

Specification for

High-pressure sodium vapour lamps

The European Standard EN 60662 : 1993 has the status of a
British Standard

ICS 29.140.30

Cooperating organizations

The European Committee for Electrotechnical Standardization (CENELEC), under whose supervision this European Standard was prepared, comprises the national committees of the following countries:

Austria	Italy
Belgium	Luxembourg
Denmark	Netherlands
Finland	Norway
France	Portugal
Germany	Spain
Greece	Sweden
Iceland	Switzerland
Ireland	United Kingdom

This British Standard, having been prepared under the direction of the Power Electrical Engineering Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 15 May 1993

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Amendments issued since publication

Amd. No.	Date	Text affected
8348	October 1994	See page a
8457	November 1995	See page a
8571	November 1995	See page a
9150	December 1996	Indicated by a double line in the margin. See also page a
9777	January 1998	Indicated by a double line in the margin. See also page a
9934	April 1998	Indicated by a double line in the margin

Summary of pages

The following table identifies the current issue of each page. In the main text of the standard, issue 1 indicates that a page has been introduced for the first time by amendment. Subsequent issue numbers indicate an updated page. Double vertical sidelining on replacement pages indicates the most recent changes (amendment, addition, deletion).

On the data sheets in sections two, three and in national annex NA, the issue number appears at the end of the reference code at the foot of each sheet (see clause 11). No sidelining is used on data sheets, but the amendment by which each page was introduced is indicated by an extension to the shoulder heading at the top of each page (e.g. EN 60662 : 1993/A5 : 1994). Where no such extension appears, the page is part of the original European Standard.

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National foreword

|| This British Standard has been prepared under the direction of Technical Committee CPL/34/(formerly LGL/6) and is the English language version of EN 60662 : 1993 and its Amendments A5, A6, A7, A9 and A10 *High-pressure sodium vapour lamps*, published by the European Committee for Electrotechnical Standardization (CENELEC). It was derived from IEC Publication 662 : 1980, plus Amendment No. 1 (1986), Amendment No. 2 (1987), Amendment No. 3 (1990), Amendment No. 4 (1992), || Amendment No. 5 (1993), Amendment No. 6 (1994), Amendment No. 7 (1995), Amendment No. 9 (1997) and Amendment No. 10 (1997), published by the International Electrotechnical Commission (IEC) and incorporates the corrigendum published in 1980. IEC Amendment No. 8 (1995), which related exclusively to lamps with cap types incompatible with use in Europe, was not adopted by CENELEC and therefore has not been incorporated into this British Standard.

The foreword of the EN makes reference to 'date of withdrawal (dow) of conflicting national standards' as '1996-09-01'. In this case the relevant national standard is BS EN 60662 but the date of withdrawal relates only to those parts of the British Standard subject to Amendment A7. Certificates and mark will not be awarded after this date with respect to the British Standard not incorporating Amendment A7. They will be awarded only to the amended British Standard. However, such certificates and marks already awarded with respect to the British Standard not incorporating Amendment A7 may continue to apply for production until 2001-09-01.

|| Analogous provisions obtain in respect of Amendments A9 and A10, for which the dows are respectively 1998-04-01 and 1998-07-01 and the expiry dates for current approvals are respectively 2003-04-01 and 2003-07-01.

This standard supersedes BS 6193 : 1990 which is withdrawn.

By a CENELEC common modification, references to E26 and E39 lamp caps, which are non-European, are deleted from EN 60662. Where references to such lamp caps appear, they should be ignored for the purposes of the European standard. Data sheets pertaining exclusively to such lamp caps are to be found in national annex NA.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

UDC 621.327.532

ICS 29.140.30

Supersedes EN 60662 : 1989

Descriptors: Sodium vapour lamp, characteristic, particular requirements, conception requirement

English version

High-pressure sodium vapour lamps

(includes amendments A4 : 1994 + A5 : 1994 + A6 : 1994 + A7 : 1995 + A9 : 1997 + A10 : 1997)
(IEC 662 : 1980 + A1 : 1986 + A2 : 1987 + A3 : 1990 + A4 : 1992 + A5 : 1993 + A6 : 1994 + A7 : 1995
+ A9 : 1997 + A10 : 1997)

Lampes à vapeur de sodium à haute pression
(inclut l'amendements A4 : 1994 + A5 : 1994
+ A6 : 1994 + A7 : 1995 + A9 : 1997 + A10 : 1997)
(CEI 662 : 1980 + A1 : 1986 + A2 : 1987
+ A3 : 1990 + A4 : 1992 + A5 : 1993 + A6 : 1994
+ A7 : 1995 + A9 : 1997 + A10 : 1997, modifiée)

Natriumdampf-Hochdrucklampen
(enthält Änderungen A4 : 1994 + A5 : 1994
+ A6 : 1994 + A7 : 1995 + A9 : 1997 + A10 : 1997)
(IEC 662 : 1980 + A1 : 1986 + A2 : 1987
+ A3 : 1990 + A4 : 1992 + A5 : 1993 + A6 : 1994
+ A7 : 1995 + A9 : 1997 + A10 : 1997, modifiziert)

This European Standard was approved by CENELEC on 1992-12-09. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B-1050 Brussels

Foreword

The text of the International Standard IEC 662 : 1980 and its amendments 1 : 1986, 2 : 1987 and 3 : 1990, together with the common modifications prepared by the CENELEC Reporting Secretariat SR 34A, was submitted to the CENELEC members for formal vote.

The text of the draft was approved by CENELEC as EN 60662 on 9 December 1992.

This European Standard supersedes EN 60662 : 1989.

The following dates were fixed:

- latest date of publication of an identical national standard (dop) 1993-12-01
- latest date of withdrawal of conflicting national standards (dow) 1993-12-01

For products which have complied with EN 60662 : 1989 before 1993-12-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 1998-12-01.

Annexes designated 'normative' are part of the body of the standard. In this standard, annex ZA is normative.

Foreword to amendment A4

The CENELEC questionnaire procedure, performed for finding out whether or not the amendment 4 : 1992 to the International Standard IEC 662 : 1980 could be accepted without textual changes, has shown that no common modifications were necessary for the acceptance as a European Standard.

The reference document was submitted to the CENELEC members for formal vote and was approved by CENELEC as amendment A4 to EN 60662 on 8 March 1994.

The following dates were fixed:

- latest date of publication of an identical national standard (dop) 1995-03-15
- latest date of withdrawal of conflicting national standards (dow) 1995-03-15

For products which have complied with EN 60662 : 1993 before 1995-03-15, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 2000-03-15.

Foreword to amendment A5

At the request of the CENELEC Reporting Secretariat SR 34A, the amendment 5 : 1993 to the International Standard IEC 662 : 1980 was submitted to the CENELEC Unique Acceptance Procedure (UAP) in October 1993 for acceptance as a European Standard.

The text of the International Standard was approved by CENELEC as amendment A5 to EN 60662 on 5 July 1994.

The following dates were fixed:

- latest date of publication of an identical national standard (dop) 1995-07-15
- latest date of withdrawal of conflicting national standards (dow) 1995-07-15

For products which have complied with EN 60662 : 1993 and its amendment A4 : 1994 before 1995-07-15, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 2000-07-15.

Foreword to amendment A6

The text of document 34A(CO)691, as prepared by Subcommittee 34A, Lamps, of IEC Technical Committee 34, Lamps and related equipment, was submitted to the IEC-CENELEC parallel vote in July 1993.

The reference document was approved by CENELEC as amendment A6 to EN 60662 on 8 March 1994.

The following dates were fixed:

- latest date of publication of an identical national standard (dop) 1995-07-15
- latest date of withdrawal of conflicting national standards (dow) 1995-07-15

For products which have complied with EN 60662 : 1993 and its amendments A4 : 1994 and A5 : 1994 before 1995-07-15, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 2000-07-15.

Foreword to amendment A7

The text of document 34A/569/DIS, future amendment 7 to IEC 662 : 1980, prepared by SC 34A, Lamps, of IEC TC 34, Lamps and related equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A7 to EN 60662 : 1993 on 1995-11-28.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1996-09-01
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 1996-09-91

For products which have complied with EN 60662 : 1993 and its amendments A4 : 1994, A5 : 1994 and A6 : 1994 before 1995-11-28, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 2001-09-01.

Foreword to amendment A10

The text of document 34A/747/FDIS, future amendment 10 to IEC 60662 : 1980, prepared by SC 34A, Lamps, of IEC TC 34, Lamps and related equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A10 to EN 60662 : 1993 on 1997-10-01.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1998-07-01
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 1998-07-01

For products which have complied with EN 60662 : 1993 and its amendments A4 : 1994, A5 : 1994, A6 : 1994, A7 : 1995 and A9 : 1997 before 1998-07-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 2003-07-01.

Foreword to amendment A9

The text of document 34A/671/FDIS, future amendment 9 to IEC 60662 : 1980, prepared by SC 34A, Lamps, of IEC TC 34, Lamps and related equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A9 to EN 60662 : 1993 on 1997-07-01.

There is no amendment 8 to EN 60662 : 1993.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1998-04-01
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 1998-04-01

For products which have complied with EN 60662 : 1993 and its amendments A4 : 1994, A5 : 1994, A6 : 1994 and A7 : 1995 before 1998-04-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 2003-04-01.

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SECTION TWO - LAMP DATA SHEETS

12. List of specific lamp types included in this publication

SECTION THREE – MAXIMUM LAMP OUTLINES

HIGH-PRESSURE SODIUM VAPOUR LAMPS

SECTION ONE – GENERAL

1. Scope

This standard specifies the characteristics of high-pressure sodium vapour lamps necessary to ensure interchangeability and safety together with test conditions and procedures. The recommendations relate only to type testing.

The standard specifies the lamp dimensions, electrical characteristics for lamp starting and operation together with information for ballast, ignitor and luminaire design purposes.

The requirements dealing with the lamp starting test and associated information for ballast/ignitor design are different depending on the practice of the country in which the lamp type was originally developed.

|| This standard applies to CENELEC countries and therefore only European practice applies.

2. General

Lamps which comply with this standard when operated with a ballast and an ignitor complying with IEC Publications 923 and 927 will start and operate satisfactorily between 92% and 106% rated supply voltage and at temperatures down to -40°C .

3. Definitions

3.1 *Rated wattage*

The wattage marked on the lamp.

3.2 *Calibration current*

The value of the current on which the calibration of the reference ballast is based.

3.3 *Reference ballast*

A special inductive type ballast designed for use :

- a) in testing lamps ;
- b) as a comparison standard for testing ballasts, and
- c) in the selection of reference lamps. It is essentially characterized by a stable voltage/current ratio which is relatively uninfluenced by variations in current, temperature and magnetic surroundings.

3.4 *Type test*

A test or series of tests made on a type test sample for the purpose of checking compliance of the design of a given product with the requirements of the relevant specification.

3.5 Type test sample

A sample consisting of one or more similar units submitted by the manufacturer or the responsible vendor for the purpose of a type test.

3.6 Designation of objective lamp voltage

For the purpose of this standard, the following designations are used as a classification according to the objective voltage at lamp terminals:

Lamp voltage description	Designation	Lamp voltage range (V)
Low lamp voltage	LV	< 70
High lamp voltage	HV	70 – 180
Extra high lamp voltage	EHV	> 180

4. Lamp marking

The following information shall be distinctly and durably marked on the lamp:

- a) *Mark of origin.* This may take the form of a trade mark, the manufacturer's mark or the name of the responsible seller.
- b) *Rated wattage.*
- c) Symbols to indicate starting method:
 - for lamps without an internal starting device and requiring an external ignitor  ,
 - for lamps having an internal starting device 

5. Lamp dimensions

The lamp dimensions shall comply with the requirements given on the relevant lamp data sheet.

6. Caps

The caps on the finished lamp shall comply with the requirements of the relevant sheet of IEC Publication 61.

7. Test requirements for lamp starting, warm-up and electrical characteristics

For the tests for lamp starting, lamp warm-up and lamp electrical characteristics the lamps shall be operated in a horizontal position in free air and at an ambient temperature of $25\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$, on a 50 Hz or 60 Hz sinusoidal power supply using the specified reference ballast at rated voltage.

7.1 Lamp starting test

7.1.1 Lamps with external ignitor

The pulse characteristics specified on the relevant lamp data sheet are measured at the lampholder terminals with the normal circuit connected and the lamp removed from the lampholder. The waveshape of the pulse and the interpretation of its principal parameters are illustrated in figures A.1 and A.2, page 23.

The peak value of the pulse height is measured from the zero voltage level of the open circuit voltage (see Appendix A). Subsequent peaks of the same pulse shall not exceed 50% of this value.

The circuit connections for lamp starting shall be such that the pulse is applied to the lamp through the eyelet terminal of the cap and with the shell substantially at earth potential.

7.1.2 Lamps with internal starting device

The test voltage shall be as indicated in the relevant lamp data sheet. The starting time measured from the instant the internal starting device has opened shall not exceed the maximum value shown in the relevant lamp data sheet.

7.2 Lamp warm-up test

Prior to the warm-up test the lamps shall have been aged for a minimum of 10 h using a suitable production ballast and cooled for a minimum of 1 h prior to the test.

The voltage at lamp terminals shall reach a minimum value within the time specified on the relevant lamp data sheet.

7.3 Ageing

Before the initial readings are taken the lamp shall be subjected to ageing for 100 h. This operation may be carried out on a production ballast.

7.4 Lamp electrical characteristics

The lamp electrical characteristics shall comply with the requirements given in the relevant lamp data sheet.

7.5 Extinguishing voltage test

A lamp shall be operated on a reference ballast at rated supply voltage and at the extinguishing voltage shown on the lamp data sheet, achieved, if necessary, by artificial means. This lamp shall not extinguish when the supply voltage falls from 100% to 90% of the rated value in less than 0.5 s and remains at that value for at least 5 s.

8. Information for ballast and ignitor design

Ballasts and ignitors shall meet the following requirements to ensure reliable starting and operating conditions. These checks do not constitute lamp requirements.

Except for subclause 8.6, these requirements shall be met over the range of 92% to 106% of the rated voltage of the ballast.

8.1 *Open circuit voltage*

Minimum r.m.s. voltage (50 Hz or 60 Hz): 198 V.

8.2 *European starting pulse characteristics*

8.2.1 An ignitor shall start lamps which comply with the specified lamp starting test.

8.2.2 The pulse height shall comply with the requirements for ballast design information on the relevant lamp data sheet when measured at the lampholder terminals with the normal circuit connected and the lamp removed from the lampholder.

8.2.3 In designing an ignitor, account shall be taken of pulse attenuation due to cable. The ballast specification shall require the ignitor to be provided with information concerning the maximum value of capacitance consistent with achieving the specified requirements for lamp starting.

8.2.4 *General guidance*

8.2.4.1 In general, the requirements in subclause 8.2.1 will be met by a positive pulse of 2 800 V peak having a width of 1 μ s at 2 500 V and occurring in either half-cycle of the supply voltage.

8.2.4.2 An ignitor may produce a negative or positive pulse in either half-cycle of the supply voltage. If the pulse is negative, it is probable that the pulse height and/or width may need to be increased.

8.2.4.3 For satisfactory performance the pulse shall occur within the phase range 60-90 or 240-270 electrical degrees of the open-circuit voltage (these values are provisional and under study).

8.2.4.4 Where the pulse repetition rate is less than once per cycle, the pulse width may need to be increased.

8.3 *North American starting pulse characteristics*

The ignitor may be an integral part of the ballast or a separate device. In either case it shall meet the following requirements:

	Rated wattage	
	250-400 W	1 000 W
Pulse height (measured from zero voltage level of the r.m.s. supply)	2 500 V minimum 4 500 V maximum	3 000 V minimum 5 000 V maximum
Pulse width (minimum)	1 μ s at 2 250 V	4 μ s at 2 700 V
Repetition rate (minimum)	Once per cycle	
Pulse position	Between the 90 % point of peak open-circuit voltage (leading edge) and 20 electrical degrees beyond centre of the half-cycle	

For this measurement, the starting pulse shall be applied to the centre contact of the lampholder. A capacitive load of 20 pF shall be connected across the lampholder terminals in place of the lamp.

NOTE – Additional capacitive loading may be necessary to simulate remote mounting of ballasts and ignitors, and further recommendations on this aspect are under consideration.

For lead type ballasts, the pulse repetition rate (minimum) is once per half-cycle. Pulse position is between the 90 % point of the peak open circuit voltage and 15 electrical degrees beyond the centre of the half-cycle.

8.4 Lamp warm-up current

The lamp warm-up current shall be measured within the range of 5 s to 15 s after the ignition of the lamp arc and shall comply with the values specified on the relevant lamp data sheet.

8.5 Current crest factor

The current crest factor shall comply with the requirements of 8.2 of IEC 923.

8.6 Lamp operating limits for the information of ballast designers

Each of the lamp operating sheets shows a diagram of the lamp voltage and lamp wattage limits within which the lamp should be operated. The minimum voltage limit (left-hand side of the diagram) is the characteristic curve of a lamp whose voltage at rated wattage is the minimum considered acceptable.

The maximum voltage limit (right-hand side of the diagram) is the characteristic curve having a voltage high enough to allow for a lamp with:

- a) maximum zero-hour voltage;
- b) voltage rise during life;
- c) maximum voltage rise due to enclosure in a luminaire.

The wattage limit lines (top and bottom of the diagram) are chosen with regard to the effect of lamp wattage on performance factors such as initial light output, lumen maintenance, lamp life, lamp warm-up, etc.

The supply voltage limits for lamp operation on reactor (choke) ballasts shall be as shown below. The upper supply voltage limit should not be exceeded continuously in lamp use, otherwise special precautions are necessary. Short-term excursions above this limit can be tolerated.

The voltage limits are:

- 1) for rated supply voltages between 100 V and 150 V:
 - between 95 % and 105 % of rated voltage of the ballast;
- 2) for rated supply voltage between 220 V and 240 V:
 - the lower supply voltages limit is 95 % of rated voltage of the ballast;
 - the upper supply voltages are:
 - for lamp ratings below 150 W: rated voltage of the ballast +7 V;
 - for lamp ratings 150 W and above: rated voltage of the ballast +10 V.

The lamp wattage obtained with a reference lamp when measured on a ballast at rated voltage, shall comply with the requirements of clause 20 of IEC 923.

Lamp operating limits and a typical ballast characteristic are given as part of each lamp data sheet.

9 Information for luminaire design

This information refers to the luminaire design checks necessary to ensure that conditions in the luminaire do not cause premature failure of lamps complying with this standard. These checks do not constitute lamp requirements.

9.1 Voltage increase at lamp terminals

The lamp voltage increase as determined in accordance with the relevant procedure given in appendix E shall not exceed the value specified on the relevant lamp data sheet.

Tests shall be carried out in accordance with the relevant requirements of appendix E.

9.2 Lamp envelope temperatures

The lamp envelope temperature, when measured at any point, should not exceed the following:

European practice

150 W or lower	310 °C
above 150 W	400 °C

North American and Japanese practice

70 W and lower	385 °C
above 70 W	400 °C

During the measurement the lamp shall be operated at its rated wattage.

9.3 Maximum cap temperatures

The temperature of the lamp cap shall not exceed the following:

Cap	Maximum cap temperature (°C)
E26/24 (North America)	190
E26/25 (Far East)	165
E27	210
E39 (North America)	210
E39 (Far East)	230
E40 –150 W and lower	210
– above 150 W	250

NOTE – The limitations in subclauses 9.2 and 9.3 should be regarded with caution. These are limitations imposed by the lamp materials, but it should be understood that, in general, if the luminaire causes a lamp to reach these temperatures, it is probable that the voltage rise limitation in subclause 9.1 will be exceeded.

9.4 Possible condition at end of lamp life

A risk exists that at the end of lamp life a number of lamps exhibit a rectifying effect. This can lead to ballast, transformer or starting device overloading. Suitable protective measures should be taken to ensure that safety is maintained under this condition.

10. Maximum lamp outlines

Maximum lamp outline requirements are provided for the guidance of designers of luminaires and are based on a maximum-sized lamp inclusive of bulb to cap eccentricity, see Section Three.

Observance of these requirements in luminaire design will ensure mechanical acceptance of lamps complying with this standard.

Mechanical acceptance of the lamp cap and the adjoining part of the lamp neck in the holder is ensured by compliance of the lamp with the gauges for testing contact-making as given in IEC Publication 60061-3.

||

11. Numbering system for lamp data sheets

The first number represents the number of this Publication (662) followed by the letters "IEC".

The second number represents the lamp data sheet number.

The third number on the sheet indicates the edition of the sheet. Only those pages of the lamp data sheet which have been modified have a new edition number.

Appendix A

Waveshape of voltage pulse for lamp-starting test

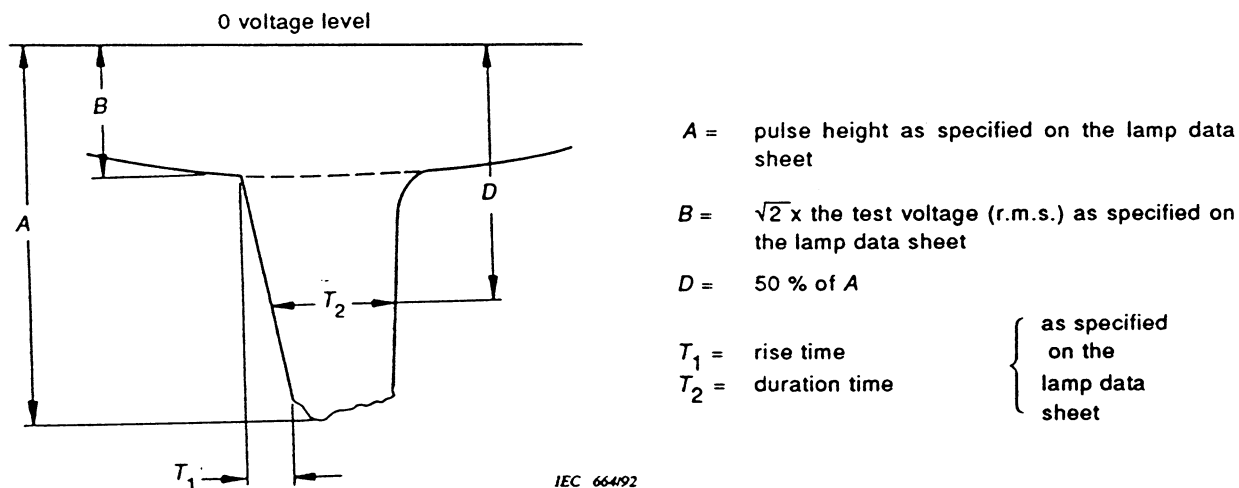


Figure A.1 – American practice

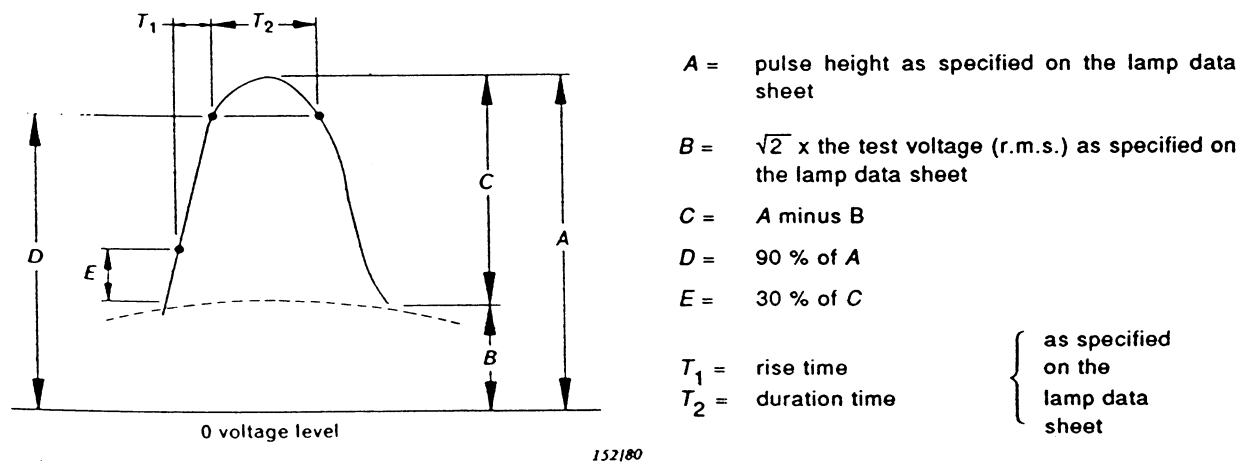


Figure A.2 – European practice

ANNEXE B

APPENDIX B

REPÉRAGE SCHÉMATIQUE DES
COTES DIMENSIONNELLES

SCHEMATIC DRAWINGS FOR LOCATION
OF LAMP DIMENSIONS

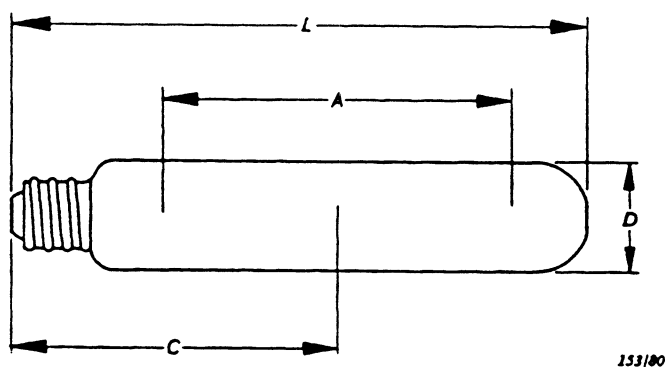


FIG. B1.- Lampe à ampoule tubulaire.
Tubular bulb lamp.

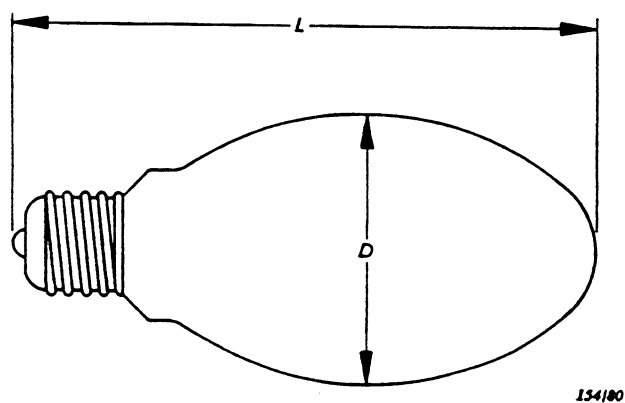


FIG. B2.- Lampe à ampoule ovoïde.
Elliptical bulb lamp.

APPENDIX C

GUIDE FOR DETERMINING QUADRILATERAL DIAGRAMS

INTRODUCTION

In a lighting system employing high-pressure sodium (HPS) lamps there are several variables that affect performance. In addition to normal production variations in both lamp voltage and ballast impedance, other factors to be accounted for are: line voltage variations, changes in lamp characteristics with time and a luminaire effect due to the reflection of radiant energy back to the arc tube. This dynamic system is more easily understood when presented in the form of a lamp parameter boundary picture which includes all variables. This boundary picture, which is called a quadrilateral diagram, is a plot of lamp operating wattage vs. lamp operating voltage.

This guide defines certain technical terms, describes the basis for determining the various sides of a quadrilateral and gives an interpretation of the final diagram. It should be noted that some quadrilateral diagrams developed earlier may not be compatible with these guidelines.

C1. Lamp characteristic curve

An HPS lamp exhibits substantial arc voltage changes with a wattage change during life. This can be contrasted to the mercury vapour lamp where lamp voltage remains relatively constant when lamp wattage changes. This relationship between lamp voltage (arc voltage) and wattage is due to the fact that the HPS arc tube contains an excess of sodium amalgam. During lamp operation the sodium and mercury are in the liquid amalgam phase and are located at a "cold spot" near one end of the arc tube. Only a small fraction of the sodium and mercury is actually in the vapour phase. The vapour pressure, and therefore the lamp voltage, depends on the cold spot temperature, which is a function of lamp wattage. The relationship between wattage and voltage is approximately linear in the region of interest around the nominal wattage. This nearly straight-line curve (shown in Figure C1 which represents this relationship) is defined as the "lamp characteristic curve".

The lamp characteristic curve for a particular lamp may be obtained by varying the wattage, either by changing the line voltage or the ballast impedance over a range.

The point at which a lamp characteristic curve crosses the line of objective wattage defines the "characteristic voltage" of that lamp. A "design centre" lamp is a lamp whose characteristic voltage is equal to the specified objective voltage at lamp terminals.

A sample of lamps of the same wattage will have nearly parallel lamp characteristic curves as shown in Figure C2. The slopes of these curves will be less steep for lamps of progressively higher characteristic voltages. As a lamp ages, its characteristic voltage rises.

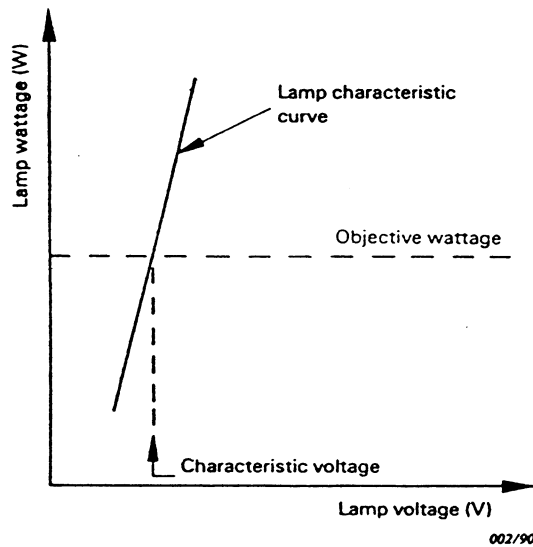


FIG. C1. – Relationship of wattage and voltage of an HPS lamp.

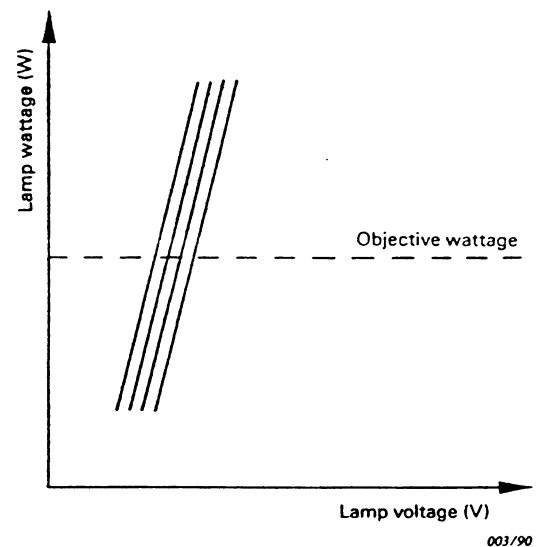


FIG. C2. – Lamp characteristic curves for several HPS lamps.

C 2. Ballast characteristic curve

When an HPS lamp operates on a ballast connected to a constant input voltage, changes in the lamp's operating voltage and wattage follow the "ballast characteristic curve". Figure C3 shows two typical ballast characteristic curves. These curves are obtained by measuring the wattage and voltage of a number of lamps with different characteristic voltages or by measuring a single lamp whose voltage is made to vary by externally causing the cold spot temperature of the arc tube to rise.

A family of ballast characteristic curves is generated when the supply voltage is varied. Figure C4 shows this effect at rated supply voltage and at increased and reduced voltages.

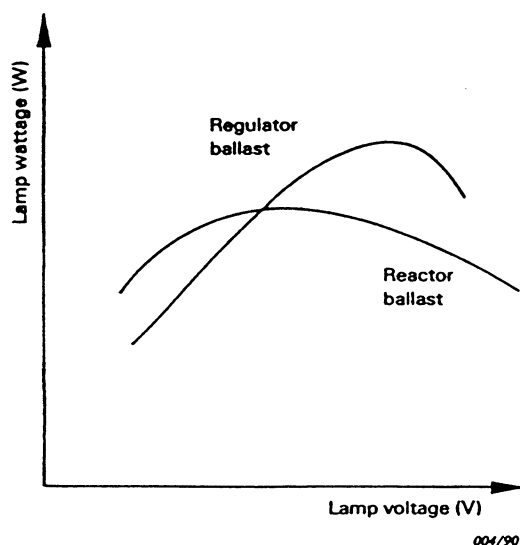


FIG. C3. – Typical ballast characteristic curves.

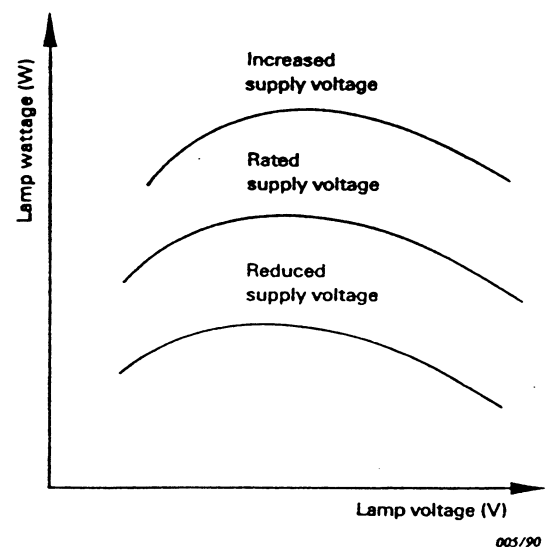


FIG. C4. – Typical lag or reactor ballast characteristic curves at different supply voltages.

C3. Maximum wattage limit

The top line of the quadrilateral diagram represents the maximum wattage limit of the HPS lamp. The maximum wattage line is determined by the maximum permissible operating temperature of the arc tube. This maximum permissible wattage is defined as a value which will result in reduced life if a lamp is operated at this value for more than approximately 25% of the time. The maximum wattage line is usually placed approximately 20% to 30% above the objective wattage.

An additional guideline for the location of the maximum wattage line is that it should lie above the ballast characteristic curve produced by a reference ballast operating at an increased voltage (for example 105% used in North America). The allowance above the peak of this reference ballast curve takes into account manufacturing and design tolerances for commercial ballasts.

The actual placement of this limit line in a quadrilateral diagram is then determined after detailed consideration of practical product requirements. Placement relative to the objective wattage varies by lamp type because the optimum wall loading of some arc tubes may be altered to accommodate other lamp design requirements.

C4. Minimum wattage limit

The lower wattage limit line is set to ensure proper lamp operation in terms of:

- a) satisfactory lamp warm-up characteristics;
- b) acceptable lamp operating stability;
- c) acceptable system lumen output;
- d) acceptable colour rendition and uniformity.

This limit line is placed approximately 20% to 30% below the objective wattage and shall be below the ballast characteristic curve of a reference ballast operating at a reduced voltage (for example 95% used in North America). The allowance below this reference ballast curve takes into account manufacturing and design tolerances for commercial ballasts. The placement of this limit line in a quadrilateral diagram in this standard is then determined after detailed consideration of practical product requirements. Figure C5 shows the maximum and minimum wattage lines and their relationship to the noted reference ballast characteristic curves.

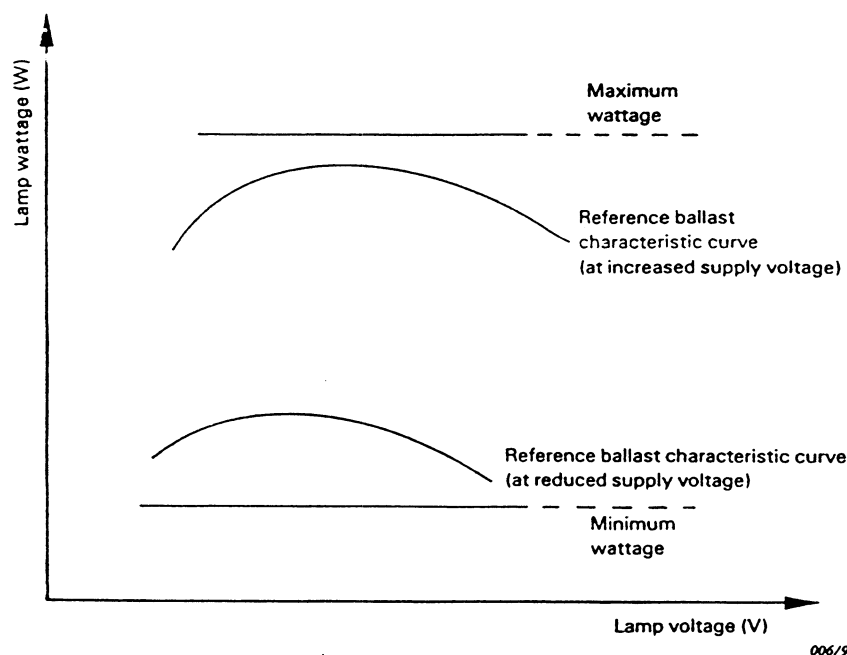


FIG. C5. – Minimum and maximum wattage lines.

C5. Minimum voltage line

The minimum voltage line, the left-hand boundary of the quadrilateral, is that lamp characteristic curve of the lamp with the minimum acceptable voltage at lamp terminals. The agreed minimum lamp voltage for each lamp type is specified on the appropriate lamp data sheet. It lies to the left of the objective voltage and objective wattage point and establishes the left-hand side of the quadrilateral.

The characteristic curves of ballasts are not to intersect the minimum wattage line before crossing the minimum voltage line.

C6. Maximum voltage line

The maximum voltage line defines the right-hand side of the quadrilateral diagram. It is determined by the following factors:

- the highest acceptable characteristic voltage of a new lamp;
- the rise in lamp voltage that takes place during life;
- the increase in lamp voltage resulting from enclosure in a luminaire;
- a locus of lamp drop-out voltages that occur on a reference ballast.

The maximum characteristic voltage is derived from the locus of drop-out voltages. (Details are under consideration.) The drop-out characteristic voltage value is then reduced by an amount equal to 20% of the nominal lamp voltage and is plotted back along the nominal wattage line. This termination point fixes the maximum characteristic voltage. From this point, a series of lamp voltage measurements are made to produce the maximum lamp characteristic curve.

In ballast design, the maximum lamp voltage and wattage limits are closely related. Increasing the limit for maximum voltage necessitates an increase in the maximum wattage limit because some types of ballast have characteristic curves that can span a greater range of voltage only if a higher wattage is allowed.

C7. Summary

C7.1 Interpretation related to lamp and ballast

The finished diagram consists of maximum and minimum wattage lines, and minimum and maximum voltage lines as shown in Figure C6. The diagram can be used as a system specification because it encompasses certain requirements for both lamp and ballast while including a luminaire effect. The quadrilateral for each wattage system provides ballast design information to operate lamps properly.

The final diagram is based on the operation of a lamp on a reference ballast with various tolerances and allowances as noted in the maximum and minimum wattage clauses. Nevertheless, the limits of lamp operation are related to underlying physical characteristics of the lamp and, therefore, are to be interpreted as relating to all types of commercial ballasts. It is apparent that the quadrilateral for a given system defines operational limits of any lamp operated on any ballast.

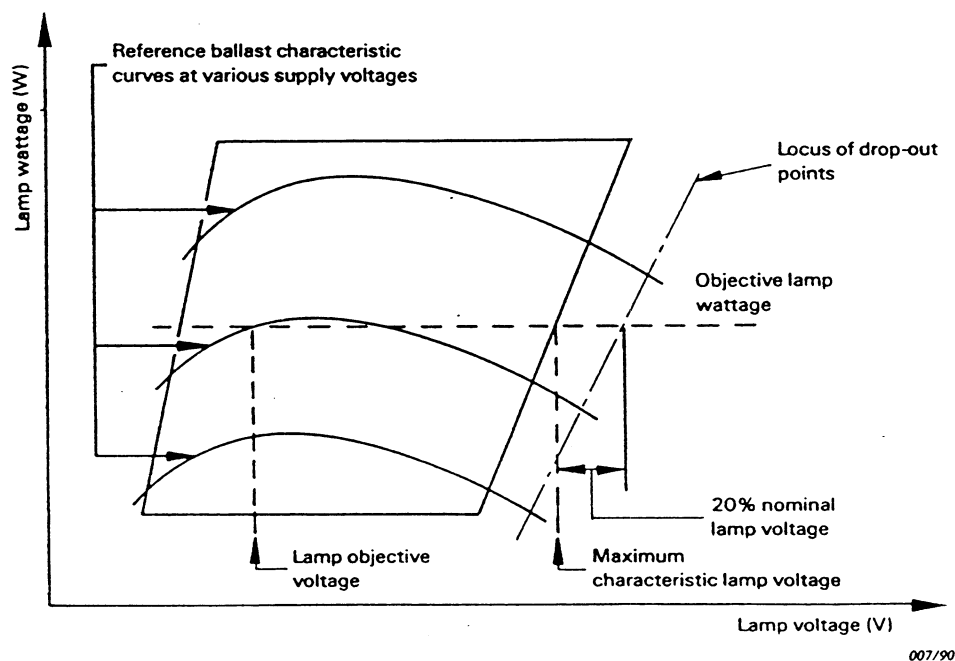


FIG. C6. Finished quadrilateral relative to the reference ballast curves and drop-out locus.

The completed quadrilateral describes qualifications for ballast design which can be summarized as follows:

- The ballast characteristic curve shall intersect both the lamp voltage limit lines and remain between the wattage limit lines throughout the life of a lamp.

- b) The design of the ballast is such that under normal conditions the lamp always operates within the quadrilateral, not only at the rated supply voltage of the ballast but also at the lowest and highest supply voltages for which the ballast is recommended.

Note – Since a lag ballast is similar to a reference ballast it cannot be expected to operate the system satisfactorily if the limits of the supply voltage variation exceed the values specified in this standard.

- c) A preferred ballast characteristic curve is one which permits the lamp to attain its maximum wattage at or before the maximum voltage line and then decreases substantially as the lamp voltage increases beyond this point. A relatively flat ballast characteristic curve located near the line of objective lamp wattage is preferable to one which rises and falls relatively steeply.
- d) To avoid short lamp-life, instability and premature drop-out, the ballast should be capable of operating the lamp beyond the maximum voltage line at the right-hand side of the quadrilateral.

Although not defined by the quadrilateral, a lamp-ballast system must also withstand an extinguishing voltage test. In such a test, the ballast must maintain lamp operation when the mains voltage is suddenly dropped to 10% below the ballast's rated value. This requirement is to be detailed in the lamp specification.

C7.2 *Interpretation related to luminaire design*

The allowance of lamp voltage rise assigned to the luminaire effect is not readily visible on the finished quadrilateral. The permissible voltage rise value is listed in the individual lamp standard data sheet.

Appendix D

Measurement of the pulse height for lamps with internal starters

Introduction

Lamps with internal starters generate voltage pulses during ignition. This appendix describes methods for measurement of the height of these pulses. Since the magnitude of the pulses generated by internal starters is dependent upon the ballast employed, its characteristics have been specified.

D.1 Ballast characteristics

Measurement of the pulse height shall be carried out using a ballast complying with the relevant requirements of IEC 923 and having the resonance characteristics given in table 1.

The resonance characteristics are determined by applying a voltage of the order of 20 V across the ballast and measuring the current at various frequencies. During this measurements any provision for earthing the ballast shall be connected to the terminal designated as the line terminal. Ballast resonance characteristics may be adjusted by the use of suitable capacitors.

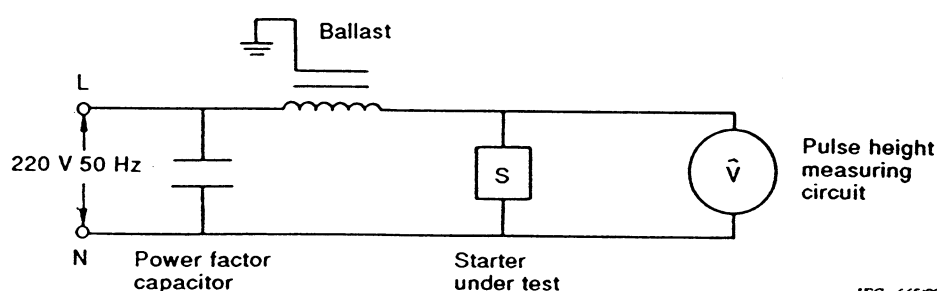
Table 1 – Ballast resonance characteristics

	70 W	150 W	250 W	400 W
Resonance frequency (kHz) $\pm 10 \%$	18	30	40	35
Impedance at resonance frequency (k Ω) $\pm 10 \%$	120	40	30	20

Note.— These resonance characteristics are representative of those 220 V reactor ballasts which are commercially available leading to the highest value of pulse voltage.

D.2 Test circuit

Starter pulses shall be measured using the circuit in the figure below.



In this circuit:

- for lamps with internal glow switch starters, "S" is a starter switch of the type used in the lamp;
- for lamps with internal thermal starters, "S" is the lamp itself;
- the ballast is that described in clause D.1;
- the power factor capacitor has a value taken from table 2 of this appendix;
- the pulse height measuring circuit is as specified in clause D.3;
- the cable capacitance between the ballast and lamp or starter shall not exceed 20 pF.

Table 2 – Power factor capacitor values for tests

	70 W	150 W	250 W	400 W
Capacitance ($\mu\text{F} \pm 10\%$)	10	20	30	40

D.3 Pulse height measuring circuit

- For lamps with internal glow switch starters, the required circuit is that described in figure 9 of IEC Publication 155.
- For lamps with internal thermal starters, the required circuit is that described in figure 2 of IEC Publication 926.

Note.– It is recognized that the above measuring circuits will not detect accurately very narrow high voltages pulses. Experience has shown, however, that such pulses do not cause practical problems.

D.4 Tests

D.4.1 Lamps with internal glow switches

Measurement shall be taken using the test circuit of clause D.2, the relevant value being the highest voltage recorded on either of the two voltmeters of the measuring circuit referred to in clause D.3 during a period of 30 s. The test is sufficient for both cold start and hot restrike conditions.

Note.– In lamps with internal glow switches, pulse voltages are limited by the starter itself. For the purpose of this test, starters of the type used in the lamp should be taken and not the complete lamp. Such separate glow starters should be provided by the lamp manufacturer.

D.4.2 Lamps with internal thermal switches

Tests shall be carried out on complete lamps which have to be conditioned before testing. It is necessary to measure the pulse height for both the cold start and hot restrike conditions.

Note.— In lamps with internal thermal switches, pulse voltage limitation is effected by a combination of starter design and arc tube characteristics.

D.4.2.1 Cold start condition

For initial conditioning, the lamps shall be operated for at least 2 h prior to any test, then switched off and remain unlit for at least 1 h.

After initial conditioning, the lamps shall be ignited and allowed to run for 5 s to 10 s, switched off and remain unlit for at least a further 15 min.

A measurement shall then be taken using the test circuit of clause D.2, the relevant value being the highest voltage recorded on either of the two voltmeters of the measuring circuit referred to in clause D.3 until 5 s after the lamp strikes.

Further measurement may be taken on the same lamp without a repeat of the initial conditioning, provided the lamp is run for only 5 s to 10 s and remains unlit for a minimum of 15 min.

D.4.2.2 Hot restrike condition

The lamps shall be operated for at least 15 min. The supply shall then be interrupted to extinguish the lamp and then restored.

A measurement shall then be taken using the test circuit of clause D.2, the relevant value being the highest voltage recorded on either of the two voltmeters of the measuring circuit referred to in clause D.3 until 5 s after the lamp restrikes.

A repeat measurement may be taken after a further 15 min operation.

D.5 Test conditions

D.5.1 Test quantities

The random nature of the voltage pulses generated by internal starter switches means that single measurements are insufficient.

- For glow switch starters, a minimum of five starters are tested.
- For lamps with internal thermal switches, at least five measurements shall be taken on at least three lamps for both the cold start and the hot restrike.

D.5.2 Condition for compliance

No voltage measurement shall exceed the maximum pulse height for ballast design specified on the relevant lamp data sheet in this standard.

Appendix E

Measurement of voltage increase at lamp terminals for luminaire design

Introduction

Two procedures have evolved for the measurement of this parameter, based on European and North American practices.

It is essential that the method to be used is identified and agreed by the lamp manufacturer prior to the commencement of tests.

E.1 Method 1: used mainly in Europe

E.1.1 *General conditions for tests*

E.1.1.1 *Lamp ageing and selection*

Using ballasts complying with subclause 8.6, lamps shall be aged for 100 h in the same burning position as that used in the luminaire to be tested.

After ageing, the lamps shall be measured at rated supply voltage using the appropriate reference ballast at an ambient temperature of $25\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.

A minimum of five lamps shall be selected for voltage increase test, and shall have a voltage at lamp terminals lying within the inclusive minimum and maximum values given on the relevant lamp data sheet.

E.1.1.2 *Ballast used for voltage increase measurement*

The ballast used for the measurement of lamp voltage increase shall be of the type supplied for use in the luminaire under test, and shall comply with the requirements of subclause 8.6 of this standard.

The ballast used for the free air measurement and for the luminaire measurement shall be the same, and shall operate in both cases under the intended mounting conditions.

E.1.1.3 *Supply voltage and frequency*

The supply voltage and frequency during the stabilization and measurement periods shall be the rated values of the ballast specified in subclause E.1.1.2.

During stabilization periods, the supply voltage shall be maintained constant within $\pm 1,0\%$. However, during the measurement periods, the voltage shall be adjusted to within $\pm 0,5\%$ of the specified testing value.

At all times the frequency shall be maintained within $\pm 0,5\%$ of the rated value.

E.1.1.4 *Instruments*

The instruments used for the measurement of lamp voltage shall be of the true r.m.s. type and shall have an impedance of not less than 100 000 Ω . The same instruments shall be used throughout the test.

E.1.1.5 *Lamp positioning*

For the measurement of the lamp voltage in and out of the luminaire, the same lateral burning position and axial orientation shall be used. For this purpose, it is advisable to indicate the correct burning position with an appropriate mark.

For luminaires which may be operated in more than one operating position, only one position need be checked. This operating position shall be that which is most generally used.

E.1.1.6 *Minimized lamp disturbance*

On each occasion when a lamp is switched off, it shall be left undisturbed for at least 60 min before being moved to another location.

E.1.2 *Method of measurement*

E.1.2.1 The lamp shall be operated in free air at an ambient temperature of $25\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$, for a period of at least 60 min and until lamp stabilization has been achieved.

Stabilization is determined when, by monitoring the electrical characteristics of the lamp at 10 min to 15 min intervals, three successive measurements show a difference of 1% or less in lamp voltage.

E.1.2.2 After the cool-down period the lamp shall be transferred to the luminaire.

E.1.2.3 In an ambient temperature of $25\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ the lamp shall be operated in the luminaire for a period of at least 60 min and until lamp stabilization has been achieved.

Stabilization is determined in an identical way with the method specified in subclause E.1.2.1.

E.1.2.4 The final value of lamp voltage recorded in subclause E.1.2.1 shall be subtracted from the final value of lamp voltage recorded in subclause E.1.2.3. The resultant difference shall be taken as the voltage increase of the individual lamp and it shall be recorded.

E.1.2.5 The procedure given in subclauses E.1.2.1 to E.1.2.4 shall be repeated for all of the lamps used for the test.

E.1.3 Interpretation of lamp voltage measurements

E.1.3.1 From the recorded values of voltage increase for each individual lamp as specified in subclause E.1.2.4, the highest value of voltage increase and the lowest value of voltage increase shall be determined.

E.1.3.2 The average voltage increase shall be calculated, omitting from the calculation the highest and lowest individual lamp values determined in subclause E.1.3.1.

This value of average voltage increase shall be used for comparison with the value specified on the relevant lamp data sheet.

E.2 Method 2: used mainly in North America

E.2.1 General conditions for tests

E.2.1.1 Lamp selection

A reference lamp is selected from any sample of seasoned lamps that have been measured on the appropriate reference ballast. The reference lamp is one that yields measured electrical characteristics (voltage, wattage, and amperage values) within $\pm 2\%$ of the nominal values given on the relevant lamp data sheet. Only one reference lamp is required for a particular wattage class.

E.2.1.2 Test ballast

The ballast used for the measurement of the lamp voltage increase shall be a reference ballast as specified for the type of lamp under test.

E.2.1.3 Supply voltage and frequency

The supply voltage and frequency during the stabilization and measurement periods shall be equal to the rated value of the reference ballast specified in subclause E.2.1.2. During the stabilization period, the supply voltage shall be maintained constant within $\pm 1\%$. However, during the measurement period, the voltage shall be adjusted within $\pm 0,5\%$ of the specified testing value.

E.2.1.4 Instruments

The instruments used for the measurements shall comply with subclause E.1.1.4.

E.2.2 Method of measurement

E.2.2.1 The reference lamp shall be operated, on the reference ballast of E.2.1.2, in free air at an ambient temperature of $25\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ for a period of at least 60 min and until lamp stabilization has been achieved.

Stabilization is as defined in subclause E.1.2.1. The presence in the test area of highly reflective surfaces and sources of radiation should be avoided. When the bare lamp reaches a stable operating condition, the lamp voltage shall be recorded.

E.2.2.2 The lamp shall be permitted to cool to essentially ambient temperature for a minimum of one hour before being transferred to the test luminaire. The luminaire shall be at a stabilized temperature of $25\text{ °C} \pm 5\text{ °C}$.

E.2.2.3 The lamp shall be operated in the test luminaire for a period of at least 60 min and until lamp stabilization has been achieved. Operation shall occur on the same reference ballast specified in E.2.1.2, which shall be located outside the test luminaire. Stabilization is determined in an identical way with the method specified in subclause E.1.2.1.

E.2.2.4 The final value of lamp voltage recorded during the stabilization check of subclause E.2.2.3 shall be recorded.

E.2.2.5 The lamp voltage increase for the luminaire under test is determined by calculating the recorded stabilized lamp voltage of subclause E.2.2.4 minus the stabilized bare lamp voltage of subclause E.2.2.1. This value of voltage increase shall be used for comparison with the value specified on the relevant lamp data sheet.

Annex F

(informative)

HPS lamp drop-out voltage measurement procedure

Introduction

The following procedure may be used to measure drop-out voltages of high-pressure sodium (HPS) lamps. Experience has shown that this kind of measurement is difficult to make and the consistency of results is affected by several factors.

Speculation has been made that the wide variety of results reported in the past is due to variations in experimental setup and procedure. It is anticipated that the use of one common method will permit the comparison of data from different sources. The procedure contained herein is recommended as that common method.

F.1 Objective

The purpose of the subject procedure is to obtain data from lamps that will help to establish the "maximum voltage" line at the right-hand side of a quadrilateral diagram.

F.2 Theory

Operating limits of an HPS lamp are defined by a quadrilateral diagram, such as figure F.2.

Typically, the voltage of an HPS lamp increases through life. At some point in time a critical voltage is reached where the ballast will not be able to sustain the lamp. This voltage is called the drop-out voltage and it is a function of both lamp and ballast operating characteristics. In order to avoid differences in ballast operating characteristics due to design and manufacturing variations, a reference ballast is used in this procedure to determine drop-out voltage of a test lamp.

This procedure for measuring drop-out points involves operating a test lamp on a reference ballast and artificially raising the lamp's voltage until the drop-out point is reached. The lamp voltage is related to the amalgam temperature and can be increased by raising the temperature of the amalgam cold spot area. This heating can be accomplished by using either an external source of radiant heat or by redirecting some of the test lamp's radiation back onto itself. A metal cylinder lowered over the lamp or other artificial methods provide a convenient and controllable means of reflecting energy from the lamp back onto the arc tube within the lamp. Clear lamps are recommended for this test work. Coated lamps diffuse this radiant energy and complicate the experiment. Therefore, they should be avoided.

In some lamp designs a reservoir, external to the arc tube, serves as the amalgam cold spot. In lamps without an external reservoir, one or both ends of the arc tube can serve as the cold spot. When the end of the arc tube that has the cold spot is artificially heated, an equivalent or greater amount of heat must be applied to the opposite end of the arc tube. This can be accomplished artificially by placing a metal cylinder or aluminium foil over the "opposite" end of the lamp.

As the cold spot end is heated by artificial means, the lamp's voltage and wattage rise for the particular supply voltage being used. They can be recorded as they follow the ballast curve. A drop-out point can be obtained from these data. See figure F.3, as an example where voltage-wattage plots were made at various supply voltages and the drop-out points identified from the discontinuity of plot direction.

F.3 Methods of artificial heating

There are four commonly used methods of artificially heating the lamp's arc tube. These are listed below in order of preference.

F.3.1 *Metal sleeve*

The inside diameter of the metal sleeve should be only slightly larger than the outside diameter of the test lamp. Aluminium foil can be used to cover the inside surface of the sleeve to increase its reflectivity. An adjustable, mechanical drive to control sleeve movement is advantageous but not absolutely necessary.

After the test lamp has been started and reached its normal operation point, the sleeve is to be positioned over the lamp from the end opposite to the cold spot. The rate of increasing coverage of the lamp is limited by "equilibrium" (see clause F.4 "Description of equilibrium").

As the expected drop-out point is approached, the coverage rate must be slowed down.

F.3.2 *Metal sleeve and projection lamp*

When method F.3.1 does not drive the test lamp to drop-out, externally generated heat must be applied also. An incandescent, ellipsoidal-mirror-type projection lamp should be used. It is necessary to be able to focus the projection lamp's light output on the test lamp's cold spot. The projection lamp is to be controlled by means of an adjustable auto-transformer.

In this method, the metal sleeve is stopped at a position where the cold spot end is still exposed. Then the (pre-aimed) projection lamp's output is slowly increased to heat up the cold spot.

F.3.3 *Foil and projection lamp method*

A piece of pre-shaped aluminum foil is fitted over the lamp end opposite to the cold spot. The foil should extend only about 1/2 the length of the arc tube. The lamp is started with this shaped foil section removed. After reaching the normal lamp operating point, the foil is placed on the lamp. After the lamp reaches another stable point, the external heat is applied to the cold spot from the projection lamp.

F.3.4 *The two projection lamp method*

In this method the output of one projection lamp is focused on the end of the arc tube opposite the cold spot, the second lamp is aimed at the cold spot end. After the test lamp is started and reaches its normal operating point, the first projection lamp is turned on and its output increased slowly. As the expected drop-out is neared, the second lamp is turned on and its output increased slowly.

F.4 Description of equilibrium

The lamp voltage must be increased at a low enough rate to keep the lamp-ballast system near "equilibrium". If the lamp voltage is increased at too high a rate, an incorrect ballast curve and drop-out point will be recorded (see figure F.4). Two tests can be used to determine if the lamp-ballast system is near equilibrium:

- a) After the lamp voltage has been raised by an amount of 5 to 10 V, the cylinder position (or external light source intensity) should be fixed and the lamp voltage-wattage monitored. If the system is in equilibrium, the operating point will either remain constant or will move along the ballast curve. If the voltage has been raised at too high a rate, the lamp wattage will increase after the cylinder position is fixed and the operating point will then move up to the true ballast curve (see figure F.5).
- b) The second test is to remove the cylinder after the lamp voltage has been raised 10 V or more. The true ballast curve will then be retraced as the lamp returns to its normal operating voltage. If the two curves overlap, the ballast-lamp system is in equilibrium. This is the easier of the two tests to use.

F.5 Equipment and test lamps (see also notes 1 and 2)

Voltage regulator or line conditioner.

Reference ballast.

Instrumentation, as necessary, to record true r.m.s. voltage and power.

Lampholder and wiring.

Aluminium foil.

Cylindrical, metal sleeve (with mechanical control of position as an option).

Tesla coil or external ignitor.

Incandescent, ellipsoidal reflector projection lamp and voltage control.

Test lamps, clear bulb, aged 100 hours.

1 EQUIPMENT NOTES

The supply voltage and frequency shall be maintained constant within $\pm 0,5$ %. However, during actual measurements the voltage shall be adjusted to within $\pm 0,2$ % of the test value. The total harmonic content of the supply voltage shall not exceed 3 %, the harmonic content being defined as the root-mean-square (r.m.s.) summation of the individual harmonic components, using the fundamental as 100 %. This implies that the supply source shall have sufficient power and that the supply circuit shall have a sufficiently low-impedance compared with the ballast impedance.

Various kinds of digital voltmeters and wattmeters with a d.c. analog output are commercially available. Other true r.m.s. voltage and wattage convertors can be used provided that the output is checked for linearity and that the impedance limitations for HPS lamp measurements are adhered to.

As far as the measurement of the rise of the lamp voltage is concerned, there is an additional requirement that the speed of response of the measuring systems should be at least equal to the rate of change in voltage and wattage. Devices with a very long settling time would not be suitable.

Use of a Tesla coil to start test lamps is the preferred method. An external ignitor is satisfactory, but its use involves special cautionary steps to avoid damage to other equipment.

2 TEST LAMP NOTES

New test lamps should have 100 hours seasoning at normal conditions before use. Lamps with clear bulbs should be used.

A particular test lamp should not be re-tested in a new operating position without first going through a re-stabilizing period.

Stabilization is determined by monitoring a lamp's electrical characteristics after an hour of operation and at 10 to 15 minute intervals thereafter until a change of 1 % or less is observed in three successive measurements. If a lamp is warmed up on one ballast and then transferred without extinguishing it to a reference ballast, an additional period of operation is usually necessary to bring the lamp into equilibrium.

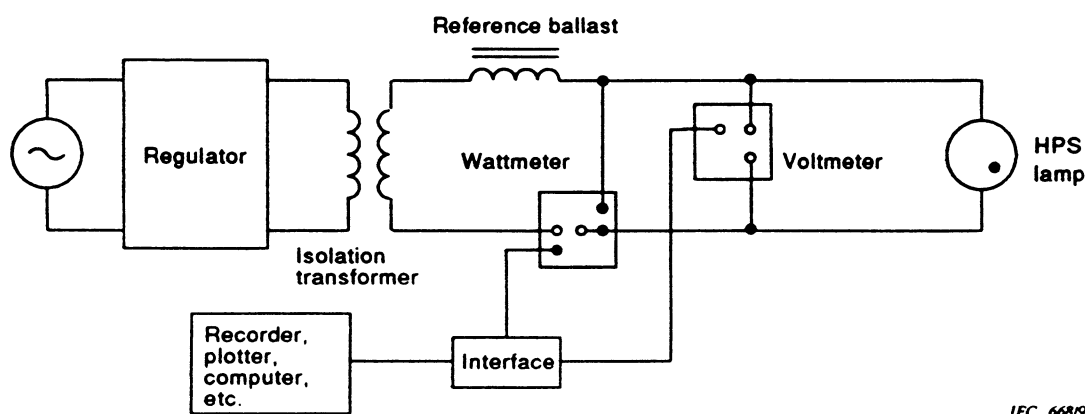


Figure F.1 – Example of a test circuit

F.6 Procedure

1. Assemble the necessary equipment and connect the components in the test circuit (see figure F.1).
2. Pre-set position of metal sleeve, foil, and/or projection lamp(s) as required, according to the method of artificial heating to be used.

3. Energize the test circuit and apply nominal voltage to the reference ballast. Commence recording and let the test lamp reach its normal operating point before introducing artificial heating.

Caution:

Disconnect all instruments during starting to protect against breakdown of electronic components due to the high voltage pulse.

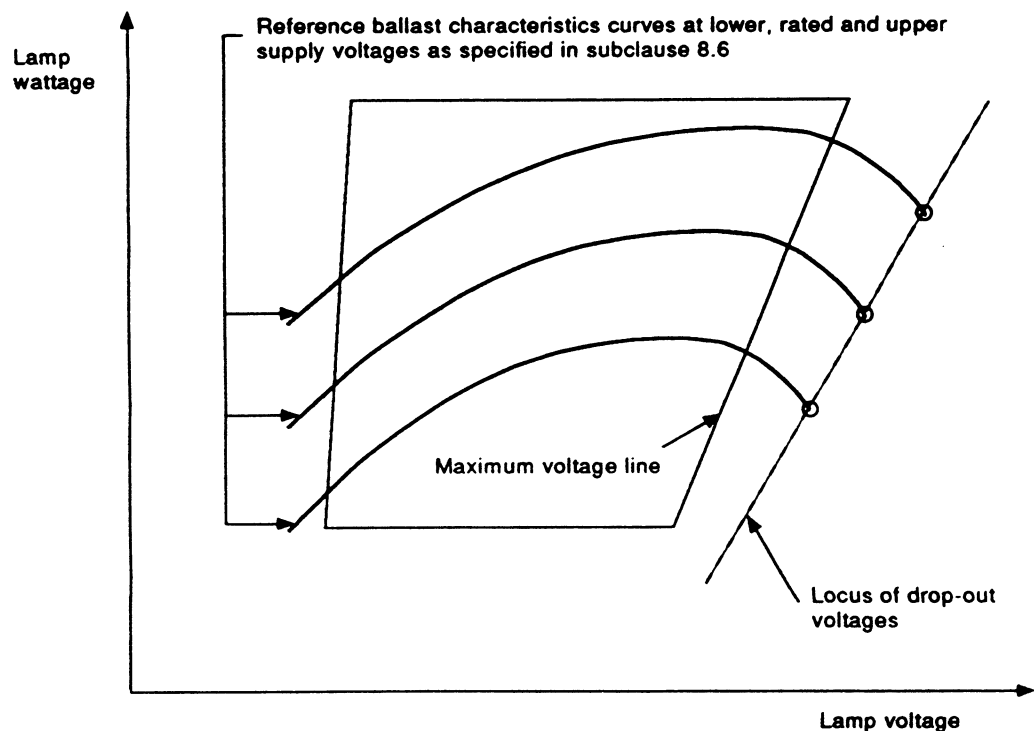
If an ignitor is used, disconnect it after starting so that it does not attempt a restart after the drop-out point. This could damage the meter.

4. Start the appropriate means of artificial heating as required. Watch for a steady rise in lamp voltage, maintain equilibrium. If the first method does not drive the lamp voltage rise up high enough to cause drop-out, use an alternative method.

5. After the test lamp has been allowed to cool, or using a new lamp each time, repeat step 3 and 4 for two other supply voltage settings as required in subclause 8.6 (IEC 662).

F.7 Report

For each particular lamp type, three voltage-wattage drop-out points will have been determined at the completion of the experimental procedure. There is a separate point for each different input voltage run. These three data points should be reported so that a "locus of drop-out voltages" as shown in figure F.2 can be drawn.



IEC 66993

Figure F.2 – Typical quadrilateral diagram showing drop-out points

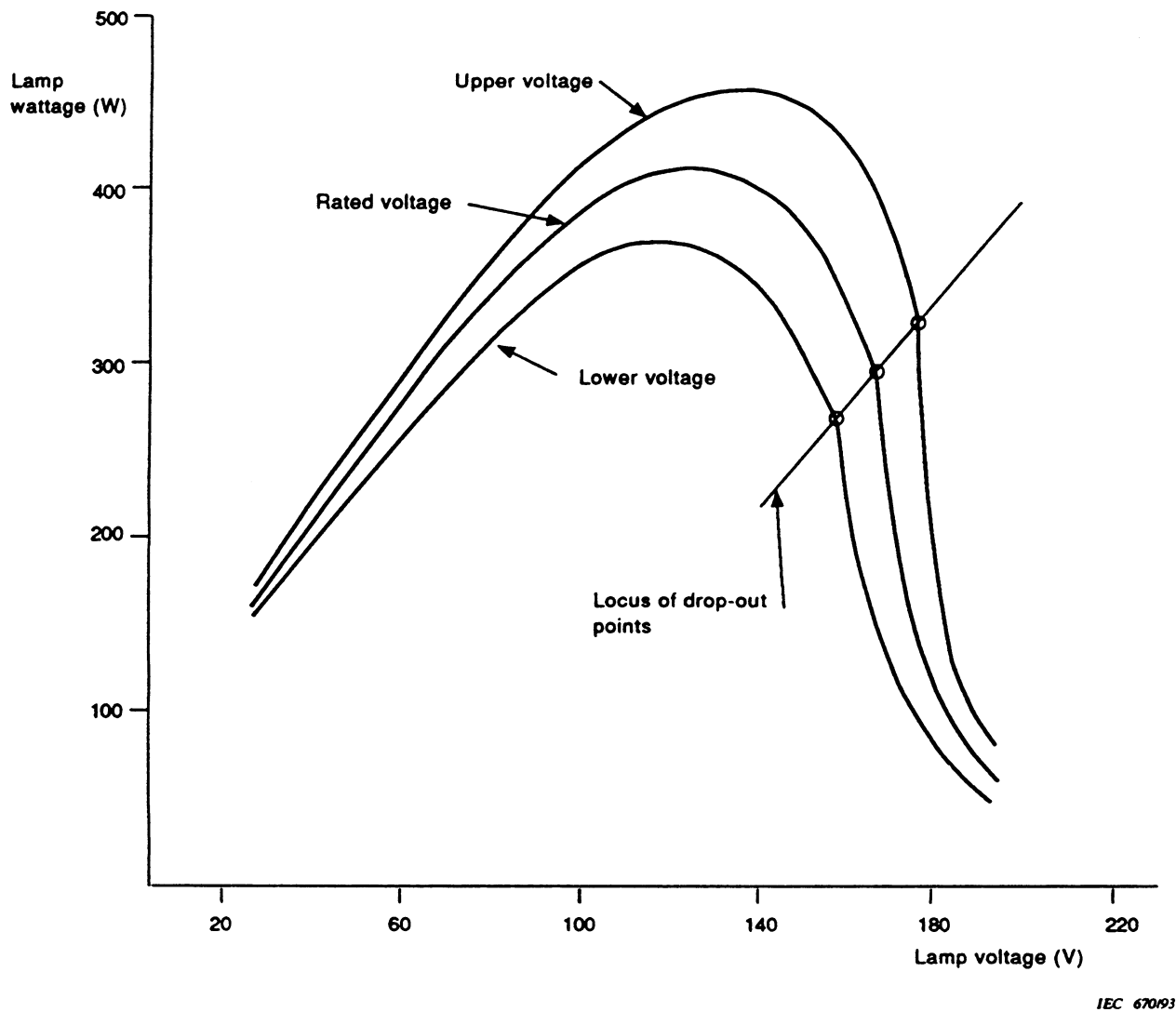


Figure F.3 – Example plot of 400 W HPS lamp ballast curves showing drop-out points

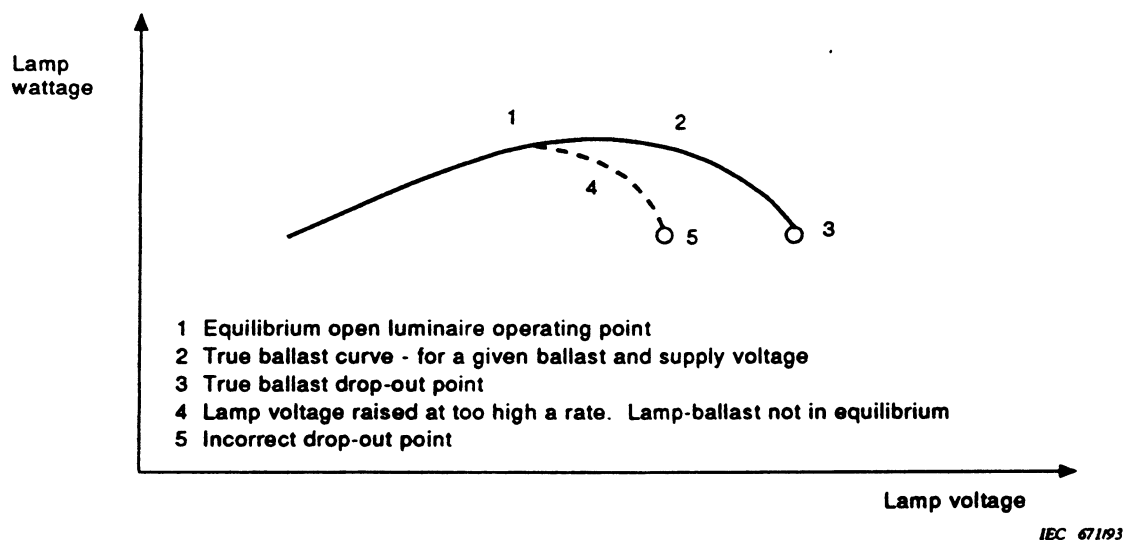


Figure F.4 – Incorrect drop-out point measurement due to raising lamp voltage at too high a rate

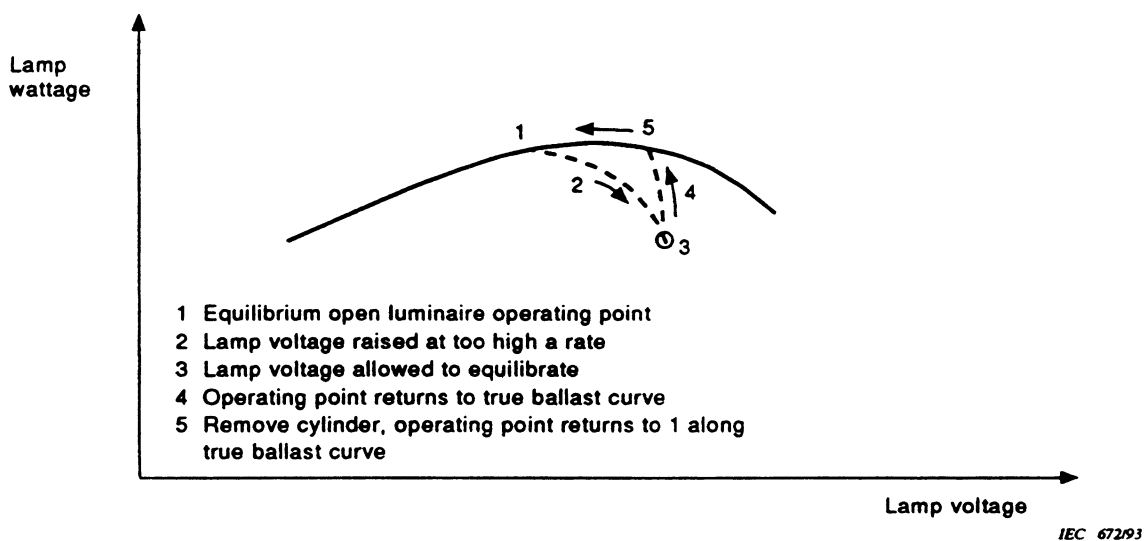


Figure F.5 – Test for lamp-ballast equilibrium

SECTION TWO – LAMP DATA SHEETS

12. List of specific lamp types included in this standard

Sheet No.	Rated wattage	Method of starting	Bulb
Normal version			
60662-IEC-1010-	250 W	Internal or external	Tubular - clear
60662-IEC-1020-	250 W	Internal or external	Elliptical - diffuse coating
60662-IEC-1030-	400 W	Internal or external	Tubular - clear
60662-IEC-1040-	400 W	Internal or external	Elliptical - diffuse coating
60662-IEC-1050-	150 W	Internal or external	Tubular - clear
60662-IEC-1060-	150 W	Internal or external	Elliptical - diffuse coating
60662-IEC-1070-	100 W HV	External	Tubular - clear
60662-IEC-1080-	100 W HV	External	Elliptical - diffuse coating
60662-IEC-1090-	100 W LV	External	Elliptical - diffuse coating or clear
60662-IEC-1100-	1 000 W EHV		Tubular - clear
60662-IEC-1110-	70 W HV	Internal	Elliptical - diffuse coating or clear
60662-IEC-1120-	70 W HV	External	Tubular - clear
60662-IEC-1130-	70 W HV	External	Elliptical - diffuse coating or clear
60662-IEC-1140-	70 W LV	External	Elliptical - diffuse coating or clear
60662-IEC-1150-	1 000 W HV	External	Tubular - clear
60662-IEC-1160-	1 000 W HV	External	Elliptical - diffuse coating
60662-IEC-1170-	50 W HV	Internal	Elliptical - diffuse coating or clear
60662-IEC-1180-	50 W HV	External	Tubular - clear
60662-IEC-1190-	50 W HV	External	Elliptical - diffuse coating or clear
Colour-improved version			
60662-IEC-2100-	150 W	External	Tubular - clear
60662-IEC-2110-	150 W	External	Elliptical - diffuse coating
60662-IEC-2120-	250 W	External	Tubular - clear
60662-IEC-2130-	250 W	External	Elliptical - diffuse coating
60662-IEC-2140-	400 W	External	Tubular - clear
60662-IEC-2150-	400 W	External	Elliptical - diffuse coating
High colour rendering			
60662-IEC-3010-	150 W	Internal	Elliptical clear and diffuse coating
60662-IEC-3020-	250 W	Internal	Elliptical clear and diffuse coating
60662-IEC-3030-	400 W	Internal	Elliptical clear and diffuse coating
Increased starting voltage			
60662-IEC-4010-	250 W	External	Tubular - clear
60662-IEC-4020-	250 W	External	Elliptical - diffuse coating
60662-IEC-4030-	400 W	External	Tubular - clear
60662-IEC-4040-	400 W	External	Elliptical - diffuse coating

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HIGH-PRESSURE SODIUM VAPOUR LAMPS

Technical data sheet

Page 1

Rated wattage: 250 W

With internal or external ignitor

Tubular bulb – clear

Lamp starting test

Test voltage	(V)	198
Maximum starting time	(s)	5 *
* In the case of lamps with internal starters, this requirement shall be 5 s after the internal starter has opened.		

Pulse characteristics	North American practice	European practice
Height (V)	$2\,225 \pm 25^{11}$	$2\,775 \pm 25^{21}$
Waveshape	Square ¹¹	Sinusoidal ²¹
Direction	A negative pulse during the negative half-cycle of the r.m.s. voltage wave	A positive pulse during the positive half-cycle of the r.m.s. voltage wave
Position	Within 80-100 electrical degrees of the r.m.s. supply voltage	Within 80-90 electrical degrees of the open-circuit voltage
Rise time – T_1 maximum	$0.100 \mu\text{s}^{11}$	$0.60 \mu\text{s}^{21}$
Duration time – T_2	$0.95 \pm 0.05 \mu\text{s}$	
Repetition rate	Once per cycle	
	¹¹ See Appendix A, Figure A1	²¹ See Appendix A, Figure A2

Lamp warm-up test

Test voltage	(V)	198
Time required to reach 50 V minimum at lamp terminals	(min)	5 (max.)

Lamp electrical characteristics at rated voltage of reference ballast

		Objective	Maximum	Minimum
Voltage at lamp terminals	(V) (r.m.s.)	100	115	85
Current	(A) (r.m.s.)	3.0	–	–
Wattage	(W)	250	–	–
Extinguishing voltage (see Sub-clause 7.5)	(V) (r.m.s.)	120	–	–

HIGH-PRESSURE SODIUM VAPOUR LAMPS

Technical data sheet

Page 2

Rated wattage: 250 W

With internal or external ignitor

Tubular bulb – clear

Reference ballast characteristics

		American practice	European practice
Rated frequency	(Hz)	60	50
Rated voltage	(V)	220	220
Calibration current	(A)	3,0	3,0
Voltage/current ratio		59,0	60,0
Power factor		0,075 ± 0,005	0,06 ± 0,005

Lamp dimensions (see appendix B)

Cap	Bulb diameter (max.) <i>D</i>	Overall length (max.) <i>L</i>	Light centre length <i>C</i>	Arc length (nominal) <i>A</i>	Deviation of any point along centre line of arc tube from axis of cap (apex of cap eyelet used as the point of reference)	Operating position limitation
	(mm)	(mm)	(mm)	(mm)	3 degrees	As indicated by lamp manufacturer
E39 ¹⁾	52	250	155-165	65		
E39 ²⁾	59	248	143-149	67		
E40	48 ³⁾	260	153-163	65		

Ballast design information (see clause 8)

		Maximum	Minimum
Lamp warm-up current for ballast design (r.m.s.)	(A)	5,2	3,0
Pulse height for ballast design	European practice (V)	5 000	2 800
	American practice (V)	4 500	2 500
Lamp operating limits are shown graphically on page 3.			

Luminaire design information (see clause 9)

Voltage increase at lamp terminals (maximum)	(V)	10
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¹⁾ Japanese practice.

²⁾ American practice.

³⁾ There are presently also lamp designs with a maximum bulb diameter of 60 mm. In some luminaires this may give rise to interchangeability problems.

HIGH-PRESSURE SODIUM VAPOUR LAMPS

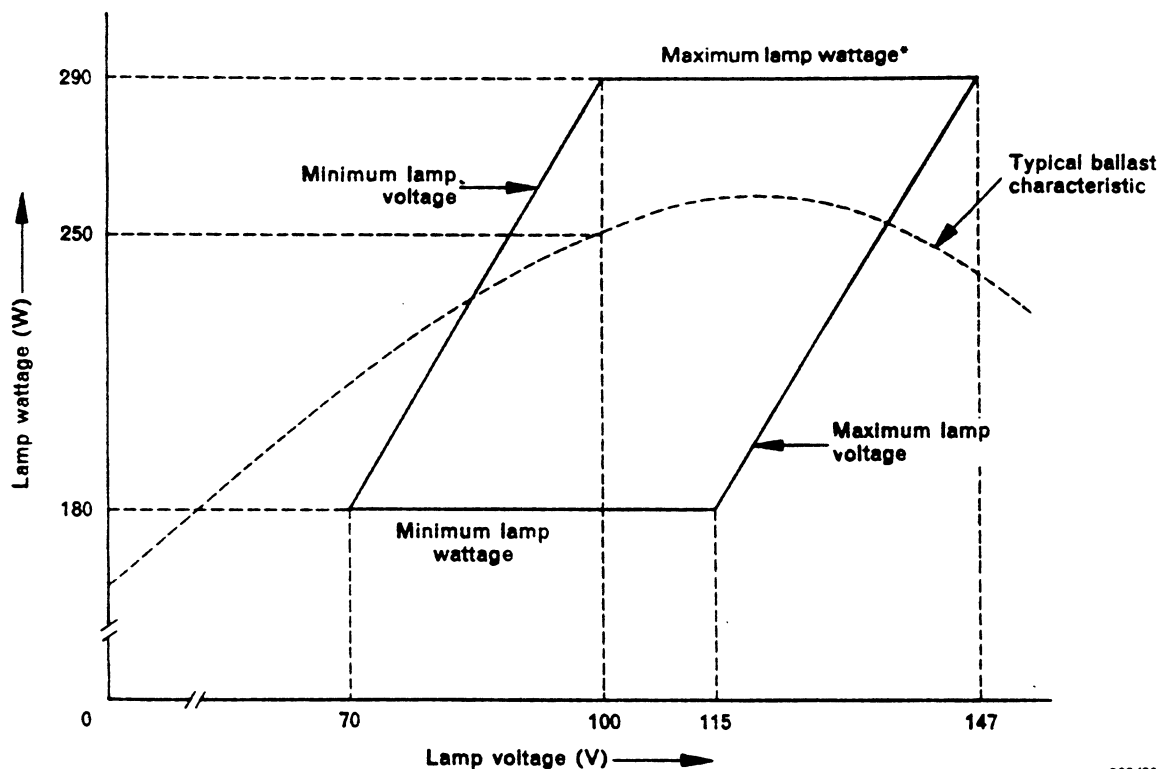
Technical data sheet

Page 3

Rated wattage: 250 W

With internal or external ignitor

Tubular bulb – clear



008/90

* For nominal supply voltages in the range 220 V-250 V the maximum wattage shall be based on the rated wattage + 20%.

A typical ballast characteristic curve at rated supply voltage is shown by the dotted line in the diagram.

FIG. 1. – Lamp operating limits for the information of ballast designers.

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HIGH-PRESSURE SODIUM VAPOUR LAMPS

Technical data sheet

Page 1

Rated wattage: 250 W

With internal or external ignitor

Elliptical bulb – diffuse coating

Lamp starting test

Test voltage	(V)	198
Maximum starting time	(s)	5 *
* In the case of lamps with internal starters, this requirement shall be 5 s after the internal starter has opened.		

Pulse characteristics	North American practice	European practice
Height (V)	$2\,225 \pm 25$ ¹⁾	$2\,775 \pm 25$ ²⁾
Waveshape	Square ¹⁾	Sinusoidal ²⁾
Direction	A negative pulse during the negative half-cycle of the r.m.s. voltage wave	A positive pulse during the positive half-cycle of the r.m.s. voltage wave
Position	Within 80-100 electrical degrees of the r.m.s. supply voltage	Within 80-90 electrical degrees of the open-circuit voltage
Rise time – T_1 maximum	$0.100 \mu\text{s}$ ¹⁾	$0.60 \mu\text{s}$ ²⁾
Duration time – T_2	$0.95 \pm 0.05 \mu\text{s}$	
Repetition rate	Once per cycle	
	¹⁾ See Appendix A, Figure A1	²⁾ See Appendix A, Figure A2

Lamp warm-up test

Test voltage	(V)	198
Maximum time required to reach 50 V minimum at lamp terminals	(min)	5 (max.)

Lamp electrical characteristics at rated voltage of reference ballast

		Objective	Maximum	Minimum
Voltage at lamp terminals	(V) (r.m.s.)	100	115	85
Current	(A) (r.m.s.)	3.0	–	–
Wattage	(W)	250	–	–
Extinguishing voltage (see Sub-clause 7.5)	(V) (r.m.s.)	120	–	–

HIGH-PRESSURE SODIUM VAPOUR LAMPS

Technical data sheet

Page 2

Rated wattage: 250 W

With internal or external ignitor

Elliptical bulb – diffuse coating

Reference ballast characteristics

		American practice	European practice
Rated frequency	(Hz)	60	50
Rated voltage	(V)	220	220
Calibration current	(A)	3,0	3,0
Voltage/current ratio		59,0	60,0
Power factor		0,075 ± 0,005	0,06 ± 0,005

Lamp dimensions (see appendix B)

Cap	Bulb diameter (max.) <i>D</i>	Overall length (max.) <i>L</i>	Light centre length <i>C</i>	Arc length (Nominal) <i>A</i>	Deviation of any point along centre line of arc tube from axis of cap (apex of cap eyelet used as the point of reference)	Operating position limitation
E39 or E40	(mm) 91	(mm) 227	(mm) –	(mm) –	–	As indicated by lamp manufacturer

Ballast design information (see clause 8)

		Maximum	Minimum
Lamp warm-up current for ballast design (r.m.s.)	(A)	5,2	3,0
Pulse height for ballast design	{ European practice (V)	5 000	2 800
	{ American practice (V)	4 500	2 500

Lamp operating limits are shown graphically on page 3.

Luminaire design information (see clause 9)

Voltage increase at lamp terminals (maximum)	(V)	10
--	-----	----