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PUBLIC REVIEW DRAFT: KS 2447-2:2013: Performance of electrical lighting equipment — Ballasts for fluorescent lamps — Part 2: Method of measurement to determine energy consumption and performance of ballast-lamp circuits

This Draft Kenya Standard has been prepared by the Electric Lamps and Accessories Technical Committee in accordance with the procedures of the Bureau, and is now being circulated for public comments.

The Committee would appreciate any comments on this Draft Standards, which should be submitted before **2013-03-12** using the attached template. It will also be appreciated if those who have no specific comments to make but find the draft standard generally acceptable can notify us accordingly. Absence of any reply or comments shall be deemed to be an acceptance of the technical contents of the draft Kenya standard and **shall constitute an approval vote**.

Suggestions entailing amendments of the text should include wording preferred and the relevant clause number quoted against any comments made.

This draft standard is subject to change and should not be referred to or used as a Kenya Standard.

All correspondence pertaining to this draft standard should be addressed to the Managing Director, Kenya Bureau of Standards for the attention of Zacheus Mwatha **(zimwatha@kebs.org)**.

Yours faithfully,

Zacheus Mwatha

For: DIRECTOR
STANDARDS DEVELOPMENT AND INTERNATIONAL TRADE
ZIM

Performance of electrical lighting equipment — Ballasts for fluorescent lamps — Part 2: Method of measurement to determine energy consumption and performance of ballast-lamp circuits

PUBLIC REVIEW DRAFT, JANUARY 2013

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The following organizations were represented in the technical committee.

IEEE Kenya Section
Institute of Engineers of Kenya
Association of Consulting Engineers of Kenya (ACEK)
Energy Regulatory Commission
Power Technics Ltd.
Nationwide Electrical Industries
Consumer Federation of Kenya
The Kenya National Chamber of Commerce and Industry
Kenya Association of Manufacturers
Consumer Information Network
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REVISION OF KENYA STANDARDS

In order to keep abreast of progress in industry, Kenya Standards shall be regularly reviewed. Suggestions for improvements to published standards, addressed to the Managing Director, Kenya Bureau of Standards, are welcome.

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Performance of electrical lighting equipment — Ballasts for fluorescent lamps — Part 2: Method of measurement to determine energy consumption and performance of ballast-lamp circuits

Foreword

This Kenya Standard was developed by the Technical Committee on Electric lamps and Wiring Accessories and is in accordance with the procedures of the Bureau.

References

For the purposes of this standard, the references to International Standards should be replaced by references to the appropriate Kenya Standards where they have been declared.

Performance of electrical lighting equipment — Ballasts for fluorescent lamps — Part 2: Method of measurement to determine energy consumption and performance of ballast-lamp circuits

1 SCOPE

This Final Draft Kenya Standard provides methods of measurement of ballast energy consumption and performance when used with their associated fluorescent lamp(s).

NOTE Requirements for testing individual ballasts during production are not included.

It specifies energy efficiency and performance measurement for ballasts used with fluorescent lamps that fall within the scope of IEC 60081 and IEC 60901.

This standard does not specify safety requirements.

2 Application

This standard applies to ballasts that are supplied as part of luminaires. This standard shall be read in conjunction with KS 2447-1:2013. This standard does not apply to ballasts which form an integral part of the lamp (for example, self ballasted lamps to IEC 60969).

3 Normative references

KS 2447-1:2013, *Performance of electrical lighting equipment — Ballasts for fluorescent lamps. Energy labelling and minimum energy performance standards requirements*

IEC 60929, *A.C supplied electronic ballasts for tubular fluorescent lamps—Performance requirements*

IEC 60081, *Double-capped fluorescent lamps—Performance specifications*

IEC 60901, *Single-capped fluorescent lamps—Performance requirements*

IEC 60921, *Ballasts for tubular fluorescent lamps — Performance requirements*

IEC 60969, *Self-ballasted lamps for general lighting services—Performance requirements*

4 Terms and definitions

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

4.1
A.C. supplied electronic ballast
mains supplied a.c. to a.c. inverter, including stabilising elements, for starting and operating one or more fluorescent lamps, generally at high frequency

4.2
ballast unit

inserted between the electricity 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 lamp(s) to the required value. The ballast may consist of one or more separate components. It may also include means for transforming the supply voltage and arrangements which help provide the starting voltage, preheating current, prevent cold starting, reduce stroboscopic effects, correct the power-factor and/or suppress radio interference.

The term includes the components in a variety of ballast circuits for example, rapid start, instant start, quick start etc.

4.3
ballast-lamp circuit
electrical circuit or part thereof, normally included in a luminaire. It consists of the ballast and lamp(s)

4.4
ballast lumen factor (*BLF*)
ratio of the light output of a reference lamp operated with the ballast under test to the light output of the same reference lamp operated with the appropriate reference ballast

4.5
Ballast Efficacy Factor (*BEF*)
Ratio of *BLF* to the total system power in watts

NOTE Some common methods of determining *BEF* are given in Annex A.

4.6
ferromagnetic ballast
mains-frequency ballast incorporating an electromagnetic (wire-wound) component

4.7
fluorescent lamp
discharge lamp of the low pressure mercury type, in which most of the light is emitted by one or several layers of phosphor excited by the ultra-violet radiation from the discharge

4.8
limiting value
maximum or minimum admissible value of a given entity in a specification

4.9
nominal value
suitable approximate quantity value used to designate or identify a component, device or equipment

4.10
rated value
objective quantity value for specified operating conditions of a component, device or equipment. The value and conditions are specified in the relevant standard or assigned by the manufacturer or responsible vendor.

4.11
reference ballast
special ballast designed for the purpose of providing comparison standards for testing ballasts and for selecting reference lamps. It is essentially characterized by the fact that at its rated frequency it has a stable voltage/current ratio, which is relatively uninfluenced by variations in current, temperature and magnetic surroundings. Refer to Annex B for requirements.

4.12
reference lamp
lamp selected for testing ballasts which, when associated with a reference ballast, has electrical characteristics, which are close to the nominal values as stated in the relevant lamp standard. Refer to Annex B for requirements.

4.13
total input power
total power supplied (in watts) to the ballast-lamp circuit, measured at the test voltage

4.14
corrected total input power
total input power in watts of the ballast lamp circuit under test corrected to comparable reference conditions

5 Measurements to be performed and requirements for testing

5.1 Selection and preparation of ballast for test
The ballast shall be selected, prepared and set up for measurements in accordance with Annex B.

5.2 Test conditions and instrumentation
All tests shall be carried out under the conditions and using instrumentation and equipment as specified in Annex B.

5.3 Measurement of energy consumption and performance parameters
Ballast energy consumption and performance parameters shall be measured in accordance with annexes C and D. For ferromagnetic ballasts with a simple two-wire connection to the lamp, the parameters may be measured in accordance with annexes E and F in lieu of annexes C and D.

5.4 Test report
Results set out in Annex G shall be reported in a suitable format.

ANNEX A
(informative)

Common methods for measuring ballast energy consumption, efficiency and performance

A1 Overview

This annex provides a brief overview of some common methods that are used to express ballast energy consumption, efficiency and performance. These methods are presented for information only.

A2 Ballast efficiency

A.2.1 Ballast Lumen Factor (*BLF*)

Measure the light output and total circuit power with a test ballast and the reference lamp. Repeat the above measurement with a reference ballast and the same reference lamp. The *BLF* is defined as the ratio of the light output of the test system (test ballast/ reference lamp combination) to the light output of the reference system (reference ballast/ reference lamp combination). (Expressed as *BLF* = 1.00 when they are equal).

$$BLF = \left(\frac{L_{\text{test}}}{L_{\text{ref.}}} \right) \qquad \text{..... A2(1)}$$

where

L_{test} is the measured light output of the reference lamp when connected to the test ballast;

L_{ref} is the measured light output of the reference lamp when connected to the reference ballast.

A.2.2 Ballast efficacy factor (*BEF*)

The *BEF* is determined as the ratio of *BLF* × 100 to the total system power in watts.

$$BEF = \frac{BLF \times 100}{P_{\text{tot.test}}} \qquad \text{..... A2(2)}$$

where,

$P_{\text{tot.test}}$ is the total input power in watts of the ballast-lamp circuit with reference lamp and test ballast

For example, a test ballast/reference lamp with a *BLF* of 1.00 (that is, equal to the reference ballast/reference lamp) and a total input power of 50 W will have a *BEF* of 2.0.

Some test methods allow lamp power to be substituted for light output in the above calculations, although in reality this can be inaccurate if the lamp power is not very close to the rated value because the ratio of light output to lamp power is not constant

NOTE Refer to Annex F for information about methods on correction of values.

$$BEF_{\text{Lamp power method}} = \frac{\left(\frac{P_{\text{test}}}{P_{\text{ref.}}} \right) \times 100}{P_{\text{tot.test}}} \qquad \text{..... A2(3)}$$

where,

P_{test} is the measured lamp power in watts of the circuit with the test ballast;

$P_{\text{ref.}}$ is the measured lamp power in watts of the circuit with the reference ballast;

$P_{\text{tot.test}}$ is the total input power in watts of the ballast-lamp circuit with reference lamp and test ballast.

This type of efficacy system is used in USA, Canada and China. Japan uses a very similar system except that the efficacy of the system is expressed as nominal lumens per watt (of the reference lamp) as opposed to relative light output per watt (that is, relative light output times rated light output divided by power input).

$$BEF_{\text{JAPAN}} = \frac{BLF \times L_{\text{rated}}}{P_{\text{tot.test}}} \quad \text{. . . . . A2(4)}$$

where,

L_{rated} is the light output of the reference lamp under reference and rated conditions according to lamp data sheet;

$P_{\text{tot.test}}$ is the total input power in watts of the ballast-lamp circuit with reference lamp and test ballast.

Korea specifies the ratio of lumens per watt for the test system versus the lumens per watt for the reference system, which is in effect a similar measure, but the units are different.

$$BEF_{\text{KOREA}} = \frac{BLF \times P_{\text{tot.ref.}}}{P_{\text{tot.test}}} \quad \text{. . . . . A2(5)}$$

where,

$P_{\text{tot.ref}}$ is the total input power in watts of the ballast-lamp circuit with reference lamp and reference ballast;

$P_{\text{tot.test}}$ is the total input power in watts of the ballast-lamp circuit with reference lamp and test ballast.

A3 Ballast performance using total input power method

This method uses the total input power method for ballast-lamp circuits together with light output (or lamp power for low frequency systems). Test ballasts are operated with an appropriate reference lamp. The total light output and lamp power is then compared when the same lamp is operated with the reference ballast. The total power and lamp lumen output (or lamp power) is normalized back to standardized levels for comparison purposes.
The corrected total circuit power (of the ballast and the lamp) is a measure of efficiency.

$$P_{\text{tot.cor.}} = P_{\text{tot.test}} \times \left(\frac{P_{\text{rated}}}{P_{\text{ref.}}} \right) \times \left(\frac{1}{BLF} \right) \quad \text{. . . . . A3}$$

where,

P_{rated} is the rated lamp or typical HF power in watts of the relevant reference lamp according to lamp data sheet;

$P_{\text{ref.}}$ is the measured lamp power in watts with the reference ballast;

$P_{\text{tot.cor.}}$ is the total input power in watts of the ballast-lamp circuit under test corrected to comparable reference conditions;

$P_{\text{tot.test}}$ is the total input power in watts of the ballast-lamp circuit with reference lamp and test ballast.

This method is used in Europe, Australia and New Zealand.
Similarly, lamp power can be used as a proxy for *BLF*, but as for *BEF*, this can be inaccurate for values other than *BLF* = 1.00.

A4 Ballast performance using watts loss method

Annex E of this standard provides for the measurement of total circuit power. In the case where there is a simple two-wire connection from the ballast to the lamp (such as a ferromagnetic ballast), it is possible to measure the lamp power during the test. In this case, the ballast watt loss can be deduced by subtraction of the lamp power from the total circuit power.
Care is required when using this type of efficiency measurement as there is no control or correction means for the light output of the test ballast during the test, which means the ballast may be over-driving or under-driving the lamp (that is results are not corrected for *BLF*).
This method now has limited application as it can only be used on simple two-wire ballasts.

ANNEX B
(normative)

Test conditions, instrumentation and equipment

B1 Scope

This annex specifies the test conditions, instrumentation accuracy and equipment required to carry out energy consumption, efficiency and performance measurements for fluorescent lamp ballasts when tested in accordance with annexes C and E.

B2 Test tolerances

The tolerances specified for parameters within this standard, using the symbol ±, indicate the allowable limits of variation from the specified parameter outside which the test or results shall be invalid. In each case the tolerance has been chosen to allow for factors such as drift of ambient conditions, instrument error, reading error, uncertainty of instrument calibration and other influences.
The statement of tolerance does not permit the deliberate variations of these specified parameters during the test.
While it is required that test parameters remain within the stated tolerance, transient effects do not necessarily render a test invalid.

B3 Ambient conditions

The following test conditions shall apply:

a) measurements shall be made in a draught free room and at an ambient temperature within the range of 20 ℃ to 27 ℃; and

b) for those tests during which the lamp shall remain stabilized, the ambient temperature surrounding the lamp shall be within the range of 23 ℃ to 27 ℃ and shall not vary by more than 1 ℃ during the test.

NOTE Apart from the ambient temperature, the air circulation also influences the temperature of the ballast. For reliable results the test room should be free from draughts.

B4 Test voltage and frequency

B.4.1 General

The test voltage shall be the rated voltage. Where the rated voltage is a range, then the test voltage shall be

a) the nominal voltage of the country/region of intended use; or

NOTE The nominal voltage for Kenya is 230 V.

b) the mid point of the rated voltage range where the country/region of intended use is unclear.

The test frequency shall be the rated frequency. Where there is more than one rated frequency, then tests shall be conducted at each rated frequency.

NOTE The nominal frequency for Kenya is 50 Hz.

B.4.2 Stability of supply and frequency

For most of the tests, the supply voltage and, where appropriate for the reference ballasts, the frequency shall be maintained within ± 0.5 %. However, during the actual measurement, the voltage shall be adjusted to within ± 0.2 % of the specified testing value.

B.4.3 Supply voltage waveform

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

B5 Measurement uncertainty and instrument accuracy

The total uncertainty of the wattage measurement shall be within ± 1.5 % for ferromagnetic ballast-lamp circuits, and ± 2.5 % for electronic ballast-lamp circuits. It is essential that all photometric and electrical corrections are made. Uncertainties are to be determined at 95 % confidence level.
The accuracy of the instruments shall be as follows:

a) Potential circuits of instruments connected across the lamp shall not pass more than 2 % of the rated lamp current.

b) Instruments connected in series with the lamp shall have a sufficiently low impedance such that the voltage drop shall not exceed 1 % of the rated lamp voltage.

c) Where measuring instruments are inserted into parallel heating circuits, the total impedance of the instruments shall not exceed 0.5 Ω.

d) Instruments shall be free of errors due to waveform distortion and shall be suitable for the operating frequencies.

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

B6 Selection of sample

Tests in this standard are type tests. The requirements and tolerances specified in this standard are based on the testing of a type test sample submitted by the manufacturer for that purpose.

B7 Number of samples

At least one specimen shall be tested.

B8 Capacitors

Ballasts with external shunt power factor correction capacitors shall have these removed prior to testing. However, where a capacitor is in-built or integrated into the ballast and cannot be removed, the test ballast shall be tested as supplied. Where an external capacitor is specified as essential for the proper function of the ballast then it shall be included during testing. The value of the capacitance measured at 1 kHz shall be within 1 % of the nominal value specified.

B9 Reference ballasts

The reference ballasts shall conform to IEC 60921 or IEC 60929 Appendix B, as applicable.

B10 Reference lamps

The reference lamps shall conform to IEC 60921 or IEC 60929 Appendix C, as applicable.

B11 Setup for measurement

The ballast-lamp circuit shall be set up and operated in accordance with the conditions as follows:

(a) For lamps operated with a starter
Figure E.1 gives an example of a suitable test circuit. It shall be used in the following manner:

(i) measurements are made with the starting device taken out of the circuit.

(ii) in the lamp circuit, potential circuits shall not be connected across the pins or contacts used for the starter.

(iii) when measuring the voltage or power of the lamp, the potential circuit of the instrument not in use is open.

(iv) when measuring lamp wattages, correction shall be made for the wattmeter dissipation.

NOTE In some cases, corrections for the dissipation of the voltage circuit of the wattmeter need not be made as at the same supply voltage, the load compensates approximately for the reduction of the power dissipation of the lamp caused by the parallel connection of the voltage circuit of the wattmeter.

If there are any doubts at this point, it will always be possible to evaluate the compensation error by repeating the measurements with other values of the load in parallel with the lamp.
This is done by adding resistances in parallel and reading, each time, the power measured by the wattmeter. It is then possible to extrapolate the results obtained in order to determine the true wattage in the absence of any parallel load.

(b) For lamps operated without a starter
Figure C.1 gives an example of a suitable test circuit. Although this is perfectly acceptable, it consists essentially of:

(i) A changeover switch, preferably quick acting, allowing the reference lamp to be connected either to the reference ballast or the ballast under test. Where the method of measuring lamp electrical and luminous characteristics without separate cathode heating has been indicated, the reference ballast-lamp circuit shown in Figure E.1 should be used.

(ii) A means of measuring photometrically a proportionate indication on the luminous flux of the lamp.

NOTE While the ideal method for this purpose is to place the lamp in a photometric integrator, it is not a necessary criterion. It is perfectly acceptable to place a photoreceptor at a given distance from the lamp and directed at the central portion, provided that suitable precautions are taken to shield the photo-receptor from other radiation and to prevent any relative movement of the lamp and the photo-receptor throughout the tests.
Two photometric readings shall be taken, one with the lamp connected to the reference ballast-lamp circuit, and one with the lamp connected to the ballast under test.

B12 Temperature stability

Measurements shall not be taken until the ballast has stabilized thermally, that is temperatures are changing at a rate less than 1 ℃ per hour.

ANNEX C
(normative)

Method of measurement for determination of ballast energy consumption and performance (all ballast types)

C1 Overview

This annex specifies a test method for the determination of ballast energy consumption and its performance. This is applicable to all types of ballasts. The relevant reference ballast shall be operated with a reference lamp to determine the reference light output, either using an integrating sphere or the equipment specified in Annex D (or equipment that provides equivalent results). The test ballast shall then be operated with the same reference lamp and the relative light output (ratio of test to reference) is determined. The total input power *($P_{tot.test}$)* is measured for each ballast when used with the reference lamp.
The reference lamp power is also measured with the reference ballast and, where possible (that is where there is only a two-wire connection to the lamp), with the test ballast.

C2 Method of measurement

Measurements of total input power, test supply voltage and lamp power (where applicable) shall be carried out with instrumentation in the ballast-lamp circuit as shown in Figure C.1.
For ferromagnetic ballasts that use an external starter, the configuration shown in Annex E Figure E.1, with the addition of a measurement of lamp light output, may be used.

C3 Preparation for testing

Test conditions, instrumentation, equipment and test samples shall be prepared and selected in accordance with Annex B.

C4 Procedure

The light output comparison between the ballast-lamp circuit with the ballast under test and the ballast-lamp circuit with a reference ballast may be made using either an integrating sphere or the equipment specified in Annex D (or equipment that provides equivalent results).
With electronic ballasts, measurement of power losses of the ballast itself cannot be measured accurately. Therefore it is necessary to measure both the total input power and the relative lamp output to determine ballast performance.
In the case of a mains-frequency test ballast and reference ballast, the reference lamp current when used with the reference ballast shall not deviate more than 1% from the rated lamp current. All measurements with the test ballast and the reference ballast in the ballast lamp circuit shall be made with supply voltage, which is equal to the test voltage specified in B.4.
In the case of a high frequency test ballast and reference ballast, the high frequency supply voltage from the generator for the reference ballast is adjusted so that the measured reference lamp current is equal to the rated lamp current ± 0.2 %. At rated lamp current on the reference lamp the measured high frequency lamp power *($P_{ref.}$)* shall be within ± 2.5 % of the rated (or typical) HF power *(P_{rated})* of the lamp. After reaching stable conditions (ballast temperature and lamp current stabilized) the measured value light output value is set at 100 %.
NOTE To reduce testing time with a reference lamp particularly when a number of ballasts are to be tested, ballasts can be thermally pre-stabilized by operating them with commercial lamps and then quickly changed over to the reference lamp. If a simple reactor ballast is under test, then the ballast can be thermally pre-stabilized without a lamp by just applying a voltage, which corresponds to its current being equal to the nominal lamp current.
Under the same test conditions (positioning of the lamp and light measuring equipment unchanged) the test ballast is connected to the lamp circuit and operated until stable conditions again are reached. All measurements with the test ballast in the ballast-lamp circuit are to be made with a supply voltage that is equal to the test voltage as specified in Annex B. The measured light output value for the test ballast-lamp circuit is then determined.
The following parameters are measured and reported during the test:
(a) Reference lamp and reference ballast:

(i) total input power *($P_{tot.ref}$)* at the supply side of the ballast (watts).

(ii) lamp power, current and voltage of the reference lamp (watts, amps and volts).

(iii) light output (actual measurement).

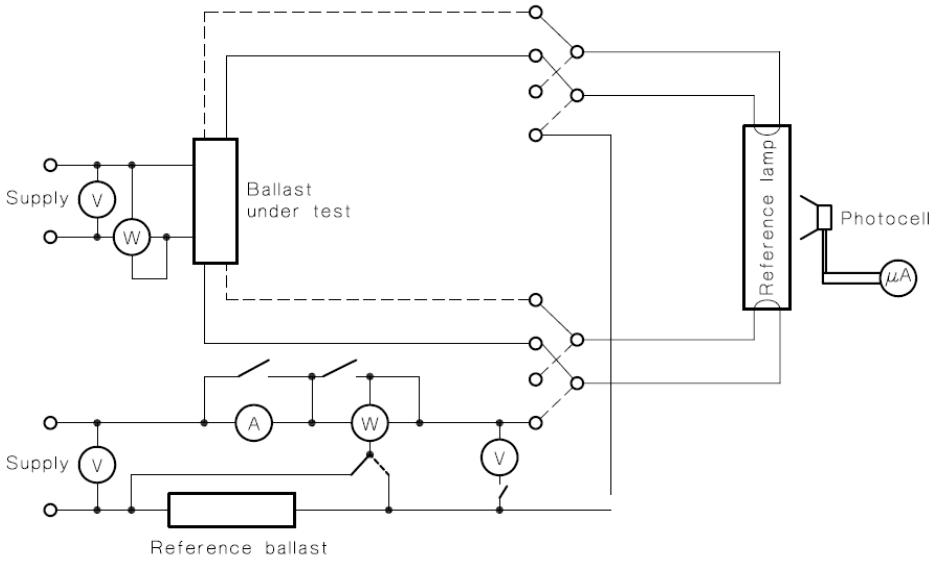
(b) Reference lamp and test ballast:

(i) total input power ($P_{tot.test}$) at the supply side of the ballast (watts).

(ii) lamp power, current and voltage of the reference lamp (watts, amps and volts) where possible.

(iii) light output (actual measurement).

A test report as specified in Annex G shall be prepared.



NOTE The circuit for measurement of lamp power, current and voltage when supplied by the test ballast will vary, and it may not be possible to make these measurements in all instances.

Figure C.1 Measurement of four-wire and six-wire ballast-lamp circuits

Annex D
(normative)

Method of measurement of relative light output

D.1 Overview

This annex specifies a method of measurement and suitable equipment for the determination of relative light output for a test ballast relative to the reference ballast where an integrating sphere is not available or where it is not economical to determine relative light output using a sphere. Alternative equipment, which provides equivalent results, is permitted.

D.2 General

For comparison of the light output measurement with the reference ballast and the light output measurement with the ballast under test, the light output measurement shall cover the entire lamp surface. HF operation lamps may be operated with 'hot' or with 'cold' electrodes. This will lead to a different light contribution from the lamp ends. It is therefore important that the light from the lamp ends and the light from the middle part of the lamp is weighted equally. The necessary condition is that the sensor is placed at the correct distance from the lamp. This can be achieved by placing the sensor as shown in Figure D.3.
The test position of the lamps shall be in accordance with the given position in the relevant lamp data sheet of IEC 60081 or IEC 60901.
The sensor signal *X* results from the luminosity φ*x* from the middle of the lamp, the sensor signal *X'* results from the luminosity φ*x'* from the end of the lamp. The sensor signal resulting from the luminosity of the lamp is proportional to the inverted square of the distance between the sensor and the lamp:

$$X = \phi x \div R^2$$

$$X' = \phi x' \div R'^2$$

$$R' = R \div \cos \alpha$$

The difference between *X* and *X'* resulting from the difference between *R* and *R'* must be minimized. When a lamp is operated with 'cold' electrodes the light contribution from the lamp end will be significantly lower compared with a lamp operated with 'hot' electrodes over a distance of about 20 mm. For a FD-18-E-G13-26/600 lamp (worst case for tubular/linear lamp) this is about 6% of the lamp length. When 5% difference between *X* and *X'* is accepted this will lead to an error on system level of 0.3 %. For longer lamps the error will be smaller.
This leads to the following result:

$$X' = (\phi x' \div R^2) \cos^2 \alpha$$

$$\cos^2 \alpha > 0.95$$

$$\cos \alpha > 0.975 \quad \alpha < 13°, \quad \tan \alpha < 0.23$$

$$\alpha \text{ is } 13° \ (R = 2\,L).$$

For the sensor, the angle of incidence of light rays has no effect on the strength of the signal particularly within the 13°, therefore no *cos* α correction is used for the sensor.
When *R* = 2*L*, the error due to different contribution in light from the centre of the lamp and the lamp end is maximum 0.3 %.
In Figures D.1 and D.2, the requirements for positioning are as follows:

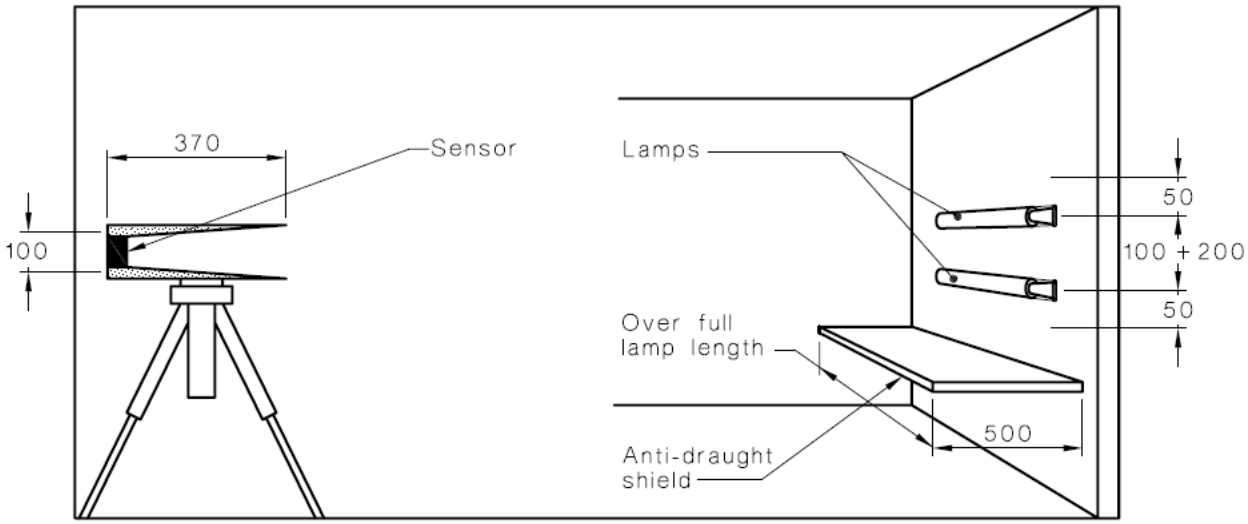
a) figures D.1 and D.2 are both applicable for single or multi linear lamp ballasts; and

b) for multi lamp ballasts (2 or 3 or 4), the figures D.1 and D.2 are still applicable with the following provisions:

i) the measuring position of the lamps is for four lamps: two lamps next to each other and two lamps above each other; and

ii) for three lamp ballasts the measuring position is: in the upper position two lamps next to each other and in the lower position one lamp in the centre.

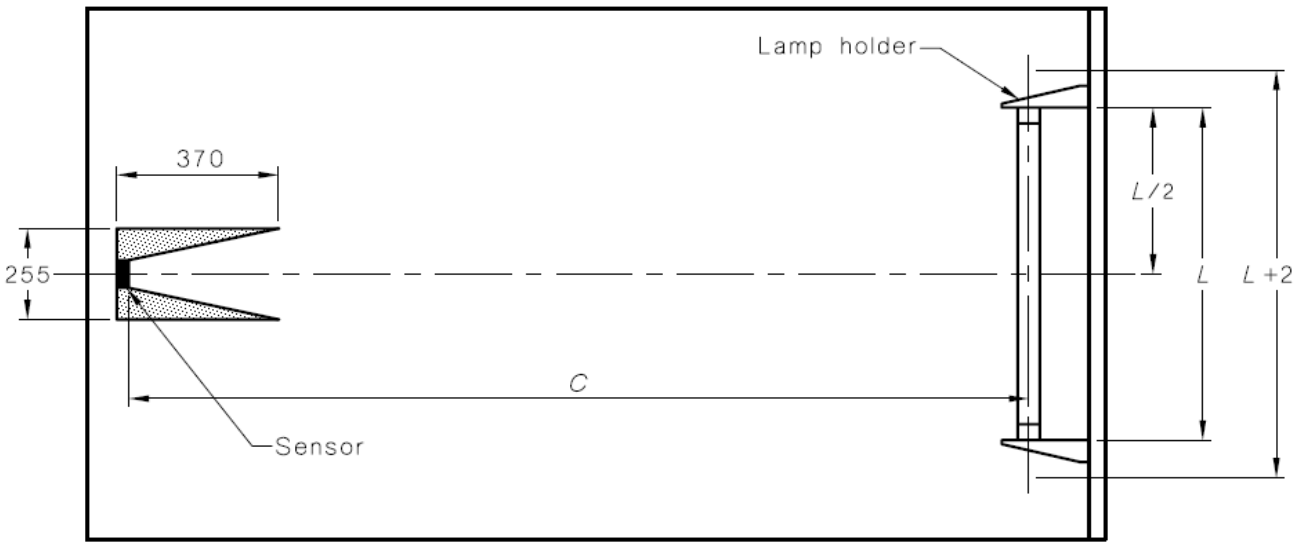
All lamps shall be visible to the photocell.
The minimum distance from the light sensor to the lamp is set at least at 0.80 m, however the sensor must 'see' for at least the lamp length + 20 %. For an amalgam lamp, care shall be taken that the reference measurements and test measurements are always taken in the same horizontal position.



DIMENSIONS IN MILLIMETRES

NOTE 1 The sensors are in a box painted matt black internally to avoid reflected light. Lamps are placed horizontally for linear double capped fluorescent lamps. For other lamps the test position according to the relevant lamp data sheet applies.
NOTE 2 The sensor view angle should be large enough to measure the total illuminance of the lamps including the cathodes.
NOTE 3 The distance of the sensor to the lamp(s) shall be at least twice the lamp length in order to ensure that the error, due to the different contributions of light from the centre of the lamp end, is a maximum of 0.3 %.

Figure D.1 — Side view of light output measurement system



LEGEND:
L = Lamp length
B = $L/2$
C = $2L$

DIMENSIONS IN MILLIMETRES

Figure D.2 — Top view of light output measurement system

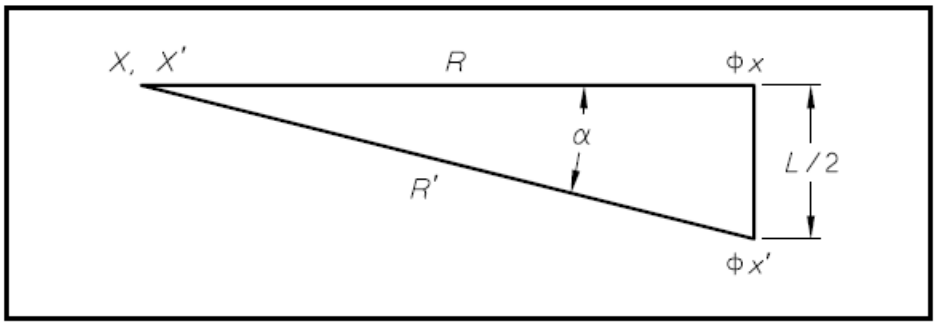


Figure D.3 — Configuration of lamp and photocell sensor

Annex E
(normative)

Method of measurement for determination of ballast energy consumption and performance (ferromagnetic ballasts)

E.1 Overview

This annex specifies an alternative test method for the determination of ballast performance, which is applicable only to ferromagnetic ballasts that have a simple two-wire connection to the lamp. No light output measurements are required for the method in this annex. The relevant reference ballast is operated with a reference lamp to determine the reference lamp power input. The test ballast shall then be operated with the same reference lamp and the lamp power input for the test system is also determined. The total input power *($P_{tot.test}$)* and reference lamp power shall be measured for each ballast when used with the reference lamp.
Care is required when reporting test results for ballasts measured using this method as there is no in-built correction for variations in actual *BLF*, which can be significant. An advisory method for estimating *BLF* using these results is included in Annex F.
The method in this annex is not suitable for ballasts operating at high frequency as the relationship between lamp light output and lamp power is substantially different in comparison with low frequency ballasts. This method is not suitable for low frequency ballasts, which have a four-wire connection to the lamp. It is generally not possible to accurately measure lamp power or current in these cases.

E.2 Preparation for testing

Test conditions, instrumentation, equipment and test samples shall be prepared and selected in accordance with Annex B.

E.3 Method of measurement

Measurements of total input power, test supply voltage and lamp power shall be carried out with instrumentation in the ballast-lamp circuit as shown in Figure E.1.

E.4 Procedure

The lamp power shall be measured for the ballast-lamp circuit with the ballast under test and the ballast-lamp circuit with a reference ballast.
The reference lamp current when used with the reference ballast shall not deviate more than ±2.5% from the rated lamp current.
Using the reference lamp and the reference ballast, the values for total input power, lamp power and lamp current shall be measured after reaching stable conditions (ballast temperature and lamp current stabilized), noting the allowable deviation on input current for the reference lamp stated above.
Using the same reference lamp and the test ballast, the values for total input power, lamp power and lamp current shall be measured after reaching stable conditions (ballast temperature and lamp current stabilized).
NOTE Refer to note in Clause C.4 for thermal pre-stabilization.
To reduce the new stabilization period of the reference lamp after transferring from one ballast circuit to another, a quick switching technique should be adopted. During the switching, the connections of the individual pins or contacts to the same reference lamp shall not be changed.
The following parameters shall be measured and reported during the test:
(a) Reference lamp and reference ballast:

(i) total input power ($P_{tot.ref}$) at the supply side of the ballast (watts);

(ii) lamp power, current and voltage of the reference lamp (watts, amps and volts).

(b) Reference lamp and test ballast:

(i) total input power ($P_{tot.test}$) at the supply side of the ballast (watts);

(ii) lamp power, current and voltage of the reference lamp (watts, amps and volts).

A test report as indicated in Annex G shall be prepared.

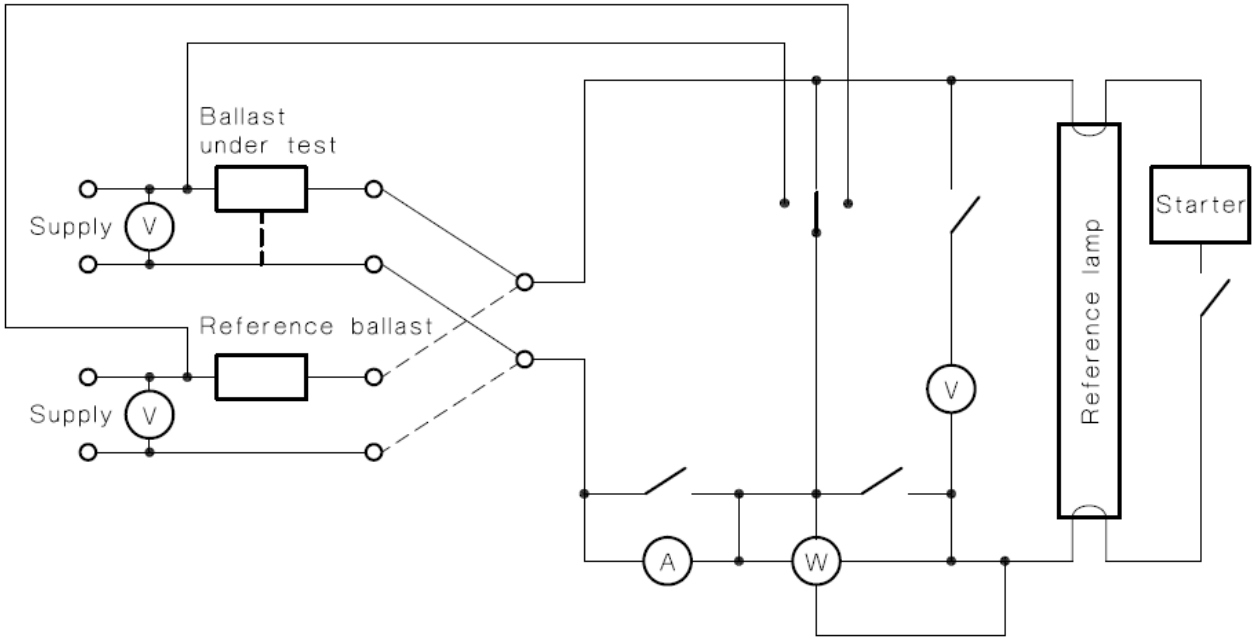


Figure E.1 Measurement of two-wire ballast-lamp circuits

Annex F
(informative)

Correction of lamp power measurements

F.1 Overview

The ratio of lamp light output to lamp power is not constant over the normal range of operation for many commercial ballasts. Many manufacturers of ferro-magnetic ballasts 'under drive' lamps, so it is difficult to get an accurate comparative measure of performance unless these differences are taken into account.
This annex provides a method for estimating lamp light output in the case of a ferromagnetic ballast where lamp power and lamp current can be accurately measured (that is, simple two-wire connection). Thus the results from a test ballast can be compared to the reference system and where necessary, adjusted back to nominal values to allow accurate comparisons.
It also provides a method of normalizing the performance of ferromagnetic ballasts. Refer to Clause F.3 for details.

F.2 Estimation of lamp light output using lamp power measurements

Typical published fluorescent lamp data shows the non-linear nature of lamp efficiency for a range of power inputs. At less than rated power the lumens per input watt are higher than the rated value and at greater than rated power the lumens per input watt are lower than the rated value. Typically the effect is illustrated in Figure F.1.

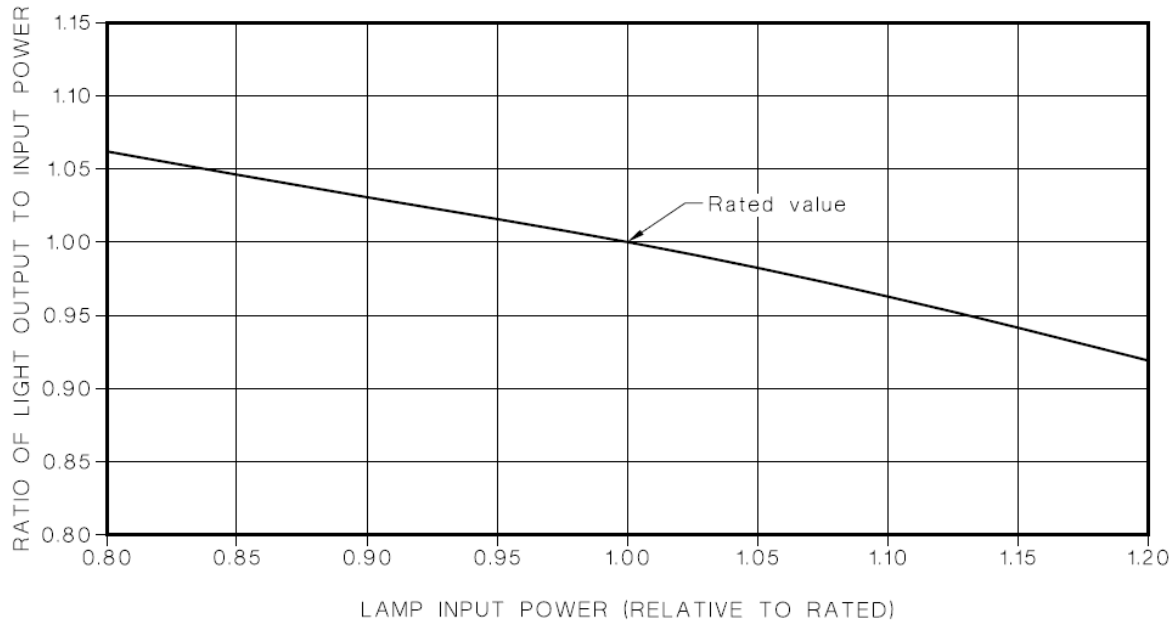
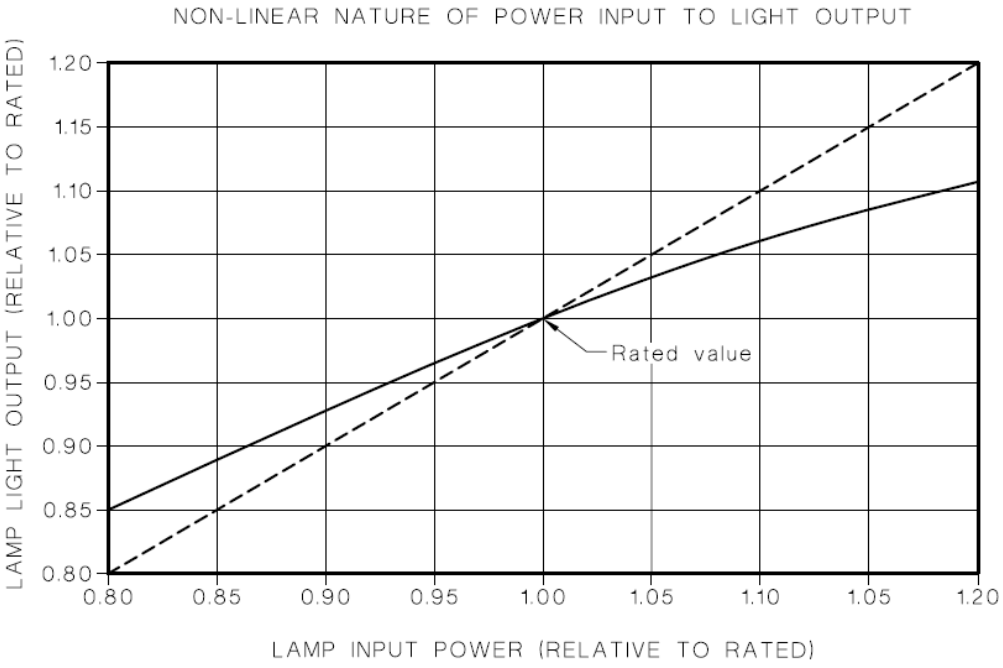


Figure F.1 — Variation of lamp efficiency with lamp input power

Typically the non-linear nature of lamp light output and lamp power input is illustrated in Figure F.1.



.2.

Figure F.2 — Variation of light output with lamp power

If only the lamp power is measured during a test (as specified in Annex C), it is possible to extrapolate the lamp light output and *BLF* by adjustment of the measured power input values in accordance with the figure above. An equation for the relative lamp output for the sample curve in Figure F.2 is given in equation F1 below.

$$RLOP = 0.64 - 0.84\,RP + 2.08\,RP^2 - 0.88\,RP^3 \quad \text{for value of } RP \text{ in the range of } 0.80 \le RP \le 1.20 \qquad \ldots\ldots(F1)$$

where

RLOP is the relative lamp light output;

RP is the relative lamp power ($P_{ref.} \div P_{rated}$)

where

P_{rated} is the rated lamp power in watts of the relevant reference lamp according to lamp data sheet;

$P_{ref.}$ is the measured lamp power in watts with the reference ballast.

RLOP provided by Equation F1 is measured relative to the rated value for the reference lamp. Where *RP* is equal to 1.00, the *RLOP* is also equal to 1.00.

Using this equation, the lamp light output can be estimated for both the test ballast with the reference lamp and the reference ballast with the reference lamp. The *BLF* (or relative light output) can be estimated as the ratio of the calculated test ballast-lamp light output to the calculated reference ballast light output.

NOTE Some lamp types may have performance characteristics that vary from Figures F.1 and F.2.

F.3 Correction of reference lamp and normalizing ballast losses (two-wire ferromagnetic ballast)

Although reference lamps are built to a precise specification, the actual performance can vary between reference lamps used in various laboratories. Further, lamp characteristics may drift with time. The requirements of this standard and other ballast standards such as IEC 60921 and IEC 60929 require that reference lamp current lie within ± 2.5 % of its rated current. This means that, in extreme cases, the difference between lamps used in various laboratories may vary by up to 5% from one another.
To compensate for variations between lamps (current and power) and to normalize the ballast losses to rated current, an equation is given below:

$$P_{\text{tot.cor.}} = P_{\text{rated}} + \left(P_{\text{tot.test}} - P_{\text{test}}\right) \times \frac{I_{\text{rated}}^2}{I_{\text{meas}}^2} \quad \ldots\ldots (\text{F2})$$

where,

I_{meas} the actual measured current of the reference lamp with test ballast;

I_{rated} the rated current of the lamp according to lamp data sheet;

P_{rated} the rated lamp power, in watts, of the relevant reference lamp according to lamp data sheet;

P_{test} the measured lamp power, in watts, of the circuit with the test ballast;

$P_{\text{tot. cor}}$ the total input power, in watts, of the ballast-lamp circuit under test corrected to comparable reference conditions;

$P_{\text{tot. test}}$ the total input power, in watts, of the ballast-lamp circuit with reference lamp and test ballast.

Annex G
(normative)

Data for test report

A test report outlining the details of the ballast under test, the reference ballast, the reference lamp used and the measurement performed shall be prepared in the following format. A test report generated from the computer complete with all the data presented in the same order shall be equally valid.

(a) Test Method used (Refer to Annex C or Annex E)

(b) Test ballast

  (i) Ballast brand and model.

  (ii) Ballast markings, rated values and specification.

(c) Reference lamp and test ballast

  (i) Total input power *(*$P_{tot.test}$) at the supply side of the ballast (watts)

  (ii) Lamp power (P_{test}) of the reference lamp where this can be determined (watts)

  (iii) Lamp current and voltage of the reference lamp where this can be determined (amps and volts)

  (iv) Light output (actual measurement) (L_{test})

  (v) Light output (relative measurement)

(d) Reference lamp and reference ballast

  (i) Total input power *(*$P_{tot.ref}$) at the supply side of the ballast (watts)

  (ii) Lamp power ($P_{ref.}$) of the reference lamp (watts)

  (iii) Lamp current and voltage of the reference lamp (amps and volts)

  (iv) Light output (actual measurement) ($L_{ref.}$)

(e) Reference lamp

  (i) Lamp brand, model and ILCOS designation

  (ii) Lamp rated power (P_{rated})(watts)

  (iii) Lamp rated current and voltage (amps and volts)

  (iv) Lamp lumen output (L_{rated})

  (v) IEC 60081 or IEC 60901 reference or designation

(f) Reference ballast

  (i) Ballast brand and model

(ii) IEC 60081 or IEC 60901 reference or designation

(g) Test parameters

(i) Ambient temperature (℃)

(ii) Test voltage (volts) and frequency

(iii) Information and documentation on the instrumentation, set-up and circuits used for electrical testing

(iv) Information on the equipment used to measure light output

