Philips MASTER PL-L lamps

To the reader

Philips MASTER PL-L lamps are low energy consuming compact fluorescent lamps that offer high quality lighting for relatively low running costs; the ideal solution for applications with long operating hours per switch-on.
This revised Product Information brochure provides you with technical data concerning the lamp, the required ballast, lampholder and luminaire design.
New information concerns the following subjects:

- Shift of the luminous flux curve to higher ambient temperatures.
- Graphs with respect to lifetime performance.
- Information regarding switching cycle effects.

All electrical and mechanical data remained unchanged which makes MASTER PL-L fully interchangeable with former PL-L products.

This publication is based on the available European product range and is intended for use by Original Equipment Manufacturers of luminaires and ballasts, specifiers and other parties in the lighting industry.

For your local Philips representative consult the internet site
http://www.eur.lighting.philips.com/contacts/contacts.shmtl

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With that input the content of the next brochure can be further improved.

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2001-09-25

1. General information on Philips MASTER PL-L lamps

1.1 Introduction

The MASTER PL-L range of compact fluorescent lamps includes 18, 24, 36, 40 and 55 watt versions. MASTER PL-L lamps offer high output, 'linear' format with compact dimensions, low energy consumption, long lamp life and good colour rendering. These lamps are up to three times brighter per unit length than traditional ('TL'D) linear fluorescent lamps.
The main applications for MASTER PL-L lamps are general lighting of shops and offices, asymmetrical 'wall washing' in shops, uplighting, decorative wall lights and task lighting.
MASTER PL-L lamps incorporate a 4-pin lamp base. The 18, 24 and 36W lamps can be operated either on conventional (copper iron) or High Frequency (electronic) ballasts, while the 40 and 55W types can be operated on electronic gear only.

1.2 Lamp technology

MASTER PL-L as well as all other Philips CFL lamps are low-pressure mercury gas-discharge lamps, which operate by the same principle as 'TL' lamps. The discharge tube has an electrode sealed into each end and is filled with inert gas and an absolute minimum of mercury at a low vapour pressure.
The light output of the lamp depends on the actual mercury vapour pressure which is determined by the coldest spot in the discharge tube.
The inside of the tube is coated with fluorescent powders which convert the UV radiation of the mercury discharge into light (visible radiation).

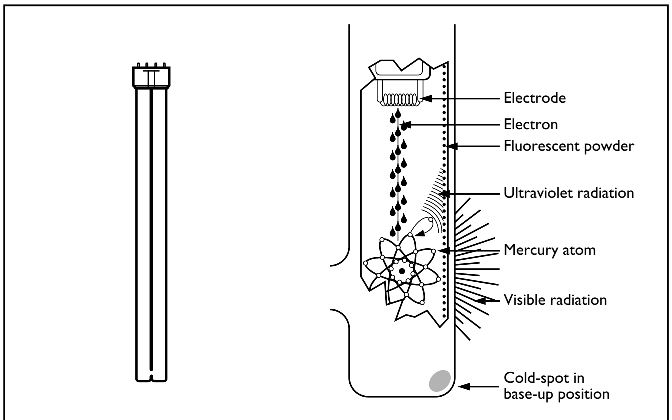


Figure 1.1: Working principle of a PL-L lamp

1.2.1 Cold-spot technology

The luminous flux of the MASTER PL-L lamp is governed by the temperature of the coldest spot in the discharge tube. In the base-up and horizontal burning position the so-called cold-spot is located at the lamp head, see figure 2.1: measuring point A. In the base-down burning position the cold-spot is located inside the lamp base (cannot be measured).
The maximum light output is reached at a cold-spot temperature of 45 °- 50 °C, corresponding to a lamp ambient temperature of about 25 °C. At lower and at higher cold-spot temperatures the luminous flux decreases (see figure 4.4.1, page 14). For a cold-spot temperature between about 32 °C and 72 °C the luminous flux will be greater than or equal to 80% of its optimum (see page 14).
Cold-spot temperatures > 72 °C can occur in completely closed, compact luminaires. Cold-spot temperatures < 32 °C can occur in luminaires which are excessively ventilated and/or at low ambient temperatures. A luminous flux lower than 80% of the optimum can lead to slight changes in light colour.

1.3 Nomenclature

The name of the lamp family is:
Compact Fluorescent Lamps - Non Integrated

The technical name of the product is:
PL-L

Example:

PL-L 36W /830 /4P : **PL-L** lamp
36Watt
/830: R_a > **8**0, T_c of **30**00 K
/**4**-**p**ins

The typical Philips Lighting cold-spot technology (see 1.2.1) has been optimized for MASTER PL-L lamps to arrive at the lowest cost of ownership, high quality and maximum care for the environment for the most common PL-L lighting applications.
MASTER PL-L lamps are fully interchangeable with all other FSQ lamps according to the ILCOS coding system. See Annex 1 for relevant ILCOS codes.

MASTER: PL-L lamps are classified as MASTER products in the Philips Lighting product classification system, which eases the selection process by customers without overwhelming them with all kind of details. 'MASTER' products are classified as 'the best in class' products.

2. Luminaire design

2.1 Introduction

In this chapter, recommendations and data are given to enable an optimal luminaire design.

2.2 IEC Recommendations

The general recommendations for luminaire design by IEC are also applicable to PL-L luminaires. Lamp-related data can be found in IEC 60901 (performance) and 61199 (safety).

2.3 Maximum operating temperatures

2.3.1 Lamp

Luminaires for PL-L lamps must satisfy the general requirements for luminaires as specified by the IEC Publication 60598 and the luminaire design information in IEC 61199.
Additionally, the lamp temperature at the points defined in figure 2.1 must not exceed certain limits.

The lamp cap temperature

The highest lamp cap temperatures are generally reached in the end-of-life situation, when the lamp no longer starts and maximum energy is dissipated near the lamp cap. To protect the lamp cap construction the cap temperature (measuring point B) should not exceed 140 °C under abnormal operating conditions.
Luminaires containing a conventional ballast should be using the intended lamp with the starter short-circuited, i.e. the cathodes operated in series. See IEC Publication 61199.
Compliance is checked in accordance with the relevant test specified in 12.5.1 of IEC Publication 60598-1.
The lamp cap temperature shall be measured at the hottest point on the cap surface at a distance of 12 mm from the reference plane of the cap (2G11).
For luminaires containing an electronic ballast no compliance tools have been defined (yet). The used electronic ballasts should prevent possible unsafe end-of-life situations as described in 4.3.

The cold-spot temperature

Next to the luminous flux, as described in section 1.2.1, the cold-spot temperature also determines the electrical characteristics of the gas discharge (see section 4.4). At high ambient temperatures (> 70 °C) these electrical characteristics will change sharply, which may have a damaging effect on the system (ballast or lamp). For this reason the cold-spot temperature (measuring point A) should not exceed 100 °C.

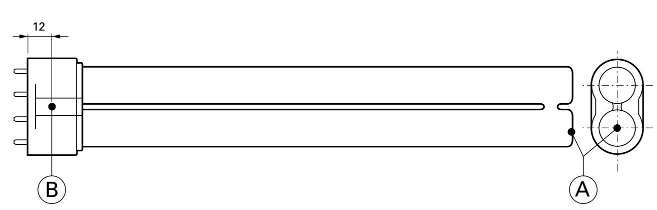


Figure 2.1: Temperature measuring points:
- A: cold spot measured on glass surface
- B: maximum lamp cap temperature

The temperatures at the measuring points may be critical under a combination of the following circumstances:
- totally enclosed luminaire with built-in ballast
- lamp in base-up position
- multi-lamp luminaires
- over-voltage situation
- high ambient temperature.

2.3.2 Multi-lamp luminaires

The design of the luminaire in which more than one PL-L lamp is used should satisfy the temperature requirements valid for each lamp individually. Putting two or more lamps close to each other can result in substantially higher temperatures inside the luminaire and may therefore reduce light output and negatively influence lamp performance.

2.4 Influences of ambient temperatures

The light output of a MASTER PL-L lamp is influenced by the temperature and the flow of the air near the lamp, i.e. the effective operating temperature. For a bare lamp, in draught-free air, this operating temperature is equal to the ambient temperature, in contrast to a lamp inside a luminaire. In this situation, the operating temperature will be Δ T higher due to the insulating effect of the luminaire and the generated heat of the burning lamp.
Because the light output is determined by the operating temperature, but scored against the ambient temperature, the curve of a MASTER PL-L lamp mounted in a luminaire can easily be constructed out of the curve of a bare MASTER PL-L lamp, by shifting this curve Δ T degrees, see figure 2.2.

The design of the luminaire and the way the MASTER PL-L is mounted inside will influence Δ T. This gives the opportunity to design luminaires for different ambient temperature ranges (see figure 2.3).

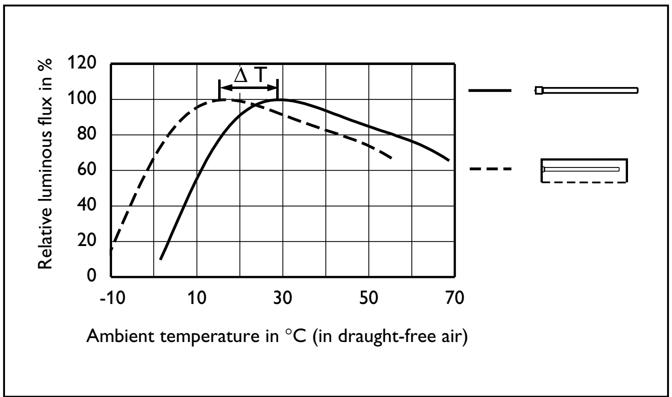


Figure 2.2

Δ T is the difference between the temperature inside and outside the luminaire.

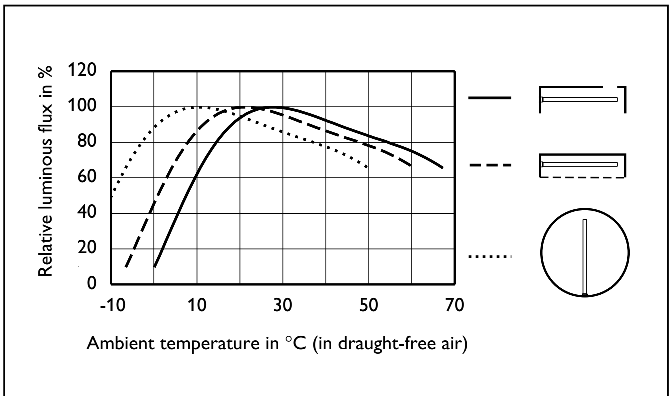


Figure 2.3

Note: *It should be understood that average values are shown for indication; fluctuations are possible.*

This means:
- at low ambient temperatures (< 10 °C) it is advisable to use totally closed luminaires
- at high ambient temperatures (> 40 °C) adequate luminaire ventilation is needed

2.5 Lampholder and lamp cap

MASTER PL-L lamps are fitted with a four-pin cap, type 2G11, see figure 2.4. This single-ended construction of the MASTER PL-L lamp contributes to easier construction and wiring of the luminaire. Lampholders to suit this cap are available from a number of manufacturers.
In principle, all requirements relating to type 2G11 lampholders are summarized in IEC Publications 60061 and 60400. The following are some notes on the background to the special requirements relating to the 2G11 in IEC Publication 60400:
- The material must be chosen so that the lampholder shall comply with the requirements of IEC Publication 60400.
- MASTER PL-L lamps require lamp-end support. For mounting position see figure 2.5 including Remark.

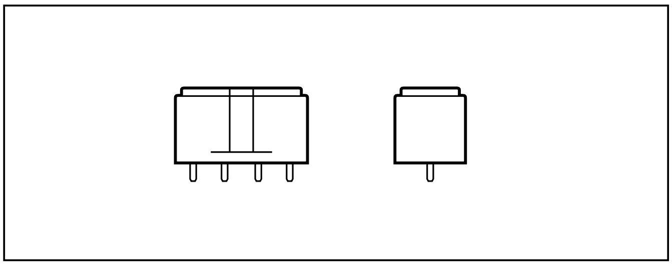
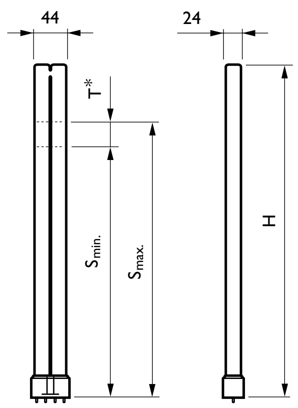


Figure 2.4 Lamp cap 2G11

2.6 Maximum lamp outlines
(according to IEC Publication 60901)

The maximum lamp outlines are provided for the guidance of designers of luminaires and are based on a maximum sized lamp taking into account any displacement and manufacturing tolerances. Observance of these outlines in luminaire design will ensure that the lamps will fit.

Note: *These outlines do not include the space needed for taking the lamp out of the holder.*



Type	H max.	S min.	S max.	T*
PL-L 18W	225	140	175	35
PL-L 24W	320	140	270	130
PL-L 36W	415	330	365	35
PL-L 40W	535	450	485	35
PL-L 55W	535	450	485	35

Figure 2.5: Maximum lamp outlines (in mm)

*) Remark:
Provision for lamp-end support must be located in this area (dimension T). It should be designed so that it does not influence the intended lamp performance.
If a part of the device is located between the limbs of the lamp, it should not exert any force on the lamp other than that of gravity, taking into account a minimum gap of 1,8 mm between the limbs of the lamp.

2.7 Various application elements

2.7.1 CE Marking

All Philips compact fluorescent non-integrated lamps (CFL-NI) comply with the EU Low Voltage Directive (73/23/EEC) and comply with safety standard EN-61199.

2.7.2 PET value

Compact fluorescent lamps radiate a very low amount of UV.
The permitted exposure time (PET value) for Philips CFL-NI lamps complies with the generally accepted value of 24 hours at 1000 lux.

2.7.3 Explosion risk

Compact fluorescent lamps are low-pressure mercury gas-discharge lamps which operate at relatively low temperatures. These lamps are not subject to specific risks of explosion and should be regarded in this respect as identical to the well-known 'TL' lamp.

2.7.4 Damage factor

Another effect of UV is the risk of colour fading of the illuminated goods. This fading risk depends on:
- the materials used in the illuminated object
- the illumination level
- the emitted UV of a light source.

For MASTER PL-L lamps 'D_{fc}' is generally no issue due to very low UV radiation.

2.8 Lamp end-blackening

A certain amount of lamp end-blackening during lamp life is normal and unavoidable. The blackening is caused by a thin layer of electrode material deposited during life on the inner wall of the discharge tube. However, accelerated blackening can occur when the gear does not provide the right (pre)heating currents (either too low or too high).

2.9 Optical design

The MASTER PL-L lamps can be used in luminaires of a variety of designs both for indoor and outdoor applications. The choice of material, shape and dimensions can help ensure optimum functioning of the lamp (mechanically, thermally and photometrically).
For luminous intensity distribution see 3.3.1.
Examples of possible luminaire types include general lighting of shops and offices, asymmetrical 'wall washing' in shops, uplighting, decorative wall lights and task lighting.

2.9.1 Luminance

The average luminance of a MASTER PL-L lamp ranges from approximately 2,5 - 4 x 10^4 cd/m^2.
Depending on the ambient brightness and the desired degree of comfort, this luminance may have to be reduced to an acceptable level, e.g. by:

- Selecting a sufficiently large shielding angle.
  For ceiling mounted luminaires a shielding angle of at least 30° is recommended.
- Reducing the luminance by means of diffuser material.
  Since an evenly distributed luminance is often desired, the distance between the lamp and the diffuser must not be too small. With strong diffusers such as opal sheet, a distance of at least 20 mm is recommended; with screenings which have less scattering effect the distance should be increased proportionally.

2.10 Radio interference

MASTER PL-L lamps, like most gas-discharge lamps, generate spurious radio frequency energy in the radio spectrum. Normally the energy level is so low that the reception of radio and/or television signals is not disturbed. Because of the frequencies generated, interference, if any, is limited to the AM broadcast band. FM and television receivers are very rarely affected by MASTER PL-L lamps.
The radio frequency energy is transmitted via radiation and conduction. MASTER PL-L luminaires should therefore not be placed close to sensitive objects, such as radio antennas or telephone equipment.

Conventional operation

As far as conducted emission is concerned, the proper construction of the luminaire, including its ballast and starter, generally prevents any disturbance. However, occasionnally, there could be interference. Experience has shown that interference may be caused by MASTER PL-L luminaires with external ballast where the radiation from the lamp wire(s) is picked up by telephone or other cables. In this case the wires between ballast and luminaire should be as short as possible.
It is also advised to apply split windings type of ballasts and in case of Class I luminaires the wires should be shielded. This shielding should be properly connected to the earth connection.

Electronic operation

To limit the possible interference with the environment the following advice for MASTER PL-L luminaire design is given:

- The operating frequency of the lamp should be as low as possible (<100 kHz).
- If MASTER PL-L lamps are used in plastic luminaires the electronic ballast should be built as close to the lamp as possible. External ballasts should not be used.
- In the case of metal luminaires, there may be a greater distance between electronic circuit and lamp, provided that the metal shielding is connected to earth.
- A distance of at least 2 cm should be observed between the lamp wire and supply/control wire.

Standards

The international standard for radio interference is CISPR 15. This standard covers conducted and radiated emission limits for all types of luminaires. No radiation limits are yet specified for frequencies above 30 MHz. It is, however, recommended that the emission limits as given in CISPR 22 are not exceeded.
For the European Union countries the derived EN 55015 applies. This EN has to be used for luminaire CE-marking purposes. In the USA emission limits, conducted and radiated, are specified in Federal Standard FCC 18 but they do not apply to 50/60 Hz operated lighting devices. In other countries local standards and/or regulations may exist.

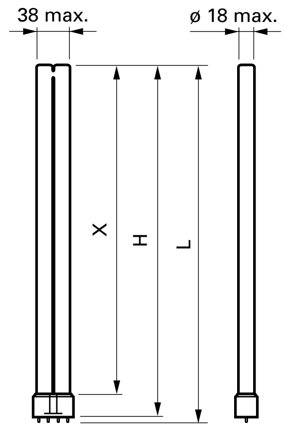
3. MASTER PL-L specifications

3.1 Range

The MASTER PL-L range consists of:

MASTER PL-L 18W
MASTER PL-L 24W
MASTER PL-L 36W
MASTER PL-L 40W
MASTER PL-L 55W

3.2 Mechanical characteristics



Type	X max.	H max.	L max.
PL-L 18W	195	220	227
PL-L 24W	290	315	322
PL-L 36W	385	410	417
PL-L 40W	510	535	542
PL-L 55W	510	535	542

Lamp cap: 2G11 (see IEC Publication 60061-1 sheet 7004-82)

Figure 3.1: Dimensions MASTER PL-L (in mm)

Pin connections

The connection of lamp electrodes to the pins of MASTER PL-L lamp caps (2G11) is shown in fig. 3.2.

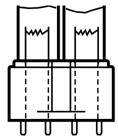


Figure 3.2 Electrode connection

3.3 Electrical and photometric characteristics

Conventional operation

Measuring conditions (according to IEC Publication 60901):
- ambient temperature: 25 °C
- burning position: horizontal, after 100 hours
- with a reference ballast

PL-L	Lamp current mA	Lamp voltage V	Lamp wattage W	Luminous flux lm	Luminous efficacy lm/W
18 W	375	58	18	1200	67
24 W	345	87	24	1800	75
36 W	435	106	36	2900	80

Reference ballast data	Rated voltage (50 Hz)	Voltage/current ratio Ω	Calibration current mA	Power factor
18 W	127 V	270	370	0,12
24 W	220 V	540	340	0,10
36 W	220 V	390	430	0,10

Electronic operation

Measuring conditions (according to IEC Publication 60901):
- operating frequency: 25 kHz
- ambient temperature: 25 °C
- burning position: horizontal, after 100 hours

PL-L	Lamp current mA	Lamp voltage V	Lamp wattage W	Luminous flux lm	Luminous efficacy lm/W
18 W	320	50	16	1200	75
24 W	300	75	22	1800	82
36 W	360	90	32	2900	90
40 W	320	126	40	3500	87
55 W	550	101	55	4800	87

Operating 4-pin lamps on properly designed electronic gear has the following main features compared to conventional operation:
- less system power consumption (approximately 20%) due to higher lamp efficacy and lower ballast losses
- longer lamp life
- flicker-free start
- no flicker due to mains supply variation
- dimmable when using suitable electronic ballasts

Energy Efficiency Label (European Union)

MASTER PL-L 36W, 40W and 55W/80 are rated energy efficiency class A, while MASTER PL-L 18W, 24W /80 and MASTER PL-L 55W/950 comply with class B, described in Annex IV of Council Directive 98/11/EC with regard to energy labelling of household lamps. MASTER PL-L lamps comply with the requirements of European standard EN 50 285.

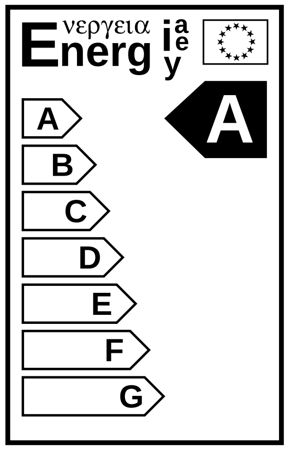


Figure 3.3 Energy efficiency label A

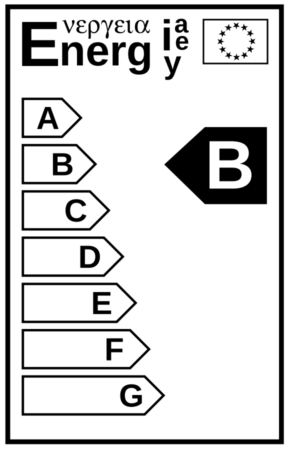


Figure 3.4 Energy efficiency label B

3.3.1 Luminous intensity distribution

The normalized polar luminous intensity distribution of a MASTER PL-L lamp is given in the following diagrams.

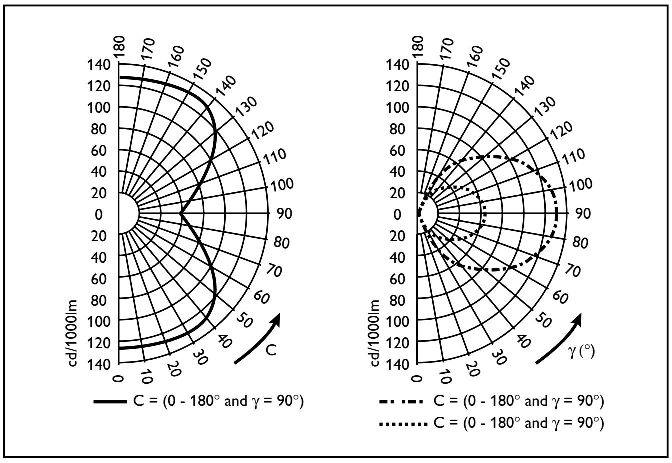


Figure 3.5

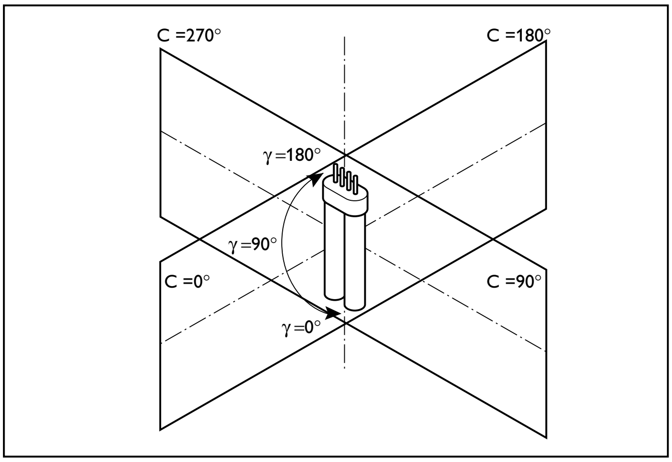


Figure 3.6: Definition of measurement planes

3.3.2 Colour characteristics

MASTER PL-L /80 colours

General colour rendering index (R_a): ≥ 80

Correlated colour temperatures: 2700 K (/827)
3000 K (/830)
3500 K (/835)
4000 K (/840)
6500 K (/865)

Chromaticity coordinates (typical):

	/827	/830	/835	/840	/865
x	0,465	0,440	0,410	0,380	0,305
y	0,420	0,405	0,395	0,380	0,325

PL-L /90 colours

General colour rendering index (R_a): 92

Correlated colour temperature: 3000 K (/930)
5000 K (/950)

Chromaticity coordinates (typical):

	/930	/950
x	0,435	0,340
y	0,395	0,350

3.3.3 Spectral power distribution

The normalized spectral power distribution of a PL-L lamp is given in the following diagrams.

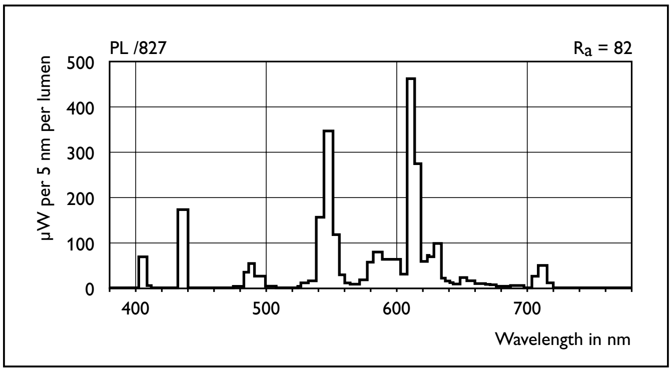


Figure 3.7: Spectral power distribution colour /827

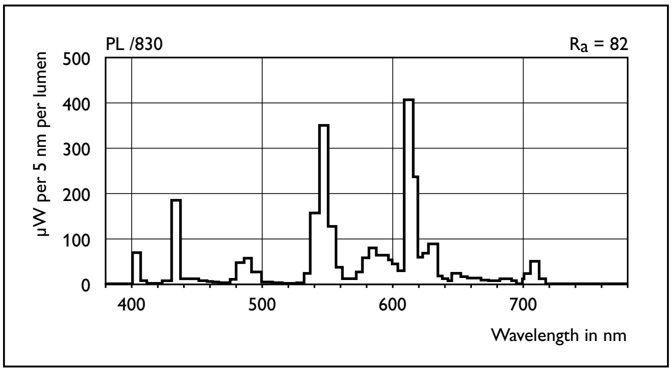


Figure 3.8: Spectral power distribution colour /830

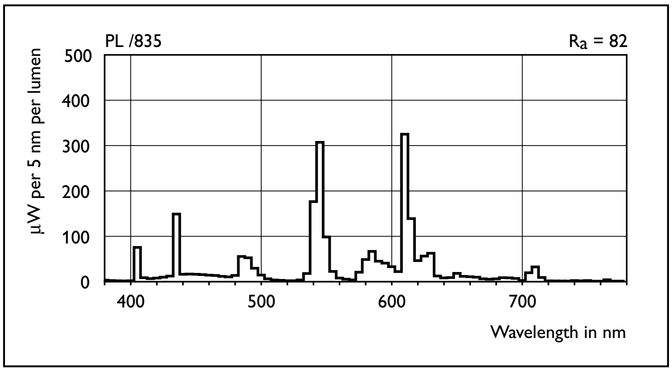


Figure 3.9: Spectral power distribution colour /835

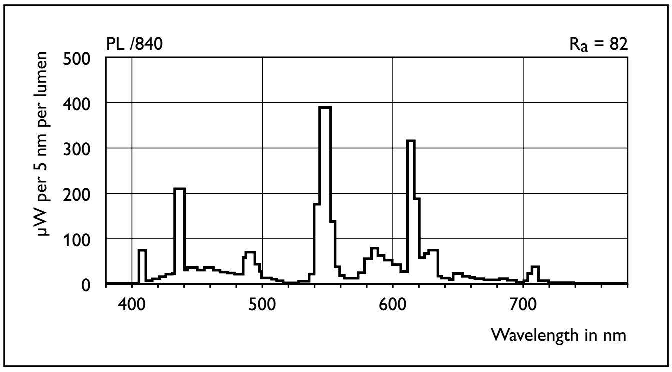


Figure 3.10: Spectral power distribution colour /840

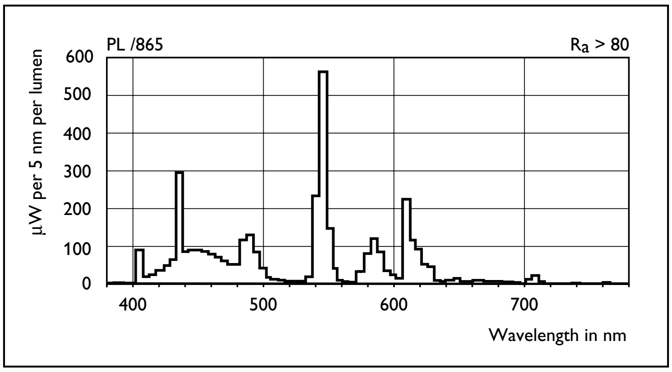


Figure 3.11: Spectral power distribution colour /865

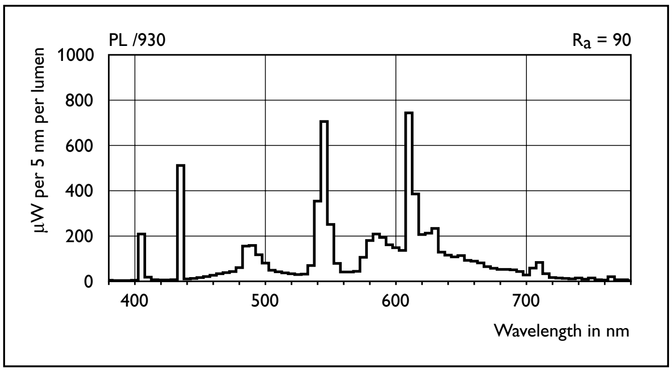


Figure 3.12: Spectral power distribution colour /930

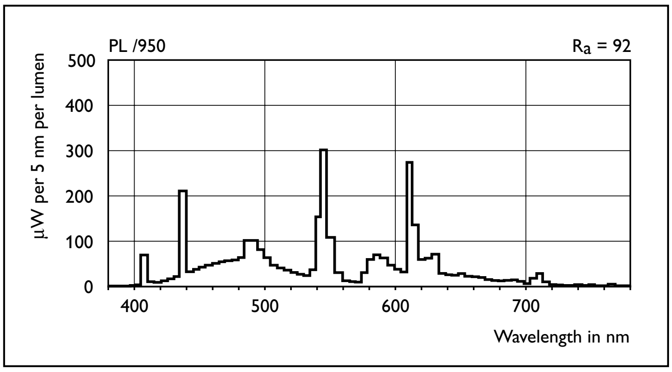


Figure 3.13: Spectral power distribution colour /950

4. Lamp operation

4.1 Starting characteristics

4.1.1 Conventional operation

Starting characteristics for MASTER PL-L lamps:
- For ambient temperatures between +5 °C and +50 °C, ignition times are:
  - ≤ 6 s in inductive (lagging) and ≤ 10 s in capacitive (leading) circuits, if using Philips starters (S2 and S10) or starters with similar specifications.
  - ≤ 2 s if using Philips electronic starters S10-E (or S2-E for MASTER PL-L 18 W)
- For reliable ignition at lower ambient temperatures, see table below.

Ambient temperature range

All data measured on recommended Philips ballasts (see Annex 3).

Reliable ignition of MASTER PL-L lamps can be expected up to the following ambient temperatures.

Mains supply voltage 230 V			
Ignition within 10 seconds			
		Circuit	
lamp type	starter type	inductive	capacitive
PL-L 18W	S2	-30 °C	-15 °C
	S10	-30 °C	-30 °C
	S10-E	-25 °C	-25 °C
PL-L 24W	S10	-30 °C	-20 °C
	S10-E	-30 °C	-25 °C
PL-L 36W	S10	-15 °C	-10 °C
	S10-E	-20 °C	-20 °C

Mains supply voltage -8% 212 V			
Ignition within 20 seconds			
		Circuit	
lamp type	starter type	inductive	capacitive
PL-L 18W	S2	-30 °C	-15 °C
	S10	-30 °C	-30 °C
	S10-E	-25 °C	-25 °C
PL-L 24W	S10	-20 °C	-20 °C
	S10-E	-25 °C	-25 °C
PL-L 36W	S10	-10 °C	-10 °C
	S10-E	-10 °C	-10 °C

Warning: Long ignition times have a negative influence on lamp life.

4.1.2 Electronic operation

The starting characteristics of MASTER PL-L lamps on electronic gear are fully determined by the selected electronic ballast.

4.2 Lifetime performance

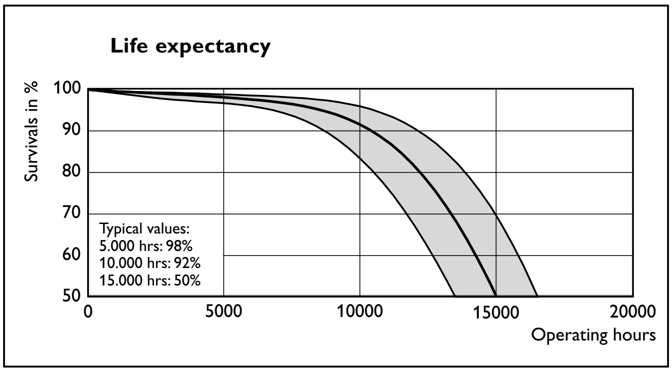


Figure 4.2.1: MASTER PL-L on conventional gear (inductive)

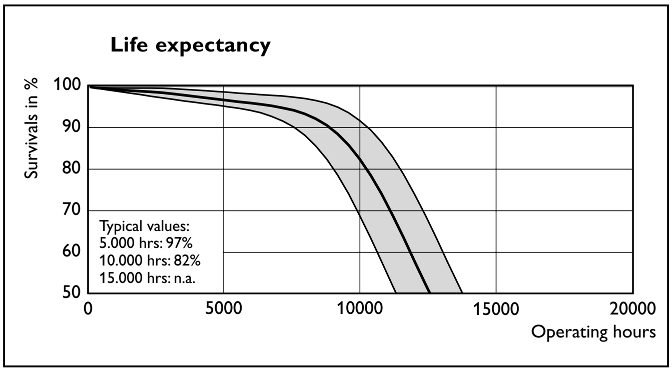


Figure 4.2.2: MASTER PL-L on conventional gear (inductive/capacitive)

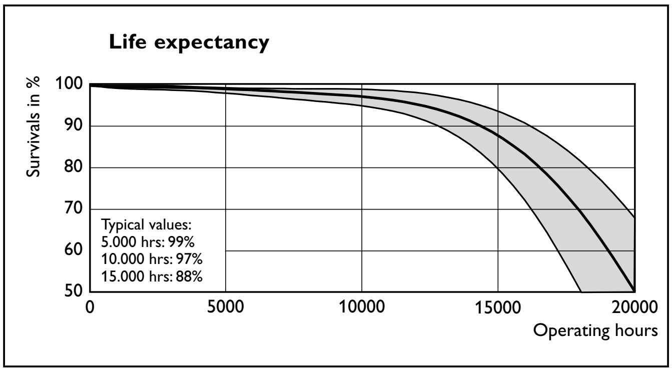


Figure 4.2.3: MASTER PL-L on HF gear (warm start)

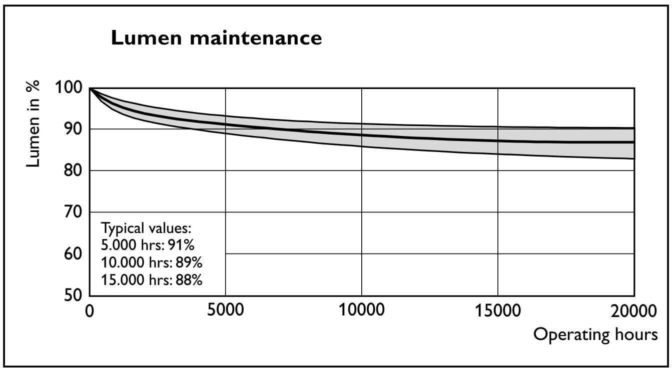


Figure 4.2.4 : MASTER PL-L on conventional gear

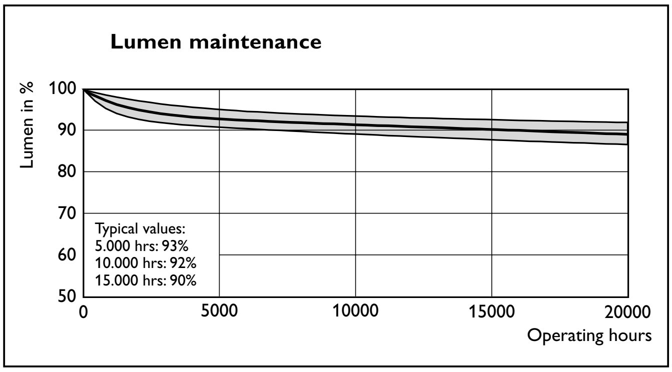


Figure 4.2.5: MASTER PL-L on HF gear

Notes on life expectancy curves:

Lamp lifetime is specified as the total number of actual operating hours under specific operating conditions. Philips MASTER PL-L lamps are designed for operating with proper preheated electrodes before lamp ignition is established and in accordance with IEC 60901. This is to ensure also reliable long life when the switching frequency is higher than the standard IEC cycle (165 minutes on, 15 minutes off).
The published curves give typical average values based on measurements made by Philips Quality Department Lighting based on large production batches of lamps and tested under laboratory conditions in accordance with IEC 60901.
In practice, the performance of individual lamps or groups of lamps may vary from the average.
Lamps are tested in conjunction with commercially available preheat control gear.
The rated average lamp life is the expected time at which 50% of any large number of lamps reach the end of their individual lives.
Actual operating conditions deviate in most cases from the applied test conditions. The most relevant factors are discussed in this product documentation (temperature, mains voltage, switching cycle and type of control gear). The differences can have a significant influence on lamp performance.

Remark:
Cold ignition (instant start) electronic ballasts are currently offered by different ballast manufacturers as drivers for MASTER PL-L lamps. These ballasts do not provide any preheating of the electrodes prior to lamp ignition. Application of this type of control gear can substantially influence MASTER PL-L lamp life, especially in applications where frequent starting is applied. Therefore only for applications with an infrequent switching (up to three times a day) and long operating time per switch-on, this type of ballast can be an alternative.

Switching cycle effects
The rated average lamp life of MASTER PL-L lamps is negatively affected when the switching frequency is higher than the IEC cycle (165 minutes on, 15 minutes off).
The tables below give an indication of the relation between the amount of switching and the lamp life.

MASTER PL-L 18W, 24W and 36W lamps operated on **conventional ballast (inductive)**:

Operating cycle time min	Rated average lamp life h	Lamp life	Switches nr.
690 on, 30 off	19.500	130%	1700
165 on, 15 off	15.000	100%	5450
90 on, 15 off	12.000	80%	8000
45 on, 15 off	9000	60%	12.100

MASTER PL-L 18W, 24W and 36W lamps operated on **conventional ballast (50% inductive/50% capacitive)**:

Operating cycle time min	Rated average lamp life h	Lamp life	Switches nr.
690 on, 30 off	18.000	145%	1570
165 on, 15 off	12.500	100%	4540
90 on, 15 off	10.000	80%	6700
45 on, 15 off	7000	55%	9400

MASTER PL-L lamps operated on **electronic gear** (designed according to the specifications in section 5.3):

Operating cycle time min	Rated average lamp life h	Lamp life	Switches nr.
690 on, 30 off	22.000	110%	1900
165 on, 15 off	20.000	100%	7250
90 on, 15 off	18.500	93%	12.400
45 on, 15 off	17.000	85%	22.700

***Note**: Lifetime figures depend on ballast type. In practice lifetimes can deviate.*

4.2.1 Colour performance over life

All fluorescent lamps suffer from a (modest) shift of colour temperature over lifetime. In the table below indicative typical values for PL-L are listed of maximum expected colour shift. Higher wattage lamps suffer more from this phenomenon than the lower wattage types.

Colour	**Expected colour shift (8000 hours)**		
	Colour coordinates		**Temperature (K)**
	δX	δY	δK
/827	+0,005	+0,002	-150 K
/830	+0,009	+0,006	-100 K
/840	+0,015	+0,015	-300 K
/865	+0,018	+0,018	-1000 K
/950	+0,018	+0,010	-650 K

***Note**: Approximate values are given.*

4.3 End-of-life behaviour and associated risks

The following four possible situations can be identified, and should be taken into account by ballast designers:

1) The lamp does not start but both electrodes are intact.
If, for whatever reason, the lamp does not start, the ballast may continue to supply the preheating current to the electrodes. This may cause overheating of the lamp cap. Ballast and luminaires should take care of maximum preheating currents (see section 5.2 and 5.3) and maximum lamp cap temperature (see section 2.3.1) to avoid this overheating.

2) The lamp operates, but one of the electrodes is de-activated or broken.
The normal end-of-life situation for fluorescent lamps is emitter depletion of one of the electrodes. In most cases the discharge will extinguish and the lamp will not start again, i.e. the above situation arises. However, if the ballast is capable of sustaining the discharge, a new condition arises. Because of the absence of emitter material the voltage drop at electrode will rise sharply, resulting in an extra power dissipation. It is concentrated in a very small region in front of the cathode and is highly asymmetric. It only occurs in that half phase when the depleted electrode has to act as cathode and emits electrons (rectification). The same applies when the cathode breaks and a lead wire acts as cathode.

Especially under HF conditions the discharge is easier maintained, because no high re-ignition voltages occur as for 50/60 Hz. The extra power in the cathode fall region may lead again to strong overheating of the cap and its surroundings, i.e. the glass and the lampholder. So the ballast should limit the sum of the power in the cathode fall to a safe level, or switch-off.

3) The lamp operates, but with both electrodes de-activated or broken.
In the previous case of rectification, the ballast does not have to switch off, but might limit the power in the cathode region, for instance by sensing the asymmetry in the voltage. The lamp then continues to operate. After some time also the emitter of the other cathode will become depleted. Now on both sides an increased electrode fall is present. The situation is symmetric again, with a higher lamp voltage. If the ballast senses asymmetry only and does not switch-off, it may return to 'normal' operation, with extra local power dissipation in both electrode falls. Again this will lead to overheating of the electrode regions. So the electronic (HF) ballast should switch off at too high values of the lamp voltage.

4) The lamp operates, but with a strongly increased lamp voltage. The lamp voltage may also increase by slow leak-in of impurities. If the ballast is capable of sustaining the discharge, with for instance a constant current, the lamp power will increase symmetrically together with the voltage. This higher lamp power is not localized as above, but may still lead to overheating of the lamp and parts of the system. So an electronic (HF) ballast should switch off at too high values of the lamp voltage, or limit the power it can deliver to the lamp.

4.4 Temperature dependency

The lamp characteristics are influenced by the lamp cold-spot and/or ambient temperature.
Relative values of luminous flux (Φ), lamp voltage (U), lamp current (I) and lamp wattage (P) as a function of the **cold-spot** temperature and measured on reference ballast are given in figure 4.4.1.

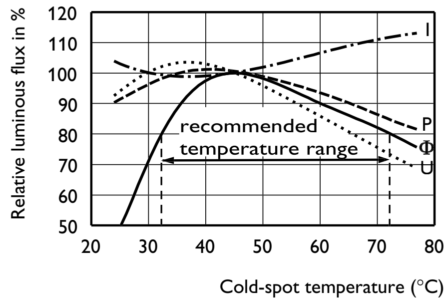


Figure 4.4.1: MASTER PL-L lamp characteristics in relation to cold-spot

Relative values of luminous flux as a function of the **ambient temperature** for a bare lamp in horizontal position are given in figure 4.4.2.

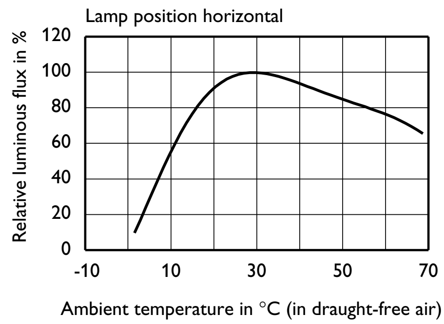


Figure 4.4.2: Luminous flux of a MASTER PL-L lamp (ambient temperature)

4.5 Influence of variation in supply voltage

If electronic control gear is applied, the supply voltage variation is mostly compensated by the electronic circuit, however with conventional control gear the lamp characteristics vary with the supply voltage.

4.5.1 Relationship to electrical and photometric characteristics

Relative values of luminous flux, lamp current, lamp wattage and lamp voltage as a function of the supply voltage at operation on a reference ballast are given in the following graphs.

Inductive (lagging) circuits (see 5.2)

PL-L 18W and 24W

Measuring conditions
- ambient temperature: 25 °C
- burning position: horizontal
- ballast type: BTA 18L31 (230V/50 Hz)
  BTA 18L25 (240V/50 Hz)

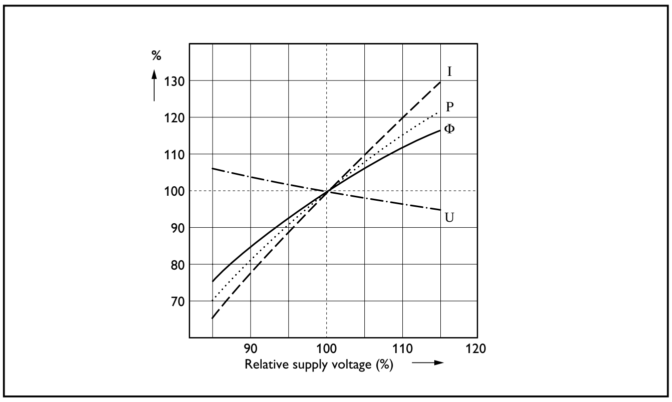


Figure 4.5.1: PL-L 18W, 24W

PL-L 36W

Measuring conditions
- ambient temperature: 25 °C
- burning position: horizontal
- ballast type: BTA 36L31 (230V/50 Hz)
  BTA 36L25 (240V/50 Hz)

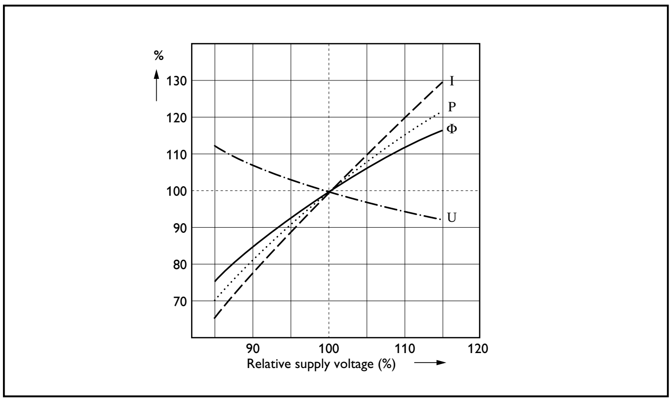


Figure 4.5.2: PL-L 36W

Capacitive (leading) circuits (see 5.2)

PL-L 18W, 24W and 36W

Measuring conditions
- ambient temperature: 25 °C
- burning position: horizontal
- ballast type: BTA 18L31 (230V/50 Hz) + 2,7 µF/450 V
  BTA 18L25 (240V/50 Hz) + 2,6 µF/450 V
  BTA 36L31 (230V/50 Hz) + 3,4 µF/450 V
  BTA 36L25 (240V/50 Hz) + 3,3 µF/450 V

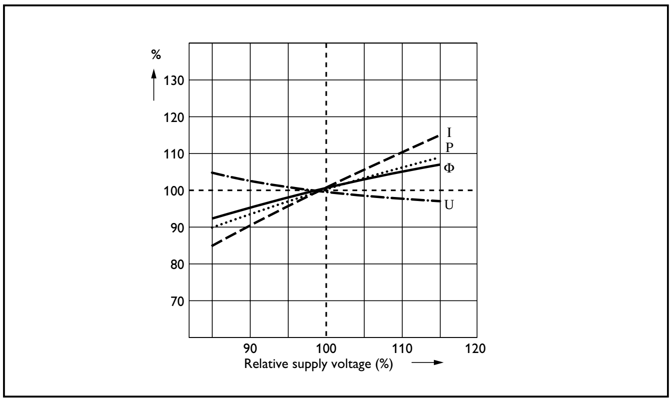


Figure 4.5.3: PL-L 18W, 24W, 36W

4.5.2 Relationship mains voltage fluctuations to colour performance

Between -8 % and +6 % of the rated voltage -the maximum permitted variations- there are hardly any colour deviations. For colours /827 and /840 indicative values are listed below:

Colour	**T_c rated** V_{mains}	**T_c** V_{mains} -8%	**T_c** V_{mains} +6%
/827	2700 K	2600 K	2750 K
/840	4000 K	3900 K	4100 K

5. Control gear

5.1 Introduction

As with all gas-discharge light sources, MASTER PL-L lamps must be operated on suitable control gear, in order to function correctly. The control gear performs a number of functions:

- it limits and stabilizes the lamp current, a necessary measure in view of the negative resistance characteristic of gas-discharge lamps (i.e. when the lamp current increases, the lamp voltage will decrease)
- it provides the ignition voltage (higher than the normal operation voltage) for the initial lamp starting
- it supplies controlled energy to heat the lamp electrodes during ignition (warm start ballasts) and in some cases also during normal operation (regulating ballasts).

In addition to these basic functions, the control gear must fulfil a number of other, equally important requirements:

- it must ensure a sufficiently high power factor
- it must limit the harmonic distortion of the mains current
- it must present a high impedance to frequencies used for switching purposes in automatic frequency regulation circuits (AFRC or Actadis) in outdoor applications, if possible
- it must offer adequate suppression of any electro-magnetic interference (EMI) that might be produced by the lamp/ballast system and that could otherwise interfere with other electronic equipment
- it must limit the short-circuit current and/or the current during running-up of the lamp, to protect the lamp electrodes from overloading
- it must switch off the lamps when these cannot be ignited normally; this safety requirement is only valid for the HF (electronic) ballasts
- it must limit the lamp voltage, lamp current and the lamp power within the specifications during mains voltage variations.

***Note**: For specific information on end-of-life behaviour related to ballasts see section 4.3.*

5.2 Control units (conventional)

The MASTER PL-L 18, 24 and 36W lamps can be operated on a 50/60 Hz conventional ballast in the AC mains starter circuit. Starter circuits can realise the necessary stabilization of the gas discharge in two ways:
1) inductively: by means of a choke coil (lagging circuit)
2) capacitively: with a capacitor in series with a choke (leading circuit)

When a reactance is placed in series with the lamp, the power factor (cos φ) will be low. It can be raised by:
1) using a dual lamp circuit, which combines inductive and capacitive stabilization (duo operation, series compensation)
2) shunting a capacitor across the mains terminals in an inductive circuit (parallel compensation)

The ballast characteristics are given in 5.2.1. The data for series and parallel compensation together with Philips ballasts are given in Annex 3.

5.2.1 Technical data at single lamp operation

The ballast for MASTER PL-L 18W and 24W lamps should have the following electrical characteristics:

Supply voltage		220 V	230 V	240 V
Open circuit voltage	min. V (r.m.s.)	198	207	216
	max. V (peak)	400	400	400
Voltage/current ratio 1)	Ω 3)	538	568	600
Preheating current 2)	min. mA	315	315	315
	max. mA	670	670	670
Recommended Philips ballast (50 Hz)		-	BTA 18L31	-

1) At ballast current 370 mA.
2) Equivalent resistance of both cathodes in series is 50 Ω.
3) Tolerance ±4%.

The ballast for MASTER PL-L 36W lamps should have the following electrical characteristics:

Supply voltage		220 V	230 V	240 V
Open circuit voltage	min. V (r.m.s.)	198	207	216
	max. V (peak)	400	400	400
Voltage/current ratio 1)	Ω 3)	391	419	447
Preheating current 2)	min. mA	365	365	365
	max. mA	775	775	775
Recommended Philips ballast (50 Hz)		-	BTA 36L31	-

1) At ballast current 430 mA.
2) Equivalent resistance of all cathodes in series is 40 Ω.
3) Tolerance ±4%.

5.3 Control units (electronic)

All MASTER PL-L lamps are four-pin lamps and are therefore well-suited for HF-operation with electronic control gear, which results in a good system performance (high efficacy, extended lamp life, etc.).
Note: MASTER PL-L 40W and 55W lamp types are designed specifically for HF-operation.
Electronic control gear should be specified according to the data in the following paragraphs. This information is intended to help electronic ballast manufacturers in finding their way to design ballasts with maximum performance. It is to be read in conjunction with IEC Publication 60929: AC Supplied Electronic Ballasts for Fluorescent Lamps.

5.3.1 Starting conditions

Like most current fluorescent lamps, MASTER PL-L lamps have electrodes with some emissive material, which among other things, facilitates ignition, provided it is heated to a sufficiently high temperature.
The best way of starting a MASTER PL-L lamp is to preheat the electrodes to this high temperature prior to raising the open circuit voltage to values that can cause any discharge.
When the preheating time has passed (t_e), the open circuit voltage must be raised from below V_{max} ($t < t_e$) (i.e. the maximum voltage during preheating) to above V_{min} ($t > t_e$) (i.e. minimum ignition voltage of the lamp).

5.3.1.1 Electrode preheating

In this section information regarding the preheating process is given.
Within IEC, the lighting industry is finalizing discussions regarding standardization of preheating values of PL-L lamps. The values published in this chapter will be proposed for insertion in the relevant data sheets of Publication 60901.

Proper electrode preheating will be achieved by providing the required energy to these electrodes.
The required amount of energy is given by the preheat information using the energy description E = Q + P x t, to be measured in an electrode substitution resistor R_{sub}. This formula shows that the energy required, is the sum of the energy supplied into the electrodes (heat content Q) and the power lost (heat loss P) by the electrodes during the preheating time.

The following tables include minimum and maximum preheating data for MASTER PL-L lamp electrodes at four different preheating times: 0,5 s, 1 s, 1,5 s and 2 s.
In addition to the energy requirements also the corresponding information is given for two basic methods of providing preheated cathodes at lamp starting, being:
1. current controlled preheating
2. voltage controlled preheating

Some preceding remarks:
1) preheating times < 0,4 s have to be discouraged
2) preheating data at non-mentioned times can be calculated by the use of the energy formula and R_{sub}
3) the values given are steady state values (constant during preheating time)
4) frequent use of preheating outside the mentioned limits will cause accelerated end-blackening and will have a negative effect on lamp life.

Preheat data using the energy description

Depending on the available time for preheating, the ballasts should give a preheating energy within the following limits:

E = Q + P x t

Lamp type PL-L	Preheating energy J	Preheating time 0,5 s	1,0 s	1,5 s	2,0 s	Q J	P W	Substitution resistor (R_{sub})
18, 24, 40W	min.	1,95	2,40	2,85	3,30	1,50	0,90	8 Ω
	max.	3,40	4,20	5,00	5,80	2,65	1,60	

Lamp type PL-L	Preheating energy J	Preheating time 0,5 s	1,0 s	1,5 s	2,0 s	Q J	P W	Substitution resistor (R_{sub})
36W	min.	2,10	2,60	3,10	3,60	1,60	1,00	7 Ω
	max.	3,70	4,55	5,45	6,30	2,80	1,75	

Lamp type PL-L	Preheating energy J	Preheating time 0,5 s	1,0 s	1,5 s	2,0 s	Q J	P W	Substitution resistor (R_{sub})
55W	min.	2,95	3,50	4,05	4,60	2,40	1,10	5 Ω
	max.	5,15	6,15	7,10	8,05	4,20	1,95	

***Note**:* *Data might be changed as a consequence of discussions and agreements to be reached within IEC for lamps with 2G11 caps.*

Current controlled preheating

Depending on the available time for preheating, the ballasts should give a preheating current within the following limits:

Lamp type PL-L	Preheating current mA	Preheating time 0,5 s	1,0 s	1,5 s	2,0 s	Substitution resistor (R_{sub})
18W, 24W 40W	min. (r.m.s.)	700	550	485	455	8 Ω
	max. (r.m.s.)	925	725	645	600	

Lamp type PL-L	Preheating current mA	Preheating time 0,5 s	1,0 s	1,5 s	2,0 s	Substitution resistor (R_{sub})
36W	min. (r.m.s.)	775	610	545	510	7 Ω
	max. (r.m.s.)	1025	805	720	670	

Lamp type PL-L	Preheating current mA	Preheating time 0,5 s	1,0 s	1,5 s	2,0 s	Substitution resistor (R_{sub})
55W	min. (r.m.s.)	1090	840	735	680	5 Ω
	max. (r.m.s.)	1440	1110	975	900	

***Note**: Data might be changed as a consequence of discussions and agreements to be reached within IEC for lamps with 2G11 caps.*

Voltage controlled preheating

Depending on the available time for preheating, the ballasts should give a preheating voltage within the following limits:

Lamp type PL-L	Preheating voltage V	Preheating time 0,5 s	1,0 s	1,5 s	2,0 s	Substitution resistor (R_{sub})
18W, 24W 40W	min. (r.m.s.)	5,6	4,4	3,9	3,6	8 Ω
	max. (r.m.s.)	7,4	5,8	5,2	4,8	

Lamp type PL-L	Preheating current V	Preheating time 0,5 s	1,0 s	1,5 s	2,0 s	Substitution resistor (R_{sub})
36W	min. (r.m.s.)	5,4	4,3	3,8	3,5	7 Ω
	max. (r.m.s.)	7,2	5,6	5,0	4,7	

Lamp type PL-L	Preheating current V	Preheating time 0,5 s	1,0 s	1,5 s	2,0 s	Substitution resistor (R_{sub})
55W	min. (r.m.s.)	5,4	4,2	3,7	3,4	5 Ω
	max. (r.m.s.)	7,2	5,5	4,9	4,5	

***Note**: Data might be changed as a consequence of discussions and agreements to be reached within IEC for lamps with 2G11 caps.*

5.3.1.2 Lamp ignition

The following table includes values for the open circuit voltages, which an electronic ballast should generate for two ambient temperature ranges: 10 ° to 60 °C and -15 ° to 60 °C (indoors and outdoors). Also differentiated for situations with and without starting-aid (e.g. earthed metal luminaire).

Without starting aid

Lamp type PL-L	Preheating voltage (r.m.s.) V_{max}	Ignition voltage (r.m.s.) V_{min} at +10 °C	Ignition voltage (r.m.s.) V_{min} at -15 °C	Substitution resistor (R_{sub})
18W	160	300	350	8-24 Ω
24W	170	320	380	8-24 Ω
36W	210	340	420	7-21 Ω
40W	230	360	450	8-24 Ω
55W	230	360	460	5-15 Ω

With any cathode substitution resistor value in the range of values given.

***Note**: The open-circuit voltages are valid for:*
- sinusoidal voltages (crest factor 1,4)
- frequency 20 - 26 kHz

With starting aid

Lamp type PL-L	Preheating voltage (r.m.s.) V_{max}	Ignition voltage (r.m.s.) V_{min} at +10 °C	Ignition voltage (r.m.s.) V_{min} at -15 °C	Substitution resistor (R_{sub})
18W	150	270	320	8-24 Ω
24W	170	290	350	8-24 Ω
36W	190	310	390	7-21 Ω
40W	220	340	440	8-24 Ω
55W	220	340	440	5-15 Ω

***Note**: The open-circuit voltages are valid for:*
- sinusoidal voltages (crest factor 1,4)
- frequency 20 - 26 kHz
- starting aid distance 12 mm.

5.4 Dimming

Dimming can be defined as the reduction of the luminous flux of a lamp, either continuously or in steps, by reducing the operating current.
For ensuring the proper operation of MASTER PL-L 4-pin lamps in dimming conditions, the conditions described in the following two sections should be fulfilled.

5.4.1 Electrical properties of the discharge

Dimming is done by reducing the discharge current flowing through the lamp. At lower lamp currents, the lamp voltage (U) will increase (see Annex 2 for the relationship between lamp voltage and current at 25 °C ambient temperature). The lamp voltage is not only dependent on the lamp current, but also on the mercury vapour pressure in the lamp. Under equilibrium conditions the mercury vapour pressure is controlled by the coldest spot inside the discharge tube. Therefore the values of lamp voltage, lamp current, lamp power and light output also depend on the temperature of the air immediately surrounding the lamp and also on the burning position of the lamp (see figure 5.4.1). Under High Frequency conditions with sinusoidal discharge current, the lamp voltage will be sinusoidal as well. The lamp power can thus be estimated with considerable accuracy using the product of lamp current by lamp voltage.

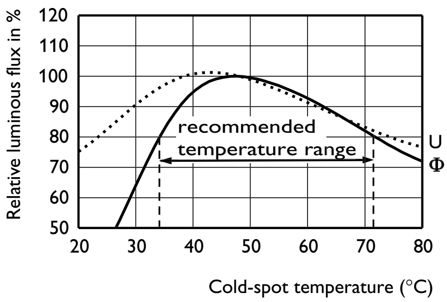


Figure 5.4.1: Dependency at rated lamp current

5.4.2 Conditions for proper operation of the electrodes

Electrodes in MASTER PL-L lamps consist of a coiled construction of tungsten wire which is filled with emissive material. The lifetime of a fluorescent lamp is determined by the lifetime of the electrode. In order to ensure sufficient electrode lifetime, its temperature should be kept within certain limits. Above a certain temperature the electrodes will be too hot, leading to enhanced evaporation of the emissive material and severe end-blackening. Below a certain temperature the electrode is too cold and sputtering of the emitter occurs. This may lead to extremely short life of the lamp.
If MASTER PL-L lamps are dimmed by reducing the lamp current, the power dissipation in the electrodes will decrease, resulting in a lower temperature of the electrode. Thus, in general, additional heating should be supplied to the electrode to maintain its proper temperature. The temperature of an electrode is primarily influenced by three currents. A simplified diagram of electrode currents is depicted in figure 5.4.2.

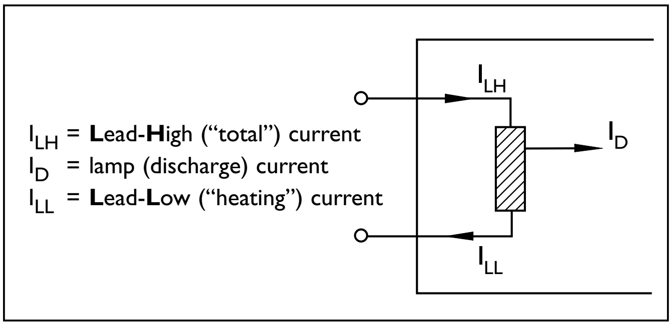


Figure 5.4.2: Lamp electrode

The currents I_{LH} and I_{LL} can be measured with a current probe around the lead-in wire.
By definition the higher of the two currents is called I_{LH} , the lower of currents I_{LL}.
If the two lead-in wires are taken together through one current probe, one measures the lamp current I_D.

Electrodes in MASTER PL-L lamps are designed in such a way that the lamp current can be varied around its rated value within certain limits.
Within these limits of the lamp current, additional heating is not strictly required. If, however, the ballast does supply an additional heating current, the currents in the lead-in wires (I_{LH} and I_{LL}) should be kept within the limits given in the tables on the following pages (Normal operation).
If the lamp current is to be dimmed over a broader range, additional heating should be supplied to the electrode for it to maintain its optimum temperature. Also in this case the currents in the lead-in wires should be kept within limits (Dimming operation).
Best lifetime and minimum end-blackening of the lamp is obtained when the "target setting" for I_{LH} and I_D is observed during dimming (see figures 5.4.3, 5.4.4 and 5.4.5). With this "target setting" (relationship between lamp current and Lead-High current), the electrode will have its optimum temperature.

For MASTER PL-L 18W, 24W and 40W lamps:

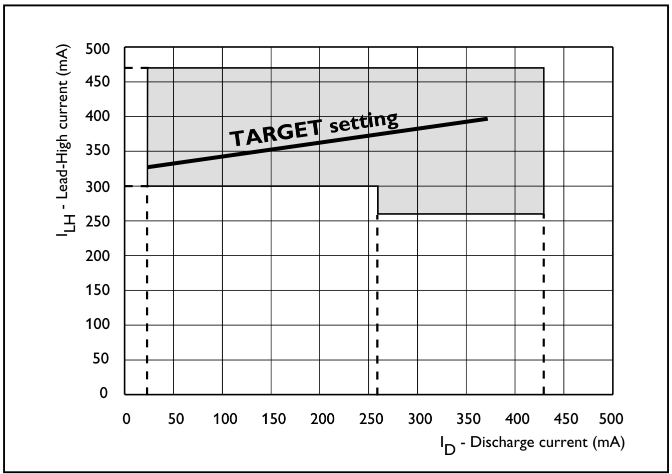


Figure 5.4.4: "target setting" curve MASTER PL-L 18W, 24W, 40W

***Note**: Also the requirement I_{LL} max.= 350 mA should be met.*

	I_D	I_{LL}	I_{LH}
Normal operation	260 - 430 mA	<350 mA	260 - 470 mA
Dimming operation	25 - 260 mA	<350 mA	300 - 470 mA

For MASTER PL-L 36W lamps:

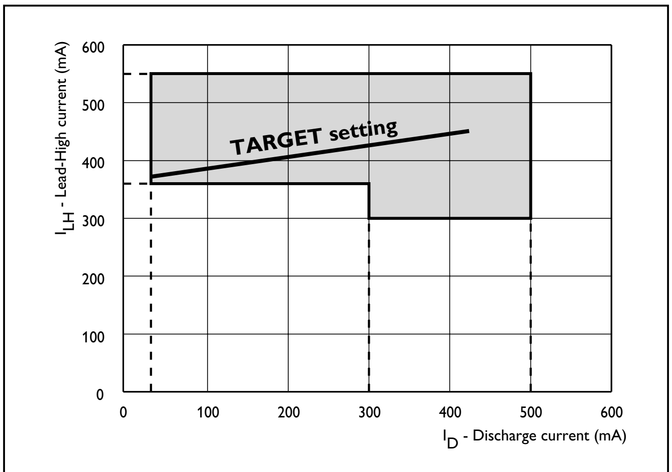


Figure 5.4.4: "target setting" curve PL-L 36W

***Note**: Also the requirement I_{LL} max.= 390 mA should be met.*

	I_D	I_{LL}	I_{LH}
Normal operation	300 - 500 mA	<390 mA	300 - 550 mA
Dimming operation	30 - 300 mA	<390 mA	360 - 550 mA

For MASTER PL-L 55W lamps

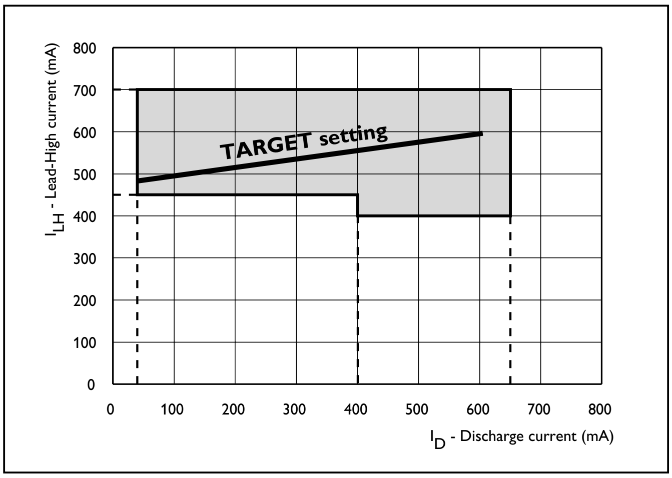


Figure 5.4.5: "target setting" curve MASTER PL-L 55W

***Note**: Also the requirement I_{LL} max.= 520 mA should be met.*

	I_D	I_{LL}	I_{LH}
Normal operation	400 - 650 mA	<520 mA	400 - 700 mA
Dimming operation	40 - 400 mA	<520 mA	450 - 700 mA

Regarding the figures and the preceding tables the following remarks should be made:

1) The actual data given in this Product Information brochure is also the subject of discussion in a working group of ELMAPS (European Lamp Manufacturers Association for the Preparation of Standards). This will result in due time in new data in the relevant IEC standards. Therefore the data given here should be considered as preliminary.
2) If the lamp current (I_D) is varied between the limits given at normal operation, additional heating is optional, but not strictly required.
3) In addition to the relation between the lamp current and the Lead-High current, the Lead-Low current (I_{LL}) may have any value < I_{LL} max. The maximum allowed values for the Lead-Low current are given in the tables. Lead-Low currents > I_{LL} max. will cause accelerated end-blackening.
4) It will be clear that practical lamp - ballast combinations will have settings deviating from the ideal "target setting" curve. The grey area in the graph indicates the "acceptable" range of deviation. It is difficult to indicate quantitatively the effects on lamp life for settings deviating from the "target setting".
   It is generally observed that higher values of the Lead High current (I_{LH}) lead to strong end-blackening. If the Lead-High current is below the "target setting" the electrode becomes too cold and sputtering of the emitter may occur. If the Lead High current is reduced below the grey area, a very short life of the lamp will occur.

5) The additional heating is directly related to the lamp current. Ballasts designs which do not make use of this direct relation, should be tested in all practical lamp operating conditions.
6) Information is only given for dimming to 10% of the rated value of the lamp current. It is observed that, at lower dimming levels, the temperature profile of the electrode is different from the one at higher lamp currents. Therefore the rules that determine the required extra heating at dimming levels > 10% cannot be extrapolated to lower "deep dimming" levels. The rules that determine low dimming are still under study.
   However some manufacturers of electronic gear, already bring ballasts to the market which permit deep dimming. Since no general rules can be given as yet, extensive life testing should be done with those lamp-ballasts combinations.

6. Definitions

Colour rendering — Effect of an illuminant on the colour appearance of objects by conscious or subconscious comparison with their colour appearance under a reference illuminant.

Colour rendering index (R) — Measure of the degree to which the psychophysical colour of an object illuminated by the test illuminant conforms to that of the same object illuminated by the reference illuminant, suitable allowance having been made for the state of chromatic adaptation.

Colour rendering index, CIE 1974 general (R_a) — Mean of the CIE 1974 special colour rendering indices for a specified set of eight test colour samples.

Colour temperature — The temperature of a Planckian radiator whose radiation has the same chromaticity as that of a given stimulus.
It is expressed in **kelvin** (K).

Colour temperature, correlated — The temperature of the Planckian radiator whose perceived colour most closely resembles that of a given stimulus at the same brightness and under specified viewing conditions.
It is expressed in **kelvin** (K).

Illuminance — (at a point of a surface). Quotient of the luminous flux incident on an element of the surface containing the point, by the area of that element.
It is expressed in **lux** (lx) = lumen per square metre (lm/m^2).

Life, rated average — The number of burning hours on average, after which 50% of large representative groups of lamps in laboratory tests, under controlled burning conditions and at a specified number of burning hours per start, have failed.

Luminance — (in a given direction, at a given point of a real or imaginary surface). Quantity defined by the formula, where the luminous flux is transmitted by an elementary beam passing through the given point and propagating in the solid angle containing the given direction; the area of a section of that beam containing the given point; the angle between the normal to that section and the direction of the beam.
It is expressed in **candela per square metre** (cd/m^2).

Luminous efficacy — (of a source). Quotient of the luminous flux emitted by the power consumed by the source.
It is expressed in **lumen per watt** (lm/W).

Luminous flux — Quantity derived from radiant flux by evaluating the radiation according to its action upon the CIE standard photometric observer.
It is expressed in **lumen** (lm).

Luminous intensity — (of a source in a given direction). Quotient of the luminous flux leaving the source and propagated in the element of solid angle containing the given direction, by the element of solid angle.
It is expressed in **candela** (cd).

Luminous intensity distribution — Distribution of the luminous intensities of a lamp or luminaire in all spatial directions.

Annex 1: International Lamp Coding System

The lamp industry strives continuously to meet customers' needs. Its innovative power has led to a tremendous variety of different light sources. To enable customers and experts to find their way within the diversity of products, a general system for the coding of lamps has been developed (see IEC Publication 61231).
The code does not replace specific markings used by individual manufacturers on their lamps or in their catalogues, but is promoted for cross-referencing purposes and, in due course, to replace national and regional lamp coding systems which already exist.
The object of the international lamp coding system is:

- to improve communication about the different types of lamps
- to help in discussions concerning interchangeability and compatibility of products;
- to create a closer relationship between international standards and manufacturers' literature (the code is given on all lamp data sheets in IEC 60901);
- to enable correct replacements of lamps;
- to be used as a complementary marking on the luminaire;
- to replace national and regional coding systems.

Below a short description is given of the structure of the ILCOS code for MASTER PL-L 4-pin lamps.

MASTER PL-L 4-pin lamps:
Example: FSD-18-E-2G11

- FSD: Fluorescent lamp Single-capped Dual shaped
- 18: wattage
- 40: colour temperature (divided by 100)
- 1B: colour rendering group according to CIE (R_a = 80 - 89)
- E: starting details: External starter/preheated
- 2G11: lamp cap

ILCOS codes for MASTER PL-L 4-pin lamps in available colours and wattages:

MASTER PL-L ..W/827 /4P: FSD-../27/1B-E-2G11
MASTER PL-L ..W/830 /4P: FSD-../30/1B-E-2G11
MASTER PL-L ..W/835 /4P: FSD-../35/1B-E-2G11
MASTER PL-L ..W/840 /4P: FSD-../40/1B-E-2G11
MASTER PL-L ..W/865 /4P: FSD-../65/1B-E-2G11
MASTER PL-L ..W/930 /4P: FSD-../30/1A-E-2G11
MASTER PL-L ..W/950 /4P: FSD-../53/1A-E-2G11

Annex 2: Lamp characteristics at dimming operation

Electronic operation

Measuring conditions (according to IEC Publication 60901):
- Ambient temperature: 25 °C
- Burning position: base up
- Operating frequency = 25 kHz

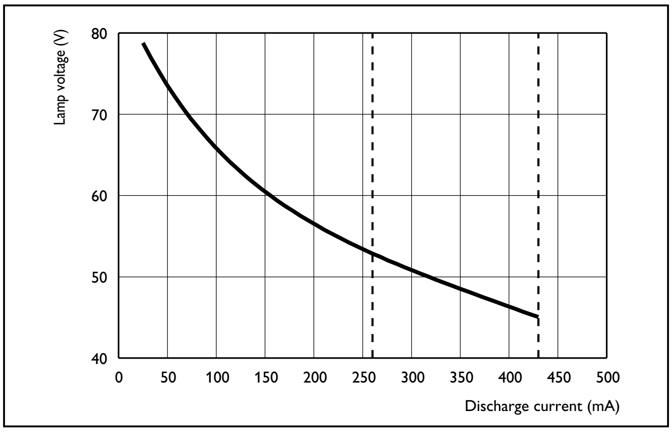


Figure 1.1: Lamp voltage MASTER PL-L 18W

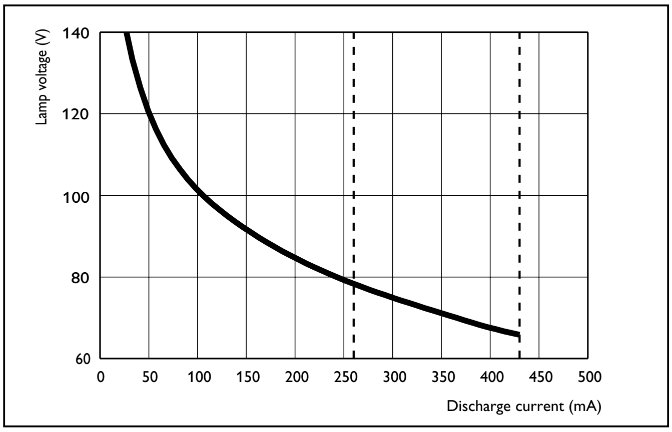


Figure 1.4: Lamp voltage MASTER PL-L 24W

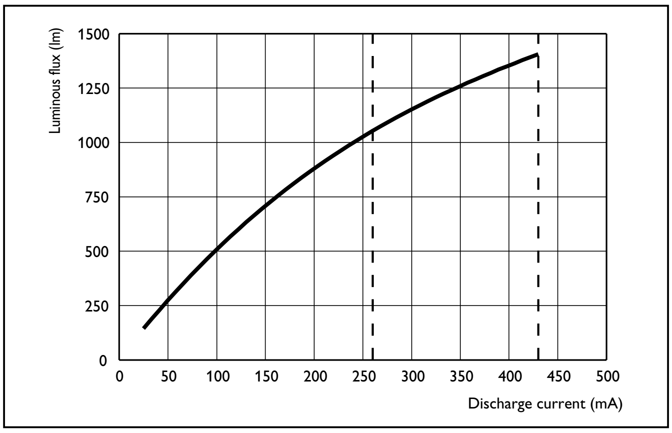


Figure 1.2: Luminous flux MASTER PL-L 18W

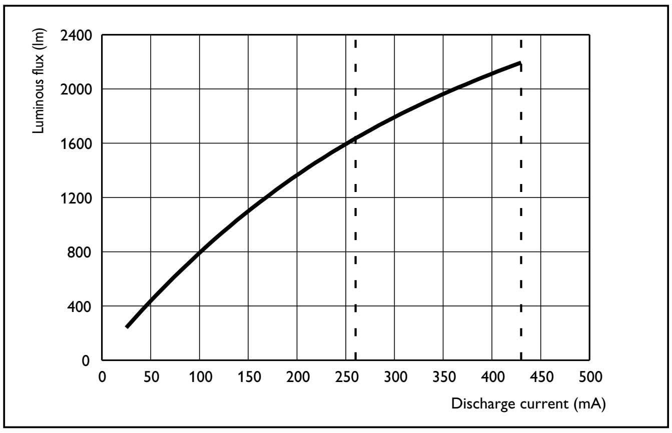


Figure 1.5: Luminous flux MASTER PL-L 24W

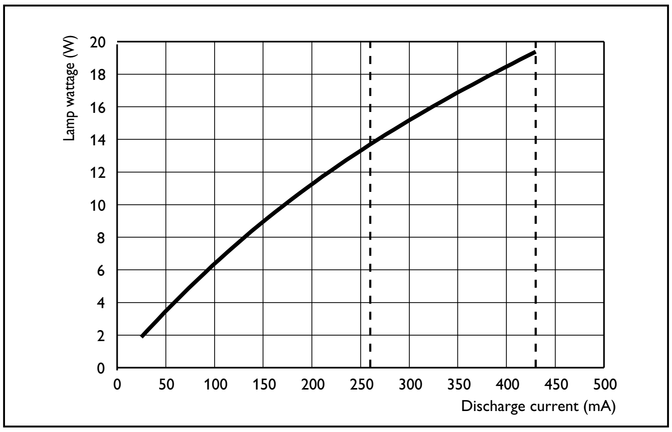


Figure 1.3: Lamp power MASTER PL-L 18W

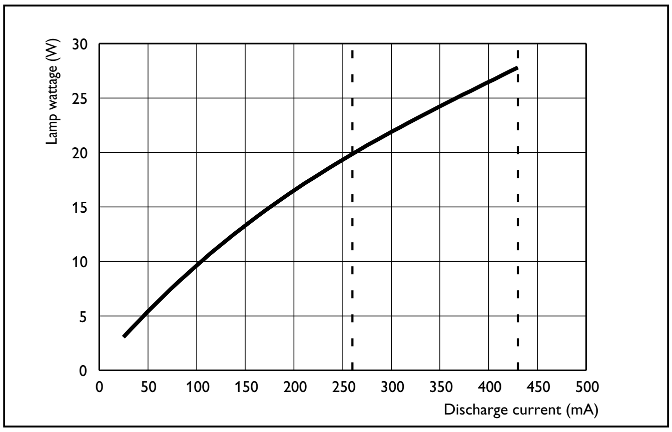


Figure 1.6: Lamp power MASTER PL-L 24W

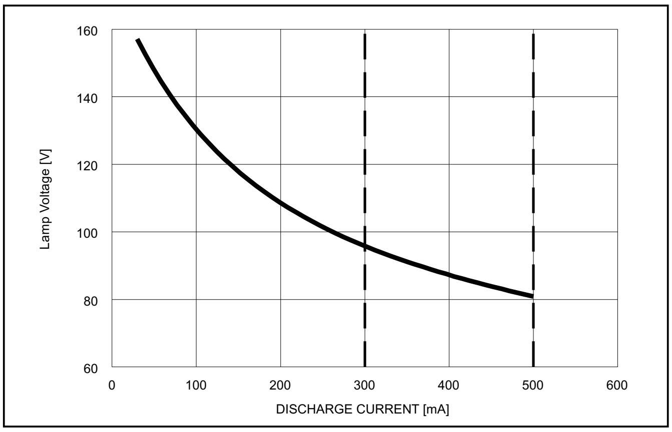


Figure 1.7: Lamp voltage MASTER PL-L 36W

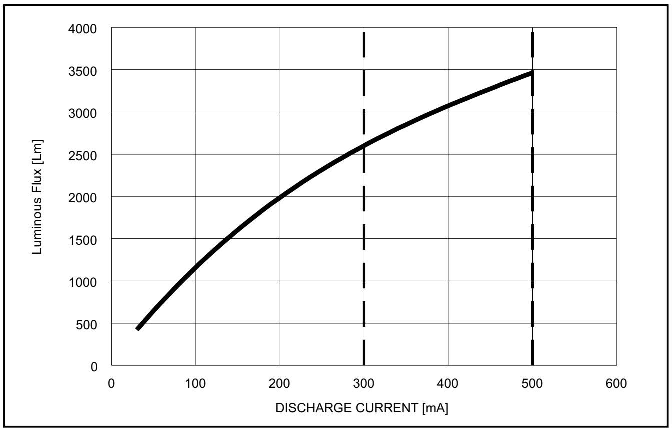


Figure 1.8: Luminous flux MASTER PL-L 36W

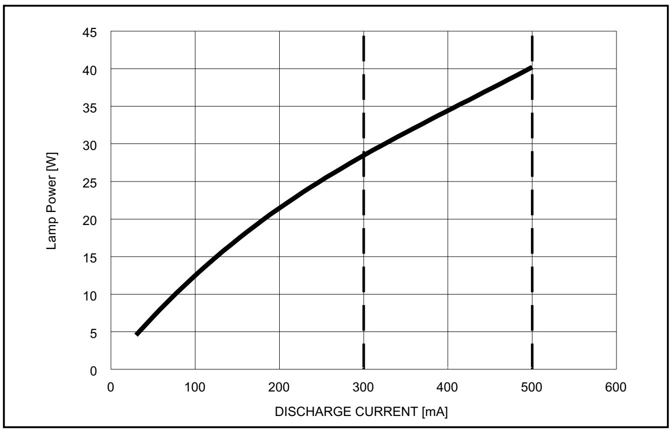


Figure 1.9: Lamp power MASTER PL-L 36W

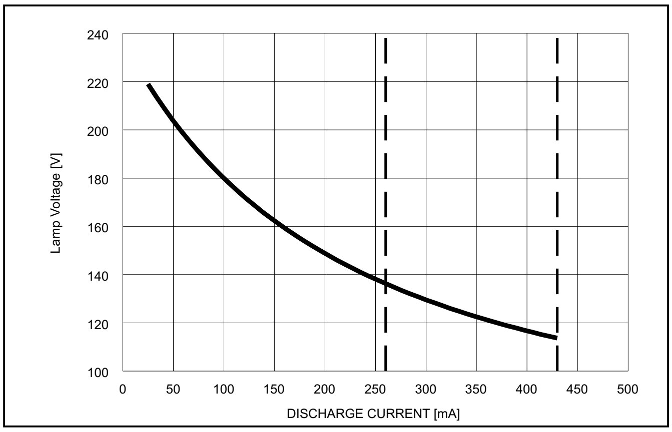


Figure 1.10: Lamp voltage MASTER PL-L 40W

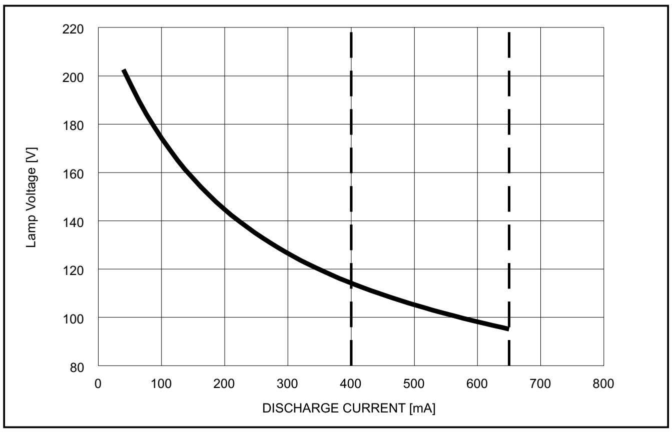


Figure 1.10: Lamp voltageMASTER PL-L 55W

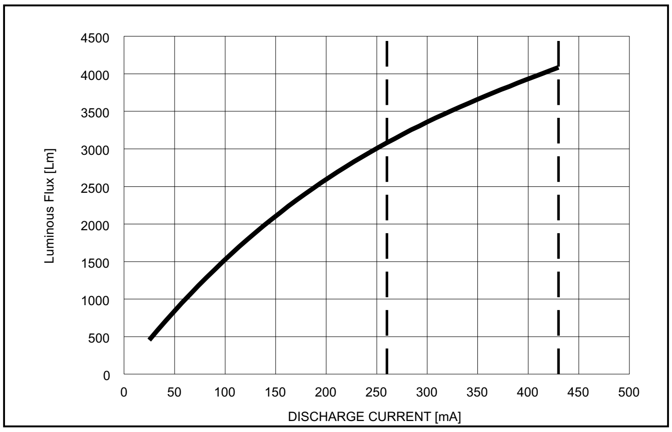


Figure 1.11: Luminous flux MASTER PL-L 40W

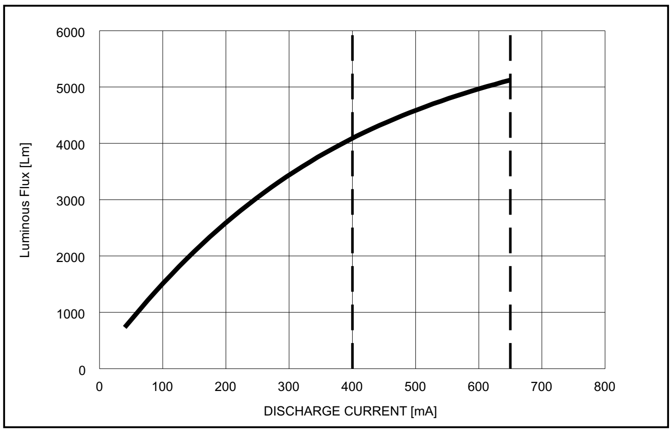


Figure 1.11: Luminous flux MASTER PL-L 55W

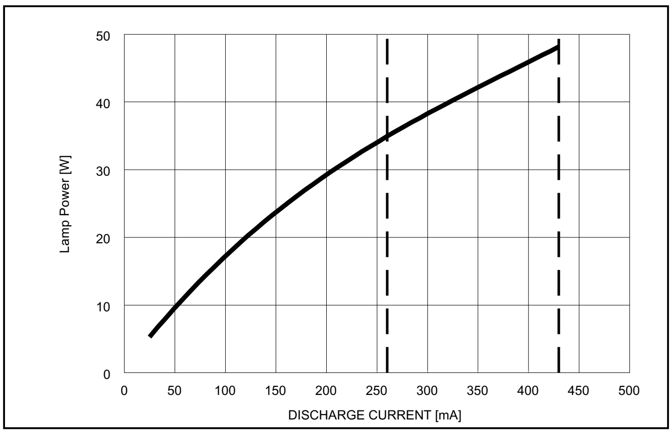


Figure 1.12: Lamp power MASTER PL-L 40W

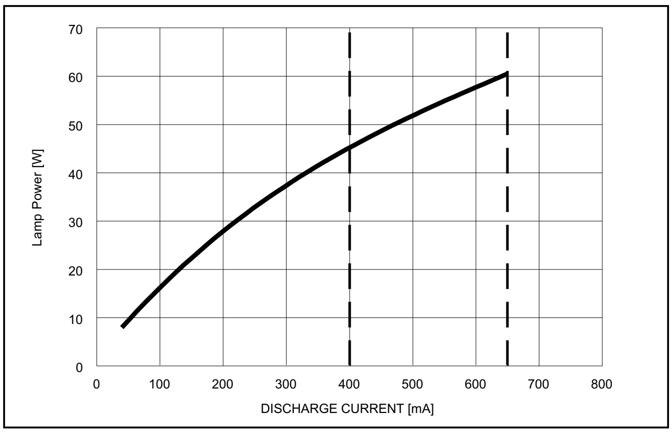


Figure 1.12: Lamp power MASTER PL-L 55W

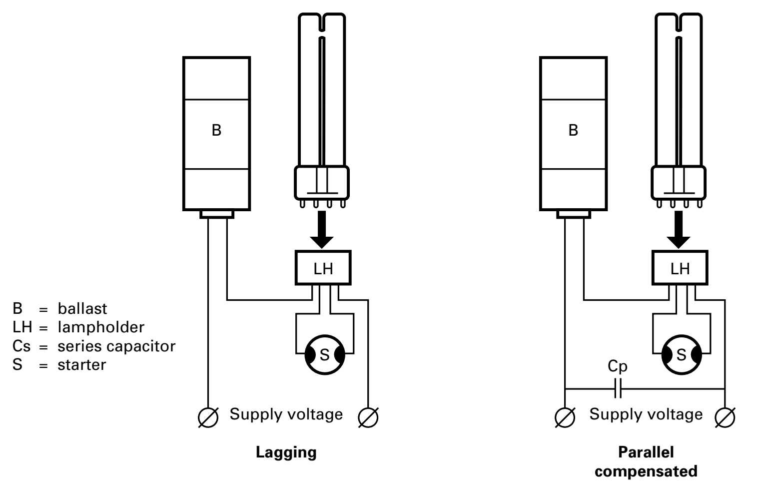
Annex 3: Technical data on PL-L circuits

3.1 Conventional operation (Single)

Operation on recommended Philips ballast types (230 V, 50 Hz).

	Ballast data		Lamp data		System data						
							Lagging		Parallel compensated		
		Power		Luminous			Supply		Compensated	Compensating	
	Philips type	losses	Power	flux	Power	Efficacy	Current		current	capacitor	
		W	W	lm	W	lm/W	mA	cos φ	mA	μF	cos φ
PL-L 18W	BTA 18L31	8,7	18,0	1200	26,7	45	370	0,33	142	4,5	≥ 0,85
PL-L 24W	BTA 18L31	8,3	24,0	1800	32,3	58	350	0,41	169	4,5	≥ 0,85
PL-L 36W	BTA 36L31	8,1	36,0	2900	44,1	64	420	0,47	232	4,5	≥ 0,85

Wiring diagrams



General remarks:
- Parallel compensation is used to realise a power factor ≥ 0.85
- Capacitor values ± 10 % 250 V~.

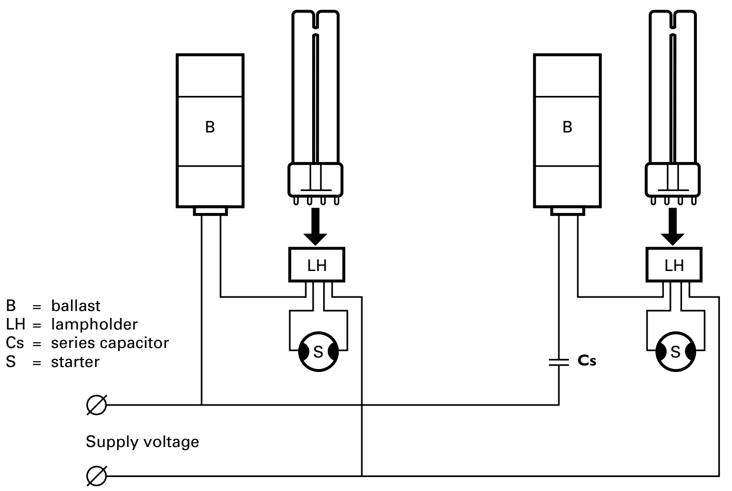
3.2 Conventional operation (Duo)

Operation on recommended Philips ballast types (230 V, 50 Hz)

1 lamp leading, 1 lamp lagging; cos φ ≥ 0.90

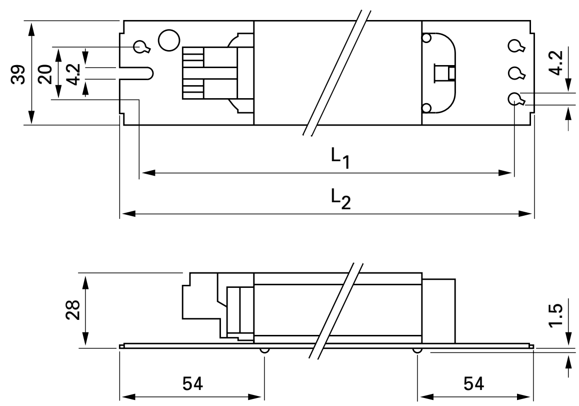
Lamps	Ballast	Supply current mA	System power W
2x PL-L 18W	BTA 18 L31 BTA 18 L31 + series capacitor 2.7 μF	270	53,4
2x PL-L 24W	BTA 18 L31 BTA 18 L31 + series capacitor 2.7 μF	320	64,6
2x PL-L 36W	BTA 36 L31 BTA 36 L31 + series capacitor 3.4 μF	430	88,5

Wiring diagrams



Dimensions

Type	L1 mm	L2 mm	W mm	H mm	Mass kg
BTA 18L31	155	140	39	28	0,48
BTA 36L31	155	140	39	28	0,55



General remarks:
• Series compensation is used to realise a power factor ≥ 0,85
• Capacitor values ± 10 % 450 V~.

3.3 Electronic operation (Non-dimming)

Operation on recommended Philips HF-Performer ballasts

Operation of PL-L lamps on electronic ballasts
for one lamp systems (220-240 V, 50/60 Hz)

Lamps	Philips type	Dimensions Length mm	Width mm	Height mm	Mass g	Max. Tcase °C	System data I A	P W	Efficacy lm/W	T min. °C	Power factor
PL-L 18W	HF-P 118 PL-L	103	67	30	150	75	0,09	20	75	-15	> 0,97
PL-L 24W	HF-P 122 TL5C/PL-L	103	67	30	150	75	0,11	26	82	-15	> 0,97
PL-L 36W	HF-P 136 PL-L	335	39	28	350	75	0,16	36	80	-15	> 0,96
PL-L 40W	HF-P 140 PL-L	335	39	28	350	75	0,16	45	84	-15	> 0,96
PL-L 55W	HF-P 155 PL-L	335	39	28	350	75	0,16	58	78	-15	> 0,96

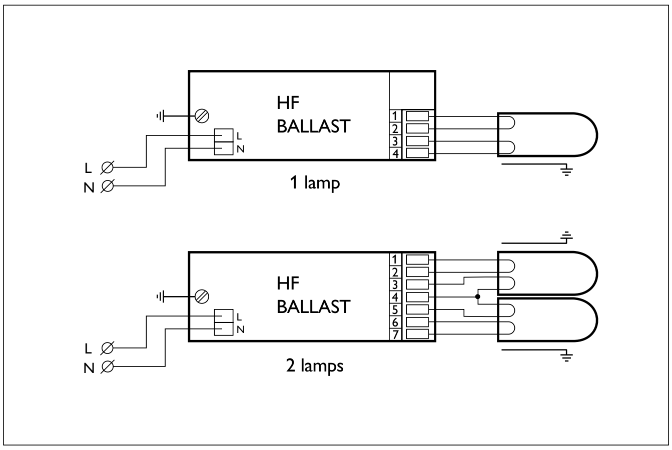
Notes:
[1]) Preheat + ignition according to IEC requirements
[1]) System also suitable for Class II application, without ignition aid

Operation of PL-L lamps on electronic ballasts
for two lamp systems (220-240 V, 50/60 Hz)

Lamps	Philips type	Dimensions Length mm	Width mm	Height mm	Mass g	Max. Tcase °C	System data I A	P W	Efficacy lm/W	T min. °C	Power factor
2 x PL-L 18W	HF-P 218 PL-L	123	79	33	230	75	0,16	37	75	-15	> 0,90
2 x PL-L 24W	HF-P 224 PL-L	123	79	33	230	75	0,22	51	82	-15	> 0,90
2 x PL-L 36W	HF-P 236 PL-L	425	39	28	510	75	0,31	72	80	-15	> 0,96
2 x PL-L 40W	HF-P 240 PL-L	425	39	28	510	75	0,40	89	85	-15	> 0,96
2 x PL-L 55W	HF-P 255 PL-L	425	39	28	510	75	0,50	116	78	-15	> 0,96

Notes:
[1]) Preheat + ignition according to IEC requirements
[2]) System also suitable for Class II application, without ignition aid

Wiring diagrams PL-L 36W, 40W, 55W



Wiring diagrams PL-L 18W, 24W

3.4 Electronic operation (Dimming)

Operation on recommended Philips HF-Regulator ballasts

Operation of PL-L lamps on electronic ballasts
for one lamp systems (220-240 V, 50/60 Hz)

		Dimensions					System data				
Lamps	Philips type	Length mm	Width mm	Height mm	Mass g	Max. Tcase °C	I A	P W	Efficacy lm/W	T min. °C	Power factor
PL-L 36 W	HF-R 136 PL-L	335	39	28	360	75	0,18	38	79	6	> 0,95
PL-L 40 W	HF-R 140 PL-L	335	39	28	360	75	0,21	47	81	5	> 0,95
PL-L 55 W	HF-R 155 PL-L	335	39	28	360	75	0,26	56	78	5	> 0,95

Notes:
[1]) Control voltage for dimming 1-10 Vdc, 10 V = 100% lamp power, 1 V = 3% lamp power
[2]) Preheat and dimming according to new IEC proposal for electrode heating control
[3]) Power factor value at 100% power.

Operation of PL-L lamps on electronic ballasts
for two lamp systems (220-240 V, 50/60 Hz)

		Dimensions					System data				
Lamps	Philips type	Length mm	Width mm	Height mm	Mass g	Max. Tcase °C	I A	P W	Efficacy lm/W	T min. °C	Power factor
2 x PL-L 36 W	HF-R 236 PL-L	425	39	28	450	75	0,33	74	78	6	> 0,95
2 x PL-L 40 W*)	HF-R 240 PL-L	425	39	28	450	75	0,41	92	83	8	> 0,95
2 x PL-L 55 W	HF-R 255 PL-L	425	39	28	450	75	0,51	113	77	6	> 0,95

Notes:
[1]) Control voltage for dimming 1-10 Vdc, 10 V = 100% lamp power, 1 V = 3% lamp power
[2]) Preheat and dimming according to new IEC proposal for electrode heating control
[3]) Power factor value at 100% power.

Wiring diagrams