PAKISTAN STANDARD

AC and/or DC-SUPPLIED ELECTRONIC CONTROL GEAR FOR TUBULAR FLUORESCENT LAMPS – PERFORMANCE REQUIREMENTS

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AC and/or DC-SUPPLIED ELECTRONIC CONTROL GEAR FOR TUBULAR FLUORESCENT LAMPS – PERFORMANCE REQUIREMENTS

0. FOREWORD

0.1 This Pakistan Standard was adopted by the authority of the Board of Directors of Pakistan Standard and Quality Control Authority after the draft prepared by the Technical Committee for "Electric Lamps (EDC-2)" had been approved and endorsed by the National Standards Committee on 19th January 2012.

0.2 This Pakistan Standard PS: 4640 was prepared in 2000 on the basis of **IEC: 60929** which was subsequently revise with latest amendment. It deemed necessary to revise the standard on the basis of latest IEC: **60929/2011** in order to keep abreast with the latest development in technology.

0.3 This Standard is a revision of PS: 4640 on the basis of latest **IEC: 60929/2011 "AC and/or DC-Supplied Electronic Control Gear for Tubular Fluorescent Lamps – Performance Requirements "** and its use is hereby acknowledged with thanks.

0.4 This Standard is subject to periodical review in order to keep pace with the changing requirements and latest development in the industry. Any suggestions for improvement will be recorded and placed before the revising committee in due course.

0.5 This Standard covers technical provisions and it does not purport to include all the necessary provision of a contract.

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AC and/or DC-SUPPLIED ELECTRONIC CONTROL GEAR FOR TUBULAR FLUORESCENT LAMPS – PERFORMANCE REQUIREMENTS

1 Scope

This Pakistan Standard specifies performance requirements for electronic control gear for use on a.c. at 50 Hz or 60 Hz and/or d.c. supplies, both up to 1 000 V, with operating frequencies deviating from the supply frequency, associated with fluorescent lamps as specified in IEC 60081 and IEC 60901, and other fluorescent lamps for high-frequency operation.

NOTE 1 Tests in this standard are type tests. Requirements for testing individual control gear during production are not included.

NOTE 2 There are regional standards regarding the regulation of mains current harmonics and immunity for end-products like luminaires and independent control gear. In a luminaire, the control gear is dominant in this respect. Control gear, together with other components, should comply with these standards.

NOTE 3 Requirements for the digital addressable lighting interface of electronic control gear are given in IEC 62386.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60081:1997, *Double-capped fluorescent lamps – Performance specifications*
Amendment 1(2000)
Amendment 2 (2003)
Amendment 3 (2005)
Amendment 4 (2010)

IEC 60901:1996, *Single-capped fluorescent lamps – Performance specifications*
Amendment 1(1997)
Amendment 2 (2000)
Amendment 3 (2004)
Amendment 4 (2007)

IEC 61347-1:2007, *Lamp controlgear – Part 1: General and safety requirements*
Amendment 1(2010)[1]

IEC 61347-2-3:2000, *Lamp controlgear – Part 2-3: Particular requirements for a.c. supplied electronic ballasts for fluorescent lamps*
Amendment 1(2004)
Amendment 2 (2006)

IEC 62386 (all parts), *Digital addressable lighting*

IEC TR 62750:2012, *Unified fluorescent lamp dimming standard calculations*

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1 There exists a consolidated edition 2.1 (2010) that comprises IEC 61347-1:2007 and its Amendment 1 (2010).

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
starting aid
a conductive strip affixed to the outer surface of a lamp, or a conductive plate which is spaced within an appropriate distance from the lamp

A starting aid is usually connected to earth potential, and can only be effective when it has an adequate potential difference from one end of the lamp.

3.2
ballast lumen factor
blf
ratio of the luminous flux of the lamp when the ballast under test is operated at its rated voltage, to the luminous flux of the same lamp operated with the appropriate reference ballast supplied at its rated voltage and frequency

3.3
reference ballast
special ballast, either inductive for lamps for operation on a.c. mains frequencies, or resistive for lamps for operation on high frequency

It is designed for the purpose of providing comparison standards for use in testing ballasts, for the selection of reference lamps and for testing regular production lamps under standardised conditions. It is essentially characterised by the fact that, at its rated frequency, it has a stable voltage/current ratio which is relatively uninfluenced by variations in current, temperature and magnetic surroundings, as outlined in this standard.

[IEC 60050-845:1987, 845-08-36, modified]

3.4
reference lamp
lamp selected for testing control gear which, when associated with a reference ballast, has electrical characteristics which are close to the nominal values as stated in the relevant lamp standard

NOTE Specified conditions are given in Annex C.

3.5
total circuit power
total power dissipated by control gear and lamp in combination, at rated voltage and frequency of the control gear

3.6
circuit power factor
λ
power factor of the combination of a control gear and the lamp or lamps for which the control gear is designed

3.7
preheat starting
type of circuit in which the lamp electrodes are brought to emission temperature before the lamp actually ignites

3.8
non-preheat starting
type of circuit which utilises a high open-circuit voltage causing secondary electron emission from electrodes

3.9
electronic control gear life time
declared average life time at which 90 % of the electronic control gears are still operating

NOTE 1 In the context of life time, an electronic control gear is “operating” if it still fulfils it intended functions.

NOTE 2 The manufacturer apply suitable methods, e.g. statistical calculation and/or reliability testing.

3.10
ambient temperature
t_a
temperature range of the air surrounding the electronic control gear declared by the manufacturer to indicate the normal operating temperature range for the electronic control gear

NOTE 1 The lifetime of the electronic control gear is given at the ambient temperature t_a; for ease of measurement, also the corresponding temperature of the t_c point is given.

NOTE 2 The measurement test condition for the ambient temperature assigned to the DUT should be in accordance to Annex D of IEC 61347-1 at the rated voltage.

4 General notes on tests

4.1 Tests according to this standard are type tests.

NOTE The requirements and tolerances permitted by this standard are based on the testing of a type test sample submitted by the manufacturer for that purpose. In principle this type test sample should consist of units having characteristics typical of the manufacturer’s production and be as close to the production centre point values as possible.

It may be expected with the tolerances given in this standard that products manufactured in accordance with the type test sample will ensure compliance with the standard for the majority of the production. However, due to the production spread, it is inevitable that there will sometimes be products outside the specified tolerances. For guidance on sampling plans and procedures for inspection by attributes, see IEC 60410.

4.2 The tests are carried out in the order of the clauses, unless otherwise specified.

4.3 One control gear is submitted to all tests, unless otherwise stated.

4.4 In general, all tests are made on each type of control gear or where a power range of similar control gear is involved, for each rated power in the range or on a representative selection from the range as agreed with the manufacturer.

4.5 The tests are made under the conditions specified in Annex A. Lamp data sheets not published in an IEC publication shall be made available by the lamp manufacturer.

4.6 All control gear specified in this standard shall comply with the requirements of IEC 61347-2-3.

4.7 Attention is drawn to lamp performance standards which contain “information for control gear design”; this should be followed for proper lamp operation; however, this standard does not require the testing of lamp performance as part of the type test approval for control gear.

5 Marking

5.1 Mandatory marking

Electronic control gear shall be clearly marked with the following mandatory marking as applicable.

a) Circuit power factor, e.g. 0,85.

If the power factor is less than 0,95 capacitive, it shall be followed by the letter C, e.g. 0,85 C.

The following marking shall also be added, if appropriate:

b) The symbol $\overline{Z}$ which indicates that the control gear is designed to comply with the conditions for audio-frequency impedance.

5.2 Additional mandatory Information

In addition to the above mandatory markings, the following information shall either be given on the control gear or be made available in the manufacturer's catalogue or the like.

a) a clear indication regarding the type of starting, viz. preheat or non-preheat;

b) indication whether a control gear needs a starting aid;

c) ballast lumen factor if different from 1 ± 0,05;

d) life time of the control gear is linked to the ambient temperature and the measured temperature on the reference point t_c.

For the information, the format of Table 1 has to be used. Corresponding to the fixed ambient temperature values 40 °C, 50 °C and 60 °C, the values of the temperature measured on the reference point t_c and the declared life time have to be inserted by the manufacturer. The value of the temperature of the t_c point given in the table shall never exceed the t_c (IEC 61347-1), therefore, in that case, the column where the temperature of t_c-point exceeds t_c will be left blank; but at least the column with ambient temperature 40 °C shall always be filled.

Table 1 – Control gear life time information

Ambient temperature	40 °C	50 °C	60 °C
Temperature measured on the reference point t_c	XX[a]	XX[a]	XX[a]
Life time	XX XXX[b]	XX XXX[b]	XX XXX[b]

[a] "°C" values declared by the control gear manufacturer

[b] "h" values declared by the control gear manufacturer

NOTE 1 Additional information from the control gear manufacturer to the ambient temperature and life time given in Table 1 is allowed.

NOTE 2 For multi power control gear the most adverse load condition or a table for each lamp-control gear combination should be given.

5.3 Non-mandatory information

Non-mandatory information which may be made available by the manufacturer:

a) rated output frequency at rated voltage, with and without lamp operating;

b) limits of the ambient temperature range within which the control gear will operate satisfactorily at the declared voltage (range);

c) total circuit power.

6 General statement

It may be expected that control gear complying with this standard, when associated with lamps which comply with IEC 60081 or IEC 60901 or other fluorescent lamps for high-frequency operation, will provide satisfactory starting of the lamp at an air temperature immediately around the lamp between 10 °C and 35 °C and operation between 10 °C and 50 °C at voltages within 92 % and 106 % of the rated voltage.

NOTE 1 The electrical characteristics as given on the lamp data sheets of IEC 60081 and IEC 60901, and applying to operation on a reference control gear at rated voltage with a frequency of 50 Hz or 60 Hz, may deviate when operating on a high frequency control gear and the conditions of item b) of 5.3 above.

NOTE 2 In some regions, there are laws on EMC for luminaires. The control gear is also contributing to this EMC behaviour. See Bibliography for reference.

7 Starting conditions

7.1 General

Control gear shall start lamps without adversely affecting the performance of the lamp when operated according to intended use. An explanation of the starting conditions is given in Annex D.

Compliance is checked by the tests according to 7.2 to 7.4, as appropriate, with the control gear operating at any supply voltage between 92 % and 106 % of its rated value.

7.2 Conditions for control gear with preheating

7.2.1 General

Control gear shall be tested according to the following requirements and in line with the requirements of Clause A.3. The same requirements for preheating also apply to controllable control gear at starting in any dimming position.

The lamp data sheet provides one substitution resistor $R_{sub(min)}$ which is used with the control gear in order to test its capability to produce the minimum energy according to the lamp data sheet. If the control gear does not provide at least the minimum energy, it has failed. The maximum energy line has to be tested with another substitution resistor $R_{sub(max)}$ which corresponds to the upper energy. If the control gear generates too high energy, it has failed. The value of the second resistor is also given on the lamp data sheet. In cases where no value is given, preliminary values may be obtained from the lamp manufacturer.

7.2.2 Preheat energy

The control gear shall deliver at least the minimum total heating energy E_{min} at t_1 according to the time/energy limits on the relevant lamp data sheets (see Figure 1). Within the interval (t_1, t_2) the total heating energy shall be between E_{min} and E_{max} according to the relevant lamp data sheet (see Figure 1).

The maximum heating energy shall not exceed the limits specified on the relevant lamp data sheet at any time before t_2. This does not apply in the interval (t_1, t_2), if $t_2 - t_1 < 0,1$ s.

The absolute minimum preheat time shall be 0,4 s unless otherwise specified on the relevant lamp data sheet.

In order to prevent arcing, the voltage supplied to the substitution resistor should remain below 11 V r.m.s., for $E < E_{min}$.

If a lamp data sheet does not give any energy data for preheating, and the preheat current requirements are not applicable, the lamp manufacturer shall provide appropriate preheat data.

Compliance with the requirements for the cathode preheat current can be tested as follows.

With a non-inductive substitution resistor of the value specified on the relevant lamp data sheet, substituted for each lamp cathode, the control gear shall deliver a minimum and maximum total heating current according to the time/current limits specified on the relevant lamp data sheet. The minimum preheat current i_k is defined as

$$i_k = \sqrt{\frac{a}{t_e} + i_m^2}$$

where

a is the constant (A^2 s) for a specific cathode type;

i_m is the absolute minimum value of the effective heating current (A) to achieve emission, if application time is of sufficiently long duration (e.g. ≥ 30 s from cold);

t_e is the time (s) to emission.

NOTE Emission time less than 0,4 s is normally not acceptable because experience has shown that satisfactory cathode preheating is not always achievable in practice.

Values for a and i_m are given on the lamp data sheet.

Measurements are conducted with a non-inductive substitution resistor for testing cathode preheat requirements of the value specified on the relevant lamp data sheet, substituted for each lamp cathode, also in case of two or more lamps simultaneously operated.

7.2.3 Open-circuit voltage

During the preheat period, the open-circuit voltage between any pair of substitution resistors shall not exceed the maximum value specified on the lamp data sheet, including the DC-offset according to Clause E.4 of IEC 60081, and Clause D.3 of IEC 60901. After the preheat period, it shall be, or rise to a value, not less than the minimum value equal to the ignition voltage as specified on the lamp data sheet.

Where two or more lamps are operated in series or parallel circuits, each position is measured in turn. The positions where not to measure are equipped with reference lamps, the position where to measure is equipped with a pair of substitution resistors for testing open-circuit voltage.

The open-circuit voltage is measured between the substitution resistors and shall comply in all cases with the value specified on the relevant lamp data sheet for one lamp.

Measurement is made with an oscilloscope. Measurements are conducted with a non-inductive substitution resistor for testing open-circuit voltages as specified on the relevant lamp data sheet.

The control gear manufacturer provides on request the value of the cathode substitution resistor within the specified range which results in the lowest open-circuit voltage for ignition.

7.3 Conditions for control gear without preheating

7.3.1 General

Control gear in accordance with definition 3.8 shall be so designed that the cumulated glow discharge periods during starting do not exceed 100 ms when measured with a reference lamp and without any earthed metal parts close by which might act as a starting aid. The glow discharge period is deemed to have finished if the lamp current is at least 80 % of the rated lamp current.

A control gear is deemed to conform with the above requirements when the following conditions are fulfilled.

7.3.2 Open-circuit voltage

Measurement is made with an oscilloscope. With a non-inductive substitution resistor R_C of the value specified on the relevant lamp data sheet, substituted for each lamp cathode (see Figure 2a), the open-circuit voltage shall comply with the value specified on the relevant lamp data sheet.

Where two or more lamps are operated in series or parallel, each position is measured in turn. The positions where not to measure are equipped with reference lamps, the position where to measure is equipped with a pair of cathode substitution resistors.

The open-circuit voltage is measured between the substitution resistors and shall comply in all cases with the value specified on the relevant lamp data sheet for one lamp.

NOTE In the case of additional cathode heating during the starting process, lower values may be sufficient provided the glow discharge period does not exceed 100 ms.

7.3.3 Control gear impedance test

With a non-inductive lamp substitution resistor R_L of the value specified on the relevant lamp data sheet, substituted for the lamp and a non-inductive resistor R_C of the value specified on the relevant lamp data sheet, substituted for each lamp cathode, (see Figure 2b), and at 92 % of the rated voltage, the control gear shall deliver a current not less than the minimum value specified on that data sheet.

7.3.4 Cathode current

Control gear of the non-preheat start type may supply some cathode heating during the starting process. In Figure 2c, the cathode (heating) current is measured in M1 and M2 as the lower current.

The cathode current, if any, shall not exceed the maximum value specified on the relevant lamp data sheet.

The measurement is carried out with substitution resistors R_i (see Figure 2c), the value of which is calculated as follows:

$$R_i = \frac{11\,\text{V}}{2{,}1 \times I_r}$$

where I_r is the rated value of the lamp operating current.

This requirement does also apply to electronic control gear with output terminals for more than one lamp. The positions where not to measure are equipped with reference lamps, the position where to measure is equipped as shown in Figure 2c.

7.4 Starting aid and distances

Lamps operated with electronic control gear complying with this standard may require a starting aid as specified in IEC 60081 or 60901. The open-circuit voltage and voltage to starting aid, during preheat and starting, shall be within the limits specified in the information for control gear design on the relevant lamp data sheet.

8 Operating conditions

8.1 Ballast lumen factor

At rated voltage and ambient temperature of (25 ± 2) °C, the ballast lumen factor shall not be less than 95 % of the value declared by the manufacturer or not less than 0,95 if not declared.

NOTE The luminous flux of a lamp is usually measured with an integrating photometer. For ratio measurements, a suitable luxmeter is sufficient as there is close relationship between flux and luminous intensity at a fixed point.

If the declared lumen factor of the control gear is less than 0,9, evidence shall be given that the performance of lamps operated on that control gear is not impaired.

The requirements of Subclause 8.3 shall be complied.

8.2 Total circuit power

At rated voltage, the total circuit power shall be not more than 110 % of the value declared by the manufacturer, when the control gear is operated with (a) reference lamp(s).

8.3 Requirements for dimming

8.3.1 Heating of the lamp cathodes

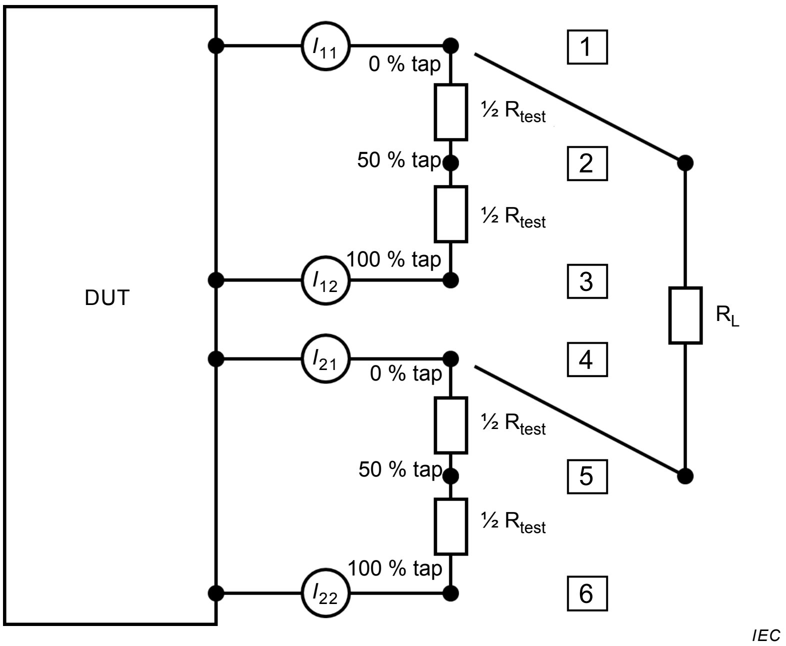
8.3.1.1 General

Fluorescent lamps operated in dimming mode (to reduce luminous flux by reducing discharge current) need their cathodes adequately heated by the electronic control gear. It has been found that measuring the currents through the two lead-in wires to the cathode and calculating the sum of the squares (SoS) of these two currents as a function of the discharge current can estimate the cathode heating. Alternatively, it has also been found that it is possible to estimate cathode heating by measuring the voltage applied across the cathode (CV) while dimming. The heating requirements are described in IEC TR 62750:2012.

The control gear is tested at lamp discharge currents (dim levels) of I_{Dmin}, I_{D30} and I_{D60}. The measurements are conducted with substitution resistors for the cathodes ($\mathrm{R}_{\mathrm{test}}$) and for the discharge, the latter dependent on the dim level (R_{L}, having nominal values of R_{L10Max} and R_{L10Min} as well as R_{L30} and R_{L60}). The lamp substitution resistor values shall be taken from the IEC lamp data sheets. Take care that the substitution resistors are capable of carrying the current, voltage and power occurring in the circuit.

All positions that on control gear that would be connected to a lamp shall instead be connected to substitution resistors. Wherever in this procedure a reference is made to “lamp”, it is intended to mean a set of substitution resistors that represent a lamp.

The hot spot location may vary on the lamp cathode during operation. This effect is simulated in the test by connecting the cathode substitution resistors in different circuit configurations. For this purpose, taps in the middle and at the ends of the cathode substitution resistor networks are equipped with switches (0 – 50 – 100 method), which allow all possible combinations of connection to be realized. The fundamental test set-up is shown in Figure 3.



Key

DUT control gear device under test

R_L lamp substitution resistor

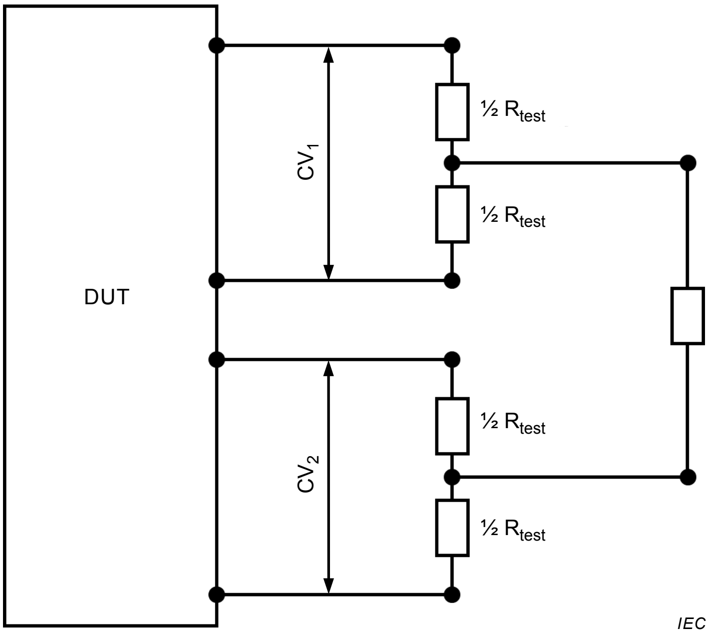
I_{nn} measured current

1…6 switch positions

Figure 3 – Fundamental test set-up for the SoS-test

In cases where the discharge current is much smaller than the auxiliary heating current, i.e. for the upper and lower heating limits at very low discharge current values (= 10 % of the test current), the cathode lead wire currents are found to be nearly equal.

Thus, for the CV-test, only the centre tap position is required for testing. The CV-test setup shown in Figure 4 is a simplified version of the SoS-test circuit.



Key

DUT	control gear device under test
R_L	lamp substitution resistor
CV_1 and CV_2	measured cathode voltages

Figure 4 – Fundamental test set-up for the CV-test

8.3.1.2 Basic test conditions

Due to the lamps being operated at high frequency, the test set-up with substitution resistors should be comparable to the set-up of the real luminaire. Relevant examples are given in Annex F.

Check the suitability of the lamp and cathode substitution resistor set-up at high frequencies for the frequency range used by the control gear.

Maintain the maximum contact resistances, parasitic inductances and coupling capacitances of the cathode circuits in test with the lamp dummy inserted (see Table 2).

Table 2 – Maximum permitted parasitic inductances, capacitances and contact resistances of a test circuit set-up according to Figures 3 and 4

Parameter	Maximum value
L (for each heating circuit)	2 μH
R (contact resistances for each heating circuit)	100 nΩ
C_1 (from heating circuit to heating circuit)	20 pF
C_2 (heating circuit to earth)	150 pF

The values of *L*, *R*, C_1, and C_2 are measured at the lamp wires next to the electronic control gear's lamp terminals. For this purpose, instead of a lamp, the cathode substitution resistors R_{test} are inserted in the test set-up.

Output circuits of electronic control gears, designed for multi-lamp operation, are each tested separately. The output circuits not involved in the test shall be connected to the substitution resistors with equal value to the output circuit which is under test. The variations of the cathode terminal switch take place only with the output circuit under test. For the other circuit(s), the switch is connected to the middle position (positions 2 and 5 in Figure 3).

Lamp substitution circuits, supplied from multi-lamp electronic control gears (i.e. gears which operate more than one lamp simultaneously), shall each be wired separately when connected with the DUT (device under test). This means that each electrode substitution resistor is equipped with 2 cables, leading to the terminal of the electronic control gear and having an immediate connection according to the electrical circuit design. Each pair of one electrode substitution resistor’s cables shall be installed together.

For wiring of the test set-up, H05V-U cables (or equivalent) shall be used. When designing the wiring layout, the values of the parasitic losses shall be in the same order for all lamp circuits. This can be achieved only if the wiring of the lamp circuits is comparable in distances, lengths, etc. and each pair of lamp circuits is located symmetrical to the axis of the device.

Check the suitability of the instruments, i.e. the tolerance at the range of expected frequency and amplitude.

For the r.m.s. current measurement, the measurement period shall be an integer multiple of the mains half wave period.

If the electronic control gear allows operation of different lamps with varying operating parameters, then safeguard with suitable means so that during operation at the lamp dummy the correct choice of parameters for that lamp(s) has been made.

Compliance with the cathode heating conditions shall be tested with each alternative lamp type.

To ensure that control gear reaches the operating state (to “start” the substitution resistors), the procedure may be modified and/or a special prepared control gear may be used, provided the cathode heating would be the same as a production control gear.

8.3.1.3 General test sequence

Table 3 gives an overview of the values for the different dimming levels which shall be measured and controlled. If an electronic control gear is designed for more than one lamp, then the same measurements and tests shall be conducted as for Lamp 1. Table 3 includes also the switching position for the simulation of the arc spot and the correlation to the test method (CV or SoS).

Table 3 – Dimming levels and measured values

Subclause	Discharge current	Lamp substitution resistor	Cathode substitution value	Arc spot simulation switch position	Values to be checked
8.3.1.4.2.2	I_{10}	R_{L10min}	R_{test3}	2-5	$CV_1 \geq CV_{min}$, etc
8.3.1.4.2.3	I_{10}	R_{L10min}	R_{test2}	2-5	$CV_1 \leq CV_{max}$, $I_{11} \leq I_{LHmax}$, etc
8.3.1.4.2.4	I_{10}	R_{L10max}	R_{test3}	2-5	$CV_1 \geq CV_{min}$, etc
8.3.1.4.2.5	I_{10}	R_{L10max}	R_{test2}	2-5	$CV_1 \leq CV_{max}$, $I_{11} \leq I_{LHmax}$, etc
8.3.1.4.3.2	I_{30}	R_{L30}	R_{test1}	2-5	$I_{11}^2 + I_{21}^2 \geq SoS_{30}$, etc
8.3.1.4.3.3	I_{30}	R_{L30}	R_{test2}	2-5	$CV_1 \leq CV_{max}$, $I_{11} \leq I_{LHmax}$, etc
8.3.1.4.4.2	I_{60}	R_{L60}	R_{test1}	2-5	$I_{11}^2 + I_{21}^2 \geq SoS_{30}$, etc
8.3.1.4.4.3	I_{60}	R_{L60}	R_{test2}	2-5	$CV_1 \leq CV_{max}$, $I_{11} \leq I_{LHmax}$, etc
8.3.1.5.2	I_{30}	R_{L30}	R_{test1}	1-4	$I_{11}^2 + I_{21}^2 \geq SoS_{30}$, etc
8.3.1.5.3	I_{30}	R_{L30}	R_{test1}	3-6	$I_{11}^2 + I_{21}^2 \geq SoS_{30}$, etc
8.3.1.5.4	I_{30}	R_{L30}	R_{test1}	1-6	$I_{11}^2 + I_{21}^2 \geq SoS_{30}$, etc
8.3.1.5.5	I_{30}	R_{L30}	R_{test1}	3-4	$I_{11}^2 + I_{21}^2 \geq SoS_{30}$, etc

8.3.1.4 Test sequence “arc attachment – middle”

8.3.1.4.1 General

All tests in 8.3.1.4 are performed with cathode tap 50 % – Figure 3 (equivalent switch positions 2 and 5) or Figure 4.

Values of the lamp and cathode substitution resistors, test current and limit values shall be those from the relevant IEC lamp data sheets.

8.3.1.4.2 Dim level I_{Dmin}

8.3.1.4.2.1 General

The control terminal of the electronic control gear is used to adjust the lamp discharge current I_D (current through the lamp substitution resistors) to I_{Dmin} as indicated on the relevant IEC lamp datasheet.

8.3.1.4.2.2 Minimum heating for minimum lamp substitution resistor R_{L10min}

This test shall be carried out with a lamp substitution resistor value R_{L10min} and filament substitution resistor value R_{test3}.

Measure CV_1 and CV_2, and then compare the achieved values with the limit values according to the formulas:

$$CV_1 \geq CV_{min} \text{ and } CV_2 \geq CV_{min}$$

Electronic control gear, operating more than one lamp:

Repeat the measurement procedure of CV_1 and CV_2 for each other lamp of multi lamp control gear.

8.3.1.4.2.3 Maximum heating for minimum lamp substitution resistor R_{L10min}

This test shall be carried out with a lamp substitution resistor value R_{L10min} and filament substitution resistor value R_{test2}.

Measure CV_1, CV_2, I_{11}, I_{12}, I_{21}, and I_{22} then compare the achieved values with the limit values according to the formulas:

$$CV_1 \le CV_{max} \text{ and } CV_2 \le CV_{max} \text{ and } I_{11} \le I_{LHmax} \text{ and } I_{12} \le I_{LHmax} \text{ and } I_{21} \le I_{LHmax} \text{ and } I_{22} \le I_{LHmax}$$

Electronic control gear, operating more than one lamp:

Repeat the measurement procedure of CV_1, CV_2, I_{11}, I_{12}, I_{21}, and I_{22} for each other lamp of multi lamp control gear.

8.3.1.4.2.4 Minimum heating for maximum lamp substitution resistor R_{L10max}

This test shall be carried out with a lamp substitution resistor value R_{L10max} and filament substitution resistor value R_{test3}.

Measure CV_1 and CV_2, and then compare the achieved values with the limit values according to the formulas:

$$CV_1 \ge CV_{min} \text{ and } CV_2 \ge CV_{min}$$

Electronic control gear, operating more than one lamp:

For further lamps, the same measurements and tests shall be conducted as for Lamp 1 (See 8.3.1.4.2.2).

8.3.1.4.2.5 Maximum heating for maximum lamp substitution resistor R_{L10max}

This test shall be carried out with a lamp substitution resistor value R_{L10max} and filament substitution resistor value R_{test2}.

Measure CV_1, CV_2, I_{11}, I_{12}, I_{21}, and I_{22}, then compare the achieved values with the limit values according to the formulas:

$$CV_1 \le CV_{max} \text{ and } CV_2 \le CV_{max} \text{ and } I_{11} \le I_{LHmax} \text{ and } I_{12} \le I_{LHmax} \text{ and } I_{21} \le I_{LHmax} \text{ and } I_{22} \le I_{LHmax}.$$

Electronic control gear, operating more than one lamp:

For further lamps, the same measurements and tests shall be conducted as for Lamp 1 (See 8.3.1.4.2.3).

8.3.1.4.3 Dim level I_{D30}

8.3.1.4.3.1 General

The control terminal of the electronic control gear is used to adjust the lamp discharge current I_D to I_{D30} as indicated on the relevant IEC lamp datasheet.

8.3.1.4.3.2 Minimum heating for lamp substitution resistor R_{L30}

This test shall be carried out with a lamp substitution resistor value R_{L30} and filament substitution resistor value R_{test1}.

Measure I_{11}, I_{12}, I_{21} and I_{22}, and then compare the achieved values with the limit values according to the formulas:

$$I_{11}^2 + I_{12}^2 \geq SoS_{30} \text{ and } I_{21}^2 + I_{22}^2 \geq SoS_{30}$$

Electronic control gear, operating more than one lamp:

For further lamps, the same measurements and tests shall be conducted as for Lamp 1.

Lamp 2:

Measure I_{31}, I_{32}, I_{41} and I_{42}, and then compare the achieved values with the limit values according to the formulas:

$$I_{31}^2 + I_{32}^2 \geq SoS_{30} \text{ and } I_{41}^2 + I_{42}^2 \geq SoS_{30}$$

Lamp 3:

Measure I_{51}, I_{52}, I_{61} and I_{62}, and then compare the achieved values with the limit values according to the formulas:

$$I_{51}^2 + I_{52}^2 \geq SoS_{30} \text{ and } I_{61}^2 + I_{62}^2 \geq SoS_{30}$$

Lamp 4:

Measure I_{71}, I_{72}, I_{81} and I_{82}, and then compare the achieved values with the limit values according to the formulas:

$$I_{71}^2 + I_{72}^2 \geq SoS_{30} \text{ and } I_{81}^2 + I_{82}^2 \geq SoS_{30}$$

8.3.1.4.3.3 Maximum heating for lamp substitution resistor R_{L30}

This test shall be carried out with a lamp substitution resistor value R_{L30} and filament substitution resistor value R_{test2}.

Measure CV_1, CV_2, I_{11}, I_{12}, I_{21}, and I_{22}, then compare the achieved values with the limit values according to the formulas:

$$CV_1 \leq CV_{max} \text{ and } CV_2 \leq CV_{max} \text{ and } I_{11} \leq I_{LHmax} \text{ and } I_{12} \leq I_{LHmax} \text{ and } I_{21} \leq I_{LHmax} \text{ and } I_{22} \leq I_{LHmax}.$$

Electronic control gear, operating more than one lamp:

For further lamps, the same measurements and tests shall be conducted as for Lamp 1 (See 8.3.1.4.2.3.).

8.3.1.4.4 Dim level I_{D60}

8.3.1.4.4.1 General

The control terminal of the electronic control gear is used to adjust the lamp discharge current I_D to I_{D60} as indicated on the relevant IEC lamp datasheet.

8.3.1.4.4.2 Minimum heating for lamp substitution resistor R_{L60}

This test shall be carried out with a lamp substitution resistor value R_{L60} and filament substitution resistor value R_{test1}.

Measure I_{11}, I_{12}, I_{21} and I_{22}, and then compare the achieved values with the limit values according to the formulas:

$$I_{11}^2 + I_{12}^2 \geq SoS_{60} \text{ and } I_{21}^2 + I_{22}^2 \geq SoS_{60}$$

Electronic control gear, operating more than one lamp:

For further lamps, the same measurements and tests shall be conducted as for Lamp 1.

Lamp 2:

Measure I_{31}, I_{32}, I_{41} and I_{42}, and then compare the achieved values with the limit values according to the formulas:

$$I_{31}^2 + I_{32}^2 \geq SoS_{60} \text{ and } I_{41}^2 + I_{42}^2 \geq SoS_{60}$$

Lamp 3:

Measure I_{51}, I_{52}, I_{61} and I_{62}, and then compare the achieved values with the limit values according to the formulas:

$$I_{51}^2 + I_{52}^2 \geq SoS_{60} \text{ and } I_{61}^2 + I_{62}^2 \geq SoS_{60}$$

Lamp 4:

Measure I_{71}, I_{72}, I_{81} and I_{82}, and then compare the achieved values with the limit values according to the formulas:

$$I_{71}^2 + I_{72}^2 \geq SoS_{60} \text{ and } I_{81}^2 + I_{82}^2 \geq SoS_{60}$$

$$I_{71}^2 + I_{72}^2 \geq SoS_{60} \text{ and } I_{81}^2 + I_{82}^2 \geq SoS_{60}$$

8.3.1.4.4.3 Maximum heating for lamp substitution resistor R_{L60}

This test shall be carried out with a lamp substitution resistor value R_{L60} and filament substitution resistor value R_{test2}.

Measure CV_1, CV_2, I_{11}, I_{12}, I_{21}, and I_{22} then compare the achieved values with the limit values according to the formulas:

$$CV_1 \leq CV_{max} \text{ and } CV_2 \leq CV_{max} \text{ and } I_{11} \leq I_{LHmax} \text{ and } I_{12} \leq I_{LHmax} \text{ and}$$
$$I_{21} \leq I_{LHmax} \text{ and } I_{22} \leq I_{LHmax}\,.$$

Electronic control gear, operating more than one lamp:

For further lamps, the same measurements and tests shall be conducted as for Lamp 1 (See 8.3.1.4.2.3).

8.3.1.5 Test sequence "arc attachment – variable" – dim level I_{30}

8.3.1.5.1 General

The control terminal of the electronic control gear is used to adjust the lamp discharge current I_D (current through the lamp substitution resistors) to I_{D30} as indicated on the relevant IEC lamp datasheet.

This test shall be carried out with a lamp substitution resistor of nominal value, R_{L30}. The cathodes are substituted with a resistor having the value of R_{test1}.

8.3.1.5.2 Arc attachment – Figure 3, switch positions 1 and 4 – (cathode tap 0 and 0)

Electronic control gear, operating one lamp:

Measure I_{11}, I_{12}, I_{21} and I_{22}, and then compare the achieved values with the limit values according to the formulas:

$$I_{11}^2 + I_{12}^2 \geq \text{SoS}_{30} \text{ and } I_{21}^2 + I_{22}^2 \geq \text{SoS}_{30}$$

Electronic control gear, operating more than one lamp:

For further lamps, the same measurements and tests shall be conducted as for Lamp 1 (See 8.3.1.4.2.3).

8.3.1.5.3 Arc attachment – Figure 3, switch positions 3 and 6 – (cathode tap 100 and 100)

Electronic control gear, operating one lamp:

Measure I_{11}, I_{12}, I_{21} and I_{22}, and then compare the achieved values with the limit values according to the formulas:

$$I_{11}^2 + I_{12}^2 \geq \text{SoS}_{30} \text{ and } I_{21}^2 + I_{22}^2 \geq \text{SoS}_{30}$$

Electronic control gear, operating more than one lamp:

For further lamps, the same measurements and tests shall be conducted as for Lamp 1 (See 8.3.1.4.3.2).

8.3.1.5.4 Arc attachment – Figure 3, switch positions 1 and 6 – (cathode tap 0 and 100)

Electronic control gear, operating one lamp:

Measure I_{11}, I_{12}, I_{21} and I_{22}, and then compare the achieved values with the limit values according to the formulas:

$$I_{11}^2 + I_{12}^2 \geq \text{SoS}_{30} \text{ and } I_{21}^2 + I_{22}^2 \geq \text{SoS}_{30}$$

Electronic control gear, operating more than one lamp:

For further lamps, the same measurements and tests shall be conducted as for Lamp 1 (See 8.3.1.4.3.2).

8.3.1.5.5 Arc attachment – Figure 3, switch positions 3 and 4 – (cathode tap 100 and 0)

Electronic control gear, operating one lamp:

Measure I_{11}, I_{12}, I_{21} and I_{22}, and then compare the achieved values with the limit values according to the formulas:

$$I_{11}^2 + I_{12}^2 \geq \text{SoS}_{30} \text{ and } I_{21}^2 + I_{22}^2 \geq \text{SoS}_{30}$$

Electronic control gear, operating more than one lamp:

For further lamps, the same measurements and tests shall be conducted as for Lamp 1 (See 8.3.1.4.3.2).

8.3.1.6 Test sequence for control gear which cannot obtain I_{Dmin}, I_{D30} and I_{D60}

8.3.1.6.1 General

Some control gear cannot dim to the specified test conditions (e.g. continuous dimming control gear with minimum level above I_{Dmin}, or certain step-dimming control gear). For such control gear, the tests below shall be performed at the values of discharge current as close as possible to I_{D10}, I_{D30}, and I_{D60}. The value of the lamp arc substitution resistor shall be within 20 % of the value calculated according to linear interpolation lamp-specific parameters specified in IEC lamp datasheets.

$$R_{\mathrm{L}} = \frac{R_{\mathrm{L60}} - R_{\mathrm{L30}}}{I_{\mathrm{D60}} - I_{\mathrm{D30}}} \cdot \left(I_{\mathrm{D}} - I_{\mathrm{D30}}\right) + R_{\mathrm{L30}} \qquad \text{for } I_{\mathrm{D30}} < I_{\mathrm{D}} < I_{\mathrm{D60}}$$

$$R_{\mathrm{Lmin}} = \frac{R_{\mathrm{L10min}} - R_{\mathrm{L30}}}{I_{\mathrm{Dmin}} - I_{\mathrm{D30}}} \cdot \left(I_{\mathrm{D}} - I_{\mathrm{D30}}\right) + R_{\mathrm{L30}} \qquad \text{for } I_{\mathrm{Dmin}} < I_{\mathrm{D}} < I_{\mathrm{D30}}$$

$$R_{\mathrm{Lmax}} = \frac{R_{\mathrm{L10max}} - R_{\mathrm{L30}}}{I_{\mathrm{Dmin}} - I_{\mathrm{D30}}} \cdot \left(I_{\mathrm{D}} - I_{\mathrm{D30}}\right) + R_{\mathrm{L30}} \qquad \text{for } I_{\mathrm{Dmin}} < I_{\mathrm{D}} < I_{\mathrm{D30}}$$

8.3.1.6.2 Dim level $I_{\mathrm{Dmin}} \leq I_{\mathrm{D}} \leq (I_{\mathrm{Dmin}} + I_{\mathrm{D30}})/2$

For the range of discharge currents between I_{Dmin} and $(I_{\mathrm{Dmin}} + I_{\mathrm{D30}})/2$, the tests of filament heat shall be performed using values of minimum and maximum arc substitution resistors R_{Lmin} and R_{Lmax} and according to the procedures given in 8.3.1.4.2.2, 8.3.1.4.2.3, 8.3.1.4.2.4 and 8.3.1.4.2.5.

8.3.1.6.3 Dim level $(I_{\mathrm{Dmin}} + I_{\mathrm{D30}})/2 \leq I_{\mathrm{D}} \leq I_{\mathrm{D30}}$

For the range of discharge currents between $(I_{\mathrm{Dmin}} + I_{\mathrm{D30}})/2$ and I_{D30}, the tests of filament heat shall be performed using values of arc substitution resistors R_{Lmin} and R_{Lmax} as calculated in 8.3.1.6.1 and according to the procedures given in 8.3.1.4.2.3, 8.3.1.4.2.5, 8.3.1.4.3.2, 8.3.1.5.2, 8.3.1.5.3, 8.3.1.5.4 and 8.3.1.5.5.

The value of minimum SoS for compliance shall be calculated according to $\text{SoS}_{\mathrm{min}} = \text{X}_1 - \text{Y}_1 \times I_{\mathrm{d}}$, where I_{d} is the minimum value of lamp current delivered by the control gear, and X_1 and Y_1 are the lamp-specific cathode coefficients specified in IEC lamp datasheets.

8.3.1.6.4 Dim level $I_{D30} \leq I_D \leq (I_{D30} + I_{D60})/2$

For the range of discharge currents between I_{D30} and $(I_{D30} + I_{D60})/2$, the tests of filament heat shall be performed using values of arc substitution resistors R_L as calculated in 8.3.1.6.1 and according to the procedures given in 8.3.1.4.3.2, 8.3.1.4.3.3, 8.3.1.5.2, 8.3.1.5.3, 8.3.1.5.4 and 8.3.1.5.5.

The value of minimum SoS for compliance shall be calculated according to $SoS_{min} = X_1 - Y_1 \times I_d$, where I_d is the minimum value of lamp current delivered by the control gear, and X_1 and Y_1 are the lamp-specific cathode coefficients specified in IEC lamp datasheets.

8.3.1.6.5 Dim level $(I_{D30} + I_{D60})/2 \leq I_D \leq I_{Dtrans}$

For the range of discharge currents between $(I_{D30} + I_{D60})/2$ and I_{Dtrans}, the tests of filament heat shall be performed using values of arc substitution resistor R_L as calculated above, and according to the procedures given in 8.3.1.4.4.2 and 8.3.1.4.4.3.

The value of minimum SoS for compliance shall be calculated according to $SoS_{min} = X_1 - Y_1 \times I_d$, where I_d is the minimum value of lamp current delivered by the control gear, and X_1 and Y_1 are the lamp-specific cathode coefficients specified in IEC lamp datasheets.

8.3.1.7 Compliance

The electronic control gear shall meet all maximum and minimum cathode heat limit values of 8.3.1.3 to 8.3.1.6. An example for test results recording is given in Annex G.

8.3.2 Control interfaces

The requirements of Annex E apply. For digital interfaces, the requirements of IEC 62386 apply together with the mandatory of the manufacturer of the electronic control gear.

At present, there are also other non-standardized interfaces, which can lead to problems of interchangeability between interfaces. Test these interfaces according to the manufacturer's specifications.

8.4 Limitation of the lamp current

Unless otherwise specified on the relevant lamp data sheet, the control gear operated at rated voltage shall limit the current delivered to a reference lamp to a value not exceeding 115 % of that delivered to the same lamp when it is operated with a reference control gear.

9 Circuit power factor

For the a.c. supplied electronic control gear, the measured circuit power factor shall not differ from the marked value by more than 0,05 when the control gear is operated with one or more reference lamp(s) and the whole combination is supplied at its rated voltage and frequency.

For controllable control gear, the power factor is measured at full power.

10 Supply current

At rated voltage, the supply current shall not differ by more than ± 10 % from the value marked on the control gear or declared in the manufacturer's literature, when the control gear is operated with (a) reference lamp(s).

For controllable control gear, the supply current shall not exceed the value marked on the control gear according to IEC 61347-1 by more than 10 % in any dimming position. The scan over all dimming positions can be replaced, if the value of the maximum supply current and the corresponding dimming positions are provided.

11 Maximum current in any lead to a cathode

In normal operation at any supply voltage between 92 % and 106 % of the rated value, the current flowing in any one of the cathode terminations shall not exceed the value given on the relevant lamp data sheet.

The measurement is made with an oscilloscope or another suitable device. The measurements shall be made with a reference lamp at all contacts to the cathodes.

12 Lamp operating current waveform

The control gear shall be operated with a reference lamp or lamps at its rated voltage. After lamp stabilisation, the waveform of the lamp current shall comply with the following conditions.

a) For a.c. supplied electronic control gear:

   In every successive half-cycle, the enveloping wave of the lamp current shall not differ by more than 4 % at the same time after phase zero passage of the mains supply voltage.

   NOTE The purpose of this requirement is to avoid flicker due to the inconsistency of the wave shape of the enveloping wave from half mains cycle to half mains cycle.

b) The maximum ratio of peak value to r.m.s. value of the lamp current shall not exceed 1,7.

   NOTE In Japan, a crest factor of 2,1 maximum is permitted, when additional cathode heating is applied.

13 Impedance at audio frequencies

Control gears marked with the audio-frequency symbol (see 5.1) are tested in accordance with Clause A.2.

For every signal frequency between 400 Hz and 2 000 Hz, the impedance of the control gear when operated with a reference lamp supplied at its rated voltage and frequency shall be inductive in characteristic. Its impedance in ohms shall be at least equal in value to the resistance of the resistor which would dissipate the same power as the lamp/control gear combination in question when it is supplied at its rated voltage and frequency. The control gear impedance is measured with a signal voltage equal to 3,5 % of the rated supply voltage of the control gear.

Between 250 Hz and 400 Hz, the impedance shall be at least equal to half the minimum value required for frequencies between 400 Hz and 2 000 Hz.

NOTE Radio interference suppressors consisting of capacitors of less than 0,2 μF (total value) which may be incorporated in the control gear may be disconnected for this test.

14 Operational tests for abnormal conditions

14.1 Removal of lamp(s)

During the operation of the control gear at rated voltage +10 % and in association with (an) appropriate lamp(s), the lamp(s) shall be disconnected for 1 h from the control gear without switching off the supply voltage. At the end of this period, the lamp(s) is (are) reconnected and shall start and operate normally. If the lamp(s) does (do) not start, the supply voltage shall be switched off for 1 min and switched on again. After that, the lamp(s) shall start.

14.2 Lamp fails to start

With an appropriate dummy cathode resistor as specified on the relevant data sheet connected in place of each lamp cathode, the control gear shall be operated at rated voltage +10 % for 1 h. At the end of this period, the resistors shall be removed; (an) appropriate lamp(s) is (are) connected and shall start and operate normally. If the lamp(s) does (do) not start, the supply voltage shall be switched off for 1 min and switched on again. After that, the lamp(s) shall start.

14.3 Control gear behaviour close to end of lamp life

It is permitted that the control gear may switch off or reduces the wattage to the lamp according to Subclause 17.3 of IEC 61347-2-3, if the asymmetric voltage reaches a value of 5 V d.c.

15 Endurance

15.1 General

The control gear shall be operated at rated supply voltage with an appropriate lamp(s) installed outside the temperature chamber. All the earthing connections of the control gear shall be connected to the earth. If the electronic control gear is marked for a range of supply voltages then the supply voltage with the most adverse effect on the temperature of the electronic control gear shall be selected.

Tests are done in sequence with the same control gear.

Dimmable control gear is tested at 100 % power.

15.2 Temperature cycling

The temperature cycling test is as follows.

a) Samples: 5 – control gear which was not submitted to other tests.

   To avoid control gear with thermal cut-off systems from switching off during the test, the cut-off device shall be disabled, so the control gear remains operating.

b) Temperature range of the test chamber:

   - minimum ambient temperature in the chamber is –20 °C ± 3 °C;
   - maximum ambient temperature in the chamber is + 80 °C ± 2 °C.

   The ambient temperature in the chamber shall be measured within 200 mm of the test samples.

c) Measure the stabilized input current of the control gear at 25 °C ± 5 °C.

d) Test routine for 220 temperature cycles:

   1) Connect the control gear with the mains and the lamp(s) at 25 °C ± 10 °C (maximum load) and place the control gear in a temperature test chamber. The lamp(s) are placed outside of the temperature chamber. Airflow restrictions can affect the temperature surrounding control gear under test (DUT). The spacing between the electronic control gear shall allow a homogeneous temperature around all DUTs.

   2) With the control gear in the off position, decrease the temperature in the test chamber to the minimum test temperature with the following conditions (see Figure 5):

      i) Initial 10 % of the transition of temperature: no requirements for temperature change rate.

ii) Final 10 % of the transition of temperature: over/undershoot shall not exceed ±5 °C from the target ambient temperature. Total transition time (*t*) shall not exceed 15 min.

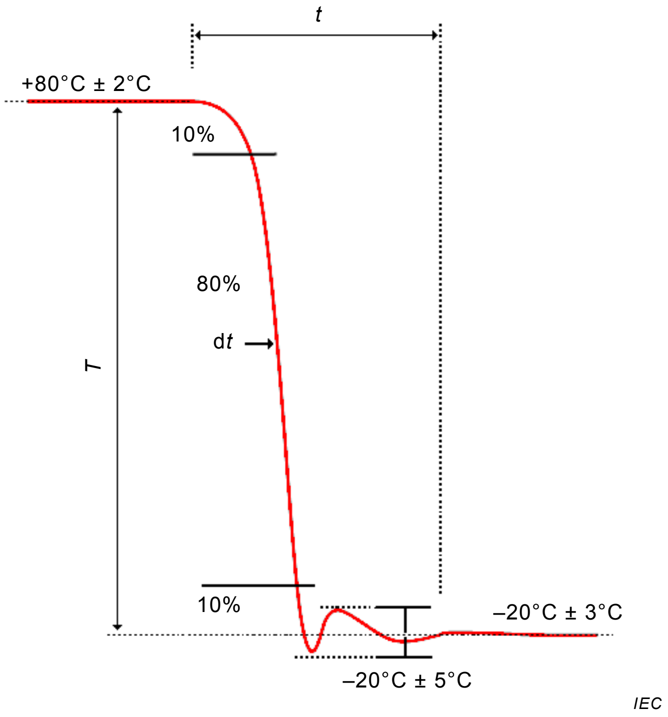


Figure 5 – Example of temperature cycling described under 15.2 d) 2)

3) At the minimum temperature level, start after 50 min at –20 °C 10 switching cycles (10 s on / 50 s off).

4) Switch on the control gear.

5) With the control gear in the on position, increase the temperature in the test chamber to the maximum test temperature with the following conditions:

   i) Initial 10 % of the transition of temperature: no requirements for temperature change rate.

   ii) Final 10 % of the transition of temperature: over/undershoot shall not exceed ±5 °C from the target ambient temperature. Total transition time (*t*) shall not exceed 15 min.

6) At the maximum temperature level, switch off the control gear after 50 min and start 10 switching cycles (50 s on / 10 s off).

7) Repeat steps 2) to 6) 219 times.

NOTE In Japan, the test chamber with 1 K/min to 15 K/min is applied.

e) Measure the stabilized input current of the control gear at 25 °C ± 5 °C.

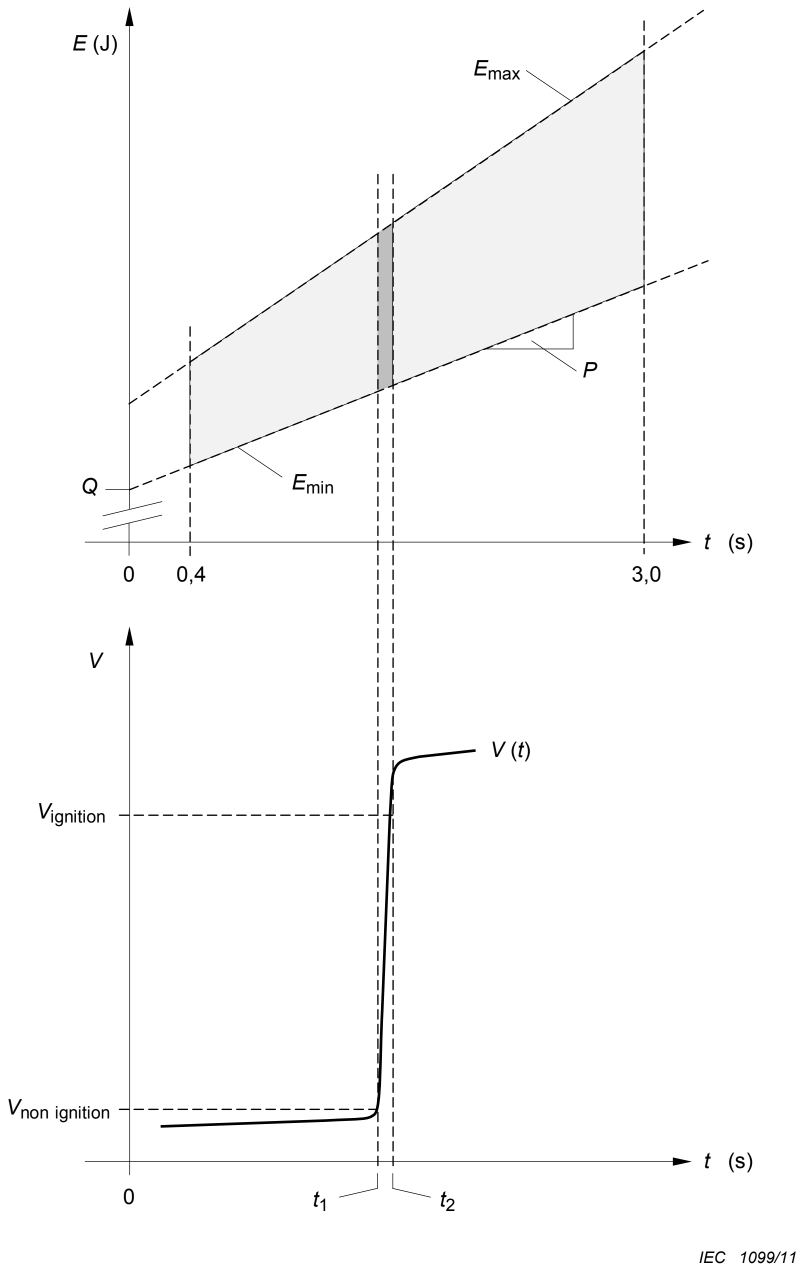
Compliance: After completing all temperature cycles and cooling down to room temperature, all control gear shall correctly start and operate an appropriate lamp(s) for 15 min. In addition the input current in step e) shall not vary by more than ±10 % from the input current measured in step c).

The humidity inside the test chamber should be limited to a value which does not cause any condensation on the DUTs.

15.3 Test at $t_c + 10$ K

The control gear shall operate at an ambient temperature which produces $t_c + 10$ K, until a test period of 200 h has elapsed. After this test period, cool the chamber down to room temperature. During this test the lamp(s) are placed outside the test chamber at an ambient temperature of 25 °C ± 5 °C.

Compliance: After completing the test procedure, all control gear shall correctly start and operate an appropriate lamp(s) for 15 min.

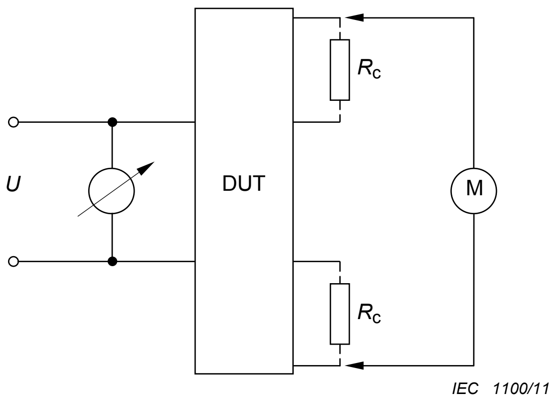


Key

Grey area	energy supply to the cathode permitted
Dark grey area	ignition permitted
E	energy supplied to the electrode for preheating (J)
E_{min} =	$Q_{min} + P_{min} \cdot t$ = minimum cathode preheat energy
E_{max} =	$Q_{max} + P_{max} \cdot t$ = maximum cathode preheat energy
$V(t)$	voltage, measured at the output terminals of the control gear
t_1 =	$t\ (V_{\text{non-ignition}})$
t_2 =	$t\ (V_{\text{ignition}})$

NOTE For the values of Q_{min}(J), Q_{max}(J), P_{min}(W), P_{max}(W), $V_{\text{non ignition}}$ (V) and V_{ignition} (V), see lamp data sheet.

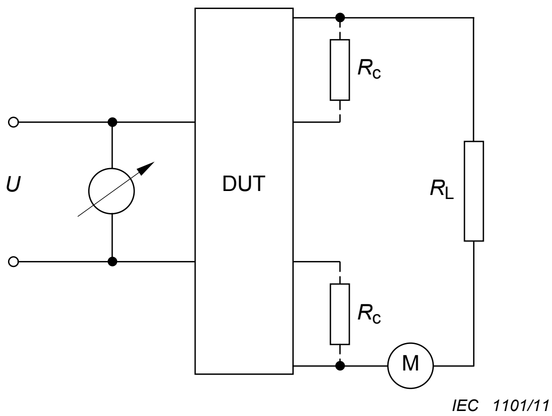
Figure 1 – Schematic illustration of the energy required for preheating and starting



Key

U	supply	M	measuring device
DUT	device (control gear) under test	R_c	See 7.3.2

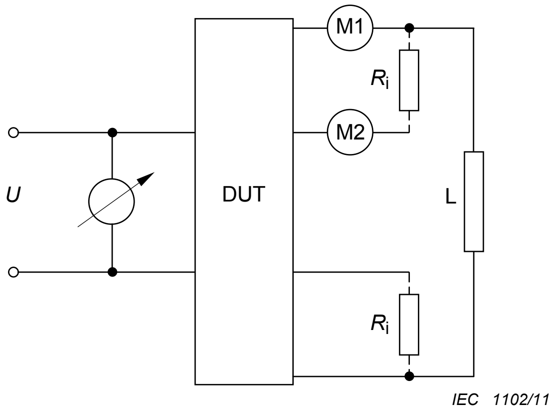
Figure 2a – Test circuit for open-circuit voltage



Key

U	supply	R_c	See 7.3.3
DUT	device (control gear) under test	R_L	See 7.3.3
M	measuring device		

Figure 2b – Test circuit for control gear impedance



Key

U	supply	R_i	See 7.3.4
DUT	device (control gear) under test	L	lamp
M	measuring device		

Figure 2c – Test circuit for cathode current

Figure 2 – Test circuits for non-preheat starting mode

Annex A
(normative)

Tests

A.1 General requirements

Tests are type tests. One sample shall be submitted to all tests.

A.1.1 Ambient temperature

Tests shall be made in a draught-free room and at an ambient temperature within the range 20 °C to 27 °C unless otherwise stated.

For those tests which require constant lamp performance, the ambient temperature around the lamp shall be within the range 23 °C to 27 °C and shall not vary by more than 1 °C during the test.

A.1.2 Supply voltage and frequency

A.1.2.1 Test voltage and frequency

Unless otherwise specified, the control gear to be tested shall be operated at its rated voltage and the reference ballast at its rated voltage and frequency.

When a control gear is marked for use on a range of supply voltages or has different separate rated supply voltages, any voltage for which it is intended may be chosen as the rated voltage.

A.1.2.2 Stability of supply and frequency

For most of the tests, the supply voltage and, where appropriate for the reference control gears the frequency, shall be maintained within ± 0,5 %. However, during the actual measurement, the voltage shall be adjusted to within ± 0,2 % of the specified testing value.

A.1.2.3 Supply voltage waveform

The total harmonic content of the supply voltage shall not exceed 3 %; harmonic content is defined as the root-mean-square (r.m.s.) summation of the individual components using the fundamental as 100 %.

A.1.3 Magnetic effects

Unless otherwise specified, no magnetic object shall be allowed within 25 mm of the face of the reference ballast gear or the control gear under test.

A.1.4 Mounting and connection of reference lamps

In order to ensure that the electrical characteristics of the reference lamps are consistent, they shall be mounted as indicated on the relevant lamp data sheet. Where no mounting instructions are given on the relevant lamp data sheet, lamps shall be mounted horizontally.

It is recommended that lamps are allowed to remain permanently undisturbed in their test lampholders.

A.1.5 Reference lamp stability

A.1.5.1 A lamp shall be brought to a condition of stable operation before carrying out measurements. No swirling shall be present.

A.1.5.2 The characteristics of a lamp shall be checked immediately before and immediately after each series of tests in accordance with Annex C.

A.1.6 Reference ballast

The reference ballast used shall be that indicated on the relevant lamp data sheet.

A.1.7 Instrument characteristics

The characteristics of the instrument are given with the following:

a) Potential circuits

Potential circuits of instruments connected across the lamp shall not pass more than 3 % of the rated lamp current.

b) Current circuits

Instruments connected in series with the lamp shall have sufficiently low impedance such that the voltage drop shall not exceed 2 % of the objective lamp voltage.

Where measuring instruments are inserted into parallel heating circuits, the total impedance of the instruments shall not exceed 0,5 Ω.

c) RMS measurements

Instruments shall be essentially free from errors due to waveform distortion and shall be suitable for the operating frequencies.

Care shall be taken to ensure that the earth capacitance of instruments does not disturb the operation of the unit under test. It may be necessary to ensure that the measuring point of the circuit under test is at earth potential.

A.2 Measurement of impedance at audio frequencies

The circuit in Figure A.1 illustrates a bridge which serves for the determination of the audio-frequency impedance Ƶ of the lamp/control gear assembly.

Let *R'* and *R''* represent the values of the resistors shown in Figure A.1 by the values of 5 Ω and 200 kΩ respectively (the latter at least not being critical). When by adjustments of *R* and *C* a balance is obtained for a given audio-frequency selected on the wave analyser (or any other suitable selective detector), we have in general:

$$Ƶ = R'R''(1/R + i\Omega C)$$

If the resistors *R*' and *R*'' have precisely the indicated values, the equation becomes:

$$Ƶ = 10^6(1/R + i\Omega C)$$

NOTE The impedances Z_1 and/or Z_2 are not necessary if the corresponding source has a low internal impedance for the currents of the other.

A.3 Measurements during preheat

A.3.1 Test equipment and measurement sequence

The test equipment shall be arranged to contain the control gear under test, the cathode substitution resistors (R) specified on the relevant lamp data sheet and a measuring device. The measuring device may be an oscilloscope provided with a voltage and/or current probe (see Figure A.2).

If applicable, connect the secondary output winding of the isolating transformer to ground at one side. If no isolating transformer is included in the control gear, then an isolating transformer shall be inserted at the input side.

For measurement of the total open-circuit voltage: this voltage is measured between both cathode substitution resistors.

The voltage to the starting aid, if any, shall comply with the specified voltage.

A.3.2 Particular conditions for measurement and data processing with preheat circuits

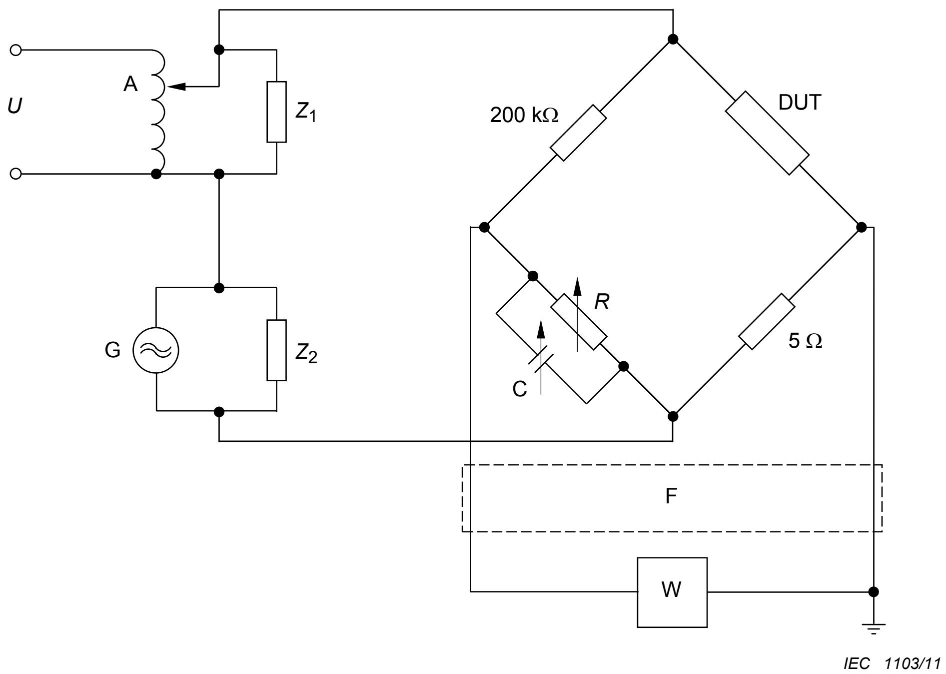
With the aid of the measuring device, the heating current and open-circuit voltage are determined in relation to time.

For a steady state r.m.s. current or r.m.s. voltage respectively, the effective value of the heating current/voltage is determined by observation of one single HF period from which the effective value and the crest factor are determined.

A direct measurement of the effective value might be possible with suitable instrumentation.

For a varying current, the effective value of the heating current is defined as such value which is equivalent to a steady state r.m.s. current of the same heating effect.

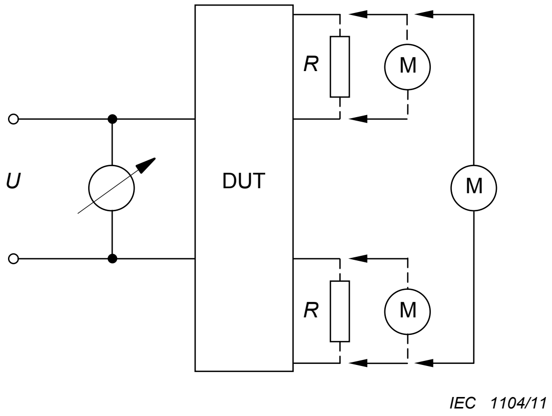
With the aid of the formula given on the lamp data sheets the time to emission is calculated (see 7.2.2).



Key

U	supply 50 Hz (60 Hz)
G	generator 250 Hz…2 000 Hz
A	supply transformer 50 Hz or 60 Hz
DUT	device (control gear) under test
Z_1	impedance of value sufficiently high for 50 Hz or 60 Hz, sufficiently low for 250 Hz to 2 000 Hz (e.g. resistance 15 Ω + capacitance 16 μF)
Z_2	impedance of value sufficiently low for 50 Hz or 60 Hz, sufficiently high for 250 Hz to 2 000 Hz (e.g. inductance 20 mH)
F	filter 50 Hz or 60 Hz
W	selective voltmeter or wave analyser
R	variable bridge resistor (*R*' = 5 Ω; *R*'' = 200 kΩ)
	NOTE The value of 200 kΩ for one branch of the bridge is not critical.
C	variable bridge capacitor

Figure A.1 – Measurement of impedance at audio frequencies



Key

U supply

DUT device (control gear) under test

M measuring device

R See lamp data sheets, substitution resistor for testing cathode preheat requirements

Figure A.2 – Test circuit for control gear for preheat starting mode

Annex B
(normative)

Reference ballasts

B.1 Marking

The reference ballast shall be provided with durable legible marking as follows:

– the words “reference ballast” or “HF reference ballast” as applicable, in full;
– identification of the responsible vendor;
– serial number;
– rated lamp wattage and calibration current;
– rated supply voltage and frequency.

B.2 Design characteristics

B.2.1 General design for frequencies of 50 Hz or 60 Hz

A reference ballast is a self-inductive coil, with or without an additional resistor, designed to give the operating characteristics of Clause B.3.

It may be used either in a circuit employing a starter or, where applicable, in a circuit including separate power sources to heat the lamp cathodes.

B.2.2 Reference ballast for frequencies of 25 kHz

A HF reference ballast is a resistor designed to give the operating characteristics of Clause B.4.

Since the type of HF reference ballast is intended to serve as a permanent baseline of reference, it is vitally important that the ballast be so constructed as to provide permanence of impedance under normal conditions of use.

For this purpose, it may be provided with suitable means of restoring the reference resistance.

An HF reference ballast shall be enclosed in a case for mechanical and electrical protection. Care should however be taken for proper conduction of the dissipated wattage losses.

B.2.3 Protection

The control gear shall be protected, for example by means of a suitable steel case, against magnetic influence in such a way that its ratio of voltage to current at the calibration current shall not be changed by more than 0,2 % when a 12,5 mm thick plate of ordinary mild steel is placed at 25 mm from any face of the control gear enclosure.

Moreover, the control gear shall be protected against mechanical damage.

B.3 Operating characteristics for frequencies of 50 Hz or 60 Hz

B.3.1 Rated supply voltage and frequency

The rated supply voltage and frequency of a reference ballast shall be in accordance with the values given in IEC 60081 or 60901 on the relevant lamp data sheets.

B.3.2 Ratio of voltage to current

The ratio of voltage to current of a reference ballast shall have the value given in IEC 60081 or IEC 60901 on the relevant lamp data sheet, subject to the following tolerances:

- ± 0,5 % at the calibration current value;
- ± 3 % at any other value of current from 50 % to 115 % of the calibration current.

B.3.3 Power factor

The power factor of the reference ballast determined at the calibration current shall be as shown in IEC 60081 or IEC 60901 on the relevant lamp data sheets, subject to a tolerance of ± 0,005.

B.3.4 Temperature rise

When the reference ballast is operated in an ambient air temperature of between 20 °C and 27 °C, at calibration current and rated frequency, and after thermal stabilisation, the temperature rise of the ballast winding shall not exceed 25 K, when measured by the “change in resistance” method.

B.4 Operating characteristics for frequencies of 25 kHz

B.4.1 General

The following specifications apply to measurements made at rated input voltage and rated frequency of the HF reference ballast and with a room temperature of 25 °C ± 5 °C and with stabilised temperature of the reference ballast.

B.4.2 Impedance

The impedance of an HF reference ballast shall have the value given on the relevant lamp data sheets in IEC 60081 or IEC 60901, subject to the following tolerances:

- ± 0,5 % at the calibration current value;
- ± 1 % at any other value of current between 50 % and 115 % of the calibration current.

B.4.3 Series inductance and parallel capacitance

The series inductance of a reference resistor shall be less than 0,1 mH and its parallel capacitance shall be less than 1 nF.

B.5 Circuit for frequencies of 25 kHz (see Figure B.1)

B.5.1 Cathode heating

HF reference ballasts may be used in a circuit employing separate power sources to heat the lamp cathodes for proper starting of the lamp. These power sources shall be disconnected when measuring a lamp.

B.5.2 Power supply

The HF voltage supply used for the adjustment of or test with the HF reference ballast shall be such that at full load the r.m.s. summation of the harmonic contents shall not exceed 3 % of the fundamental component.

This supply shall be as steady and free from sudden changes as possible. For best results the voltage should be regulated to within 0,2 %.

For resistor type reference ballasts the frequency shall be within 2 %.

B.5.3 Instruments

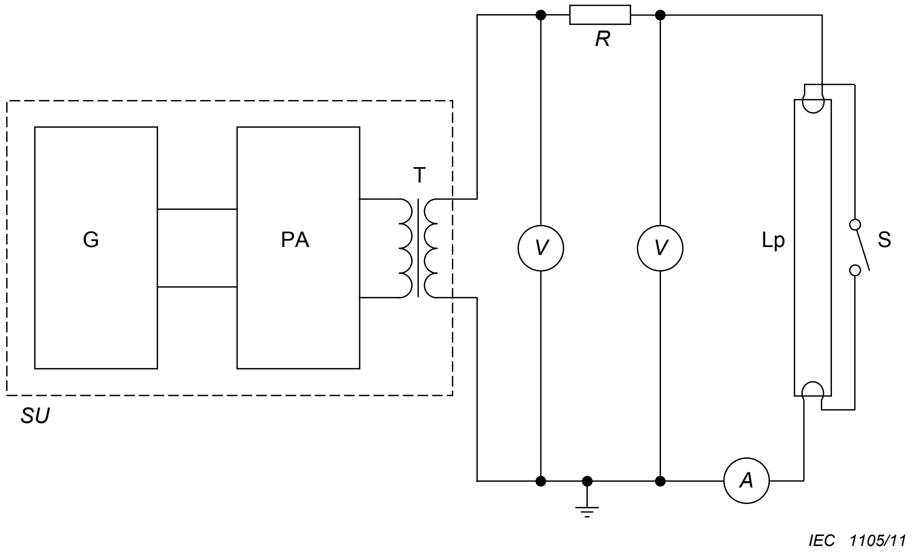
All instruments used in HF reference ballast measurements should be suitable for high frequency operation.

Details are under consideration.

B.5.4 Wiring

Connecting cables should be as short and straight as possible to avoid parasitic capacitance.

The parasitic capacitance parallel to the lamp shall be less than 1 nF.



Key

SU	supply
G	sine generator
PA	power amplifier
T	isolating transformer
R	reference resistor
Lp	lamp
S	starting switch

Figure B.1 – HF reference circuit

Annex C
(normative)

Conditions for reference lamps

A lamp which has been aged for at least 100 h is considered to be a reference lamp according to 3.4 if, when associated with a reference ballast under the conditions defined in Annex A and operating in an ambient temperature of 25 °C, the lamp wattage, voltage at lamp terminals or lamp operating current do not deviate by more than 2,5 % from the corresponding rated values, as appropriate, given in IEC 60081 and IEC 60901.

For reference lamps operated without a starter, if the cathode resistance is higher than 10 % over the rated value of the lamp data sheet, it may be reduced by using a shunt resistor.

A reference lamp of a type suitable for the ballast under test shall always be used.

The waveform of the current passed by a stabilised reference lamp associated with a reference ballast shall show substantially the same waveform in successive half-cycles.

NOTE This limits the possible generation of even harmonics by any rectifying effect.

Annex D
(informative)

Explanation of starting conditions

D.1 General

The requirements for starting conditions given in Clause 7, and the associated data given in lamp data sheets in IEC publications, have been specified to encompass the different lamp starting methods which can be employed by electronic control gear.

As these starting methods can be more complex than those of conventional 50 Hz or 60 Hz circuits, this annex is provided to assist the interpretation of the requirements of this standard and the data specified on lamp data sheets.

D.2 Characteristics which affect lamp starting

There are five main physical characteristics which influence the starting mechanism of a fluorescent lamp:

– cathode heating: Energy supplied for preheating and time of application;
– open circuit voltage: Voltage across lamp and to starting aid both during preheating and at the moment of lamp ignition;
– environmental conditions: Ambient temperature, relative humidity;
– lamp physical conditions: Type of filling gas and its pressure, lamp dimensions, the inclusion of an internal conducting film;
– supply and luminaire conditions: Operating frequency, starting aid dimension and spacing.

All of these characteristics interact with each other in a complex manner and if the correct combination is not obtained for a chosen method of starting, poor lamp performance can result (e.g. reduced lamp life, reduced number of starting cycles for a given lamp life, excessive end blackening of the lamp).

D.3 Principal methods of lamp starting

Traditionally, there have been two principal methods of starting fluorescent lamps associated with 50 Hz or 60 Hz control gear, preheated cathode starting and non-preheated cathode starting.

Both of these methods can be used with electronic control gear, but due to the higher technological features that can be built into electronic control gear, revised methods of specifying, measuring and assessing the starting characteristics often have to be adopted.

Although electronic control gear may produce lamp starting conditions in a more complex way than conventional 50 Hz or 60 Hz control gear, the same principles apply if good lamp performance is to be obtained.

D.4 Particular methods of lamp starting

D.4.1 Preheat starting

Different methods of providing preheated cathode lamp starting are normally used, but all can be summarised in that a sufficient amount of energy has to be supplied to the cathode. Particular solutions may exist on basis of more or less constant current or voltage controlled preheat mode.

With all of these methods, the following requirements must be satisfied during the starting period if satisfactory lamp performance is to be obtained.

a) Prior to cathodes reaching emission, open-circuit voltages across the lamp and/or from lamp to starting aid must be kept below the level which causes cathode-damaging lamp glow currents.
b) After cathodes have reached emission, open-circuit voltages must be adequate to start the lamp quickly and without repeated starting attempts.
c) If open-circuit voltages have to be elevated to achieve lamp starting, once cathodes have reached emission, the transition from low to high open-circuit voltage must occur whilst the cathodes are still at emission temperature.
d) During the cathode preheating period, the heating current or voltage must not be so excessive that the emissive material on the cathodes is damaged by overheating.

As the required open-circuit voltages for preheat starting are relatively low, multilamp series circuits can be utilised for some types of lamps.

In such a scheme, starting capacitor(s) are sometimes employed to shunt part of the combination of lamps while full open-circuit voltage is applied to the unshunted lamp. The size of the starting capacitor relates to the potentially troublesome glow current during the initial phase of starting. Attention is necessary to balance starting capacitor size with ease of starting and other lamp and control gear performance attributes.

D.4.2 Non-preheat starting

This method of lamp starting takes advantage of the field emission that occurs at the unheated cathodes of a lamp when a high open-circuit voltage is instantaneously applied across the lamp.

The level of open-circuit voltage and the source impedance of the control gear determine the time it takes for the lamp to pass through the glow current stage of the discharge to the full arc state.

One of the major reasons for excessive lamp end blackening and subsequent early lamp failure is due to unduly high and/or long-lasting glow discharge currents during the starting process. To minimise the damaging effects of the glow discharge current it is necessary to ensure that a minimum value of open-circuit voltage is provided and that the control gear has the ability to “drive’” the lamp rapidly through this phase without making repeated attempts at lamp starting which extend for greater than 100 ms.

Some control gear may make use of currents in the lamp cathodes for purposes other than adequate cathode heating (e.g. for supporting starting with reduced starting voltages). In such instances the limitations on maximum cathode current must be observed to avoid cathode overheating.

D.5 Interpretation of the requirements of Clause 7 and the information given on lamp data sheets

D.5.1 Preheat starting

D.5.1.1 Heating energy and emission time (t_s)

D.5.1.1.1 Minimum values for the heating energy

The amount of heat necessary to bring a given cathode type to the minimum emission temperature can be stated in terms of time and two constants, Q and P, which are determined by the physical properties of the given cathode type.

This relationship can be expressed by the following equation:

$$E_{min} = Q_{min} + P_{min} \times t$$

$$E_{max} = Q_{max} + P_{max} \times t$$

where

$t = t_s$ is the time to starting (s). Lamp standards use the parameter t_s as a certain, distinct point of time. In reality, however, this is a value between t_1 and t_2. The interval (t_1, t_2) is depicted in Figure 1;

NOTE Emission time less than 0,4 s is normally not acceptable because experience has shown that satisfactory cathode preheating is not always achievable in practice.

Q_{min} is a constant dependent on the cathode type (J);

P_{min} is a constant dependent on the cathode type (W);

E_{min} is the minimum value of the heating energy (J);

Q_{max} is a constant dependent on the cathode type (J);

P_{max} is a constant dependent on the cathode type (W);

E_{max} is the maximum value of the heating energy (J).

The values of the constants Q and P are given on each relevant lamp data sheet, together with the value of the cathode substitution resistor. Elementary calculations can of course be done in order to transform energy values into current or voltage values, if needed for the special type of control gear.

The value of the effective heating energy E_{min} can be calculated by inserting the measured value of t_s into the above equation which is also given on each lamp data sheet.

D.5.1.1.2 Maximum values of heating energy

Maximum levels of heating energy are calculated from the formula for E_{max} and the values given on each lamp data sheet, measured with the required value of the substitution resistor.

A schematic representation of these requirements is given in Figure 1.

NOTE If the preheat energy supply is interrupted, the energy transfer to the electrodes is zero. Since Figure 1 shows the energy supplied (and not the energy content of the electrodes), at the time of supply interruption, the energy curve remains constant, i.e. a horizontal line. The energetic behaviour of the electrodes, e.g. losses due to cooling down, are described by the slope P of the equation $E = Q + P \times t$.

D.5.1.2 Open-circuit voltages

The data in the relevant lamp data sheets is given for systems that require the use of a starting aid and for systems that do not require a starting aid. It is essential that the correct system is identified before the testing.

For some lamp types, the relevant lamp data sheets specify values of maximum open-circuit voltage prior to time t_e being reached which are higher than, or the same as, the minimum values of open-circuit voltage specified after time t_e has been reached. Control gear designed for these lamp types do not necessarily have to elevate the open-circuit voltage to start these lamps correctly.

D.5.2 Non-preheat starting

Open-circuit voltage measurement alone does not necessarily ensure that a control gear will start a lamp cleanly and with the required minimal glow current period. Some control gear are initially unable to supply the current necessary to drive the lamp quickly through the glow state and into the arc state.

To avoid this situation a control gear impedance test is made with a lamp substitution resistor.

The values of the lamp substitution resistor and the minimum current level which must be obtained in this resistor are shown on the relevant lamp data sheet.

D.6 Measurement requirements

As the pre-start and starting characteristics of electronic control gear do not necessarily provide steady state voltage and currents, it is necessary to apply measuring devices and techniques that will cope with these conditions.

Annex E
(normative)

Control interface for controllable control gear

E.1 Overview

This annex specifies the control interface for controllable control gear. The arc power of the electronic control gear is controlled between minimum/off and maximum values by the control signal applied to the control terminals of the control gear.

If the control signal is not connected, the control gear shall give the maximum value of arc power as defined in IEC 61347-1 and IEC 61347-2-3 or the system failure level, if applicable.

This annex does not cover any requirements for the control unit.

E.2 Control by d.c. voltage

E.2.1 Circuit diagram

A functional specification for d.c. voltage control is shown in Figure E.1.

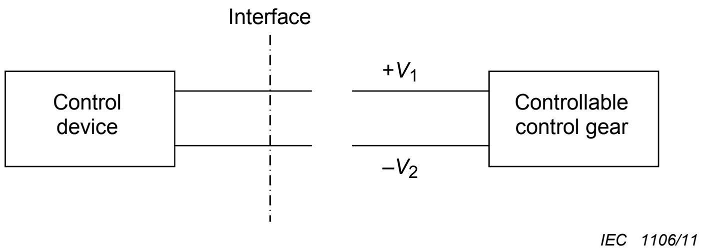


Figure E.1 – Functional specification for d.c. voltage control

The arc power of a controllable control gear is controlled by the d.c. voltage on the control input of the controllable control gear. The d.c. voltage has the following characteristics:

Control signal range

$V_{1,2}$ = between 10 V and 11 V: maximum value of arc power

$V_{1,2}$ = between 0 V and 1 V: minimum value of arc power / minimum light output

$V_{1,2}$ = between 1 V and 10 V: arc power rising from minimum to maximum value

$V_{1,2}$ = between 0 V and 11 V: stable lamp operation with stable light output

E.2.2 Connection diagram

Depending on current-carrying capacity, several controllable control gear can be connected to one control device in the following way (see Figure E.2):

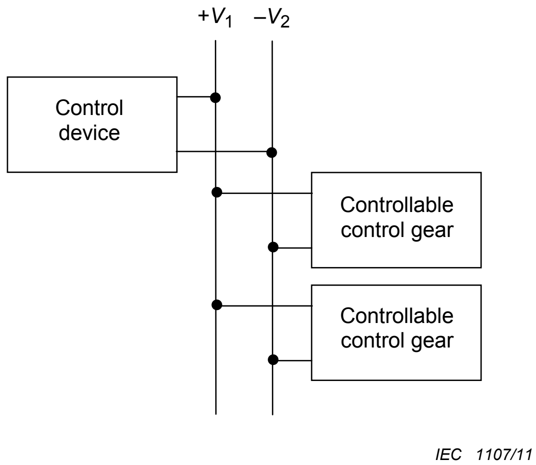


Figure E.2 – Connection diagram for several controllable control gear

E.2.3 Electrical specifications

E.2.3.1 Circuit diagram

The controllable control gear is current sourcing (see Figure E.3).

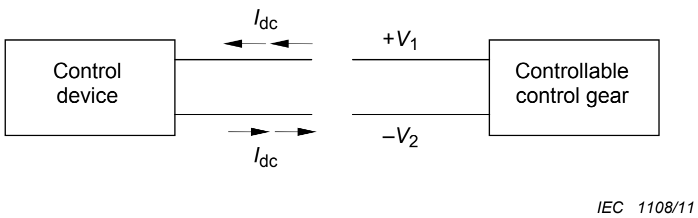


Figure E.3 – Circuit diagram with current sourcing

E.2.3.2 Control input voltage limits

The control gear shall not be damaged when the control input voltage $V_{1,2}$ is between –20 V and +20 V.

The control gear shall not produce voltages that exceed the limiting values for the control unit and under no circumstances shall exceed the following:

$V_{1,2}$ between –20 V and +20 V.

The control terminals shall be reverse polarity protected. In that case, the control gear shall operate with minimum light output or shall not operate.

At control input voltages between 0 V and 11 V, there shall be stable light output.

This shall be tested by visual inspection.

E.2.3.3 Control input current limits

Limits for the control input current, to be supplied to the control unit, are 10 μA minimum and 2 mA maximum.

The value of the control input current shall be declared or stated on the control gear.

E.2.3.4 Switch-on

Switch-on is allowed at any dimming position.

E.3 Control by pulse width modulation (PWM)

E.3.1 Circuit diagram – functional specification for PWM control

The schematic circuit diagram of the functional specification for PWM is shown in Figure E.4 and Figure E.5.

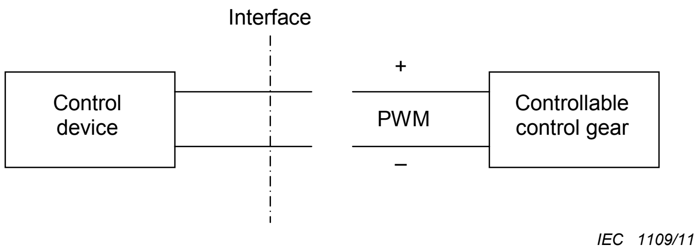


Figure E.4 – Functional specification for PWM control

The arc power of a controllable control gear is controlled by the PWM signal on the control input of the controllable control gear. The arc power is changed by varying the percentage of time for which the PWM signal is at V_{signal}. The PWM signal has the following characteristics:

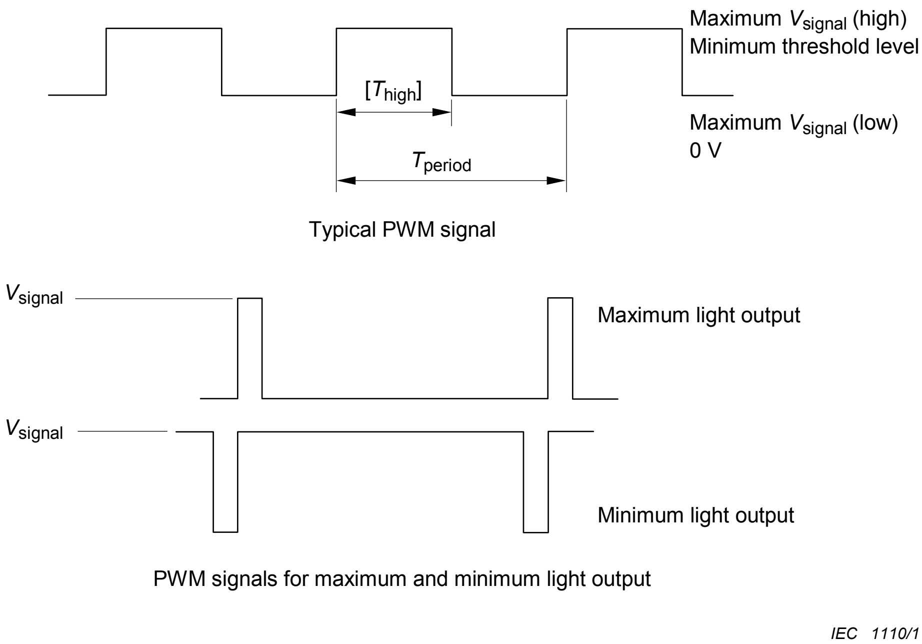


Figure E.5 – PWM signal characteristics

The voltage of the signal is between V_{signal}(low) and V_{signal}(high), where:

V_{signal}(low) minimum is 0 V;
V_{signal}(low) maximum is 1,5 V;
V_{signal}(high) minimum is 10 V;
V_{signal}(high) maximum is 25 V;
T_{period}(cycle time) is 1 ms minimum and 10 ms maximum.

For the light output, the following specification are defined:

– full light output when signal width - $T_{(high)}$ - is 0 % to 5 % ± 1 %;
– 1 % or minimum light output when signal width - $T_{(high)}$ - is 95 % ± 1 %;
– switch-off when signal width - $T_{(high)}$ - is $>$95 %;

NOTE This part of the signal is reserved for switch-off. However, if a control gear does not possess this feature its output should remain at minimum.

– no switch-off when signal width - $T_{(high)}$ - is $<$95 %.

E.3.2 Connection diagram

Depending on current-carrying capacity, several controllable control gear can be connected to one control unit in the way present in Figure E.6.

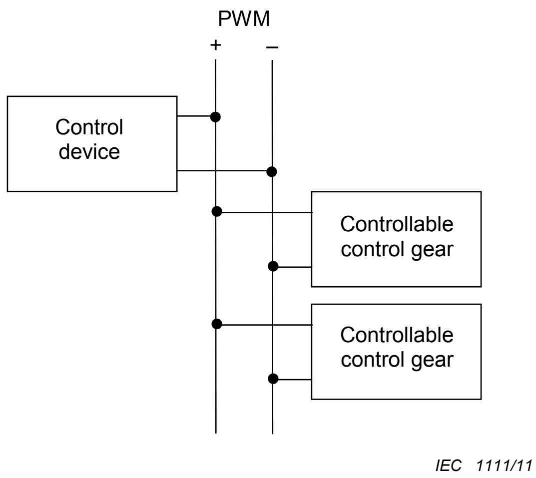


Figure E.6 – Connecting diagram for PWM controllable control gear

E.3.3 Electrical specifications

The control unit is current-sourcing and the control gear is current-sinking.

E.3.3.1 Signal voltage limits

The control gear shall not be damaged when the signal voltage V_{signal} is below 25 V.

The control terminals shall be reverse polarity protected. In that case, the control gear shall not operate.

E.3.3.2 Control terminals impedance

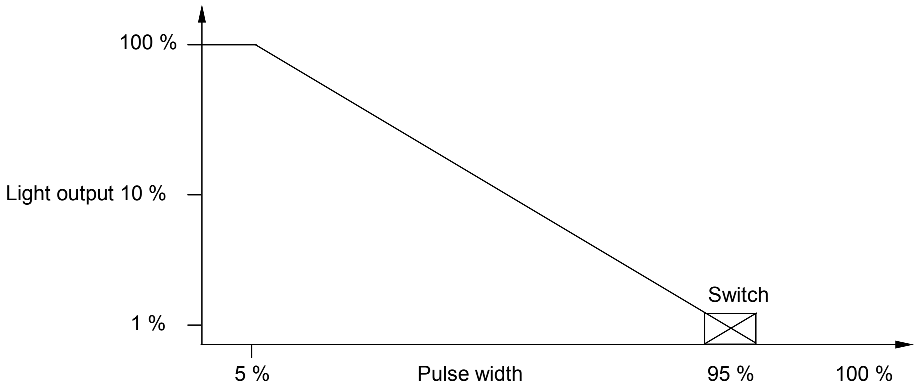
The control terminal impedance shall be between 1 kΩ and 10 kΩ.

E.3.3.3 Input current

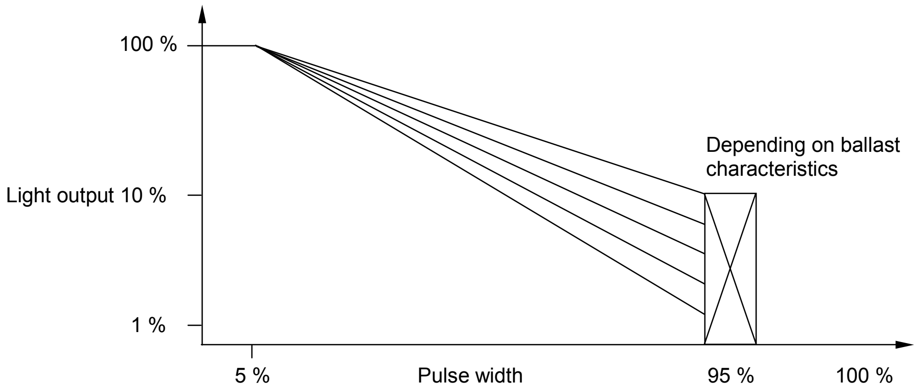
The value of the input current at 12 V stable shall be declared or stated on the control gear.

E.3.4 Examples of control characteristics

Figure E.7 gives examples of control characteristics.



Dimming curve for controllable control gear with minimum light output 1 %



Dimming curve for controllable control gear with minimum light output higher than 1 %

IEC 1112/11

Figure E.7 – Dimming curve for controllable control gear

Annex F
(informative)

Examples of suitable test set-ups for SoS and CV testing

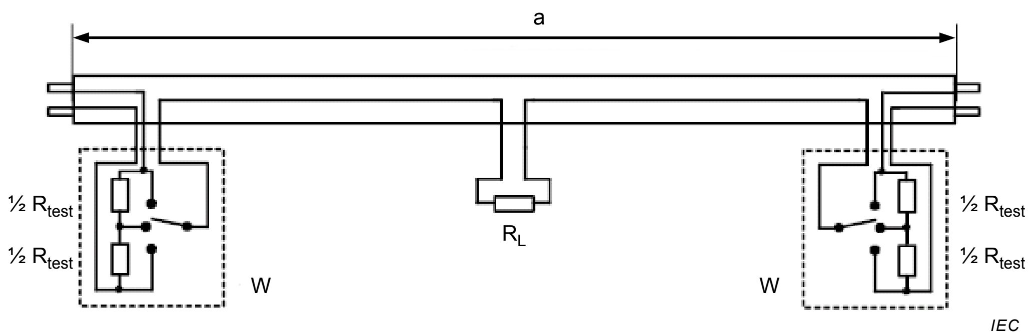
F.1 General

Conductor length and arrangement between control gear and substitution resistors are according to CISPR TR 30-1. Substitution resistors and switches should be located as close as possible to the location of lamp electrodes, and lamp resistors should be located as close as possible to the lamp centre.

F.2 Lamp dummy for double-capped fluorescent lamps

See Figure F.1.

NOTE A "lamp dummy" represents the complete replacement of one lamp, consisting of R_L and R_{test}.



Key

R_L lamp substitution resistor

R_{test} cathode substitution resistor

W cathode substitution circuit

Figure F.1 – Lamp dummy for double-capped fluorescent lamps

F.3 Circuit set-up for single and multi-lamp electronic control gear for double-capped fluorescent lamps

The test set-up contains lamp dummies and substitution resistors; hence, it simulates the layout of symmetrically wired real lamps in a luminaire.

Figure F.2a represents the measurement set-up for single or double electronic lamp control gears and Figure F.2b for three and four lamp electronic control gears. For details see CISPR TR 30-1.

Dimensions in millimetres

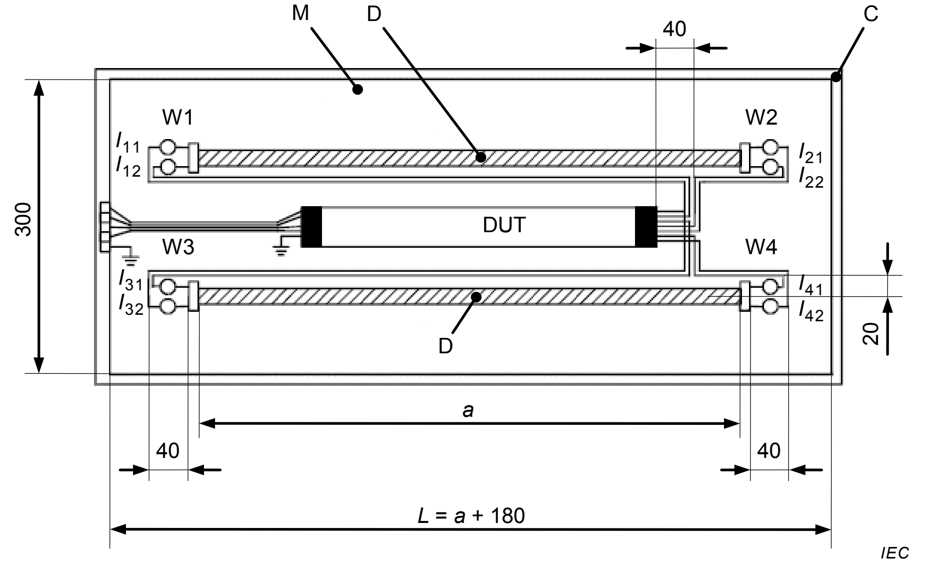


Figure F.2a – Typical test set-up for electronic control gear operating one or two double-capped fluorescent lamps

Dimensions in millimetres

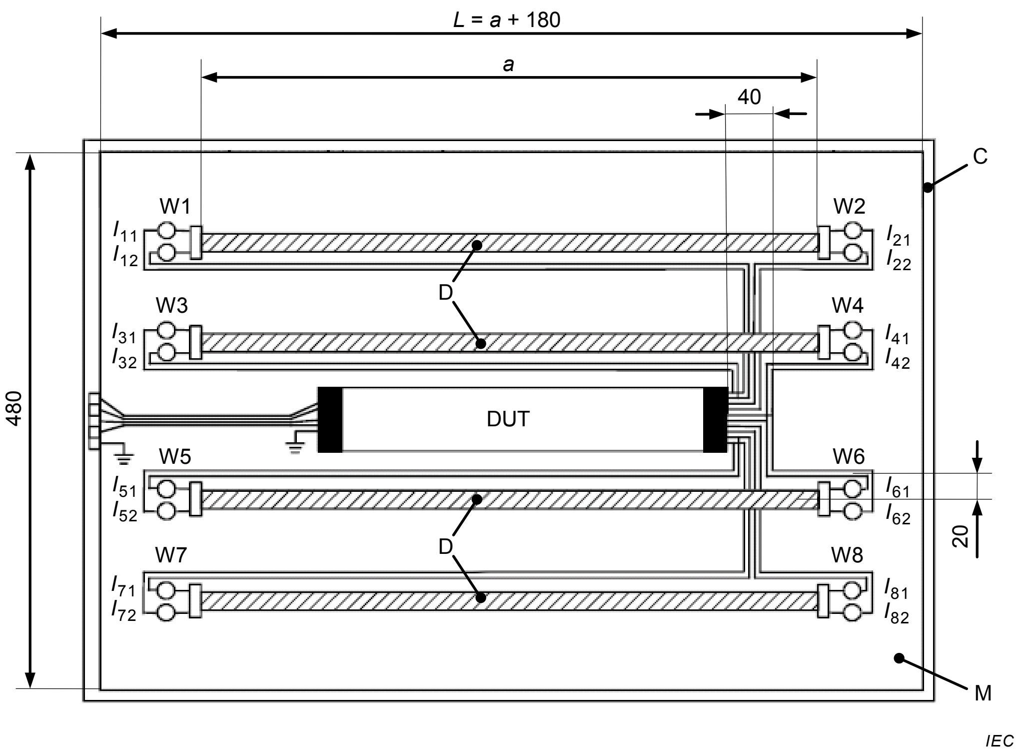


Figure F.2b – Typical test set-up for electronic control gear operating three or four double-capped fluorescent lamps

Key

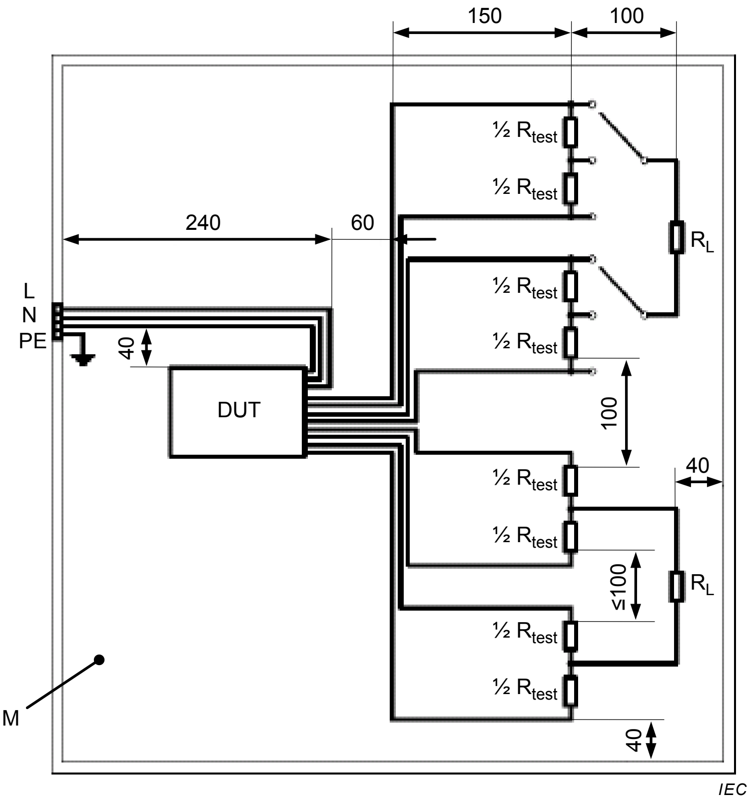
DUT	control gear under test	M	metal plate
D	lamp dummy	*a*	length of the lamp
C	insulation material	W1…*m*	substitution circuit for cathode (= filament) 1…*m*
I_{nn}	currents as explained in Figure 3		

Figure F.2 – Typical test set-ups for electronic control gear operating double-capped fluorescent lamps

F.4 Circuit set-up for single and multi-lamp electronic control gear for single-capped fluorescent lamps

Figure F.3 shows the test set-up for electronic control gears, operating simultaneously one or two compact fluorescent lamps.

Dimensions in millimetres



Key

M metal plate, 1 mm thick

DUT control gear under test

R_L lamp substitution resistor

See also Figure 3.

Figure F.3 – Typical test set-up for electronic control gear operating one or two single-capped fluorescent lamps

F.5 Circuit set-up for connecting two lamps in series

Figure F.4 shows the test circuit set-up for connecting two lamps in series. It is set to following Figure F.4a or Figure F.4b with the connection method of a common filament.

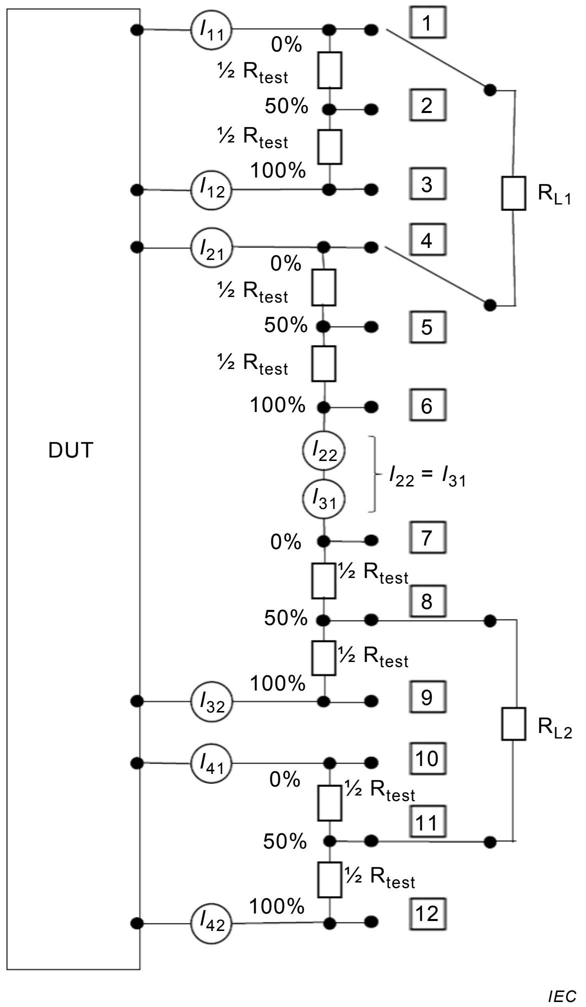


Figure F.4a – Common filament connected in series

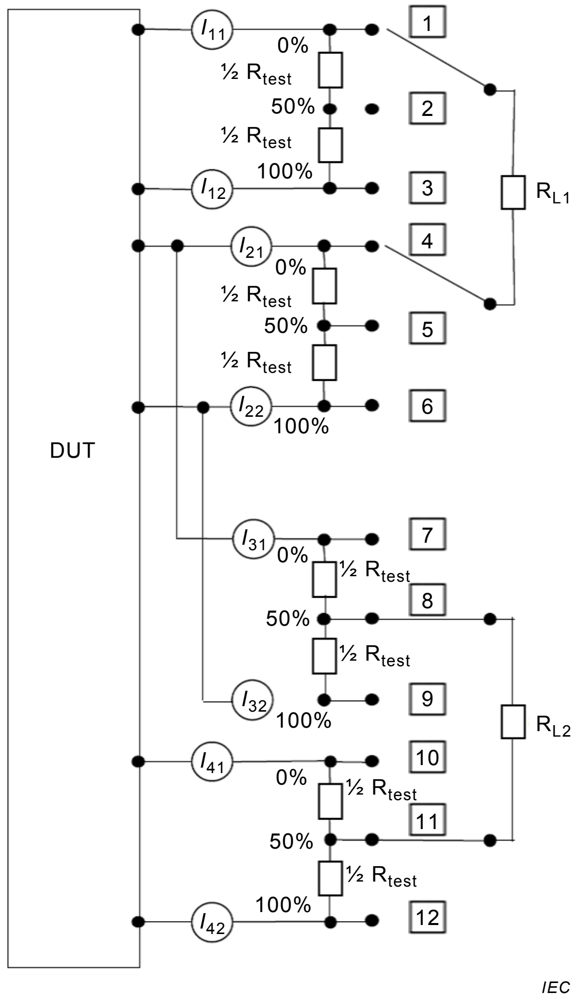


Figure F.4b – Common filament connected in parallel

Key

DUT	control gear device under test
R_{L1}, R_{L2}	lamp substitution resistor
1…6, 7…10	switch positions

Figure F.4 – Typical test set-up for electronic control gear for connecting two lamps in series

Annex G
(informative)

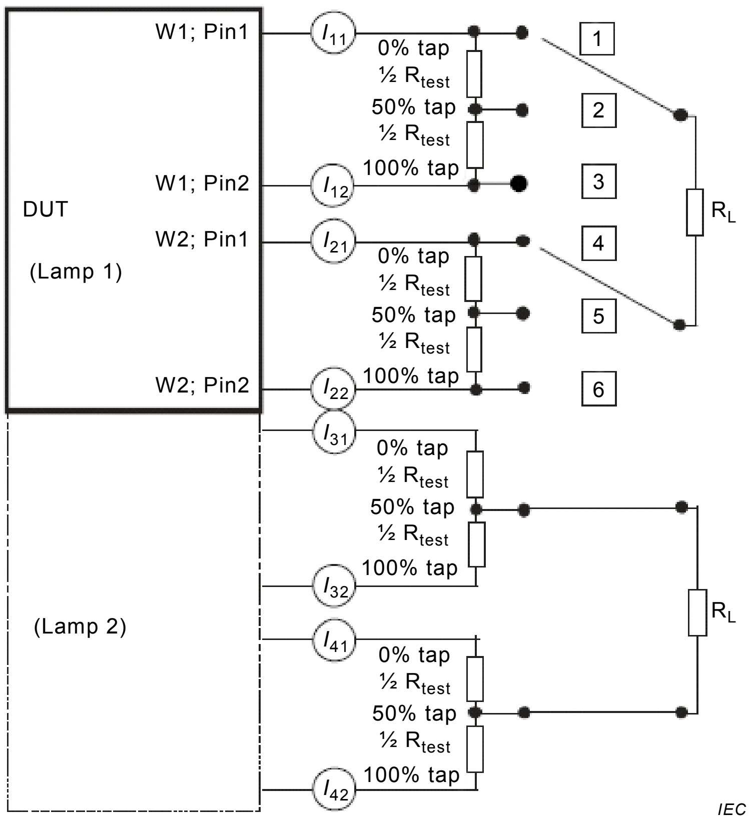
Example of a SoS-CV test with diagrammatic view

G.1 Listing of the necessary tests

In Annex G, the transformation of the measured data is made by means of the relevant equation from the IEC lamp data sheets and analysis is made by presentation of the calculated results in diagrams. Table G.1 shows a survey of the necessary tests on one example. Figure G.1 shows the corresponding circuit.

Table G.1 – List of necessary tests

Check I_D vs I_{LHmax} and CV vs CV_{max}
Check CV vs CV_{min} at 10 % I_{test}
Check SoS vs SoS_{min} at 30 % I_{test}
Check SoS vs SoS_{min} at 60 % I_{test}



Key

1…6 switch positions

W*x*; Pin*y* control gear terminal for cathode *x*, lead wire *y*

See also Figure 3.

Figure G.1 – Example of test circuit set-up reflecting the necessary measurements of Table G.1

G.2 Form sheet (example) for recording the measured values of a continuous dimming electronic control gear with lamps FDH-54-G5-L/P-16/1150

Examples of recording of values for a continuous dimming control gear according to Figure F.2 are given in the following form sheets. Items in light grey are substitution resistor values. Items in dark grey are measured values of pin current or cathode voltage.

FDH-54-G5-L/P-16/1150		
I_{test}	A	0,480
$I_{D,min}$	A	0,050
$I_{D,max}$	A	0,380
CV_{max}	V	4,35
I_{LHmax}	A	0,670
CV_{min} at 10 % I_{test}	V	3,20
SoS_{min} at 30 % I_{test}	A^2	0,282
SoS_{min} at 60 % I_{test}	A^2	0,154
R_{test1}	Ω	7,5
R_{test2}	Ω	8,5
R_{L10min}	Ω	3 000
R_{L10max}	Ω	5 600
R_{L30}	Ω	1 100
R_{L60}	Ω	470

Check I_D vs I_{LHmax} and CV vs CV_{max}					
I_D	A	0,050		0,144	0,288
R_L	Ω	3 000	5 600	1 100	470
R_{test}	Ω	8,5			
Switches W1-W8:50 % tap					
I_{11}	A				
I_{12}	A				
I_{21}	A				
I_{22}	A				
I_{31}	A				
I_{32}	A				
I_{41}	A				
I_{42}	A				
I_{51}	A				
I_{52}	A				
I_{61}	A				
I_{62}	A				
I_{71}	A				
I_{72}	A				
I_{81}	A				
I_{82}	A				
CV_1	V				
CV_2	V				
CV_3	V				
CV_4	V				
CV_5	V				
CV_6	V				
CV_7	V				
CV_8	V				

Check CV vs CV_{min} at 10 % I_{Test}			
I_D	A	0,050	
R_L	Ω	3 000	5 600
R_{test}	Ω	7,5	
Switches W1-W8: 50 % tap			
CV_1	V		
CV_2	V		
CV_3	V		
CV_4	V		
CV_5	V		
CV_6	V		
CV_7	V		
CV_8	V		

Check Lamp 1 SoS vs SoS_{min} at 30 % I_{Test}						
I_D	A	0,144				
R_L	Ω	1 100				
R_{test}	Ω	7,5				
Switches W1-W8: 50 % tap unless noted		W1: 50 % W2: 50 %	W1: 0 % W2: 0 %	W1: 100 % W2: 100 %	W1: 0 % W2: 100 %	W1: 100 % W2: 0 %
I_{11}	A					
I_{12}	A					
I_{21}	A					
I_{22}	A					
SoS_1	A^2					
SoS_2	A^2					

Check Lamp 2 SoS vs SoS_{min} at 30 % I_{Test}						
I_D	A	0,144				
R_L	Ω	1 100				
R_{test}	Ω	7,5				
Switches W1-W8: 50 % tap unless noted		W3: 50 % W4: 50 %	W3: 0 % W4: 0 %	W3: 100 % W4: 100 %	W3: 0 % W4: 100 %	W3: 100 % W4: 0 %
I_{31}	A					
I_{32}	A					
I_{41}	A					
I_{42}	A					
SoS_3	A^2					
SoS_4	A^2					

Check Lamp 3 SoS vs SoS_{min} at 30 % I_{Test}						
I_D	A	0,144				
R_L	Ω	1 100				
R_{test}	Ω	7,5				
Switches W1-W8: 50 % tap unless noted		W5: 50 % W6: 50 %	W5: 0 % W6: 0 %	W5: 100 % W6: 100 %	W5: 0 % W6: 100 %	W5: 100 % W6: 0 %
I_{51}	A					
I_{52}	A					
I_{61}	A					
I_{62}	A					
SoS_5	A^2					
SoS_6	A^2					

Check Lamp 4 SoS vs SoS_{min} at 30 % I_{Test}						
I_D	A	0,144				
R_L	Ω	1 100				
R_{test}	Ω	7,5				
Switches W1-W8: 50 % tap unless noted		W7: 50 % W8: 50 %	W7: 0 % W8: 0 %	W7: 100 % W8: 100 %	W7: 0 % W8: 100 %	W7: 100 % W8: 0 %
I_{71}	A					
I_{72}	A					
I_{81}	A					
I_{82}	A					
SoS_7	A^2					
SoS_8	A^2					

Check SoS vs SoS_{min} at 60 % I_{Test}		
I_D	A	0,288
R_L	Ω	470
R_{test}	Ω	7,5
Switches W1-W8: 50 % tap		
I_{11}	A	
I_{12}	A	
I_{21}	A	
I_{22}	A	
I_{31}	A	
I_{32}	A	
I_{41}	A	
I_{42}	A	
I_{51}	A	
I_{52}	A	
I_{61}	A	
I_{62}	A	
I_{71}	A	
I_{72}	A	
I_{81}	A	
I_{82}	A	
SoS_1	A^2	
SoS_2	A^2	
SoS_3	A^2	
SoS_4	A^2	
SoS_5	A^2	
SoS_6	A^2	
SoS_7	A^2	
SoS_8	A^2	

G.3 Form sheet (example) for recording the measured values of a 50 % step-dim electronic control gear with lamps FDH-54-G5-L/P-16/1150

Examples of recording of values for a 50 % step-dimming control gear according to Figure F.2 are given with the following form sheets. Items in light grey are substitution resistor values. Items in dark grey are measured values of pin current or cathode voltage.

FDH-54-G5-L/P-16/1150		
I_{test}	A	0,480
I_D (50 %)	A	0,240
CV_{max}	V	4,35
I_{LHmax}	A	0,670
A	—	96,17
B	—	−1,266
R_L	Ω	(586 calculated) 560 selected
X'_1	A^2	0,410
Y'_1	A	0,889
SoS_{min} at I_D (calculated)	A^2	0,197
R_{test1}	Ω	7,5
R_{test2}	Ω	8,5

Check I_D vs I_{LHmax} and CV vs CV_{max}		
I_D	A	0,240
R_L	Ω	560
R_{test}	Ω	8,5
Switches W1-W8: 50 % tap		
I_{11}	A	
I_{12}	A	
I_{21}	A	
I_{22}	A	
I_{31}	A	
I_{32}	A	
I_{41}	A	
I_{42}	A	
I_{51}	A	
I_{52}	A	
I_{61}	A	
I_{62}	A	
I_{71}	A	
I_{72}	A	
I_{81}	A	
I_{82}	A	
CV_1	V	
CV_2	V	
CV_3	V	
CV_4	V	
CV_5	V	
CV_6	V	
CV_7	V	
CV_8	V	

Check Lamp 1 SoS vs SoS_{min} at I_D						
I_D	A	0,240				
R_L	Ω	560				
R_{test}	Ω	7,5				
Switches W1-W8: 50 % tap unless noted		W1: 50 % W2: 50 %	W1: 0 % W2: 0 %	W1: 100 % W2: 100 %	W1: 0 % W2: 100 %	W1: 100 % W2: 0 %
I_{11}	A					
I_{12}	A					
I_{21}	A					
I_{22}	A					
SoS_1	A^2					
SoS_2	A^2					

Check Lamp 2 SoS vs SoS_{min} at I_D						
I_D	A	0,240				
R_L	Ω	560				
R_{test}	Ω	7,5				
Switches W1-W8: 50 % tap unless noted		W3: 50 % W4: 50 %	W3: 0 % W4: 0 %	W3: 100 % W4: 100 %	W3: 0 % W4: 100 %	W3: 100 % W4: 0 %
I_{31}	A					
I_{32}	A					
I_{41}	A					
I_{42}	A					
SoS_3	A^2					
SoS_4	A^2					

Check Lamp 3 SoS vs SoS_{min} at I_D						
I_D	A	0,240				
R_L	Ω	560				
R_{test}	Ω	7,5				
Switches W1-W8: 50 % tap unless noted		W5: 50 % W6: 50 %	W5: 0 % W6: 0 %	W5: 100 % W6: 100 %	W5: 0 % W6: 100 %	W5: 100 % W6: 0 %
I_{51}	A					
I_{52}	A					
I_{61}	A					
I_{62}	A					
SoS_5	A^2					
SoS_6	A^2					

Check Lamp 4 SoS vs SoS_{min} at I_D						
I_D	A	0,240				
R_L	Ω	560				
R_{test}	Ω	7,5				
Switches W1-W8: 50 % tap unless noted		W7: 50 % W8: 50 %	W7: 0 % W8: 0 %	W7: 100 % W8: 100 %	W7: 0 % W8: 100 %	W7: 100 % W8: 0 %
I_{71}	A					
I_{72}	A					
I_{81}	A					
I_{82}	A					
SoS_7	A^2					
SoS_8	A^2					

G.4 Form sheet (example) how to depict the measured values of a continuous dimming electronic control gear with two lamps in series

Examples of recording of values for a continuous dimming control gear according to Figure F.4 are given in the following form sheets. Items in light grey are substitution resistor values. Items in dark grey are measured values of pin current or cathode voltage.

Check I_D vs I_{LHmax} and CV vs CV_{max}					
I_D	A				
R_L	Ω				
R_{test}	Ω				
Switches W1 to W8: 50 % tap					
I_{11}	A				
I_{12}	A				
I_{21}	A				
I_{22}	A				
I_{31}	A				
I_{32}	A				
I_{41}	A				
I_{42}	A				
CV_1	V				
CV_2	V				
CV_3	V				
CV_4	V				
CV_5	V				
CV_6	V				
CV_7	V				
CV_8	V				

Check CV vs CV_{min} at 10 % I_{test}			
I_D	A		
R_L	Ω		
R_{test}	Ω		
Switches W1 to W12: 50 % tap			
CV_1	V		
CV_2	V		
CV_3	V		
CV_4	V		
CV_5	V		
CV_6	V		
CV_7	V		
CV_8	V		

Check Lamp 1 SoS vs SoS_{min} at 30 % I_{test}						
I_D	A					
R_L	Ω					
R_{test}	Ω					
Switches W1 to W8		W1: 50 % W2: 50 %	W1: 0 % W2: 0 %	W1: 100 % W2: 100 %	W1: 0 % W2: 100 %	W1: 100 % W2: 0 %
I_{31}	A					
I_{32}	A					
I_{41}	A					
I_{42}	A					
SoS_1	A^2					
SoS_2	A^2					

Check Lamp 2 SoS vs SoS_{min} at 30 % I_{test}						
I_D	A					
R_L	Ω					
R_{test}	Ω					
Switches W1 to W8: 50 % tap unless noted		W1: 50 % W2: 50 %	W1: 0 % W2: 0 %	W1: 100 % W2: 100 %	W1: 0 % W2: 100 %	W1: 100 % W2: 0 %
I_{31}	A					
I_{32}	A					
I_{41}	A					
I_{42}	A					
SoS_3	A^2					
SoS_4	A^2					

Check SoS vs SoS_{min} at 60 % I_{test}		
I_D	A	
R_L	Ω	
R_{test}	Ω	
Switches W1 to W8: 50 % tap		
I_{11}	A	
I_{12}	A	
I_{21}	A	
I_{22}	A	
I_{31}	A	
I_{32}	A	
I_{41}	A	
I_{42}	A	
SoS_1	A^2	
SoS_2	A^2	
SoS_3	A^2	
SoS_4	A^2	

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