Lighting Industry Federation Limited

Lamp Guide 2001

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LIF Lamp Guide

Fourth edition 2001. Editor **Richard Forster** I Eng MILE MCIBSE MSLL

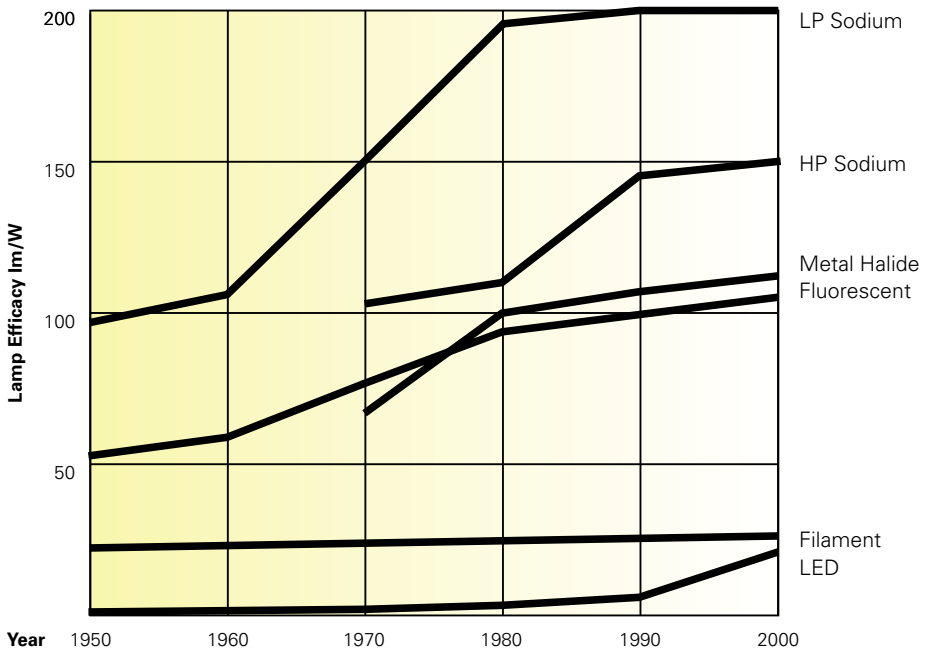
Lighting Industry Federation

The Lighting Industry Federation is a trade association representing British manufacturers of lighting equipment. Its members design and manufacture electric lamps, luminaires, lampholders, low-voltage lighting, emergency lighting, road lighting, control gear and equipment associated with lighting, within the European Community and other parts of the world.

Most lamp types associated with the general lighting within and around buildings can be used in different applications. Consequently the classification and description of lamps is based on how the lighting is generated and not by end usage. This Guide offers a survey of lamp types to enable the suitability of different lamps to be judged against lighting needs of specific situations. Detailed information about individual lamps is available from lamp manufacturer members of the Lighting Industry Federation (see page 28).

Energy Efficient Lighting

One aspect of good lighting is the prudent use of electrical energy. The lighting industry has a long record of continuous improvement in the efficiency of lamps, control gear and luminaires. The following graph shows the improvement in light output for given electrical power during the last fifty years. Note that luminous efficiency is markedly different for different lamp types.



A review of lamps

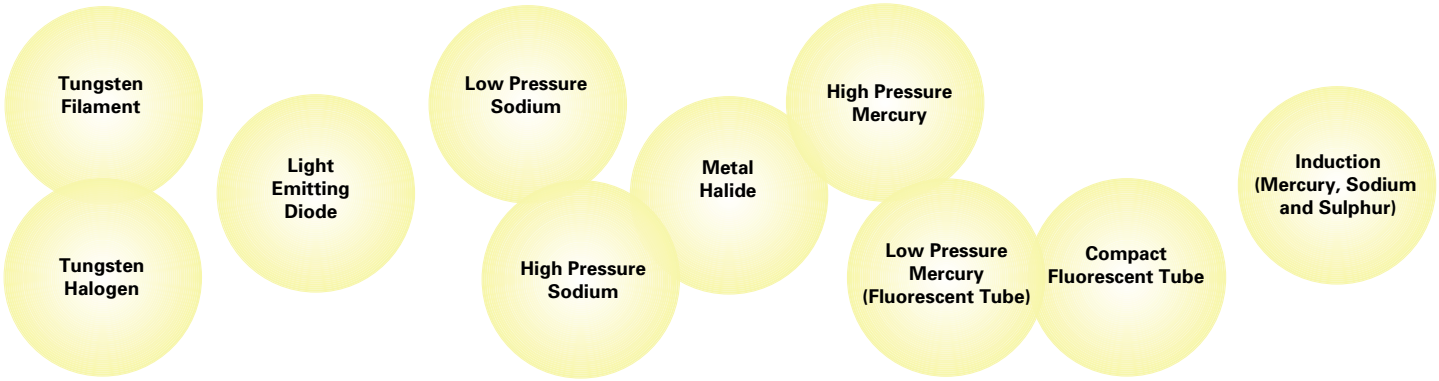
The *LIF Lamp Guide* has been compiled by the Lighting Industry Federation to help users in the choice of appropriate types of lamps for lighting commercial, institutional and industrial installations (special lamps, such as for vehicle and photographic use have not been included).

The principal types of lamps are reviewed within the *LIF Lamp Guide* and their different characteristics are explained. It is important to understand the various lamp characteristics not only when dealing with new installations, but also when older installations are up-dated to an improved lighting standard or in order to save energy. Good lighting, using the latest lamps and luminaires, can pay for itself in reduced running costs as well as improving working conditions.

NB. The *LIF Lamp Guide* is only intended to help users make their initial decisions. Once more precise technical information is required (e.g. up-to-date values of light output) it is essential to consult the latest technical literature from LIF lamp manufacturers.

Families of lamps

There are ten principal families of lamps, according to the manner of light emission.



Notes:

1. Fluorescent lamps incorporate a low pressure Mercury discharge but the majority of the light output is from the fluorescence of the phosphors which coat the inside of the glass.
2. High pressure discharge lamps are sometimes known as High Intensity Discharge lamps (HID).
3. The Pressure of the High Pressure Sodium Lamps is less than one atmosphere, but they are so called to distinguish them from Low Pressure Sodium Lamps.
4. Many lamps require separate control gear, but some compact fluorescent and Induction lamps incorporate integral control gear.

Lamp selection

Principal characteristics

When lamp types are being selected for a new installation, the following are the principal characteristics which should be taken into consideration:

1 Colour appearance and colour rendering
2 Efficacy and light output
3 Service period

Other characteristics include:

shape, need for control gear, starting and restarting time, operating position, effect of ambient temperature, relative cost (initial and running), accessibility.

Colour rendering

Coloured objects require light that falls on them to contain components that will faithfully reproduce the correct colour. A degree of fidelity for colour reproduction is given by the colour rendering index (CRI), on a scale of 0-100. The higher the number means the better the reproduction of colour. See Fig 2 page 9.

Colour appearance

The colour temperature of a lamp is given in Kelvin and this figure indicates whether the lamp has a warm (below 3000K) intermediate (3500K) or cool (above 4000K) appearance and effect. The colour appearance of a lamp (including colour temperature) is no guide to its colour rendering.

For all fluorescent and discharge lamps the term Correlated Colour Temperature is used but this is only an approximation and not an accurate numerical reference. For example two fluorescent lamps may be given the same CCT by different manufacturers but this does not ensure they will appear the same colour.

Efficacy

Luminous efficacy is the ratio of light output (lumens) to lamp power (Watts). For lamps operating on separate control gear total circuit power should be included in calculations of overall efficacy.

Luminous flux

The quantity of light (lumens) emitted by the lamp measured under standardised conditions. For fluorescent and discharge lamps, the initial value is measured after 100 hours of operation.

Service period

This is the average life for filament lamps, or the time after which lamps should be changed for fluorescent and discharge lamps.See page 25.

Basis of lamp selection

Lighting design guidance may be obtained from the various publications issued by the Society of Light and Lighting. Subject to their recommendations (illumination level, colour rendering, reduction of glare etc.) preference should be given to lamps with an efficacy as high as possible. The chart (Fig.3 page 9) indicates the ranges of efficacies available for common lamps of each family. Nevertheless, the fact that there are so many lamp types indicates that they all have their applications.

For England and Wales Part L of the Building Regulations includes the conservation of power including lighting. The Approved Document associated with Part L sets out specific methods as to how lighting should be assessed for ordinary interior situations. A revision to Part L has been drafted and The Building Regulations are scheduled for amendment in 2001.

Lamp prefixes and codes

(non-exhaustive list)

ILCOS = International Lamp Coding System. BS IEC 62131 Second edition 1998/99.

	Proprietary Codes	ILCOS Code	Description of lamp(s)
Filament lamps	GLS	IA IB IN	Large incandescent >45mm Compact incandescent ≤45mm Other (non-reflector)
	R	IRR	Reflector, normal R bulb
	PAR	IPAR	Normal PAR reflector
	TH	HS HD	Single ended Tungsten Halogen Double ended Tungsten Halogen
	K	HS HD	Single ended general display/misc. Double ended general display/misc.
	MR	HR HM HR_S HM_S	Dichroic reflector Tungsten Halogen Metal reflector Tungsten Halogen Self shielded dichroic reflector Self shielded metal reflector
Tubular fluorescent lamps	MCF	FD	Double capped switch start (ss)
	MCFE	FD	Silicone coated starterless and ss
	MCFA	FD	Earth striped,starterless and ss
	MCFR	FDR	As MCF with internal reflector
	T2		7mm nominal diameter
	T5	FD	16mm nominal diameter
	T8	FD	26mm nominal diameter
	T12	FD FS	38mm nominal diameter Single capped, including circles and U's
	Circle	FSC FSD FSG FSM FSQ	Single cap circular shaped Single cap Dual shaped (2 limbed) Single cap, Globular Single cap, Multi limbed (eg 6 limbed) Single cap, Quad shaped (4 limbed)
	2D	FSS FSD	Single cap, Square shaped Single cap, U shaped
High Pressure Sodium lamps	LU_/D, NAV E, SHP,	SE	Single ended lamps with elliptical bulb with diffuse coating
	SON, SON-E	SC	Single ended lamps with clear elliptical bulb
	LU_/T, NAV T, SHP-T, SON-T	ST	Single ended lamps with tubular clear bulb
	LU_/HO/D, NAV E_SUPER SHP-S, SON-S, SON-PLUS	SE	Single ended lamps with elliptical bulb with diffuse coating and increased efficacy and life
	LU_/HO/T, NAV T_SUPER SHP-TS, SON-T-PLUS	ST	Single ended lamps with tubular clear bulb and increased efficacy and life
	LU_/CL/E, NAV E DELUXE SHP HCRI, SON COMFORT SON DL	SEM	Single ended lamps with elliptical bulb diffuse coating and improved colour. SONMF Mercury free
	LU_/CL/T, NAV T DELUXE, SHP HCRI, SON T COMFORT, SDW-T	STM, STH	Single ended lamps with tubular clear bulb and improved colour SONTMF Mercury free

High Pressure Sodium lamps continued on next page

Proprietary Codes	ILCOS Code	Description of lamp(s)	
LUH_/D/EZ, NAV E, NAV T SHX, SON-H	SEQ/STQ	Single ended lamps for replacement in high pressure mercury equipment	
Citylight DS	SEM	Single ended lamp with high and low power settings	
LU_/-/SBY/T, LU_/_/SBY/D, SHP Twinarc, SHP-T Twinarc SON EXTRA	SE_/T, ST_/T	Single ended lamps with two arc tubes to give hot restrike and longer life capability	
LU_/TD, NAV TS, SON TD	SD	Double ended clear lamps	
LU_/RFL, NAV R, SON R	SR	Lamps with internal reflector	
SOX	LS	Single capped lamps with "U" shaped arc tube.	Low Pressure Sodium lamps
SOX-E	LSE	E type with increased efficiency	
SOX-PLUS	LSE	E type with increased life	
MBF, H, HPL-N, HQL, HSL-BW	QE	Single capped lamps with elliptical bulb and diffuse coating	High Pressure Mercury
MBFSD, H_DX, HPL COMFORT, HQL DE LUXE, HSL-SC	QE	Single capped lamps with elliptical bulb and warmer diffuse coating	
MBFR, H_R, HPLRN, HQL-R, HSR-BW	QR	Single capped lamps with internal reflector	
MBTF, MBTFR, HML, HSB-BW, HWL	QB, QBR	Single capped lamps with integral filament self ballasting	
MBI_/T/, MBI_/TX/ ARC_/T/ G12, HQI-T, HSI-T	MT	Single ended two pin capped lamps with Quartz arc tube	Metal Halide Lamps
CMH/TC/UVC/U, CMH/T/UVC/U, CDM-TC, CDM-T, HCI-TC, HCI-T	MT	Single ended two pin capped lamps with Ceramic arc tube	
HSI-TD_UVS, MBIL_MHN-TD, MHW-TD, SPL/_/L	MN	Double ended lamps. Those with UVC and UVS in their designations have low radiated UV	
CMH/TD/UVC/U, CDM-TD, HCI-TS	MD	Double ended lamps with Ceramic arc tube	
HPI, MBI, KRC_/E, HPI, HQI-E CDMTT	MC	Single capped elliptical clear bulb. Good colour rendering.	
MBID, MBIF, KRC_/D, HQI-E CDMET	ME	Single capped elliptical bulb with diffuse coating. Good colour rendering	
MS, MVR, MXR	MW	Single capped elliptical bulb with either clear or diffuse coating. Moderate colour rendering	
MBI, KRC_/T, SPL_/T, HQI T	MT	Single capped tubular clear bulb. Good colour rendering	
CMH/PAR/UVC, CDM-R	MPAR	Sealed beam reflector with Ceramic arc tube	
CSI_G38, SPL_G38	MR	PAR 64 reflector lamps with G38 base	

Lamp suffixes and codes

Supplementary coding data to indicate operating positions and starting.

Code letter	Function
/U	Universal, often not marked
/V	Operation in vertical plane
/H	Operation in horizontal plane
/HR	Hot restrike
/BD	Operated cap (base) down
/BDH	Operated cap (base) down to horizontal
/BU	Operated cap (base) up
/BUH	Operated cap (base) up to horizontal
/VBU	Operated vertical cap (base) up
/BUS	Operated vertical cap (base) up with internal starting device (Note internal or external starting device symbol)
/P	Protected arc tube or bulb
/p	Position indexed lamp cap

The ILCOS code also has supplementary information code detail which depending on the complexity chosen can indicate similar information plus items such as cap (base) and dimensions (see BS IEC 61231 for details).

Lamp standards

LIF members and staff participate in the drafting and revision of International, European and British Standards and participate in schemes for independent assurance of quality.

The following table lists the principal lamp standards. The safety standards have been listed in the 'Official Journal of the European Communities' and thus compliance with these standards is the best method, where relevant, of giving assurance that the requirements of the Low Voltage Directive (73/23/EEC amended by 93/68/EEC) and the EMC Directive (89/336/EEC amended by 92/31/EEC) have been attained.

In many instances modern lighting product standards and revisions are drafted in the IEC and parallel voted both internationally and in Europe (CENELEC). This has speeded the process of publishing new standards and revising/updating existing standards. This has allowed BSI standards to also have enhanced publication/revision capability and the adoption by IEC of the 5 digit standard number used by CENELEC has simplified the cross referencing of relevant international, regional and national standards.

IEC, EN, BS EN Standard number	Category – Safety or Performance	Description	Comment
55015	Safety	EMC emission. Limits and measurements	Applies to EN60968 lamps
60061	Safety	Lamp caps and gauges	Parts 1,3 & 4
60064	Performance	Tungsten filament lamps (GLS)	
60081	Performance	Tubular fluorescent lamps, double capped	
60188	Performance[1]	High pressure mercury lamps	
60192	Performance[1]	Low pressure Sodium lamps	
60357	Safety & Performance	Tungsten Halogen lamps (non-vehicle)	See 60432-2
60432-1	Safety	Tungsten filament lamps (GLS)	
60432-2	Safety	Tungsten Halogen lamps (GLS types)	
60662	Performance[1]	High pressure Sodium lamps	
60901	Performance	Single capped fluorescent lamps	
60968	Safety	Compact fluorescent with integral control gear	
60969	Performance	Compact fluorescent with integral control gear	
60983	Performance	Miniature filament lamps	
61167	Performance[1]	Metal Halide lamps	
61195	Safety	Tubular fluorescent lamps, double capped	
61199	Safety	Single capped fluorescent lamps	
61547	Safety	EMC immunity. Limits and measurements	Applies to EN60968 lamps
61549	Safety & Performance	Miscellaneous lamps	
62035	Safety	High Intensity Discharge lamp safety	(IEC draft at 3/98)

[1]Use this standard for safety assessments until EN 62035 is published.

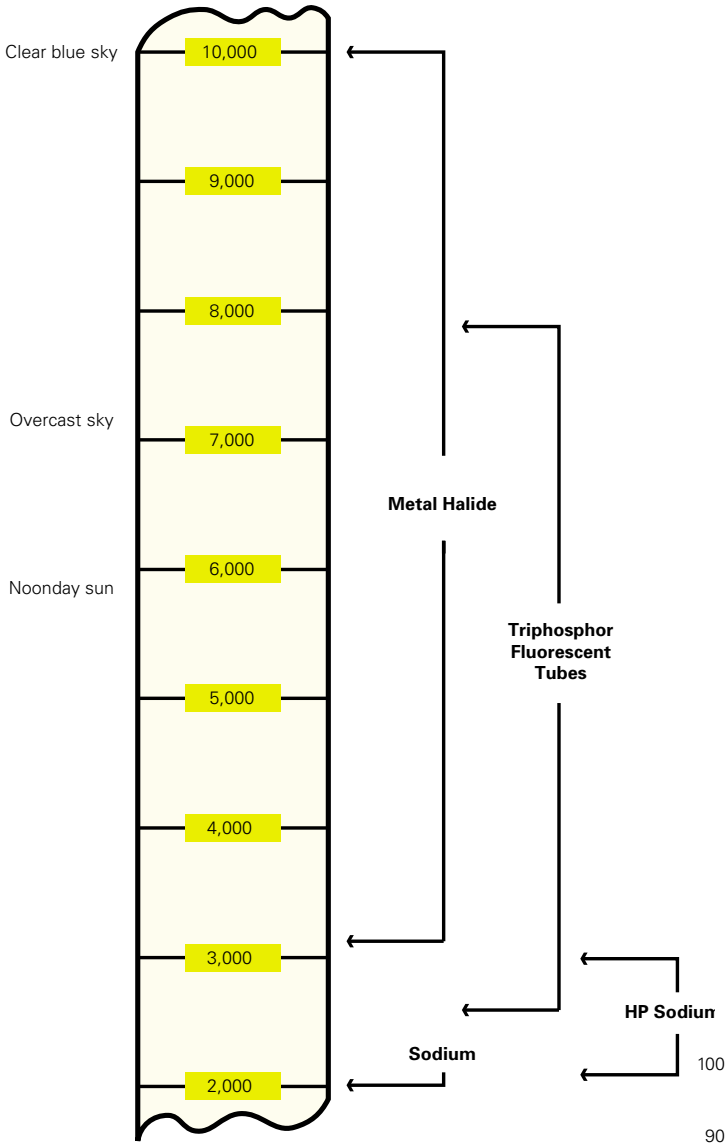


Fig 1 Correlated Colour Temperature (CCT) for some lamps

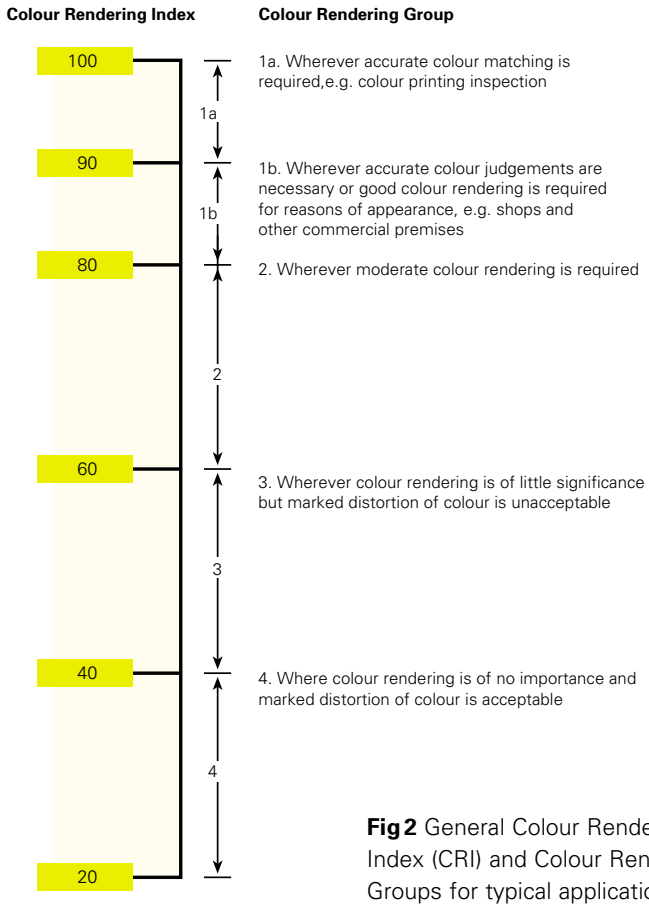


Fig 2 General Colour Rendering Index (CRI) and Colour Rendering Groups for typical applications.

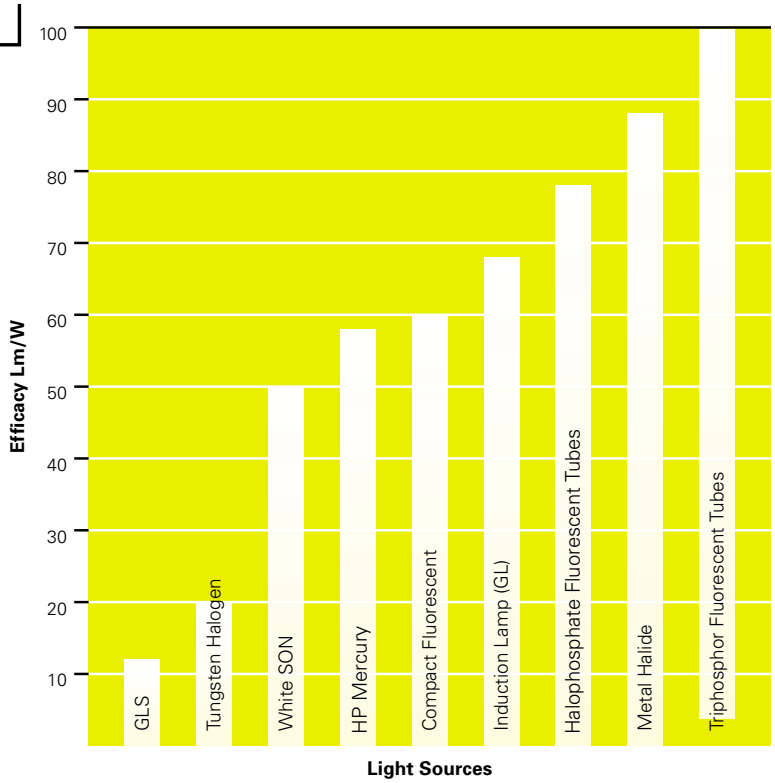
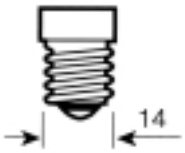


Fig 3 Comparative Efficacies of Light Sources.

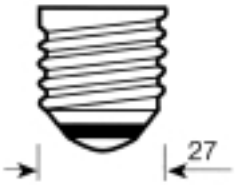
Common lamp caps

excluding vehicle and photographic lamps

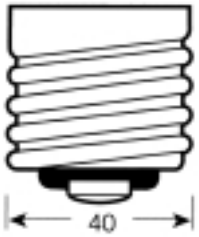
Dimensions in mm Drawings not to scale



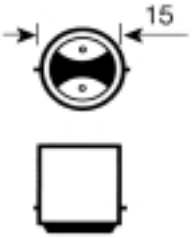
E14



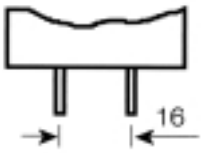
E27



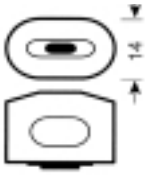
E40



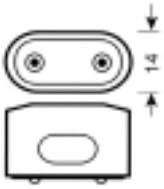
B15d



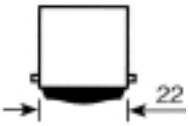
GX16d



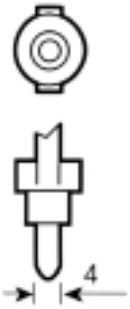
S14s



S14d

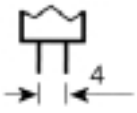


B22d

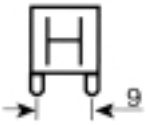


Fa4

R7s-7



G4



G9

G53

GY6.35

GY4

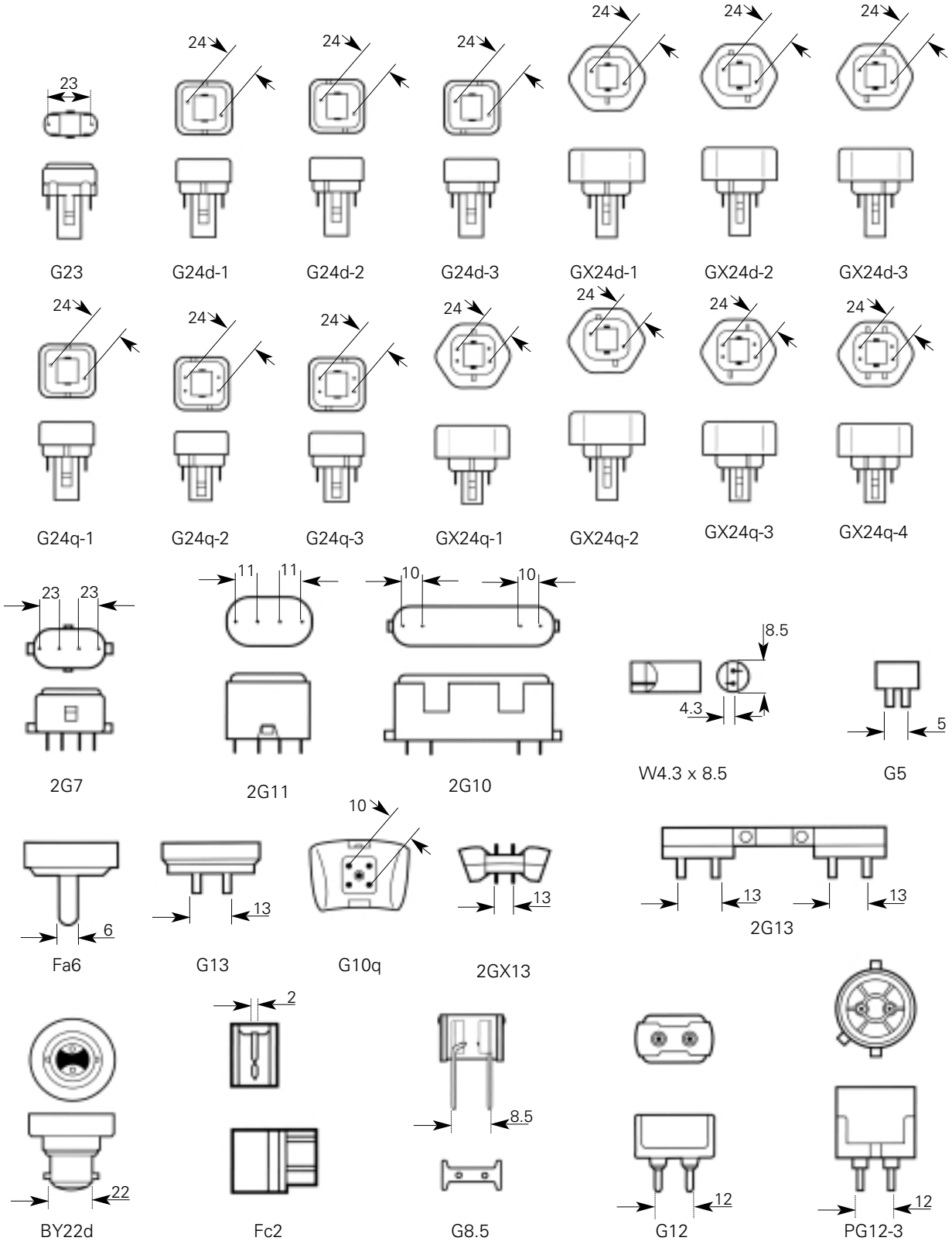
GU4

GX5.3

GU5.3

GU10

GZ10


23
24
G23
G24d-1
G24d-2
G24d-3
GX24d-1
GX24d-2
GX24d-3
G24q-1
G24q-2
G24q-3
GX24q-1
GX24q-2
GX24q-3
GX24q-4
2G7
11
2G11
10
2G10
8.5
4.3
W4.3 x 8.5
5
G5
Fa6
6
G13
13
G10q
2GX13
2G13
BY22d
22
2
Fc2
G8.5
G12
12
PG12-3

Lamp characteristics and applications

Drawings on pages 12-19 not to scale

Tubular fluorescent lamps (ILCOS F)

OPERATING POSITION	→ Any
CONTROL GEAR	→ Yes
STARTING	→ Prompt
RESTARTING	→ Prompt
COLOUR TEMPERATURE (K)	→ 2700–6500
COLOUR RENDERING	→ 50–98

The light output comes from phosphors that convert energy from a low pressure mercury discharge. Colour temperature and colour rendering are determined by the phosphor mix coated on the inside of the tube.

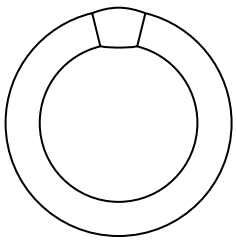
Choice of length and rating

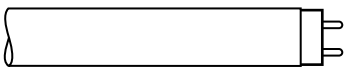
For new installations or major refurbishments the recently introduced 16mm diameter (T5) range of fluorescent lamps should be used as it offers higher efficacy and reduce luminaire size.

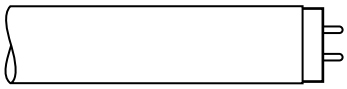
For replacement lamps in existing installations the old technology argon filled T12 (38mm dia) tubes are gradually being discontinued. The modern range of krypton filled triphosphor 26mm diameter (T8) tubes should be the first choice for both switch-start and high frequency circuits. These lamps are more energy efficient, improve LOR of many luminaires from their higher light output and as such offer long term cost savings. In addition they provide better colour rendering, improved lumen maintenance and longer life.

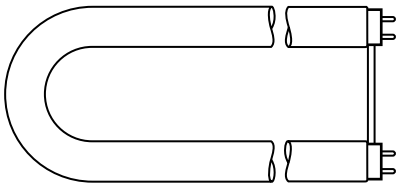
Other types

Other types of fluorescent tube are the new T5 ‘ring’ lamps, offering the same benefits as the linear T5 types but in a circular format. Ultra-slim 7mm diameter (T2) lamps are available for special applications where unobtrusive light sources are required e.g. under shelf lighting, picture lighting and display cabinet lighting.









The following table shows a selection from the principal 'white' colours, to demonstrate the relation between colour appearance and colour rendering, and to show the systems of proprietary colour names.

For the latest ranges of colours it is essential to consult the up-to-date catalogues of individual lamp manufacturers.

Colour Appearance	Triphosphor Colour rendering Group 1b	Multi-phosphor Colour rendering Group 1a
Northlight (6000-6500K)	**Colour 865** **Lumilux Plus ECO 860** **Luxline Plus ECO 860** **Polylux XL 860**	**Colour 965**
Daylight (5000-5500K)		**Colour 950** **Lumilux De Luxe 950**
Cool White (4000K)	**Colour 840** **Lumilux Plus ECO 840** **Luxline Plus ECO 840** **Polylux XL 840**	**Colour 940** **Lumilux De Luxe 940** **Polylux Deluxe 940**
Intermediate (3500K)	**Colour 835** **Lumilux Plus ECO 835** **Luxline Plus ECO 835** **Polylux XL 835**	
Warm White (3000K)	**Colour 830** **Lumilux Plus ECO 830** **Luxline Plus ECO 830** **Polylux XL 830**	**Colour 930** **Lumilux De Luxe 930** **Polylux Deluxe 930**
Very Warm (2700K)	**Colour 827** **Lumilux Plus ECO 827** **Luxline Plus ECO 827** **Polylux XL 827**	

Selection of colours

Colour **appearance** is largely a matter of taste. The general preference is to use cool colours for a business-like atmosphere (e.g. in offices, factories, shops), and warm colours for a social atmosphere (e.g. in restaurants and the home).

Colour **rendering** depends upon the application. For most applications, and especially in offices, triphosphor lamps (Group 1b) offer the optimum combination of high efficacy, good colour rendering, slow depreciation and suitability for enclosed luminaires.

For applications requiring high fidelity colour rendering (e.g. art galleries), multiband lamps (Group 1a) offer the highest colour rendering, with a small sacrifice in efficacy.

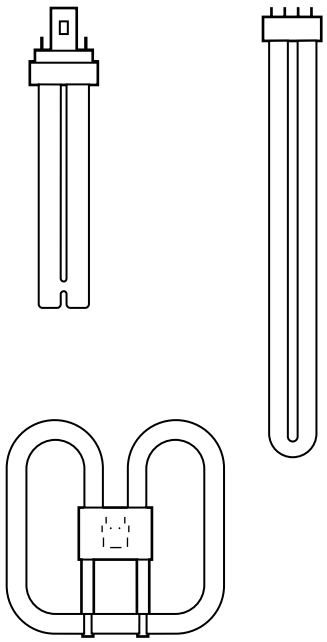
Other phosphors

The halophosphates, Group 3 lamps, are still made, mainly for use in packs of luminaire and lamp. They do not have the favourable characteristics of the triphosphor lamps.

In addition to 'white' lamps, many special fluorescent lamps are available for example for use in aquaria, food display and photocopiers.

Lamp characteristics and applications continued

Compact fluorescent lamps (ILCOS FS)



Compact fluorescent lamps (CFLs) have the characteristics and advantages of linear fluorescent lamps, but with compact size. Lamp designers have been able to fold the discharge path while retaining high efficacy. The phosphors used are triphosphors. New lamps are frequently introduced, and it is essential to consult the catalogues of LIF lamp manufacturers. This Guide explains the variety of CFLs. The two main groups are: CFLs – External Control Gear, and CFLs – Integral Control Gear.

Colour temperature (K) _ 2700–6000K
Colour rendering (CRI) _ 82–98

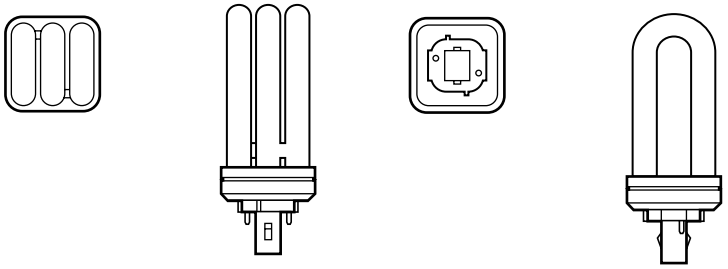
CFLs – External Control Gear

These lamps make possible the design of new compact, energy efficient luminaires. High Frequency control gear is now available integrated into CFL lampholders, making luminaire conversion from GLS to CFL a relatively simple operation.

Two pin lamps have an integral starter, and require a separate ballast. Four pin lamps require separate control gear and starting device, or high frequency control gear. Four pin lamps are normally required for emergency lighting luminaires and where dimming is included.

Various shapes are available. The Table indicates some of them, and shows the relation between prefixes used by LIF lamp manufacturers.

2 limb ILCOS:FSD	**4 limb** ILCOS:FSQ	**6 limb** ILCOS:FSM	ILCOS:FSM	**8 limbed Square** ILCOS:FSS	**L (longer)** ILCOS:FSD
2 pin (with integral starter)					
BIAX S	BIAX D	DULUX T		BIAX 2D ORBIS 2B	
DULUX S	DULUX D	LYNX T			
LYNX S	LYNX D	PL-T			
PL-S	PL-C	TBX			
		BIAX T			
4 pin					
BIAX S/E	BIAX D/E	DULUX T/E	BIAX Q/E		2D 4-pin BIAX L
DULUX S/E	DULUX D/E	LYNX T/E		DULUX F	DULUX L
LYNX S/E	LYNX D/E	PL-T 4-pin		ORBIS 2B	
	LYNX L				
PL-S 4-pin	PL-C 4-pin	BIAX TE			
					PL-L
	DULUX F				



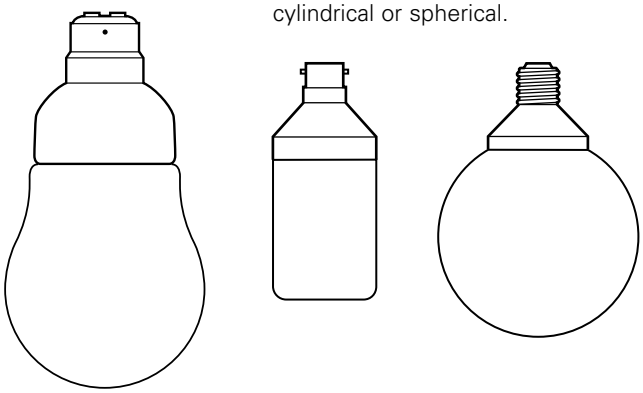
Lamp characteristics and applications continued

CFLs – Integral Control Gear

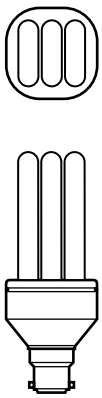
These lamps incorporate control gear and have a normal cap (BC, ES), so that they can be connected direct to the 50Hz mains supply. The control gear is either a conventional 50Hz with starter, or an electronic High Frequency type. The principal application is as energy-saving long-life replacements for GLS filament lamps in suitable luminaires.

Integral 50Hz Control Gear

Lamps with 50Hz control gear usually have an outer diffusing bulb, which is often cylindrical or spherical.



Integral Electronic Control Gear



Lamps with electronic high frequency control gear offer the advantages of reduced size and weight with enhanced higher efficacy, and no mains-related flicker.

The principal types are based on the multi-limb lamps. There is also a circular lamp. Other versions have an outer bulb, and some have an integral reflector.

Lamp characteristics and applications continued

Metal Halide Lamps (ILCOS_M)

OPERATING POSITION	→ Universal (Limited for some types)
CONTROL GEAR	→ Yes
STARTING	→ Run-up
RESTARTING	→ Delay or assisted hot re-strike
COLOUR TEMPERATURE (K)	→ 3,000–10,000
COLOUR RENDERING (CRI)	→ 60–93

These have quartz or sintered alumina (ceramic) arc-tubes. Most lamps have an outer glass bulb. Light output is from mercury and from other metallic elements introduced in the form of halides. Lamps with very low ultra violet output have now been introduced which incorporate UV absorbing quartz. These do not require external UV filters on the luminaires.

Metal halide lamps of the 'protected' type are now available for operation in luminaires without safety screens. Fragments from a shattered lamp are prevented from leaving the luminaire, either by suppressing the violence of the exploding arc-tube by the inclusion of an open-ended quartz tube surrounding the arc-tube, or by using a PTFE coating on the outer bulb to maintain the integrity of the lamp in the event of a shattered arc-tube.

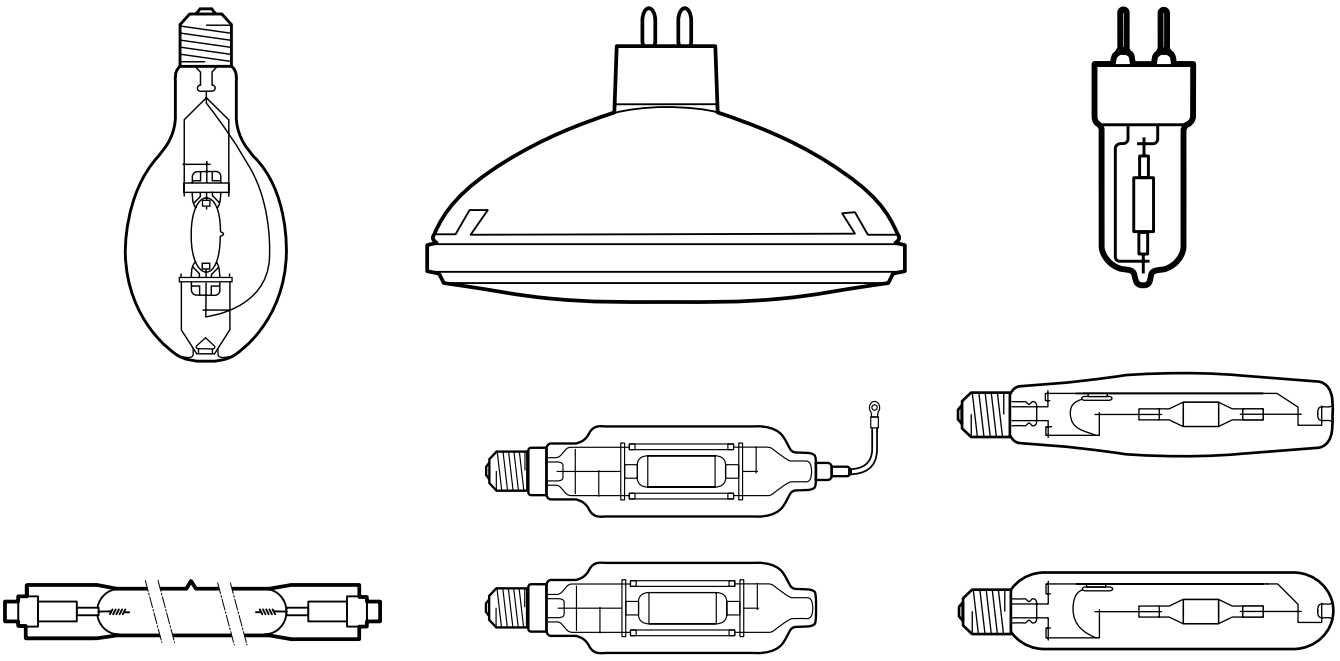
According to the mix of elements, there is a wide range of efficacy and/or colour appearance, but colour rendering is generally good.

Lamps of different makes are not necessarily interchangeable, either visually or electrically. Compatibility between lamp and control gear should always be checked with the individual manufacturers.

Metal halide lamps are mainly used in commercial interiors, industry and floodlighting, as well as for colour TV lighting in stadia and studios. Smaller ratings are used for retail lighting.

Metal halide lamps, which can be retrofitted into high pressure sodium lamps installations, are specifically manufactured to be dimensionally and electrically compatible with the replaced lamp.

'Ceramic' arc-tube metal halide lamps have improved colour stability throughout their life.



Lamp characteristics and applications continued

High Pressure Sodium Lamps (ILCOS S)

OPERATING POSITION	→ Any
CONTROL GEAR	→ Yes
STARTING	→ Run-up
RESTARTING	→ Short delay
COLOUR TEMPERATURE (K)	→ 2000-3000
COLOUR RENDERING	→ 25 Std & Plus 60 Deluxe/Comfort 80 'White' SON

The light is generated by an electrical discharge in a gas containing sodium and mercury (sodium amalgam), contained in a sintered alumina arc-tube.

'Super' or 'Plus' versions, for exterior and industrial applications, have a significant increase in light output and lumen maintenance compared with Standard ILCOS S lamps. SON lamps are used for road lighting, for floodlighting and industrial interior lighting. They also have some commercial applications, e.g., for sports halls and public concourses. Standard versions offer high efficacy and long life.

De Luxe (Comfort) versions have improved colour rendering (CRI 65/Group 2) but give slightly lower light-output.

Mercury-free lamps are available and provide similar performance to equivalent existing standard ILCOS S lamps. Twin arc tube lamps are also available which extend lamp life and provide more rapid hot restarting. However as the arc tubes are off the lamp central axis this may alter the light output and distribution in some luminaires.

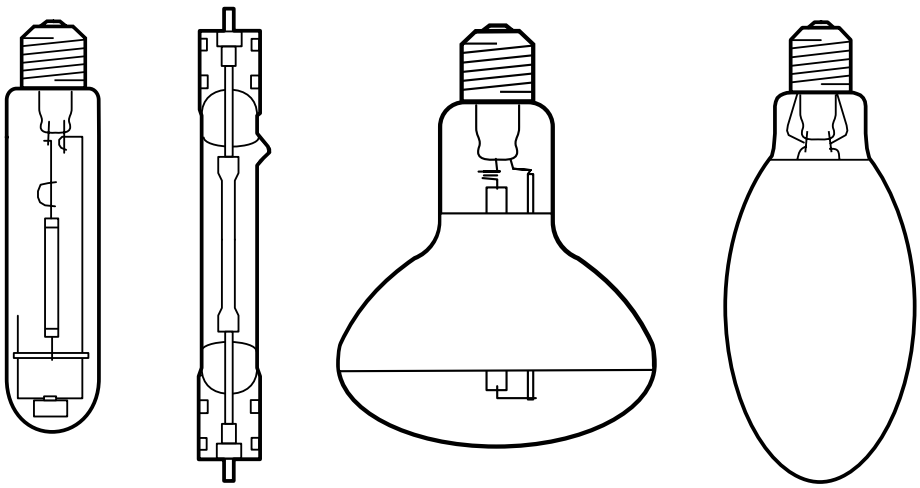
Low wattage ILCOS SM and SH lamps operate at a higher sodium pressure. They are designed for display lighting and have significantly better colour rendering (CRI 85/Group 1B) but with reduced efficacy and life.

Method of starting:

lamps with an internal ignitor are marked 

lamps requiring an external ignition device are marked 

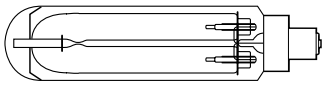
There is also a range of 'plug-in' high pressure sodium lamps designed to replace high pressure mercury lamps with ballasts, which comply with BS EN 60922/923. (Some ballasts may not have adequate insulation between windings.) Small changes may be required to ballast tapping, values of PF capacitor, or to some wiring. Reference should be made to the technical literature of lamp manufacturers.



Lamp characteristics and applications continued

Low Pressure Sodium Lamps (ILCOS L)

OPERATING POSITION	→ Limited
CONTROL GEAR	→ Yes
STARTING	→ Run-up 8–12 mins
RESTARTING	→ Instant – 10 mins
COLOUR TEMPERATURE (K)	→ 1800
COLOUR RENDERING	→ Not applicable



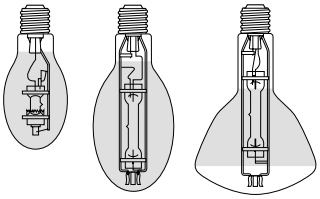
These lamps consist of a U tube containing the discharge and an outer heat-reflecting jacket. The light is concentrated in the yellow part of the visible spectrum. This is close to the maximum sensitivity of the human eye at normal lighting levels, and the efficacy is the highest of all lamp types but with very poor colour rendering. These lamps are mainly used for exterior applications such as road lighting and security lighting.

At low lighting levels such as secondary road lighting the eye response changes and the use of white light sources is replacing SOX lamps particularly in amenity areas and pedestrianised shopping centres.

SOX-E lamps give improved efficacy with lower power consumption and SOX-PLUS lamps have a longer life. SOX-E and SOX-PLUS lamps give optimum performance only when used with appropriate control gear.

High Pressure Mercury Lamps (ILCOS Q)

OPERATING POSITION	→ Any
CONTROL GEAR	→ Yes
STARTING	→ Run-up 2–5 mins
RESTARTING	→ 4–7 mins
COLOUR TEMPERATURE (K)	→ 3300-3800
COLOUR RENDERING	→ 42– 52



The high pressure mercury discharge operates in a quartz arc tube. MBF(HPL-N, HQL) lamps have an outer ellipsoidal bulb with an internal phosphor coating, which improves the colour rendering. MBFR (HPL-R, HQL-R) lamps have a shaped outer bulb with an internal reflector coating.

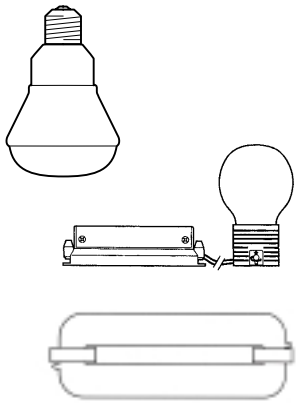
Mercury lamps were used for illuminating road signs and industrial lighting but have largely been replaced by more efficient lamps now available.

De Luxe versions with improved colour rendering have a special phosphor coating.

Mercury lamps offer low cost discharge lighting where high efficacy is not important. The lamps incorporate a third electrode for starting and so the control gear to operate mercury lamps is only a ballast and power factor correction capacitor. No external ignitor is required.

Note: MBTF (ML,HWL) is a mercury discharge tube connected in series with a tungsten filament in the same outer bulb: external control gear not required.

Induction Lamps



Induction is a process whereby the generated power is passed from one circuit to another without the use of physical electrical conductors. This is the principle for transformers and radio receivers. It does enable lamps to be constructed without the need for wire connections to pass through the glass or quartz envelope. This simplifies construction and extends lamp life.

Induction lamps are available as low pressure mercury lamps using the same triphosphor coating of the inner bulb surface. Low wattage versions use integral control gear but the higher power ratings have external control gear. There is also a high pressure discharge induction lamp, which uses sulphur vapour.

As the commercially available range is limited and diverse a summary of typical operating characteristics has not been included.

Lamp characteristics and applications continued

Light Emitting Diodes (LEDs)

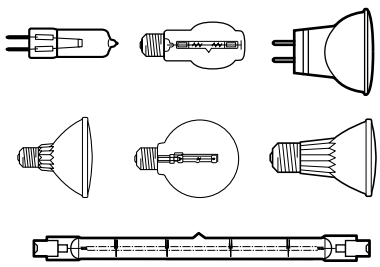
OPERATING POSITION	→ Any
CONTROL GEAR	→ Yes
STARTING	→ Instant
RESTARTING	→ Instant
COLOUR TEMPERATURE (K)	→ Wide range
COLOUR RENDERING	→ Wide range

This lighting product has been used for indicating purposes for several decades. Recent development has created larger diodes and extended the range of colours available including white. Also there is a dramatic increase in efficacy predicted by the lamp manufacturers over the next few years.

LEDs are being used for the general and decorative lighting of buildings. Arrays of LEDs mounted on a printed circuit board can be considered as the 'lamp' part of the luminaire. However LEDs have an extremely long life and are likely to be built into the luminaire as an integral part and not intended to be replaced. Consequently they will probably not exist as a consumable item for the end user.

Filament lamps (Tungsten Halogen)

OPERATING POSITION	→ Various
CONTROL GEAR	→ Transformer for ELV lamps
STARTING	→ Instant
RESTARTING	→ Instant
COLOUR TEMPERATURE (K)	→ 3000–3400
COLOUR RENDERING (CRI)	→ 100



These are filament lamps with a halogen (added to the gas filling), which prevents evaporated tungsten blackening the bulb. Tungsten Halogen lamps have an increased light output and/or extended life compared with standard filament lamps. The bulb is of small dimensions, and made from quartz or hard glass. Some mains voltage lamps have an outer bulb.

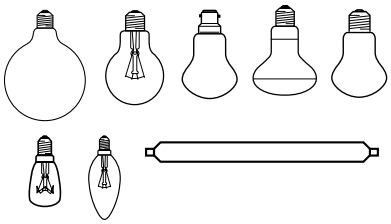
Manufacturers clearly mark tungsten halogen lamps where dosed quartz has been used to reduce UV emissions. Similarly lamps that are suitable for use in luminaires without safety screen will be marked. Otherwise tungsten halogen lamps should only be used in suitably enclosed luminaires.

Mains voltage lamps for small floodlights are usually linear format with contacts at each end. Single-ended lamps have applications as for GLS lamps. PAR Halogen lamps have internal reflectors.

ELV (Extra-Low-Voltage) lamps are more compact than their mains voltage counterparts and the small filament size improves the optical efficiency of integral or external reflectors. ELV reflector lamps make possible compact luminaires for display lighting. A range of beam intensities and widths is available for lamps of the same size. ELV lamps are operated via a transformer from the mains supply.

Filament lamps (GLS and Reflector)

OPERATING POSITION	→ Any
CONTROL GEAR	→ No
STARTING	→ Instant
RESTARTING	→ Instant
COLOUR TEMPERATURE (K)	→ 2500–2700
COLOUR RENDERING (CRI)	→ 100



There are many types of filament lamp. The most common are known as General Lighting Service (GLS) and Decorative (e.g. candle lamps). Their finish – clear, diffuse or coloured – is often a significant factor in their application. Reflector lamps either blown bulb or PAR are similar to GLS lamps but have a bulb with an internal reflector coating. Replacements should normally be of the same type as originally used unless it is desired to change the beam intensity and width. Crown-silvered lamps are intended to be used in conjunction with a metal reflector as part of the luminaire.

Advantages: Low cost, simple operation and good colour rendering.

Disadvantages: Low efficacy and relatively short life.

Note: Some suppliers offer extended life GLS lamps e.g. 16 times normal life is claimed. These lamps are approximately half the efficacy of standard-life GLS lamps, which means they give only half the light output for the same power consumption.

Filament lamps are mainly used for domestic and display lighting.

High Frequency (HF) operation of fluorescent lamps

High frequency operation of all types of modern fluorescent lamps, whether single capped, double capped or CFLs with integral control gear has now become more prevalent. Energy efficiency schemes and legislation, both in Europe and North America, are requiring elimination of the old 50Hz control gear. Operating fluorescent lamps at high frequency (i.e. typically at and above 30 kHz) enables losses in the lamp and control gear to be reduced.

This gain in overall efficiency can be utilised to provide either lower power consumption for the same light output or additional light output for the same power input (compared to 50Hz control gear). Normally the choice is to reduce power for the same light output. Figure 4 illustrates the increase of lumen output for constant power into the lamp, as frequency increases from the normal 50 Hz value.

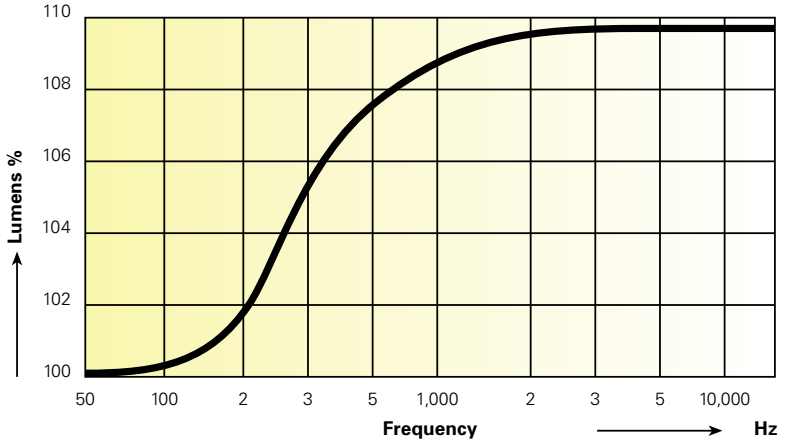


Fig 4 Light output as a function of frequency (with constant lamp power).

High frequency control gear provides silent operation, improved comfort from the reduction in flicker and ease of dimming control in addition the economic and ecological benefits.

16 mm diameter T5 fluorescent tubes are designed to operate only from dedicated high frequency electronic control gear. Both krypton filled and argon filled 26mm diameter T8 fluorescent lamps can be operated on HF control gear, the former at reduced wattage from their marked value. Some 4-pin capped Compact Fluorescent Lamps also can be operated on appropriate HF ballasts. Other CFLs have integral HF ballast, but note that 2-pin CFLs should not be used with HF control gear unless specific instructions to do so are given by the manufacturer. For lamp compatibility, it is essential to follow the instructions supplied with HF ballasts and HF luminaires.

High Frequency Regulation (HFR)

Lamps in HFR circuits can be regulated in power and light output. In addition to the basic HF advantages HFR offers: individual control of local light output, quick adaptation of lighting to changes in use of an area, programmed illuminances in shops, and economy by linking artificial lighting with daylight.

The relation between lamp power and light output is almost linear. There is little shift in colour appearance over the regulated range. Regulation may also be used for theatrical effect ('dimming'), e.g. in restaurants.

Induction Fluorescent Lamps ('Electrodeless Lamps')

Many of these lamps operate at radio frequencies in the ISM* band, but other frequencies around 200kHz are also used. Because of induction the lamps have no electrodes and the service period is very long compared to other fluorescent lamps. Both separately ballasted and integrally ballasted types have been developed and utilise triphosphors for good colour rendering and maintenance of luminous flux.

*ISM = Industrial Scientific and Medical.

Lamps and the environment

The energy issue

The lighting industry is acutely aware of its responsibility to develop lamps which are environmentally sound. The continued success of efforts to provide ever increasing efficacy (see graph on page 3) have resulted in a corresponding reduction in fossil fuel consumed through electricity generation at power stations.

The penetration of energy efficient lamps into the domestic marketplace was limited by cost and size concerns, however, the industry is now overcoming these problems with the introduction of lower priced, GLS size and shape, compact fluorescent lamps. It is estimated that, in the UK alone, a change to CFLs in suitable applications would produce a reduction of 5 Megatonnes of carbon dioxide (greenhouse gas) released into the atmosphere per year. There would also be reduction of 74 tonnes of sulphur dioxide (which creates acid rain) and 22 tonnes of nitrogen oxides (responsible for bronchial problems).

CE Marking and Energy Labelling

CE marking on lamp packaging indicates that the product meets the requirements of:

1. Low Voltage Directive for Electrical Safety (73/23/EEC as amended by 93/68/EEC).
2. EMC Directive for electromagnetic compatibility(89/336/EEC as amended by 92/31/EEC).
3. For household lamps – Energy Labelling directive (98/11/EU).

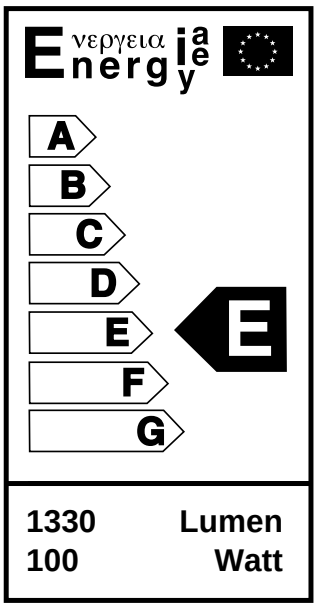
House hold lamps are classified as:

- Filament lamps (GLS and tungsten halogen)
- Fluorescent tubes
- CFLs for use with external control gear
- CFLs with integral control gear

The Labelling Directive does not apply to:

- Lamps with a light output in excess of 6500 lm
- Lamps with an input power of less than 4W
- Reflector lamps
- Lamps operated from batteries
- Lamps not primarily for illumination

The lamps within the scope of the Energy Labelling Directive have to include an energy efficiency classification graded A to G with A being the most efficient. This format is also applied to other electrical domestic products.



Energy Efficiency Classification	Typical Lamp types
A or B	Fluorescent tubes and CFLs
C or D	Tungsten halogen
E	GLS (25W – 200W)
E or F	Candle lamps
G	Striplights

Lamps and the environment continued

Atmospheric pollution

Every kWh of electrical energy saved prevents the release of 0.7kg of carbon dioxide into the atmosphere. In addition, there are reduced emissions of gases such as sulphur and nitrogen oxides which contribute to 'acid rain'.

The saving of 7 TWh of electrical energy per year corresponds to a reduction in mercury emissions from power stations, as a result of burning less fossil fuel, of approximately 200kg per year. This is over 3 times the amount of mercury contained in the energy efficient light sources used.

Sky-glow pollution

Skyward light wastes energy and affects astronomical observations and appreciation of the night sky. LIF leads the call for luminaires and lighting installations that make good use of the output of lamps, and put light where it is required. For roadway lighting, less obtrusive light can be achieved by using high pressure sodium lamps in place of low pressure sodium lamps. This is due to the better optical control possible from the more compact arc tube.

Material use efficiency

Over the years, lamp manufacturers have been able to progressively reduce the amount of materials used and also increase the service lives of lamps. This reduces the requirement for the non-renewable materials used in lamp construction. In the case of tungsten, the introduction of long-life CFLs has reduced the requirement for tungsten filaments for short-life GLS lamps.

Recycling of lamp materials is explained in LIF Technical Statement No 10

Packaging

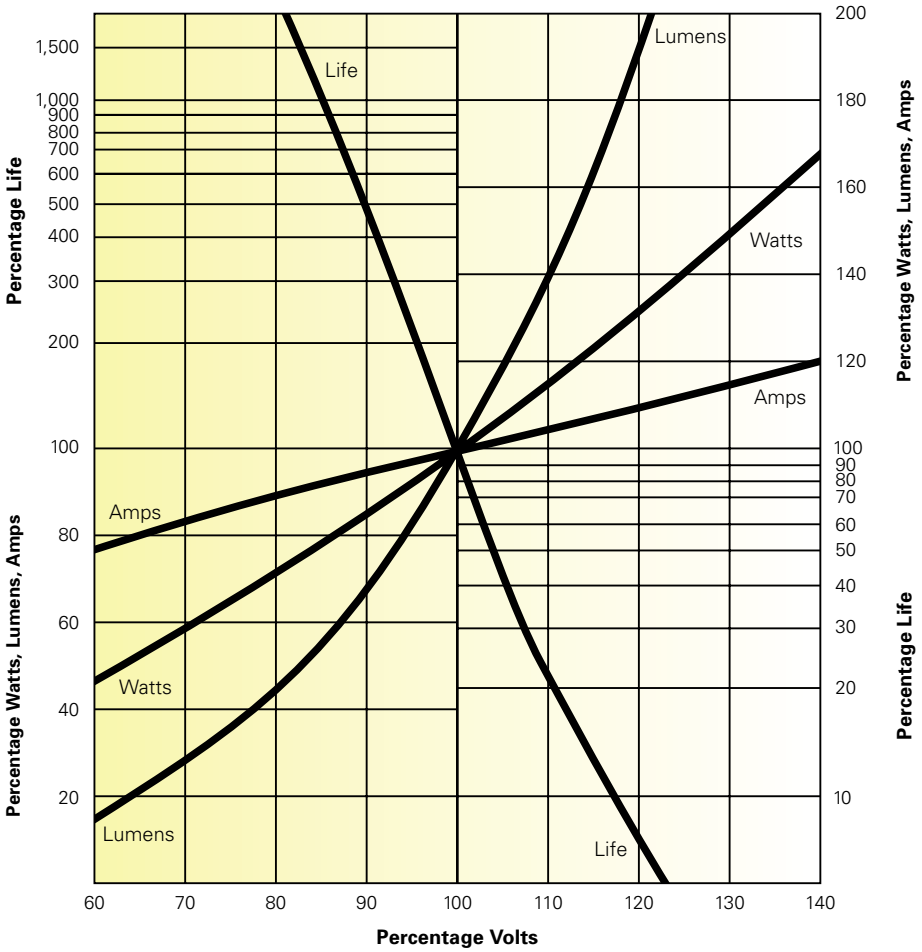
LIF lamp manufacturers design product packaging which minimises the use of materials consistent with protection of the product and safe handling. Recycled packaging materials are used in packaging design whenever possible.

Material sensitive to the environment

The element of principal public concern is mercury, an essential constituent of most discharge lamps. Lamp manufacturers have progressively reduced the quantity of mercury in fluorescent lamps, and a 90% reduction in quantity has been achieved over the last 20 years. Cadmium was eliminated from fluorescent lamps in the early 1980s.

Useful lamp data

Fig 5 The graph shows the effect of changes in the supply voltage on GLS filament and tungsten halogen lamps. For example, a supply voltage 5% higher than nominal reduces lamp life by 60%



Lamps and Power

All the input electrical power to a lamp is transformed into other forms of power, proportioned in terms of total lamp power as follows:

	% Radiant power			% Heat
Lamp type	**Light**	**Infrared**	**Ultraviolet**	**Conducted/Convected**
GLS	9	84	<0.1	7
Tungsten Halogen	13	79	0.1	8
Fluorescent tube	25	35	0.4	40
HP Sodium	30	47	0.3	23
LP Sodium	26	44	0	30
Mercury	14	49	2.0	35
Metal Halide	20	50	3	27
Daylight(6500K)	53	42	5	0

Notes:
1 Light is radiant energy of wavelengths visible to the human eye. It must be included in heat loading calculations.
2 The power loss of ballasts should be added to the conducted/convected heat.

Useful lamp data continued

Fig 6 Switching frequency and electrical life of fluorescent lamps.

Note this curve is for switch start circuits. Modern High Frequency circuits which provide preheating will reduce the effect of switching upon lamp life.

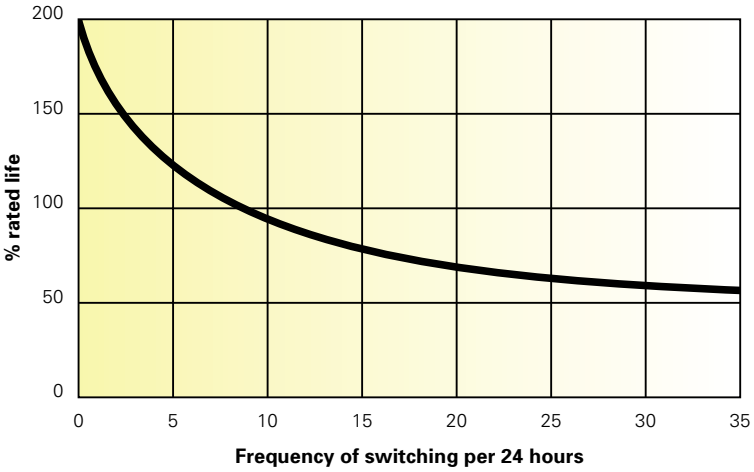
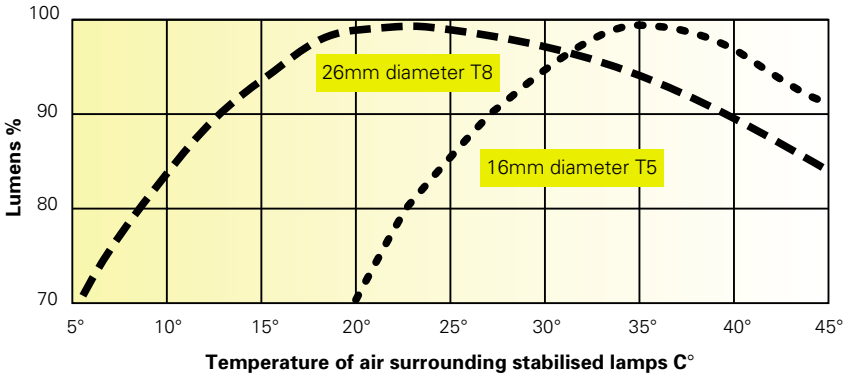


Fig 7 Variation of light output with air temperature for fluorescent lamps.



Lighting quantities and units

Quantity	Quantity symbol	Unit	Unit symbol
Luminous Intensity	I	Candela	cd
Luminous Flux	ϕ	Lumen	lm
Illuminance	E	Lux	lx
Luminance	L	Candela per sq. metre	Cd/m^2
Luminous Efficacy	η	Lumen per Watt	Lm/W

Notes:
ϕ is the Greek letter *phi* (pronounced fie).
η is the Greek letter *eta* (pronounced eeta).

Lamp service period

When applied to electric lamps the word 'life' has two distinct meanings and the term 'service period' is preferred:

1 the time after which lamps cease to operate

2 The time after which the light output is reduced, by normal deterioration, when it may be economic to replace lamps, even though still operating electrically.

Filament lamps

The **first** definition of 'life' applies.

The rated life of common types under specified conditions is defined in international standards and is accepted as a practical survival/efficacy compromise. The depreciation of light output is small. Fig 8 shows a typical survivor curve for a group of filament lamps operated under standard test conditions. (Life expectancy in a practical installation is affected by heat, vibration and supply voltage variations: see Fig 5).

It should be noted that 'rated life' applies to a group and not to individual lamps, and represents the 50% survivor point. Lamps failing earlier are balanced by lamps failing later.

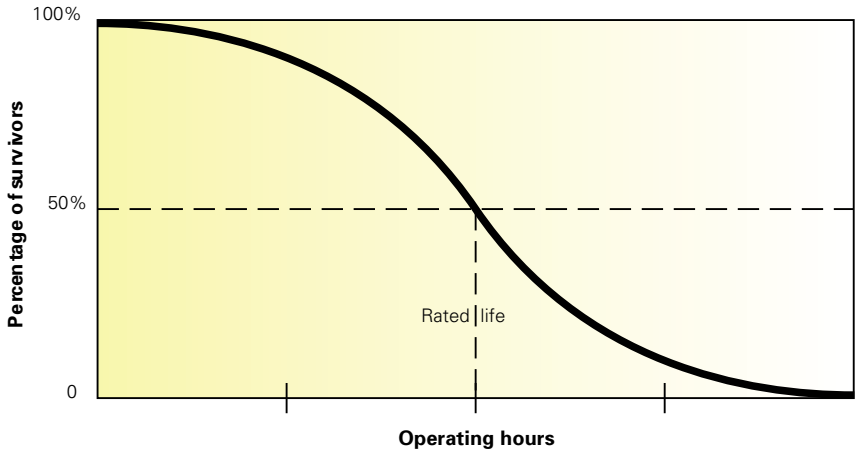


Fig 8 Typical survivor curve for filament lamps.

Discharge and fluorescent lamps

The **second** definition of 'life' applies.

Present day discharge lamps and fluorescent lamps will survive for many thousands of hours, but during that time the light output steadily depreciates, so that if lamps were operated until electrical failure, the light output could be half or less of what it was initially. In practice, discharge lamps and fluorescent lamps should be group changed at the most economic time.

Recent developments in lamp and phosphor design have yielded greater lives, together with superior lumen maintenance. Refer to LIF lamp manufacturers' literature for full details.

Planned lamp replacement

In all but the smallest installations it is sensible to replace discharge lamps and fluorescent lamps as a group at planned intervals. The advantages of planned replacement are as follows:

1. Labour costs can be reduced by phasing the replacement cycle to fit the cleaning cycle.

2. When there would be an interruption to a production process, replacement can be planned for a non-production period.

3. Lamps will be of matching output and colour initially and over the service period, and will be of the latest technology.

4. Replacing lamps before electrical wear-out reduces the possibility of failure of control gear.

5. For design to economic planned maintenance (see latest Society of Light and Lighting Code), fewer lighting points may be required.

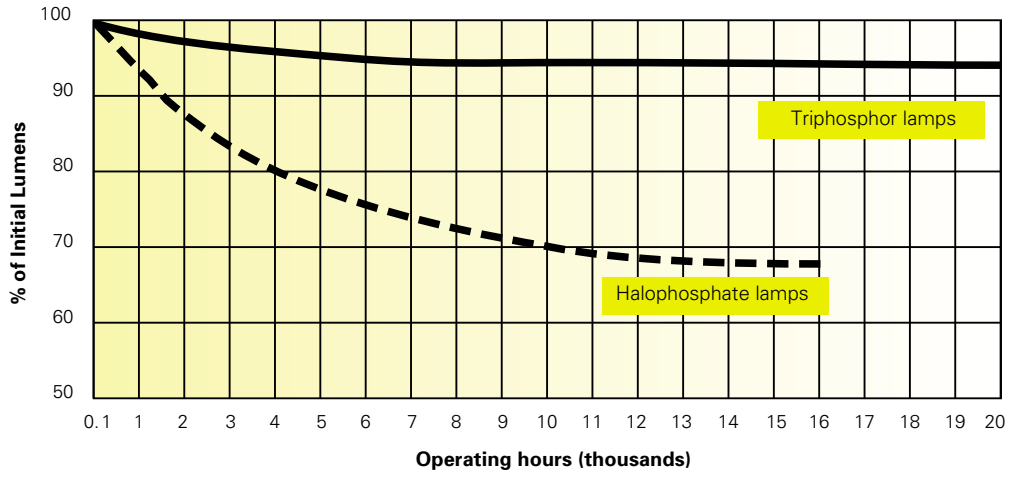
For many installations the most **economic** time for group replacement is when the light output of the lamps has fallen below 80% of the initial value and the lamp failures are becoming significant in the loss of average illuminance. The **latest** time for group replacement is when the designed 'maintained illuminance' has been reached.

If 'spot' replacement of individual lamps is used instead of planned bulk replacement, then it is likely that lumen depreciation, except from lamps with good lumen maintenance, may result in low installation efficacy and unacceptable lighting levels.

Modern lamps however such as the new generation of triphosphor T5 and T8 tubes has excellent lumen maintenance, so the maintenance schedule for the installation is likely to be determined by the luminaire depreciation rather than a reduction in lamp lumens.

Fig.9 shows a typical curve of depreciation of light output of a group of fluorescent lamps under standard test conditions. (Depreciation in practical installations is usually faster). The rate varies with lamp type, rating and colour. Reference should be made to the technical literature of LIF lamp manufacturers.

Fig 9 Typical lumen depreciation curve for fluorescent lamps.



Note to Fig 8 and Fig 9:

Curves for proprietary lamps may add a tolerance band, to represent spread over production groups.

Questions and answers

Here are brief answers to some of the more common questions asked about lamps.

Q Is GLS lamp life affected by switching rate?

A Life is tested with one switching per 12 hours. One switching per hour reduces life about 1%.

Q What is the effect of switching frequency on the electrical life of linear fluorescent lamps?

A A guide to this effect is shown in Fig 6, p.24. With electronic circuits those including preheating will extend lamp life but those with 'cold start will not.

Q Is there high energy consumption at switch-on of fluorescent and discharge lamps?

A The energy taken during starting is a small fraction of the energy taken during one minute's operation. Current taken is usually higher than during operation. There can be a high transient current where capacitors are across the supply.

Q Should tungsten halogen lamps be dimmed?

A Life will not usually be affected, but the extra efficacy of the halogen lamp will be lost during dimming. If lamps are rarely operated at full light output, blackening can develop earlier than usual, and could be unacceptable. Blackening can be removed by operating the lamps at full power for a short period.

Q Will high pressure discharge lamps go out if the supply voltage drops?

A A transient drop may put out the lamp, which must then cool before restarting. A slow decline in supply voltage (say down to 85%) can usually be tolerated. There are twin arc tube lamp types and hot restrike ignitor systems that can minimise 'lamp out' time. Modern electronic circuits can compensate for variations in supply voltage and supply constant lamp operating conditions.

Q Should 'energy limiters' (supply voltage reducers) be used?

A Lamp life, starting, and operation may be impaired. Lamp replacement arrangements may be annulled. In some instances these devices can render equipment unsafe. LIF strongly recommends that energy should not be saved by reducing lighting levels, but by the selection of more efficient lamps and equipment, or by engineered regulation of output.

Q Is there a high level of UV from unenclosed tungsten, fluorescent or discharge lamps?

A Even at 1000 lux, UV levels are lower than outside on an average day. Observe any special instructions supplied with these lamps. Lamp standards have been amended to include maximum allowable UV output of relevant lamps and UV block lamp types have been developed. Special consideration should be given to display situations where delicate materials are exposed to high lighting levels e.g. retail clothing displays or museums and art galleries.

Q Why replace existing T12 tubes with triphosphor T8 lamps rather than the less expensive halophosphate T8 versions?

A Although both will provide approximately 10% energy saving, the triphosphor tube will give about 12% more light and greatly improved colour rendition. Combined with excellent lumen maintenance, the service life of the triphosphor tubes can be almost twice that of the halophosphate tubes, virtually halving annual lamp replacement and maintenance costs, which will more than offset the extra cost of the triphosphor tubes.

Q Why do T5 tubes give their maximum light output at 35°C instead of the normal 25°C for other fluorescent tubes?

A Because the ambient temperature in the new smaller enclosed T5 luminaires is closer to 35°C. If the maximum light output was at 25°C it would be necessary to design larger luminaires and not exploit the opportunities offered by the physical reduction of T5 tubes.

Q What are amalgam CFLs and what are their advantages?

A The lamps use an alloy of mercury instead of pure mercury. The amalgam enables a relatively constant mercury vapour pressure over a wide temperature range and thus maximum light output. This offers flexibility in luminaire design and acceptable environmental conditions.
Amalgam CFLs emit 90% or more lumens in 5°C to 65°C ambient temperatures. Mercury CFLs only emit 90% or more lumens in 20°C to 45°C ambient temperatures.

Q Can T12 tubes be operated on high frequency ballasts?

A It is possible to operate some T12 tubes on HF ballasts designed for T8 lamps. However this is not recommended as the T12 lamps will only operate at a reduced light output.

Q Why do metal halide lamps shift in colour in use and can it be prevented?

A Low supply voltage or incorrect ballast tapping can under power the lamp and produce a noticeable colour shift. Also there is a slow diffusion by some of the metals through the quartz arc tube, changing the metallic mixture and hence the colour of the lamp. This problem has been over come by making arc tube from polycrystalline alumina which prevent diffusion losses and ensures colours stability throughout life.

Useful information

LIF Technical Statements

Number	Title
2 Issue 6	Fluorescent lighting & short switch periods
3 Issue 6	Energy limiter & tubular fluorescent lamps
4 Issue 7	Gas discharge lamps & the environment
6 Issue 9	Precautions against ultraviolet radiation from tungsten halogen lamps
7 Issue 6	Precautions against ultraviolet radiation from HID lamps
8 Issue 6	UV radiation & health
9 Issue 8	Precautions against infrared radiation from halogen heat lamps
10 Issue 8	COSHH Regulations 1988, Health & Safety at Work Act 1974, and disposal of lamps
11 Issue 4	Compact fluorescent lamps, power factor and harmonic content
16 Issue 2	Compact fluorescent lamps and infrared remote control systems
17 Issue 2	Use of PIR detectors with electronic ballasts and fluorescent lamps

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