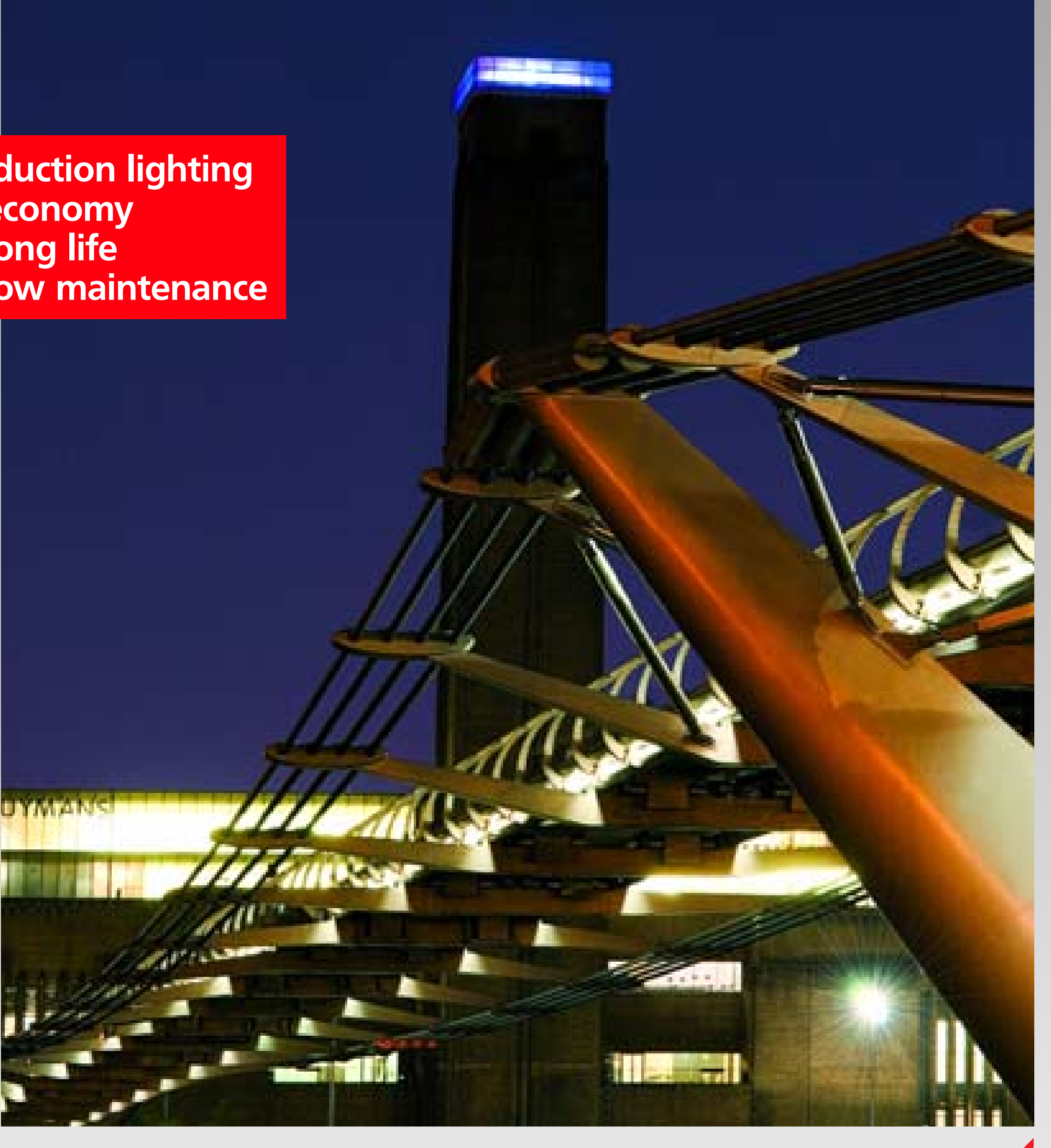
LICHT FORUM

Specialist periodical for lighting

49



Induction lighting
• economy
• long life
• low maintenance

www.licht.de

Fördergemeinschaft Gutes Licht

1

60,000 hours induction lighting

Cover photograph: Visible from afar, the chimney lighting of the Tate Modern makes the modern art showcase a landmark of London at night. The Tate Gallery's celebrated new base – opened in 1996 – was formerly a power station. 32 (ring-shaped) induction lamps were used; the chimney rises 99 metres into the air. Since induction lamps have a service life of 60,000 operating hours, no lamp replacement will be necessary for a number of years

Incandescent lamps – first made on an industrial scale in 1879 – are the oldest electrical light source. Although still in widespread use today, they have been replaced for many applications by lamps with a much better energy balance and a considerably longer service life: low-pressure gas discharge lamps. These come in the form of linear three-band fluorescent lamps, compact fluorescent lamps – and induction lamps.

Induction lamps have many advantages (see "Induction lighting offers high lighting quality" and "Induction lamps guarantee efficient operation"). They can be summarised as:

- properties which enhance visual comfort
- energy-saving lamp operation and
- a service life of 60,000 operating hours.

Induction lighting applications

These advantages make induction lamps suitable for nearly any application, especially where lamp replacement is difficult and expensive – e.g. in factory bays or on tall lighting columns.

Examples of **interior lighting** applications include manufacturing bays, sports halls, indoor swimming pools, railway station concourses, entrance halls and large salesrooms.

In **exterior lighting**, the most important applications for these long-life energy-efficient lamps are roofs – e.g. over filling station facilities – streets and façades.

And then there are the numerous **special applications** for which induction lamps are the solution of choice: tunnels, mines, oil rigs, elevated displays …

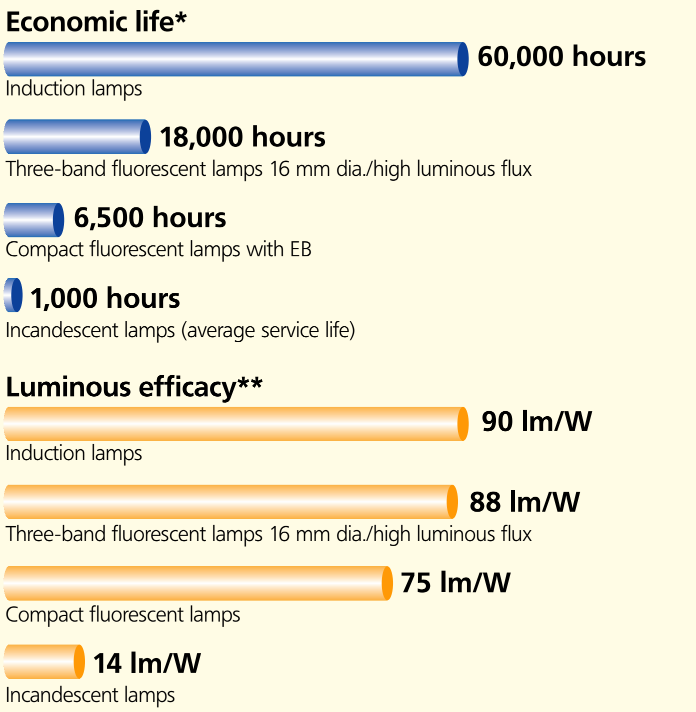
Economical lighting

Lighting costs are made up of capital costs (acquisition, installation) and operating costs, which can be subdivided into maintenance (lamp replacement, servicing) and energy. Acquisition and maintenance each account for 25 percent of these overall expenses. The rest – i.e. half of the total cost – is due to the energy consumed by the lighting.

Obviously, lower energy consumption – meaning high luminous efficacy – as well as a long service life and very low maintenance costs considerably reduce the burden of expense. As induction lamps combine all these characteristics, they are a very economical light source.

What cannot be readily quantified in euros and cents are the enhanced lighting quality and comfort obtained where induction lighting is used: good quality of light, non-flicker instant starting, flicker-free lighting, dimming control and automatic shutdown in the event of lamp failure.

Induction lamps are suitable for nearly any application, e.g. foyers (Photo 1), manufacturing bays (2), indoor swimming pools (3), salesrooms (4), façade lighting (5) … They are particularly recommended where lamp replacement is difficult and expensive.



* Economic life is the length of time for which the lighting system delivers at least 70% of its initial luminous flux. Please note: in the case of fluorescent lamps, the basis used for measuring economic life is normally 80%. The same basis is used here.

** Maximum luminous efficacy of lamps in lumens/watt (lm/W)

Fig. 1

Induction lighting offers high lighting quality

- Very good light quality: colour rendering index $R_a \geq 80$.
- Range of light colours: warm white (2,700 degrees Kelvin (K), 3,000 K) and neutral white (4,000 K).
- Non-flicker instant start.
- Rapid re-ignition: under 0.2 seconds.
- Flicker-free lighting: easy on the eyes, no strobe effect e.g. where rapidly rotating machine parts are present
- Dimming control: 100 to 30 percent with appropriate EB (ring-shaped lamps only).
- Automatic shutdown in the event of lamp failure.

Induction lamps guarantee efficient operation

- High luminous efficacy: system luminous efficacy up to 80 lm/W.
- 60,000 hours economic life = just under 7 years of maintained operation.
- Slow reduction of luminous flux over the entire service life.
- Over 85 percent luminous flux over a wide operating temperature range (amalgam temperature) of 55°C to 125°C.
- Any burning position (except ring-shaped lamps in vertical or inclined positions): connection side must face downwards).
- High degree of protection against switching voltages.
- DC voltage operation possible, thus suitable for emergency lighting.


2


3


4

5

Photo 6: Maintained lighting in an airport building, a typical application for induction lighting.

Electrodeless induction lamps

The principles involved in generating light by electromagnetic induction of gas discharge were explained by contemporaries of Edison (1847 to 1931) (see "Nearly 100 years on the road to market"). But it is only now that we have reliable electronics to control the process, only now that electronic ballasts (EBs) for induction lamps are available at competitive prices.

Discharge lamps generate light when a current passes through ionised gas or metal vapour (electric discharge). Depending on the type of gas in the discharge vessel, either visible light is emitted directly or UV radiation is produced in the glass bulb and converted into visible light by a luminescent coating on the inside of the bulb. A distinction is made between low-pressure and high-pressure discharge lamps, depending on the operating pressure in the bulb.

Low-pressure discharge

Fluorescent lamps and induction lamps contain low-pressure mercury vapour. In each case, UV radiation is converted into visible light by an identical fluorescent coating. In order to produce the gas discharge, both lamps require a constant flow of electrons (current flow). Where the technologies differ is in the way the electrons are produced:

- In fluorescent lamps (see Fig. 3) the electrons are produced in two electrodes made from tungsten wire (discharge path).
- In induction lamps, the gas discharge is induced into the lamp by electromagnetic fields.

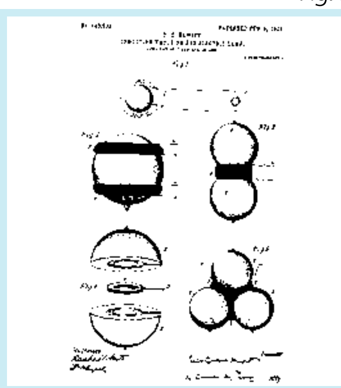
The term "electrodeless induction lamp" highlights this crucial difference. Because induction lamps have no electrodes or other parts which are subject to wear, such as heating coils, they have an extremely long service life of up to 60,000 hours.

Nearly 100 years on the road to market

The history of the induction lamp stretches back to 1891. That was the year in which Nikola Tesla presented his "wireless light" in New York. The first patent (Fig. 2) for an induction lamp was issued in 1907 and was taken out by the US electrical engineer P. C. Hewitt. The theoretical basis on which today's induction lamps work was developed by J. J. Thomson (publication in1927), who drew on the research findings of W. Hittorf (1884). Other pioneers in the field included J. Bethenod and A. Claude (US patent 1936) and J. M. Anderson (US patent 1970).

Despite the advances in science, it took nearly 100 years for the first induction lamps to come onto the market. What paved the way were reliable electronics and a manufacturing process that enabled the long-life lamps to be produced at competitive prices.

Fig. 2



Lamp + EB form a system
Induction lamps work only with the electronic ballasts (EBs) specifically designed for them. Lamp and ballast together form a system. The EB delivers the high-frequency current, produces the required ignition voltage and limits the lamp current after ignition.

Since the actual lamp has no components which are subject to wear, any premature failure of an induction lamp is due to the EB. The failure rate of quality EBs, however, is extremely low.

60,000 hours service life
Although lamps rarely fail, their service life is nevertheless limited – by the decline in luminous flux that is inevitable due to soiling of the lamp bulb. After 60,000 operating hours – that means nearly seven years of maintained operation or 14 years of half-day operation – the luminous flux of an induction lamp is around 30 percent lower than when it was new.

Like any other spent discharge lamps, induction lamps should be disposed of after use as special waste. Information on recycling is available from the AGLV, the lamp recycling working group of the German Electrical and Electronic Manufacturers' Association (ZVEI), at www.lampen-recycling.de. From August 2005, the legal framework for waste disposal in Germany will be defined by the Electrical and Electronic Equipment Act (ElektroG). Information on the subject is available in German at www.altgeraete.org.

Adequate radio interference suppression
High-frequency electromagnetic energy that is beamed through the air or transmitted by cable can interfere with other electrical appliances. The requirements that need to be met to limit interference emissions and ensure that appliances possess adequate immunity are set out in regulations and standards, including the EMC Directive (Electromagnetic Compatibility) and DIN EN standards 55015, 61000-3-2, 61000-3-3 and 61547.

Because they are designed for high-frequency operation, induction lamps can, in theory, cause radio interference. In the finely tuned system of lamp, luminaire and ballast, however, filter and housing form a shield which keeps the interference emitted at an admissible level. It is important to note, however, that only quality lamps in quality luminaires ensure that emissions really are within the permitted limits.

Ring-shaped or bulb-shaped
Most induction lamps come in one of two basic designs:
- flattened ring design, external electromagnetic induction, operating frequency 250 kHz.
- ellipsoid bulb design, internal electromagnetic induction, operating frequency 2.65 MHz.


7


8

Photo 7: Ring-shaped induction lamp with electronic ballast (EB).

Photo 8: Bulb-shaped induction lamp with EB.

How a fluorescent lamp works
When current flows, electrons pass from two tungsten-wire electrodes into a discharge tube filled with low-pressure mercury vapour. Here, the electrons collide with the mercury atoms and energize an electron in each one. The impact energy absorbed is then emitted in the form of UV radiation, which is converted into visible light by the fluorescent coating on the inside of the glass bulb.

Fig. 3

9

10

The ring-shaped induction lamp

The close-loop style discharge tube of the ring-shaped lamp is filled with low-pressure mercury vapour for the electric discharge. It runs through the central axis of one or more magnetic ferrite ring cores.

The electrical power for the discharge is induced from outside by first applying a sinusoidal AC voltage to the induction coils of the ferrite ring cores. The magnetic fields thus induced produce voltage along the tube. The principle is similar to that of a transformer, with the ferrite ring cores acting as the primary winding and the discharge tube as the secondary.

The actual production of light occurs in the same way as in three-band fluorescent lamps (see Page 5): the electrons – as described above – are accelerated by external induction and collide with mercury atoms. On impact, free electrons in the mercury are energized and emit the energy absorbed in the form of UV radiation. The fluorescent coating on the inside of the tube converts the UV radiation into visible light.

The electronic ballast (EB) specifically designed for use with the ring-shaped lamp in question converts the mains (50/60 Hz) or battery current into 250 kHz high-frequency voltage. It also reduces the high ignition voltage from approximately 1,000 volts after ignition to the 170 - 200 V operating voltage required to operate the lamp.

Ring-shaped induction lamps in use: manufacturing bay (Photo 9), Alexanderplatz underground station in Berlin (Photo 10), high-bay warehouse (Photo 11), library (Photo 12), works entrance checkpoint (Photo 13), car showroom (Photo 14).

Performance data: ring-shaped lamp

Table 1

Lamp type in Watts (W)	Power rating of the system / lamp in the system in W	Luminous flux in lumens (lm)	Luminous efficacy of the lamp in lm/W	Luminous efficacy of the system in lm/W	Light colour in degrees Kelvin (K)	Colour rendering index R_a
70	82/72	6.500	90	80	3.000 (ww), 4.000 (nw)	≥ 80
100	107/96	8.000	83	75	3.000 (ww), 4.000 (nw)	≥ 80
150	153/144	12.000	83	78	3.000 (ww), 4.000 (nw)	≥ 80

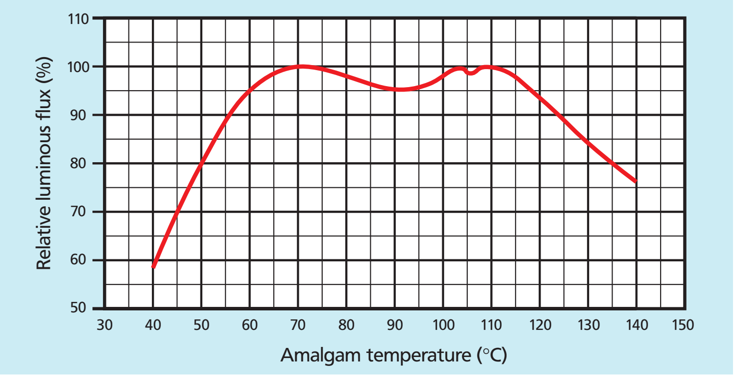


Fig. 4: Luminous flux/temperature curve of a ring-shaped lamp. With this lamp, the operating (amalgam) temperature range for ≥ 90 percent light is between 55°C and 125°C. To the left and right of this, luminous flux drops off sharply, as with other fluorescent lamps. Induction lamps should not be operated as general-diffuse light sources, i.e. without luminaires, as this results in overheating.

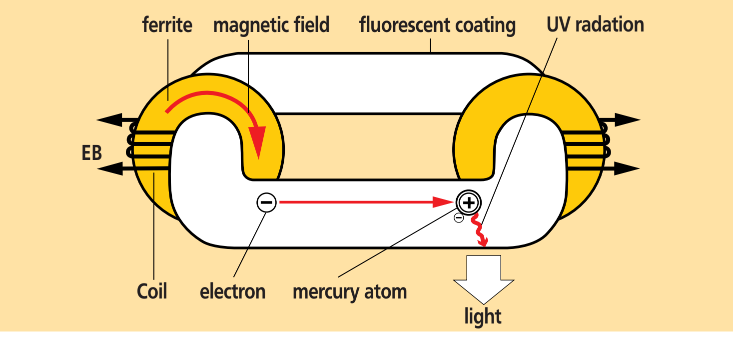
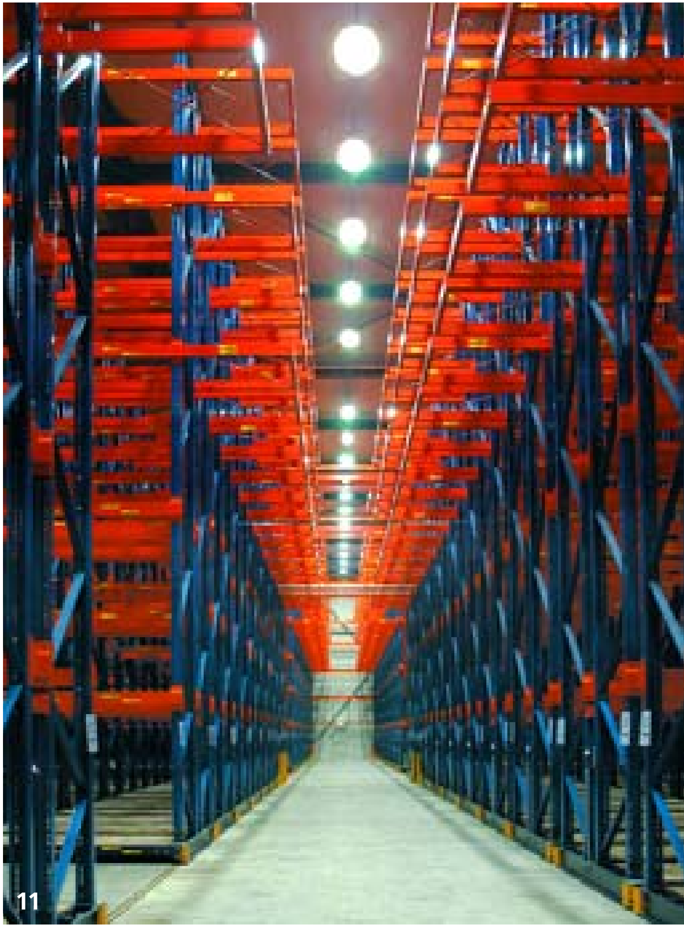


Fig. 5: The ring-shaped lamp consists of a close-loop style discharge tube with an internal fluorescent coating and one or more magnetic ferrite ring cores with coils. The electrical power for the discharge is induced from outside. Light generation is on the same principle as in a three-band fluorescent lamp (see Page 5): the fluorescent coating converts the UV radiation emitted by mercury electrons into visible light. An electronic ballast (EB) specifically designed for the lamp is needed to operate it.



11

12

13

14

The bulb-shaped induction lamp

15

16

Bulb-shaped induction lamps, which bear a strong resemblance to incandescent lamps, are filled with low-pressure mercury vapour. A "power coupler" inside the lamp provides the connection to the lamp interior. Among other things, it carries a magnetic ferrite core ("antenna").

The electrical power is induced from inside by applying AC voltage to the coil of the ferrite core and creating an electromagnetic field in the internal atmosphere. The principle is similar to that of a transformer, with the ferrite ring core acting as the primary winding and the discharge tube as the secondary. The actual production of light occurs in the same way as in a three-band fluorescent lamp (see Page 5): the electrons – as described above – are accelerated by internal induction and collide with the mercury atoms. On impact, free electrons in the mercury are energized and emit the energy absorbed in the form of UV radiation. The fluorescent coating on the inside of the bulb converts the UV radiation into visible light.

The electronic ballast (EB) specifically designed for use with the bulb-shaped lamp in question converts the mains (50/60 Hz) or battery current into 2.65 MHz high-frequency voltage. It also regulates the high ignition voltage from approximately 1,000 volts after ignition to the voltage required to operate the lamp. A shielded cable connects the EB to the "power coupler".

Bulb-shaped induction lamps in use: decorative lighting in a square (Photo 15), filling station (Photo 16), foyer (Photo 17), sports hall (Photo 18).

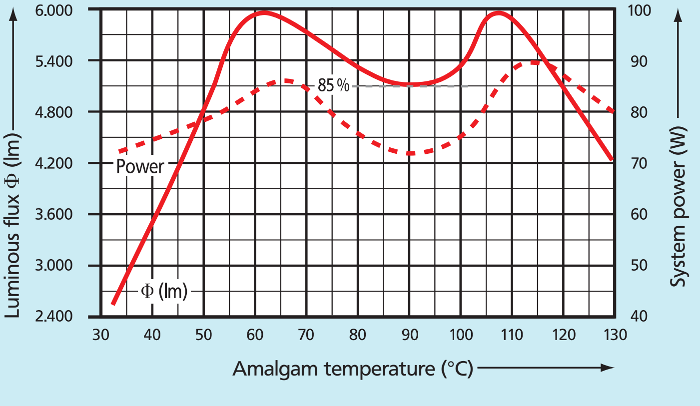


Fig. 6: Luminous flux/temperature curve of a bulb-shaped lamp. With this lamp, the operating (amalgam) temperature range for ≥ 85 per cent light is between 55°C and 125°C. To the left and right of this, luminous flux drops off sharply, as with other fluorescent lamps. Induction lamps should not be operated as general-diffuse light sources, i.e. without luminaires, as this results in overheating.

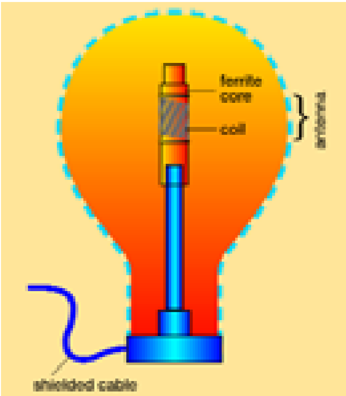


Fig. 7: The bulb-shaped lamp consists of a glass bulb with an internal fluorescent coating and a "power coupler" inside it with a ferrite core and coil ("antenna"). The electrical power for the discharge is induced from inside the lamp. An electronic ballast (EB) specifically designed for use with the lamp is required to operate it.

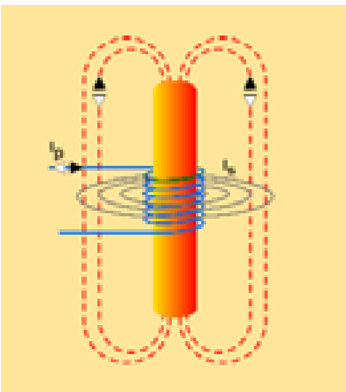


Fig. 8: The way induction occurs in a bulb-shaped lamp: the AC current (Ip) in the ferrite core (blue: primary winding) magnetically induces a corresponding current (Is) in the internal atmosphere (grey: secondary winding).

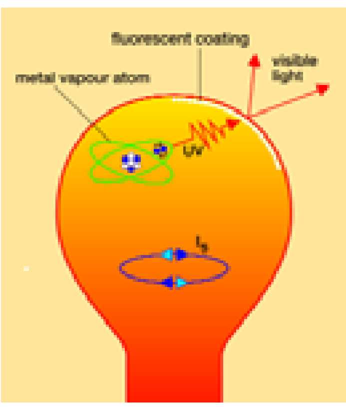


Fig. 9: An induction lamp that works by internal electromagnetic induction produces light in the same way as a three-band fluorescent lamp (see page 5): the fluorescent coating converts the UV radiation emitted by the mercury electrons into visible light.

17

18

Performance data: bulb-shaped lamp

Table 2

Lamp type in Watts (W)	Power rating of the system / lamp in the system in W	Luminous flux in lumens (lm)	Luminous efficacy of the lamp in lm/W	Luminous efficacy of the system in lm/W	Light colour in degrees Kelvin (K)	Colour rendering index R_a
55	55/47	3.500	74	64	2.700 (ww), 3.000 (ww) 4.000 (nw)	≥ 80
85	85/76	6.000	79	71	2.700 (ww), 3.000 (ww) 4.000 (nw)	≥ 80
165	165/150	12.000	80	73	3.000 (ww), 4.000 (nw)	≥ 80

Examples of applications with special requirements are tunnel lighting (Photo 19), neon advertising (Photo 20) and lighting for locations endangered by potentially explosive atmospheres, such as mines or oil rigs (Photos 21 and 22).

Special applications

The key attraction of induction lamps is their long service life of 60,000 hours. The idea that no money will need to be spent on replacing showroom lamps for more than ten years is one that greatly appeals to the keen cost manager. But induction lamps have other strengths too, making them a particularly interesting option for applications where lamp replacement is difficult and other special requirements need to be met.

Tunnels are a good example (Photo 19). Every lamp replacement here means closure, diversions, traffic hold-ups. Since induction lamps are suitable for emergency lighting, no additional luminaires need to be installed.

Another example is neon advertising (Photo 20). Every lamp replacement operation here is difficult, time-consuming and expensive. The electronic ballast (EB) can be kept easily accessible by accommodating it in the column up to 20 metres away from the lamp (ring-shaped lamps only).

And mines/oil rigs are yet another example (Photos 21 and 22). In locations endangered by potentially explosive atmospheres, Ex luminaires with induction lamps are used to meet the requirements of the ATEX Directive observed throughout Europe. Lamps need be able to withstand considerable shocks. Lamp replacement is complicated, because luminaires are difficult to access.

Regardless of how difficult lamp replacement is, Ex luminaires with induction lamps are a good choice for any locations endangered by potentially explosive atmospheres. Details of their suitability for this purpose are found on the type plate (see Fig. 10) on the luminaire, which, among other things, shows the EC-type-examination certificate of the Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig, the authorizing body responsible for the enforcement of weights and measures regulations in Germany. Detailed information about Ex luminaires can be found in Lichtforum 41 (orderable at www.licht.de).

And the list of special applications goes on: electrolysis plants, refrigerated warehouses and cold stores, ships' holds and engine rooms, landing and take-off strips on aircraft carriers, lighting for bridges or radio masts …

Fig. 10: Type plate of an Ex luminaire for use in areas endangered by potentially explosive atmospheres.

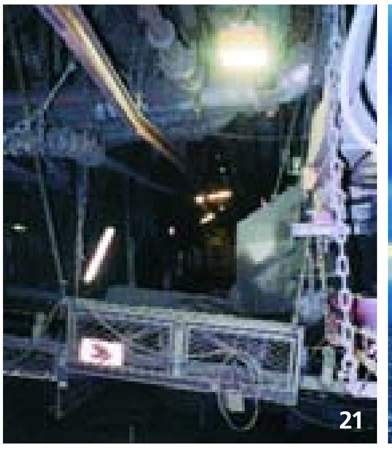
Model company

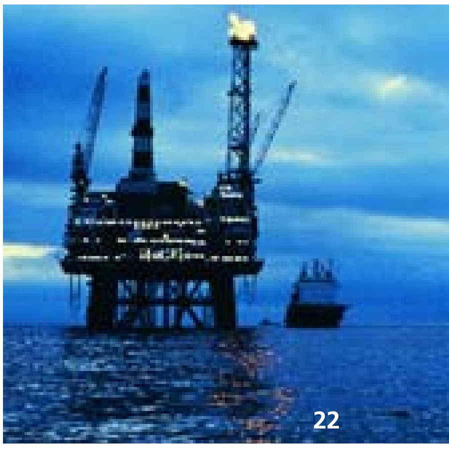
4712 Sample luminaire IP 54

Ex II 2 G E EX e d IIC T4 -20°C≤T≤+40°C

PTB 02 ATEX 0816

2x36W/40W IEC 81 G13 CE 0102





Products that solve problems

The latest from the lighting industry

23

Decorative

This decorative exterior luminaire is a member of a modular family of pendant, side-entry and post-top luminaires for mounting heights between 3.5 and 6 metres. The optical elements are not only stylish but also highly functional: options include louver unit, diffuser, refractor, spot, axially symmetrical reflector and a reflector for streetlighting. The maintenance-friendly luminaire is fitted with a 55 W bulb-shaped induction lamp.

24

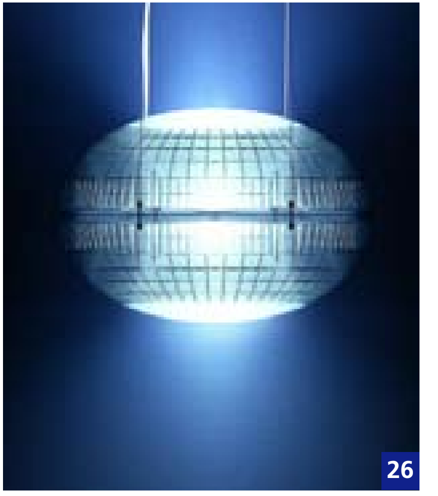
Alternative

Both the housing and the reflector of this high-bay reflector luminaire are aluminium. With its safety glass enclosure providing IP 54 protection, it comes with a direct wide-angle or wide-angle beam. Lamp options: 100 W or 150 W ring-shaped induction lamp. Alternatively, the luminaire can be supplied for 85 W bulb-shaped lamps, in which case it comes with a structured acrylic refractor for direct/indirect lighting and a structured glass enclosure.

Maintenance-free

This street luminaire with a 150 W ring-shaped induction lamp is designed for mounting heights from six to eight metres. The specular reflector, made from highly polished anodised ultra-pure aluminium, produces a direct wide-angle beam. The luminaire has a universal fastening for side-entry and post-top mounting up to a spigot length of 76 millimetres and is maintenance-free.

25



26

Design-oriented

This design-orientated luminaire, suspended by hangers from the ceiling, provides direct or direct/indirect lighting (double reflector). The two parts of the housing are made of pearlescent polycarbonate; photogravure makes for optimum optical control. Designed for a high degree of protection, IP 65, this luminaire is particularly suitable for maintained operation in high bays. It is fitted with a 85 W bulb-shaped induction lamp.

Universal

For sports, exhibition or assembly halls, refrigerated warehouses, filling stations or tunnels – this luminaire is a universal solution. It is impact-resistant and, with IP 65, offers a very high degree of protection. The non-retro-reflecting specular system produces a direct wide-angle beam. The special steel housing can be coated in any RAL colour. The luminaire is fitted with a 150 W ring-shaped induction lamp.

27

www.licht.de
Everything about lighting

Imprint

Published by: Fördergemeinschaft Gutes Licht (FGL), Stresemannallee 19, 60596 Frankfurt am Main, Germany.

Editing: rfw. redaktion für wirtschaftskommunikation, Darmstadt.

Graphics and layout: Kugelstadt MedienDesign, Darmstadt.

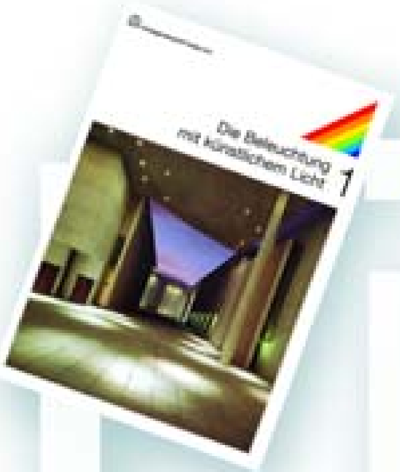
Photos: Richard Sibley, Hungerford/GB (cover photograph – "Swiss Light", artist: Michael Craig-Martin, architects: Herzog & de Meuron);
Andreas Kelm, Darmstadt (Photos 7, 8); Werkfotos.

FGL on the Internet: www.licht.de

Printed by: Druckhaus Haberbeck, 32791 Lage/Lippe
2/05-0

Members of Fördergemeinschaft Gutes Licht

LUMINAIRE MANUFACTURERS: GEBR. ALBERT • ANSORG • ARI • ARTEMIDE • ASMUTH • A + G SCHREDER • BANKAMP • BAULMANN • BEGA • BÖHMER • BPS • BRUCK • BRUMBERG • CASABLANCA • CEAG NOTLICHT • COOPER CROUSE-HINDS • DERUNGS • DOLIN • DURLUM • ELEKTRA • ERCO • ETAP • EUTRAC • FAGERHULT • ALOYS FISCHER • FLOS • GLAMOX • GLASHÜTTE LIMBURG • GROSSMANN • HELESTRA • HELLUX • HERNER GLAS • HESS FORM + LICHT• HIRT • HOFFMEISTER • HOLOPHANE • HOLTKÖTTER • IGUZZINI • INPROTEC • KAUFEL-NIFE • KOTZOLT • KPM • LICATEC • LICHTWERK • LITE-LICHT • LMT • LOUIS POULSEN • MENZEL • MERK • MOONLIGHT • M. MÜLLER • NIERMANN • NOBILÉ • NORKA • OLIGO • CHR. PALME • PHILIPS AEG LICHT • POPP • PRACHT • PRÄZISA • PUBLIC SCREEN • RADEMACHER • RECHLATERNEN • REIHER • REISS INTERNATIONAL • RIDI • ROBERS • RSL RODUST • RUHSTRAT • RZB-LEUCHTEN • SCHMITZ • GJCS SCHNEIDER • SCHUCH • SCHUPA • SEMPERLUX • SILL • SIMON & SCHELLE • SIS-LICHT • SITECO • SONLUX • SPITTLER • R. STAHL • STENG • STRASSACKER • SYSTEMTECHNIK • TECNOLIGHT • TRILUX • VULKAN • WALDMANN • WE-EF • WILA • DR. WILLING• Z-I-LICHTSYSTEME • ZUMTOBEL STAFF • **LIGHTING COMPONENT MANUFACTURERS:** BAG • ECKERLE • ERC • HADLER • HELVAR MERCA • HÜCO • INSTA • LT ELEKTRONIK • OSRAM • PHILIPS LICHT • TRIDONIC.ATCO • VLM • VOSSLOH SCHWABE • VS OPTOELECTRONIC • **LAMP MANUFACTURERS:** AURALIGHT • BLV • GE LIGHTING • G.L.E. • LUMILEDS • NARVA LICHTQUELLEN • OSRAM • PHILIPS LICHT • RADIUM • SLI LICHTSYSTEME



Information from the source

Lighting tips with product and manufacturer search at www.licht.de

Order form for FGL publications

fax: 069 98955-198
mail: Fördergemeinschaft Gutes Licht
Stresemannallee 19
60596 Frankfurt am Main
Germany
email: fgl@octopus-net.de
website: www.licht.de

Name:

Address:

Date:

Booklet No./Title			Qty
1*	Lighting with Artificial Light	€ 9,–	
2*	Good Lighting for Schools and Educational Establishments	€ 9,–	
3*	Good Lighting for Safety on Roads, Paths and Squares	€ 9,–	
4*	Good Lighting for Offices and Office Buildings	€ 9,–	
5	Good Lighting for Trade and Industry	€ 9,–	
6*	Good Lighting for Sales and Presentation	€ 9,–	
7*	Good Lighting for Health Care Premises	€ 9,–	
8*	Good Lighting for Sports and Leisure Facilities	€ 9,–	
9	Prestige Lighting	€ 9,–	
10	Notbeleuchtung, Sicherheitsbeleuchtung	€ 9,–	
11	Good Lighting for Hotels and Restaurants	€ 9,–	
12*	Lighting Quality with Electronics	€ 9,–	
14	Ideen für gutes Licht zum Wohnen	€ 9,–	
16*	Urban image lighting	€ 9,–	

* English translation available as pdf file (download: www.licht.de)

Booklets 13 and 15 are out of print

Fördergemeinschaft Gutes Licht