Chapter H
LV switchgear: functions & selection

Contents

1 The basic functions of LV switchgear

The role of switchgear is:
■ Electrical protection
■ Safe isolation from live parts
■ Local or remote switching

National and international standards define the manner in which electric circuits of LV installations must be realized, and the capabilities and limitations of the various switching devices which are collectively referred to as switchgear.

The main functions of switchgear are:

- Electrical protection
- Electrical isolation of sections of an installation
- Local or remote switching

These functions are summarized below in **Figure H1**.

Electrical protection at low voltage is (apart from fuses) normally incorporated in circuit-breakers, in the form of thermal-magnetic devices and/or residual-current-operated tripping devices (less-commonly, residual voltage- operated devices - acceptable to, but not recommended by IEC).

In addition to those functions shown in Figure H1, other functions, namely:

- Over-voltage protection
- Under-voltage protection

are provided by specific devices (lightning and various other types of voltage-surge arrester, relays associated with contactors, remotely controlled circuit-breakers, and with combined circuit-breaker/isolators… and so on)

Electrical protection against	Isolation	Control
■ Overload currents ■ Short-circuit currents ■ Insulation failure	■ Isolation clearly indicated by an authorized fail-proof mechanical indicator ■ A gap or interposed insulating barrier between the open contacts, clearly visible	■ Functional switching ■ Emergency switching ■ Emergency stopping ■ Switching off for mechanical maintenance

Fig. H1 : Basic functions of LV switchgear

1.1 Electrical protection

Electrical protection assures:
■ Protection of circuit elements against the thermal and mechanical stresses of short-circuit currents
■ Protection of persons in the event of insulation failure
■ Protection of appliances and apparatus being supplied (e.g. motors, etc.)

The aim is to avoid or to limit the destructive or dangerous consequences of excessive (short-circuit) currents, or those due to overloading and insulation failure, and to separate the defective circuit from the rest of the installation.

A distinction is made between the protection of:

- The elements of the installation (cables, wires, switchgear…)
- Persons and animals
- Equipment and appliances supplied from the installation

The protection of circuits

□ Against overload; a condition of excessive current being drawn from a healthy (unfaulted) installation

□ Against short-circuit currents due to complete failure of insulation between conductors of different phases or (in TN systems) between a phase and neutral (or PE) conductor

Protection in these cases is provided either by fuses or circuit-breaker, in the distribution board at the origin of the final circuit (i.e. the circuit to which the load is connected). Certain derogations to this rule are authorized in some national standards, as noted in chapter H1 sub-clause 1.4.

The protection of persons

□ Against insulation failures. According to the system of earthing for the installation (TN, TT or IT) the protection will be provided by fuses or circuit-breakers, residual current devices, and/or permanent monitoring of the insulation resistance of the installation to earth

The protection of electric motors

□ Against overheating, due, for example, to long term overloading, stalled rotor, single-phasing, etc. Thermal relays, specially designed to match the particular characteristics of motors are used.
Such relays may, if required, also protect the motor-circuit cable against overload. Short-circuit protection is provided either by type aM fuses or by a circuit-breaker from which the thermal (overload) protective element has been removed, or otherwise made inoperative.

1 The basic functions of LV switchgear

A state of isolation clearly indicated by an approved "fail-proof" indicator, or the visible separation of contacts, are both deemed to satisfy the national standards of many countries

1.2 Isolation

The aim of isolation is to separate a circuit or apparatus (such as a motor, etc.) from the remainder of a system which is energized, in order that personnel may carry out work on the isolated part in perfect safety.

In principle, all circuits of an LV installation shall have means to be isolated.
In practice, in order to maintain an optimum continuity of service, it is preferred to provide a means of isolation at the origin of each circuit.

An isolating device must fulfil the following requirements:

- All poles of a circuit, including the neutral (except where the neutral is a PEN conductor) must open(1)
- It must be provided with a locking system in open position with a key (e.g. by means of a padlock) in order to avoid an unauthorized reclosure by inadvertence
- It must comply with a recognized national or international standard (e.g. IEC 60947-3) concerning clearance between contacts, creepage distances, overvoltage withstand capability, etc.:

Other requirements apply:

□ Verification that the contacts of the isolating device are, in fact, open.
The verification may be:
- Either visual, where the device is suitably designed to allow the contacts to be seen (some national standards impose this condition for an isolating device located at the origin of a LV installation supplied directly from a MV/LV transformer)
- Or mechanical, by means of an indicator solidly welded to the operating shaft of the device. In this case the construction of the device must be such that, in the eventuality that the contacts become welded together in the closed position, the indicator cannot possibly indicate that it is in the open position

□ Leakage currents. With the isolating device open, leakage currents between the open contacts of each phase must not exceed:
- 0.5 mA for a new device
- 6.0 mA at the end of its useful life

□ Voltage-surge withstand capability, across open contacts. The isolating device, when open must withstand a 1.2/50 µs impulse, having a peak value of 6, 8 or 12 kV according to its service voltage, as shown in **Figure H2**. The device must satisfy these conditions for altitudes up to 2,000 metres. Correction factors are given in IEC 60664-1 for altitudes greater than 2,000 metres.

Consequently, if tests are carried out at sea level, the test values must be increased by 23% to take into account the effect of altitude. See standard IEC 60947.

Service (nominal voltage (V)	Impulse withstand peak voltage category (for 2,000 metres) (kV)	
	III	IV
230/400	4	6
400/690	6	8
690/1,000	8	12

Fig. H2 : Peak value of impulse voltage according to normal service voltage of test specimen. The degrees III and IV are degrees of pollution defined in IEC 60664-1

(1) the concurrent opening of all live conductors, while not always obligatory, is however, strongly recommended (for reasons of greater safety and facility of operation). The neutral contact opens after the phase contacts, and closes before them (IEC 60947-1).

1 The basic functions of LV switchgear

Switchgear-control functions allow system operating personnel to modify a loaded system at any moment, according to requirements, and include:
- *Functional control (routine switching, etc.)*
- *Emergency switching*
- *Maintenance operations on the power system*

1.3 Switchgear control

In broad terms "control" signifies any facility for safely modifying a load-carrying power system at all levels of an installation. The operation of switchgear is an important part of power-system control.

Functional control

This control relates to all switching operations in normal service conditions for energizing or de-energizing a part of a system or installation, or an individual piece of equipment, item of plant, etc.

Switchgear intended for such duty must be installed at least:
- At the origin of any installation
- At the final load circuit or circuits (one switch may control several loads)

Marking (of the circuits being controlled) must be clear and unambiguous.

In order to provide the maximum flexibility and continuity of operation, particularly where the switching device also constitutes the protection (e.g. a circuit-breaker or switch-fuse) it is preferable to include a switch at each level of distribution, i.e. on each outgoing way of all distribution and subdistribution boards.

The manœuvre may be:
- Either manual (by means of an operating lever on the switch) or
- Electric, by push-button on the switch or at a remote location (load-shedding and reconnection, for example)

These switches operate instantaneously (i.e. with no deliberate delay), and those that provide protection are invariably omni-polar(1).

The main circuit-breaker for the entire installation, as well as any circuit-breakers used for change-over (from one source to another) must be omni-polar units.

Emergency switching - emergency stop

An emergency switching is intended to de-energize a live circuit which is, or could become, dangerous (electric shock or fire).

An emergency stop is intended to halt a movement which has become dangerous.

In the two cases:
- The emergency control device or its means of operation (local or at remote location(s)) such as a large red mushroom-headed emergency-stop pushbutton must be recognizable and readily accessible, in proximity to any position at which danger could arise or be seen
- A single action must result in a complete switching-off of all live conductors (2) (3)
- A "break glass" emergency switching initiation device is authorized, but in unmanned installations the re-energizing of the circuit can only be achieved by means of a key held by an authorized person

It should be noted that in certain cases, an emergency system of braking, may require that the auxiliary supply to the braking-system circuits be maintained until final stoppage of the machinery.

Switching-off for mechanical maintenance work

This operation assures the stopping of a machine and its impossibility to be inadvertently restarted while mechanical maintenance work is being carried out on the driven machinery. The shutdown is generally carried out at the functional switching device, with the use of a suitable safety lock and warning notice at the switch mechanism.

(1) One break in each phase and (where appropriate) one break in the neutral.

(2) Taking into account stalled motors.

(3) In a TN schema the PEN conductor must never be opened, since it functions as a protective earthing wire as well as the system neutral conductor.

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2.1 Elementary switching devices

Disconnector (or isolator) (see **Fig. H5**)

This switch is a manually-operated, lockable, two-position device (open/closed) which provides safe isolation of a circuit when locked in the open position. Its characteristics are defined in IEC 60947-3. A disconnector is not designed to make or to break current(1) and no rated values for these functions are given in standards. It must, however, be capable of withstanding the passage of short-circuit currents and is assigned a rated short-time withstand capability, generally for 1 second, unless otherwise agreed between user and manufacturer. This capability is normally more than adequate for longer periods of (lower-valued) operational overcurrents, such as those of motor-starting. Standardized mechanical-endurance, overvoltage, and leakage-current tests, must also be satisfied.

Load-breaking switch (see **Fig. H6**)

This control switch is generally operated manually (but is sometimes provided with electrical tripping for operator convenience) and is a non-automatic two-position device (open/closed).

It is used to close and open loaded circuits under normal unfaulted circuit conditions.

It does not consequently, provide any protection for the circuit it controls.

IEC standard 60947-3 defines:

- The frequency of switch operation (600 close/open cycles per hour maximum)
- Mechanical and electrical endurance (generally less than that of a contactor)
- Current making and breaking ratings for normal and infrequent situations

When closing a switch to energize a circuit there is always the possibility that an unsuspected short-circuit exists on the circuit. For this reason, load-break switches are assigned a fault-current making rating, i.e. successful closure against the electrodynamic forces of short-circuit current is assured. Such switches are commonly referred to as “fault-make load-break” switches. Upstream protective devices are relied upon to clear the short-circuit fault

Category AC-23 includes occasional switching of individual motors. The switching of capacitors or of tungsten filament lamps shall be subject to agreement between manufacturer and user.

The utilization categories referred to in **Figure H7** do not apply to an equipment normally used to start, accelerate and/or stop individual motors.

Example

A 100 A load-break switch of category AC-23 (inductive load) must be able:

- To make a current of 10 In (= 1,000 A) at a power factor of 0.35 lagging
- To break a current of 8 In (= 800 A) at a power factor of 0.45 lagging
- To withstand short duration short-circuit currents when closed

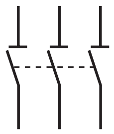

Fig. H5 : Symbol for a disconnector (or isolator)

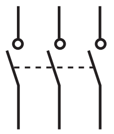

Fig. H6 : Symbol for a load-break switch

Utilization category		Typical applications	Cos φ	Making current x In	Breaking current x In
Frequent operations	Infrequent operations				
AC-20A	AC-20B	Connecting and disconnecting under no-load conditions	-	-	-
AC-21A	AC-21B	Switching of resistive loads including moderate overloads	0.95	1.5	1.5
AC-22A	AC-22B	Switching of mixed resistive and inductive loads, including moderate overloads	0.65	3	3
AC-23A	AC-23B	Switching of motor loads or other highly inductive loads	0.45 for I ≤ 100 A 0.35 for I > 100 A	10	8

Fig. H7 : Utilization categories of LV AC switches according to IEC 60947-3

(1) i.e. a LV disconnector is essentially a dead system switching device to be operated with no voltage on either side of it, particularly when closing, because of the possibility of an unsuspected short-circuit on the downstream side. Interlocking with an upstream switch or circuit-breaker is frequently used.

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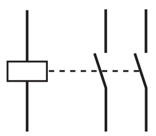

Fig. H8 : Symbol for a bistable remote control switch

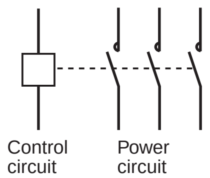

Fig. H9 : Symbol for a contactor

Two classes of LV cartridge fuse are very widely used:
- *For domestic and similar installations type gG*
- *For industrial installations type gG, gM or aM*

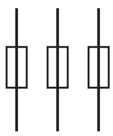

Fig. H10 : Symbol for fuses

Remote control switch (see Fig. H8)

This device is extensively used in the control of lighting circuits where the depression of a pushbutton (at a remote control position) will open an already-closed switch or close an opened switch in a bistable sequence.

Typical applications are:
- Two-way switching on stairways of large buildings
- Stage-lighting schemes
- Factory illumination, etc.

Auxiliary devices are available to provide:
- Remote indication of its state at any instant
- Time-delay functions
- Maintained-contact features

Contactor (see Fig. H9)

The contactor is a solenoid-operated switching device which is generally held closed by (a reduced) current through the closing solenoid (although various mechanically-latched types exist for specific duties). Contactors are designed to carry out numerous close/open cycles and are commonly controlled remotely by on-off pushbuttons. The large number of repetitive operating cycles is standardized in table VIII of IEC 60947-4-1 by:
- The operating duration: 8 hours; uninterrupted; intermittent; temporary of 3, 10, 30, 60 and 90 minutes
- Utilization category: for example, a contactor of category AC3 can be used for the starting and stopping of a cage motor
- The start-stop cycles (1 to 1,200 cyles per hour)
- Mechanical endurance (number of off-load manœuvres)
- Electrical endurance (number of on-load manœuvres)
- A rated current making and breaking performance according to the category of utilization concerned

Example:

A 150 A contactor of category AC3 must have a minimum current-breaking capability of 8 In (= 1,200 A) and a minimum current-making rating of 10 In (= 1,500 A) at a power factor (lagging) of 0.35.

Discontactor(1)

A contactor equipped with a thermal-type relay for protection against overloading defines a "discontactor". Discontactors are used extensively for remote push-button control of lighting circuits, etc., and may also be considered as an essential element in a motor controller, as noted in sub-clause 2.2. "combined switchgear elements". The discontactor is not the equivalent of a circuit-breaker, since its short-circuit current breaking capability is limited to 8 or 10 In. For short-circuit protection therefore, it is necessary to include either fuses or a circuit-breaker in series with, and upstream of, the discontactor contacts.

Fuses (see Fig. H10)

The first letter indicates the breaking range:
- "g" fuse-links (full-range breaking-capacity fuse-link)
- "a" fuse-links (partial-range breaking-capacity fuse-link)

The second letter indicates the utilization category; this letter defines with accuracy the time-current characteristics, conventional times and currents, gates.

For example
- "gG" indicates fuse-links with a full-range breaking capacity for general application
- "gM" indicates fuse-links with a full-range breaking capacity for the protection of motor circuits
- "aM" indicates fuse-links with a partial range breaking capacity for the protection of motor circuits

Fuses exist with and without "fuse-blown" mechanical indicators. Fuses break a circuit by controlled melting of the fuse element when a current exceeds a given value for a corresponding period of time; the current/time relationship being presented in the form of a performance curve for each type of fuse. Standards define two classes of fuse:
- Those intended for domestic installations, manufactured in the form of a cartridge for rated currents up to 100 A and designated type gG in IEC 60269-1 and 3
- Those for industrial use, with cartridge types designated gG (general use); and gM and aM (for motor-circuits) in IEC 60269-1 and 2

(1) This term is not defined in IEC publications but is commonly used in some countries.

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The main differences between domestic and industrial fuses are the nominal voltage and current levels (which require much larger physical dimensions) and their fault-current breaking capabilities. Type gG fuse-links are often used for the protection of motor circuits, which is possible when their characteristics are capable of withstanding the motor-starting current without deterioration.

A more recent development has been the adoption by the IEC of a fuse-type gM for motor protection, designed to cover starting, and short-circuit conditions. This type of fuse is more popular in some countries than in others, but at the present time the aM fuse in combination with a thermal overload relay is more-widely used.
A gM fuse-link, which has a dual rating is characterized by two current values. The first value In denotes both the rated current of the fuse-link and the rated current of the fuseholder; the second value Ich denotes the time-current characteristic of the fuse-link as defined by the gates in Tables II, III and VI of IEC 60269-1.

These two ratings are separated by a letter which defines the applications.

For example: In M Ich denotes a fuse intended to be used for protection of motor circuits and having the characteristic G. The first value In corresponds to the maximum continuous current for the whole fuse and the second value Ich corresponds to the G characteristic of the fuse link. For further details see note at the end of sub-clause 2.1.

An aM fuse-link is characterized by one current value In and time-current characteristic as shown in Figure H14 next page.

Important: Some national standards use a gI (industrial) type fuse, similar in all main essentails to type gG fuses.
Type gI fuses should never be used, however, in domestic and similar installations.

gM fuses require a separate overload relay, as described in the note at the end of sub-clause 2.1.

Fusing zones - conventional currents

The conditions of fusing (melting) of a fuse are defined by standards, according to their class.

Class gG fuses

These fuses provide protection against overloads and short-circuits.
Conventional non-fusing and fusing currents are standardized, as shown in **Figure H12** and in **Figure H13**.

- The conventional non-fusing current Inf is the value of current that the fusible element can carry for a specified time without melting.

Example: A 32 A fuse carrying a current of 1.25 In (i.e. 40 A) must not melt in less than one hour (table H13)

- The conventional fusing current If (= I2 in Fig. H12) is the value of current which will cause melting of the fusible element before the expiration of the specified time.

Example: A 32 A fuse carrying a current of 1.6 In (i.e. 52.1 A) must melt in one hour or less

IEC 60269-1 standardized tests require that a fuse-operating characteristic lies between the two limiting curves (shown in Figure H12) for the particular fuse under test. This means that two fuses which satisfy the test can have significantly different operating times at low levels of overloading.

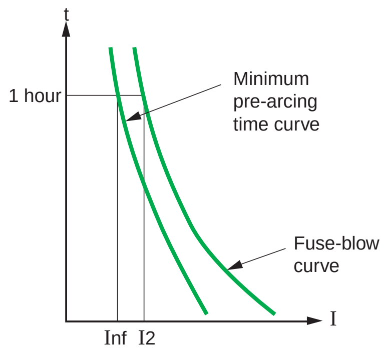


Fig. H12 : Zones of fusing and non-fusing for gG and gM fuses

Rated current(1) In (A)	Conventional non-fusing current Inf	Conventional fusing current I2	Conventional time (h)
In ⩽ 4 A	1.5 In	2.1 In	1
4 < In < 16 A	1.5 In	1.9 In	1
16 < In ⩽ 63 A	1.25 In	1.6 In	1
63 < In ⩽ 160 A	1.25 In	1.6 In	2
160 < In ⩽ 400 A	1.25 In	1.6 In	3
400 < In	1.25 In	1.6 In	4

Fig. H13 : Zones of fusing and non-fusing for LV types gG and gM class fuses (IEC 60269-1 and 60269-2-1)

(1) Ich for gM fuses

Class aM fuses protect against short-circuit currents only, and must always be associated with another device which protects against overload

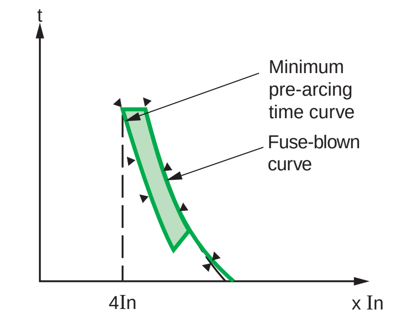
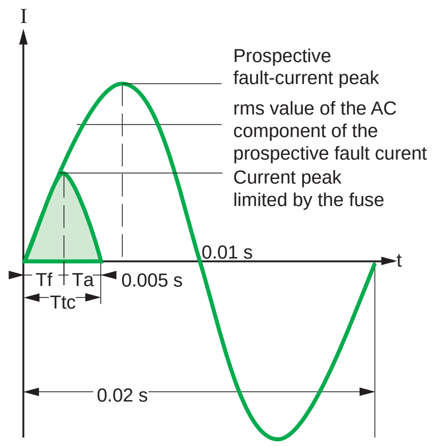


***Fig. H14** : Standardized zones of fusing for type aM fuses (all current ratings)*



Tf: Fuse pre-arc fusing time
Ta: Arcing time
Ttc: Total fault-clearance time

***Fig. H15** : Current limitation by a fuse*

(1) For currents exceeding a certain level, depending on the fuse nominal current rating, as shown below in Figure H16.

- The two examples given above for a 32 A fuse, together with the foregoing notes on standard test requirements, explain why these fuses have a poor performance in the low overload range
- It is therefore necessary to install a cable larger in ampacity than that normally required for a circuit, in order to avoid the consequences of possible long term overloading (60% overload for up to one hour in the worst case)

By way of comparison, a circuit-breaker of similar current rating:

- Which passes 1.05 In must not trip in less than one hour; and
- When passing 1.25 In it must trip in one hour, or less (25% overload for up to one hour in the worst case)

Class aM (motor) fuses

These fuses afford protection against short-circuit currents only and must necessarily be associated with other switchgear (such as discontactors or circuit-breakers) in order to ensure overload protection < 4 In. They are not therefore autonomous. Since aM fuses are not intended to protect against low values of overload current, no levels of conventional non-fusing and fusing currents are fixed. The characteristic curves for testing these fuses are given for values of fault current exceeding approximately 4 In (see **Fig. H14**), and fuses tested to IEC 60269 must give operating curves which fall within the shaded area.

Note: the small "arrowheads" in the diagram indicate the current/time "gate" values for the different fuses to be tested (IEC 60269).

Rated short-circuit breaking currents

A characteristic of modern cartridge fuses is that, owing to the rapidity of fusion in the case of high short-circuit current levels(1), a current cut-off begins before the occurrence of the first major peak, so that the fault current never reaches its prospective peak value (see **Fig. H15**).

This limitation of current reduces significantly the thermal and dynamic stresses which would otherwise occur, thereby minimizing danger and damage at the fault position. The rated short-circuit breaking current of the fuse is therefore based on the rms value of the AC component of the prospective fault current.

No short-circuit current-making rating is assigned to fuses.

Reminder

Short-circuit currents initially contain DC components, the magnitude and duration of which depend on the XL/R ratio of the fault current loop.

Close to the source (MV/LV transformer) the relationship Ipeak / Irms (of AC component) immediately following the instant of fault, can be as high as 2.5 (standardized by IEC, and shown in **Figure H16** next page).

At lower levels of distribution in an installation, as previously noted, XL is small compared with R and so for final circuits Ipeak / Irms ~ 1.41, a condition which corresponds with Figure H15.

The peak-current-limitation effect occurs only when the prospective rms AC component of fault current attains a certain level. For example, in the Figure H16 graph, the 100 A fuse will begin to cut off the peak at a prospective fault current (rms) of 2 kA (a). The same fuse for a condition of 20 kA rms prospective current will limit the peak current to 10 kA (b). Without a current-limiting fuse the peak current could attain 50 kA (c) in this particular case. As already mentioned, at lower distribution levels in an installation, R greatly predominates XL, and fault levels are generally low. This means that the level of fault current may not attain values high enough to cause peak current limitation. On the other hand, the DC transients (in this case) have an insignificant effect on the magnitude of the current peak, as previously mentioned.

Note: On gM fuse ratings
A gM type fuse is essentially a gG fuse, the fusible element of which corresponds to the current value Ich (ch = characteristic) which may be, for example, 63 A. This is the IEC testing value, so that its time/ current characteristic is identical to that of a 63 A gG fuse.
This value (63 A) is selected to withstand the high starting currents of a motor, the steady state operating current (In) of which may be in the 10-20 A range.
This means that a physically smaller fuse barrel and metallic parts can be used, since the heat dissipation required in normal service is related to the lower figures (10-20 A). A standard gM fuse, suitable for this situation would be designated 32M63 (i.e. In M Ich).

The first current rating In concerns the steady-load thermal performance of the fuselink, while the second current rating (Ich) relates to its (short-time) starting-current performance. It is evident that, although suitable for short-circuit protection,

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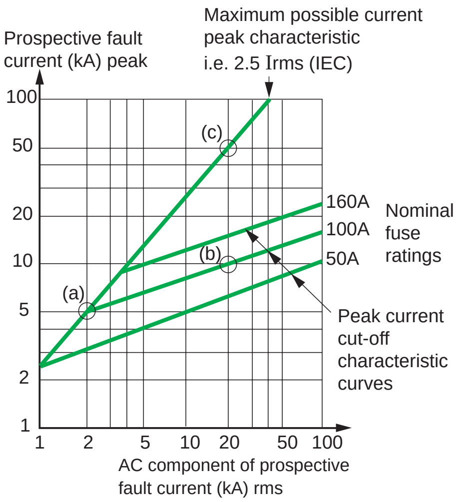

Fig. H16 : Limited peak current versus prospective rms values of the AC component of fault current for LV fuses

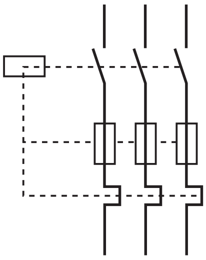

Fig. H17 : Symbol for an automatic tripping switch-fuse

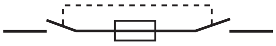

Fig. H18 : Symbol for a non-automatic fuse-switch

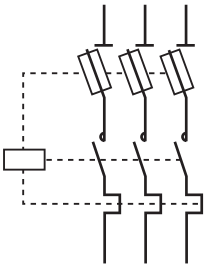

Fig. H20 : Symbol for a fuse disconnector + discontactor

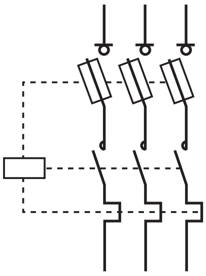

Fig. H21 : Symbol for a fuse-switch disconnector + discontactor

overload protection for the motor is not provided by the fuse, and so a separate thermal-type relay is always necessary when using gM fuses. The only advantage offered by gM fuses, therefore, when compared with aM fuses, are reduced physical dimensions and slightly lower cost.

2.2 Combined switchgear elements

Single units of switchgear do not, in general, fulfil all the requirements of the three basic functions, viz: Protection, control and isolation.

Where the installation of a circuit-breaker is not appropriate (notably where the switching rate is high, over extended periods) combinations of units specifically designed for such a performance are employed. The most commonly-used combinations are described below.

Switch and fuse combinations

Two cases are distinguished:

- The type in which the operation of one (or more) fuse(s) causes the switch to open. This is achieved by the use of fuses fitted with striker pins, and a system of switch tripping springs and toggle mechanisms (see **Fig. H17**)
- The type in which a non-automatic switch is associated with a set of fuses in a common enclosure.

In some countries, and in IEC 60947-3, the terms "switch-fuse" and "fuse-switch" have specific meanings, viz:

- A switch-fuse comprises a switch (generally 2 breaks per pole) on the upstream side of three fixed fuse-bases, into which the fuse carriers are inserted (see **Fig. H18**)
- A fuse-switch consists of three switch blades each constituting a double-break per phase.

These blades are not continuous throughout their length, but each has a gap in the centre which is bridged by the fuse cartridge. Some designs have only a single break per phase, as shown in **Figure H19**.

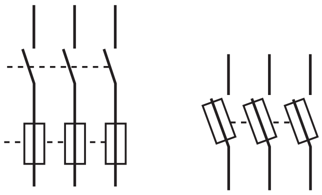

Fig. H19 : Symbol for a non-automatic switch-fuse

The current range for these devices is limited to 100 A maximum at 400 V 3-phase, while their principal use is in domestic and similar installations. To avoid confusion between the first group (i.e. automatic tripping) and the second group, the term "switch-fuse" should be qualified by the adjectives "automatic" or "non-automatic".

Fuse – disconnector + discontactor
Fuse - switch-disconnector + discontactor

As previously mentioned, a discontactor does not provide protection against short-circuit faults. It is necessary, therefore, to add fuses (generally of type aM) to perform this function. The combination is used mainly for motor control circuits, where the disconnector or switch-disconnector allows safe operations such as:

- The changing of fuse links (with the circuit isolated)
- Work on the circuit downstream of the discontactor (risk of remote closure of the discontactor)

The fuse-disconnector must be interlocked with the discontactor such that no opening or closing manœuvre of the fuse disconnector is possible unless the discontactor is open (**Figure H20**), since the fuse disconnector has no load-switching capability.

A fuse-switch-disconnector (evidently) requires no interlocking (**Figure H21**). The switch must be of class AC22 or AC23 if the circuit supplies a motor.

Circuit-breaker + contactor
Circuit-breaker + discontactor

These combinations are used in remotely controlled distribution systems in which the rate of switching is high, or for control and protection of a circuit supplying motors.