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High Intensity Discharge lamps

Technical information on reducing the wattage

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1. Introduction

High intensity discharge lamps generate light by exciting mercury respectively other metals in a plasma. The plasma is generated in an arc tube by current flowing between two electrodes. The electrodes are inserted into the discharge vessel so that it is sealed completely.

Discharge lamps have to be operated with a ballast and are rated for a certain wattage. The ballasts consist of conventional chokes (CCG) and electronic ballasts (ECG).

When operating discharge lamps at a choke, the lamp wattage follows the curve shown below, depending on the lamp voltage. The lamp voltage is normally selected near to half the grid voltage because the curve is flat at this point, i.e. the wattage only undergoes relatively slight changes when the lamp voltage increases. The voltage of high pressure sodium lamps and metal halide lamps increases during the lamp life.

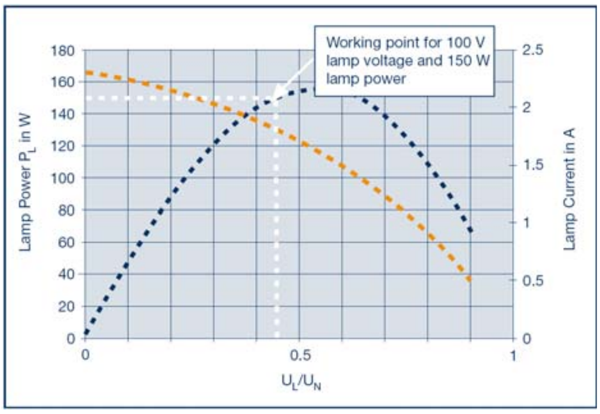

Fig. 1: Model of a choke curve, lamp wattage in blue, lamp current in orange

The inductivity of the choke leads to a phase shift between the lamp current (and choke current) and the supply voltage, as also shown in figure 2. Before every zero crossing, the current decreases because of its approximate sine shape. The lower current means that both the plasma and the electrodes cool down. The recombination of electrons with ions reduces conductivity. This is why following the zero crossing of lamp current and voltage, the plasma is not immediately capable of carrying the current that the choke wants to drive.

The voltage across the lamp increases initially, forming the so-called re-ignition peak – so the plasma has to be re-ignited first. The higher voltage results in greater ionization with increased conductivity and therefore reduced voltage again.

If the re-ignition voltage now exceeds the value of the supply voltage at this point in time, then the lamp extinguishes. One great advantage of electronic ballast with rectangular voltage and current is the steep zero crossing. This means that plasma and electrodes scarcely cool down at all and there is almost no more formation of a re-ignition peak.

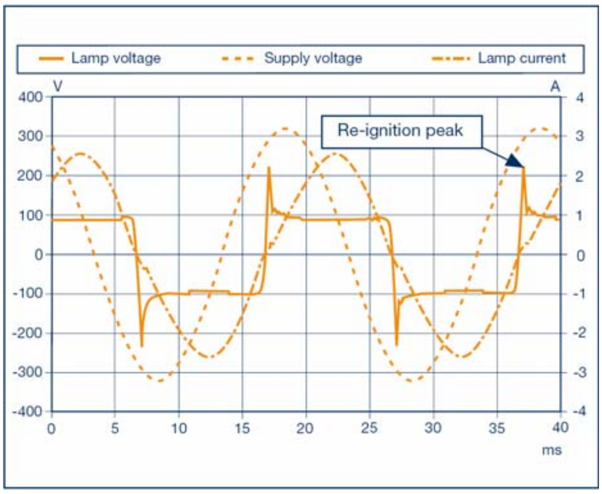

Fig. 2: Lamp voltage and current and supply voltage in a metal halide lamp

To change the nominal lamp wattage of a lamp, the following physical general conditions are significant for the resulting effects:

- The electrodes of discharge lamps are rated for a certain lamp current. If the current is too high, parts of the electrode melt and evaporate. If the current is too low, the electrode is operated in cold state. This changes the mechanisms of how electrons are released from the electrode so that more electrode material is eroded to the arc tube wall. Deviations of the lamp current from the nominal value in both directions can thus cause a blackening on the arc tube wall with a decrease in luminous flux, together with negative effects on the light color and possibly also on the life of the lamp.
- The vapor pressure of the filling components responsible for producing the light depends on the temperature of the arc tube wall. A change in the arc tube wall temperature caused by a change in the lamp wattage influences the composition of the filling in the plasma arc and thus the electric and photometric properties of the lamp.

2. Methods of reducing wattage

The following dimming methods are generally known (by conventional means or electronic ballast):

- Reducing the supply voltage
- Phase control: **leading** edge, **trailing** edge
- Increasing the choke impedance respectively reducing the lamp current (amplitude modulation)
- Changing the frequency for high-frequency operation

Reducing the supply voltage

A reduction in supply voltage also decreases the lamp wattage. While reducing the lamp wattage also decreases the lamp voltage and the re-ignition peak, this is generally to a lesser extent than the reduction in supply voltage.

This reduces the interval between re-ignition peak and supply voltage, making it more probable that the lamp will go out. This applies particularly to old lamps where the lamp voltage and re-ignition voltage have already increased.

Fig. 3 shows, as an example, the behavior of certain lamp types on reducing the supply voltage. It illustrates the ratio of re-ignition peak to supply voltage compared with the value at 220 V.

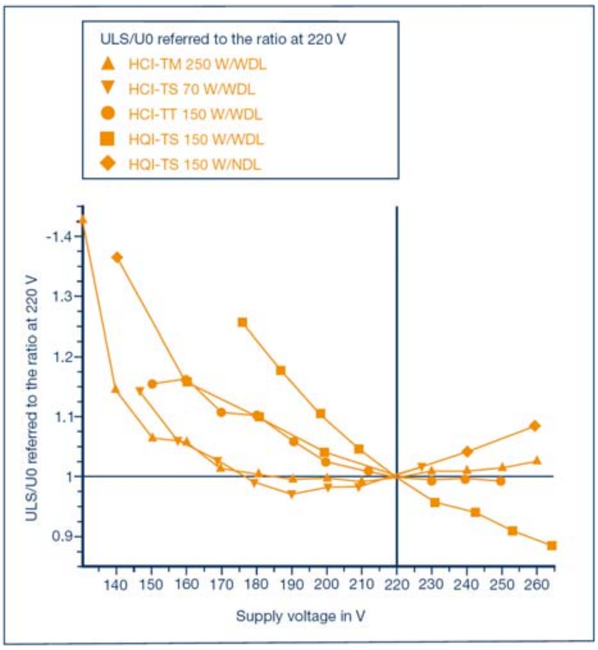

Fig. 3: Relative change in re-ignition peak (ULS) to supply voltage referred to the ratio at 220 V

Accordingly with the exception of the high pressure mercury lamps, dimming must **not** be brought about by reducing the supply voltage, as the re-ignition peak can cause the lamp to go off earlier or to flicker.

Phase control: leading edge, trailing edge

Figs. 4 and 5 show the decrease in effective supply voltage by phase control with leading edge and trailing edge. There are also variations in which the supply voltage is reduced in the middle and not before or after the zero crossing. It is also possible just to reduce the supply voltage and not to take it right down to zero.

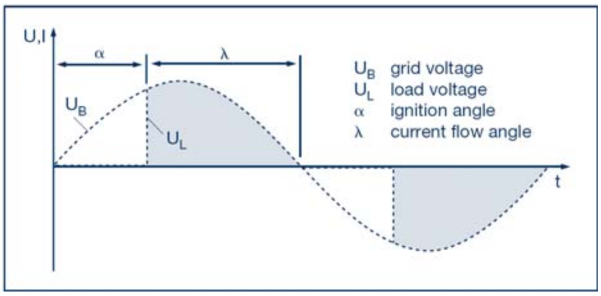

Fig. 4: Principle of phase control with leading edge (idealized diagram)

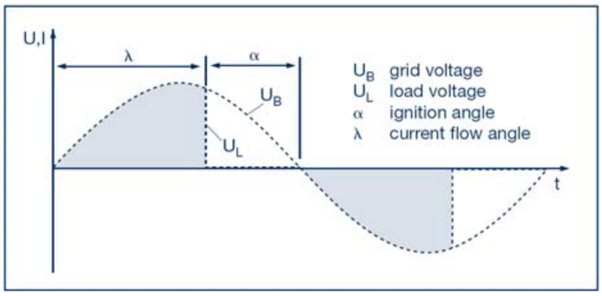

Fig. 5: Principle of phase control with trailing edge (idealized diagram)

For phase control with **leading** edge, the resulting idle intervals result in a greater cooling down of plasma and electrodes, thus increasing the re-ignition peak so that the lamp goes off earlier.

For phase control with **trailing** edge or other methods where the supply voltage is temporarily switched off or reduced, suitable means are required to provide an uninterrupted "smooth" lamp current as the lamp can otherwise flicker and go off.

Increasing choke impedance respectively reducing lamp current

Increasing choke impedance reduces the current through the lamp. The supply voltage remains the same so that the voltage is still high enough to re-ignite the lamp. The flatter zero crossing of the current does however result in greater cooling down of plasma and electrodes, with greater blackening caused by the processes at the electrode during re-ignition.

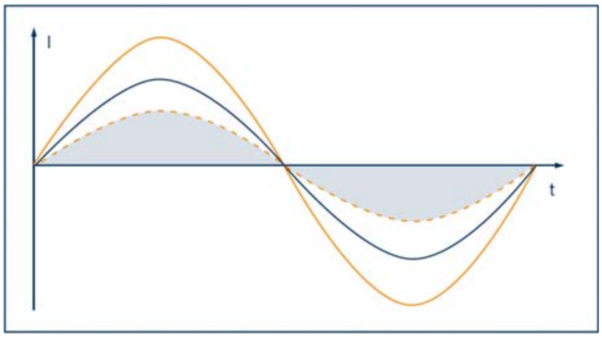

Fig. 6: Amplitude modulation e.g. by choke changeover

The least disadvantages are expected from current reduction in rectangular mode. The steep zero crossings mean that lower re-ignition peaks and less blackening from sputtering can be expected.

Changing the frequency in high-frequency operation

Consideration must be given to the possible occurrence of acoustic resonance when discharge lamps are operating at high frequency. In the discharge tube, resonances can start to oscillate depending on arc tube geometry and plasma temperature, when the high-frequency parts of the lamp wattage meet a resonance frequency of the lamp. This can cause flickering and, in the worst case, destruction of the lamp. This is why the proposed standard for electronic operation of metal halide lamps limits the amount of high-frequency oscillations.

It is therefore difficult to find reliably resonance-free operating windows, because the resonance frequencies change during the start-up phase and also over the life of the lamp, and because it should be possible to operate lamps with differing geometries and fillings at the same operating device. A reduction in wattage also changes the resonance frequencies due to the change in plasma temperature.

3. Recommendations for reducing the wattage of High Intensity Discharge lamps

High pressure mercury lamps

These lamps can be dimmed to 50 % of the rated wattage, whereby they must start up with 100 % wattage. Dimming is possible by voltage reduction, phase control and amplitude modulation.

High pressure sodium lamps

All VIALOX® NAV® lamps can be operated at 50% of their rated wattage without negative impact on lifetime through

- step switching by changing to inductive control gear with the next lower rating
- step switching with additional inductance,

whereby in both cases electronic power switches have to be used.

The lamps must be started at rated wattage and must operate at rated wattage for about 10 minutes before reducing lamp power.

Lamp power must not be reduced by lowering the mains voltage or leading edge phase control.

OSRAM recommends for dimming the electronic control gear POWERTRONIC® PTo.

Metal halide lamps

POWERSTAR® HCI® (cylindrical arc tube) and POWERSTAR® HQI®

Reduced wattage operation of POWERSTAR® HCI® (cylindrical arc tube) and HQI® lamps is **not permitted** as this could result in considerable deviations in color, poorer maintenance and reduced lamp lives.

POWERBALL® HCI®

Basically it is possible to dim POWERBALL® HCI®.

While the higher thermal load capacity of the round ceramic permits better dimming behavior in luminous efficacy and color rendering compared to metal halide lamps with quartz arc tube or with the normal cylindrical ceramic, dimming still causes a shift in color coordinates. Dimmed lamps show in general a somewhat stronger drop in light output and a wider color spread through-out the life of the lamp.

OSRAM therefore recommends not to reduce power with currently available lamps on conventional control gear, as dimming here changes the properties of POWERBALL® HCI®.

If the lamp is still to be dimmed, it is recommended that only adjustable electronic ballasts with square wave operation are used for this purpose. The wattage can be reduced by at most by 50% of the rated lamp wattage.

In any case, the lamp must be run with 100 % wattage for at least 15 minutes after switching on, so that the lamp lights up correctly.

Generally we accept no warranty for dimmed POWERBALL® HCI®. Only when POWERBALL® HCI® are dimmed on POWERTRONIC® PTo we accept a warranty regarding lifetime of the lamps.

Operation of POWERBALL® HCI® on POWERTRONIC® PTo:

The combination of POWERBALL® HCI® lamps and POWERTRONIC® PTo allows an energy saving operation, where optimal color representation is not of importance - like in outdoor lighting.

The PTo with square wave operation and optimized ignition operates the POWERBALL® HCI® lamps in the best possible way down to 60 % of the rated lamp wattage. There will be no significant negative effects when dimming.

Operation between 85% and 60 % of the rated lamp wattage has also no negative influence on failure rate. Lamp color, however, tends to shift then slightly to greenish and the colors between the lamps can differ (color spread).

Luminous flux decreases a little more over lifetime than with 100 % operation at the PTo. This effect can be reduced by mixed operation between reduced power and 100 % of the rated lamp wattage.