# IEC 60269 gG & aM
# STANDARD LOW VOLTAGE FUSE

## 1. INTRODUCTION

Fuses gG and aM as per IEC 60269 are proposed in many different technologies formerly defined by local standards such as British Standards, French standards, German Standards etc. However when they are marked gG or aM their electrical characteristics comply with IEC 60269 electrical requirements i.e. the melt curves must go between the same gates, testing conditions are the same, power losses must be less than a maximum value etc.

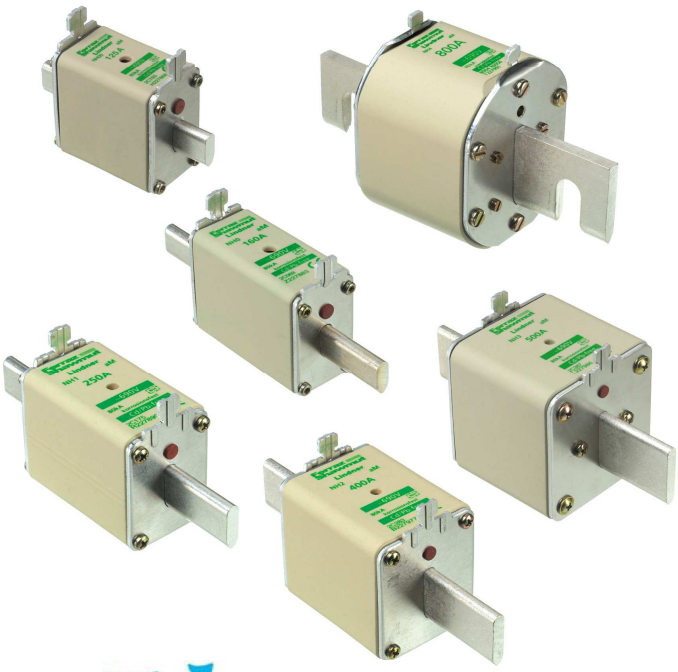
**D / D0**


**CP**

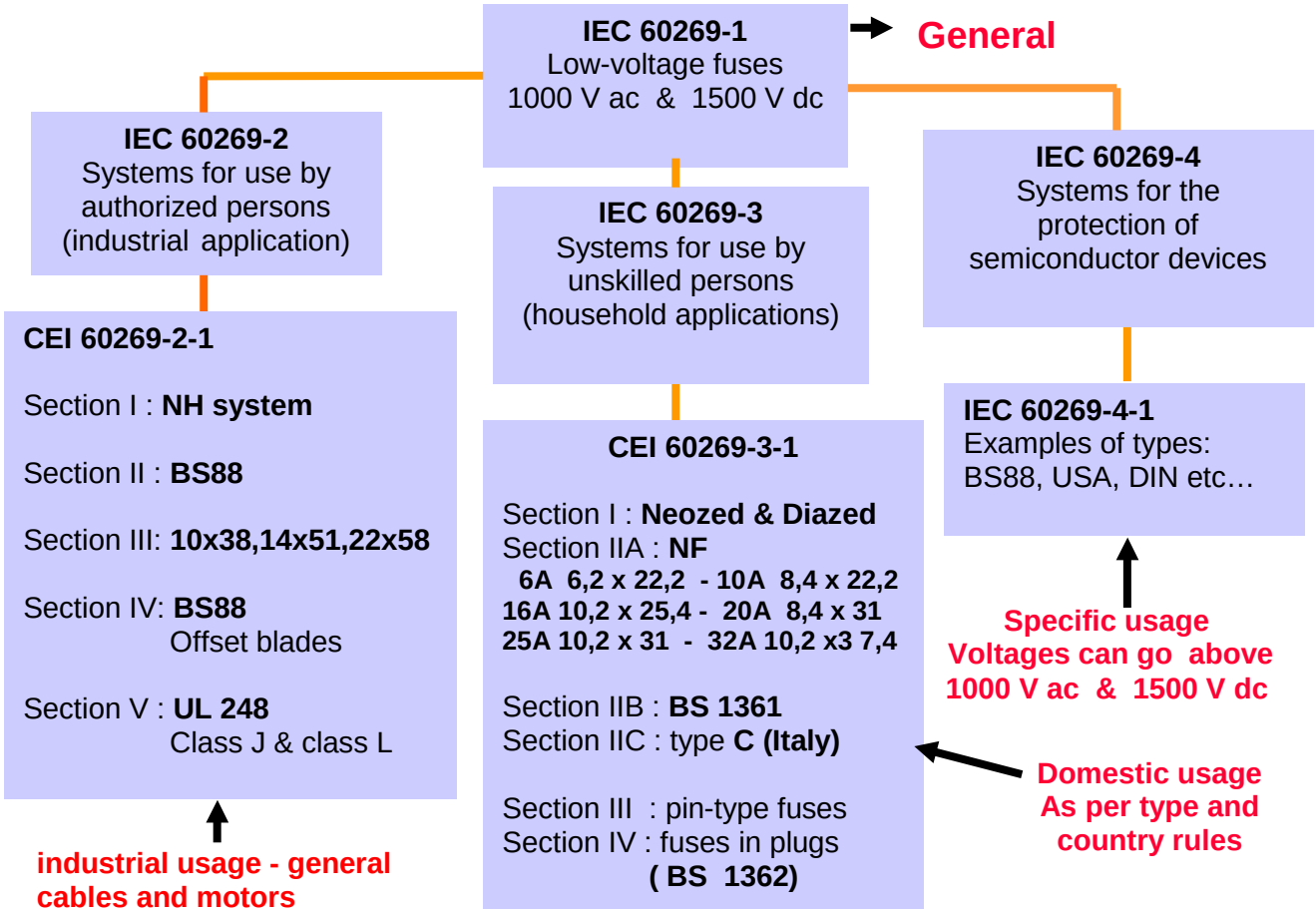

**BS**




**NH**



## 2. INTRODUCTION TO THE IEC 60269 STANDARD




**IEC 60269 APPLICATION CATEGORIES:** aM, aR, gR, gG, gTr …… etc.

- **The first letter indicates the main operating mode:**

**a =** associated fuse. It must be associated to another protective device as it cannot interrupt faults below a specified level. Short circuit protection only.
**g =** general purpose fuse. It will interrupt all faults between the lowest fusing current (even if it takes 1 hour to melt the fuse elements) and the breaking capacity. Overload and short circuit protection

- **The second letter indicates the object to be protected :**

**G** = cable and conductor protection , general
**M** = motor circuit protection
**R** = semi conductor protection
**S** = semi conductor protection
**Tr** = transformer protection
**N** = North American conductor protection
**D** = North American "Time Delay" (for Motor circuit protection)


**BS 88**

**TABLE 1**

| FUSE TYPE | TYPICAL INDUSTRIAL APPLICATIONS | OPERATING RANGE |
|---|---|---|
| **gG** | General purpose fuse essentially for conductor protection | Full range |
| **gM** | Motor protection | Full range |
| **aM** | Motor circuits protection against short circuit only | Partial range |
| **gN** | North American fast acting fuse for general purpose applications, mainly for conductor protection ( for example fuse class J and class L) | Full range |
| **gD** | North American general purpose time-delay fuse for motor circuit protection and conductor protection (for example: fuse class AJT, RK5 and A4BQ) | Full range |
| **aR** | IEC 269 fuse for semi conductor protection | Partial range |
| **gTr** | Transformer protection | Full range |
| **gR, gS** | Fuse for semi conductor protection and conductor protection | Full range |
| **gL, gF, gI** | Former type of fuses for conductor protection replaced today by the gG fuses | Full range |

IEC does not supply certificates showing the fuse compliance with the requirements of the IEC 60269 standard.

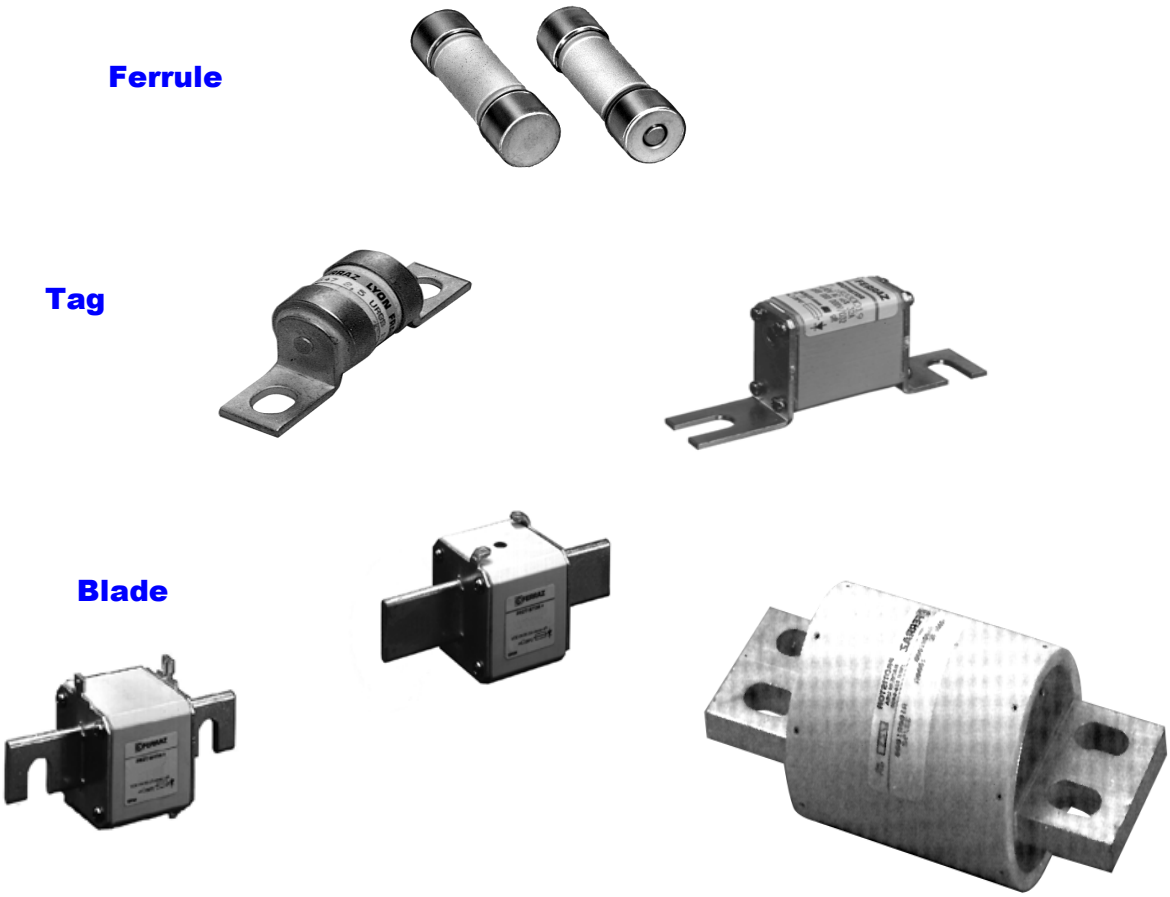



**Figure 1: examples of different types of terminals**

## 3. COMPARISON OF THE TIME CURRENT CURVES OF DIFFERENT FUSE TYPES

### 3.1. Comparison of IEC and UL fuses

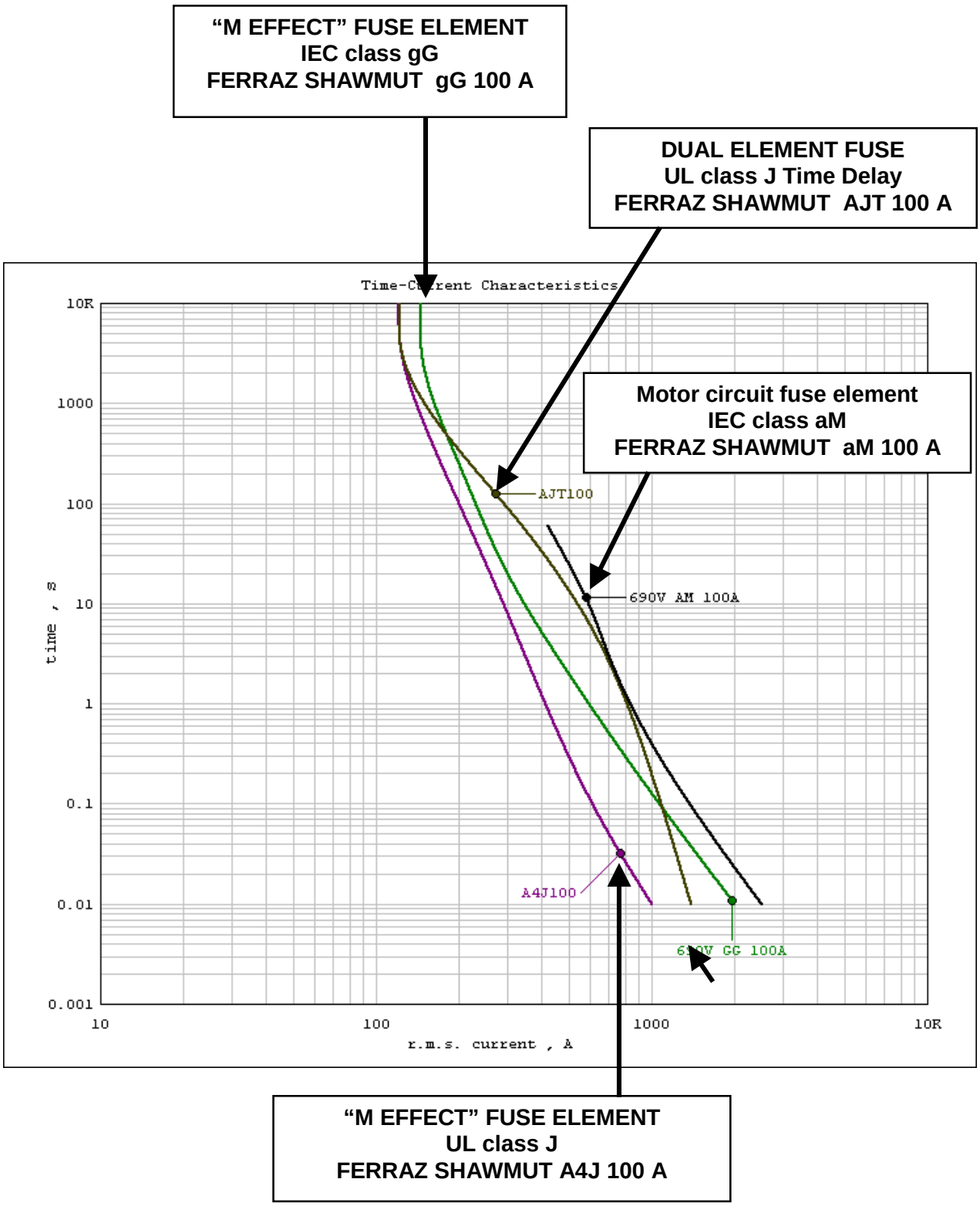



**Figure 2 : comparison of IEC and UL fuses**

### 3.2. Comparison of the time current curve of 4 IEC fuse types

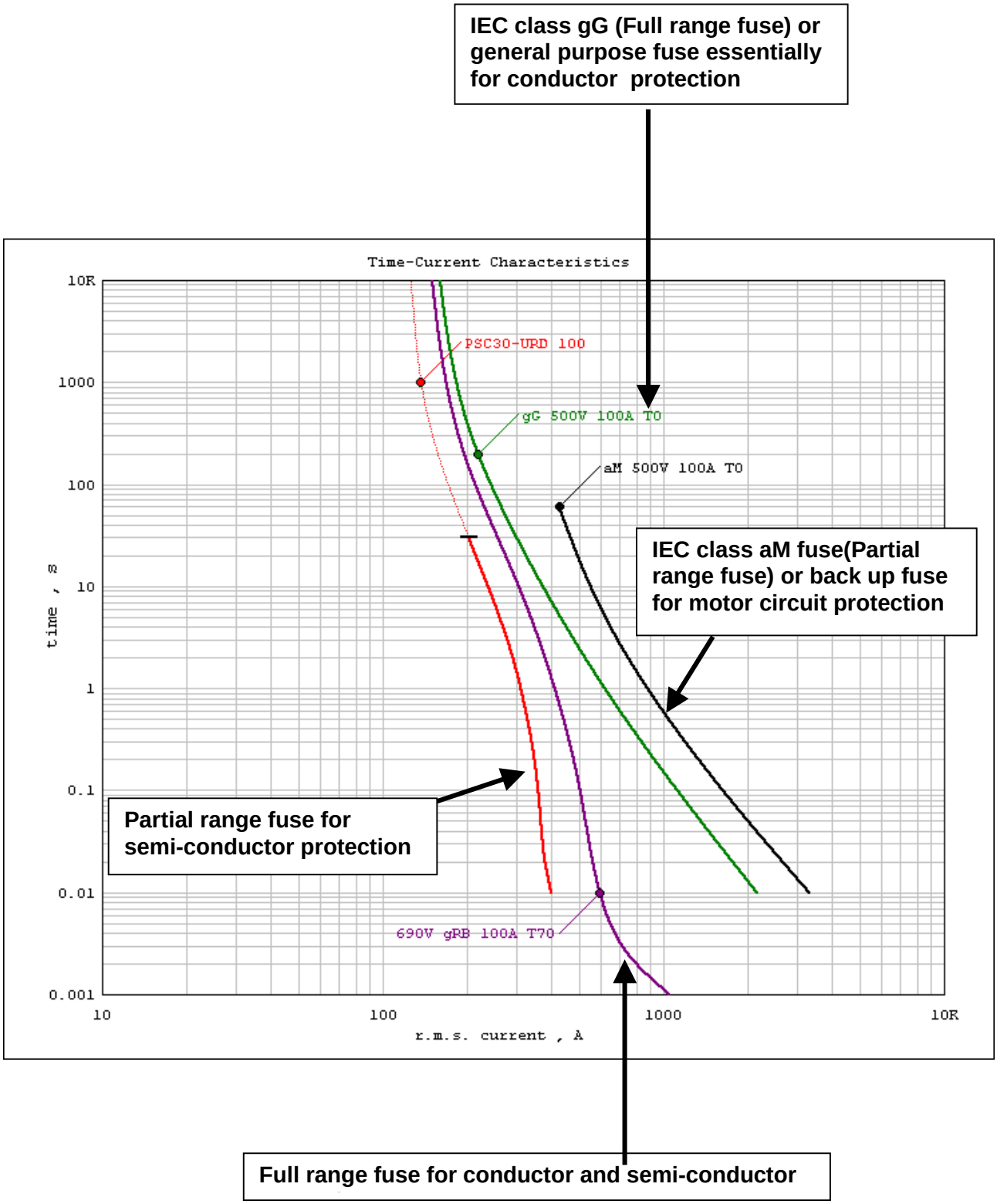



**Figure 3 : comparison of the time current curve of 4 different IEC fuses**

## 4. A gG FUSE MADE IN ANY TECHNOLOGY CAN BE REPLACED BY ANOTHER gG FUSE FROM ANY OTHER TECHNOLOGY (id. for aM fuses)

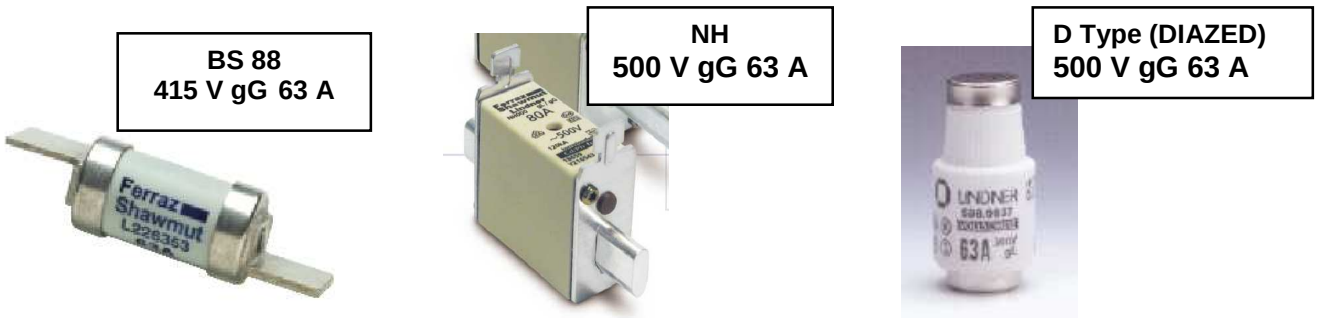



Figure 4

**In the above example the NH fuse and the DIAZED fuse can replace the BS 88 fuse . But the BS 88 fuse cannot replace the 2 others because of the voltage rating, unless the circuit to protect is fed by a 400 V or less power supply.**

**The replacement of the Diazed fuse by the NH fuse or the BS88 is possible because they have the same curves and same max $I^2t$ , same temperature rise etc. as they are specified by the** IEC 60269.

However it is **absolutely necessary to check the voltage and the breaking capacity of the new fuse** are not lower than the values of the other fuses or at least fit with the circuit requirement.

### 4.1. gG time current curves as per IEC definition: examples

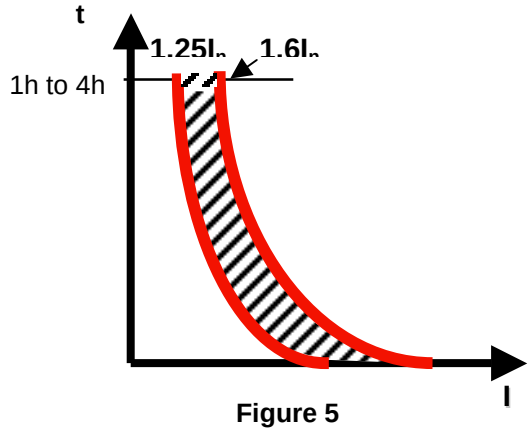



Figure 5

TABLE 2

| Fuse rating (A) | Imini at 10s (A) | Imax at 5s (A) | Imini at 0,1s (A) | Imax at 0,1s (A) |
|---|---|---|---|---|
| 25 | 52 | 110 | 150 | 260 |
| 80 | 215 | 425 | 610 | 1100 |
| 250 | 750 | 1650 | 2590 | 4500 |
| 800 | 3060 | 7000 | 10600 | 19000 |
| 1250 | 5000 | 13000 | 19000 | 35000 |

### 4.2. aM time current curves as per IEC definition

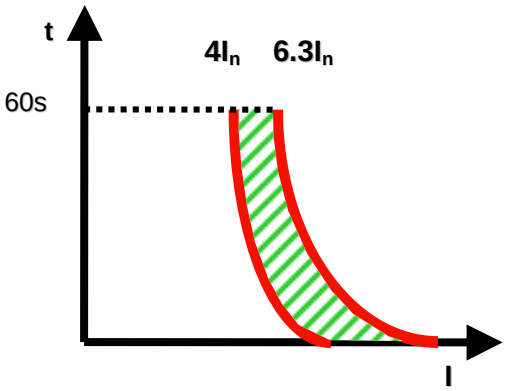



Figure 6

TABLE 3

| current | tmini (S) | tmax (S) |
|---|---|---|
| 4 **In** | 60 | |
| 6,3 **In** | | 60 |
| 8 **In** | 0,5 | |
| 10 **In** | 0,2 | |
| 12,5 **In** | | 0,5 |
| 19 **In** | | 0,1 |

## 5. PROTECTION LEVEL / PROTECTION COORDINATION IEC 60947 § 8.2.5.1.

IEC 60947- 4 - 1 belongs to: contactors and motor-starters electromechanical contactors et motor-starters

§ 8.2.5.1. : Performance under short circuits conditions

In this paragraph coordination types are defined as follows:

**type 1 coordination:**
requires that, under short circuit conditions, the contactor or starter shall cause no danger to persons or installations and may not be suitable for further service without repair and replacement of parts.

**type 2 coordination:**
**requires that, under short circuit conditions, the contactor or starter shall cause no danger to persons or installations and shall be suitable for further use. The risk of contact welding is recognized, in which case the manufacturer shall indicate the measures to be taken as regards the maintenance of the equipment.**

## 6. SELECTION OF THE FUSE VOLTAGE RATING $U_N$

Voltage is the most critical parameter. Any fuse selection must start by the choice of the voltage rating $U_N$ of the fuse. The maximum voltage of the circuit $V_{CIRCUIT\ MAX}$ (this is the rated voltage + variation) must be lower than the maximal operational voltage of the fuse $U_{FUSE\ MAX}$ given in the table.

$$U_{FUSE\ MAX} > V_{CIRCUIT\ MAX}$$

Example 1: a circuit is rated 400 V ± 15% then Vcircuit max = 460 V
Consequently the fuse rated 500 V must be used.

Example 2: a circuit is rated 400 V ± 10% then Vcircuit max = 440 V
Consequently the fuse rated 400 V can be used.

**TABLE 4**

| FUSE TYPE | Rated voltage $U_N$ (V) | Maximum operational voltage of the fuse $U_{FUSE\ MAX}$ (V) |
|---|---|---|
| gG, gM, aR, aM | 230 | 253 |
| | 400 | 440 |
| | 500 | 550 |
| | 690 | 725 |
| gN, gD (American ranges) | 600 | * 600 |

## 7. gG AND aM FUSE SELECTION: influence of the environment

### 7.1. Ambient temperature and air cooling

When the temperature $\theta_a$ is higher than 40°C and when there is an air cooling with air velocity V on the fuse, the fuse current rating $I_N$ is obtained from the operating current $I_B$ as follows:

$$I_N = I_B \frac{K_\theta}{K_V}$$

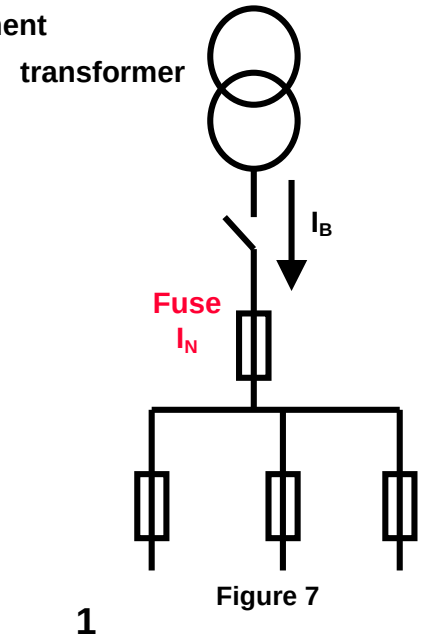



Figure 7

**TABLE 5**

| θ | K θ |
|---|---|
| 40 | 1 |
| 45 | 1.03 |
| 50 | 1.07 |
| 55 | 1.11 |
| 60 | 1.16 |
| 65 | 1.21 |
| 70 | 1.27 |

**TABLE 6**

| V (m / s) | $K_V$ |
|---|---|
| 0 | 1 |
| 1 | 1.05 |
| 2 | 1.10 |
| 3 | 1.15 |
| 4 | 1.20 |
| 5 | 1.25 |
| > 5 | 1.25 |

$$K_\theta = \frac{1}{A_1}$$

$$A_1 = \sqrt{\frac{120 - \theta_a}{80}}$$

$$K_V = 1 + 0.05\,v$$

with **v** between 0 m/s and 5 m / s

### 7.2. Altitude

IEC defines normal atmospheric operating conditions. Regarding the altitude it is generally written that fuse characteristics are not modified up to 2000m.

For altitudes above 2000 m the current rating $I_N$ alone of the fuse is changed. The currant rating of the fuse is derated by 0,5 % every 100 m above 2000 m .

The operating current **I** of the fuse at an altitude h higher than 2000 m is given by:

$$I = I_N * \left(1 - \frac{(h - 2000)}{100} * \frac{0,5}{100}\right)$$

For example a fuse rated 400 A working at 2500 m can carry:

$$I = 400 * \left(1 - \frac{(2500 - 2000)}{100} * \frac{0,5}{100}\right) = 400 * (1 - 5 * 0,005) = 400 * 0,975 = 390 \text{ A}$$

Conversely the current rating of the fuse carrying a current $I_B$ is given by:

$$I_N \geq I_B * K_{altitude} \quad \text{with} \quad K_{altitude} = \frac{1}{\left(1 - \frac{(h - 2000)}{100} * \frac{0,5}{100}\right)}$$

- **NOTE : obviously other parameters must always be considered ( §7.1. ), consequently:**

$$I_N \geq I_B \, K_{altitude} \frac{K_\theta}{K_V}$$

## 8. gG FUSE SELECTION: SELECTIVITY BETWEEN FUSES

**When fuse F1 operates , fuses F2 and F3 must not operate and moreover their characteristics should not be altered.**

**Selectivity: selectivity between gG fuse is achieved when the ratio between 2 ratings is about 1.60**

**Example:**

**F1 = 200 A**

**F2 = 315 A does not melt when F1 melts because 315 / 200 = 1.575**

F3 = 550 A does not melt when F2 melts because 550 / 315 = 1.746

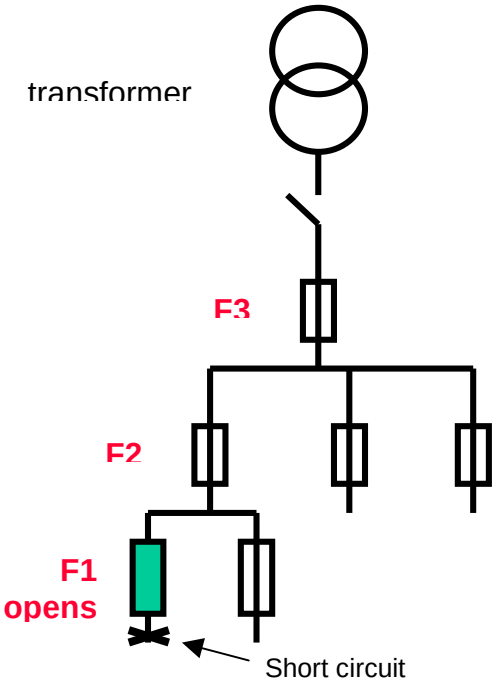



**Figure 8**

## 9. GENERAL RECOMMENDATION FOR CABLES OVERLOAD PROTECTION

The protection of the cable is checked with the following parameters:

$I_B$ : operating current of the cable
$I_Z$ : maximum current carrying capacity of the cable
$I_N$ : rated current of the fuse
$I_F$ : conventional fusing current of the fuse

The cable is protected when the 2 following conditions are fulfilled:

$$I_B \leq I_N \leq I_Z$$

$$I_F \leq 1.45\, I_Z$$

Values of $I_Z$ are given in table 7

**The choice of the fuse is made after :**

- **calculation of the acceptable current in the conductors**
- **determination of the number of conductors according to the installation method**

**(1) PEN wires: wire achieving neutral wire and protection wire at the same time**

**(2) When the current is shared as evenly as possible between the phases the cross section of neutral conductors can be smaller than the phases conductors cross section. When this sharing is not good the neutral conductor and phases conductors have the same cross section.**

**The fuses have to be fitted at the starting point of the circuit to be protected**

**For 30℃ ambient the minimal cross section of phas e and neutral conductors is indicated in the table 8.**

## TABLE 7

| Rated current $I_N$ | Cross section of copper cables or bar | Conventional time | Iz |
|---|---|---|---|
| (A) | ($mm^2$) | (h) | (A) |
| 12 | 1 | 1 | 15 |
| 16 | 1.5 | 1 | 19.5 |
| 20 & 25 | 2.5 | 1 | 26 |
| 32 | 4 | 1 | 35 |
| 40 | 6 | 1 | 46 |
| 50 & 63 | 10 | 1 | 63 |
| 80 | 16 | 2 | 85 |
| 100 | 25 | 2 | 112 |
| 125 | 35 | 2 | 138 |
| 160 | 50 | 2 | 168 |
| 200 | 70 | 3 | 213 |
| 250 | 120 | 3 | 299 |
| 315 | 185 | 3 | 392 |
| 400 | 240 | 3 | 461 |
| 400 < $I_N$ | BAR | 4 | BAR |

## TABLE 8

| Maximum operating current and ratings of gG fuses | Minimum cross section of copper wires ($mm^2$) | | | Maximum operating current and ratings of gG fuses | Minimum cross section of aluminium wires ($mm^2$) | | |
|---|---|---|---|---|---|---|---|
| | phase | neutral | PEN [1] | | phase | neutral | PEN [1] |
| 12 | 1,5 | 1,5 | 1,5 | | | | |
| 16 | 2,5 | 2,5 | 2,5 | | | | |
| 20 | 4 | 4 | 4 | | | | |
| 32 | 6 | 6 | 6 | 32 | 10 | 10 | 10 |
| 40 | 10 | 10 | 10 | 40 | 16 | 16 | 16 |
| 63 | 16 | 16 | 16 | 63 | 25 | 25 | 25 |
| | | | | 63 | 35 | 35 | 35 |
| 80 | 25 | 25 | 25 | 80 | 50 | 35 | 35 |
| 100 | 35 | 25 (2) | 25 | 100 | 70 | 35 (2) | 35 |
| 125 | 50 | 25 (2) | 25 | 125 | 95 | 50 (2) | 50 |
| 160 | 70 | 35 (2) | 35 | 160 | 120 | 70 (2) | 70 |
| 160 | 95 | 50 (2) | 50 | 160 | 150 | 70 (2) | 70 |
| 200 | 120 | 70 (2) | 70 | 200 | 185 | 70 (2) | 70 |
| 250 | 150 | 70 (2) | 70 | 250 | 240 | 95 (2) | 95 |
| 250 | 185 | 70 (2) | 70 | | | | |
| 315 | 240 | 95 (2) | 95 | 315 | 2x120 | 120 (2) | 120 |
| | | | | 315 | 2x120 | 150 (2) | 150 |
| 400 | 2x120 | 120 (2) | 120 | 400 | 2x185 | 150 (2) | 150 |
| 500 | 2x150 | 150 (2) | 150 | 500 | 3x120 | 185 (2) | 185 |
| 500 | 2x185 | 150 (2) | 150 | 500 | 3x150 | 185 (2) | 185 |
| 630 | 3x120 | 185 (2) | 185 | 630 | 3x185 | 240 (2) | 240 |
| 630 | 3x150 | 185 (2) | 185 | | | | |
| 800 | 3x185 | 240 (2) | 240 | 800 | 3x240 | 240 (2) | 240 |

## 10. GENERAL RECOMMENDATIONS FOR LOW VOLTAGE TRANSFORMER PROTECTION

- Primary and secondary fuse combinations are often used: in this case the primary fuse can be “a “ style fuse but the secondary fuse must be a “ g “ style fuse
- With American Time Delay fuses, fusing the primary only is possible (see “ UL 248 LV fuses USA “)

The inrush peak current at 10 ms can reach 40 times the rated current $I_{NTRANS}$ of the transformer, the RMS value is then 16 times $I_{NTRANS}$

## 11. GENERAL RECOMMENDATION FOR MOTOR CIRCUIT PROTECTION

The aM fuse must be associated to other protective devices because it must not operate for times above 60 seconds

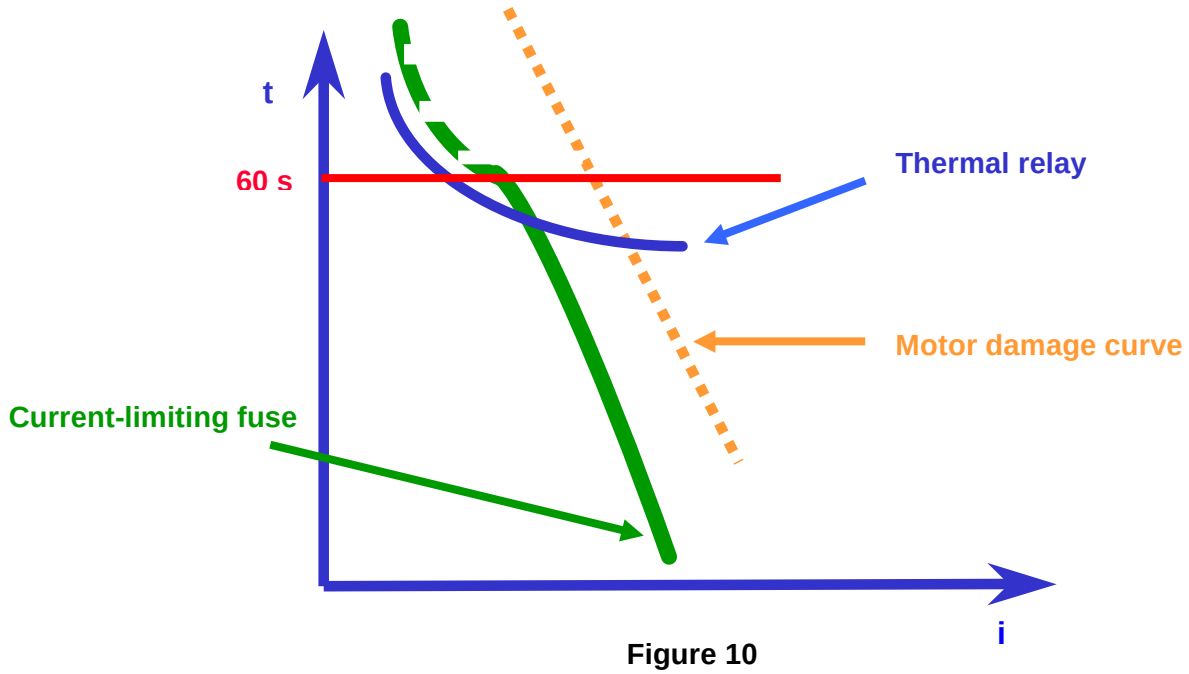



**Figure 10**

## 12. GENERAL RECOMMENDATIONS FOR CAPACITOR PROTECTION

The fuse selection must take into account:

- the inrush current occurring when the capacitor is switched on
- the harmonic currents during the normal operation of the network
- the recovery voltage across the fuse terminals after a fault interruption.