Control gear and control equipment

In addition to lamps and luminaires supplementary equipment is often required in order for a lighting installation to function. The most important additional equipment is control gear, which is necessary for the operation of many lamp types.

Lighting control equipment, on the other hand, is not required to operate the luminaires. It is used to switch luminaires on and off and to control their brightness – and sometimes also other luminaire characteristics.

2.4.1 Control gear for discharge lamps

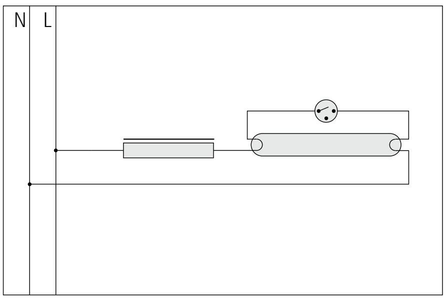
Typical of all discharge lamps is their negative current versus voltage characteristic, i.e. the lower the voltage the higher the operating current. In contrast to incandescent lamps, where the filament acts as a current limiting device, the operating current in the case of discharge lamps is constantly on the increase due to the avalanche ionisation effect of the inert gas, which if left uncontrolled would result in the destruction of the lamp.

To operate discharge lamps it is therefore necessary to use a ballast to limit the current. In their simplest form these are ohmic current limiters. This type of current limiting device is not frequently used, however, since it tends to heat up, which in turn leads to substantial energy consumption; they are occasionally used for self-ballasted mercury lamps, which use a filament as an ohmic current limiter.

Current limitation using super-imposed capacitors – i.e. via capacitive reactance – reduces the loss of energy, but decreases the lamp life, so is similarly not a popular solution. In practice, current limitation is mainly effected via the application of inductive current limiting devices such as lag ballasts or transformers, especially as this kind of ballast has the added advantage that it can be used to produce the striking voltage to ignite the lamp. High-frequency electronic control gear is gaining importance alongside inductive ballasts. Besides their function as current limiting devices electronic ballasts also serve as ignitors and ensure that the lamp operates more effectively.

The ignition voltage of discharge lamps is well above their operating voltage and usually also above the mains voltage provided. Special equipment is therefore required to ignite the lamps. This may be a matter of auxiliary electrodes built into the lamp that ionise the gas in the lamp via a luminous discharge. However, ignition is usually effected via a voltage surge, which can be produced inductively by the starter and the ballast, but a leakage transformer or an ignitor is required in the case of higher ignition voltages.

More recently both electronic starters and electronic ignition devices have become available.



Circuit diagram of a fluorescent lamp with an inductive ballast and ignition device (not power-factor corrected).

2.4.1.1 Fluorescent lamps

Fluorescent lamps can be operated on a *conventional ballast* (CB) and a starter. In this case the ballast functions as an inductive resistor; it comprises a lag ballast which consists of a laminate iron core and a copper-wire winding.

Conventional ballasts are the cheapest kind of ballasts, but they do give rise to significant losses of energy due to the generation of heat.

Low loss ballasts (LLB) are comparable to conventional ballasts, except that their core material is of a higher quality and they have thicker copper wires to reduce the loss of energy in the control gear. Low loss ballasts are only slightly more expensive than conventional ballasts, so they are frequently used in lieu of the latter.

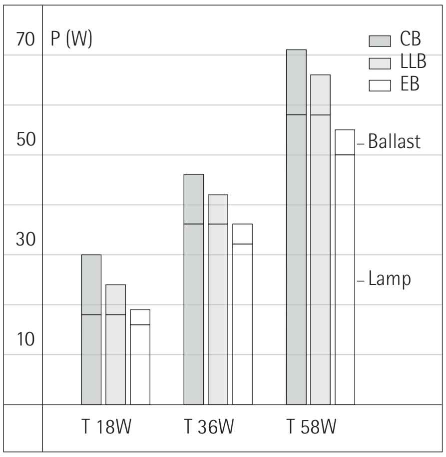
Electronic ballasts (EB) differ in weight, form and function from conventional, inductive ballasts. They consist of a filter, which prevents any reactive feedback onto the mains supply, a rectifier and a high-frequency inverter.

Electronic ballasts have an integrated ignition device, which means that no additional ignitor is required. They ensure a flicker-free start and switch off automatically if the lamp is defective, which prevents the ignitor being activated time and again; switching and operation are as trouble-free as with incandescent lamps.

Operating the lamps at 25–40 kHz presents a number of advantages, above all, enhanced luminous efficacy. This in turn means that the luminous power is achieved, but at a lower energy consumption. At the same time there is considerably less power loss. The high operating frequency of the lamps also prevents stroboscopic and flicker effects, and magnetic interference and humming, all of which are associated with conventional ballasts.

Electronic ballasts are to a large extent insensitive to voltage and frequency fluctuations. They can be operated at both 50 and 60 Hz and over a voltage range of between 200 and 250 V. As they are also designed to be run on direct current, fluorescent lamps with EBs can be operated on batteries, should there be a current failure, thereby simplifying the provision of emergency lighting. Electronic ballasts are, however, more expensive than inductive ballasts.

If fluorescent lamps are operated using inductive ballasts it is necessary to provide a separate starter. The starter first preheats the lamp electrodes. Once the electrodes are sufficiently heated the starter breaks the circuit. This induces a voltage surge in the ballast which in turn ignites the lamp. The simplest form of ignitors are *glow starters*. They comprise bimetal electrodes



Power consumption P (lamp power and power loss of ballast) of standard fluorescent lamps run on conventional (CB), low-loss (LLB) and electronic ballasts (EB).

encased in a glass tube filled with inert gas. Switching the lamp on produces a luminous discharge between the electrodes in the starter, which in turn heats up the electrodes. During this process the bimetal electrodes bend inwards until they touch, thereby closing the heater or filament circuit of the fluorescent lamp. After a short time the starter electrodes cool down and separate. This disconnection induces a voltage surge in the ballast which in turn ignites the lamp. When the lamp has been ignited it is only the operating voltage of the lamp that is applied to the starter. This is insufficient to produce a luminous discharge in the starter. The electrodes therefore remain open, which avoids the lamps being permanently heated.

Glow starters are the starters most frequently used and they are the most economical. They do have one drawback: they repeatedly try to ignite the lamp in the event of it being defective. This gives rise to noise and flickering lamps. Moreover, ignition problems may arise in the case of undervoltage or low ambient temperatures due to the fact that the preheating times are inadequate.

Safety starter switches are similar to glow starters. They switch off automatically after repeated attempts to ignite the lamp, thereby ensuring that defective lamps are not subjected to continuous ignition. To operate the starter again it is necessary to reset the safety switch manually.

Thermal starters have contacts that are normally closed when the lamp is switched on. The contacts are disconnected by means of an additional heating element which heats up a bimetal strip or dilating wire. The starter only opens when it has been sufficiently preheated and since the preheating time is prolonged if the temperature or the voltage conditions are not ideal, ignition is not always trouble-free. As there is no need for an initial warm up period to the point of contact, the result is that thermal starters ignite faster than glow starters. Thermal starters are more expensive than glow starters. Some versions require a separate heating current supply through the ballast.

Electronic starters open and close the preheating circuit without any mechanical contacts. They ensure a quick and safe start under a much wider range of conditions; in the case of defective lamps the re-ignition process is terminated.

2.4.1.2 Compact fluorescent lamps

Compact fluorescent lamps are operated on the same ballasts as conventional fluorescent lamps. In the case of lamps with a bipin base the starter is integrated, so they can be operated on inductive ballasts without an additional ignition device. Lamps with four-pin bases can be operated on an inductive ballast with a separate starter or on an electronic ballast.

2.4.1.3 High-voltage fluorescent tubes

High-voltage fluorescent tubes require an operating voltage that is considerably higher than mains voltage. They are therefore run on a leakage transformer, which handles the ignition with its high open potential, and then reduces the voltage during the operation of the lamp. Additional starters or ignition devices are not necessary.

Special regulations have to be observed in Germany (VDE 0128, 0713, 0250) for high-voltage fluorescent tubes run at 1000 V and above. Planners prefer to opt for installations comprising shorter high-voltage fluorescent tubes and voltages below 1000 V, which only have to meet the requirements laid down for low-voltage installations (VDE 0100).

2.4.1.4 Low-pressure sodium lamps

Some linear type low-pressure sodium lamps – similar to fluorescent lamps – can be run on chokes or inductive ballasts with an additional starter. As a rule, ignition and operating voltage are so high, however, that a leakage transformer is used to handle ignition and current limitation.

2.4.1.5 High-pressure mercury lamps

High-pressure mercury lamps are ignited using a glow discharge through an auxiliary electrode. Additional starters or ignition devices are therefore not required. Current limitation is controlled via inductive ballasts, as for fluorescent lamps. These ballasts must, however, be designed to handle the higher operating current.

2.4.1.6 Metal halide lamps

Metal halide lamps are run on inductive ballasts. An extra ignition device is generally required (e.g. impulse generator).

Instant re-ignition of the lamps after a power failure is required in the case of the lighting of certain traffic installations and meeting places. Double-ended metal halide lamps are equipped with special ignitors which supply the necessary high ignition voltages that make an instant restart possible.

Electronic control gear is also available for metal halide lamps. They have similar properties and advantages to the electronic ballasts for fluorescent lamps, while at the