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Appareillages de lampes –

Partie 2-3:  
Prescriptions particulières pour les ballasts  
électroniques alimentés en courant alternatif  
pour lampes fluorescentes

Lamp controlgear –

Part 2-3:  
Particular requirements for a.c. supplied  
electronic ballasts for fluorescent lamps

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International Electrotechnical Commission  
Telefax: +41 22 919 0300

e-mail: [inmail@iec.ch](mailto:inmail@iec.ch)

3, rue de Varembeé, Geneva, Switzerland  
IEC web site: <http://www.iec.ch>



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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## LAMP CONTROLGEAR -

Part 2-3: Particular requirements for a.c. supplied electronic ballasts  
for fluorescent lamps

## FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
- 3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
- 4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
- 5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
- 6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61347-2-3 has been prepared by subcommittee 34C: Auxiliaries for lamps, of IEC technical committee 34: Lamps and related equipment.

This first edition of IEC 61347-2-3, together with IEC 61347-1, cancels and replaces the second edition of IEC 60928, published in 1995, and constitutes a minor revision.

This standard shall be used in conjunction with IEC 61347-1. It was established on the basis of the first edition (2000) of that standard.

This part 2 supplements or modifies the corresponding clauses in IEC 61347-1 so as to convert that publication into the IEC standard: Particular requirements for a.c. supplied electronic ballasts for fluorescent lamps.

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

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

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

FDIS	Report on voting
34C/500/FDIS	34C/514/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

Annexes A to J form an integral part of this standard.

IEC 61347 consists of the following parts, under the general title *Lamp controlgear*.

- Part 1: General and safety requirements
- Part 2-1: Particular requirements for starting devices (other than glow starters)
- Part 2-2: Particular requirements for d.c. or a.c. supplied electronic step-down convertors for filament lamps
- Part 2-3: Particular requirements for a.c. supplied electronic ballasts for fluorescent lamps
- Part 2-4: Particular requirements for d.c. electronic ballasts for general lighting
- Part 2-5: Particular requirements for d.c. supplied electronic ballasts for public transport lighting
- Part 2-6: Particular requirements for d.c. supplied electronic ballasts for aircraft lighting
- Part 2-7: Particular requirements for d.c. supplied electronic ballasts for emergency lighting
- Part 2-8: Particular requirements for ballasts for fluorescent lamps
- Part 2-9: Particular requirements for ballasts for discharge lamps (excluding fluorescent lamps)
- Part 2-10: Particular requirements for electronic invertors and convertors for high-frequency operation of cold start tubular discharge lamps (neon tubes)
- Part 2-11: Particular requirements for miscellaneous electronic circuits used with luminaires<sup>1)</sup>

The committee has decided that the contents of this publication will remain unchanged until 2003. At this date, the publication will be

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

<sup>1)</sup> To be published.

## INTRODUCTION

This first edition of IEC 61347-2-3, published in conjunction with IEC 61347-1, represents an editorial review of IEC 60928. The formatting into separately published parts provides for ease of future amendments and revisions. Additional requirements will be added as and when a need for them is recognized.

This standard, and the parts which make up IEC 61347-2, in referring to any of the clauses of IEC 61347-1, specify the extent to which such a clause is applicable and the order in which the tests are to be performed; they also include additional requirements, as necessary. All parts which make up IEC 61347-2 are intended to be self-contained and, therefore, do not include references to each other. However, for the case of emergency lighting lamp controlgear, some cross-referencing has been necessary.

Where the requirements of any of the clauses of IEC 61347-1 are referred to in this standard by the phrase "The requirements of clause n of IEC 61347-1 apply", this phrase is interpreted as meaning that all requirements of the clause in question of part 1 apply, except any which are clearly inapplicable to the specific type of lamp controlgear covered by this particular part of IEC 61347-2.

## LAMP CONTROLGEAR –

### Part 2-3: Particular requirements for a.c. supplied electronic ballasts for fluorescent lamps

#### 1 Scope

This part of IEC 61347 specifies particular safety requirements for electronic ballasts for use on a.c. supplies up to 1 000 V at 50 Hz or 60 Hz with operating frequencies deviating from the supply frequency, associated with fluorescent lamps as specified in IEC 60081 and IEC 60901, and other fluorescent lamps for high-frequency operation.

Particular requirements for electronic ballasts with means of protection against overheating are given in annex C.

Particular requirements for a.c./d.c. supplied electronic ballasts for maintained emergency lighting are given in annex J.

Performance requirements are the subject of IEC 60929.

#### 2 Normative references

For the purpose of this part of IEC 61347, the normative references given in clause 2 of IEC 61347-1 which are mentioned in this standard apply, together with the following normative references.

IEC 60598-2-22, *Luminaires – Part 2-22: Particular requirements – Luminaires for emergency lighting*

IEC 61347-1, *Lamp controlgear – Part 1: General and safety requirements*

IEC 61347-2-7, *Lamp controlgear – Part 2-7: Particular requirements for d.c. supplied electronic ballasts for emergency lighting<sup>1)</sup>*

#### 3 Definitions

For the purpose of this part of IEC 61347, the definitions of clause 3 of IEC 61347-1 apply, together with the following:

##### 3.1

##### **a.c. supplied electronic ballast**

mains-supplied a.c. to a.c. inverter including stabilizing elements for starting and operating one or more tubular fluorescent lamps, generally at high frequency

<sup>1)</sup> To be published.

**3.2****controllable ballast**

lamp power (light output) of the electronic ballast controlled between the minimum value (or off) and the maximum value by the signal on the control input of the ballast

**3.3****maximum value of lamp power (of a controllable ballast)**

lamp power (light output) which complies with 8.1 of IEC 60929, unless otherwise declared by the manufacturer or responsible vendor

**3.4****maximum allowed peak voltage**

highest permitted peak voltage across any insulation under open-circuit condition and any normal and abnormal operating conditions. The maximum peak voltage is related to the declared r.m.s. working voltage; see table 1

**3.5****minimum value of lamp power (of a controllable ballast)**

lowest percentage of the lamp power defined in 3.3 declared by the manufacturer or responsible vendor

**3.6****control terminals**

connections to the electronic ballast which are used to apply a control signal for changing the light output

NOTE The power supply terminals can also act as control terminals.

**3.7****control signal**

signal which may be an a.c. or d.c. voltage, and which by analogue, digital or other means may be modulated to convey the necessary information to the ballast for the purpose of changing the light output

**3.8****a.c./d.c. supplied electronic ballast for maintained emergency lighting**

mains/battery-supplied a.c./d.c to a.c. inverter including stabilizing elements for starting and operating one or more tubular fluorescent lamps, generally at high frequency for emergency lighting

**3.9****cathode dummy resistor**

cathode substitution resistor as specified on the relevant lamp data sheet of IEC 60081 or IEC 60901 or as declared by the relevant lamp manufacturer or by the responsible vendor

**4 General requirements**

The requirements of clause 4 of IEC 61347-1 apply, together with the following additional requirement:

AC/d.c. electronic ballasts for emergency lighting shall comply with the requirements of annex J.

## 5 General notes on tests

The requirements of clause 5 of 61347-1 apply together with the following additional requirement:

Number of specimens

The following number of specimens shall be submitted for testing:

- one unit for the tests of clause 6 to 12 and 15 to 21;
- one unit for the test of clause 14 (additional units or components, where necessary, may be required in consultation with the manufacturer).

Tests to meet the safety requirements for a.c./d.c. supplied electronic ballasts for emergency lighting are made under the conditions specified in annex J.

## 6 Classification

The requirements of clause 6 of IEC 61347-1 apply.

## 7 Marking

Ballasts which form an integral part of the luminaire need not be marked.

### 7.1 Mandatory markings

In accordance with the requirements of 7.2 of IEC 61347-1, ballasts, other than integral ballasts, shall be clearly and durably marked with the following mandatory markings:

- items a), b), c), d), e), l) and k) of 7.1 of IEC 61347-1, together with
- the symbol for earthing, as applicable;
- for controllable ballasts, the control terminals shall be identified;
- a declaration of the maximum working voltage (r.m.s.) according to 12.2 between
- output terminals;
- any output terminal and earth, if applicable.

Marking for each of these two values shall be in steps of 10 V when the working voltage is equal to, or less than, 500 V, and in steps of 50 V when the working voltage is higher than 500 V. The marking of maximum working voltage is referenced in two situations, the maximum between output terminals and the maximum between any output terminal and earth. It is acceptable for only the higher of these two voltages to be marked.

Marking shall be U-OUT=...V..

### 7.2 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 similar:

- items h), i), and j) given in 7.1 of IEC 61347-1.



## 8 Protection against accidental contact with live parts

The requirements of clause 10 of IEC 61347-1 apply.

## 9 Terminals

The requirements of clause 8 of IEC 61347-1 apply.

## 10 Provisions for earthing

The requirements of clause 9 of IEC 61347-1 apply.

## 11 Moisture resistance and insulation

The requirements of clause 11 of IEC 61347-1 apply together with the following additional requirements:

The leakage current that may occur from contact with fluorescent lamps operated at high frequency from a.c. supplied electronic ballasts shall not exceed the values in figure 2 when measured in accordance with annex I. The values are in r.m.s. values.

The limits of leakage current values for frequencies between the values shown in figure 2 should be obtained by calculation according to the formula in the figure (under consideration).

NOTE Limits of leakage current values for frequencies above 50 Hz are under consideration.

*Compliance with these requirements is checked in accordance with annex I.*

## 12 Electric strength

The requirements of clause 12 of IEC 61347-1 apply.

## 13 Thermal endurance test for windings

The requirements of clause 13 of IEC 61347-1 do not apply.

## 14 Fault conditions

The requirements of clause 14 of IEC 61347-1 apply.

## 15 Protection of associated components

### 15.1

Under conditions of normal operation, verified with dummy cathode resistors inserted and conditions of abnormal operation, as specified in clause 16, the voltage at the output terminals shall at no time exceed the maximum permitted peak value specified in table 1.

**Table 1 – Relation between r.m.s. working voltage and maximum peak voltage**

Voltage at output terminals	
RMS working voltage V	Maximum permitted peak voltage V
250	2 200
500	2 900
750	3 100
1 000	3 200

NOTE Linear interpolation between the given voltage steps is allowed.

**15.2**

Under normal operating conditions and abnormal operating conditions as specified in clause 15, except for the rectifying effect, and from 5 s after the switch on or beginning of the starting process, the voltage at the output terminals shall not exceed the maximum working voltage for which the ballast is declared.

**15.3**

In the case of a rectifying effect, i.e. abnormal operating condition according to 16 d), the r.m.s. voltage at the output terminal shall not exceed the maximum permitted value for which the ballast is designed for a period longer than 30 s after switch-on, or beginning of the starting process.

For ballasts which make more than one attempt to start a failed lamp, the combined duration of voltages above the maximum working voltage for which the ballast is declared shall not exceed 30 s.

**15.4**

For the tests of 15.1, 15.2 and 15.3, the output voltages measured shall be those between any output terminal and earth. Additionally, voltages that appear between output terminals shall be measured in cases where the voltage is present across insulation barriers within associated components.

**15.5**

For controllable electronic ballasts, the control input shall be isolated from the mains circuit by an insulation at least equal to basic insulation.

NOTE This requirement does not apply to those ballasts where control signals are injected via the supply terminals or where the control signals are completely isolated from the ballast by being transmitted remotely from infra-red or radio wave transmitters.

If SELV is to be used, then double or reinforced insulation is required.

**16 Abnormal conditions**

The ballast shall not impair safety when operated under abnormal conditions at any voltage between 90 % and 110 % of the rated supply voltage.

*Compliance is checked by the following test.*

Each of the following conditions shall be applied with the ballast operating according to the manufacturer's instructions (including a heat sink, if specified) for 1 h:

- 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) the lamp operates, but one of the cathodes is de-activated or broken (rectifying effect);
- e) short circuit of the starter switch, if any.

For the test simulating operation with a de-activated lamp, a resistor is connected in place of each lamp cathode. The resistor value is derived from the value of the nominal running current of the lamp prescribed in the relevant lamp data sheet of IEC 60081 and IEC 60901 and substituted in the following equation:

$$R = \frac{11,0}{2,1 \times I_n} \Omega$$

where

$I_n$  is the nominal running current of the lamp.

For lamps not covered by IEC 60081 and IEC 60901, the values declared by the lamp manufacturer shall be used.

When testing electronic ballasts for the rectifying effect, the circuit shown in figure 1 is used. The lamp is connected to the midpoints of the appropriate equivalent resistors. The rectifier polarity is chosen so as to give the most unfavourable conditions. If necessary, the lamp is started using a suitable starting device.

During and at the end of the tests specified under items a) to e), the ballast shall show no defect impairing safety nor shall any smoke be produced.

## 17 Construction

The requirements of clause 15 of IEC 61347-1 do not apply.

## 18 Creepage distances and clearances

The requirements of clause 16 of IEC 61347-1 apply.

## 19 Screws, current-carrying parts and connections

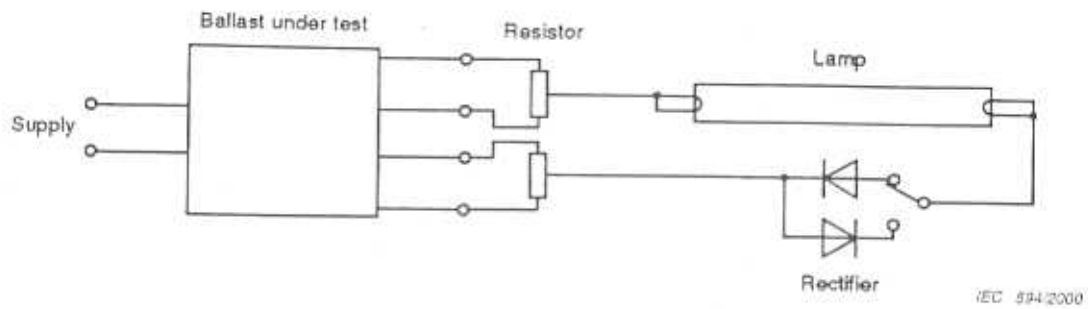
The requirements of clause 17 of IEC 61347-1 apply.

## 20 Resistance to heat, fire and tracking

The requirements of clause 18 of IEC 61347-1 apply.

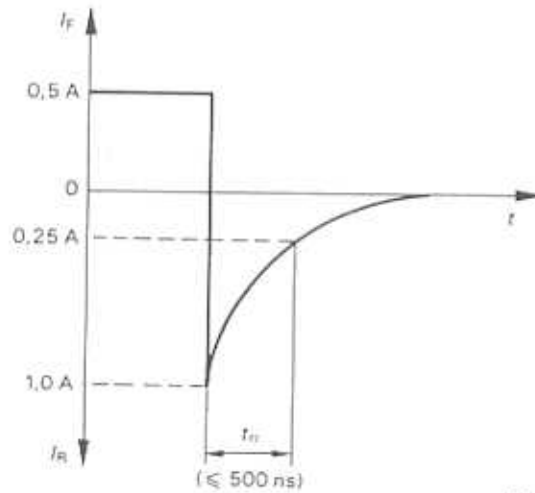
## 21 Resistance to corrosion

The requirements of clause 19 of IEC 61347-1 apply.



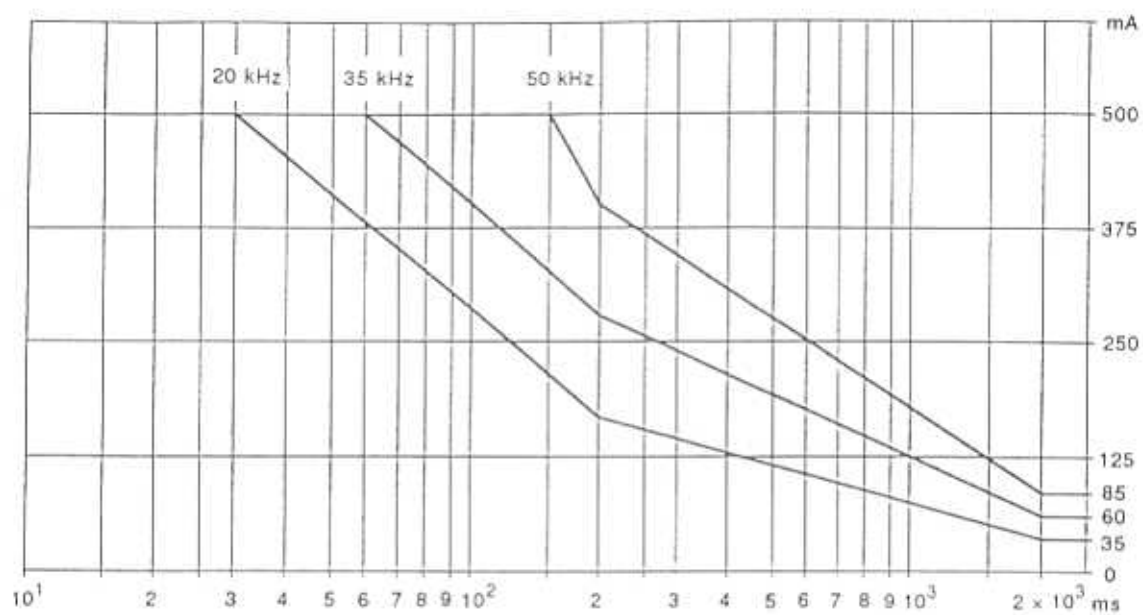
The rectifier characteristics shall be:

Peak inverse voltage	$U_{RRM}$	$\geq$	3 000 V
Reverse leakage current	$I_R$	$\leq$	10 $\mu$ A
Forward current	$I_F$	$\geq$	three times nominal lamp running current
Reverse recovery time (maximum frequency: 150 kHz)	$t_{rr}$	$\leq$	500 ns (measured with $I_F = 0,5$ A and $I_R = 1$ A to $I_R = 0,25$ A)



NOTE The following types of diodes (three diodes in series) are recommended as a suitable rectifier: RGP 30 M, BYM 96 E, BYV 16.

Figure 1 – Circuit for testing rectifying effect



IEC 596:2000

Figure 2 – Limits for capacitive leakage current in r.m.s. of HF-operated tubular fluorescent lamps depending on duration.

**Annex A**  
(normative)

**Test to establish whether a conductive part  
is a live part which may cause an electric shock**

The requirements of annex A of IEC 61347-1 apply.

**Annex B**  
(normative)

**Particular requirements for thermally protected  
lamp controlgear**

The requirements of annex B of IEC 61347-1 are not applicable.

**Annex C**  
(normative)

**Particular requirements for electronic lamp controlgear  
with means of protection against overheating**

The requirements of annex C of IEC 61347-1 apply.

**Annex D**  
(normative)

**Requirements for carrying out the heating tests  
of thermally protected lamp controlgear ballasts**

The requirements of annex D of IEC 61347-1 apply.

**Annex E**  
(normative)

**Use of constant  $S$  other than 4 500 in  $t_w$  tests**

The requirements of annex E of IEC 61347-1 are not applicable.

**Annex F**  
(normative)

**Draught-proof enclosure**

The requirements of annex F of IEC 61347-1 are not applicable.

**Annex G**  
(normative)

**Explanation of the derivation of the values of pulse voltages**

The requirements of annex G of IEC 61347-1 are not applicable.

**Annex H**  
(normative)

**Tests**

The requirements of annex H of IEC 61347-1 are not applicable.

## Annex I (normative)

### Measurement of high-frequency leakage current

Electronic ballasts are tested for capacitive high-frequency leakage current, as follows.

The ballast is tested in the circuit shown in figure I.1 with two normal lamps, each being connected to the circuit at only one end ("crossed pair of lamps"). This method would also provide the worst-case leakage to earth.

The glass tube of one of the two lamps, whichever gives the worst value, is wrapped with a 75 mm wide metal foil, together with a non-inductive 2 000  $\Omega$  resistor and a measuring device suitable for the test circuit.

The test shall be conducted with the lamps supported on two 75 mm high wooden blocks and placed on a wooden table, such that no external influence from metallic surfaces is caused.

The leakage current (i.e. the high-frequency current flowing from the metal foil through the 2 000  $\Omega$   $\pm$  50  $\Omega$  resistor to earth) is measured under the following simulated operating conditions.

- Two normal lamps, each being inserted at only one end into a pair of holders, with the supply voltage switched on.
- In order to take care of the most adverse condition (that is to ensure that the highest leakage current which may occur will be measured) the procedure shall be carried out in such a way that all of the four possible holder contact/cap-pin combinations are covered.
- For ballasts with multi-lamp operation, the leakage current from each lamp position is measured separately.
- Where a range of ballasts are submitted for test, each ballast type shall be checked, not just the higher or lower power variants.
- Under each of the specified operation conditions, the capacitive leakage current measured shall not exceed the limits specified in figure 2.

NOTE Leakage currents are derived from IEC 60479.

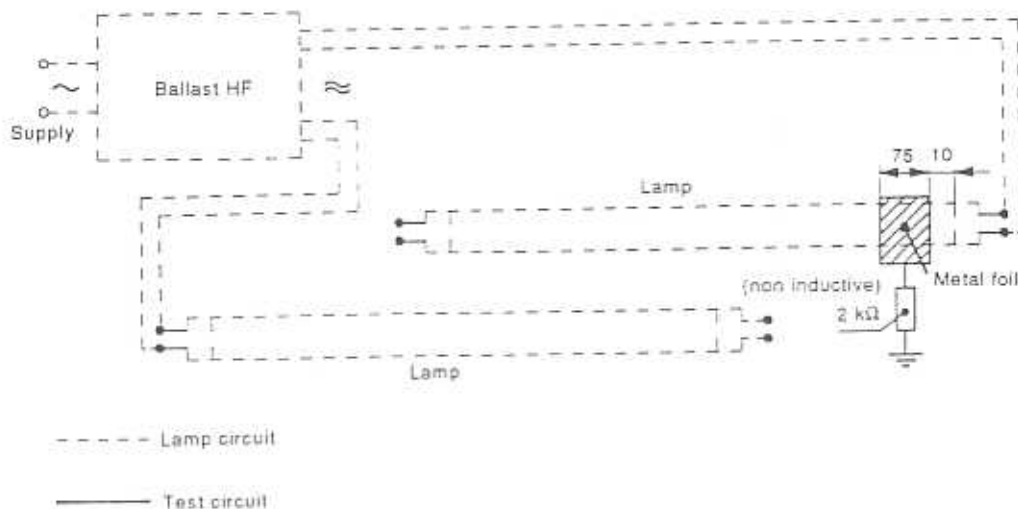


Figure I.1 - Test arrangement



## Annex J (normative)

### Particular additional safety requirements for a.c./d.c. supplied electronic ballasts for emergency lighting

#### J.1 Scope

This annex specifies particular safety requirements of a.c./d.c. supplied electronic ballasts for maintained emergency lighting purposes as well as specific requirements, as specified in IEC 60598-2-22.

It applies to a.c./d.c. supplied electronic ballasts for maintained emergency lighting not including batteries which are intended for connection to an emergency power supply. This can be a central battery supply system.

It does not apply to ballasts used in self-contained emergency lighting luminaires.

This annex also includes the operational requirements applicable to electronic ballasts operating on an a.c. supply in the emergency mode.

#### J.2 Definitions

The definitions in clause 3 apply together with the following:

##### J.2.1

##### **emergency lighting**

lighting provided for use when the supply to the normal lighting fails; it includes escape lighting and standby lighting

##### J.2.2

##### **maintained emergency lighting**

lighting provided when normal and emergency lighting is required

##### J.2.3

##### **a.c./d.c. maintained emergency lighting operation ballast**

ballast for operating a lamp from the normal lighting supply with normal switching and also from the emergency lighting supply when failure of the normal lighting supply occurs

##### J.2.4

##### **rated battery voltage**

voltage declared by the battery manufacturer

##### J.2.5

##### **rated emergency power supply voltage**

rated voltage of the emergency power supply claimed by the manufacturer for the information of the installer or user

**J.2.6****starting aid**

device which facilitates the starting of the lamp

NOTE A conductive strip affixed to the outer surface of the lamp and a conductive plate which is spaced within an appropriate distance from a lamp are examples of starting aids.

**J.2.7****ballast lumen factor**

ratio of the luminous flux of a reference lamp when the ballast under test is operated at its rated voltage and frequency compared with the luminous flux of the same lamp operated with the appropriate reference ballast supplied at its rated voltage and frequency

**J.2.8****reference ballast**

special ballast designed for the purpose of providing comparison standards for use in testing ballasts, for the selection of reference lamps and for testing regular production lamps under standardized conditions; essentially characterized by the fact that at its rated frequency, it has a stable voltage/current ratio relatively uninfluenced by variations in current, temperature and magnetic surroundings as outlined in the relevant ballast standard

**J.2.9****reference lamp**

discharge lamp selected for the purpose of testing ballasts and which, when associated with a reference ballast under specified conditions, has electrical values which are close to the rates specified in the relevant lamp standard or assigned by the manufacturer or responsible vendor for the particular lamp

**J.2.10****calibration current of a reference ballast**

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

**J.2.11****total circuit power**

total power dissipated by ballast and lamp in combination, at rated voltage and frequency of the ballast

**J.2.12****preheat starting**

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

**J.2.13****non-preheat starting**

type of circuit which utilizes a high open-circuit voltage causing field emission from electrodes

**J.2.14****pre-start time**

for ballasts according to J.2.12, period after switching on the supply voltage during which the lamp current is  $\leq 10$  mA

### **J.3 Marking**

#### **J.3.1 Mandatory markings**

Ballasts shall, in addition to the requirements of 7.1, be clearly marked with the following mandatory marking:

- a) a.c./d.c. maintained emergency lighting operation ballast (symbol under consideration);
- b) rated emergency power supply voltage and voltage range.

#### **J.3.2 Information to be provided if applicable**

In addition to the above mandatory markings and the requirements of 7.2, the following information shall either be given on the ballast or be made available in the manufacturer's catalogue or similar:

- a) a clear indication regarding the type of starting, i.e. preheat or non-preheat;
- b) indication whether a starting aid is needed for the lamp(s);
- c) limits of the ambient temperature range within which an independent ballast will operate satisfactorily at the declared voltage (range);
- d) ballast lumen factor in the emergency operation mode.

### **J.4 General statement**

The provisions of clause 6 of IEC 60929 apply at 90 % and 110 % of the rated emergency power supply voltage.

Furthermore, starting and operation of lamps shall be guaranteed across the widest rated d.c. voltage range due to the highest and lowest battery voltages.

NOTE 1 The electrical characteristics, as given on the lamp data sheets of IEC 60081 and IEC 60901, and applying to operation on a reference ballast at rated voltage with a frequency of 50 Hz or 60 Hz, may deviate when operating on a high-frequency ballast and the conditions of item c) of J.3.2 above.

NOTE 2 A starting aid is only effective when it has an adequate potential difference from one end of the lamp.

### **J.5 Starting conditions**

The provisions of clause 7 of IEC 60929 apply. In addition, tests shall be made with rated d.c. supply voltage, and, where the highest or lowest a.c. voltage limits are given, tests shall be made with  $\pm 10$  % d.c. voltage, respectively.

### **J.6 Operating conditions**

The provisions of clause 8 of IEC 60929 apply. In addition, tests shall be made with rated d.c. supply voltage.

### **J.7 Supply current**

The provisions of clause 10 of IEC 60929 apply.

**J.8 Maximum current in any lead to a cathode**

The provisions of clause 11 of IEC 60929 apply. In addition, tests shall be made with rated d.c. supply voltage, and, where highest or lowest a.c. voltage limits are given, tests shall be made with  $\pm 10\%$  d.c. voltage, respectively.

**J.9 Lamp operating current waveform**

The provisions of 12.2 of IEC 60929 apply. In addition, tests shall be made with rated d.c. supply voltage.

**J.10 Mains transient overvoltages**

The provisions of clause 15 of IEC 60929 apply.

**J.11 Pulse voltage from central battery systems**

NOTE This pulse voltage is under consideration.

The ballast shall withstand, without failure, any pulses caused by switching other equipment in the same circuit.

Compliance is checked by operating the ballast at the maximum voltage of the rated voltage range in association with the appropriate number of lamps and in an ambient temperature of 25 °C. The ballast shall withstand, without failure, the number of pulse voltages given in table J.1 superimposed, with the same polarity, on the supply voltage.

Table J.1 – Pulse voltages

Number of voltage pulses	Pulse voltage		Period between each pulse s
	Peak value V	Pulse width at half peak ms	
3	Equal to design voltage	10	2

NOTE A suitable measuring circuit is shown in figure G.2 of IEC 61347-1.

**J.12 Tests for abnormal conditions**

The provisions of clause 16 of this standard and 16.1 and 16.2 of IEC 60929 apply. In addition, the tests shall be made with  $\pm 20\%$  rated d.c. supply voltage.

**J.13 Temperature cycling test and endurance test**

The provisions of clause 25 of IEC 61347-2-7 apply. The tests shall be made with d.c. supply voltage.