

INTERNATIONAL STANDARD

NORME INTERNATIONALE

AC and/or DC-supplied electronic control gear for tubular fluorescent lamps –
Performance requirements

(standards.iteh.ai)

Appareillages électroniques alimentés en courant alternatif et/ou continu pour
lampes tubulaires à fluorescence – Exigences de performances

IEC 60929:2011
<https://standards.iteh.ai/catalog/standards/sist/523fccc1-50df-4d56-8216-d4239cd51ffa/iec-60929-2011>



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2011 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch

Tel.: +41 22 919 02 11

Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,...). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: www.iec.ch/online_news/justpub

Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Electropedia: www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.

- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:

Email: csc@iec.ch

Tél.: +41 22 919 02 11

Fax: +41 22 919 03 00

INTERNATIONAL STANDARD

NORME INTERNATIONALE

AC and/or DC-supplied electronic control gear for tubular fluorescent lamps –
Performance requirements

Appareillages électroniques alimentés en courant alternatif et/ou continu pour
lampes tubulaires à fluorescence – Exigences de performances

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX



ICS 29.140.30

ISBN 978-2-88912-509-8

CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references	7
3 Terms and definitions	8
4 General notes on tests	9
5 Marking	10
5.1 Mandatory marking.....	10
5.2 Additional mandatory Information	10
5.3 Non-mandatory information	10
6 General statement.....	11
7 Starting conditions.....	11
7.1 General.....	11
7.2 Conditions for control gear with preheating.....	11
7.2.1 General	11
7.2.2 Preheat energy.....	11
7.2.3 Open-circuit voltage	12
7.3 Conditions for control gear without preheating.....	13
7.3.1 General	13
7.3.2 Open-circuit voltage	13
7.3.3 Control gear impedance test.....	13
7.3.4 Cathode current.....	13
7.4 Starting aid and distances.....	14
8 Operating conditions	14
8.1 Ballast lumen factor.....	14
8.2 Total circuit power	14
8.3 Requirements for dimming.....	14
8.3.1 Lamp cathode heating	14
8.3.2 Control interfaces	14
8.4 Current limitation.....	14
9 Circuit power factor	14
10 Supply current.....	15
11 Maximum current in any lead to a cathode.....	15
12 Lamp operating current waveform.....	15
13 Impedance at audio frequencies	15
14 Operational tests for abnormal conditions.....	16
14.1 Removal of lamp(s)	16
14.2 Lamp fails to start.....	16
14.3 Control gear behaviour close to end of lamp life	16
15 Endurance.....	16
15.1 General.....	16
15.2 Temperature cycling.....	16
15.3 Test at $t_c + 10$ K.....	17
Annex A (normative) Tests.....	21
Annex B (normative) Reference ballasts	26

Annex C (normative) Conditions for reference lamps	30
Annex D (informative) Explanation of starting conditions.....	31
Annex E (normative) Control interface for controllable control gear	35
Bibliography.....	40
Figure 1 – Schematic illustration of the energy required for preheating and starting	18
Figure 2 – Test circuits for non-preheat starting mode	20
Figure A.1 – Measurement of impedance at audio frequencies.....	24
Figure A.2 – Test circuit for control gear for preheat starting mode	25
Figure B.1 – HF reference circuit	29
Figure E.1 – Functional specification for d.c. voltage control.....	35
Figure E.2 – Connection diagram for several controllable control gear	36
Figure E.3 – Circuit diagram with current sourcing	36
Figure E.4 – Functional specification for PWM control	37
Figure E.5 – PWM signal characteristics	37
Figure E.6 – Connecting diagram for PWM controllable control gear	38
Figure E.7 – Dimming curve for controllable control gear	39
Table 1 – Control gear life time information.....	10

iTeh STANDARD PREVIEW
(standards.iteh.ai)

[IEC 60929:2011](https://standards.iteh.ai/catalog/standards/sist/5231ecc7-56df-4d5b-8216-d4239cd51ffa/iec-60929-2011)

<https://standards.iteh.ai/catalog/standards/sist/5231ecc7-56df-4d5b-8216-d4239cd51ffa/iec-60929-2011>

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60929 has been prepared by subcommittee 34C: Auxiliaries for lamps, of IEC technical committee 34: Lamps and related equipment.

This fourth edition cancels and replaces the third edition published in 2006, IEC 60925 published in 1989, its Amendment 1 (1996) and its Amendment 2 (2001). This fourth edition constitutes a technical revision. The essential change with respect to the third edition is the extension to DC supplied control gear and the deletion of the requirements for digital signal control of electronic control gear.

The text of this standard is based on the following documents:

FDIS	Report on voting
34C/963/FDIS	34C/976/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with ISO/IEC Directives, Part 2.

NOTE In this standard, the following print types are used:

- Requirements proper: in roman type.
- *Test specifications: in italic type.*
- Explanatory matter: in smaller roman type.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The contents of the corrigendum of September 2011 have been included in this copy.

iTeh STANDARD PREVIEW (standards.iteh.ai)

IEC 60929:2011

<https://standards.iteh.ai/catalog/standards/sist/5231ecc7-56df-4d5b-8216-d4239cd51ffa/iec-60929-2011>

INTRODUCTION

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

These control gear are intended to operate lamps at various frequencies including high frequencies and at various lamp powers. Attention is drawn to the fact that operating frequencies below 20 kHz may cause audio noise disturbance, whereas frequencies above 50 kHz may increase radio interference problems.

Some lamps may be specifically designed for high-frequency operation on high-frequency control gear. Two starting modes, preheat and non-preheat, are described.

NOTE Lamps, only specified for preheat starting may be operated on other types of circuits. The control gear manufacturer should provide test data which shows satisfactory starting and operation similar as the ones stated in Clause 6.

In order to obtain satisfactory performance of fluorescent lamps and electronic control gears, it is necessary that certain features of their design be properly co-ordinated. It is essential, therefore, that specifications for them be written in terms of measurement made against some common baseline of reference, permanent and reproducible.

These conditions may be fulfilled by reference ballasts. Moreover, the testing of control gear for fluorescent lamps will, in general, be made with reference lamps and, in particular, by comparing results obtained on such lamps with control gear to be tested and with reference ballast.

IEC 60929:2011

Whereas the reference ballast for frequencies of 50 Hz or 60 Hz is a self-inductive coil, the high-frequency reference ballast is a resistor because of its independence of frequency and the lack of influence of parasitic capacitance.

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

1 Scope

This international 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.

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) <https://standards.iteh.ai/catalog/standards/sist/5231ecc7-56df-4d5b-8216-d4239cd51ffa/iec-60929-2011>
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*

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 its 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 $1 \pm 0,05$;
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 $R_{\text{sub}(\text{min})}$ 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 $R_{\text{sub}(\text{max})}$ 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 $E < E_{\text{min}}$.

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.

[IEC 60929:2011](https://standards.iteh.ai/catalog/standards/sist/5231ecc7-56df-4d5b-8216-d4239cd51ffa/iec-60929-2011)

7.3.3 Control gear impedance test

<https://standards.iteh.ai/catalog/standards/sist/5231ecc7-56df-4d5b-8216-d4239cd51ffa/iec-60929-2011>

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:

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

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.