
Best Practice Guide 9

Safe installation of retrofit LED lamps



Best Practice Guide

Electrical Safety First is indebted to the following organisations for their contribution and/or support to the development of this Guide:

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Electrical Contractors' Association



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Lighting Industry Association



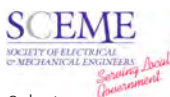
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*Electrical Safety First (formerly the National Inspection Council for Electrical Installation Contracting) is a charitable non-profit making organisation set up in 1956 to protect users of electricity against the hazards of unsafe and unsound electrical installations.

Electrical Safety First
The UK's electrical safety experts

Published by:

Electrical Safety First
45 Great Guildford Street
London SE1 0ES

Email: bpg@electricalsafetyfirst.org.uk

Website: www.electricalsafetyfirst.org.uk

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Electrical Safety First in association with
the bodies indicated on Page 2.**

1. Introduction

Lamps containing light emitting diodes (LEDs) are becoming the increasingly dominant light source of choice for industrial, commercial, amenity and more latterly domestic lighting following the arrival of compact, high luminous efficacy white light types having a very long operating life (if installed correctly).

The continued development of ever more efficient LED light sources, coupled with the relative ease of controlling brightness and even colour output has resulted in further development of the fluorescent lamp to virtually cease. It is inevitable therefore that the use of LED lighting will continue to grow in the years to come.

The introduction of LED lighting brings with it an increasing number of products onto the UK market available for sale not only from more conventional outlets such as wholesalers and DIY stores but also from a range of sources via the internet. Whilst many of the LED lamps available for purchase are

of an acceptable quality, there are a number of safety concerns relating to some readily available products. These concerns relate typically to the risk of electric shock occurring during installation, maintenance or inspection and testing work. As with any other lamp type, there is also the possibility of a poor quality LED lamp or luminaire causing a fire.

Ever more innovations and advancements are being made in the field of LED lighting and currently these precede somewhat the development of standards for such products. However, a number of product standards are now available while others are currently still in production, nevertheless specifiers and users of LED lighting need to be aware of the risks that poor quality products and incorrect installation may present. The Lighting Industry Association (LIA) Technical Statement TS01 gives details of National, European and International Standards and guidance covering LED lighting products that have been published or which are under development.

2. Aims

The aims of this guide are to

- Highlight potential dangers and risks associated with the
 - Use of self-ballasted LED lamps designed as a direct replacement for tungsten filament, compact fluorescent and similar lamps
 - Conversion of fluorescent luminaires to work with self-ballasted LED lamps and their subsequent use and maintenance
- Promote best practice by providing practical advice and guidance on how best to deal with the potential hazards and risks listed above.

This guide does not consider issues such as energy efficiency or lighting design performance.

3. Installation of LED lighting

In general LED lamps may be installed:

- In luminaires designed specifically for use with LEDs
- In existing lampholders or light fittings as a replacement of less efficient lamps
- In an existing fluorescent luminaire either as a retrofit lamp replacement or following conversion of the luminaire.

4. Replacement of conventional lamps

A range of LED lamps having integral controlgear, defined in *BS EN 62560: 2012 - Self-ballasted LED - lamps for general lighting services by voltage > 50 V* — *Safety specifications* as self-ballasted LED lamps are available as a direct replacement for 230 V lamps¹ having a wide range of lamp caps, including bayonet cap, Edison screw cap², plug-in G-type caps³, GZ10 and GU10 pins.



Fig 1. Example of LED lamp for direct replacement of Edison Screw lamp. Image courtesy of Osram.

Electric shock risk

Clause 4.1 of *BS EN 60968: 2013 - Self-ballasted lamps for general lighting services - Safety requirements* states that self-ballasted lamps shall be so designed and constructed that in normal use

they function reliably and cause no danger to the user or surroundings.

Whilst the use of high quality LED replacement lamps should not present an electric shock risk, there have been a number of cases where lamps have been found on the market that have exposed live parts on the accessible faceplate of the lamp. This clearly presents a direct contact electric shock risk during lamp replacement or if the face of the lamp is touched for any reason when the supply to the lighting circuit is on.

In research, carried out on behalf of Electrical Safety First, touch voltages were measured for normal and reverse polarity between Earth and the accessible LED leads and solder contacts that might reasonably be touched during insertion or removal of the lamps. The results are shown in Table 1. The full laboratory test report relating to this research can be downloaded free of charge from the 'Electrical professionals' section of the Electrical Safety First website.

Where test results are shown in red in Table 1 this indicates a non-compliance with Clause 7 of *BS EN 62560* which requires lamps to be so constructed that, without any additional enclosure in the form of a luminaire, no internal metal parts, basic insulated external metal parts or live metal parts of the lamp cap or of the lamp itself are accessible when the lamp is installed in a lampholder.

Table 1

Sample designation and recorded values (Red = Failure)												
Conditions	A	B	C	D	E	F	G	H	I	J	K	L
Normal polarity (V)	70.4	20.8	79.3	53.5	170.1	186.4	7.5	23.4	157.9	88.1	206.0	191.2
Reverse polarity (V)	175.2	21.5	157.8	103.5	73.3	64.9	7.4	23.8	83.1	201.0	47.8	58.7

- Unit which cannot be dismantled without being permanently damaged, provided with a lamp cap and incorporating a LED light source and any additional elements necessary for stable operation of the light source
- Lamps with E11, E12, E17 and E26 caps are excluded from the scope of EN 62560:2012 as they do not comply with European safety requirements
- G24, G23, 2G7, 2G10, 2G11, etc.

Where the source of supply for the LED lamp does not meet the requirements for the protective measure separated extra-low voltage (SELV), the lamp should be of Class II construction (See *BS EN 60598-1: 2008⁴ - Luminaires - General requirements and tests*).

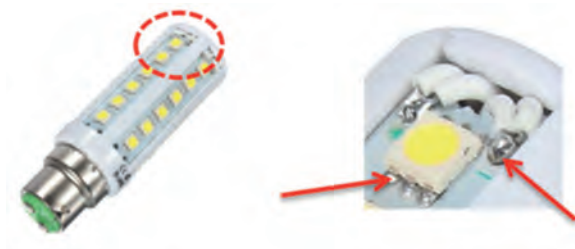


Fig 2 Example of LED lamp having exposed live contacts that are possible to touch on the sides

One way of avoiding such risks is to choose lamps having the component parts on the faceplate encapsulated in an insulating material.



Fig 3. Example of LED lamp having encapsulated live parts on surface that is accessible with lamp installed. Image courtesy of Osram.

Alternatively lamps having an integral lens in front of the component parts may be chosen.



Fig 4. Example of LED lamp having an integral lens. Image courtesy of Megaman UK.

It is highly recommended that the supply to the relevant circuit is switched off or the lamp/luminaire is unplugged before removing or replacing LED lamps, which is good practice for all relamping exercises.

A number of lamps available on the market in the UK are so manufactured that they can be easily disassembled, without the use of tools, such that access to live parts is possible.



Fig 5. Example of LED lamp that can be easily disassembled to allow access to live parts

Clause 9.1 of *BS EN 62560* specifies torque levels at which a lamp cap shall remain firmly attached to the bulb or that part of the lamp which is used for screwing the lamp in or out for bayonet cap and Edison screw lamp caps. However, during testing commissioned by Electrical Safety First⁵, it was found that in some cases, merely applying a turning force which is reasonable to remove a lamp from a lampholder was sufficient to cause the lamp body to separate from the lamp cap, permitting access to internal components. In some cases, this was because the bond between the lamp body and lamp cap broke. In other cases, the lamp body merely unscrewed from the lamp cap.

Currently no torque values are stated for a number of other lamp caps, including GU10 type, but specification of such values is under consideration.



Fig 6. Example of where body of LED lamp has separated from lamp cap when force representative of that required for lamp replacement is applied allowing access to live parts

Fire risk

A number of cases have been recorded of dramatic lamp failure where component parts have fallen from the lamp causing a fire.

In January 2013 an investigation of a fire that resulted in a fatality concluded that the most likely cause of the fire was a faulty self-ballasted LED lamp. This fault resulted in burning debris falling onto a bed immediately below the light fitting in which the LED lamp was housed, setting fire to the bedclothes. It is unclear whether the fault in the lamp was due to the failure of a capacitor or as a result of heat produced by a high resistance soldered connection in a printed circuit board, the resultant heat build-up either igniting the plastic barrel of the lamp or possibly causing the failure of the adjacent capacitor.



Fig 7. Parts of damaged LED lights found within the remnants of a bed deemed to be the source of fire that resulted in a fatality. Note the remains of an aluminium heatsink melted onto one of the mattress springs. Image courtesy of London Fire Brigade.

Clause 11 of *BS EN 62560* states that external parts of insulating material providing protection against electric shock, and parts of insulating material retaining live parts in position shall be sufficiently resistant to heat.

In the fatal fire incident mentioned above, the most severely damaged of the three GU10 LED lamps in the luminaire above the bed had, as a result of heat damage, lost the envelope, heat sink and control printed circuit boards (PCBs) all of which had fallen onto the bed. (See Fig 7).



Fig 8. Luminaire after fatal fire. The remains of the plastic body of the lamp can be seen protruding from the body of the luminaire. Image courtesy of London Fire Brigade.

This incident highlights the need to purchase lamps that meet the requirements of relevant product standards such as *BS EN 62560*.

5. Conversion of fluorescent fittings

There is a Publicly Available Specification (PAS 62776 – *Double-capped LED lamps for general lighting services – safety specifications*) covering the safety of double-capped LED lamps for general lighting services. This can be used whilst a full standard is being developed. This will include the requirements for double-capped 'retrofit' LED lamps designed for use with unmodified linear fluorescent luminaires.

Once the standard is published it will provide a presumption of conformity with the Low Voltage Directive, (limited to its scope and the relevant requirements that are covered).

Retrofit

Retrofit is a term that generally covers the replacement of a component with a component of a different type – i.e. changing from a linear fluorescent lamp to a linear LED lamp. Sometimes there is little or no modification required to the original luminaire. Other times there is a considerable modification required to the internal wiring. This can lead to unsafe situations if the work is not carried out by skilled/competent persons.

A summary of compatibility between self-ballasted LED tubes and modified or unmodified fluorescent lamp luminaires is given in Table 2.

IEC document 34/221/INF contains a more complete risk analysis of the various possible combinations of wiring arrangements found in luminaires and the various LED tube lamp types that are available.

Luminaires incorporating wire wound (electromagnetic) control gear

In most cases, switch-start fluorescent luminaires incorporating wire wound (electromagnetic) control gear can be altered relatively simply to permit use with 'retrofit' LED lamps. This is achieved by the replacement of the original starter switch followed by the installation of an LED 'starter' and double-capped self-ballasted lamp. Some LED lamp manufacturers state that there is no need to modify the luminaire or the controlgear therein in any way. Other manufacturers state that the ballast and power factor correction capacitor of the luminaire should be disconnected to achieve maximum efficiency.

Table 2

Compatibility of self-ballasted led tubes with modified and unmodified fluorescent light luminaires

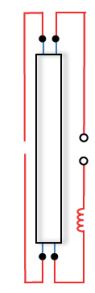
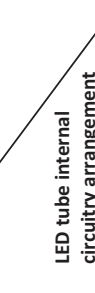
Luminaire wiring arrangement		Switch-start luminaire with starter removed and nothing put in its place	Switch-start luminaire with starter replaced by proprietary link or fuse	Luminaire converted to have line and neutral at both tube ends	Luminaire converted to have supply to pins at one end of tube only	Luminaire converted to have line to both pins at one end tube and neutral to both pins at other end of tube
LED tube internal circuitry arrangement		Lamp does not light	Lamp does not light	Normal operation	Normal operation in one direction	Lamp does not light
		Short-circuit	Short-circuit	Normal operation	Lamp operates but live pins at one end if other end still in lampholder	Short-circuit
		Lamp does not light	Normal operation	Short-circuit	Normal operation in one direction but short-circuit in other direction	Lamp does not light
		Lamp does not light	Possibility of overheating	Possibility of overheating	Only half-functional	Lamp does not light
		Lamp does not light	Lamp does not light	Normal operation in one direction but lamp does not light in other direction	Lamp does not light	Normal operation
		Normal operation	Short-circuit	Short-circuit	Short-circuit	Normal operation
		Only half functional	Only half functional	Lamp does not light	Lamp does not light	Normal operation
		Lamp does not light	Possibility of overheating as the two arrays will be in series	Normal operation	Lamp does not light	Normal operation
		Only half functional	Only half functional	Short-circuit	No function and short-circuit in one direction	Normal operation
		Lamp does not light	Lamp filaments will glow until burnt out BUT Normal function will resume if original starter is refitted	Lamp filaments will glow until burnt out BUT Normal function will resume if original starter is refitted	Lamp filament at one end will glow until burnt out	Lamp does not light
		Lamp does not light	Lamp does not light	Lamp filaments will glow until burnt out BUT Normal function will resume if original starter is refitted	Lamp filament at one end will glow until burnt out	Lamp does not light



Fig 9. Example of LED tube and replacement for starter switch that may be used to replace a fluorescent tube in a switch-start fluorescent fitting. Images courtesy of Philips.

It is recommended that LED tubes are selected which may be installed, in conjunction with the associated replacement starter, without the need for any further modification of the luminaire.

The draft BS EN 62776 proposes that double-capped LED lamps suitable for use with magnetic ballasts should be marked with the symbol shown in Fig 10.



Fig 10. Double-capped LED lamp suitable for 50 Hz or 60 Hz operation

The draft BS EN 62776 also proposes that where double-capped LED lamps need to be used in conjunction with components replacing a starter switch, the type reference of the replacement starter shall be marked on the lamp and that the LED replacement starter shall be marked as shown in Fig 11.



Fig 11. LED replacement starter marking

High frequency luminaires

Fluorescent luminaires having electronic ballasts can also be converted to accept linear LED lamps. However, in most cases the installer must bypass the electronic ballast completely and wire directly to the lamp contacts.

Such conversion presents a number of issues:

- The original manufacturer of the luminaire will no longer be seen as responsible for the safety of the product unless they specifically agree that this is the case.
- The modifications made may adversely affect the safety of the luminaire. For example, in the case of 'Ex' certified equipment for use in potentially explosive atmospheres the person who carries out the conversion will need to obtain third party certification of the modified product to the relevant standard.

The manufacturer, importer, distributor and retailer involved in the sale of LED lamps for use in fluorescent luminaires have a responsibility to ensure that when the conversion kit is installed the modified luminaire is safe and complies with the safety requirements of the Low Voltage Directive (LVD). The person carrying out the conversation will have a responsibility to

- carry out a conformity assessment on the converted luminaire
- produce appropriate technical documentation
- provide a declaration of conformity, and
- ensure the application of CE marking to the luminaire.

A more in-depth discussion of the post-production modification of lighting products is given in Technical Statement TS25 published by the Lighting Industry Association.

At least one manufacturer now offers an LED tube that is compatible for use with luminaires having electronic ballasts without the need for any conversion to the luminaire.

Electrical Safety First recommends the use of such lamps in preference to those that require modification of the luminaire.

The draft *BS EN 62776* proposes that double-capped LED lamps suitable for use with electronic ballasts should be marked with the symbol shown in Fig 12.



Fig 12. Double-capped LED lamp suitable for high frequency operation

Potential hazards associated with conversion of luminaires

In some cases, the pins at one end of a double-capped linear LED lamp can be hazardous-live when the pins at the other end of the lamp are installed in the lamp cap of a luminaire (See Figs 13, 14 and 15 and Table 2 of this guide). This is unacceptable. Lamps presenting this shock risk should not be used. Indeed, such lamps should not be for sale.



Fig 13. Simplified circuit diagram of one type of double capped LED linear lamp available for purchase. With this configuration, if the lamp is installed into a luminaire providing both line and neutral to one end of the lamp, the pins at one end of tube will be hazardous-live when the pins at other end of tube are engaged in the lampholder whilst circuit is still energised. See also Figs 14 and 15.

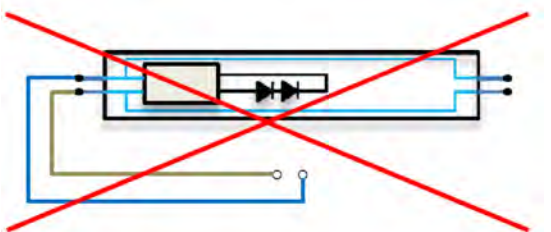


Fig 14. Luminaire wiring typically found after modification of a fluorescent luminaire. In this configuration and this type of LED lamp installed the pins at one end of tube will be hazardous-live if pins at other end of tube are engaged in the lampholder whilst circuit is still energised.

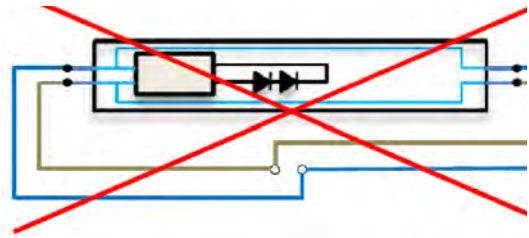


Fig 15. Luminaire wiring typically found after modifying an electronic ballast luminaire with ballast bypassed. In this configuration and this type of LED lamp installed the pins at one end of tube will be hazardous-live if pins at other end of tube are engaged in the lampholder whilst circuit is still energised.

If a fluorescent lamp is inadvertently installed in an energised luminaire that has been converted for use with LED lamps there is a possibility of violent rupturing of the cathodes at the tube ends at the moment of insertion. Although possibly insufficient to break the glass wall of the lamp, it may invoke a surprise reaction that could result in injury from, say, a fall from access equipment during relamping.

In an effort to avoid such a potentially dangerous situation occurring, it is recommended that a label is affixed in a position visible to persons performing relamping, stating which types of lamp are suitable for use with the luminaire.

The conversion of electronic ballast luminaires is not recommended. However if such luminaires are converted, the work must be carried out by suitably competent persons taking account of the recommendations of the LED lamp manufacturer.

Emergency lighting luminaires

Care must be taken when making any modifications to a luminaire containing a lamp on an emergency lighting circuit such as replacing a fluorescent lamp with a linear LED lamp. Because the emergency lighting module would have been designed originally to operate a fluorescent lamp, it is very unlikely that it will operate a linear LED lamp in the emergency mode. LIA Technical Statements TS14 and TS25 give more guidance on this subject.

6. Recalls

As mentioned previously in this Guide, there have been numerous incidents of dangerous and potentially dangerous LED lamps being placed on the market. Once safety issues are discovered, they may be subject to a compulsory or voluntary product recall in accordance with the degree of risk. Electrical Safety First has a list of recalled electrical equipment and appliances, including LED lamps, on their website at:

www.electricalsafetyfirst.org.uk/product-recalls

7. Markings

Approval and similar markings on a product do not of themselves make a product safe to use. However, it is assumed in this guide that products and their packaging that are correctly marked in accordance with the requirements of relevant product safety standards will provide important information about the correct use of a product and may act as an indicator of the quality of said product.

Clause 5.1 of *BS EN 62560* requires the following markings to be placed on self-ballasted lamps:

- Mark of origin – Trademark, manufacturer's name, or name of responsible vendor
- Rated voltage or voltage range – 'V' or 'volts'
- Rated power – 'W' or 'watts'
- Rated frequency or frequency range – 'Hz'

Minimum height of letters or numbers, 2 mm.

Minimum height of symbols, 5 mm.

In addition, Clause 5.2 of that standard requires the following information to be provided on the lamp, or its immediate wrapping or packaging:

- Rated current – 'A' or 'ampere'
- Special conditions or restrictions which shall be observed for lamp operation – such as 'not suitable for dimming' (see fig 16).
- For lamps of significantly higher weight than that of the lamps that they replace, attention should be drawn to the fact that the increased weight may reduce the mechanical stability of certain luminaires and lampholders, and may impair contact making and lamp retention.



Fig 16. Symbol that lamp is not suitable for use with a dimmer switch.

Self-ballasted LED lamps sold in the UK should carry the CE mark as shown in Fig 17.



Fig 17. CE marking

A CE marking on a product is a declaration by the manufacturer that their product meets all the essential requirements of the relevant European Directives, including those for safety, performance and environmental issues. Do not rely on a CE mark alone as a guarantee of safety. Like all markings, it can be easily misused.

8 Disposal

A number of statutory documents, including the Waste Electrical and Electronic Equipment Regulations 2006 (as amended), make the holder responsible for the disposal of waste products such as lamps and luminaires. The holder remains responsible for the waste even after it has been removed from their premises.

9. Recommendations summary

Always use good quality products obtained from a reputable source.

A good quality product will not:

- have accessible parts that could become live in operation or under fault conditions.
- be readily dismantled, either deliberately or unintentionally.

Always take manufacturers' instructions into account when installing, using and removing LED lamps.

Ensure that the supply to the relevant circuit is switched off or the lamp/luminaire is unplugged before removing or replacing LED lamps.

Where LED tubes are to be installed in a fluorescent luminaire, the use of an LED tube type that does not require any further modification beyond the use of a replacement of the starter of a switch-start luminaire is recommended.

If any conversion work is required this must only be carried out by a suitably competent electrically skilled person. Guidance on competence is given in HSE publication HSR25.

Where a luminaire designed for use with fluorescent lamps is converted for use with LED lamps, a label should be placed on the luminaire in a position visible to persons performing relamping, stating which types of lamp are suitable for use with the luminaire.

Look for the required markings on the lamp and/or packaging and instructions discussed in section 7 of this guide.

10. Standards and other publications referenced in this guide

BS EN 60598-1: 2008 - Luminaires - General requirements and tests.

BS EN 60968: 2013 - Self-ballasted lamps for general lighting services - Safety requirements.

BS EN 62560: 2012 - Self-ballasted LED lamps for general lighting services by voltage > 50V — Safety specifications.

IEC 34/221/INF - Risk analysis on new G5/G13 luminaire for LED lamp.

IEC PAS 62776: 2013 - Double-capped LED lamps for general lighting services — safety specifications.

HSR 25 – Memorandum of guidance on the Electricity at Work Regulations 1989

LIA TS01 - LED Standards & Guidance.

LIA TS14 - T5 and T8 Fluorescent Lamp and LED Lamp/Module Adaptors "Retro-fit Conversion Units" for T8, T10 & T12 Luminaires.

LIA TS25 - Post Production Modification of Lighting Products

NOTES



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Electrical Safety First

45 Great Guildford Street, London SE1 0ES

Email: enquiries@electricalsafetyfirst.org.uk Web: www.electricalsafetyfirst.org.uk

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