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British Standard

Ballasts for tubular fluorescent lamps

Part 1. Specification for ballasts for use internationally

Ballasts pour lampes tubulaires à fluorescence

Partie 1. Ballasts pour usage sur le plan international — Spécifications

Vorschaltgeräte für Leuchtstoffröhren

Teil 1. Vorschaltgeräte für internationale Verwendung

BS 2818 : Part 1 : 1985

National foreword



This Part of BS 2818 has been prepared under the direction of the Electrical Illumination Standards Committee. It is identical with IEC Publication 82 : 1984 including Amendment No. 1. 'Ballasts for tubular fluorescent lamps' published by the International Electro - technical Commission (IEC). It supersedes BS 2818 : Part 1 : 1981 which is withdrawn.

This Part of BS 2818 specifies requirements, including safety requirements (see sections one and two), for ballasts for use internationally and Part 2 specifies requirements for ballasts for use with tubular fluorescent lamps used in the UK not included in BS 1853 'Tubular fluorescent lamps for general lighting service' Part 1 'Specification for internationally specified lamps'.

Terminology and conventions. The text of the international standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

The comma has been used as a decimal marker in the figures. In British Standards it is current practice to use a full point on the baseline as the decimal marker.

Where page numbers are quoted with reference to figures they are IEC page numbers indicated in square brackets at the foot of each page.

Cross-references

International standards	Corresponding British Standards
IEC 155 : 1983	BS 3772 : 1981 Specification for starters for fluorescent lamps (Identical)
IEC 216 : 1974	BS 5691 Guide for the determination of thermal endurance properties of electrical insulating materials Part 1 : 1979 General procedures for the determination of thermal endurance properties, temperature indices and thermal endurance profiles (Identical)
IEC 598-1 : 1979	BS 4533 Luminaires Part 101 : 1981 Specification for general requirements and tests (Technically equivalent)

The Technical Committee has reviewed the provisions of IEC 81 and IEC 566 to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard. Related standards to IEC 81 and IEC 566 are BS 1853 : Part 1 and BS 4017, respectively.

It should be noted that BS 1853 : Part 2 : 1979 is a specification for lamps used in the United Kingdom not included in BS 1853 : Part 1.

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



Textual error. It should be noted that in paragraph 4 of Clause 15, 'Table V' should be read as 'Table IV'. The IEC are aware of this error and a correction will be published in due course.

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British Standard

Ballasts for tubular fluorescent lamps

Part 1. Specification for ballasts for use internationally

INTRODUCTION

This standard for ballasts for tubular fluorescent lamps constitutes a complete specification, of which Section One describes general requirements, while Section Two gives thermal and mechanical requirements and Section Three gives electrical requirements which the ballasts are required to fulfil.

Particular requirements for thermally protected ballasts are given in Appendix F of this standard.

The association of lamps and ballasts is checked with the use of special inductive ballasts called "reference ballasts" having particular characteristics which are stable and reproducible. These ballasts are used for the testing of ordinary ballasts and for the selection of reference lamps. Moreover, the testing of ballasts presents particular difficulties which require a proper definition of testing methods. Such tests will generally be made with reference lamps, and in particular by comparing the results obtained when such lamps are operated on a reference ballast with the results obtained when the same lamps are operated on the ballast being tested.

The thermal characteristics of ballasts are specified by the rated maximum operating temperature of the winding (symbol t_w), which should not be exceeded in order to ensure a sufficient length of life for the ballast when the ballast is built into a luminaire. Moreover, the indication of the rated temperature rise of a winding (symbol Δt) may be added, but it remains optional.

For checking the rated maximum operating temperature t_w , the present standard includes an endurance test period of 30 days as the standard method and, at the manufacturer's choice, an optional endurance test period of 60 days. Values for theoretical test temperatures, as well as the limiting temperatures under abnormal conditions, are given.

Further, referring to equation (2) of Appendix A concerning the endurance tests, this standard includes the use of constants S other than 4 500 in t_w tests. If a claim is not made to the contrary, the endurance testing of ballasts is based on the constant S given in equation (2) having a value of 4 500, but a manufacturer may claim the use of other values if this can be justified by either of the tests specified.

Since it has been considered necessary to have the values for theoretical test temperatures, as well as the limiting temperatures under abnormal conditions, listed for each value of S , a limited number of standardized values for S have been adopted.

Note. — For equation (2), refer to Appendix B for the use of constants S other than 4 500 in t_w tests.

This edition of IEC Publication 82 specifies a measurement of lamp power and current, for lamps operated without starter, in a reference ballast circuit that makes no provision for separate power sources to heat the cathodes during lamp operation. Although the influence on the ballast specification is small, it has nevertheless been deemed useful for some preheat low-voltage cathode lamps, operated without a starter, to include provision for two alternative methods of measurement of lamp power and current:

- 1) measurement of lamp power and current without additional cathode heating;

- 2) measurement of lamp power and current with additional cathode heating.

The test method to be adopted for appraisal is to be stated by the manufacturer.

SECTION ONE — GENERAL REQUIREMENTS

1. Scope

This standard covers built-in ballasts, excluding resistance types, for use on a.c. supplies up to 250 V at 50 Hz, or 60 Hz, associated with tubular fluorescent lamps with pre-heated cathodes operated with or without a starter switch and having rated wattages, dimensions and characteristics as specified in IEC Publication 81: Tubular Fluorescent Lamps for General Lighting Service. It applies to complete ballasts and to their component parts such as reactors, transformers and capacitors having a capacitance equal to or less than 0.1 μF .

Capacitors having a capacitance of greater than 0.1 μF are covered by IEC Publication 566: Capacitors for Use in Tubular Fluorescent and Other Discharge Lamp Circuits.

Note. — Requirements are also included for all those features of reference ballast construction and performance which are considered necessary to ensure accurate and reproducible results when testing ballasts, particularly with regard to the selection of reference lamps.

2. Definitions

For the purpose of this standard, the following definitions apply.

2.1 Ballast

A unit inserted between the supply and one or more discharge lamps which, by means of inductance, capacitance, or a combination of inductance and capacitance, serves mainly to limit the current of the lamp(s) to the required value.

It may also include means for transforming the supply voltage and arrangements which help to provide starting voltage and pre-heating current, prevent cold starting, reduce stroboscopic effects, correct the power-factor and/or suppress radio interference.

2.2 Built-in ballast

A ballast, consisting of one or more separate units, exclusively designed to be built into a luminaire, a box, an enclosure or the like.

2.3 Reference ballast

A special inductive-type ballast designed for the purpose of providing comparison standards for use in testing ballasts and for the selection of reference lamps. It is essentially characterized by a stable voltage-to-current ratio, which is relatively uninfluenced by variations in current, temperature and the magnetic surroundings, as outlined in this standard.

2.4 *Reference lamp*

A lamp selected for testing ballasts which, when associated with a reference ballast under the conditions specified in Appendices C and D of this standard, has electrical characteristics which are close to the values given in IEC Publication 81 within the limits defined in Appendix D.

2.5 *Calibration current of a reference ballast*

The value of the current on which are based the calibration and control of the ballast.

Note. — Such a current should always be approximately equal to the nominal running current of the lamps for which the reference ballast is suitable.

2.6 *Supply voltage*

The voltage applied to the complete circuit of lamp(s) and ballast.

2.7 *Supply current*

The current supplied to the complete circuit of lamp(s) and ballast.

2.8 *Circuit power factor: cosine ϕ*

The power factor of the combination of a ballast and the lamp or lamps for which the ballast is designed.

2.9 *High power factor ballast*

A ballast having a circuit power factor of at least 0.85 (leading or lagging).

Note. — The value 0.85 takes into account the effect on the power factor of the distortion of the current waveform. Certain countries will approve only high power factor ballasts.

2.10 *High audio-frequency impedance ballast*

A ballast of which the impedance in the frequency range 250 Hz to 2 000 Hz exceeds the values specified in Clause 27, Section Three, of this standard.

Note. — Certain countries will approve only high audio-frequency impedance ballasts.

2.11 *Low-distortion type ballast*

A ballast of which the harmonic content complies with the more severe requirements of Sub-clause 25.1, Section Three, of this standard.

2.12 *Rated maximum operating temperature (of a capacitor): symbol t_c*

That temperature, which must not be exceeded by the hottest part of the capacitor surface during operation in service.

Note. — The internal losses in a capacitor, though small, will result in the surface temperature being above ambient air temperature and due allowance for this should be made. The temperature difference will depend upon the nature of the enclosure.

2.13 Rated maximum operating temperature (of a ballast winding): symbol t_w

The winding temperature assigned by the manufacturer as the highest temperature at which the ballast may be expected to have a service life of at least ten years' continuous operation.

2.14 Rated temperature rise (of a ballast winding): symbol Δt

The temperature rise assigned by the manufacturer to the winding, under the conditions specified in this standard.

Note. — The specifications for the supply and mounting conditions of the ballast are given in Clause A5 of Appendix A.

2.15 Working voltage

The highest r.m.s. voltage which may occur across any insulation, transients being neglected, in open circuit conditions or during lamp operation.

2.16 Parallel cathode heating (or pre-heating)

Type of heating (or pre-heating) supplied by a low tension winding of the ballast directly connected to the cathode terminations of the lamp.

Note. — This type of heating circuit is used in practice only with lamps operated without starter.

2.17 Series cathode heating (or pre-heating)

Type of heating (or pre-heating) in which a cathode is connected in series in the main circuit before the lamp has started.

2.18 Rectifying effect

The effect which may occur at the end of lamp life when one cathode either is broken or has insufficient electron emission resulting in the arc current in consecutive half cycles being unequal.

2.19 Short-circuit power

The short-circuit power of a voltage source is the quotient of the square of the voltage to be generated at its output terminals (in open circuit conditions) and the internal impedance of the source (as seen from the same terminals).

2.20 Type test

A test or a 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.

2.21 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. General requirements

Ballasts shall be so designed and constructed that in normal use their performance is reliable and without danger to the user or surroundings. Capacitors and other components incorporated in ballasts shall comply with the requirements of the appropriate IEC standard.

In general, compliance for ballasts and other elements is checked by carrying out all the tests specified.

4. General notes on tests

- 1) The tests are considered as type tests.
- 2) The tests are carried out in the order of the clauses unless otherwise specified.
- 3) The type test is carried out on one sample consisting of one or more items submitted for the purpose of the type test. See definition of Sub-clause 2.20.

One sample of eight ballasts is required of which seven are for the endurance test and one for all the other tests. For conditions of compliance for the endurance test, see Clause 12.

Note. — With the exception of the endurance test, certain countries require three ballasts to be tested and therefore ten ballasts are required of which seven are for the endurance test and three for all other tests.

- 4) The tests are made under the conditions specified in Appendices A and E.

5. Classification

Under consideration.

6. Marking

6.1 *Mandatory markings*

Ballasts shall be clearly marked with the following mandatory markings:

- 1) Mark of origin (this may take the form of a trade mark, or the manufacturer's name or the name of the responsible vendor).
- 2) Manufacturer's model number or type reference.
- 3) Wiring diagram indicating clearly the position of terminals, unless connections are self-evident.

In the case of built-in ballasts having no terminals, a clear indication shall be given on the wiring diagram of the significance of the code used for the connecting wires.

- 4) Rated supply voltage (or voltages, if there are several), frequency and supply current(s).
- 5) Rated wattage of, and if necessary, the designation of the type or types of lamp for which the ballast is designed. If the ballast is to be used with more than one lamp, the number and wattage of each lamp shall be indicated.
- 6) Rated maximum operating temperature of the windings, following the symbol t_w , values increasing in multiples of 5 °C.
- 7) Circuit power-factor, for example $\cos \phi$ 0.85.

If the power-factor is less than 0.95 leading, it shall be followed by the letter "C", for example $\cos \phi$ 0.80 C.

For ballasts intended for the additional application of operating lamps in series, the appropriate power factors shall be marked on the ballast.

The following additional marking shall be added if appropriate.

- 8) In the case of a ballast consisting of more than one separate unit, the current controlling inductive element(s) shall be marked with the essential details of the other unit(s) and/or essential capacitors.
- 9) In the case of an inductive ballast used with a separate series capacitor other than a radio interference suppression capacitor, the marking of rated voltage, capacitance and, if necessary, the rated maximum operating temperature and/or the test voltage of the capacitor, shall be repeated on the ballast.
- 10) The symbol $\overline{Z}$ which indicates that the ballast is designed to comply with the conditions for audio-frequency impedance (see Clause 27, Section Three).
- 11) The symbol for earth terminal $\perp$, 417-IEC-5019.

6.2 Information to be provided, if applicable

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

- 1) For ballasts which, at the manufacturer's choice, have to be tested for a period of 60 days during the endurance test, with the symbol "D6", placed between brackets immediately after the t_w indication.

Note. — The symbol "D6" is an abbreviation of 60 days.

The endurance test period of 30 days need not be marked.

- 2) For ballasts for which a constant S other than 4 500 is claimed by the manufacturer, the symbol S together with its appropriate value in thousands, for example "S6", if S has a value of 6 000. The following values of S are preferred: 4 500, 5 000, 6 000, 8 000, 11 000, 16 000.
- 3) The symbol H which indicates that the ballast is not of the low distortion type.

Note. — In the case of a ballast incorporating a capacitor other than a radio interference suppression capacitor, the repetition on the ballast of a rated voltage, capacitance and, if necessary, the rated maximum operating temperature and/or the test voltage of the capacitor is recommended.

6.3 Other information

The manufacturer may provide the following non-mandatory information, if available:

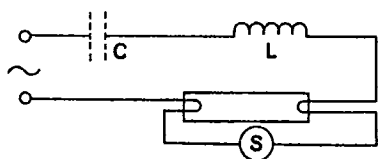
The rated temperature rise of the winding following symbol Δt , values increasing in multiples of 5 °C.

6.4 Legibility and durability of marking

Marking shall be durable and easily legible.

Compliance is checked by inspection and by trying to remove the marking by rubbing lightly for 15 s with one piece of cloth soaked with water and another with hexane spirit.

The figure below illustrates a typical example of ballast-marking.

BRAND	Model number	220 V ~ 50 Hz
		$1 \times 65 \text{ W} - 0.67 \text{ A} \cos \phi 0.50$ $C = 5.7 \mu\text{F} \pm 5\% 380 \text{ V} - 0.68 \text{ A} \cos \phi 0.50 \text{ C}$
	$I_w 120$ $(D6) S6$	

Note. — The typical ballast marking above indicates that the ballast may be used to supply a lamp of 65 W either in an inductive circuit ($0.67 \text{ A} \cos \phi 0.50$), or in series with a capacitor ($5.7 \mu\text{F} \pm 5\% 380 \text{ V}$), in a capacitive circuit ($0.68 \text{ A} \cos \phi 0.50 \text{ C}$).

SECTION TWO — THERMAL AND MECHANICAL REQUIREMENTS

7. Protection against accidental contact with live parts

Lacquer or enamel is not deemed to be adequate protection or insulation against accidental contact with live parts.

Ballasts incorporating a capacitor of capacitance exceeding $0.5 \mu\text{F}$ shall be provided with a discharge device so that the voltage across the capacitor, 1 min after disconnection of the ballast from a source of supply at rated voltage, does not exceed 50 V.

8. Terminals

8.1 When terminals are provided, they shall permit the connection of conductors with cross-sectional areas in one or more of the following ranges:

- 0.5 mm^2 to 1.0 mm^2 .
- 0.75 mm^2 to 1.5 mm^2 .
- 1.0 mm^2 to 2.5 mm^2 .
- 1.5 mm^2 to 4.0 mm^2 .

Compliance shall be checked by fitting conductors of the smallest and largest cross-sectional areas specified.

8.2 Screw terminals shall comply with the requirements of Section 14 of IEC Publication 598-1: Luminaires, Part 1: General Requirements and Tests.

8.3 Screwless terminals shall comply with the requirements of Section 15 of IEC Publication 598-1.

9. Provision for earthing

9.1 The earthing terminal, if any, shall comply with the requirements of Clause 8. The clamping means shall be adequately locked against accidental loosening and it shall not be possible to loosen the



clamping means by hand. For screwless terminals, it shall not be possible to loosen the clamping means unintentionally.

Compliance is checked by inspection, by manual test and by the tests of Clause 8.

- 9.2 All parts of an earth terminal shall be such as to minimize the danger of electrolytic corrosion resulting from contact with the earth conductor or any other metal in contact with them.



The screw or the other parts of the earthing terminal shall be of brass or other metal no less resistant to corrosion, or a material with a non-rusting surface and at least one of the contact surfaces shall be of bare metal.

Compliance is checked by inspection.

10. Constructional requirements

- 10.1 Ballasts shall be mechanically robust and shall be so designed and constructed as to minimize the effects thereon of moisture in the atmosphere and of temperature changes during use.

- 10.2 Adequately robust means of fixing shall be provided.

Compliance with the requirements of Sub-clauses 10.1 and 10.2 shall be checked by inspection.

11. Moisture resistance and insulation

- 11.1 The ballast shall be moisture-resistant. It shall not show any appreciable damage after being subjected to the moisture treatment described in Appendix A, Clause A2.

- 11.2 Insulation shall be adequate:

- between poles;
- between live parts and external parts including fixing screws.

The insulation resistance measured immediately after the humidity conditioning under the conditions specified in Appendix A, Sub-clause A2.1, shall be not less than 2 MΩ.

Immediately after the insulation resistance test, the ballast shall, in addition, withstand a voltage test for 1 min under the conditions specified in Appendix A, Sub-clause A2.2, the test voltage corresponding to the values of Table I.

TABLE I

Test voltages after moisture treatment

Working voltage (<i>U</i>)	Test voltage
Up to and including 42 V	500 V
Above 42 V	$2 U + 1\,000\text{ V}$

For the insulation between live parts and external parts, the test voltage shall be based on the rated voltage of the ballast if this voltage is higher than the working voltage.

- 11.3 If a capacitor is connected between live parts and external metal parts of the ballast, the measurement of the insulation resistance between these parts is replaced by a measurement of the leakage

current in accordance with the diagram given in Figure 1, page 90, the ballast being connected to a voltage equal to 110% of the rated supply voltage at rated frequency.

The leakage current is measured between each pole of the supply source and the external metal parts, with and without lamps.

The resistance of the measuring circuit shall be $2000 \pm 50 \Omega$. The leakage current shall not exceed 0.5 mA.

12. Thermal endurance of windings

The test is carried out on seven new ballasts, which have not been subjected to the preceding tests. They shall not be used for further testing.

Before the test, each ballast shall start and operate a lamp normally and the lamp arc current shall be measured under normal conditions of operation and at rated voltage. The windings of the ballasts shall withstand the thermal endurance test described in Appendix A, Clause A4. The thermal conditions shall be so adjusted that the objective duration of the test shall be either 30 days or 60 days for ballasts marked with "D6". If no indication is given, the test period shall be 30 days.

After the test, when the ballasts have returned to ambient temperature, they shall satisfy the following requirements:

- a) At rated voltage each ballast shall start the same lamp and the lamp arc current shall not exceed 115% of the value measured before the test, as described above.

Note. — This test is to determine any adverse change in ballast setting.

- b) The insulation resistance between the winding and the ballast case measured at approximately 500 V d.c. shall be not less than 1 M Ω .

The result of the test shall be considered to be satisfactory if at least six of the seven ballasts satisfy these requirements. The test shall be considered to be failed if more than two ballasts fail the test.

In the case of two failures, the test shall be repeated with seven more ballasts and no failure of these ballasts shall be permitted.

13. Limitation of ballast heating

13.1 Before the test, the following shall be checked and measured:

- a) The ballast shall start and operate the lamp(s) normally.
- b) The resistance of each winding shall be measured at the ambient temperature.

13.1.1 Voltage across capacitors

At rated frequency, the voltage across a capacitor incorporated in a ballast shall comply with the requirements given in Items a) and b) below.

The requirements of Items a) and b) below do not apply to the capacitors in starters or those having a capacitance equal to or less than 0.1 μ F (nominal).

The requirements of Item b) do not apply to self-healing capacitors.



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a) Under normal conditions, when the ballast is tested at its rated supply voltage, the voltage across the capacitor shall not exceed the rated voltage of the latter.



b) Under abnormal conditions (see Sub-clause 13.3) when the ballast is tested at 110% of its rated supply voltage, the voltage across the capacitor shall be not greater than the appropriate test voltage for the endurance test as specified in Clause 19 of IEC Publication 566.

13.2 Normal and abnormal conditions

When the ballast is tested in accordance with the requirements of Clause A5 of Appendix A, the temperature shall not exceed the appropriate value given in Table II for the test under normal and abnormal conditions.

Unless otherwise indicated on the ballast, the limiting temperatures specified in column S4.5 of Tables VIA and VIB apply. The use of constants other than S4.5 shall be justified in accordance with Appendix B.

13.3 Abnormal conditions

Abnormal conditions are working conditions in which one or more of the following apply:

- a) the lamp or one of the lamps is not inserted;
- b) the lamp does not start because one of the cathodes is broken;
- c) the lamp does not start although the cathode circuits are intact (de-activated lamp);
- d) in switch-start circuits, one starter is short-circuited;
- e) the lamp operates, but one of the cathodes is de-activated or broken (rectifying effect).

For test purposes, the abnormal conditions shall be the most severe of the conditions stated in Items a) to e) above.

During the abnormal test, the capacitor voltage shall be measured (see Item b) of Sub-clause 13.1.1). If the voltage is higher than the appropriate test voltage given in IEC Publication 566, the test shall be repeated with the capacitor short-circuited.

Note. — Self-healing capacitors are excluded from the requirements of the last two paragraphs of this sub-clause.

TABLE II

Limiting temperatures in degrees Celsius¹⁾

Parts	Normal operation at 110% of rated voltage	Abnormal operation at 110% of rated voltage
Windings	2)	See Tables IIA and IIB ³⁾
Capacitor enclosure		
— without temperature marking	50	60
— with indication of rated maximum operating temperature t_c	t_c	$t_c + 10$
Terminals for external wiring	85	
Part made of:		
— wood-filled phenolic mouldings	110	
— mineral-filled phenolic mouldings	145	
— urea mouldings	90	
— melamine mouldings	100	
— laminated, resin-bonded paper	110	
— rubber	70	
— thermoplastic materials	4)	
If materials or manufacturing methods are used other than those indicated in the table, they shall not be operated at temperatures higher than those which are proved to be permissible for these materials. Temperatures related to screwless terminals are under consideration.		

¹⁾ The limiting temperatures in Table II shall not be exceeded when the ballast is operated at its maximum ambient temperature. The values in the table are based on an ambient temperature of 25 °C. The test shall be carried out according to the conditions specified in Appendix A, Clause A5.

²⁾ The measurement of the temperature rise of the winding under normal conditions at 100% rated voltage in accordance with Clause A5 of Appendix A, viz. verification of the marked Δt value is non-mandatory and its measurement is only performed so as to provide information for luminaire design.

³⁾ The limiting temperatures under abnormal conditions correspond to the maximum temperature the ballast may reach during the endurance test—see Appendix A, Clause A4. This maximum temperature corresponds to an endurance period of 20 days in the case of ballasts tested for 30 days and 40 days for those tested for 60 days.

⁴⁾ The temperature of thermoplastic material other than that used for the insulation of the wiring, which provides protection against contact with live parts or supporting such parts, is also determined. The value so obtained will serve in order to establish the conditions of the test of Sub-clause 16.1.

TABLE IIA

Limiting temperatures of windings under abnormal operating conditions and at 110% of rated voltage for ballasts subjected to an endurance test duration of 30 days

Constant S	Limiting temperature (°C)					
	$S4.5$	$S5$	$S6$	$S8$	$S11$	$S16$
for $t_w =$	90	171	161	147	131	119
	95	178	168	154	138	125
	100	186	176	161	144	131
	105	194	183	168	150	137
	110	201	190	175	156	143
	115	209	198	181	163	149
	120	217	205	188	169	154
	125	224	212	195	175	160
	130	232	220	202	182	166
	135	240	227	209	188	172
	140	248	235	216	195	178
	145	256	242	223	201	184
	150	264	250	230	207	190

TABLE IIB

Limiting temperatures of windings under abnormal operating conditions and at 110% of rated voltage for ballast marked "D6" which are subjected to an endurance test duration of 60 days

Constant S	Limiting temperature (°C)					
	$S4.5$	$S5$	$S6$	$S8$	$S11$	$S16$
for $t_w =$	90	158	150	139	125	115
	95	165	157	145	131	121
	100	172	164	152	137	127
	105	179	171	158	144	132
	110	187	178	165	150	138
	115	194	185	171	156	144
	120	201	192	178	162	150
	125	208	199	184	168	155
	130	216	206	191	174	161
	135	223	213	198	180	167
	140	231	220	204	186	173
	145	238	227	211	193	179
	150	246	234	218	199	184

Tests under condition e) apply only to starterless ballasts having capacitive reactance control and apart from possible radio interference capacitors, nothing but an inductive impedance connected in parallel with the lamp. Such ballasts shall be subjected to the test in Appendix A, Sub-clause A5.2.

In the case where a ballast is designed for more than one lamp, only the starter, whose failure would cause the highest temperature, is short-circuited, the unaffected lamps shall operate normally.

If the requirements of Sub-clause 13.1.1b) with regard to the voltage across capacitors under abnormal conditions is not fulfilled in the case of a series capacitor, the ballast shall not be deemed to be unsatisfactory provided it withstands an additional heating test under abnormal conditions with the capacitor short-circuited instead of the starter.

13.4 After these heating tests and after cooling down, the ballast shall comply with the following conditions:

- a) the ballast marking shall still be legible;
- b) the ballast shall withstand without damage a voltage test according to Sub-clause 11.2, the test voltage, however, being reduced to 75% of the values given in Table I, but not less than 500 V.

14. Screws, current-carrying parts and connections

14.1 Screwed connections, electrical or otherwise, the failure of which might cause the ballast to become unsafe, shall withstand the mechanical stresses occurring in normal use.

Screws transmitting contact pressure which have a nominal diameter less than 3 mm shall screw into metal.

Compliance is checked by inspection and for screws and nuts transmitting contact pressure by the following tests:

The screws or nuts are tightened and loosened:

- ten times for screws in engagement with a thread of insulating material;
- five times for nuts and other screws.

Screws in engagement with a thread of insulating material are completely removed and reinserted each time.

When testing terminal screws and nuts, a solid conductor of the largest cross-section specified in Sub-clause 8.1 is placed in the terminal. The test is made by means of a suitable test screwdriver or spanner applying a torque as shown in Table III. Column I applies to screws without heads if the screw, when tightened, does not protrude from the hole. Column II applies to other screws and to nuts.

TABLE III

Torque test requirements for terminals

Nominal diameter of screw (mm)	Torque (Nm)	
	I	II
Up to and including 2.8	0.2	0.4
Over 2.8 up to and including 3.0	0.25	0.5
Over 3.0 up to and including 3.2	0.3	0.6
Over 3.2 up to and including 3.6	0.4	0.8
Over 3.6 up to and including 4.1	0.7	1.2
Over 4.1 up to and including 4.7	0.8	1.8
Over 4.7 up to and including 5.3	0.8	2.0
Over 5.3 up to and including 6.0	—	2.5

The conductor is moved each time the screw or nut is loosened.

During the test, no damage impairing the future use of the screwed connections shall occur.

Screws which may be operated when connections are made to the ballasts include, for example, terminal screws, screws for fixing covers when they have to be loosened to open the ballast, etc. Conduit thread connections and screws to fasten the ballasts to their supports are excluded.

The shape of the blade of the test screwdriver shall match the slot of the screw to be tested. The screws shall not be tightened in jerks. Nuts are tested in a similar manner. Damage to covers is neglected.

- 14.2 Screws in engagement with a thread of insulating material shall have a length of engagement of at least 3 mm plus one-third of the nominal screw diameter, except that this length need not exceed 8 mm. Correct introduction of the screw into the screw hole or nut shall be ensured.

Compliance is checked by inspection, by measurement and by manual test.

The requirement with regard to correct introduction is met if introduction of the screw in a slanting manner is prevented, for example by guiding the screw by the part to be fixed, by a recess in the female thread or by the use of a screw with the leading thread removed.

- 14.3 Electrical connections shall be so designed that contact pressure is not transmitted through insulating material other than ceramic, pure mica or other material with characteristics no less suitable, unless there is sufficient resiliency in the metal parts to compensate for any possible shrinkage of the insulating material.

- 14.4 Self-tapping screws shall not be used for the connection of current-carrying parts, unless they press these parts directly and conductively together, and unless they are locked against loosening by suitable means.

Thread-cutting screws may be used for the interconnection of current-carrying parts which do not consist of soft materials liable to yield, such as zinc or aluminium.

Self-tapping screws may be used for earth continuity connections which need not be disassembled during the intended use. At least two equivalent screws should then be used which are adequately protected against loosening.

Compliance is checked by inspection.

- 14.5 Screws and rivets which serve as electrical as well as mechanical connections shall be locked against loosening.

Compliance is checked by inspection and by manual test.

Spring washers may provide satisfactory locking. For rivets, a non-circular shank or an appropriate notch may be sufficient.

Sealing compound which softens on heating provides satisfactory locking only for screw connections not subject to torsion in normal use.

- 14.6 Current-carrying parts shall be of copper, an alloy containing at least 50% copper, or other metal no less resistant to corrosion than copper and having mechanical properties no less suitable.

Compliance is checked by inspection.

The requirements do not apply to screws which do not essentially carry current, such as terminal screws.

15. Creepage distances and clearances

Creepage distances and clearances shall be not less than the values given in Table IV, expressed in millimetres:

The contribution to the creepage distance of any groove less than 1 mm wide shall be limited to its width.

Any air-gap of less than 1 mm shall be ignored in computing the total air path.

Note. — Creepage distances are distances in air, measured along the surface of insulation.

A metal enclosure shall have an insulating lining if, in the absence of such a lining, the creepage distance or clearances between live parts and the enclosure would be smaller than the value prescribed above.

In open-core ballasts, enamel, or the like, which forms the insulation for a wire and withstands the voltage test for Grade 1, or Grade 2, of IEC Publication 317: Specifications for Particular Types of Winding Wires, is judged to contribute 1 mm to the values given in Table V between enamelled wires of different windings or from enamelled wires to covers, iron cores etc. However, this applies only in the situation when the creepage distances and clearances are not less than 2 mm in addition to the enamelled layers.

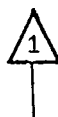


TABLE IV

Creepage distances and clearances (mm)

Working voltage	Up to and including 24 V	Above 24 V up to and including 250 V	Above 250 V up to and including 500 V	Above 500 V up to and including 750 V
<i>Creepage distance</i>				
1. Between live parts of different polarity.	2	3 (2)	5	6
2. Between live parts and accessible metal parts which are permanently fixed to the ballast including screws of devices for fixing covers or fixing the ballast to its support.	2	4 (2)	6	7
<i>Clearance</i>				
3. Between live parts of different polarity.	2	3 (2)	5	6
4. Between live parts and accessible metal parts which are permanently fixed to the ballast including screws of devices for fixing covers or fixing the ballast to its support.	2	4 (2)	6	7
5. Between live parts and a flat supporting surface or a loose metal cover, if any, if the construction does not ensure that the values under 4 above are maintained under the most unfavourable conditions.	2	6	10	12*

* Under consideration.



The values between brackets apply to creepage distances and clearances where the surface area is not liable to contamination by dust or moisture.

16. Resistance to heat and fire

- 16.1 External parts of insulating material, providing protection against electric shock, and parts of insulating material retaining live parts in position, shall be sufficiently resistant to heat.

Compliance is checked by the test specified in Clause A6 of Appendix A.

The test is not made on parts of ceramic material.

16.2 External parts of insulating material shall be resistant to abnormal heat and fire.

External parts of insulating material which retain live parts in position shall be tested as specified in Sub-clause 13.3.1 of IEC Publication 598-1.

External parts of insulating material which do not retain live parts in position, but which provide protection against electric shock shall be tested as specified in Sub-clause 13.3.2 of IEC Publication 598-1.

17. Resistance to corrosion

Ferrous parts, the rusting of which may endanger the safety of the ballast, shall be adequately rust-protected. This requirement applies to the outer surface of iron cores.

Protection by varnish is deemed to be adequate for the outer surface of iron cores.

Compliance is checked by inspection.

SECTION THREE — ELECTRICAL REQUIREMENTS

18. General

Unless otherwise stated on the technical lamp data sheet in IEC Publication 81, it may be expected that ballasts which comply with this standard when associated with lamps complying with IEC Publication 81 and, where appropriate, operated with a starter complying with IEC Publication 155: Starters for Fluorescent Lamps, will ensure satisfactory starting of the lamps at an air temperature immediately around the lamps between 10 °C and 35 °C and for voltages between 90% and 110% of rated supply voltage; and also proper operation between 10 °C and 50 °C at rated supply voltage.

For all tests, the requirements of Appendix A, Clause A1, apply.

19. Open-circuit voltage at terminations of lamp or starter (if any)

The test shall be carried out in accordance with the requirements of Appendix E, Clause E4.

19.1 For lamps operated with a starter

A ballast, when operated at any voltage between 90% and 110% of its rated supply voltage, shall provide the following open-circuit voltages:

- a) at terminations of the starter, an r.m.s. voltage of at least the value given in IEC Publication 81 on the relevant lamp data sheet.
- b) at lamp terminations, a peak voltage (excluding the surge of the starter) not exceeding the value given in IEC Publication 81 on the relevant lamp data sheet.

When ballasts are designed to operate lamps in parallel circuits, the relevant requirements shall be met for each separate lamp, even in the most adverse load conditions.

19.2 *For lamps operated without a starter*

A ballast, when operated at any voltage between 90% and 110% of its rated voltage, shall provide an open-circuit voltage at lamp terminations such that:

- a) its r.m.s. value is at least the value given in IEC Publication 81 on the relevant lamp data sheet;
- b) its peak value does not exceed the value given in IEC Publication 81 on the relevant lamp data sheet.

When ballasts are designed to operate lamps in parallel circuits, the relevant requirements shall be met for each separate lamp, even in the most adverse conditions.

Note. — For the checking of open-circuit voltage at lamp terminations, the maximum value of the four possible measurements between lamp terminals is taken.

20. Pre-heating conditions

The test shall be carried out in accordance with the requirements of Appendix E, Clause E5.

20.1 *For lamps operated with starter*



A ballast when operated at any voltage between 90% and 110% of its rated supply voltage and at rated frequency, shall provide a pre-heating current as specified on the relevant lamp data sheet in IEC Publication 81: Tubular Fluorescent Lamps for General Lighting Service. For lamps where such data is not given in IEC Publication 81, the pre-heating current shall be as specified by the lamp manufacturer.

Note. — The use of an uncompensated capacitive ballast resulting in the reduction in the pre-heating current has an unfavourable influence on the life of certain lamps.

If several samples are submitted for test, the average of the ratios of pre-heat current to nominal running current shall be at least 0.9 but no individual ballasts shall be below 0.85.

20.2 *For lamps operated without starter*

With a resistor of the appropriate value specified in the relevant lamp data sheet in IEC Publication 81 substituted for each lamp cathode, the ballast shall present a voltage across each substitution resistor not less than the minimum and not greater than the maximum specified in the relevant table when measured at the supply voltage indicated.

The voltages given in the relevant lamp data sheet in IEC Publication 81 are valid only for the circuit conditions specified. Deviating values may occur during normal lamp operation. If the maximum voltage delivered to the substitution resistor exceeds this value, a further test shall be made using a resistor of half the value specified in the relevant lamp data sheet in IEC Publication 81. The current passed through this resistor at 110% of rated supply voltage shall not exceed 1.8 times the nominal running current of the lamp.

21. Lamp power and current

The test shall be carried out in accordance with the requirements of Appendix E, Clause E6.

21.1 *For lamps operated with starter*

The ballast shall limit the power and current of a reference lamp to not less than 92.5% for the power and not more than 115% for the current of the corresponding values delivered to the same lamp when operated with a reference ballast. Both the reference ballast and the ballast under test shall have the same rated frequency and each shall be operated at its rated voltage.

For ballasts intended for the additional application of operating lamps in series, each lamp not exceeding 20 W rating, the limits at rated voltage are widened by an additional 5%, i.e. 87.5% for power and 120% for current at rated voltage instead of 92.5% and 115% respectively. The reference ballast data used for this test shall be the sum of the individual lamp powers.

21.2 *For lamps operated without starter*

The ballast shall limit the current delivered to the reference lamp to a value not exceeding 115% of that delivered to the same lamp when it is operated with a reference ballast.

The power supplied to the lamp shall be such that the luminous flux from a reference lamp shall be not less than 90% of the luminous flux from the same reference lamp when operated on a reference ballast in a circuit either with or without separate cathode heating, as may be required by the measurement method being used (see Appendix E).

For those lamps where both methods of measurement of electrical and luminous characteristics are specified on the relevant lamp data sheet of IEC Publication 81, the manufacturer shall state the method to be used.

For these tests, the reference ballast shall have the same rated frequency as the ballast under test and each of them shall be operated at its rated voltage.

22. Circuit power-factor

The measured circuit power-factor shall not differ from the marked value by more than 0.05 when the ballast is operated with one or more reference lamps and the whole combination is supplied at its rated voltage and frequency. In cases where a minimum value of power-factor is required for a ballast, it shall be 0.85 measured under the conditions stated above. For these high power-factor ballasts, the measured value shall in no case be less than 0.85.

23. Supply current

At rated voltage, the supply current to the ballast shall not differ by more than $\pm 10\%$ from the value marked on the ballast when the latter is operated with a reference lamp.

24. Maximum current in any lead to a cathode

This requirement applies only to ballasts for lamps operated without starter, when tested in accordance with the requirements of Appendix E, Clause E7.

In normal operation and at a supply voltage of 110% of the rated value, the current flowing in any one of the cathode terminations shall not exceed the value given in IEC Publication 81 on the relevant lamp data sheet.