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How to use retrofit kits to convert fluorescent light fittings to T5 fluorescent or LED lamps

Installing retrofit kits to convert existing, less efficient non-high frequency, fluorescent light fittings to use T5 fluorescent or LED lamps can be a cost effective way of reducing carbon emissions. There are many examples of successful installations, however, there are important issues to consider before undertaking this process to ensure that safety is maintained, savings successfully delivered and that the final light levels are fit for purpose as conversion will not be possible in every case.

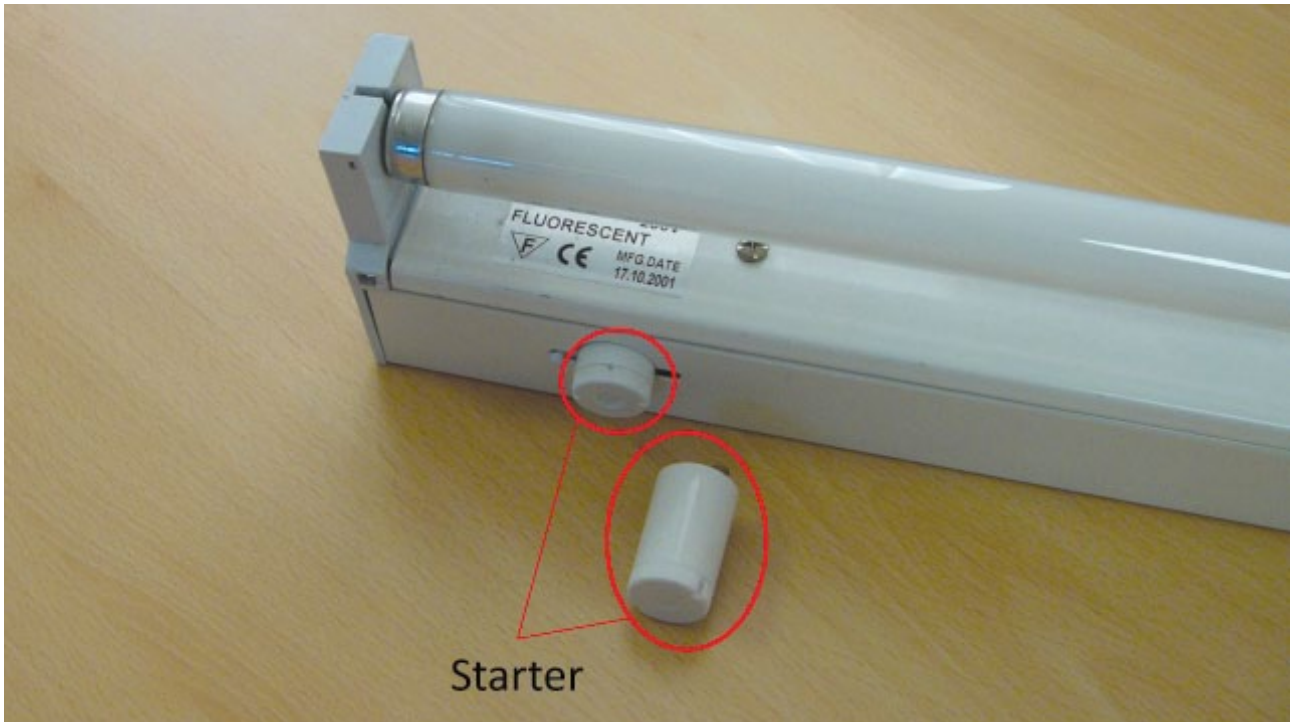
1. How do you know if you have high frequency lighting?

There are two main types of fluorescent lighting control gear which can be used in fittings with fluorescent tubes:

- high frequency (using high frequency electronic ballasts).

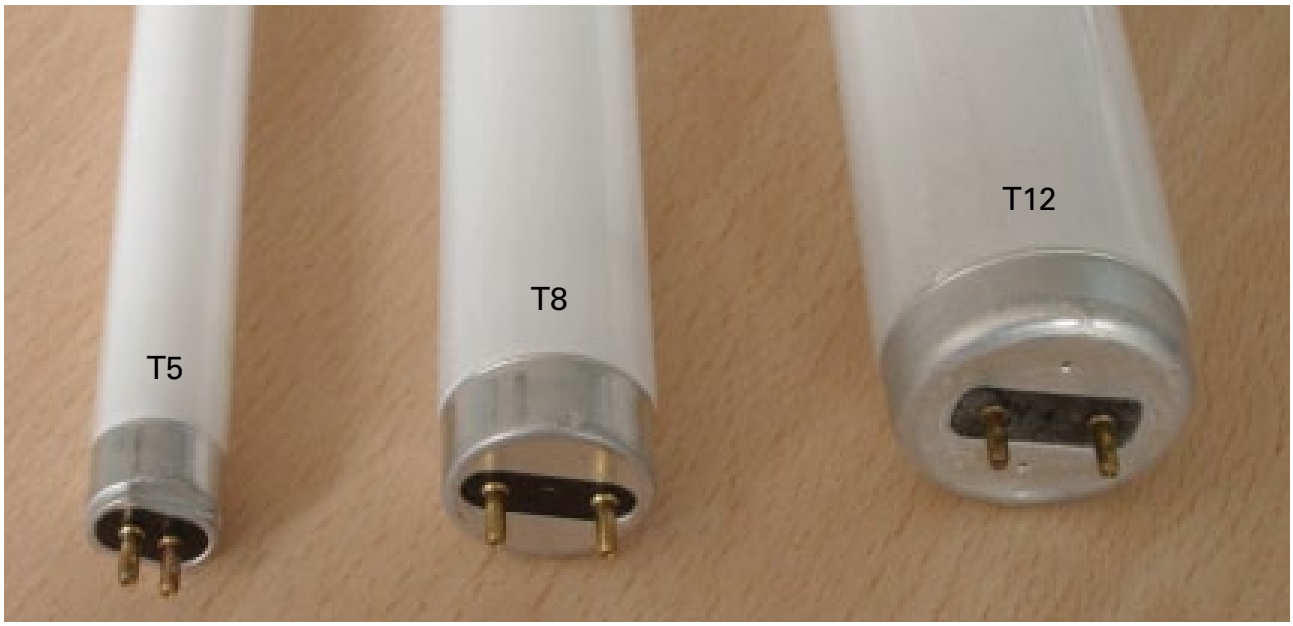
The high frequency control gear is significantly more efficient, typically using 10% less electricity than the mains frequency equivalent. It also improves lamp life compared to switch start systems. High frequency control gear also does not cause the fluorescent lamps to flicker at 100 Hz which certain people can be adversely sensitive to. Therefore use of high frequency control gear is preferable.

Mains frequency control gear can be easily identified as the lamps often flicker as they switch on, and also by the presence of a starter on the fitting, as illustrated in the following figure. It is mains frequency control gear which may be suitable to use with retrofit kits:



Mains frequency control gear only applies to T12 or T8 fluorescent lamps, not T5 ones. If you have T5 lamps, your lighting is already high frequency, and retrofit kits are not appropriate. The difference between the lamps is in their diameter, as illustrated below:

Tube diameter	T5	T8	T12
Inches	%	1	1½
mm	16	25	38



If you are uncertain which type of light fittings you have consult a qualified electrician.

2. Replacing versus retrofitting mains frequency lighting

If you have mains frequency lighting you need to consider the following to decide whether to: a) retain the existing fittings and use a retrofit kit to convert the fitting to be able to use T5 lamps or LEDs; or to b) replace the entire fitting with a new high frequency unit depending upon which is the most appropriate choice. You will need to review:

1. The age of the fitting – if your lighting is more than 10 years old, it is likely to be more cost-effective to completely renew the fittings rather than convert them. That way, you'll get the added benefits of higher light output ratio fittings. Have a look at our guide How to implement lighting refurbishments (CTL163) for more information.
2. The condition of the fitting – if the fitting is in poor condition or damaged then it should probably be replaced.
3. Whether the existing fitting is fit for purpose – the use of buildings can change over time and lead to changes in lighting requirements. Some fittings may become obsolete e.g. above bookshelf or may be better replaced with different type of fitting e.g. lower level lighting, or task lighting. In some cases areas are simply over lit which not only wastes energy, it also makes the working environment uncomfortable. See the Lighting Technology Overview (CTV049) for further advice on which type of lighting to use for different applications.
4. Opportunities for installing lighting controls – these control lighting on the basis of whether the area is occupied or whether there is sufficient natural light or both. There may be an opportunity to install new fittings with integrated automatic lighting controls which should be considered. See our guide How to implement lighting controls (CTL161) for further information.

Replacing the fittings is more expensive than using retrofit kits and consequently may have a longer payback period. However, installing new fittings together with automatic lighting controls will help to reduce this payback period and remember that the lifetime of retrofits tends to be shorter than new replacement fittings.

As for fluorescent lighting, retrofit kits can be suitable for many, varied applications: from schools, hospitals, and universities, to factories and warehouses. However, limitations of light levels and quality may make them unsuitable in a given situation and lamp fitting as explained in the following section. The Lighting Industry Association Technical Statements 41 and 51 should be consulted before proceeding any further.

3. What sort of retrofit should I undertake?

Having established that the current fittings are mains frequency and that using a retrofit kit is an appropriate option then the choice of kit needs to be considered. There are two main options available as retrofit kits:

1. Baton or end cap type kits (see below) which convert the fittings to high frequency and take T5 fluorescent tubes. Energy savings of up 30% are typically achievable from these types of conversions.

2. Kits which convert the fitting to use LEDs (see below). The range of options in this category is increasing and is likely to continue to improve in performance as LED lighting technology develops.

In choosing which type of kit to install there are a range of considerations:

1. Light output – whether they will supply sufficient light to meet the required lux levels (see table below) remembering that in some cases using task lighting to achieve higher lux levels may be more appropriate. Further details on appropriate lighting levels are provided in EN12464:1 2011. Also, compare what their luminous efficiency is in lumens/watts as this is a measure of their energy efficiency. It is not uncommon for the light levels produced using kits to be lower than those from using a new lamp in the existing fitting, particularly for currently available LEDs. Also, be aware that in low temperatures the light output from T5 fluorescent tubes reduces which can cause problems in low temperature applications. The life of the tube can also be compromised in low temperatures.

Lux level	Area or activity
100	Circulation areas e.g. corridors, stores and warehouses, changing rooms and rest areas
150	Active circulation e.g. stairs, escalators, loading bays
200	Facility lighting e.g. washrooms, foyers, lounges, archives, dining rooms, assembly halls and plant rooms
300	General background lighting e.g. IT office, packing, assembly (basic), filing, retail background, classrooms, sports halls, gymnasium and swimming pools
500	General lighting e.g. offices, CAD, laboratories, meeting rooms, general manufacturing, kitchens and lecture halls
750	Detailed lighting e.g. manufacturing & assembly (detail), paint spraying and inspection
1000	Precision lighting e.g. precision manufacturing, quality control, examination rooms
1500	Fine precision lighting e.g. Jewellery, watch making, electronics & fine working

2. **Light quality** – colour temperature and colour rendering (particularly important for LEDs). Also the uniformity of illumination can be an issue for all kits as they may alter how the existing optical components of the fitting work. Fittings are designed to reflect the light correctly for the tubes they are built for. T5 tubes are narrower, and with some adaptors, they can be offset in the fitting. The LEDs currently emit light through a much narrower angular range than the fluorescent tubes they replace and this may be a problem too. The light distribution and potential problems with glare should be considered. It is usually best to trial one or two before committing to a full installation.
3. **T5 or LED** – whereas T5 fluorescents have been in use for many years LED technology is still maturing and is only just coming of age in its suitability for replacing general fluorescent lighting. Achieving the required brightness from LEDs can be an issue, for further information see How to implement LED lighting (CTL164).
4. **Lifetime of the components** – different types of kit will have components with different lifetimes. Check also how the life-time is specified: is it, for example, for a 10% or for a 30% drop in light output? Knowing this will ensure that you are comparing like with like.
5. **Physical dimensions of replacement** – i.e. will the kit actually fit in the existing fittings as not all types are compatible.
6. **Emergency lighting** – the kits are not compatible with integrated emergency lights.
7. **Electrical issues** – a competent electrician will need to review the existing fitting installations and the requirements of the retrofit kit to ensure that they are compatible. In general the starter is replaced and the lamp (plus end caps/baton, depending upon design) is inserted in the fitting. In some cases additional wiring changes and removal of parts of the control gear may be required, the manufacturer should be consulted by the electrician about the requirements.
8. **Kit conformation** – see whether the kit conforms to the relevant standards such as CE marking and this needs to be considered in conjunction with the implications for any alterations of the existing fitting. The Lighting Industry Association Technical Statements 41 and 51 are essential reading.
9. **Budget availability** – see if budget available for capital investment and whether alternative "invest to save" funding sources are available for these projects.

It is therefore important that a trial is undertaken to ensure that chosen option is safe, suitable and physically fits into all the intended types of light fitting into which it is to be installed before bulk purchase is committed to. Ideally a trial of a range of options would be undertaken to determine the best option from a range of suppliers as they usually do not supply all the available types of options (LED, T5 baton/end kit). Where applicable, you should assess the impact the lighting will have on heat output. For example, LEDs have heat management issues and work well in cold conditions. You should take care not to enclose LED tubes in high ambient temperature fixtures.

Please note this is a rapidly changing area so always take time to review the most current options available.

4. Procurement of retrofit kits

Although you can find suppliers on the web, it's wise to get references if possible. The following checklist can be used to agree the specification with your suppliers.

1. Project description

- Scope of work – set out what you want the contractor to deliver. For example, are they going to install the retrofit kits as well as supply them or are you going to use an in house electrician?
- Application – Include a clear definition of what it is that you are looking to light e.g. a factory or office.
- Functional objectives – specify the functional objectives of the lighting e.g. work station illumination, emergency lighting, aesthetics etc.
- Layout and technology – Provide a description and annotated schematics of the required lighting and its layout (as a minimum provide the existing layout and indicate it as such).
- Target energy consumption – ask the supplier to specify the target energy consumption (and reduction) of the lighting solution (kWh/year).

2. Technology specification for lighting

- Lamp type and wattage – define lamp type and wattage, and ensure you remember to specify colour temperature and CRI.
- Luminaire – this should ensure details of the works required to ensure the retrofit kit is compatible with the existing light fittings are agreed.
- Estimated number of units.
- Key characteristics – Specify other key characteristics of the lighting such as colour appearance/colour rendering, light levels and uniformity.

3. Performance requirements

- Standards and legal/regulatory requirements – specify that the contractor should comply with all legal and good practice requirements including for example:
  - Building Regulations Part L.
  - If electrical wiring is altered, installation and commissioning needs to comply with the latest BS7671 IEE electrical wiring regulations.
  - CE and EN marking of all electrical equipment supplied and a Certificate of Conformity for the modified luminaires will be required.
  - PAT Testing of all qualifying equipment.
- If installation is undertaken separately from supply, responsibility for issues of compatibility, warranty and CE marking need to be agreed.
- Commissioning and Performance testing – specify what responsibilities to expect of the Contractor for commissioning of the new system, including following any guidance from the manufacturers and CIBSE Commissioning Code L. Post installation testing required should be detailed including measurements to ensure that the required lux levels and uniformity are achieved as part of the commissioning process.
- Other information requirements – specify any other information that will be needed including:
  - Trial of fittings.
  - Lifecycle cost (or best estimate) including capital cost, installation cost, running costs, maintenance costs and disposal costs.
  - Warranties (both for the lamps/retrofit kits, any wiring changes to the existing fittings that will be undertaken and how the warranty of the existing fittings will be affected).
  - Ongoing support provision.

Installing the retrofit kits can be a straight forward process but if installation is carried out incorrectly the benefits expected may not materialise. The main problem tends to be the reduction in lighting levels. If the brightness before the change was only just adequate, a new T5 lamp may take it down too far. Choose higher lumen lamps to get the best light output. You might find it hard to access some fittings, which could influence the type of conversion kit you choose. Also, in some mirror reflector light fittings, the baton type adapter's 'spine' can interfere with light output. It is always a good idea to test a conversion kit and lamp before ordering in bulk.

5. Business case

It is usually necessary to develop a business case to allow the investment in retrofit kits to proceed. The costs and savings can be calculated as follows:

1. Calculate the current lighting power demand by taking the power rating of all the current fluorescent lamps (in Watts) and add the power consumption of the current control gear to give the total power use (typically ranging from 5% and 20% extra consumption but actual loads can be measured):

   Power used by current fluorescent lamps (Watts) + power used by current control gear (Watts) = Total current lighting power demand (Watts).

2. Calculate the new lighting power demand by taking the power rating of the new fluorescent or LED lamps (in Watts) and add the power consumption of the new control gear to give the new total power use:

   Power used by new fluorescent or LED lamps (Watts) + power used by new control gear (Watts) = Total new lighting power demand (Watts).

3. Take the difference between the two power demands and you have the Power saving. Divide by 1,000 to convert to kW.

4. Then estimate the annual operating hours of the system e.g. 9am to 5pm Monday to Friday, for 51 weeks per year equates to 2,040 hours per year.

5. Multiply the Power saving (in kW) by annual operating hours to give the annual kWh saving.

6. Use your current electricity cost, which can be found on your bill (in p/kWh) to give annual cost savings. Divide by 100 to convert to £.

7. Use the estimate of capital cost (in £) together with the annual cost saving (in £) to give the simple payback period in years.

Changing the lamp type to tri-phosphor and also switching to high frequency control gear provides scope for also improving the lamp life. Considering this as part of the business case can be important as the cost of replacing lamps and therefore maintenance can be much reduced. Typically the quoted lamp life is divided by the annual operating hours to give the number of years of lamp life. The cost of the replacement lamp is then divided by this to give the cost per year which can be compared between the old and the new lamps.

Also consider any other benefits which may arise such as elimination of flicker which could be helpful to mention when presenting the business case.

Example:

A corridor containing twenty 65W T12 fluorescent lamps, not using high frequency control gear is to be replaced with T5 lamps using retrofit kits costing £35 each including installation. The lights are typically on in the corridor from 8am to 7pm Monday to Friday. Electricity costs 10p/kWh.

1. The current power consumption of the lighting is:

   20 x (65W [lamp] +13W [control gear]) = 1,560 W.

2. The power consumption of the new lighting should be:

   20 x (35W [lamp] + 4W [control gear]) = 780 W.

3. The power saving is:

   1,560 W – 780 W = 780 W = 0.78kW.

4. The annual operating hours are:

   11 hours per day x 5 days x 52 weeks per year = 2,860 hours per year.

5. The annual energy saving is:

   0.78 kW x 2,860 hours per year = 2,230.8 kWh per year.

6. The annual cost saving is:

   2,230.8 kWh per year x 10 p/kWh = 22,308 p per year = £223.08 per year.

7. The simple payback is:

   (20 x £35)/£223.08 per year = 3.1 years.

You should also remember to consider other options such as replacing the fittings or re-lamping as they may also present attractive options for reducing energy consumption.

6. Sources of further information

Carbon Trust resources

Lighting technology overview (CTV049)

How to implement lighting refurbishment (CTL163)

How to implement lighting controls (CTL161)

External sources

The Lighting Industry Association

LIA Technical Statement No. 41, "T5 and T8 Fluorescent Lamp and LED Lamp/Module Adaptors "Retro-fit Conversion Units" for T8, T10 & T12 Luminaires", available from www.thelia.org.uk

LIA Technical Statement No. 51, "Safety of LED T8 replacement tubes and modified luminaires" available from www.thelia.org.uk

The Institution of Lighting Professionals

7. Glossary

Ballast: Component found on mains frequency fluorescent light fittings which helps to regulate the current which controls fluorescent tubes discharge, and hence light output.

Control gear: The electronics which controls all fluorescent light fittings, regulating the fluorescent tubes discharge which causes the visible light to be emitted by the phosphorous lining of the tube.

Fluorescent tube: a glass tube containing usually mercury vapour and noble gases, in which electricity is used to excite the molecules of the gas which then emit UV light which, when it hits the phosphor coating of the glass tube is converted to visible light and emitted from the tube.

High frequency: Control gear which operates in the kilo-Hertz range rather than Hertz frequency range.

LED: stands for light emitting diode, a solid state electronic device which converts electricity directly to light.

Switch start: Control gear which operates at 50Hz and requires a ballast to start and control the fluorescent lamp.

The Carbon Trust is a not-for-profit company with the mission to accelerate the move to a low carbon economy. We provide specialist support to business and the public sector to help cut carbon emissions, save energy and commercialise low carbon technologies. By stimulating low carbon action we contribute to key UK goals of lower carbon emissions, the development of low carbon businesses, increased energy security and associated jobs.

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- setting standards for carbon reduction.

We reduce potential future carbon emissions by:

- opening markets for low carbon technologies
- leading industry collaborations to commercialise technologies
- investing in early-stage low carbon companies.

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