

American National Standard

Approved: June 6, 2002 Secretariat: ANSLG-- National Electrical Manufacturers Association

For Lamp Ballasts-- Method of Measurement of Fluorescent Lamp Ballasts

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American National Standard

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This standard is
Dedicated to the memory
of

J. F. Luchetta

Who gave more than
40 years of service to
the lighting industry.

We will miss you.

1933-2001

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Foreword (This Foreword is not part of ANSI C82.2-2002.)

Suggestions for improvement of this standard should be submitted to the Secretariat C82, American National Lighting Group of the National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1847, Rosslyn, VA 22209. This standard was processed and approved by Accredited Standards Committee on Lamp Ballasts, C82, and its Sub-Committee, C82-1. Committee approval of the standard does not necessarily imply that all committee members voted for that approval. Information concerning the approval of this standard is based on the documents listed in the table below:

CDV	RV
C82(1)/m680	C82(1)/m681v2

At the time of publications the C82 committee consisted of the following members:

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Randolph N. Roy, Secretariat
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AMERICAN NATIONAL STANDARD

For Lamp Ballasts-- Method of Measurement of Fluorescent Lamp Ballasts

1 Scope

This standard outlines the procedures to be followed and the precautions to be observed in measuring and testing line frequency fluorescent lamp ballasts as specified in C82.1 with either hot-cathode or cold-cathode fluorescent lamps.

2 Normative references

This standard is intended for use in conjunction with the following American National Standards. When the American National Standards referred to in this document are superseded by a revision approved by the American National Standards Institute, Inc. the revision shall apply.

ANSI/NFPA No. 70-1993, *National Electrical Code*

ANSI C78.1-1991 (R1996), C78.2-1991 (R1996), C78.3-1991 (R1996), C78.4-1992 (R1997), *American National Standards for Dimensional and Electrical Characteristics of Fluorescent Lamps*

ANSI C78.375-1997, *American National Standard for Fluorescent Lamps- Guide for Electrical Measurements*

ANSI C82.1-1997, *American National Standard for Lamp Ballast- Line Frequency Fluorescent Lamp Ballasts*

ANSI C82.3-1983 (R1998), *American National Standard Specification for Fluorescent Lamp Reference Ballasts*

Code of Federal Regulations 10CFR430, *Energy Conservation Program for Consumer Products*

ANSI/UL 935-1992, Underwriters Laboratories Inc., *Standard for Fluorescent Lamp Ballasts*

3 Pertinent measurements

The measurements in 3.1 and 3.2 are required to determine the compliance of ballast and ballast-lamp combinations with the specification of ANSI C82.1. Additional limitations as related to specific test conditions are listed in the appropriate lamp data sheets.

3.1 Ballast output circuit measurements

3.1.1 Lamp starting conditions

- RMS open-circuit voltage
- Peak open-circuit voltage
- Lamp voltage waveshape - crest factor
- Maximum-peak (open-circuit) voltage from starting aid to any cathode on each lamp circuit (rapid start ballast)
- Capacitance of starting capacitor(s) (rapid start ballast)
- RMS voltage to cathode dummy-load (rapid start ballast)
- RMS current through dummy-load resistor (instant start ballast and some rapid start ballasts)
- RMS preheat current (preheat start ballasts)

3.1.2 Lamp operating conditions

- RMS voltage
- RMS current
- Peak current
- Power (switch start and instant start ballasts)
- Relative light output (rapid start ballast)
- Cathode heating voltage (rapid start ballast)
- Lamp current wave shape - crest factor

3.2 Ballast input circuit measurements

3.2.1 Operating Conditions

- RMS voltage
- RMS current
- Power factor
- Ballast efficiency factor

4 Electrical supply characteristics- test ballast measurement circuits

4.1 Test voltage and frequency

For test purposes, ballasts shall be operated at either their rated line voltage or for certain types of tests at other voltages as specified in ANSI C82.1. In addition, specific test input voltages as related to tests conducted on ballast-lamp combinations can be found in the appropriate lamp data sheets. Where ballasts are labeled for a range of primary voltages, testing should be conducted on the lowest and highest USA design center voltage for the given ballast. Ballasts shall always be operated at their rated frequency.

4.2 Line voltage wave shape

Throughout the full range of test requirements the AC voltage supply at the input terminals to the ballast-lamp combination shall have a wave shape such that the RMS summation of the harmonic components does not exceed 3 % of the fundamental.

4.3 Stability of supply voltage

The line voltage shall be as steady and free from sudden changes as possible. For best results the voltage should be regulated to within 0.1%. If adequate automatic regulation is not available, constant checking and readjustments are essential for obtaining accurate measurements.¹

4.4 Supply-source impedance

The supply source shall have sufficient power capacity and sufficiently low impedance, compared with the ballast impedance, to ensure that the voltage to the ballast or lamp-ballast combination does not vary by more than 3% with the lamp-ballast combination in and out of the circuit.

5 Electrical supply characteristics - reference ballast measurement circuits

The general characteristics of reference ballasts are described in ANSI C82.3 and ANSI C78.375. The specific values of impedance, reference current, and rated input voltage for the reference ballasts corresponding to each lamp type are given in the appropriate lamp data sheets. The reference ballast while operating fluorescent lamps shall meet all electrical supply characteristics cited in ANSI C82.3 and ANSI C78.375.

6 Ambient conditions for lamp measurements

Variations in ambient temperature, air movement along the bulb wall surface, and lamp burning positions can affect the electrical characteristics as well as the output of a reference lamp. The ambient conditions for lamp measurements cited in ANSI C78.375 shall be followed when testing line frequency ballasts on reference lamps.

Unless otherwise specified, the ambient temperature for all tests is $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$.

7 Test measurement circuits

7.1 Circuit grounding

In all of the wiring diagrams shown in the standard, the side containing the instrument's current coil is shown connected to the grounded supply conductor. This is a recommended safety precaution, since many types of portable instruments have current coil terminals that are not insulated and that can constitute a shock hazard if not kept at ground potential. In those situations where the available power source is grounded at some other potential (for example, a 120/240, three-wire supply with a midpoint ground), the grounded connection as shown in these diagrams shall not be

¹ If the static type voltage stabilizer is used, it is particularly important to check the wave shape to see that it meets the specification given in 4.2. This should be checked both with and without load.

used, but in such cases other arrangements shall then be made to minimize the shock hazard.

7.2 Basic instrument circuit

The recommended methods of connecting the instruments to the lamp and ballast circuit are provided in and Figure 2. If individual instruments are used then only one instrument at a time shall be connected in the measurement circuits.

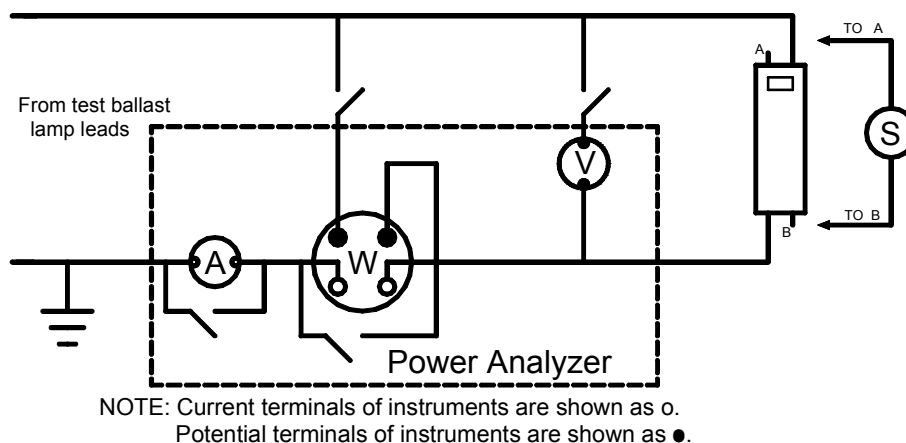


Figure 1 - Input-characteristics measurement circuit

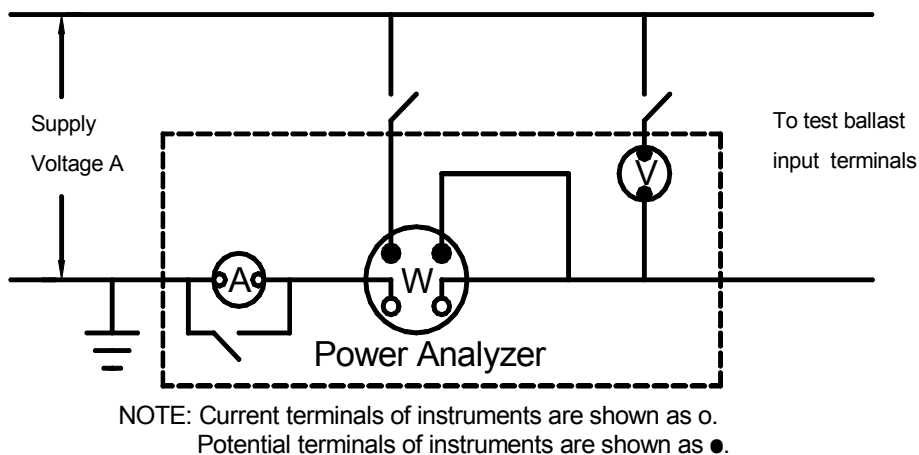


Figure 2 - Lamp-characteristics measurement circuit

7.3 Test circuits

The measurement circuits shown in Figure 1, Figure 2, and Figure 3 can be used for each lamp of a multi-lamp ballast. When measuring multi lamp ballasts, each

reference lamp shall be operated on its own reference ballast. It is desirable that all lamps be switched simultaneously in transferring between ballasts.

The resistance of the measurement circuit, including the contact resistance of all switches and relays, should be low enough as to not contribute a voltage drop exceeding 0.75 percent of the lamp voltage. This limitation applies to the part of the circuit that is between the ballast and the lamp sockets.

8 Electrical Instruments

The instruments used in measuring the operating characteristics of ballast or ballast-lamp combinations shall meet all the requirements outlined in ANSI C78.375.

9 Open circuit voltage

Measurements of open-circuit voltage are necessary for ballasts that incorporate a transformer as an integral part of the ballast. The open circuit voltage and voltage crest factor requirements are listed in the appropriate lamp data sheets.

9.1 Measurement

The test ballast shall be operated at its rated frequency and at the input voltages that provide the lowest and the highest open circuit voltage readings as specified in C82.1.

The RMS and peak open circuit voltages are measured at the output terminals (those intended for connection to the lamp), using the conditions cited Sections in 9.2 and 9.3, and 9.4.

The open circuit peak lamp voltage is defined as the greater of the maximum positive peak or the maximum negative peak value over the same period.

When ballasts are designed to operate lamps in parallel circuits, the relevant voltage requirements shall be met for each separate lamp circuit.

9.2 Series-sequence instant start ballasts

In such ballasts, the open-circuit voltage of each lamp position shall be measured with an operable lamp connected in the other position. The lamps should be at room temperature.

9.3 Rapid start ballasts

On rapid start ballasts there are four terminals that connect to each lamp. The open circuit voltage shall be measured between the two terminals that give the highest voltage. On ballasts that operate two or more lamps in series, the open circuit voltage to be measured is the highest voltage that would be applied to the lamps in series.

All cathode circuits should be connected to appropriate dummy-load resistors when open circuit voltages are being measured. The dummy load values can be found in the appropriate lamp data sheets.

9.4 Peak voltage

Measurement of open circuit peak voltages (between lamp terminals and from lamp terminals to ground) shall be made with instruments that respond to peak values of voltage. Instruments that respond to RMS or average values are sometimes calibrated in terms of peak voltage, but are not satisfactory for this work. Peak reading, high impedance voltmeters and calibrated oscilloscopes are suitable.

10 Starting current for instant start and rapid start ballasts

Measurements of lamp starting current are necessary for ballasts that incorporate a transformer as an integral part of the ballast. The lamp starting current requirements are listed in ANSI C82.1 and in the appropriate lamp data sheets. Starting current is determined by measuring the current through a test resistor.

10.1 Measurement

The test ballast shall be operated at its rated frequency and over the range of input voltage specified in C82.1. The minimum value of current through the test resistor over that range shall be recorded.

The RMS current through the specified test resistor can be measured using either a current transformer² connected to a suitable measurement system or an ammeter³.

10.2 Single lamp ballasts

The test resistor is connected to the test ballast in place of the lamp and the RMS current through the test resistor⁴ is measured.

10.3 Multi-lamp ballasts

The test resistor⁴ is connected in place of one of the lamps with all other lamp circuits connected to lamps. The RMS current is measured through the test resistor. The test resistor is to be connected in each of the lamp circuits.

10.3.1 Two lamp series-sequence ballasts

Two-lamp series-sequence instant start ballasts that operate either 96 inch T12 or 48 inch T12 or T17 lamps are a special case of multi-lamp ballasts. For these ballasts both lamps are replaced with the test resistors⁴ specified and the current through each is measured.

10.3.2 Two-lamp rapid start ballasts

Two-lamp rapid start ballasts operating 1500 mA lamps shall be tested using the specified load resistors in place of the lamps. The RMS current through specified resistors is measured. The specific values for the resistive loads and test conditions are listed in the appropriate lamp data sheets.

² The current transformer shall have a linear response over the entire measurement range.

³ The internal resistance of the ammeter should be included in the overall test resistor values.

⁴ The specific value of the test resistor and the associated lamp types can be found in ANSI C82.1

11 Input power factor

Measurements of input power factor are necessary for all ballast types that are designated as high-power factor or power factor corrected. The input power factor requirements are listed in ANSI C82.1.

11.1 Measurements

The test ballast shall be operated at its rated frequency and rated line voltage using reference lamps as the ballast load. The input power factor can be measured using any suitable true RMS measurement system (see).

The input power factor of any ballast-lamp combination can be calculated after measuring the active power (watts), input voltage (volts) and input current (amps).

12 Ballast factor

Ballast factor measurements are made using reference lamp(s) operating under the conditions specified in ANSI C78.375 and C82.3. The minimum ballast factor requirements are listed in ANSI C82.1. Although ballast temperature has an effect on ballast factor, these effects are relatively small and a long time is required to arrive at a stabilized ballast condition. Hence in the interest of uniformity and economy of testing, ballasts are operated at room temperature.

12.1 Measurement

The test ballast shall be operated at its rated frequency and input voltage using reference lamps as the ballast load. The ballast factor of each lamp shall be measured using the conditions cited in Sections 12.2 or 12.3. When switched to the ballast under test, the output may drift as the ballast warms up and the lamps re-stabilize, therefore ballast factor measurements are taken within 30 seconds after switching to the test ballast without additional stabilization.

The reference lamp shall be operated first on the reference ballast. When the lamp has reached a condition of stable operation, the brightness⁵ of the lamp shall be measured. The lamp shall then be transferred to the test ballast without being extinguished and its brightness measured again. The lamp should be transferred back to the reference ballast for verification of reference data.

12.2 Switch-start (preheat) and instant start ballasts

For these types of ballasts the ballast factor is specified as the ratio of the power delivered to a reference lamp operated on the test ballast as compared to the power delivered to the same reference lamp by the appropriate reference ballast. The lamp power, in both test conditions, is measured using the circuit described in Figure 2.

⁵ Depending on lamp type, brightness is determined either by lamp watts or relative light output as measured by a photometer.

12.3 Rapid start ballast

For rapid start ballasts the ballast factor is the ratio of the light output of the reference lamp operated on the test ballast as compared to the light output of the same reference lamp when operated by the appropriate reference ballast.

When light output is measured, a photodiode of the silicon type with a visibility-correcting filter is recommended. The photometer shall have a linear response over the entire measurement range. The detector shall be mounted at least 5 inches (127mm) from the lamp (farther away for some of the brighter lamps) and shall view the center of the lamp.

The photodiode shall be stabilized by being exposed to light of a reference ballast-lamp combination for at least 1/2 hour before the light output measurements are taken. During the time the photocell shall be connected to its measurement circuit so that normal current will be flowing.

13 Ballast efficiency factor (BEF)

The ballast efficiency factor is defined in C82.1. The BEF is calculated using the measured ballast factor and the measured ballast input power operating the same reference lamps. The input power is measured using instruments and test circuits as described in Section 7.

14 Ballast regulation

Determination of the test ballast regulation involves the measurement of reference lamp power or light output at low and high line voltage conditions. These measurements are made in the same manner as described in Section 12. The measurement should be made within 30 seconds of the lamp transfer to the test ballast and no additional time is necessary between the measurements to allow the lamp to re-stabilize. The particular voltage and ballast factor limitations for determining ballast regulation conformance are listed in ANSI C82.1.

15 Current measurements

The current of the reference lamp shall be measured on both the ballast under test and the reference ballast using a suitable ammeter. Specific requirements for rms and peak lamp current are listed in C82.1 and C78.4.

15.1 Measurement

The test ballast shall be operated at its rated frequency and at the input voltages specified in ANSI C82.1 or in the appropriate lamp data sheet.

15.2 Switch-start (preheat) and instant start ballasts

For instant start and switch-start ballasts the RMS and peak lamp current of each operational reference lamp can be measured using an ammeter as shown schematically in Figure 2.

15.3 Rapid start ballasts

The measurement of both RMS and peak lamp current for rapid start ballasts requires special instrumentation that provides a vector summation of the currents in the two leads of a cathode. The RMS and peak lamp current of each operational reference lamp is measured using a current transformer² connected to a suitable measurement system as shown schematically in Figure 3.

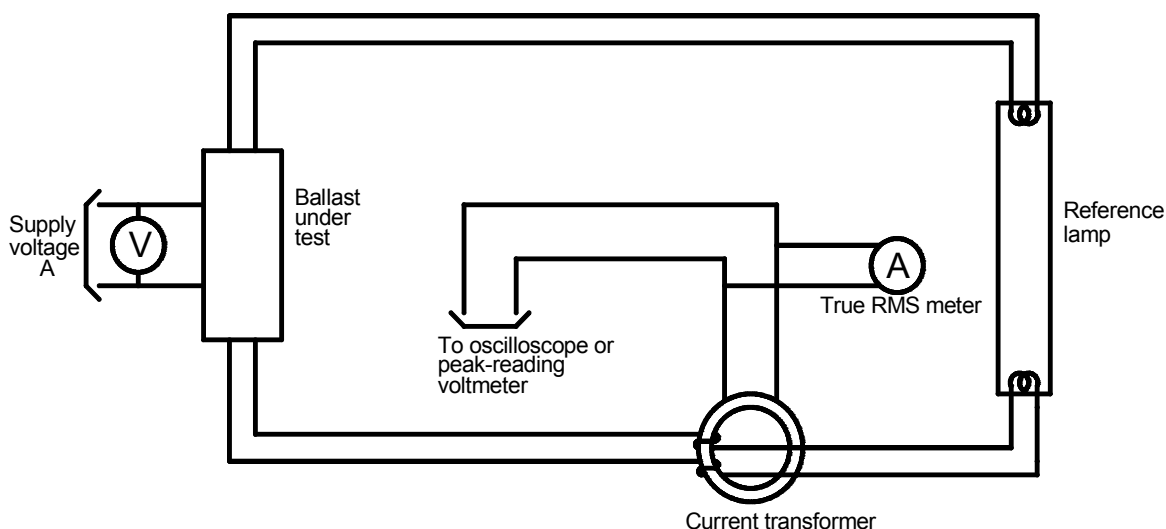


Figure 3 – Measurement of peak and RMS lamp current for rapid start lamps

16 Cathode heating- voltage requirements

Measurements of cathode heating voltage are necessary only for ballasts that incorporate a transformer as an integral part of the ballast. The cathode heating voltage requirements are listed in the appropriate C78 lamp data sheets.

16.1 Measurement

The test ballast shall be operated at its rated frequency and at the input voltages as specified by the ANSI C78 lamp data sheet. The minimum, nominal and the maximum voltages across the cathode heating terminals⁶ are recorded. At the time the data is collected, all cathode-heating terminals are to be loaded. The RMS voltage across the cathode heating terminals must be within the limits specified on the appropriate lamp data sheet for the conditions cited in Sections 16.2 and 16.3.

16.2 Resistive dummy load

With only the appropriate dummy load resistor connected across each set of cathode heating terminals, the voltage is measured across each dummy load resistor.

16.3 Lamp load

While the test ballast is operating the appropriate lamp(s), cathode-heating voltage shall meet the limits as given in the appropriate C78 lamp data sheet.

17 Cathode heating – preheat current requirements

This measurement is only needed on ballasts that supply a preheat current to the lamp cathodes terminals. The preheat current requirements are listed in the appropriate lamp data sheets and in ANSI C82.1.

⁶ The terminals or lead wires intended for connection to the lamp.

17.1 Measurement

The test ballast shall be operated at its rated frequency and within the range of primary voltages specified on the appropriate lamp data sheet. The maximum and the minimum preheat currents supplied to cathode heating terminals⁶ shall be measured using the conditions cited in Sections 17.2 and 17.3.

17.2 Compact fluorescent ballasts

For those lamps where the integral starter is not accessible, a dummy load resistor⁷ is specified for determining proper starting current. This dummy load resistor is connected to the test ballast in place of the lamp(s) and the RMS current through the load resistor is measured using either a current transformer² or an ammeter³.

17.3 Switch start ballasts

The test ballast is connected to the lamp with the appropriate starter in the circuit as shown in Figure 2. With the starter terminals shorted, the RMS current that flows through the lamp filaments and the shorted starter is measured.

18 Starter terminal voltage

With the test ballast operating at its rated frequency and at both 90% and 110% of the nominal input voltage, the starter terminal voltage shall be measured using reference lamps and deactivated lamps. A deactivated lamp may be simulated by; connecting the filaments from a lamp to one side of the test circuit and the filaments of a second lamp connected to the other side of the test circuit.

19 Starting capacitor

In the case of the series types of rapid start ballasts, the capacitance of the starting capacitor(s) should be measured using a universal capacitance bridge. The measurement shall be made across the appropriate test ballast lamp circuit(s) with the ballast deactivated.

⁷ The specific value of the test resistor and the related lamp types can be found in ANSI C78.4