GLOSSARY OF LIGHT TECHNOLOGY

COMPILED BY DIPL.-REST. FRANZISKA HERZOG MARCH 2007

ZKM Center for Art and Media Karlsruhe
WWW.ZKM.DE
WWW.INSIDE-INSTALLATIONS.ORG
inside installations

CONTENTS

INDEX

GLOSSARY OF LIGHT TECHNOLOGY

Absorption

refers to the weakening of an electromagnetic wave, i.e. a light ray, as it passes through the lighted substance and is transformed into heat.

Additive Coloured Mixture

describes the optical model for the mixing characteristics of light colours. Unlike > subtractive colour mixing, the colour mixtures are not achieved by repeated reductions in the > spectrum but are instead achieved through the addition of new spectral areas. This additive process works on the three colour theory (primary colours, red|green|blue) of Young and Helmholtz.
In additive colour synthesis, white is the sum of all colours combined and black is the absence of light.
The principle of additive colour mixing is applied, for example, in > light emitting diodes.

Alternating Current (AC)

> Electrical Current

Alternating Voltage

> Electrical Voltage

Ballasts

are devices, which are responsible for limiting the current in > gas discharge lamps during their operation.
They prevent the discharge current, which arises through the ignition of the lamp, from increasing so much that the lamp is destroyed. Ballasts deliver > fluorescent lamps the voltage surge necessary to ignite the lamp, together with the > starter.
Ballasts are matched to the electrical parameters of a particular lamp for their perfect operation, whereby the > power, > frequency and > mains voltage all play a part.
There are > electromagnetic and > electronic ballasts.They can be built in to the lighting fixture as a separate component or integrated into the lamp itself (e.g. in > compact fluorescent lamps|energy saving lamps). Some types of lamp require ballasts which contain an > ignition device (e.g. > high pressure sodium vapour lamps) or a > starter (e.g. fluorescent lamps).
Most ballasts belong to the > protection system IP00 and > protection class I.

Bases (Caps)

describe in light technology parts of > lamps with which the lamps can be secured in and released from the holdings of > lighting fixtures. They are thus the opposite of the > holder.
The join between base and lamp i.e. the glass bulb, is very sensitive to mechanical influences e.g. vibrations.
Bases are roughly divided into single ended and double ended bases. Single ended bases include > screw|E bases, > bayonett|B bases and > prefocus|P bases as well as numerous special types. Double ended bases include the > R|S bases and special types.
Single ended bases are found e.g. in > incandescent lamps, double ended bases e.g. in > fluorescent lamps. > Cable|K bases and > pin|G|F bases are single ended and|or double ended bases.
Bases are also classified according to the base material. There are glass, ceramic and metal bases.

Base Descriptions

are based on the > IEC codes and are systematically structured.
The capital letter in the code indicates the type of construction (e.g. 'B' stands for bayonet|B base).
The following number is a base size in millimetres. For screw|E, bayonet|B and Cable|K bases the number indicates the diameter of the base casing, for R|S bases the diameter of the ceramic ring and for P bases the size of the prefocus ring (e.g. E27 stands for screw|E base, 27 for 27mm diameter of the base casing).
The small letter indicates the number of contacts|connections, whereby s-single=1, d-double=2, t-triple=3, q-quadruple=4, p-penta=5 contacts (e.g. in the abbreviation B15d, B stands for bayonet|B base, 15 for 15mm diameter of the base casing, d for 2 connections).
Last of all, after a dash, further specification attributes can be given. Individual > lamp manufactures have their own description schemes alongside this system.

Bayonet|B Bases (Push-twist, Swan Bases)

are > lamp > bases.
With a bayonet|B base the illuminant is fixed in the > holder over an engaging mechanism.

Bayonet|B Bases
cont.

Pins fastened to the base provide a secure seat for the illuminant in the > holder. The positioning of the pins and the diameter of the base prevent the installation of the wrong illuminant.
BA9s and B15d are typical markings (> base descriptions).
Bayonet|B bases are found e.g. in high voltage halogen lamps.

Bimetallic Relays

are > relays which are activated by thermally active components called bimetallic strips. These strips consist of two different metals and change form based on the effect of temperature due to their different heat expansion coefficients. Applying a current leads to a warming of the bimetallic strips and finally to deformation. When a defined, pre-determined temperature is reached, a switching mechanism shuts off.
Bimetallic relays are used for control applications and switching processes.
In light technology for example, bimetallic relays can be built into > incandescent lamps where they are positioned near the filament. After a short heating-up period, the light begins to blink. This heating-up leads to an interruption in the current flow and cooling-down causes the re-closing of the current flow and thereby the illumination of the lamp.

Blended Lamps

are a combination of > thermal radiators and > gas discharge lamps, more precisely a combination of > incandescent lamps and > high pressure mercury vapour lamps.
The construction of blended lamps is similar to that of high pressure mercury vapour lamps. Because the current limiting is secured by a special tungsten filament which surrounds the discharge chamber i.e. burner, a > ballast is not needed for operation. The outer bulb is coated with a > phosphor just like in high pressure mercury vapour lamps.
Blended lamps have the following characteristics.
They have a relatively higher > light output than incandescent lamps whereby the > light colour changes from yellow|reddish towards bluish|white after a particular burning-in period. For complete >luminous flux rendering a start-up time of approximately 2 min is required. Immediate reignition after a power failure of < 10ms is possible, otherwise a cooling time of 5-10min is necessary. The average lifetime is 5,000h. The > power is 160-500W.
The most common constructions are the standard form (> incandescent lamp) and the ellipsoid form. The > screw|E base is most prominent. A precise classification of blended lamps is provided by > ILCOS 1231 or the particular > lamp manufacturers.
Similar to incandescent lamps, blended lamps are operated with mains voltage (230V). The > dimming of the lamps is possible.

Cable

describes the bundling of several > flexes, i.e. single insulated wires, which are held together by an additional insulation, the cable sheath.
The purpose of an electric cable is to minimise the loss of the current flow in the energy supply.
For > direct current the wire insulation (> wire) is red and black. For > alternating current brown|black is used for the > live conductor and blue for the > neutral conductor. The > protective earth conductor has a green-yellow wire insulation. For > heavy current there is a blue|previously grey > neutral conductor, and one each of a black, grey and brown > live conductors. For > high voltage, single wire cables are mostly used.
Wire insulation and cable sheaths are manufactured from various plastics according to need e.g. from polyvinylchloride (PVC), polyethylene (PE), Teflon (PTFE), rubber (when mechanically stressed) or silicon (when thermally stressed).
Cable manufacture is subject to standardisation through the > IEC.

Cable|K Bases
(Y bases)

are single ended and|or double ended > lamp > bases.
The electrical connection is made with a cable provided with terminals separate from the > holder, which in this way allows a better and safer electrical connection.
Cable|K bases can be used for lamps with a high > power.
Typical descriptions are K24s, K39d (> base descriptions).
Cable|K bases are found e.g. in double ended > gas discharge lamps with more than 6,000W power.

Candela

is the unit of measurement for > luminous intensity.
It describes the > luminous flux of a > light source in a particular solid angle. It is measured in Candela (cd).

Candela
cont.

> Luminous intensity is the base unit for light technology.
It unites the physical with the physiological system of units whereby the latter takes into consideration human > eye sensitivity.
The name candela is based on the early technical measurement implementation of a standardised oil candle (Hefner Candle).
The current use of the term candela is purely theoretical. It is based on the definition of the luminous intensity of a radiant source that emits a monochromatic light with a wavelength of 555nm (the maximum for eye sensitivity) and a radiant intensity of 1/683 watts per solid angle.

Capacitors (Condensers)

are electronic components for the storing of electrical energy in an electric field.
They consist of two electrical conductors, the electrodes, which are separated by an insulator called a dielectric. When a voltage is applied to the electrodes there is a short flow of electrical current which charges one electrode positively (anode) and the other negatively (cathode). If the flow of current is interrupted, the capacitor remains charged for a particular period of time.
The charge is proportional to the voltage. The proportionality constant is referred to as the capacitance (C).
Capacitors are available in various constructions. There are single compensation (one capacitor per lighting fixture), group compensation (one capacitor for several lighting fixtures) and central compensation (additional coverage of other consumers).
Compensation capacitors are categorised as type A (unprotected), type B (protected) and FPU (flame and explosion safe).
In light technology, capacitors are used in > ballasts for compensation of the inductive idle power, which simultaneously guarantees the power factor recommended by the electricity provider.

CIE

is the abbreviation for **C**ommission **I**nternationale de L'**E**clairage (the International Commission on Illumination).
Since 1913, this professional organization has been dedicated to fundamental research and the distribution of knowledge in the area of light and lighting technology.
In 1931 the CIE and the CIE-associate committees defined the CIE-colour norm values (XYZ-colour norm system).

Circuits

describe the ordering of the electrical connections between the current source and the electronic devices e.g. > light sources.
There are phase-phase connections (out-dated?), > star connections, > parallel connections and > series connections.

Circuit diagrams

are abstract graphical descriptions of > circuits.
They give information about the electrical functions and current flows of electrical devices. Circuit diagrams can either be standardised or individually made. Standardised symbols are used as a basis.
Circuit diagrams can be divided into three different types: > principal diagrams, > current flow diagrams and > overview circuit diagrams.
Circuit diagrams are prepared during the design of electronic devices and are later needed for maintenance or repairs.

Colour Rendering (Ra)
Colour Rendering Index|CRI

describes how true colours appear in the light of a > light source. To determine the colour rendering index, eight or fourteen colour tables are observed under the artificial light source and reference light source, i.e. a light source with the same colour temperature (TF < 5,000 K the radiation of a black body, TF > 5,000 K daylight radiation).
The smaller the colour variation is, the better the colour rendering. The highest possible index is R_a = 100, which corresponds to the first of four levels. The higher the colour rendering, the more even is the distribution of the spectrum. For this reason a high colour rendering always results in a reduction of the light output.

COLOUR RENDERING INDEX CLASSES

CLASS	Ra	COLOUR RENDERING
1A	100-90	very good
1B	89-80	good
2A	79-70	satisfactory
2B	69-60	acceptable
3	59-40	moderate
4	39-20	poor

Colour Temperature

refers, in light technology, to the > light colour or quality of light of an > electrical light source and is measured in Kelvin (K). It is based on Lord Kelvin's discovery that the light colour of radiation of a heated, black body is in direct relation to the temperature of the body. Because this effect was discovered during experiments using a black body, the term 'black body radiator' was introduced. The Kelvin system (0°K ~ 273°C) is used to measure colour temperature.

Colour Temperature
cont.

The spectral energy distribution of a light source is compared to a spectral energy distribution similar to that of the black radiator. Therefore, the colour temperature does not correspond to the actual thermal temperature of the light source. Colour temperatures are roughly divided into artificial light and daylight. An average colour temperature for artificial light (incandescent lamps) is about 3,000K (temperature of the tungsten wire). The value of natural light emitted from the sun is approximately 5,500K.
Colour temperature information for characterising the light colour is usually included with > fluorescent lamps.

Coloured Filters (Gels)

allow, in light technology, the filtering out of particular spectral areas from the > spectrum. This filtering is based on the principle of > subtractive colour mixing. Certain wavelengths of the spectrum are hereby absorbed (> absorption) or reflected (> reflection), for example.
A distinction is made between pigment filters, gelatine filters and coloured glasses. Among the various synthetic material filters, the polycarbonate filter proves to be very heat resistant. Filters are used e.g. with > spotlights and > fluorescent lamps.

Colourimetry

means colour measurement.
The term was introduced by the International Commission on Illumination > CIE.
Standards for types of light from particular light sources were established as a basis for colour measurement in order to evaluate and assess colours and measurements of lamps as well as generally accepted technical premises with a set of unified pre-requisites. This is necessary because the > spectrum of a light source depends on physical light generation principles. The spectral light distribution of an incandescent lamp is fundamentally different to that of a fluorescent lamp, for example.
The norms for types of light are divided into different categories based on their > colour temperature.
The categories A-C (Tk = 2855, 6K – 6774K) are e.g. for > incandescent lamps, whereas categories D-E (from Tk = 5500 K) are e.g. for > gas discharge lamps.

Compact Fluorescent Lamps

are > gas discharge lamps, more precisely > low pressure discharge lamps. They are short > fluorescent lamps. The principle of light generation is based on gas discharge.
In compact fluorescent lamps the glass bulb, the discharge chamber, is formed into a U-shape, whereby several of these can be joined together in series.
Compact fluorescent lamps have the following characteristics.
A high > light output can be achieved with optimal vapour pressure and sufficient cooling. The > light colours are comparable to those of fluorescent lamps. The relatively high luminous flux is highly dependent on the surrounding temperature (optimum 20-25°C) and the > operating position. Amalgam lamps are used to reduce the temperature. The average lifetime is, depending on the ballast, 10x as long as that of an incandescent lamp. The > power depends on the length of the lamp and is 3-80W.
A distinction is made between different types of construction. There are one- to four-tube lamps, standard lamps and bulb lamps.
Screw|E bases and pin|G bases are found as base construction types.
Compact fluorescent lamps are roughly divided into the pin base lamps with|without integrated > starter and the screw base lamps with integrated > electronic ballast. Screw base lamps are also described as energy saving lamps. A precise classification of compact fluorescent lamps is provided by > ILCOS 1231 or the particular > lamp manufacturers.
Compact fluorescent lamps are operated with mains voltage (230V). A > starter and a > ballast are necessary for their operation. > Dimming the lamps is possible in exceptional cases and only with the use of a corresponding ballast.

Connectors

allow a separable attachment or connection between > wires und conductors.
Connectors are divided into screw connectors and screwless connectors, whereby springs are used in the latter. The types of construction are e.g. strip connectors and screw connnectors.
The strip connectors from the manufacturer WAGO are to be recommended, for example. The connectors can be used in many ways (e.g. for stiff and flexible > wires up to a diameter of 2,5mm).

Contactors

are > relays and thus electromagnetic switches.
They have a high switching capacity and are therefore used in heavy current technology (> three-phase alternating current).
Contactors are switched on by the control current of a magnetic coil and held in their on position as long as the control current is present. If the current flow in the control circuit decreases, then a mechanical spring puts the contactor back into its starting position and so interrupts the electrical circuit.

Control Units

are used in light technology in addition to > switched mode power supplies if a control function is needed e.g. for > dimming.
They are connected on the primary side between the lamp and the operating device. Control units are used e.g. in > light emitting diodes.

Control Voltage

is used in light technology to control > dimmers. A control voltage of 0V|1V-10V is usual, whereby 10V corresponds to 100% modulation. 1V for 0% ensures that a fault in the conductor can be recognised and that the dimming is not activated. A current signal can also be used for control. Currents of 4-20mA are usual in this case.

Conventional Ballasts

> electromagnetic ballasts

Cord Grip

is a mechanical protective device for cables.
It protects the connection between the cable and the end piece against mechanical stress.

Core Cable Ends

provide protection to the ends of the > flex circuits.
According to > VDE codes, circuits containing individual flexes must be equipped with core cable ends. Otherwise, there is the danger that the fine flexes will be damaged by fastening screws or spring fasteners and, therefore, perfect electrical contact will not be possible. Corrosion or fire hazard could be the result.
The inner diameter of the core cable ends should be suitable for the sockets they are meant to protect so they can be attached easily. The cable ends are squeezed with a crimping tool to create a secure contact.
There are core cable ends with and without coloured protective shrouds, which indicate the inner diameter of the cable end and provide extra protection against bending.
Many lighting objects do not exhibit core cable ends.

Current

> electrical current

Current Flow Diagrams

show circuits strictly according to the sequence in which the current flows through the individual components.

DALI

is the abbreviation for **D**igital **A**ddressable **L**ighting **I**nterface and is a digital control protocol which is used in light technology for addressing > control devices or > dimmers, for example. Every system device that is connected to a DALI-Interface can be individually controlled by DALI-Short Addresses. 64 devices can be controlled with this system. For example, DALI is used to control > Light Emitting Diodes-Modules as well as > fluorescent lamps in large, complex systems.

Dimmers

are adjustable electronic components which are applied in light technology to adjust the brightness of > lamps. Dimming makes the reduction of the service electricity possible and has a positive effect on the lifetime of the lamp.
With phase control modulation, by means of > triacs, the dimming results from a central control of the operating voltage. Simple dimmers, e.g. for > incandescent lamps, regularly cut off the sinus-shaped half-waves of > alternating current creating high frequency interference signals which impair other devices (e.g., audio and video systems). Low frequency interference signals lead, among other things, to a vibration of the filament which leads to humming and increased mechanical demands i.e., breakage of the coil.
With phase control modulation (> phase control modulator), dimming is achieved through an electronic system device. > Transistors or > thyristors enable a gradual variation in the electrical current. After a certain time in the run of an alternating current half-wave, the transistor shuts off on a time-control. Because the switching time is much greater, there are fewer disturbances.

Dimmers
cont.

With > gas discharge lamps, for example, the minimum voltage for the service of the light source must be guaranteed so that the discharge is maintained despite the dimming and the lamp is not extinguished.

Direct Current

> electrical current

Direct Voltage

> electrical voltage

Disposal

of old lamps has been defined since 2005 by common European regulations. These regulations correspond to the code 2002/96/EG for defunct electrical devices and defunct electronic devices. The regulations are divided into ten categories whereby number five deals with lighting installations. All lamps containing mercury (almost all > gas discharge lamps, e.g.> fluorescent lamps) must be properly disposed of. > Incandescent lamps and > halogen lamps are not dealt with in these regulations.

DMX
(DMX 512 as well as DMX-512/ 1990)

is the abbreviation for **D**igital **M**ultiplex and is a digital control protocol used in stage and show lighting to control > dimmers, > spotlights or stroboscopes, for example.
It enables high flexibility of the composition of time and special effects. 512 Channels can be transmitted with an 8 bit resolution (265 stages) per connection. DMX has a high protection against disturbances due to a symmetrical transmission process.

Earthing

refers to the electrically conductive connection with the earth potential, which is implemented for the purpose of technical safety. The earth enables a defined connection potential or a potential balance to be created. This is meant to prevent possible occurrences of > electrical voltage and thus dangerous body currents.
Because the earth always exhibits > electrical resistance, a low electrical voltage remains in the case of a permanent current flow.

Electric Light Sources

also commonly referred to as > lamps they are characterised by the emission of visible, artificial light.
They include > lamps, i.e. light media, and > the lighting fixture.
Light sources are categorised according to their principle of light generation into > thermal radiators, > electrical luminescence radiators and plasma radiators (> gas discharge lamps).

Electrical Current (I)

is the directed movement of free electrons in an electrical conductor and is measured in amperes (A).
The source of electrical current is the > electrical voltage which causes the movement of the electrons.
The current intensity (I) indicates how many load carriers flow through an electrical conductor in a particular time.
The original definition, that the current flows from the positive pole to the negative pole (called the technical current direction), is derived from the magnetic fields produced by the movement of electrons. The behaviour is actually the opposite (called the physical current direction).
A distinction is made between alternating current (AC) and direct current (DC). The abbreviations AC and DC are found on the housing of electrical devices. Direct current (DC) displays a constant voltage and current course. Alternating current (AC) alternates direction periodically whereby a convenient transformation of the current|voltage is possible even over great distances.

Electrical Power (P)

Formula: $P = U \cdot I$
U|Electrical Voltage in Volt
I|Current Intensity in Ampere

refers to the work, i.e. energy, of a load (> lamp, > light source) in a particular time. It is measured in watts (W).

Electrical Resistance (R)

Formula: $R = U / I$
U|Electrical Voltage in Volt
I|Current Intensity in Ampere

refers to the property of certain electrical components to limit the current flow. It is measured in Ohms (Ω).
According to Ohms Law an electrical conductor imposes resistance on the electrons (direct current resistance) as soon as the electrons collide with atoms as they pass through and conductor. The result is a loss of energy in the form of heat.
The more the voltage must be increased to achieve a current flow in the conductor|component, the greater the resistance and the lower the conduction (formula symbol G with the unit of measurement S for Siemens).

Electrical Resistance (R) cont.

Along with Ohm resistance, a distinction is made between inductive resistance (> transformer) and capacity resistance. Both are called blind resistance which effect a phase shift between an > electrical voltage and an > electrical current.

Electrical Voltage (U)

describes the attempt of separate charges to balance and is measured in volts (V).
Voltage results from a separation of charges whereby the electrons attempt to remove the separation. The intensity of an electrical voltage is also called the potential.
A distinction is made between direct voltage and alternating voltage (> electrical voltage). Impulse voltage describes a brief voltage surge and is used e.g. in the context of > transformers.

Electroluminescence

is the property of certain substances, e.g. > semiconductors, to emit completely or partly the energy from an applied > electrical voltage as visible light.

Electroluminescence Radiators

are > electrical light sources.
The principle of light generation is based on electroluminescence. This means that a semiconductor is lighted by the application of electrical voltage. Because the electron transition takes place between defined atomic energy levels, the resulting energy is transformed into visible, narrow-band, monochromatic radiation. Included in this group are > light emitting diodes (LEDs), organic light emitting diodes (OLEDs) and > electroluminescent films|bands.

Electroluminescent Films|Bands

belong to the group > electroluminescence radiators.
The principle of light generation is based on > electroluminescence. Electroluminescent films are backing films (synthetic material) on which the underlying electrodes in the form of a metal coating (e.g. aluminium) are absorbed. An electrical insulator is connected which is called a dielectric. This is a mixture of zinc sulphide with diverse metal additives or phosphors according to the desired light colour. The second electrode follows in the form of a conducting, transparent coating of aluminium|zinc oxide. Finally there is a moisture resistant protective layer of synthetic film, which also secures the electrical insulation.
Electroluminescent films are operated on a mains voltage of 230V. Special power packs (> switched mode power supplies) are necessary for operation.

Electromagnetic (Inductive) Ballasts

are > ballasts which are used in > fluorescent lamps.
A distinction is made between conventional ballasts and low-loss ballasts.
Conventional ballasts are > inductors (chokes) which have a relatively high power loss and thus negatively effect the > light output and the > luminous flux. The lamps tend to flicker.
The conventional ballast serves to limit the current of a fluorescent lamp, which has a negative current voltage characteristic due to its plasma (> gases). An increase in the current would lead to a decrease in the burning voltage. If the fluorescent lamp is operated without conventional ballast in a network these negative characteristics could lead to a short circuit and a destruction of the system.
The inductance of conventional ballasts is also used for the generation of the required ignition voltage. In the beginning, the lamp is bridged through the starter so that a current can flow through the filaments and the starter.When the filaments are heated by the current, the bimetallic switch on the > starter suddenly interrupts the current. As a result of the change in current and the inductance, a high voltage is induced which is sufficient to ignite the plasma luminant in the lamp.
Low loss ballasts are a further development of conventional ballasts with the difference being that the power loss of the inductor is lower due to the application of low loss metals.
Important parameters for the characterisation of electromagnetic ballasts are the power loss (P_v), the threshold temperature of the winding (T_w), i.e. the highest permissible temperature during prolonged operation, the overheating temperature of the winding (Δt), i.e. the temperature increase during normal operation relative to the room temperature, and the overheating temperature of the winding (Δt_{an}), i.e. the temperature increase during abnormal operation, i.e. defective operation. These specifications are found on the housing covers of the devices (nameplate).
Electromagnetic ballasts, i.e. above all conventional ballasts, are typically larger constructions than > electronic ballasts.

Electromagnetic Transformers

are also known as conventional transformers.
Here it deals with > transformers which are used to regulate electrical current in > electrical light sources, e.g. in > high voltage light tubes.
Conventional transformers, simply put, consist of an iron core and at least one multiply tapped wire coil or several coils.
Current generation is brought about through > induction. A change in the magnetic flow of the first coil in the primary circuit is caused by the application of an alternating current and causes a voltage induction (> primary voltage). The altered magnetic flow carries through the second coil in a secondary circuit and by induction generates a further voltage (secondary voltage). A continuously changing voltage, i.e. an alternating voltage is thus necessary for the operation of transformers. The maximum level of inducted voltage depends not only on the initial voltage but also on the number of windings in the coil. The maximum level of current depends on the construction, i.e. on the size and on the cross-section of the conductor, and the properties of the material (of the iron core etc.). With larger constructions, the power loss must be countered with cooling as transformers overheat if the overload is too great, i.e. they can “burn out”.
Due to the relatively high inner resistance|inductive resistance (> electrical resistance) of electromagnetic transformers there is a negative effect on the lifetime and the > luminous flux of the lamp according to the load created. To prevent the destruction of the device due to an increased current from the inner resistance during a short circuit, a thermal fuse|thermal switch is necessary.
There are various constructions which differ in their respective functions, e.g. short circuit protected and non-short circuit protected types. Isolating transformers, for example, exhibit separate windings which generate galvanically separate electrical circuits (> galvanic isolation) and make possible a protective isolation.
The dimensions and weight of electromagnetic transformers are in comparison to > electronic transformers relatively high.
> Dimming of conventional transformers is possible by means of a phase control modulator (> triac).

Electronic Ballasts

are > ballasts which are used in > gas discharge lamps.
Electronic ballasts are built-in devices, which are characterised by the following properties:
Due to their low energy consumption (power loss) as well as the possibility of saving energy by the use of > dimmers, they guarantee a high > light output. Electronic ballasts maintain a constant > luminous flux due to their constant lamp power over a wide range of mains voltage, constant lamp power and a corresponding long lifetime of the lamp. Electronic ballasts prevent flickering light. An automatic shut-off activates when the lamp is defective which makes switching the light on again immediately possible. Electronic ballasts can be used in the operation of both alternating and direct voltage. The permissible operation is indicated on the housing cover (nameplate). They can be operated with > extra low voltage and thus from batteries.
Electronic ballasts are divided into cold start and warm start electronic ballasts whereby the flatter are more common and suitable for the lamp. Warm start ballasts ignite the illuminant after a preheating period of the electrodes (0.5-2s).
A distinction is also made between dimmable and non-dimmable electronic ballasts. Dimmable electronic ballasts are operated by control devices, which can be analogue (> 1-10V interface) or digital (> DALI). Sensors are applied when the > power is regulated according to the amount of daylight.
Important parameters of electronic ballasts are the maximum permissible housing temperature ($t_{c\ max.}$) and the surrounding air temperature ($t_{a\ max.}$). Operation outside these parameters has a negative effect on the lifetime of the ballast. All of these parameters are found on the housing cover (nameplate). Electronic ballasts are available in small, compact forms, which integrate all the parts of the device. The construction varies according to the type of lamp and the manufacturer. For example, in fluorescent lamps the form is oblong and ovular as opposed to compact fluorescent lamps where the form is rectangular.

Electronic Transformers

are > transformers which are used in > electrical light sources to regulate current, e.g. in > light emitting diodes.
The construction of electronic transformers corresponds to that of > switched mode power supplies. Due to their low energy consumption they have a lower power loss than > electromagnetic transformers which has a positive effect on the > luminous flux and the > light output of the lamp. As heating in the housing is reduced, they are more efficient in dealing with a wide variety of loads.

Electronic Transformers
cont.

An integrated electronic fuse reacts in the case of a short circuit, overload or over-heating.
Electronic transformers are small, compact and lightweight constructions. They are dimmable either digitally by means of a phase > control modulator or analogue by means of a > potentiometer.

Emergency Switches

also called emergency-offs, are switches which safeguard electrical installations in the case of danger.
There are three categories, which are grouped according to the requirement whereby only the first category is of importance in the context of light technology.
When the switch (a red button on a yellow background) is activated, the current flow is interrupted.
The emergency switch can be a technical safety requirement of a national certification body for lighting objects and is found thus e.g. with > high voltage light tubes.

ENEC

is the abbreviation for **E**uropean **N**orms **E**lectrical **C**ertification.
It serves as the unified safety mark for lighting fixtures and can be found on lighting fixtures of all types. The badge is based on the Lum-Agreement (1992), which regulates the use of a conformity marking for lighting fixtures corresponding to European norms.

Exposure (H)

defines how much > illumination intensity is produced on a surface from a light source within a particular time period and is given in Lux-Seconds (lx·s).

Extra Low Voltage (ELV)

is also described as weak current. It comprises alternating voltages of up to 50V and direct voltages of up to 120V.
It comprises SELV (safety|separated extra low voltage), PELV (protective extra low voltage) and FELV (functional extra low voltage).
SELV has a special significance in light technology. SELV is a protection from electric shocks and is described as > protection class III according to > VDE codes.
With SELV there is no protective earth conductor, so that metal housings are not allowed to be earthed. The voltage must be chosen to be so small that electrical body currents do not have any effect. The voltage source must not be the mains supply e.g. a battery. If the nominal voltage of the alternating voltage is less than 25V or for direct voltage less than 60V, the direct protection against contact must be provided by means of insulation or a covering.

Eye Sensitivity

describes the sensitivity functioning of the human eye.
It is often indicated by the international abbreviation V (λ) as the V (λ)-Curve. This curve describes the relative spectral light sensitivity of the eye in daylight conditions.
It spans from 380nm (the threshold of ultraviolet radiation) to 780nm (the threshold of infrared radiation) and is at its maximum at 555nm.

Fire Protection Marks

are based on the > IEC|VDE codes and are found in various symbols on > lighting fixtures.
The ‘F’ symbol applies to installation on buildings. The ‘M’ symbol applies to installation on furniture and other such items. If the ignition point of a lighting fixture is greater than 200°C the lighting fixture must have an ‘F’ or ‘M’ symbol, e.g. when the lighting fixture is mounted on wood. If the ignition point of the lighting fixture is less than 200°C, only lighting fixtures with an ‘MM’ symbol can be mounted on wood, for example.
In fire hazard areas, only lighting fixtures with a ‘D’ symbol can be used.
Lighting fixtures with no marking can only be mounted on non-flammable materials.

Flexes
(Stranded Wires, Litz Wires)

are electrical conductors composed of numerous (hundreds), thin, flexible individual wires.
These individual wires are enclosed together in an insulated covering and create the flex conductor. Several grouped flex conductors in a cable are called > wires.
Depending on the requirements, i.e. flexibility and stress factor, there are forms of flex conductors ranging from fine wire to finest wire.
Metals with the lowest possible specific > electrical resistance, e.g. copper, are used to manufacture flexes.

Fluorescent Lamps

are > gas discharge lamps, more precisely > low pressure discharge lamps.
The majority of gas discharge lamps are fluorescent lamps.
The principle of light generation is based on low pressure mercury discharge.
Fluorescent lamps consist of a cylindrical glass tube with a preheated electrode, i.e. a tungsten filament with an activation layer, at each end.
The glass bulb is filled with a small amount of mercury and a noble gas. The interior surface of the glass is coated with a > phosphor. A low pressure discharge of the mercury in the gas occurs as a result of applied voltage. The resulting emission of UV radiation is transformed through the phosphor into visible radiation.
Fluorescent lamps have the following characteristics.
The relatively high > light output is dependent on the > mains voltage. If this is higher than the required operating voltage, the light output is increased while the lifetime of the lamp and the ballast are decreased. Due to the various phosphors (five-band phosphors), fluorescent lamps are available in diverse > light colours. These are principally categorised as warm white (TF < 3,300K), neutral white (TF 3,300K – 5,000K) and daylight white (TF > 5,000K). The de luxe version enables an improved > colour rendering with lower > light output. The > luminous flux is dependent on the surrounding temperature (optimum 20-25°C). Fluorescent lamps require a relatively short start-up time (< 1min) before producing full luminous flux rendering. The lifetime is dependent on the type of ballast used and especially on the frequency of switching. The > power depends on the length of the lamp and is 6-80W.
A distinction is made between three different types of construction. There is the rod form, the U-form and the ring form with different sizes for each.
Base construction types are > pin|G base and the R|S base.
A precise classification of fluorescent lamps is provided by > ILCOS 1231 or the particular > lamp manufacturers (> fluorescent lamp designations).
Fluorescent lamps are operated with mains voltage (230V). A > ballast is necessary for operation which, in conjunction with the > starter, delivers the voltage impulse needed to ignite the lamp and regulates the lamp current during operation. The > dimming of the lamps is possible by means of appropriate > ballasts.

Fluorescent Lamp Designations

are found on the lamp itself and on the packaging.
The classification of fluorescent lamps corresponds to > ILCOS 1231 or those of the particular > lamp manufacturers.
In Europe, lamp diameters are classed in 38|32|29|26|16|7mm,for example, which corresponds to T12|T10|T9|T8|T5|T2 inches.
The length of the lamp differs depending on the power. There are lamps which are 150mm in length (for 38mm|20-65W or 26mm|10-58W) on down to miniature lamps which are 523mm (for 7mm|6W).
The light colour is always given as a three digit number after the > power (W). The first digit indicates the area of the > colour rendering index R_a, the other two digits are the abbreviation for the colour temperature. E.g. in the abbreviation TL-D 58W/840, the TL-D indicates a lamp in rod form, 58W is the rated power, 8 is the colour rendering with R_a = 8 (85), 40 is the colour temperature, i.e. 4,000K and therefore the light colour cool white.
The three digit code for the description of > light colour and > colour rendering is used for > compact fluorescent lamps in the same way as for fluorescent lamps. The outer diameter of the glass tube in compact fluorescent lamps depends on the type of lamp and is 11-17mm which corresponds to T4/T5 inches.

Frequency (f)

describes the number of oscillations of electromagnetic waves in a given time. It is measured in Hertz (Hz).
The frequency of alternating current is 50Hz in the European and 60Hz in the American mains supply.

Fuses

are protective devices against overcurrent or short circuits, which interrupt an electrical circuit when the current is too high.
A distinction is made between melting fuses and automatic fuses.
Melting fuses interrupt an electrical circuit by melting a wire and thus can only be used once. These conductors are warmed by the current flow and melt as soon as the fuse’s nominal current is exceeded.
Automatic fuses in contrast actuate a switch mechanism with an overcurrent, which can be switched on again after the fault has been rectified.

Fuses
cont.

There are high and low voltage fuses and appliance fuses.
The latter are used for light sources with a electrical current strength of 0.032-20A. The usual sizes for European fuses are 5-20mm, for American fuses ¼ -1¼ inches. The speed of reaction to an overcurrent is an important criterion for fuses, along with the > nominal current and > nominal voltage of the light source.
There are five reaction types for fuses from FF|very fast acting and F|fast acting (i.e. < 20ms) und M|medium time lag (i.e. up to 90ms) to T|time lag (i.e. up to 300ms) und TT|long time lag.

Galvanic Isolation

is carried out, like > earthing, for technical safety reasons.
It prevents an openly accessible, conducting part of an electronic device from carrying a mains voltage and endangering a user by exceeding the maximum allowed voltage (> protection classes). A galvanic isolation is produced by an isolating transformer (> electromagnetic transformer). This has two isolated windings, which are only magnetically connected. A mains disconnection achieved by means of an isolating transformer is necessary e.g. for carrying out repairs to high voltage light tubes.

Gas Discharge Lamps

are > electric light sources, in which the principle of light generation is based on gas discharge generation of a plasma (> gases). The radiation is generated by a discharge process in ionised gases, i.e. metal vapours and|or noble gases. The process takes place in a sealed glass bulb, the discharge chamber. In addition to the gas filling, > phosphors can be used, as e.g. in fluorescent lamps.
Gas discharge lamps have the following characteristics.
The emitted radiation depends on the pressure in the glass bulb. For > low pressure discharge lamps the operating pressure is 1-100mbar and for > high pressure discharge lamps 1-20bar. Discharge lamps have a relatively high light output and lifetime. For operation they need current-limiting devices i.e. > ballasts.
Gas discharge lamps are divided into > low pressure discharge lamps and > high pressure discharge lamps.
The low pressure discharge lamps are further divided into > fluorescent lamps, > compact fluorescent lamps, > high voltage light tubes, > induction lamps and > low pressure sodium vapour lamps. The > high pressure discharge lamps are divided into > high pressure mercury vapour Lamps, > metal halide lamps and > high pressure sodium vapour lamps.

Gases

are used in > gas discharge lamps.
According to their function they are divided into ignition gases, lighting gases or buffer gases.
In > fluorescent lamps, for example, a mixture of argon and mercury vapour is used as a filling gas. Argon serves as the ignition gas because of its low ignition voltage and also during operation as the buffer gas, to regulate the total pressure of the lamp. The lighting gas is mercury, which is under a very low pressure of ca. $6 \cdot 10^{-6}$bar (1 bar ~ atmospheric air pressure).
In illuminated advertising two different sorts of gas filling have established themselves. Neon provides the red discharge and an argon-mercury mixture the blue discharge.
The mercury vapour pressure is determined by the coldest part of the tube. The mercury gas is excited and ionised by the electrical voltage. An ionised gas is called plasma. A very low mercury pressure is used in a fluorescent lamp, whereby a line spectrum arises. Mercury has a very pronounced line in the ultraviolet area. This UV radiation is transformed into visible light of the desired colour with the help of a phosphor.
The emission of the phosphor depends on the material used and encompasses only a small area of the spectrum.
For this reason, phosphors for white light are always a mixture of at least three colours. The higher the > colour rendering index should be, the more phosphors are needed (five-band phosphors).

Glow Lamps

are > gas discharge lamps, more precisely > low pressure discharge lamps.
The principle of light generation is based on gas discharge, which is also described as the glow discharge. Neon is often used as the gas filling, resulting in the red light colour. The electrodes in the outer bulb can be so formed that they appear to be a disc when viewed from above.
A distinction is made between different types of construction. There are standard, bulb, candle and tube lamps. Among the base construction types are screw|E bases and bayonet|B bases.

Glow Lamps
cont.

A precise classification of glow lamps is provided by > ILCOS 1231 or the particular > lamp manufacturers. Glow lamps are operated with mains voltage (230V). A transformer is necessary for operation. > Dimming the lamps is not possible.

Halogen Lamps

belong to the group of > thermal radiators.
The principle of light generation and their construction is comparable to that of the > incandescent lamps. In contrast to these, halogen compounds are added to the filling gas. These allow the halogen cycle to occur and thus reduce the oxidation of the tungsten, i.e. they reduce the blackening of the glass bulb.
The relatively high temperature of the lamp bulb (250°C) requires the use of a glass with a high softening temperature e.g. quartz glass. This allows the construction of low-volume, compact lamps because of its mechanical stability.
Halogen lamps have the following characteristics.
They have a high > light output with a higher > colour temperature (3,300K) than incandescent lamps. These parameters can be increased depending on the halogen compound used, e.g. xenon. An increase is also possible with the use of a reflective coating (infrared coating).
Touching the glass bulb, i.e. grease from fingers, results in a reduction of the > luminous flux. The average lifetime is 2,000-4,000h. The > power is 5-2,000W.
A distinction is made between numerous types of construction. There are, for example, standard lamps, pyramid candle and reflector lamps. Clear or opaque glass is used for the bulb.
Among the base construction types are > screw|E bases and pin|F bases. A classification of the different types of lamps is provided by > ILCOS 1231 or the particular > lamp manufacturers.
> High voltage halogen lamps are operated with > mains voltage (230V).
> Low voltage halogen lamps (6V|12V|24V) require an additional > transformer of the appropriate voltage for operation with mains voltage.
> Dimming halogen lamps is possible.

Heavy Current

> three-phase alternating current

High Frequency

is the description in electronics for high > frequency, i.e. electromagnetic oscillations, of an > electrical current and is measured in hertz (Hz).
The high frequency region of electrical current is, according to the application, over 10kHz, the low frequency region is under 10kHz. There is no precisely defined boundary to distinguish between high and low frequency. Fluorescent lamps, for example, which are operated with mains frequency (50Hz), are said to be low frequency, in contrast to the high frequency operation of a > ballast with ca. 30-40kHz.

High Pressure Discharge Lamps

are > gas discharge lamps and are sub-divided into > high pressure sodium vapour lamps and > high pressure mercury vapour lamps on the one hand and > metal halide lamps on the other hand.
High pressure discharge lamps work with a pressure of more than 1 bar in a small volume, short discharge chamber with a high > luminous intensity.
High pressure discharge lamps are characterised by a high > luminous flux, independent of the surrounding temperature. The > light output and the > colour rendering vary reciprocally.
A > ballast is used for operation. Depending on the lamp type, an > ignition device may be used in addition, whereby a warm up time of several minutes is needed before the correct vapour pressure is achieved. A reignition i.e. cooling-time of several minutes may be needed, according to the length of the power failure.

High Pressure Mercury Lamps

are > gas discharge lamps, more precisely > high pressure discharge lamps.
The principle of light generation is based on the gas discharge of mercury and argon.
The > lamp is composed of a discharge chamber, called a burner, (most often quartz glass) and an outer bulb. The burner contains the electrodes as well as the mercury and argon. The outer bulb protects the burner and the current leads from corrosion and carries the phosphor coating.
High pressure mercury lamps have the following characteristics.
They are distinguished by a relatively high > light output with moderate > colour rendering and vice versa. The light colour is bluish|white with a high yellow and green content.

High Pressure Mercury Lamps cont.

The application of > phosphors enables a manipulation of the > spectrum and therefore, a light colour in the direction of neutral white to warm-white (2,900-4,200K). A start-up phase of 3-5 minutes is necessary for complete luminous flux rendering. Immediate reignition is possible after a power failure of < 10ms, otherwise a cooling time of 5-15min is necessary. The lifetime depends on short-term voltage fluctuations and is on average 20,000h. The > power is 50-1,000W.
A distinction is made between the following constructions. There is the tube lamp, the globe lamp, the ellipsoid form as well as the mushroom form with a reflector.
The > screw|E base is the dominant base construction. A precise classification of high pressure mercury vapour lamps is provided by > ILCOS 1231 or the particular > lamp manufacturers.
High pressure mercury vapour lamps are operated with mains voltage (230V). Along with a > ballast, an > ignition device, which be integrated into the lamp, is necessary.
The > dimming of high pressure mercury vapour lamps is not permitted by the manufacturer.

High Pressure Sodium Vapour Lamps

are > gas discharge lamps, more precisely > high pressure discharge lamps.
The principle of light generation is based on gas discharge.
The lamp consists of a discharge chamber, called a burner, and an outer bulb. Unlike > high pressure mercury vapour lamps, the burner is made of aluminium oxide ceramic and contains the main|ignition electrodes as well as mercury, sodium and xenon. The outer bulb protects the burner and the current leads.The emitted visible radiation is distributed over a wider spectrum than that of > low pressure sodium lamps.
High pressure sodium lamps have the following characteristics.
The light output is approximately twice as high as that of high pressure mercury vapour lamps with a moderate > colour rendering. The > light colour is perceived as warm white at a temperature of 2,000K.
According to the type of lamp, a start-up time of 5-8min is necessary for complete luminous flux rendering. Reignition is immediately possible after a power failure of < 10ms, otherwise a cooling time of 5-15min is necessary. The lifetime is on average ca. 16,000h and depends on the type of lamp and short-term voltage fluctuations (tolerance +/-3%). The > power is 50-400W.
A distinction is made between numerous types of construction. There is the ellipsoid form, the tube form and the festoon form. The glass bulb can be clear or coated. The > operating position depends on the type.
High pressure sodium vapour lamps have > screw|E bases, > bayonet|B bases, > pin|G bases or > R bases. A precise classification of high pressure sodium vapour lamps is provided by > ILCOS 1231 or the particular > lamp manufacturers.
High pressure sodium vapour lamps are operated with > mains voltage (230V). A > ballast and an > ignition device are necessary for operation. The > dimming of the lamps is possible.

High Voltage

describes, in Europe, an alternating electrical voltage (> electrical voltage) of over 1,000V|1kV.
High voltage lighting in public places, i.e. museums, must be labelled according to the technical safety requirements of the appropriate national body.

High Voltage Cables

are used in light technology with > high voltage light tubes.
They connect a > transformer to a > neon system or multiple neon systems to each other.
High voltage cables were previously labelled with a yellow colour and corresponding inscription according to the > VDE|IEC codes. Today, transparent high insulation cables (diameter: 7mm) and also white cables (diameter: 2mm) are most common.
The exact composition of the cable sheath is not described by the manufacturer. It is however possible to observe in transparent cables under particular conditions, that constituents migrate and can react with other materials while current flows, e.g. metals.

High Voltage Halogen Lamps

are > thermal radiators, more precisely a sub-group of the > halogen lamps.
In contrast to the > low voltage halogen lamps their > power is relatively high at 25-2,000W. The average lifetime is 2,000-4,000h.
The base types comprise > pin|G bases, bayonet|B bases and screw|E bases. The pin|G bases are divided into pre-focus pin|GZ bases for cold light reflectors and GU bases for temperature-sensitive lamps.High voltage halogen lamps are connected directly to the mains voltage (230V).

High Voltage Light Tubes

are > gas discharge lamps, more precisely > low pressure discharge lamps.
In principle they are > fluorescent lamps and have corresponding technical parameters, e.g.> light output, >luminous flux and lifetime.
The type of construction is characteristic for neon systems.
They are individually made by glass blowers and thus can be formed into any desired shape. The diameter of the glass tubes (10-13mm) is relatively smaller than that of fluorescent lamps.
The light colour depends on the phosphor coating on either clear or coloured glass, the type of glass used (e.g. filter glass|transparent coloured glass) and the gas filling.
Country-specific manufacturing processes can be recognised by the type of construction.In the USA, the phosphor coating is applied early e.g. before the forming of the glass. The phosphor is burned into the glass in the kinks during bending and leaves clearly visible darker patches.
The manufacturing country can also be discerned from the type of glass. Soda lime glass indicates manufacture in Germany, Pyrex-Glass|borosilicate glass indicates manufacture in France or Spain.
There is no > base, the connection is established by direct cabling.
High voltage light tubes are operated with > high voltage.
A > transformer is necessary for operation with mains current (230V), which first of all produces the required > ignition voltage and then the burning voltage. The transformer regulates the flow of current in the lamp to a constant value of ca. 60-120mA. The burning voltage depends on the length of the tube and on the number of electrodes in the case of a series connection of several lamps.
For example, an installation of ten neon systems needs three transformers for its operation, so that a constant brightness can be achieved for every system. A system means, in this case, a tube element with an electrode at each end. The length of such a system varies between 10 and 250cm and should neither be longer nor shorter for technical reasons (e.g. minimum burning voltage and maximum ignition voltage of the transformer, danger of breakage if too long).

Holder

describes the device which allows a > lamp with its > base to be fixed to and released from the > lighting fixture. The holder is complementary to the > base.
An electrical contact is made at the same time as the lamp is screwed into, pushed into or clamped in the holder.
There are numerous types of construction, which differ according to the various technical demands. There are e.g. holders with|without screw mountings, with|without fixing flanges or lugs, with|without starter attachment, as well as recessed holders, raised holders and push-through holders.
Holders are manufactured from various materials, such as plastic, metal and porcelain.

IEC

is the abbreviation for the International **E**lectrotechnical **C**ommission (http://www.iec.ch).
This professional, internationally active organisation is concerned with questions of standardisation and coding in light technology. The coding system > ILCOS 1231 comes from the IEC, for example.

Ignition Devices

are used in > gas discharge lamps when an > ignition voltage which is higher than the > mains voltage is required. Common ignition voltages lie in the kV region.
The size of the voltage depends on the particular > lamp. There are three types: superimposed ignition devices, pulse ignition devices and immediate ignition devices
In superimposed ignition devices the ignition voltage is produced with a > transformer on the secondary side and a > capacitor on the primary side. This type of ignition device works relatively independently of the > ballast and delivers defined ignition voltage impulses coupled with a certain power loss. There are superimposed ignition devices with or without automatic cut out. The latter are called timer ignition devices and are available as analogue or digital types. The digital type allows a precise programming of the ignition process depending on the type of light source and its operating state (warm|cold). Superimposed ignition devices must be located near to the > holder (max. 2m away).
Pulse ignition devices use the inductance of the > ballast to produce the ignition voltage. This type of ignition device can be located up to 20m away from the lamp.

Ignition Devices
cont.

Immediate ignition devices allow an immediate reignition of the warm lamp after a mains interruption. Voltage impulses of up to 36kV are necessary in this case. These types can only be used in special lamps with special bases (double ended bases).
Ignition devices can generally also be integrated into the base.
Ignition devices are found in e.g. > metal halide lamps, > high pressure sodium lamps, > high voltage light tubes and > fluorescent lamps.

Ignition Voltage

is the > electrical voltage needed to start a gas discharge (> gas discharge lamps). It is produced amongst other things with the help of an > ignition device.

ILCOS 1231

is the abbreviation for the **I**nternational **L**amp **C**oding **S**ystem.
This is a coding system developed by the > IEC for > lamps.
The system is divided into the naming part and the standardisation part, whereby the latter is less often used.
The naming part consists of a series of letters and a series of numbers. The first letter describes the > lamp category, further letters indicate the type of construction.The series of numbers characterise the > power, voltage, > base and size of the lamp.
There are three different ILCOS 1231 versions.
ILCOS L, the short version, comprises the letter series of the naming part is used for the classification of lamps (e.g. I indicates an incandescent lamp, IA a standard incandescent lamp, IB a candle lamp).
ILCOS D, the intermediate version, comprises the whole of the naming part (e.g. in the abbreviation IB/W-40-230-E27 IB stands for candle lamp, W for white, 40 for the power in W, 230 for the voltage in V, E for a screw base, 27 for the size in mm).
ILCOS T, the full version, comprises the naming part and the standardisation part.
Individual lamp manufacturers, e.g. Osram and Philips, have their own coding system in addition to ILCOS 1231.

Illuminants

> lamps

Illumination Intensity (E)

Formula: $E = \Phi / A$
Φ|luminous flux in lm
A|surface in m^2

also called luminous flux density, is defined as the behaviour of a luminous flux as it falls on a surface relative to the size of the surface.
The amount of light, i.e. the product of time and applied luminous flux, is measured in Lux (lx) using a light meter (> photometry).

Incandescent Lamps

also known as all-purpose lamps, are > thermal radiators.
The principle of light generation is based on heating a tungsten wire in a glass bulb to ca. 3,000K, as a result of which radiation is emitted.
Incandescent lamps have the following characteristics.
The amount of visible emitted radiation is small and thus the > light output (ca. 10lm/W) is also relatively low. The latter increases with the lamp's > power. The > light colour appears with a > colour temperature of > 3,000K warm white|WW. The continuous reduction of the > luminous flux, caused by the oxidation i.e. blackening of the bulb by particles of tungsten, is slowed down with a gas filling of argon and nitrogen (90%-10%). The > luminance can be controlled with the coiling of the filament i.e. double coil or single coil. The average lifetime is 1,000h and depends on the operating temperature. The > power is 1-1,000W.
A distinction is made between numerous types of construction: standard, candle, golf ball, bulb, tube and reflector lamps as well as numerous special types. Clear, coloured or opaque glass can be used for the bulbs. Among the base construction types are screw|E bases and bayonet|B bases. A precise classification of incandescent lamps is provided by > ILCOS 1231 or the particular > manufacturer.
Incandescent Lamps are operated with > mains voltage (230V), apart from some special types. A > transformer is required for special types operated with > extra low voltage.
> Dimming incandescent lamps is possible.

Induction

describes the production of an > electrical voltage, the induction voltage, through the movement of electrical conductors in a magnetic field or through a change in a magnetic flux. It is based on a discovery by Faraday and is used e.g. in the generation of electricity or in > transformers.

Induction Lamps

are > gas discharge lamps, more precisely > low pressure discharge lamps.
The principle of light generation is based on gas discharge. The coupling of the energy occurs through a magnetic field and not through metallic electrodes. This type of lamp is therefore also described as an electrodeless lamp.
Induction lamps have the following characteristics.
They have a high > light output and a good > colour rendering. The high > luminous flux is independent of the surrounding temperature. The long lifetime (60,000h) is explained by the lack of electrodes, which are the lifetime-limiting factors because of wear. The > power is 70-200W.
A distinction is made between two different types of construction. There is the ring lamp with external electromagnetic coupling and the ellipsoid bulb lamp with internal electromagnetic coupling. A precise classification of induction lamps is provided by > ILCOS 1231 or the particular > lamp manufacturers.
Induction lamps are operated with mains voltage (230V).
A special > electronic ballast is necessary for their operation. > Dimming the lamps is possible.

Inductors (Chokes)

are electronic components which are used to suppress high current impulses. The inductor is the foundation stone of > ballasts. It is characterised by its low energy consumption, i.e. low power loss. In lamps with preheating electrodes (e.g. fluorescent lamps) it delivers the preheating current and, in conjunction with the > starter, the ignition voltage needed to ignite the lamp.

Interference

means that two or more electromagnetic waves i.e. light rays, interact with each other, which can lead to reciprocal amplification, weakening or extinguishing.

Lamps

refer to the illuminants found in an > electrical light source, e.g. fluorescent lamps. The term lamp is commonly used as a synonym for an > electrical light source.

Lamp Bases

> base

Lamp Manufacturers

alongside the large, international manufacturers, they are numerous and diversely represented in all countries in the EU. Alphabetical listings of manufacturers, lamps and operating devices can be found at:
http://www.licht.de/de/hersteller-von-a-bis-z/
http://www.on-light.de/htm/lampen/ index.htm
Some of the manufacturers, which were of particular importance to the exhibition ‚light art from artificial light' are listed alphabetically here.

LAMP MANUFACTURERS	LINK 1	LINK 2 (ENGLISH)
General Electrics (GE)	http://www.ge.com/en/	http://www.gelighting.com/na/
EL FOLIE	http://www.el-folien.com/	
Eurolite	http://www.eurolite.de/	
Hitachi	http://www.hitachi.de/	http://www.hitachi.com/
LAES-Lamparas EspecialesS.L.		http://www.laes.com/
Leuci		http://www.leuci.it/
LUMILEDS		http://www.lumileds.com/
Nichia		http://www.nichia.co.jp
Osram	http://www.osram.de/	http://www.osram.com/
Ormalight	http://www.ormalight.nl/	
Philips	http://www.philips.de/	http://www.philips.co.uk/
Radium	http://www.radium.de/	
Sinostar Lighting Co.		http://www.ssinostar.com/
Sylvania		http://www.sylvania.com/
Tungsram		http://www.tungsram.hu/tungsram/english/S

Lamp Power

is the electrical connection power of a lamp measured in watts (> electrical power).

Lenses

are used in light technology to purposefully influence the direction of light.

Lenses
cont.

Lenses vary in their geometric composition and therefore in their optical effect. For example, collective (convex) lenses and positive lenses lessen the divergence of a radiation bundle whereas dispersion (concave) lenses and negative lenses increase the divergence. In each group, three types of lenses are differentiated, the bi-convex/concave lenses, the plane-convex|concave lenses and the convex|concave lenses. Fresnel lenses, i.e. graded lenses, a special form, let the light rays refract to single saw tooth shaped ordered rings whereby the thickness of the lenses and the heat absorption can be reduced.

Light

describes, in the context of physics, the part of electromagnetic radiation, which can be perceived by the human eye. This lies between 380nm and 780nm and is distinguished from other electromagnetic radiation by its wavelength.
Ultraviolet (UV) radiation is the area below the 380nm threshold and infrared (IR) radiation is the area above the 780nm threshold. Together with the radiation perceived as light they form the optical radiation.
Many artificial light sources produce UV and IR radiation in addition to light and are thus sources of optical radiation.

Light Colour

> colour temperature

Light Direction

describes the various possibilities and factors, which influence the directing of a light ray. Some examples are: > refraction, > interference, > transmission, > absorption and the > reflection.

Light Emitting Diodes (LEDs)

are > electrical luminescence radiators.
The principle of light generation is based on electrical luminescence.
LEDs consist of a > semiconductor with a housing. The housing protects the sensitive semiconductors.
Like all other diodes, LEDs are pole dependent, i.e. they have connection ends, which function as cathode (negative) and anode (positive). The anode is marked by a longer connection peg. When in doubt, the cathode connection end can be recognised by the flattened area of the border.
The light emitted from LEDs contains almost no heat radiation, because the temperature incurred directly in the chip is dissipated through the housing of the lighting fixture (thermal management).
Due to the monochromatic radiation emission of the light generation as well as the lack of semiconductors, which can simultaneously produce many colours, only primary colours are available in LED technology. > Additive colour mixing or > phosphors must be used to produce the light colour white.
LEDs have the following characteristics.
The > light output and the > colour rendering are dependent on the lamp power and are therefore e.g. at 1-10W relatively low. The lifetime is relatively high at 1,000h-100,000h. It depends greatly on the thermal load of the semiconductor.LEDs are, like all semiconductors, sensitive to electrostatic charges and the corresponding voltage peaks, which can lead to the destruction of the fine connection wires in the housing.
A distinction is made between diverse types of constructions whereby the most commonly used LEDs are small and compact with a diameter of 0.3cm or 0.5cm. There are jumbo-LEDs, mini-LEDs and surface mounted devices, i.e. components, which can be mounted on outer surfaces. Pin|G-sockets are dominant. A precise classification of LEDs is provided by > ILCOS 1231 or the particular > lamp manufacturers.
LEDs are operated on > weak current. A > switched mode power supply is necessary for operation with mains voltage (230V).
Dimming LEDs is possible.

Light Output (η)

Formula: $\eta = \phi / P$
ϕ|luminous flux in lm
P|expended power in W

refers to the effectiveness of a > lamp and indicates the generated > luminous flux with respect to the expended > electrical power. It is measured in lm/W.
The light output can be ascribed to the power input of the lamp alone or to the entire system (system light output). The light output of a 100W incandescent lamp, for example, is 12 lm/W and a low pressure sodium vapour lamp, 105 lm/W.

Light Sources

> electrical light sources

Lighting Fixtures

are fittings for the distribution and|or transformation of the > luminous flux of a > lamp.
These fittings have components, which are required for the fastening, the connection to the power supply and the protection of the lamp.
Lighting fixtures allow the light from the lamp to be modelled to produce specific light effects. This modelling can be achieved with the help of various principles of light steering, e.g. with > reflection, > transmission or > interference.
Lighting fixtures are categorised according to the following criteria: according to application (e.g. decorative lighting fixtures|functional lighting fixtures), the operational location (e.g. indoor lighting fixtures|outdoor lighting fixtures), the type|number, the type of construction, the type of protection, the type of installation (fixed, removable) and according to technical parameters (e.g. > luminous flux, > luminous intensity).
A technically optimal lighting fixture is characterised by a maximum degree of light effect, and a luminous intensity distribution (also the light intensity distribution) as well as a shade which correspond to its application.
From a technical safety standpoint, lighting fixtures must be safe and may not pose any danger to the user during normal operation.

Lighting Fixture Markings

include along with symbols for > protection class, for > protection type and for > fire protection the following marks:
CE markings are mandatory for all lighting fixtures to prove that they meet applicable European safety regulations (EU code).
EMC markings are found on lighting fixtures with electronic or electromagnetic > ballasts as well as > electronic transformers which can radiate and transmit high frequency signals. Because of this, they are only approved for operation when they fulfil the requirements regarding non-interference and are within the limits of interfering transmissions according to the >
VDE|IEC codes. EMC markings (EMC stands for **E**lectro**m**agnetic **c**ompatibility) are found in > control devices and > switched mode power supplies in > LEDs.
Other markings on lighting fixtures are > rated voltage, the rated frequency, when it deviates from 50Hz, and the > rated power of the lamp.
In Germany the VDE badge is prominent or, in other countries, the markings of the corresponding European institutions (e.g. BSI|Great Britain, KEMA|Netherlands, UTE|France, AENOR|Spain, IMQ|Italy).

Live Conductors

are all the materials capable of conducting electricity which are commonly used in an electrical service under voltage and do not include > neutral conductors.
In > three-phase alternating current, there are three live conductors, which achieve their alternating current amperage in various phases. The phase of the amperage is identical in the live conductor and the neutral conductor when there is only one live conductor in the electrical circuit.

Low Frequency

> high frequency

Low Loss Ballasts

> electromagnetic ballasts

Low Pressure Discharge Lamps

are > gas discharge lamps of which some are categorised as either > fluorescent lamps, > compact fluorescent lamps, > induction lamps, or > high voltage light tubes, and others as > low pressure sodium vapour lamps.
Low pressure discharge lamps work with a pressure of less than 1bar and mostly in a rod-form discharge chamber with small > luminescence. The > spectrum is linear, often with a UV content.
For operation, current limiting operating devices are necessary, i.e. > ballasts, in conjunction with > starters, which deliver the required voltage impulse. The current limitation is necessary to prevent a sudden increase in voltage leading to a short circuit, which could destroy the light source. In high voltage systems, > transformers are used which provide the required > ignition voltage and burning voltage while simultaneously limiting the current. A start-up time of a few minutes is necessary before the right vapour pressure is created.

Low Pressure Sodium Vapour Lamps

are > gas discharge lamps, more precisely, > low pressure discharge lamps.
The principle of light generation is based on gas discharge.

Low Pressure Sodium Vapour Lamps
cont.

Low pressure sodium vapour lamps consist of a sodium resistant discharge chamber (made of ceramic or special glass), the burner, containing the sodium necessary for light generation and a gas for ignition and buffering. The maximum light generation is achieved at 290°C, so the burner must have a very good thermal insulation e.g. an infrared reflecting layer.
Low pressure sodium vapour lamps have the following characteristics. They attain a particularly high > light output by virtue of their yellow-orange monochrome > spectrum, which lies near to the maximum > eye sensitivity. The spectrum of a low pressure sodium vapour lamp consists of a double line with a very narrow bandwidth, so these lamps have no > colour rendering. Before they attain their full > luminous flux they need a relatively long warm up time (10-20 min.). Reignition is possible after a power failure of < 10 ms, otherwise a cooling time of 5-10 min is necessary. The > luminous flux is constant over a wide temperature range.The average life is relatively high. The > power is 18-135W.
The most common construction is the tube form. The > operating position is type-specific.The base constructions are screw|E base and bayonet|B base.
A precise classification of low pressure sodium vapour lamps is provided by > ILCOS 1231 or the particular > lamp manufacturers.
Low pressure sodium vapour lamps are operated with mains voltage (230V). An > ignition device is required for operation, along with a > ballast. Special lamps require an > electronic ballast. The > dimming of the lamp is possible using an appropriate > ballast.

Low Voltage Halogen Lamps

are > thermal radiators, more precisely a sub-group of > halogen lamps.
They distinguish themselves from > high voltage halogen lamps by small dimensions in conjunction with thick filaments. Their > power is 5-10W. The average lifetime is 2,000-4,000h.The prevailing base type is the pin|G base.
Low voltage halogen lamps require > transformers for operation with mains voltage (230V).

Lumen

> luminous flux

Luminance (L)

Formula: $L = I/(A \times \omega)$
I|current Intensity in Ampere
A|surface in m^2
ω|solid angle

is a measure of the impression of brightness created in the eye by a self-illuminating or illuminated surface.
It is measured in cd/m^2.
The luminance is the only 'visible' measurement in light technology. The luminance of a pearl light bulb is 5-40cd/m^2 and of a clear light bulb 200-3,000cd/m^2.

Luminescence

refers to the glowing of a body without a simultaneous increase in temperature.
A distinction is made between a fluorescent glow and a phosphorescent glow according to the type of stimulation. As opposed to fluorescence, an afterglow can be observed for a short time after the radiation of phosphorescence.

Luminous Flux (Φ)

Formula: $\Phi = I \cdot \Omega$
I|luminous intensity in cd
Ω|solid angle in steradian

is a physiological measurement which indicates the visually assessed radiant power which is radiated on all sides of a > light source. It is measured in lumen(lm).
Because the brightness sensitivity of the human eye depends on the spectral composition of the light, the visible > radiant power is not given in watts which is the usual measurement of technical energy power of a lamp (> radiant power).
So if a light source radiates equally in a solid angle Ω = 1sr with a > luminous intensity of I = 1cd, then the light source radiates with a > luminous flux of
ϕ = 11m. This corresponds to 0.00144W.
The luminous flux of a 100W incandescent lamp is 1.380lm, and that of a 36W fluorescent lamp is 3.200lm, for example.

Luminous Intensity

Formula: $I = \Phi / \Omega$
ϕ|luminous flux in lm
Ω|solid angle in steradian

describes the quantity of light, which is emitted in a particular direction in a space.
It is composed of the relationship between the part of the > luminous flux and the accompanying solid angle element. Luminous intensity is measured in candela (cd).
The luminous intensity of a lighting fixture is not equally distributed all over a room.

Luminous Intensity cont.

This directional dependency is given in luminous intensity distribution curves as a polar diagram or linear diagram. The luminous intensity for various emission angles is displayed on these curves.
In reflector lamps the luminous density distribution curves are provided, for example, in the product list or manufacturer list.

Lux

> luminous intensity

Mains Voltage

refers to the electrical voltage, which is offered by respective electrical energy providers.
In Europe the > nominal value is 230V|400V with a tolerance of +6% or -10%. The value 220V is outdated. In the USA the > nominal value is 117V which is commonly rounded down to the value 110V.

Metal Halide Lamps

are > gas discharge lamps, more precisely > high pressure discharge lamps.
The principle of light generation is based on gas discharge. Other than in high pressure mercury vapour lamps, the discharge chamber also contains halogen compounds along with mercury and argon, which allow an extended spectral radiation distribution. Their construction corresponds to that of a > high pressure mercury vapour lamps. According to the material of the discharge chamber, i.e. the burner, metal halide lamps are divided into quartz glass burners and ceramic burners.
Quartz glass lamps have the following characteristics.
They have a high > light output with a very good > colour rendering. The bandwidth of possible > light colours is wide and lies at a > colour temperature of 3,000-6,000K.
A warm up time of 3-5min is required before the full luminous flux output is achieved. Reignition is possible immediately after a power failure of up to 10ms, otherwise a cooling time of 8-10min is necessary. The lifetime depends on short-term voltage fluctuations (tolerance +/-3%) and is on average 20,000h. The > power is 20-3,500W.
A distinction is made between numerous types of construction. The > operating position is type-dependent here. There are tube forms and designs without an outer bulb. The glass bulbs can be clear or coated.
The base construction types comprise screw|E bases, pre-focus|P bases, recessed|R bases and pin|G bases. A precise classification is provided by > ILCOS 1231 or the particular > lamp manufacturers.
Quartz glass lamps are operated with mains voltage of 230V for types up to 1,000W and 400V for types of 2,000-3,500W. An > ignition device (timer-ignition device) is necessary for operation along with a > ballast, whereby the ignition device can be integrated into the lamp. With > electromagnetic ballasts care should be taken to use a design with an integrated temperature switch for safety reasons.
Ceramic lamps have the following characteristics.
Their > light output and > light colour correspond to those of quartz glass lamps. The material-dependent higher operating temperatures allow a higher > luminous flux with an improved > colour rendering in the red area of the > spectrum. A warm up time of 90s or 3-5min, depending on the ballast, is required before the full luminous flux output is achieved. Reignition is possible immediately after a power failure of up to 10ms, otherwise a cooling time of 5-15min is necessary. Ceramic Lamps have a long lifetime. The > power is 20-250W.
Dimming of both types of lamp is not recommended but is possible by up to 60% of the lamp power. The > Dimming must be preceded by a burning-in of the lamps at their > rated power from 15min (quartz glass lamp) to 100h (ceramic lamp).
Because metal halide lamps are subject to colour changes in the course of their lifetime, a group change is recommended for multiple lamps. The lamp types can be sub-divided according to their colour temperature, as for > fluorescent lamps.

Neon Systems

> high voltage light tubes

Neutral Conductors

are conductors, which are connected to the star point of a three-phase alternating current or to the return conductor of a single-phase alternating current. In single-phase alternating current it is also called the middle conductor.
Neutral conductors are, like > live conductors, active conductors. A current flow is absent from a neutral conductor when currents of equal intensity flow through the live conductors. If the currents flowing through the live conductor are not equal, current flows through the neutral conductor to compensate for the asymmetry.

Neutral Conductors cont.

Neutral conductors are marked with the letter N and the colour light blue (formerly grey).

Nominal (Rated) Current

> nominal (rated) voltage

Nominal (Rated) Voltage

according to > IEC codes, is the value of the voltage necessary for the operation of a device.
Information about nominal voltage is found on the nameplates of electronic devices.
The nominal voltage is equal to the > secondary voltage when the secondary winding of the transformer takes up the maximum permissible power (nominal load operation).

1-10V Interfaces

are applied in light technology for the analogue control of > dimmers.
A > potentiometer, i.e. a voltage divider of approximately 100kΩ, hereby generates an analogue current input which is transformed by a control device into a PWM-signal, i.e. pulse-wide modulation signal.
Up to fifty independent pieces of equipment can be addressed with the help of a hand-held control device.

Operating (Burn|Burning) Position

defines the position of the > lamp in operation.
The operating position influences light technology parameters, e.g. the > luminous flux and the lifetime.
Operating positions are categorised as follows:
The standing position (s) with a vertical lamp service (base at bottom); the hanging position (h) with a vertical lamp service (base at top); the horizontal position (h/p) with a horizontal lamp service and a variable operating position. BU (base up) and BD (base down) are common markings.
The number following the abbreviation indicates the permissible angle of the operating position in angular degrees (e.g., p45 stands for a horizontal operating position with a permissible angle of +45°).
The operating position is most relevant for > gas discharge lamps. For these types of lamps, not all positions are permitted because operation in some positions can lead to an overheating of the lamp.

Operating Devices

in light technology, is the generic term for electronic components used to operate > light sources.
Operating devices are, for example, > transformers, > ballasts and > switched-mode power supplies. The term is commonly used in light technology but not in electronics.

Operating Voltage

is the required voltage for an electrical device, e.g. a > light source. It is equated with the > rated voltage of the device.

Overview Circuit Diagrams

are a variety of > current flow diagrams.
They display parallel running conductors with the same order of components as a flat picture. The number of parallel conductors is marked with slashes or numbers.

Parallel Connection

means that the elements of a circuit are connected in parallel.
They can, therefore, be provided with equal > potential.

Phase Control Modulation

and phase fired control are methods of regulating electrical power in components which operate on alternating current.
In light technology they are used in > dimmers.
In phase control modulation, which is mostly controlled by a > triac, there is a delayed switching on of the voltage after the zero point of the alternating current and it remains on until the next zero point.
In phase fired control the voltage is switched on immediately after the zero point and shut off again before the next zero point. The complexity of the switching here is greater and is mostly guaranteed by > transistors or > thyristors.

Phosphors

are materials, which are excited by ultraviolet radiation.
The UV radiation results from the mercury emission during the gas discharge. The UV radiation is absorbed by the phosphors in the form of energy and is transformed into visible radiation. Phosphors are used e.g. in > fluorescent lamps and > Leeds. Phosphors are crystalline, inorganic compounds.

Phosphors
cont.

They display > luminescence because they possess energetically separated 'contaminants', i.e., activators, which produce the luminescence. Examples of activators are: heavy metals such as copper, silver, manganese, antimony, lead or noble earths.

Photometry

is the science of measurement of visible light in terms of its perceived brightness to human vision.
The human eye cannot objectively perceive differences in brightness and adapts itself to the particular lighting situation by means of brightness adaptation.
Measuring instruments are used for an objective assessment of the situation. A luminance meter serves to determine the > luminance. A light meter is used to determine the > illumination intensity.

Pin G|F Bases

are single ended and|or double ended > lamp > bases.
The pins make the electrical contact and enable the adjustment in the > holder. Different pin thicknesses or spacings prevent the lamp being inserted into a holder for which it is not intended. The letter 'F' indicates a single pin base, the letter G a two or multi-pin base. The latter seem to be used less often.
Pin bases are used up to a > power of 4,000W.
Typical descriptions are G4/GU10 and G/13/G5 and Fc2 (> base descriptions).
Pin bases are found in e.g. halogen lamps, fluorescent lamps and high pressure sodium vapour lamps.

Plasma Radiators

> gas discharge lamps

Plugs

serve to connect the cable of an electrical device to the mains supply.
A plug system comprises the plug and the socket.
The plug is usually on the end of a cable, the socket can be built into the housing of a device or fixed to the end of a cable. > Cord grips can be fitted to prevent damage to the cable. Sockets are also colloquially called plugs.
Plug systems are subject to technical safety codes, which result in certain devices being incorporated on the cable, e.g. > core cable ends, or on the plug itself, e.g. > **p**rotective **e**arth conductor (PE).
The testing and approval is carried out by the respective European bodies equivalent to the > VDE.
There are numerous international standardised plug connectors. Only a few examples are mentioned here.
This standardisation of plugs was developed in the USA and is divided into standards for the shape of the plug and standards for the electrical signal.
The classification of international household plugs uses the letters A-M.
For example type A/B indicates American 2/3 pin plug systems, type C CEE 7/16 European flat plug, type E French plug systems, type EF CEE 7/17 Europlug systems, type F CEE7/4 German Schuko plug systems (Schuko" is a short form of the German term Schutzkontakt, literally: protective contact), type G BS 1363 British plug systems, type J Swiss plug systems und type L Italian plug systems.
American plugs are characterised by two very flat contacts, which are parallel to each other (type A). A round contact pin, which is located offset between them, mostly serves as the > protective earth conductor (type B).
The European flat plug was developed for universal use in Europe for a maximum load of 2.5 ampere. It is found in low power protectively insulated devices e.g. light sources. The standard for the European flat plug is EN50075. It is manufactured as a unit with an injection moulding process and thus cannot be opened|repaired. The two contacts are parallel to each other, 9 mm long and made of metal. The tip is rounded.
Numerous plugs on light art objects, especially older ones, do not fulfil the technical safety requirements. It can thus be necessary to replace the plug with a new, safe one and to keep the original plug separately from the object.
With light objects, the plug shapes are an initial visual indication of incompatible systems e.g. USA|110V - Europe|230V. A > transformer will be necessary here. In individual cases an adaptor can help.

Potential

> electrical voltage

Potentiometers

commonly referred to as pots, are continually adjustable > resistors. They consist of a holder, which is coated with a resistant material and a moveable sliding contact, which divides the total electrical resistance into two partial resistances.
Potentiometers are commonly used for controlling electrical devices. In light technology they can be found in control arrangements of > dimmers.

Power

> electrical power

Power Converters

are switchable electrical devices which convert one type of current into another with the help of electronic components e.g. > thyristors or > triacs.
Power converters, which convert alternating current into direct current, are called rectifiers. Those, which convert direct current into alternating current, are called inverters.
There are power converters, which can be selected to operate as rectifiers or inverters.

Power Supply

> switch mode power supply

Prefocu|P Bases

are single ended > lamp > bases.
They are distinguished by a relatively wide supporting surface which enables a better placement in the > holder. Base lobes prevent placement in an inappropriate base.
Typical designations are P40s, (13.5s) (> base descriptions).
Prefocus bases are used for > metall halide lamps and > low voltage halogen lamps for example.

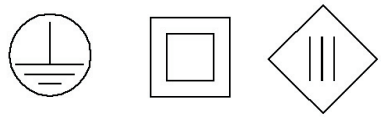
Primary Voltage

refers to the voltage which is applied to the supply side of > transformers. The voltage on the second connection of the transformer is called the > secondary voltage. The primary voltage is the same as the > mains voltage if the transformer is operated from the mains.

Protection Classes

of lighting fixtures are based on the German > VDE codes are serve to prevent the danger of an electric shock from touching.
There are three protection classes, which are found on the housing covers as symbols.
Protection class III is applicable to lighting fixtures connected to a > weak current which is generated with batteries or a > transformer.
Protection class II is applicable to lighting fixtures with reinforced protective insulation. In these any metal parts, which could receive a voltage as soon as a fault occurs, may not be touchable.
Protection class I applies to lighting fixtures with a simple base insulation. These have an attachment point for the > protective earth conductor, with which all touchable metal parts which could receive an electrical voltage as soon as a fault occurs must be connected.

PROTECTION CLASSES



Protection Systems

of lighting fixtures are based on the > IEC codes and classify the protection against external influences.
This **I**nternational **P**rotection|IP system is used for all electrical devices and is found on the housing covers (nameplate). The coding system comprises an IP number, a number x and a number y. The number x indicates the protection against foreign bodies (grid symbol) and the number y the protection against water (drop symbol).

Protective Earth Conductors (PE)

also called protective earths or earths, are electrical conductors which protect humans against dangerous body currents.
Protective earth conductors are directly earthed. They build an electrical connection between the outer metal housing of the electrical device e.g. a light source and the earth potential. The resistance between housing and earth must be small enough to allow effective safety.
Should the electrical supply voltage reach the outer part of device when a fault occurs and thus endanger humans, the current flows through the protective earth conductor and not through the person when they touch the device. If a > residual current device is built into the circuit, it is activated by a flow of current through the protective earth conductor.
Protective earth conductors must be indicated with the colour combination green|yellow (previously red). To avoid confusion, > wire insulation may not be red, green or yellow (cable).

Quantity of Light (Q)

gives information about how much > luminous flux is emitted in a particular period of time (e.g. lifetime of a light source).
It is given in lumen-hours (lm·h).

R|S Bases

are double ended > lamp > bases.
The lamps are clamped or screwed into the > holder with the R|S base, whereby this connection makes the electrical contact at the same time.
R|S base are used for a > power of up to 4,000 W.
Typical descriptions are R7s, RX7s, SFa, SFc.
R|S bases are found in e.g. > high voltage halogen lamps and > metal halide lamps.

Radiant Power (Φe)

describes the energy sent out as radiation from a light source in its characteristic spectral region.
It is measured in watts (W). It is not assessed with the > eye sensitivity. If the radiant power is assessed with the eye sensitivity this gives the > luminous flux.

Rated Power

according to > IEC codes, is the established value of > electrical power for the designation of a > lamp.
Information about the rated power can be found on the lamp packaging as well as on the lamps themselves.

Reflection

means that a part of the electromagnetic waves, i.e. the light ray, are thrown back on impact with a material.

Reflectors

are devices on > electric light sources that can throw back electromagnetic waves i.e. light rays.
The direction of the reflected radiation can be influenced by the choice of suitable material and the shaping. Reflectors are found in spotlights or also in lamps (reflective coating in > halogen lamps).

Refraction

means the change in direction of an electromagnetic wave, i.e. of a light ray, at the border between two media.

Relays

are mostly electromagnetically operated switches that are operated with electrical current.
Relays are activated by a control circuit and can close, open or switch one or more load circuits.They are used to simultaneously switch several load circuits with a single control circuit. They can also be used to control a high power load circuit with galvanically isolated (> galvanic isolation)low power circuit.
There are various types of relays, e.g. > contactors, solid state relays (SSR) (> transistors) and timing relays.

Residual Current Devices (RCD)

are used to avoid dangerous body currents, where a current of only 40mA can be fatal for humans.
A body current arises when a person touches two poles of different voltages e.g. the live wire and the earth of the housing.
The RCD receives current from the > live conductor L and the > neutral conductor N of the appliance circuit. If a fault occurs in N, a part of the current flows through the housing. A residual current arises between L and N. If this exceeds a defined threshold, the RCD disconnects the appliance circuit from the mains supply.

Resistance

> electrical resistance

Screw|E Bases (Edison Bases)

better known as edison bases are single ended > lamp > bases.
Typical descriptions are e.g. E10 and E27 (> base descriptions).
Screw|E bases are found in e.g. > incandescent lamps.

Secondary Voltage

is the same as the > nominal voltage of electrical devices when the maximum allowed power of a > transformer is drawn from its secondary winding.
The term is used in connection with > transfomers and is found on their housing covers (nameplate).

SELV (Safety|Separated Extra Low Voltage)

> extra low voltage (ELV)

Semiconductors

are thermal electronic components which, depending on the temperature,act as conductors or non-conductors.

Semiconductors cont.

The conductivity increases with increasing temperature. The conductivity can be controlled by applying a > control voltage or control current. Discrete semiconductors e.g. diodes and transistors can be built as a combination of N-type and P-type i.e. negative and positive doped regions. Complex semiconductors are, however, put together from many components in a single crystal. An example of this is an integrated circuit. Semiconductors are used e.g. in > light emitting diodes.

Series Connection

means that the components in an electrical circuit are connected in series. Thus the whole circuit is broken when a break occurs in one place e.g. when a lamp burns out.
A special form of series connection is used with > fluorescent lamps. In this case, two fluorescent lamps are operated in series from one > ballast, whereby one device can be saved and the idle power reduced.

Short Circuit

refers to a faulty connection in electrical conductors, which are carrying electrical voltages of different polarities.
A short circuit triggers an overload switch or a (melting) fuse. The resulting current overload can destroy electric devices.

Spectrum

describes in light technology the distribution of > light depending on its wavelength.

Spotlights

are > electrical light sources, with which the > luminous flux of the > lighting fixture is concentrated in a narrow angular range.
The light focussing can be achieved with > reflectors, > lenses or a reflector-lens combination. A good focussing can be achieved with parabolic or ellipsoid mirrors.
The escaping beam of light can be influenced externally with > filters, screens > vignettes i.e. patterned screens and shutters i.e. metal blades.
Spotlights are manufactured in various sizes e.g. for > halogen lamps, > high pressure mercury lamps, > metal halide lamps and > high pressure sodium lamps.
Spotlights are divided into three types according to their construction: those with symmetric, asymmetric and rotationally symmetric luminous intensity distributions.
Spotlights are typified by their > luminous intensity, their > illumination intensity at a given distance, their luminous intensity distribution in the beam, their scattering and their spotlight efficiency.
There are various types e.g. floodlights, lens spotlights and profile spotlights.

Star Connection (Y Connection)

means that the elements of a > three-phase alternating current circuit are connected in a star.

Starters

are electronic components, which are used in fluorescent lamps to preheat the electrodes.
They interrupt the electrical circuit after the preheating phase and thus deliver, along with the > ballasts, the > ignition voltage necessary for fluorescent lamps. Starters consist of a bimetallic strip, which is warmed by the current flow and thus interrupts the electrical circuit after a certain time.
There are three types of starter, glow starter, safety starters and electronic starters
In a glow starter, the glow ignitor and the radio frequency interference (RFI) capacitor (capacitor) preheat the electrodes and generate the ignition voltage in the > ballast. The power consumption for this process is low. After the lamp has been switched, the glow starter is immediately ready for operation.
In a safety starter, the starter is switched off by means of a > bimetallic relay if the lamp does not ignite. With the help of a button projecting out of the starter housing, the bimetallic switch can be switched on again and the starter activated. According to the type of lamp, there are different safety starters with a switch-off time of 20-75s. This type of starter prevents damage to the device considerably.
Electronic starters allow a definable preheating of the lamp electrodes. The ignition time is less than 1.7s. They also switch off after failed attempts to ignite and thus prevents damage to the electrical device.

Starters
cont.

There are different types of construction of starters, e.g. starters for > series connection or single connection, standard starters and starters for special uses.

Strip Connectors

> Connectors

Subtractive Colour Mixture

describes an optical model for the behaviour of surface colours in the mixing of colour pigments.
Surface colours are only visible with lighting. The visible spectrum encompasses all the colour components of the light spectrum to which the receptors in the human eye can react.
An object is perceived as coloured because it absorbs all the colour components except its own colour, hence the term subtraction. If two colours are subtractively mixed, both decrease the spectrum.
The principle of subtractive colour mixture is used e.g. in > filters.

Supply Voltage

is a synonym for > mains voltage

Switch Mode Power Supplies (SMPSs)

are switchable electronic components that can transform the required > electrical voltage (e.g. a light source) from the mains voltage. They mostly contain a > transformer for the > galvanic isolation of input and output.
First of all a direct voltage is generated from the mains voltage i.e. alternating current (> electrical current). This direct voltage is then switched at a high frequency and so transformed up or down according to the switching.
The advantage of SMPSs is the high operating frequency of the load circuit, through which the necessary inductive components (> induction) are for the same power significantly smaller. SMPSs are characterised by a relatively low weight and volume. The disadvantage of SMPSs is the possible interference due to the high frequency switching (> light fixture markings).
SMPSs are used in light technology e.g. in > light emitting diodes or > halogen lamps. They are also known in computers and charging devices.

Thermal Radiators

are electrical light sources which emit the main part of their radiation as infrared radiation i.e. heat radiation, hence their name.
The radiation is emitted by heating a material (mostly tungsten).
The emission spectrum is continuous and temperature dependent. The part of the emitted radiation in the visible region is relatively small. Thermal radiators have a relatively small > light efficiency and lifetime. They are operated mostly with the mains current but also with a > transformer.
Thermal radiators include > incandescent lamps and > halogen lamps.

Three-phase Alternating Current

is also referred to as heavy current.
It describes three alternating currents which are connected and are set according to time. They are thereby referred to as phase-shifted. The middle point is called the star point. The star circuit enables a four conductor mains with three live conductors (L 1|2|3 with **L** as the abbreviation for **L**ive conductor) and a neutral conductor (N).
Between L 1|2|3, each carries a voltage of 100V, between L 1-3 and N, the voltage is 230V. Because of this configuration various connections are possible whereby all three phases should be equally loaded.

Current

> Electrical current

Thyristor

is a word formed from **thyr**atron and trans**istor**.
Thyristors are > power converters, more precisely rectifiers. They are operated with > alternating current and produce > direct current.
More precisely they are controllable > semiconductors which are used e.g. in > dimmers as electronic switches.

Transformers

are devices which enable > alternating voltages to be transformed up and down and thus to meet the particular usage requirements.
Transformers are used for lamps in high voltage operation and low voltage operation. The transformer produces the required > ignition voltage for high voltage light tubes and after the ignition voltage the burning voltage.

Transformers
cont.

There are > electromagnetic and > electronic transformers. Diverse types and types of construction are existant. Electromagnetic transformers are often big and heavy. They are therefore mostly located separately from the light source. Electronic transformers are lighter and smaller. They can be concealed in the lighting fixture.
All the important specifications of transformers like e.g. the > secondary voltage and > primary voltage are found on the housing cover (nameplate).

Transistor

stands for the abbreviation of **trans**formation res**istor**.
These are electronic components, more precisely > semiconductors, which are used to switch > electrical voltages|currents. More precisely, they are > electrical resistances which can be controlled by a current.

Transmission

means that a part of the electromagnetic wave i.e. the light ray passes through a material.
The transmittance indicates the translucence of a material.

Triac

Stands for the abbreviation of **tri**ode **a**lternating **c**urrent switch. Triacs are power converters, more precisely inverters. They are operated with > direct current and produce > alternating current. More precisely they are controllable semiconductors which are used for > dimmers as electronic switches.

VDE

is the abbreviation for the Germany-based **V**erband **d**er **E**lektrotechnik Elektronik Informationstechnik e.V. i.e. the organisation for electrotechnical, electronic and information technology (http://www.vde.com/vde).
The VDE corresponds to European organisations like e.g. BSI (Great Britain), KEMA (The Netherlands), UTE (France), AENOR (Spain), IMQ (Italy).

Vignettes (Deckles, Gobos)

are used in light technology to project light patterns onto surfaces with a > spotlight.
Vignettes are small, mostly round metal or glass plates into which a pattern is stamped. The pattern is formed when the opaque coating is removed from certain places, depending on the pattern. The use of multi-layered coloured glasses allows patterns to be produced in any colour. Glass vignettes are more heat-resistant than metal vignettes.

Voltage

> electrical voltage

Weak Current

> extra low voltage (ELV)

Wires

refers to the individual current conducting wires or > flexes of a > cable.
In multi core cables the individual wires are always insulated by a wire insulator. All of the wires in a multi core are housed in an outer layer called the cable sheath.

Xenon Arc Lamps

are > gas discharge lamps, more precisely > high pressure discharge lamps.
The principle of light generation is based on gas discharge. Pure xenon is used as the gas filling.
Xenon arc lamps are characterised by a very good > colour rendering. The lifetime is around 2,000h (?).
An > ignition device and > ballast are necessary for their operation.

LIST OF SOURCES

LITERATURE CONSULTED

Ris, Hans Rudolf
Beleuchtungstechnik für Praktiker, 3rd ed., Berlin (2003)

Mueller, Jens
Handbuch der Lichttechnik, 2nd revised and expanded ed., Bergkirchen (2005)

Hilbert, Günter S.
Sammlungsgut in Sicherheit, 3rd fully revised and expanded ed., Berlin (2002)

Baer, Roland
Beleuchtungstechnik-Grundlagen, 3rd fully revised ed., Berlin (2006)

Tkotz, Klaus
Fachkunde Elektrotechnik, 24th revised and expanded ed., Haan-Gruiten (2004)

Gillich, Helmut
Experimente mit Elektrolumineszenz, Poing (2003)

Weis, Bruno
Beleuchtungstechnik, München (1996)

Zieseniß, Carl-Heinz
Beleuchtungstechnik für den Elektrofachmann, 7th newly revised ed., München (2002)

Van Wetten, Katja
Vom Umgang mit Hochspannungs-Leuchtröhren an Kunstobjekten – am Beispiel von Bruce Nauman, Joseph Kosuth und Mario Merz, Diplomarbeit (Degree Dissertation), Stuttgart (1997)

Weibel, Peter und Jansen, Gregor
Lichtkunst aus Kunstlicht - Lightart from Artifical Light, Ostfildern (2006)

Sonepar Deutschland GmbH
Licht und Leuchten, Düsseldorf (2005/06)

LITERATURE CONSULTED (NO STATED AUTHOR)

Brockhaus Encyclopaedia in 24 volumes, 20th newly revised ed., Leipzig/Mannheim (1996)
Lighting Technology – Beleuchtungstechnik, in: engine – Englisch für Ingenieure, Vol.4, Darmstadt (2005), pp.22-25

INTERNET ADDRESSES

http://www.iec.ch/ nov 06

http://www.lagotronics.nl/ dez 06
http://www.proav.de nov 06
http://www.shepperd.co.uk/techlinks/pages/Lighting/Manufacturers/ dez 06
http://www.vde.com/vde nov 06
http://de.wikipedia.org/wiki nov 06
http://www.cwaller.de/deutsch.htm feb 07
http://www.infoline-licht.de/infoline/licht/grundbegriffe/index.htm feb 07
http://www.licht.de feb 07
http://www.schorsch.com/de/kbase/glossary/ feb 07
http://www.viva-lite.com/de/glossar.shtml feb 07
http://www.info.dimmer.de/dindex.htm feb 07
http://www.osram.de/service_corner/lichtlexikon/index.html feb 07
http://www.siteco.de/de/licht/glossar.html feb 07
http://www.ptb.info/de/org/4/41/412/groessen.htm feb 07
http://www.on-light.de/htm/lampen/index.htm feb 07
http://www.on-light.de/htm/leuchten/index.htm feb 07
http://www.on-light.de/htm/leuchttechnik/index.htm feb 07
http://www.bailey.nl/ feb 07
http://www.bulbrite.com/ feb 07
http://www.eiko-europe.de/ feb 07
http://www.encapsulite.co.uk feb 07
http://www.feldmann-speziallampen.de feb 07
http://www.zumbtobel.com/com/de/Default.htm feb 07
http://www.trilux.de/tx/opencms/DE/de/Trilux/News/Lichtmanagement.html feb 07
http://www.brumberg.com/deutsch.php?id=1 feb 07
http://www.britannica.com feb 07
http://www.askoxford.com feb 07
http://www.getinfo-doc.de feb 07
http://www.howstuffworks.com feb 07