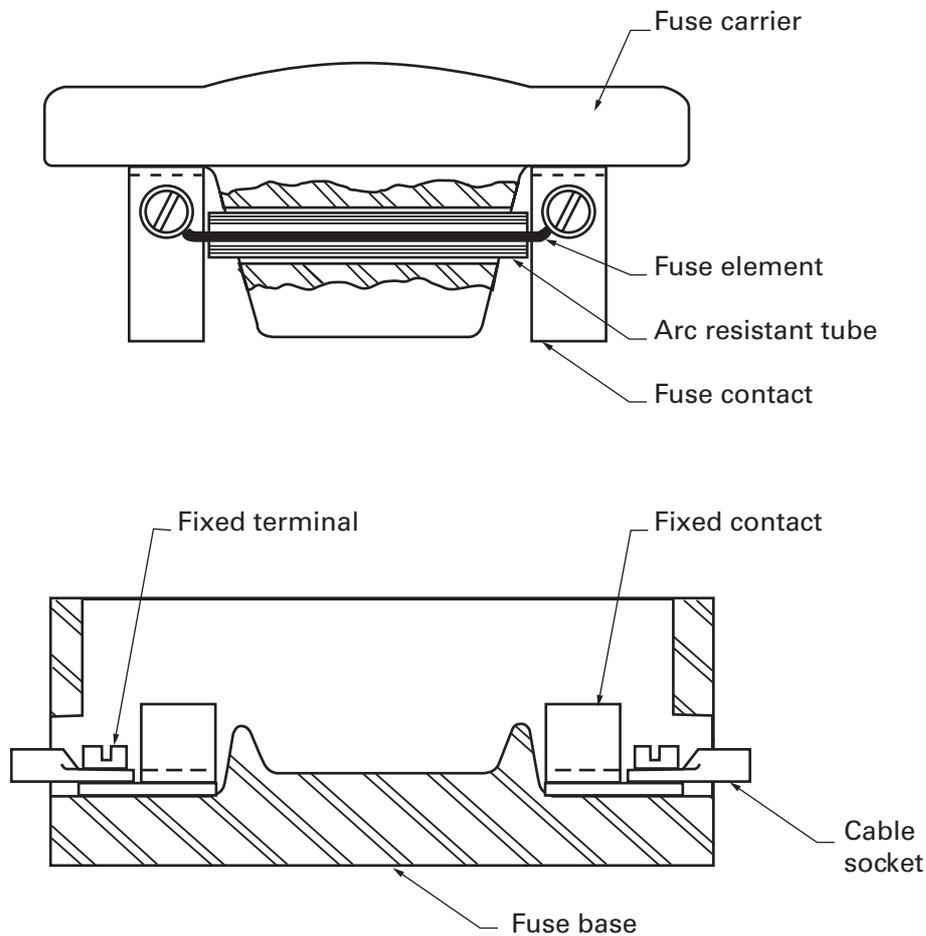
1. Introduction

Rewireable fuses, more correctly known as semi-enclosed fuses, are one available option for protection against overcurrent and/or indirect contact in an electrical installation. Many installation designers express a preference for cartridge fuses or circuit-breakers; but, nonetheless, rewireable fuses remain an available option. Such fuses continue to be suitable in many existing installations and persons carrying out periodic inspections should not recommend their replacement without good reason. One reason that rewireable fuses are popular is because the fuse element (a length of suitable wire) is inexpensive to replace. See Fig 1.

This rewireable feature is also a disadvantage because of the risk of the fuse-element (the wire), being replaced inadvertently, or in some cases deliberately, with a fuse-element of a higher fusing current. The circuit then may have inadequate protection against overcurrent and indirect contact (where the device provides such protection). A further disadvantage of rewireable fuses is that the let-through energy (when compared to let-through energy for a cartridge fuse) is very high. Manufacturer's information may need to be obtained for certain applications.

BS 7671 recognises the risk of the fuse-element being replaced with one with a higher fusing current and requires, in Regulation 533-01-04, that rewireable fuses, where selected, are to be fitted with a fuse element in accordance with the manufacturer's instructions. In the absence of manufacturer's instructions, rewireable fuses are to be fitted with a single element of tinned copper wire of the appropriate diameter, in accordance with Table 53A of *BS 7671*, which is reproduced later in this topic.

The requirements applicable to rewireable (semi-enclosed) fuses are specified in *BS 3036: Semi-enclosed electric fuses*. Semi-enclosed fuses are restricted to a.c. circuits.

Semi-enclosed (rewireable) fuse

Drawing courtesy of British Standards Institution

Fig 1

2. Categories

There are three basic types of *BS 3036* fuse, categorized according to duty. These categories of duty are S1A, S2A and S4A. Each category of duty is applicable to particular standard sizes of fuse. See item 4 of this topic. Details of the categories of duty are given in item 5 of this topic.

3. Rated voltage and frequency

The rated voltage of a fuse is defined in *BS 3036* as: 'a voltage stated by the manufacturer to be the highest declared voltage, and the highest voltage to earth, if less than 240 volts, that may be associated with the fuse.'

A fuse needs to be selected such that its rated voltage is suitable for the circuit in which it is to be connected. The voltage between conductors of the circuit must not exceed the rated voltage of the fuse, and the voltage between any conductor and earth must not exceed 240 V a.c. Alternatively, where the fuse is suitable only for a voltage to earth of less than 240 V a.c., the voltage to earth must not exceed the value declared by the manufacturer. For example, 415 V rated *BS 3036* fuses are considered to be suitable for use in three-phase a.c. electrical systems having an earthed star-point in which the voltage between phases does not exceed 415 V a.c. and phase to neutral voltage does not exceed 240 V a.c.

BS 3036 fuses are rated at the following nominal voltages:

- 240 V a.c. single-phase: the maximum voltage to earth not exceeding 240 V a.c., or
- 415 V a.c. three-phase: the maximum voltage to earth not exceeding 240 V a.c.

The rated frequency for *BS 3036* fuses is 50 Hz. The fuses should not be used for circuits operating at other frequencies.

4. Rated current I_n

The rated current I_n , of a fuse is defined in *BS 3036* as: ‘a current, less than the minimum fusing current, stated by the manufacturer to be the current that the fuse will carry continuously without deterioration.’ Minimum fusing current, as defined in *BS 3036*, is: ‘the minimum current at which a fuse-element in a fuse will melt.’

The scope of *BS 3036* is limited to fuses having rated current values of up to and including 100 A. Within this range *BS 3036* specifies a number of standard rated currents. These are given in Table 1 of *BS 3036*, which is reproduced below for ease of reference.

Table 1 of BS 3036: Sizes for each category of duty

Category of duty	Number of sizes	Standard sizes (Maximum current rating in amperes)
S1A	6	5, 15, 20, 30, 45, 60
S2A	7	5, 15, 20, 30, 45, 60, 100
S4A	4	30, 45, 60, 100

The standard fuse sizes as stated in *BS 3036* Table 1 are maximum rated current values and are related to category of duty. See item 5 of this topic. The rating of the fuse-element (the wire) fitted in a fuse is to be selected to be suitable for the circuit in which it is installed and is not to exceed the maximum rated current value for that fuse*.

* A ‘fuse’ comprises all the parts that form the complete device, including (i) the fuse carrier fitted with the fuse contacts, the arc resistant tube and the fuse element (the wire) and (ii) the fuse base fitted with the fixed terminals, the fixed contacts and the cable sockets. See Fig 1.

Regulation 533-01-04 requires fuse-elements (the wire) to be fitted in accordance with the manufacturer's instructions, or in the absence of such instructions, fitted with a single element of tinned copper wire of the appropriate diameter in accordance with Table 53A of *BS 7671*, which is reproduced below for ease of reference.

TABLE 53A
Sizes of tinned copper wire for use in semi-enclosed fuses

Nominal current of fuse element (A)	Nominal diameter of wire (mm)
3	0.15
5	0.20
10	0.35
15	0.50
20	0.60
25	0.75
30	0.85
45	1.25
60	1.53
80	1.80
100	2.00

The rated current (I_n) of a fuse applies to specific ambient temperature conditions. Where the ambient temperature conditions vary significantly from the ambient air temperature specified in *BS 3036*, correction factors may have to be applied. (See item 9 of this topic).

For overload current protection, the rated current of a fuse should be selected to meet the requirements of Section 433 of *BS 7671*. The term 'rated current' used in *BS 3036* generally means the same as 'nominal current' (or current setting) as used in *BS 7671*.

In order to provide overload current protection, Regulation 433-02-03 requires the nominal current (I_n) of a *BS 3036* fuse to be selected such that it does not exceed 0.725 times the current-carrying capacity (I_z) of the lowest rated conductor in the circuit protected. (See item 6 of this topic). This may require conductors to be of a larger cross-sectional area where overload current protection is afforded by a *BS 3036* fuse, compared with those where overload current protection is afforded by another type of overcurrent protective device.

In addition to providing overcurrent protection, a fuse can be used for the protective measure of Earthed Equipotential Bonding and Automatic Disconnection of supply (EEBAD), for protection against indirect contact. In such cases, the value of the earth fault loop impedance (Z_s) of the associated circuit is to comply with the requirements of Regulation Groups 413-02 and 471-08, according to the type of system earthing. Further information regarding protective devices and protection against indirect contact is given in Topic **117-5**.

5. Rated breaking capacity

The rated breaking capacity, of a rewireable fuse is defined in *BS 3036* as: 'a prospective current stated by the manufacturer to be the greatest prospective current to which a fuse may be subjected under prescribed conditions of voltage and of power factor.'

The rated breaking capacities of *BS 3036* fuses are:

- 1 kA at a lagging power factor of 0.8 to 0.9 for category of duty S1A,
- 2 kA at a lagging power factor of 0.7 to 0.8 for category of duty S2A and
- 4 kA at a lagging power factor of 0.7 to 0.8 for category of duty S4A.

BS 3036 fuses are also tested in circuits with a power factor of 0.4 to 0.5 lagging at a current of between 5 and 7 times the minimum fusing current[†].

All rated breaking capacities of *BS 3036* fuses correspond to the stated rated voltage of the fuse.

The rated breaking capacity of a *BS 3036* fuse must be selected to meet the requirements of Section 434 of *BS 7671*. However it may be found that the relatively low rated breaking capacity of *BS 3036* fuses is a disadvantage because it restricts the use of such fuses to installations where the fault level is low, unless suitable back-up protection is provided (Regulation 434-03-01 refers).

6. Time/current characteristics and fusing factor

The time/current characteristic of a fuse is a curve giving the pre-arcing time or operating time as a function of the prospective current under specified conditions. Fig 2 illustrates time/current characteristics for rewireable fuses to *BS 3036* with current rating from 5 A to 60 A. Manufacturers of fuses to *BS 3036* are required by that Standard to produce time/current characteristics for their fuses and to make copies of these available on request.

BS 3036 requires that the time/current characteristic of a fuse is ascertained by causing samples of the fuse to operate at not less than six different currents. This will facilitate the production of the time/current characteristic curve, an example of which is shown in Fig 2. The manufacturer's selected test currents must include two defined current values; the first is a current of not greater than 1.05 times the minimum fusing current[†] of the fuse; the second is the current, usually the greatest, that causes the fuse to operate in not more than 0.5 s.

[†] See item 4 for definition of minimum fusing current.

Example of time-current characteristics of semi-enclosed fuses to BS 3036

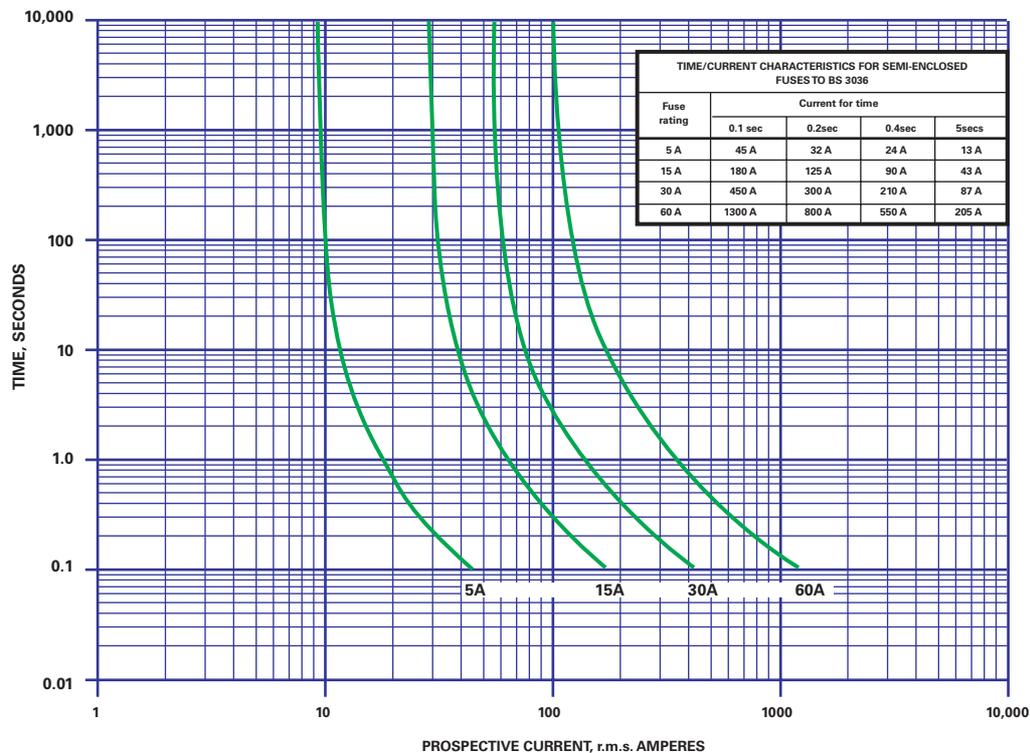


Diagram reproduced courtesy of the Institution of Electrical Engineers

Fig 2

The fusing factor of a BS 3036 fuse is defined in BS 3036 as: 'The ratio, greater than unity, of the minimum fusing current to the current rating of a fuse', and is not to exceed 2.0.

In this Technical Manual, the symbol generally used for minimum fusing current is I_2 . This is because 'minimum fusing current' means the same as the term 'current causing effective operation of the protective device' used in BS 7671, in relation to which the symbol I_2 is used.

Regulation 433-02-03 of BS 7671 recognizes that the minimum fusing current I_2 for a BS 3036 fuse can be as high as $2.0 I_n$ and advises that, where a BS 3036 fuse is used for overload current protection, compliance with condition (iii) of Regulation 433-02-01 is afforded where the nominal current I_n of the fuse is selected such that it does not exceed 0.725 times the current-carrying capacity I_z of the lowest rated conductor in the circuit protected. This is because, where I_n is equal to $0.725 I_z$ and $I_2 = 2.0 I_n$, then by substitution $I_2 = 2 \times 0.725 I_z$, giving $I_2 = 1.45 I_z$.

7. Discrimination

BS 3036 recommends, in view of the complexity of predicting discrimination, that the assistance of the manufacturer is sought. Discrimination in general is addressed in Topic **D61-1** of this Technical Manual.

8. Marking

The following information is required to be clearly and indelibly marked by the manufacturer on the fuse carriers of *BS 3036* fuses:

- Current Rating e.g. 15 A
- Voltage rating e.g. 240 V
- Manufacturer’s name or identifying mark
- Category of duty e.g. S1A
- *BS 3036* and date of the Standard.

9. Ambient air temperature

Where a *BS 3036* fuse is installed in an ambient air temperature which varies materially from the ambient temperature specified in *BS 3036*, correction factors may have to be applied to the rated current value of the fuse.

The reference ambient air temperature conditions specified for *BS 3036* fuses are an air temperature having a peak value not exceeding 40 °C and an average value, over 24 hr. periods, not exceeding 35 °C.

Where the air temperature conditions vary significantly from the values specified in *BS 3036*, the manufacturer should be consulted regarding the implications.



Topics referred to in this text:

D61-1	DISCRIMINATION: General
I17-5	INDIRECT CONTACT, PROTECTION AGAINST: Earth fault loop impedance, maximum values of



Topics not referred to in this text, which are related and may be of interest:

None listed



***BS 7671* (Requirements for electrical installations)**

Some of the most important requirements are found in:

Protection by earthed equipotential bonding and automatic disconnection of supply	413-02 and 471-08
Protection against overload current	Section 433
Protection against fault current	Section 434
Overcurrent protective devices	Section 533-01

