"Knowledge is power"

The Hager Guide to current thinking on the regulations, protection and control of Klik lighting circuits

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klik

ahead of current thinking

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Being supportive

It is now standard practice to use luminaire supporting couplers (LSC), such as Klik from Hager, when designing and installing commercial lighting installations. Designers, inspecting engineers and electrical contractors often misunderstand key areas of specification for compliance with the *BS 7671* wiring regulations for LSCs.

Q What product standards do the Wiring Regulations specify for LSCs?

Regulation *511-01-01* says that equipment should "comply with the relevant requirements of the applicable British Standard or harmonised standard."

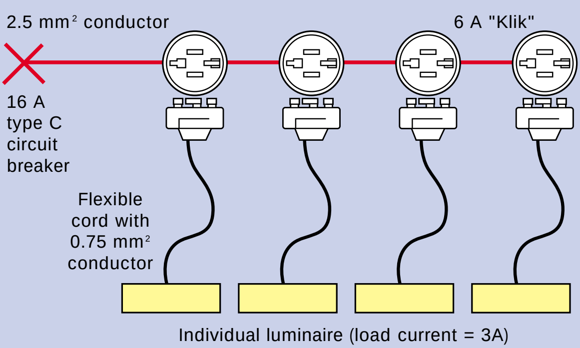
Appendix 1 of the regulations identifies *BS 6972* as the specification for general requirements for luminaire supporting couplers for domestic, light industrial and commercial use. It gives general requirements for the construction of LSC plugs and LSC outlets with particular reference to safety. LSCs must comply with either *BS 6972* or *BS 7001*.

Q Where exactly can LSCs be used?

Referring to *BS 6972*, LSCs are for use in final circuits rated at not more than 16 A, where the supply voltage does not exceed 250 V ac and the electrical load connected to any one LSC plug does not exceed 6 A.

BS 6972 also specifies the conductor cross sectional area of the flexible cord for LSC plugs which are not part of the luminaire as between 0.5 mm² to 1.00 mm² (see figure 1).

Figure 1: An example of a specification of flexible cord for LSC plugs



Q How can you use a 16 A circuit breaker when the LSC plug and flexible cord are rated at 6 A?

To best answer this, we need to split the question into three parts. Firstly, how is overcurrent defined? Overcurrent is defined as overload currents or fault currents.

Second, how do you define overload current? Overload current is an overcurrent occuring in a circuit that is electrically sound. An example might be a user plugging in more appliances than the circuit is intended for, which may in turn cause an overload.

The designer needs to decide if a circuit is liable to carry overload current. It is clear in figure 1 that the circuit cable with 2.5 mm² conductor requires overload protection. In this instance the user may plug in additional luminaires and create higher power consumption than the circuit is intended for.

Finally, can overload protection be omitted? There are some conditions where overload protection is not necessary. Regulation *473-01-04 (ii)* tells us that overload protection is not necessary for a conductor, which, because of the characteristics of the load, is not likely to carry overload current.

In figure 1 we can assume that the LSCs and their 0.75 mm² flexible cord supplying the luminaires are protected against overload current by the characteristics of the load.

And so, answering the original question, when overload current protection is not required the nominal current of the protective device can be greater than the current carrying capacity of the flexible cord, as in figure 1.

Q So what if the luminaire is swapped with one that has a higher load current than that of the flexible cord rating?

It is wrong and against the Wiring Regulations' guidance to do this. Before making any addition or alteration to an existing installation, you must check that the rating and condition of any existing equipment is adequate to carry the additional load. This is a fundamental requirement for safety.

Q How do I calculate the conductor cross sectional area of the flexible cord?

Appendix 4 of the Wiring Regulations tells how to go about this process.

$$I_t \geq \frac{I_b}{C_a \, C_g \, C_i}$$

Where:
I_t = the value of current tabulated for the type of cable and installation method concerned, for a single circuit in an ambient temperature of 30°C:
I_b = load current;
C_a = correction factor for ambient temperature;
C_g = correction factor for grouping;
C_i = correction factor for thermal insulation.

Having calculated I_t, this value can then be used to select the appropriate cross sectional area of flexible cord from the relevant table in Wiring Regulations.

Q When calculating the load current are there any special factors for discharge lamps?

Discharge lamps take a higher than normal current during starting. This current may be up to several times the conductor current rating.

Generally the duration of this starting current is considered not long enough to cause unacceptable overheating of the conductors.

The important characteristics of the starting current are the magnitude of the current and its duration.

However, the flexible cord must be capable of carrying the total steady current of the lamp(s) and any associated gear and also their harmonic currents.

The *IEE Guidance note 1* states: "Where more exact information is not available, the demand in volt-amperes is taken as the rated lamp watts multiplied by not less than 1.8. This multiplier is based upon the assumption that the circuit is corrected to a power factor of not less than 0.85 lagging, and takes into account control gear losses and harmonic current."

Q Does the type of lampholder used affect the current rating of the circuit protection device?

Where the lampholder and its associated wiring are not contained within earthed metal or an insulating material having the ignitability characteristic 'P', as specified in *BS 476: Part 5*, or is not protected by its own overcurrent protective device, table 1 (see below) shall apply. This is a requirement of regulation *553-03-01*.

Table 1 Overcurrent protection of lampholders

Type of lampholder	Cap type	Maximum rating of overcurrent protective device protecting the circuit (A)
BS5042 or *BS EN 61184* Bayonet type	B15 SBC B22 BC	6 16
BS EN 60238 Edison screw	E14 SES E27 ES E40 GES	6 16 16

Note: Where overload protection is omitted, then a calculation must be made to ensure that the conductors concerned are large enough to carry the fault currents without damage until the overcurrent device operates.

Current affairs

Overload protection is not required for the flexible cord from the luminaire supporting coupler plug to the luminaire. However, we need to ensure that the conductors concerned are large enough to carry any fault currents without damage until the overcurrent device operates.

This section describes how to make the necessary calculation.

Q How would you define fault current?

A fault current is an overcurrent caused by either a short circuit (between live conductors) or an earth fault (between a live conductor and an exposed conductive part or protective conductor).

Q What do the Wiring Regulations specify to protect the flexible cord against fault current?

If overload protection is not required then a calculation must be made. Regulation *434-03-03* provides an equation for calculating the maximum duration of the fault current, but it is not immediately apparent how to apply it. A simple transposition, however, gives us the equation.

$$I^2t \leq k^2S^2$$

- where I^2t is proportional to the thermal energy let through the protective device;
- k^2S^2 indicates the thermal capacity of the conductor. If the conductor is not to be damaged I^2t must not exceed k^2S^2;
- t = the maximum fault current duration in seconds (disconnection time);
- k = a factor taking account of the resistivity, temperature coefficient and heat capacity of the conductor material, and the initial and final temperatures, derived from *BS 7671*;
- S = the nominal cross-sectional area of the conductor in mm^2;
- I = the value of fault current an amperes, expressed for ac as the rms value, due account being taken of the current limiting effect of the circuit impedances.

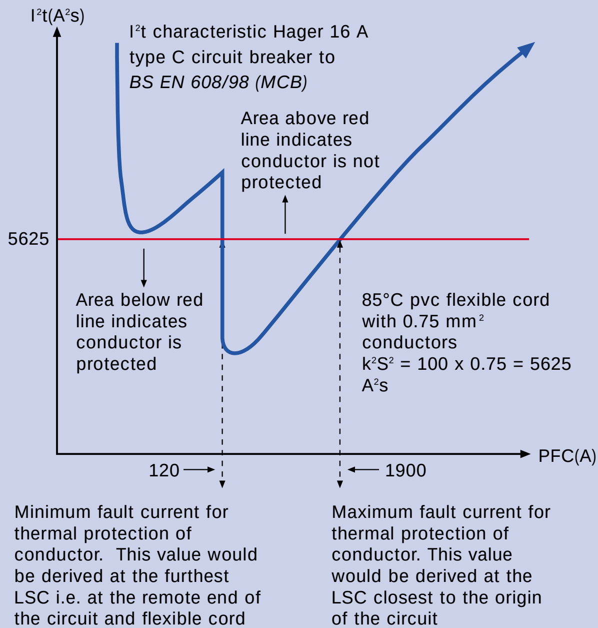
Note for very short duration (less than 0.1 secs) and for current limiting devices, I^2t must be designated by the manufacturer's data.

Q How do I apply this formula?

The simplest way of assessing the degree of thermal protection provided by an overcurrent device is by using the manufacturer's I^2t characteristics.

Calculate k^2S^2 and

Figure 1: Assessing protection using the manufacturer's data



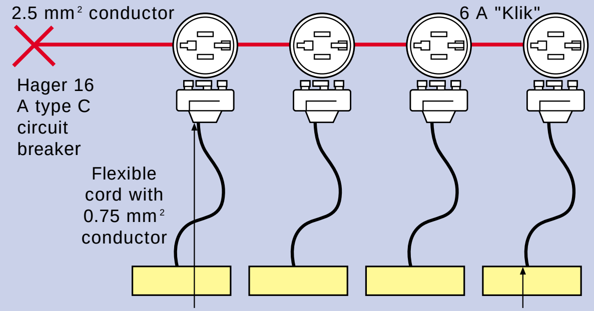
superimpose this value as a horizontal line on the graph showing the protective device's I^2t characteristics (see figure 1).

Provided that the fault levels are within the minimum and maximum values specified in figure 1, the flexible cord will be protected against thermal damage and comply with the Wiring Regulations.

Q Where are the minimum and maximum fault currents likely to occur?

The minimum fault current will probably be determined by the earth loop impedance at the end of the flexible cord at the furthest LSC. The maximum fault current will probably be between live conductors at the LSC closest to the origin of the circuit (see figure 2).

Figure 2: The maximum fault current usually lies between the conductors at the LSC closest to the origin of the circuit



Q Are these calculations always necessary?

Where an overcurrent protective device provides overload protection and has a breaking capacity not less than the prospective fault current at its point of installation, it can be assumed that the conductors on the load side of the device are protected against fault current.

This assumption applies when the neutral and protective conductors are of equal cross sectional area to the phase conductor and are manufactured of the same material. Such an assumption must be checked for conductors in parallel and for non-current limiting types of circuit breaker. In this instance no further calculations are necessary for overload or fault current protection (See figure 3).

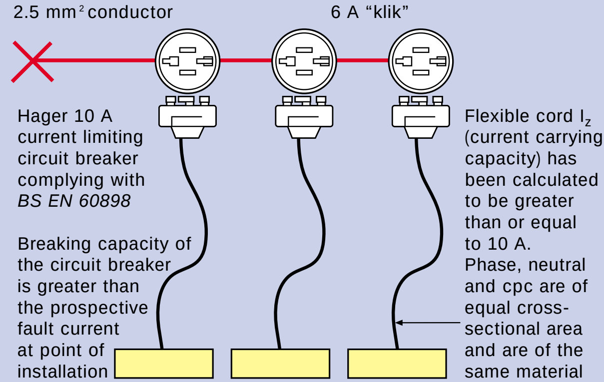
Q Is it possible to purchase flexible cord with 12mm conductors prewired to an LSC plug?

Yes, Klik, for example, offers this as standard.

Q Are there any other key factors affecting the selection of flexible cord?

The flexible cord length is influenced by voltage drop, protection against electric shock, the effects of fault current and the selection and erection of the wiring system.

Figure 3: An example of when further calculation is not required for overload or fault current protection of the flexible cord



Length matters

Electrical engineers frequently debate how the length of flexible cord between the luminaire supporting coupler (LSC) and the luminaire raises a number of design considerations.

The next two technical sections within this booklet will fully illustrate the technical information and the key requirements necessary to determine the correct length of this flexible cord (see figure 1).

Q Do any British Standards specify a maximum length for the flexible cord?

No.

Q What requirements does the contractor need to consider for the maximum length of flexible cord?

There are four requirements which need to be taken into account:

- Voltage drop;
- Protection against electric shock by indirect contact when applying earthed equipotential bonding and automatic disconnection of the supply;
- Protection against the effects of fault current;
- Selection and erection of the wiring system.

This month's article will deal with the first two of the listed requirements; next month's technical Q&A will cover the second two.

Q What needs considering for voltage drop?

The regulations are satisfied for a supply given in accordance with *The Electricity Supply Regulations 1988*, as amended if; the voltage drop from the origin of the installation to the terminals of the fixed equipment does not exceed 4% of the nominal voltage supply.

At present the nominal voltage supply in the UK is 230 V + 10% - 6%. The maximum voltage drop permitted is therefore: 230 x 4/100 = 9.2 V (see figure 2).

The requirements for voltage drop in the regulations are concerned solely with safety. The contractor should always consider other effects of voltage drop on the equipment; efficiency, for example.

A mistake often made is to ignore the flexible cord length in the voltage drop calculations. Details of this calculation are available on request.

Q How does the length of flexible cord influence the calculations for protection against electric shock?

The most common method of protection against electric shock is earthed equipotential bonding and automatic disconnection of supply.

If the protective device is to operate correctly you

Figure 1: The flexible cord length between the LSC and the luminaire

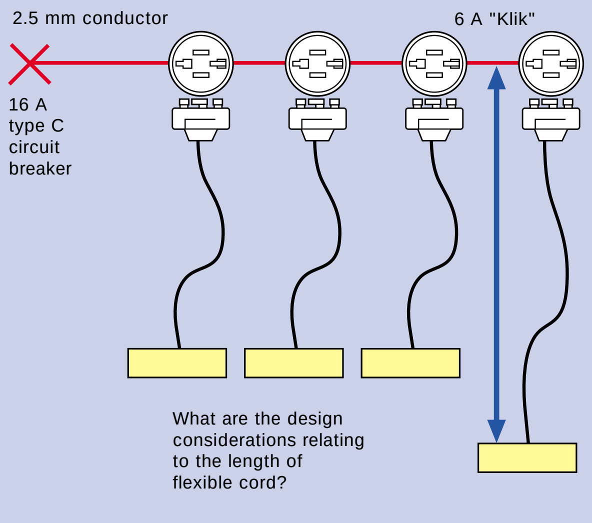


Figure 2: An example showing he maximum permitted voltage drop in installation

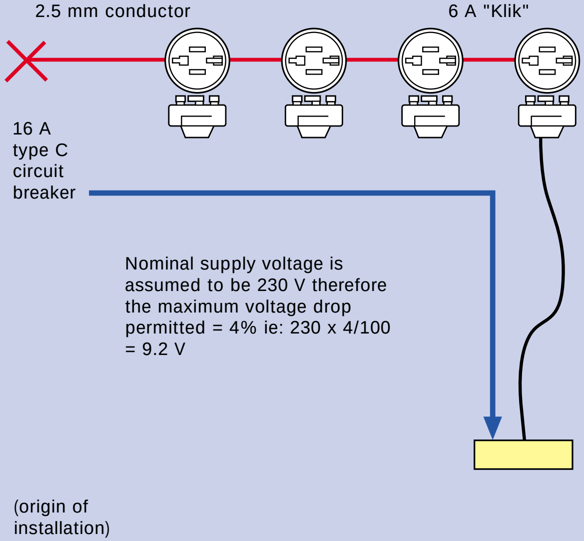
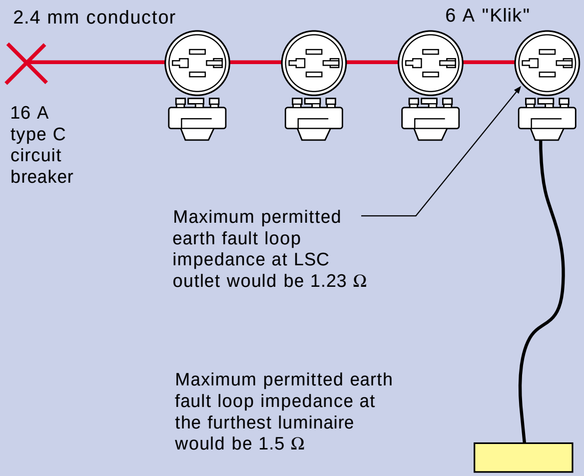


Figure 3: Verifying the maximum permitted earth fault loop impedance



must always consider the length of flexible cord in these calculations.

Q How does automatic disconnection apply to the LSC circuit?

The contractor must verify that the earth fault loop impedance does not exceed the maximum tabulated values in *BS 7671*, or any values derived by applying the appropriate formula specified in *BS 7671* for the overcurrent protective device.

Manufacturers frequently provide data derived from his formula.

If the circuit is designed to comply with *BS 7671: 1992 table 41B2* the maximum earth fault loop impedance for the 16 A type C circuit breaker for 0.4 and 5 second disconnection time would be 1.5 Ω (see figure 3).

Light wire

In the previous section we illustrated the requirements for complying with voltage drop and automatic disconnection. In this section we will examine the other two factors to be considered, namely that the circuit protective conductor is large enough to carry the earth fault currents and the selection and erection of a wiring system.

Q Why do I need to protect against the effects of fault current?

Fault currents generate heat, so you must ensure that the circuit protective conductor (CPC) can carry the earth fault currents without thermal damage until the overcurrent device operates.

Q How do I protect against the effects of fault current?

If the cross sectional area of the cpc has been worked out by applying table *54G* of *BS 7671*, and the overcurrent protective device is providing protection against overload currents and fault currents, no further checks are needed. *Table 54G* details the minimum cross-sectional area of the protective conductor in relation to the cross-sectional area of the associated phase conductor.

Q If the overcurrent protective device is not providing protection against overload current and I have a cpc that does not comply with table 54G, what do I do?

You need to apply the formula in regulation *543-01-03*:

$$S = \frac{\sqrt{(I^2t)}}{k} \quad \text{or } I^2t = k^2S^2$$

S = nominal cross sectional area of the cpc in mm^2;
I = fault current in amperes;
t= operating time of disconnecting device in seconds;
k = factor taken from *BS 7671*.

Q Is there a quick and simple method of applying $I^2t = k^2S^2$?

Yes. Use the manufacturer's I^2t characteristics for the overcurrent protective device. Calculate k^2S^2 and superimpose this value as a horizontal line on the graph showing the protective device's I^2t characteristics. This was illustrated in the article *Current affairs* in the March 2000 issue of *EC*.

Hager has already completed these calculations. They are available upon request.

What do the Wiring Regulations specify for the selection and erection of the wiring system?

Chapter 52 specifies the requirements for:

- selection of the wiring system;
- selection and erection in relation to external influences;
- current-carrying capacity of the conductors;
- cross-sectional area of conductors.

Note: the latter two points have been covered in previous articles.

Are there any other British Standards to consider?

BS 7540: 1994 provides a guide to the proposed safe use of electric cables, including flexible cords to *BS 6141*. This identifies that cables should be selected so that they are suitable for any external influences that may exist, for example:

- ambient temperature;
- presence of rain, steam or accumulation of water;
- presence of corrosive, chemical or polluting substances;
- mechanical stresses such as through holes or sharp edges in metal work;
- fauna - rodents;
- flora - mould;
- radiation - sunlight.

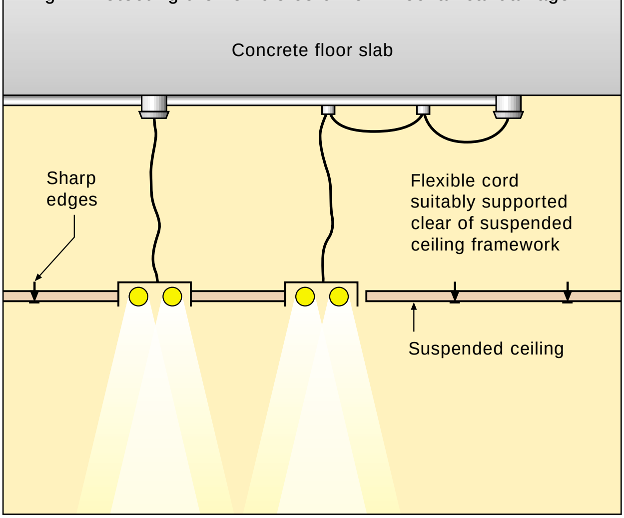
Are there any key requirements with respect to the increased use of suspended ceilings in commercial premises?

You must take into account the sharp edges forming the grid of such ceilings. Flexible cords with pvc or similar sheathing should not rest on the grid, but be supported clear of the framework to avoid deviating from *BS 7671* regulation *522-08-01*, ie avoid damage to the sheath and insulation of the flexible cord during installation and subsequent use (see figure 1).

Is there a quick and simple method of supporting the flexible cord?

There are a number of supporting systems available. One of the simplest is to use a self adhesive cable clip. Alternatively, clips are easily attached to a supporting structure using adhesive.

Fig 1: Protecting the flexible cord from mechanical damage



Splendid isolation

Q Why is the isolation and switching off of luminaires important?

Facilities should be designed into every electrical installation so that it can be maintained in a safe condition. The electrical design engineer is duty bound under the *Electricity at Work Regulations 1989* to ensure that this is the case.

The advent of computer controlled luminaires and other automatic lighting control systems have introduced further complications to the safety issues of isolation and switching.

Q Is there a difference between isolation and switching off for mechanical maintenance?

Yes.

Q What is isolation?

Isolation is defined in *BS 7671* as a function intended to cut off, for safety reasons, the supply from all, or a discrete section of, the installation by separating it from every source of electrical energy.

Q Why do you need isolation?

It prevents death or personal injury from electric shock, electric burn, fires of electrical origin, electric arcing or explosions initiated or caused by electricity.

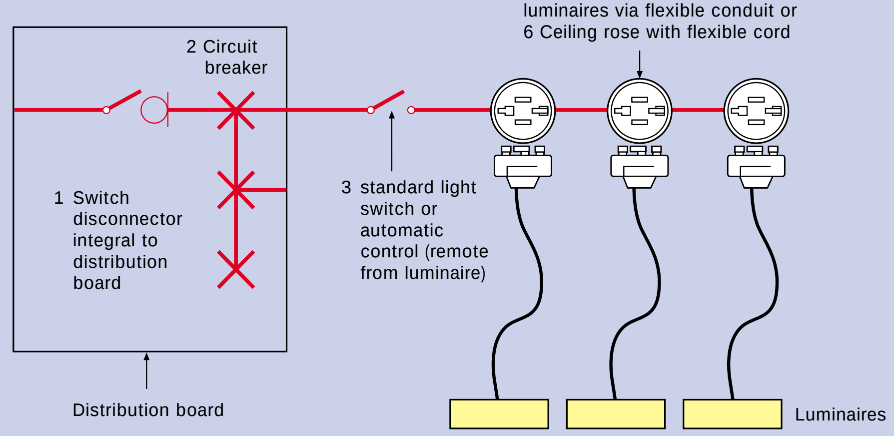
Isolation enables electrically skilled persons to carry work on, or adjacent to, parts which would otherwise be live, eg replacing a faulty ballast or ignitor in a luminaire.

Q What design considerations are necessary for isolation?

Consider the purpose of the installation and the client's requirements for maintenance and repair?

It should enable simple and safe electrical maintenance and repair with minimum inconvenience and disruption to other parts of the electrical installation. You must also take suitable precautions to prevent equipment from being inadvertently or unintentionally energised.

Figure 1: The lsc provides a means of on-load isolation while also minimising the disruption to other parts of the installation



Q What are the key requirements for devices used for on-load isolation?

You must consider several factors. There must be sufficient isolating distance between contacts and their position must be clearly and reliably indicated.

Also the on-load device must be suitable for the prescribed load characteristics. Note the standard for LSCs, *BS 6972*, specifies the requirements for load making and breaking with an inductive load and with tungsten filament lamps. Finally the device must be manually operated and it can not be a semiconductor.

Q What do you classify as lamp replacement?

Mechanical maintenance, which *Part 2* of *BS 7671* defines as: "the replacement, refurbishment or cleaning of lamps and non-electrical parts of equipment, plant and machinery."

Q What is the objective of switching off for mechanical maintenance?

It enables non-skilled people to carry out maintenance on electrical equipment without risk of burns or injury from mechanical movement.

Switching off for mechanical maintenance is not isolation of live parts.

Q What are the design considerations for switching off for mechanical maintenance?

You must know what the installation is being used for, including your client's requirements for mechanical maintenance. The system should allow maintenance to be safe and with minimum disruption to other parts of the installation. You must also ensure that there are precautions in place preventing equipment from being inadvertently reactivated.

Q What are the requirements for the devices used in switching off for mechanical maintenance?

The device must clearly indicate its off or open position and be suitable for the prescribed load characteristics.

Q Which device best complies with *BS 7671* for the on-load isolation and switching off for mechanical maintenance of a luminaire?

Only an LSC provides a means of on-load isolation while also minimising disruption to other parts of the electrical installation (see figure 1).

The advantages of using an LSC for on-load isolation and mechanical maintenance of luminaires are:

- minimum inconvenience and disruption to the installation;
- a large isolating distance between contacts;
- the position of the contacts is clearly and reliably indicated;
- it is suitable for on-load operation;
- it has manual operation;
- you can take precautions against inadvertent or unintentional operation;
- it enables bench level maintenance of luminaires.

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