# Contents

1. Introduction
2. Categories
3. Rated voltage and frequency
4. Rated current ($I_n$)
5. Rated breaking capacity
6. Time/current characteristics and fusing factor
7. Discrimination
8. Marking
9. Ambient air temperature

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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.
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**

<table>
<thead>
<tr>
<th>Category of duty</th>
<th>Number of sizes</th>
<th>Standard sizes (Maximum current rating in amperes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1A</td>
<td>6</td>
<td>5, 15, 20, 30, 45, 60</td>
</tr>
<tr>
<td>S2A</td>
<td>7</td>
<td>5, 15, 20, 30, 45, 60, 100</td>
</tr>
<tr>
<td>S4A</td>
<td>4</td>
<td>30, 45, 60, 100</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Nominal current of fuse element (A)</th>
<th>Nominal diameter of wire (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.15</td>
</tr>
<tr>
<td>5</td>
<td>0.20</td>
</tr>
<tr>
<td>10</td>
<td>0.35</td>
</tr>
<tr>
<td>15</td>
<td>0.50</td>
</tr>
<tr>
<td>20</td>
<td>0.60</td>
</tr>
<tr>
<td>25</td>
<td>0.75</td>
</tr>
<tr>
<td>30</td>
<td>0.85</td>
</tr>
<tr>
<td>45</td>
<td>1.25</td>
</tr>
<tr>
<td>60</td>
<td>1.53</td>
</tr>
<tr>
<td>80</td>
<td>1.80</td>
</tr>
<tr>
<td>100</td>
<td>2.00</td>
</tr>
</tbody>
</table>

The rated current \( (I_a) \) 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 \( (I_c) \) 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 I17-5.
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.
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 $I_z$. 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 $I_z$ is used.

Regulation 433-02-03 of BS 7671 recognizes that the minimum fusing current $I_z$ 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 $0.725I_z$ and $I_z = 2.0I_n$, then by substitution $I_z = 2 \times 0.725I_z$, giving $I_z = 1.45I_z$.

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.