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American National Standard

for reference ballasts for fluorescent lamps

ANSI C82.3-1983

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ANSI®
C82.3-1983
Revision of
ANSI C82.3-1977

American National Standard for Reference Ballasts for Fluorescent Lamps

Secretariat

National Electrical Manufacturers Association

Approved May 16, 1983

American National Standards Institute, Inc

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American National Standard

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Foreword

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In order to obtain satisfactory performance of fluorescent lamps and their associated ballasts, it is necessary that certain features of their designs be properly coordinated. Specifications for the operation of either the lamps or the ballasts must naturally be written in terms of measurements made against some common baseline of reference.

Because of the inherent instability of gaseous discharge lamps, experience has shown them to be unsuited as a reference. A ballast, however, can be specially designed to provide a reasonably permanent and reproducible baseline for measurements. Such ballasts are designated as reference ballasts. This standard describes those characteristics that have been found necessary in ballasts to ensure permanence and reproducibility.

This standard was originally published for trial and criticism in 1950 and again in 1953. It was first approved as an American National Standard in 1956. Subsequent editions were published in 1957, 1962, 1972, and 1977.

Dimensions in this standard are given in inches; millimeter conversions are given in parentheses and have been rounded.

Suggestions for improvements of this standard will be welcome. They should be sent to the National Electrical Manufacturers Association, 2101 L Street, NW, Washington, D.C. 20037.

This standard was processed and approved for submittal to ANSI by American National Standards Committee on Lamp Ballasts, C82. Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the C82 Committee had the following members:

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Fred P. Smith, Secretary

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Contents

SECTION PAGE

1. Scope 7

2. Related Standards 7

3. Definitions 7
   3.1 General 7
   3.2 Fluorescent Lamp Reference Ballast 7
   3.3 Reference Current 7

4. Ballast Marking 8
   4.1 Marking 8

5. Design Characteristics 8
   5.1 General Design 8
   5.2 Permanence of Impedance 8
   5.3 Enclosure 8
   5.4 Magnetic Shielding 8
   5.5 Inclusion of Instrument Current Coils 8

6. Operating Characteristics 8
   6.1 General 8
   6.2 Rated Input Voltage 8
   6.3 Impedance 8
   6.4 Linearity 9
   6.5 Ballast Power Factor 9
   6.6 Temperature Rise 9

7. Circuits 9
   7.1 General 9
   7.2 Preheat Start 9
   7.3 Instant Start 9
   7.4 Rapid Start 9

8. Adjustment and Calibration 9
   8.1 General 9
   8.2 Circuit Grounding 9
   8.3 Power Supply 9
   8.4 Stability of Supply Voltage 9
   8.5 Instruments 9
   8.6 Impedance Measurements 11
   8.7 Power-Factor Measurement 11
   8.8 Circuit Connections 11
   8.9 Linearity 11

9. Revision of American National Standards Referred to in This Document 11

Figures
   Fig. 1 Circuit for Impedance Measurement 10
   Fig. 2 Circuit for Power-Factor Measurement 10

Appendixes
   Appendix A Inclusion of Instrument Current-Coil Impedances in the Impedance of the Reference Ballast 13

   Figures
      Fig. A1 Circuit for Impedance Measurement 13
      Fig. A2 Circuit for Power-Factor Measurement 14

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SECTION PAGE

Fig. A3 Circuit for Alternate Method of Power-Factor Measurement, Normal-Power-Factor Wattmeter and Ammeter Included in Reference-Ballast Impedance (Z_{RB}) 15
Fig. A4 Circuit for Alternate Method of Power-Factor-Measurement, Normal-Power-Factor Wattmeter Included in Reference-Ballast Impedance (Z_{RB}) 15
Fig. A5 Circuit for Alternate Method of Power-Factor Measurement, Ammeter Included in Reference-Ballast Impedance (Z_{RB}) 16

Appendix B Measurement and Adjustment of the Impedance and Power-Factor Characteristics of a Reference Ballast – Guide for the Use of the Preferred Method 17

Appendix C Description of and Guide for an Alternate Method of Measurement and Adjustment of the Impedance and Power-Factor Characteristics of a Reference Ballast 18

Fig. C1 Circuit for Alternate Method of Power-Factor Measurement When High-Quality Low-Power-Factor Wattmeter Is Not Available 19

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American National Standard for Reference Ballasts for Fluorescent Lamps

1. Scope

This standard describes the essential design features and operating characteristics of reference ballasts for fluorescent lamps. The items specified are those that have been found necessary to ensure accurate and reproducible results when either lamps or ballasts are being tested. The specific values of rated input voltage and impedance needed for each size of lamp are listed in the applicable American National Standard for the Dimensional and Electrical Characteristics of Fluorescent Lamps – Rapid-Start Types, ANSI C78.1-1978 and C78.1a-1980.

2. Related Standards

This standard is intended for use in conjunction with the following American National Standards (see Section 9):

ANSI C78.1-1978 and C78.1a-1980, Dimensional and Electrical Characteristics of Fluorescent Lamps – Rapid-Start Types

ANSI C78.375-1973 (R1978), Guide for Electrical Measurements of Fluorescent Lamps

ANSI C82.1-1977 (R1982), Specifications for Fluorescent Lamp Ballasts

ANSI C82.2-1977, Methods for Measurement of Fluorescent Lamp Ballasts

ANSI/IEEE 100-1977, Dictionary of Electrical and Electronics Terms

3. Definitions

3.1 General. The definitions in 3.2 and 3.3 cover terms that are specifically related to the subject of this American National Standard. For definitions of other less directly related terms, see the appropriate sections of ANSI/IEEE 100-1977.

3.2 Fluorescent Lamp Reference Ballast. A special inductive-type ballast having certain prescribed characteristics. It serves as a comparison standard for use in testing ballasts or lamps and is also used in selecting the reference lamps that are necessary for the testing of ballasts. A reference ballast is characterized by constant impedance over a wide range of operating current and also by constant characteristics that are relatively uninfluenced by time and temperature. A reference ballast may be either of the types given in 3.2.1 and 3.2.2.

3.2.1 Fixed-Impedance Type. A reference ballast designed for use with one specific type of lamp and after adjustment during the original calibration, expected to hold its established impedance throughout normal use.

3.2.2 Adjustable-Impedance Type. A reference ballast consisting of an adjustable inductive reactor and a suitable adjustable resistor in series. These two components are usually designed so that the resulting combination has sufficient current-carrying capacity and range of impedance to be used with a number of different sizes of lamps. The impedance and power factor of the reactor–resistor combination are adjusted and checked each time the unit is used.

3.3 Reference Current. That value of current at which the impedance of a reference ballast is specified and measured. The reference current for each size of reference ballast is normally the same as the rated current of the lamp type which the ballast is intended to operate. Since the reference ballast is a standard that is representative of the impedance of lamp power sources installed, it is not necessary to change this current value unless major changes in lamp standards require modification of the ballast impedance. The reference current for each reference ballast is specified in the applicable American National Standard for the Dimensional and Electrical Characteristics of Fluorescent Lamps – Rapid-Start Types, ANSI C78.1-1978 and C78.1a-1980.

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4. Ballast Marking

4.1 Marking. A reference ballast shall be provided with a durable and legible metal nameplate securely attached to a permanent portion of the ballast structure. The information shown in 4.1.1 or 4.1.2 shall be legibly etched or stamped on the nameplate.

4.1.1 Fixed-Impedance Type

(1) Manufacturer's name
(2) Manufacturer's catalog or model number
(3) Manufacturer's serial number
(4) Lamp type, wattage, and current
(5) Supply voltage and frequency
(6) Impedance

4.1.2 Adjustable-Impedance Type

(1) Manufacturer's name
(2) Manufacturer's catalog or model number
(3) Manufacturer's serial number
(4) Impedance range at rated frequency (or frequencies)
(5) Maximum voltage per coil and maximum voltage across reactor
(6) Maximum current per coil
(7) Frequency (or frequencies)
(8) Connection diagram

5. Design Characteristics

5.1 General Design. A reference ballast is an inductive reactor, either with or without an additional series resistor, designed to give the operating characteristics listed in Section 6.

5.2 Permanence of Impedance

5.2.1 Fixed-Impedance-Type Ballasts. Since this type of reference ballast is intended to serve as a permanent baseline of reference, it is vitally important that the ballast be so constructed as to provide permanence of impedance under normal conditions of use and abuse.

A recheck of the impedance of the ballast shall give values within 0.1% of those previously determined.

5.2.2 Adjustable-Impedance-Type Ballasts. This type of reference ballast, when adjusted to any given value of impedance, shall be capable of holding that adjustment through normal periods of use. For this purpose suitable means shall be provided for mechanically locking the movable core (or other movable parts) in any desired position.

5.3 Enclosure. A reference ballast shall be enclosed in a steel case for mechanical protection. In the case of the adjustable-impedance-type ballast, the series resistor need not be in the same enclosure with the reactor.

5.4 Magnetic Shielding. A reference ballast, to be considered magnetically shielded, shall be so designed and constructed that its impedance at reference current shall not be changed by more than 0.2% when a 1/2-inch (13-mm) plate of magnetic steel is placed within 1 inch (25 mm) of any face of the ballast enclosure. The steel plate shall have dimensions at least 2 inches (51 mm) greater than the maximum dimension of the ballast enclosure and shall be placed in geometric symmetry to each surface as tested. In the event that a reference ballast is not magnetically shielded, precautions shall be taken to keep magnetic objects far enough removed from the leakage field so that the impedance of the ballast will not be altered by more than the 0.2% mentioned above.

5.5 Inclusion of Instrument Current Coils. When an adjustable-impedance-type reference ballast is being used, a choice may be made as to whether the impedances of the instrument current coils (the ammeter and wattmeter) will or will not be included as part of the impedance of the reference ballast. Either procedure is satisfactory, but the other aspects of the calibrating procedure and also the subsequent use of the ballast must be compatible with the particular procedure being followed. For the sake of simplicity, the procedures described in this standard are arranged for the condition of not including the impedances of the current coils in the reference-ballast impedance. Appendix A, however, covers the changes in procedures and circuitry that would be required if the current coils were to be included.

6. Operating Characteristics

6.1 General. The following specifications apply to measurements made at the rated frequency of the reference ballast and with the ballast parts and windings conditioned at an ambient temperature of 25°C ± 5°C. (When reference ballasts are used to operate lamps, the requirements of the lamps usually demand temperature control within ± 1°C.)

6.2 Rated Input Voltage. The rated input voltage of a reference ballast shall be in accordance with the value specified in the applicable American National Standard for the Dimensional and Electrical Characteristics of Fluorescent Lamps – Rapid-Start Types, ANSI C78.1-1978 and C78.1a-1980.

6.3 Impedance. The impedance of a reference ballast at the specified reference current shall be within 0.5% of the value specified in the applicable American National Standard for the Dimensional and Electrical

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Characteristics of Fluorescent Lamps – Rapid-Start Types, ANSI C78.1-1978 and C78.1a-1980.

6.4 Linearity. For any value of current from 50% to 115% of reference current, the impedance of the reference ballast shall be within ± 3.0% of the value specified in the applicable American National Standard for the Dimensional and Electrical Characteristics of Fluorescent Lamps – Rapid-Start Types, ANSI C78.1-1978 and C78.1a-1980.

6.5 Ballast Power Factor. The effective power factor of the reference ballast (ratio of wattage loss to the product of ballast voltage and current) when the ballast is carrying reference current shall be 0.075 ± 0.005.

6.6 Temperature Rise. When the reference ballast is operated in open air at an ambient temperature of 25°C, and at reference current and rated frequency, the steady-state temperature rise of the winding when measured by the resistance method shall not exceed 25°C.

7. Circuits

7.1 General. Reference ballasts may be used with any of the three basic types of fluorescent lamps. In each case certain details of the circuit are dictated by the characteristics of the lamp type as given in 7.2 through 7.4.

7.2 Preheat Start. Preheat-start hot-cathode bipin lamps are provided with two contact pins on each end of the lamp. One pin at each end is connected to the operating circuit, and the remaining two pins are connected to the starter circuit.

7.3 Instant Start. Instant-start lamps are of either the single-pin or bipin type and require no starter circuit.

7.4 Rapid Start. Rapid-start lamps have two pins (or recessed contacts) at each end of the lamp. Reference ballasts for rapid-start lamps are intended for use in conjunction with low-voltage transformers which supply separate cathode heat. The low-voltage cathode heating transformers are adjusted to center values of 3.6 volts (low-resistance cathodes) or 8.5 volts (high-resistance cathodes).

NOTE: The three circuits referred to in 7.2 through 7.4 are described in ANSI C82.2-1977. Specifications for values of cathode heating voltages for specific lamp types are shown in ANSI C82.1-1977.

8. Adjustment and Calibration

8.1 General. Ballasts of the fixed-impedance type shall be adjusted and calibrated at the time of manufacture; their calibration should also be rechecked periodically during their subsequent use.

Ballasts of the adjustable-impedance type shall be adjusted and calibrated each time they are set up for a different type of lamp. Their calibration should also be rechecked periodically during use, even if they are being operated for long periods of time at the same setting.

8.2 Circuit Grounding. In all the wiring diagrams given in this standard, it will be noted that the portion of the circuit containing the instrument current coils has been identified as the grounded conductor. This wiring arrangement is a recommended safety precaution since many types of portable instruments have current-coil terminals that are not insulated and that could constitute a shock hazard if not kept at ground potential. In those situations where neither of the two supply conductors is at ground potential, or where the system ground is located at an excessive distance from the test location, an isolating transformer shall be interposed between the power source and the measurement circuit, and the side of the test circuit containing the instrument current coils shall be connected to a reliable ground point in the vicinity. Alternatively, other arrangements such as insulation of exposed terminals may be made to minimize shock hazards. Further, where the grounding of one input terminal of an electronic instrument is necessary for its proper and safe operation, the use of an isolating transformer may be required. If an isolating transformer is employed, the test-circuit grounded conductor may be grounded adjacent to the appropriate instrument.

8.3 Power Supply. The ac voltage supply used for the adjustment or test of reference ballasts shall be such that the rms summation of the harmonic components shall not exceed 3% of the fundamental component.

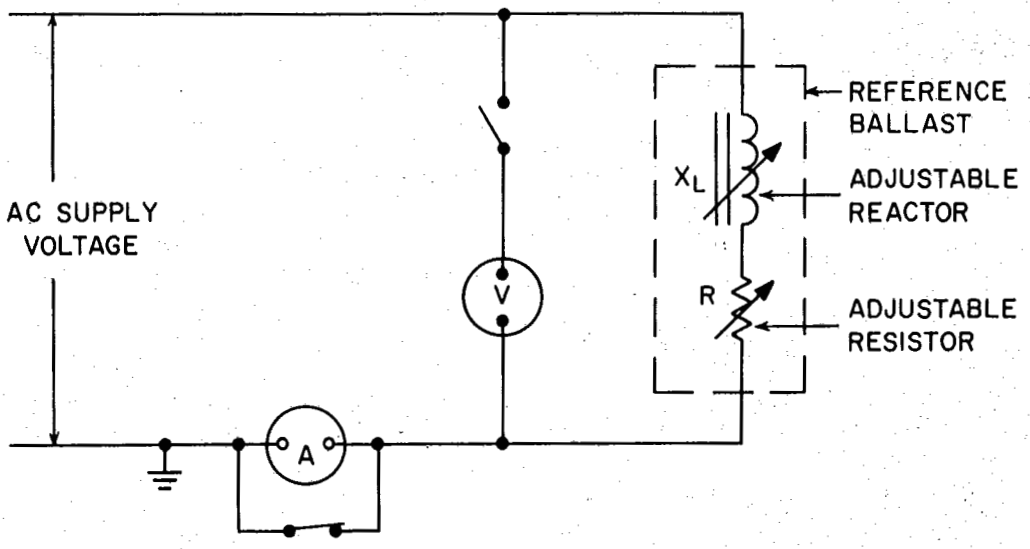
8.4 Stability of Supply Voltage. The line voltage shall be as steady and free from sudden changes as possible. For best results the voltage should be regulated to within 0.1%. If adequate automatic voltage regulation is not available, constant checking and readjustment are essential to obtaining accurate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

NOTE: If the static type voltage stabilizer is used, it is particularly important to check the waveshape to see that it meets the specification given in 8.3. This should be checked both with and without load.

8.5 Instruments. A discussion of the impedance limitations and the necessary accuracy of electrical instruments may be found in the section on instrumentation in ANSI C78.375-1973.

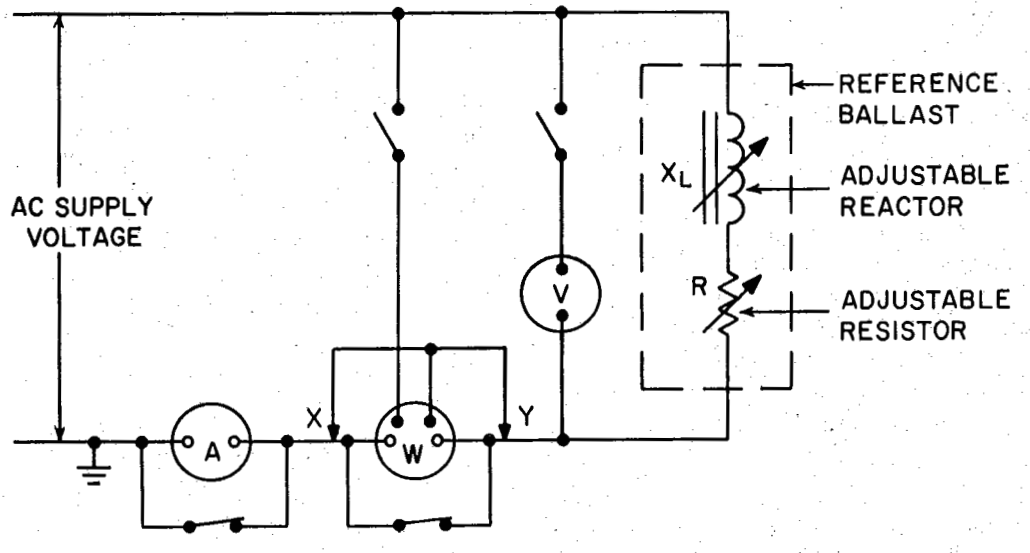
All instruments used in reference-ballast measurements should have accurate and up-to-date scale calibrations available.

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NOTE: Current terminals of instruments are shown as o. Potential terminals of instruments are shown as ●.

Fig. 1
Circuit for Impedance Measurement



NOTE: Current terminals of instruments are shown as o. Potential terminals of instruments are shown as ●.

Fig. 2
Circuit for Power-Factor Measurement

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8.6 Impedance Measurements. The instruments should be connected as shown in Fig. 1. The voltmeter should not draw a current greater than 3% of the reference current. For the circuit as shown, no correction for the presence of the voltmeter is necessary since the voltmeter current will not only be small but will also have a phase difference of about 85% with respect to the reference-ballast current. The impressed test voltage should be equal to the product of the reference current times the reference-ballast impedance, as specified in the applicable American National Standard for the Dimensional and Electrical Characteristics of Fluorescent Lamps – Rapid-Start Types, ANSI C78.1-1978 and C78.1a-1980.

8.7 Power-Factor Measurement

8.7.1 Preferred Method. For this method the wattmeter used shall be suitable for low-power-factor measurements. The instrument connection should be as shown in Fig. 2. The potential coil of the wattmeter may be connected in either of two ways. If connected at point X, the instrument reading will include the power in the current coil as well as the power in the load. If connected at point Y, the instrument reading will include the power in the potential coil. In either case the power in one of the instrument coils will have to be calculated and then subtracted from the instrument reading. The connection chosen should be the one that will result in the smaller subtraction.

In order not to complicate the process of making corrections for the presence of instruments in the circuit, the voltmeter should not be in the circuit when a wattage reading is being taken and the wattmeter should not be in the circuit when a voltage reading is being taken. No correction need be made for the voltmeter (for reasons given in 8.6). The correction for the wattmeter is determined in the manner described in the preceding paragraph.

The ballast power factor is calculated as the ratio of the wattage loss to the product of the current and voltage when the ballast is carrying reference current. A measurement of voltage was obtained as part of the impedance measurement covered in 8.5.

An example illustrating the procedures given for the calibration of a reference ballast is shown in Appendix B.

8.7.2 Alternate Method. If a high-quality low-power-factor wattmeter is not available, it is possible to determine the power consumed by the reference ballast by utilizing the wattmeter that is normally used to measure the lamp power. The procedure for determining the power factor by this method is outlined in Appendix C.

8.8 Circuit Connections. The circuit used for the calibration of a reference ballast should have connections that are as short and direct as practicable and the wire size should be adequate to carry the current required by the ballast. The impedance and power factor as measured should include only the ballast itself (reactor plus the variable resistor), except that the instrument current coils may be included if desired.

The resistance of the measurement circuit, including the contact resistance of all switches and relays, should not be high enough to add a voltage drop exceeding 0.75% of the lamp voltage. This limitation applies to that part of the circuit that is on the lamp side of the point at which the line voltage is being controlled.

8.9 Linearity. With the ballast connected in the same circuit as previously used for the impedance measurements (Fig. 1), the impressed voltage should be varied as necessary to obtain values of current over the range specified in 6.4. Readings of current and voltage should be taken at various points and a curve plotted to show the variation of impedance over the specified range of current.

If it is known from previous measurements that the adjustable reactor being used has an impedance characteristic meeting the linearity requirements mentioned above, this additional check does not need to be made on subsequent adjustments of the reactor at this current value.

9. Revision of American National Standards Referred to in This Document

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.

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Appendixes

(These Appendixes are not a part of American National Standard C82.3-1983, but are included for information only.)

Appendix A

Inclusion of Instrument Current-Coil Impedances in the Impedance of the Reference Ballast

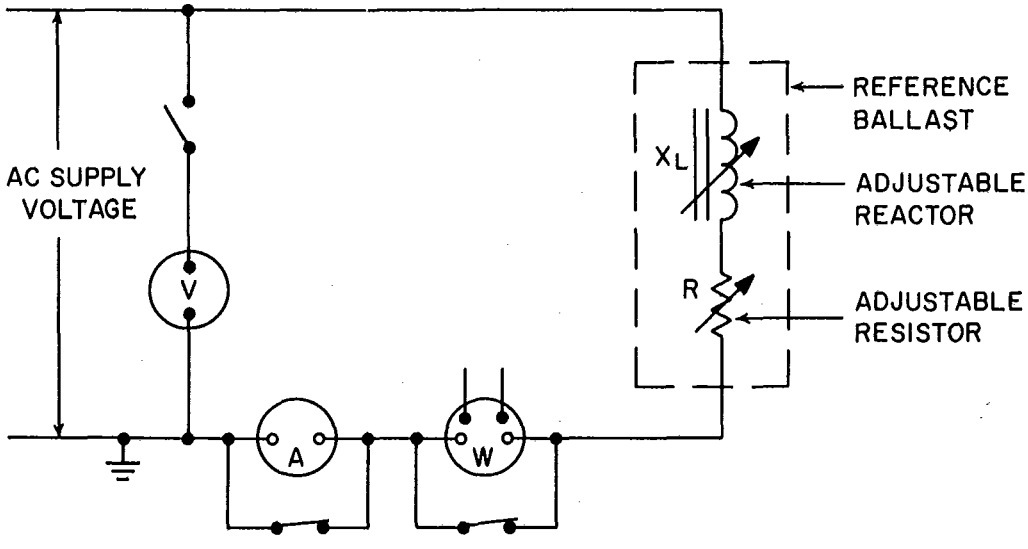
A1. General

As pointed out in 5.5, it is quite possible to include the impedance of either the ammeter or the wattmeter current coil, or both, as part of the calibrated impedance of the reference ballast. This modified procedure is perfectly satisfactory if properly used, and it has the advantage that when lamp measurements are being taken, the process of compensating for the presence of instruments is considerably simplified. The modified procedure, however, makes it imperative that any instrument current coils included in the original calibration be left in the circuit at all times during subsequent use of the reference ballast to operate lamps.

The variations in procedures given in A2 and A3 would be required in calibrating a reference ballast with the impedance of the current coils included as part of the ballast impedance.

A2. Impedance Measurements

The circuit connections would be as shown in Fig. A1. This circuit shows both the ammeter and the normal-power-factor wattmeter current coil included with the reference-ballast impedance. If only the wattmeter is to be included, then the ammeter would be connected on the input side of the voltmeter. If only the ammeter is to be included, the wattmeter would simply be removed from the circuit. In any case no correction for the presence of the voltmeter is needed.



NOTE: Current terminals of instruments are shown as o. Potential terminals of instruments are shown as ●.

Fig. A1
Circuit for Impedance Measurement

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APPENDIX

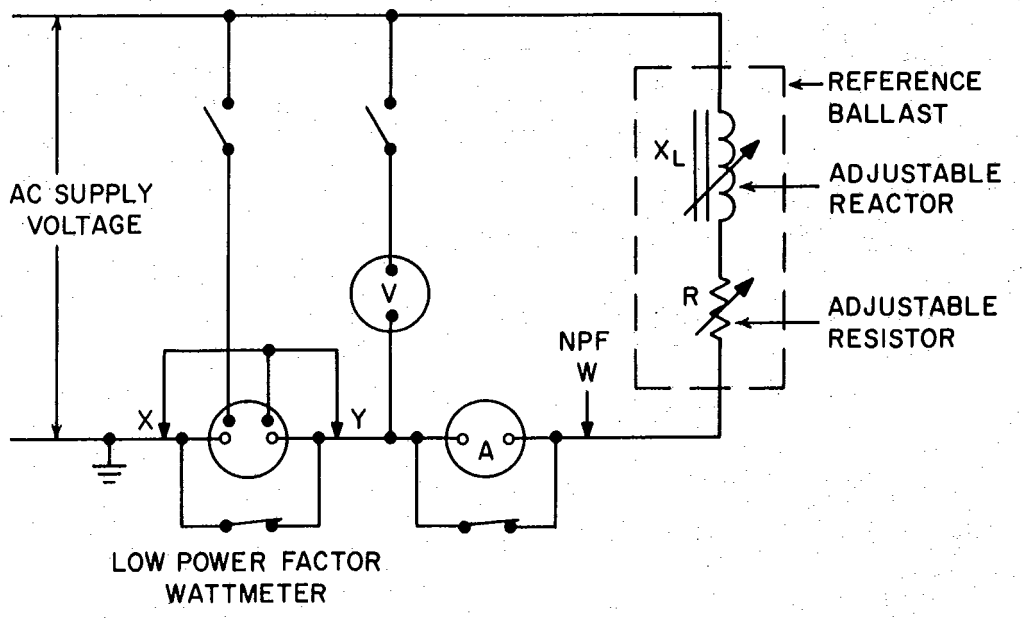
A3. Power-Factor Measurements

A3.1 Preferred Method. The circuit connections would be as shown in Fig. A2. This shows only the impedance of the ammeter included. There would be no reason to include the current coil of a low-power-factor wattmeter since this type of instrument would not be suitable for use in lamp circuits. It would, however, be possible to include the current coil of the normal-power-factor wattmeter that would be used for the lamp measurements. If this were done, the current coil would be connected into the circuit at point W with its potential coil disconnected (still leaving the low-power-factor instrument connected as shown).

No correction would be needed for the voltmeter, and the correction for the wattmeter would be the same as described in 8.7.1.

A3.2 Alternate Method. See Appendix C for a general description of the alternate method. When instrument current-coil impedances are to be included in the impedance of the reference ballast, the measurement circuit should be modified as shown in Fig. A3, A4, or A5.

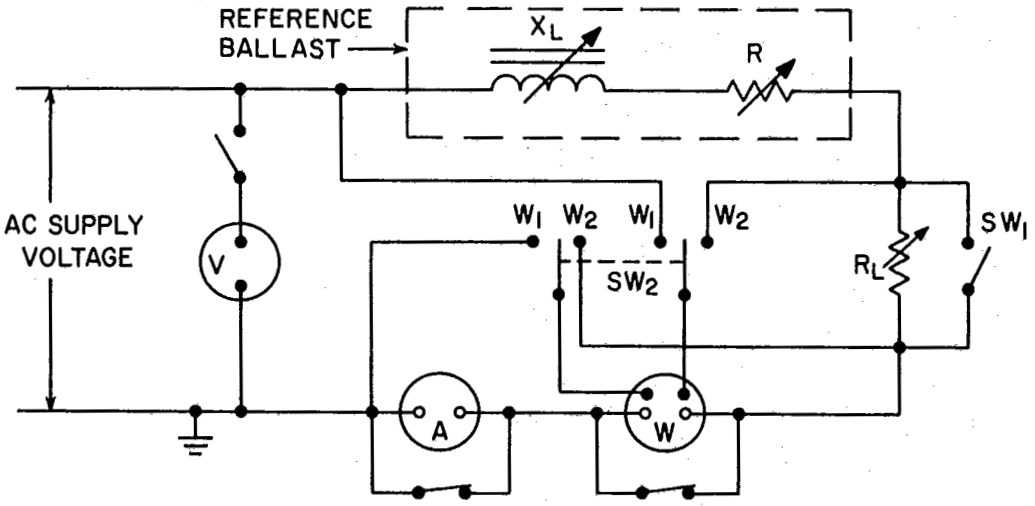
The circuit shown in Fig. A3 should be used when the current coils of the normal-power-factor wattmeter and ammeter are included in the reference-ballast impedance. Fig. A4 should be used if only the wattmeter current coil is included, and Fig. A5 should be used if only the ammeter is included.



NOTE: Current terminals of instruments are shown as o. Potential terminals of instruments are shown as ●.

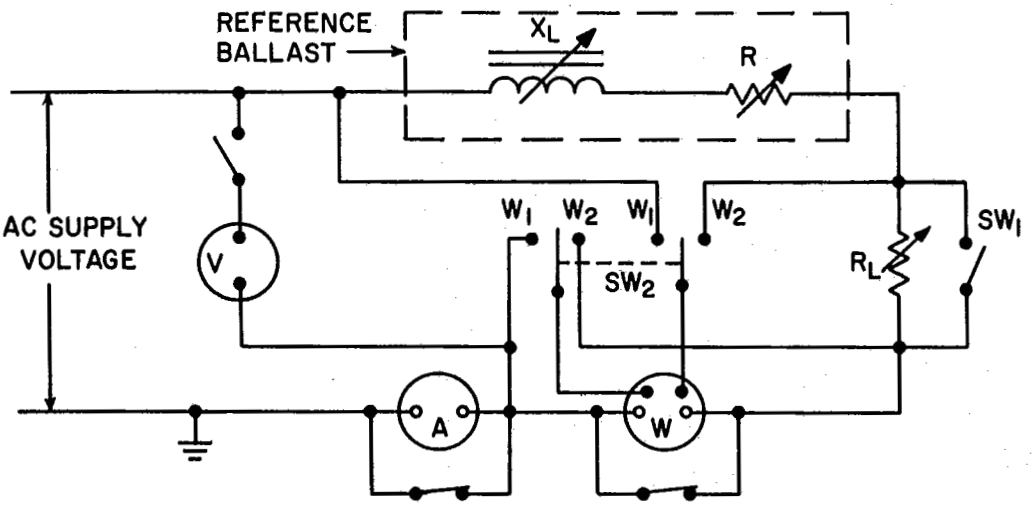
Fig. A2
Circuit for Power-Factor Measurement

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NOTE: Current terminals of instruments are shown as o. Potential terminals of instruments are shown as ●.

Fig. A3
Circuit for Alternate Method of Power-Factor Measurement
Normal-Power-Factor Wattmeter and Ammeter Included in Reference-Ballast Impedance (Z_{RB})

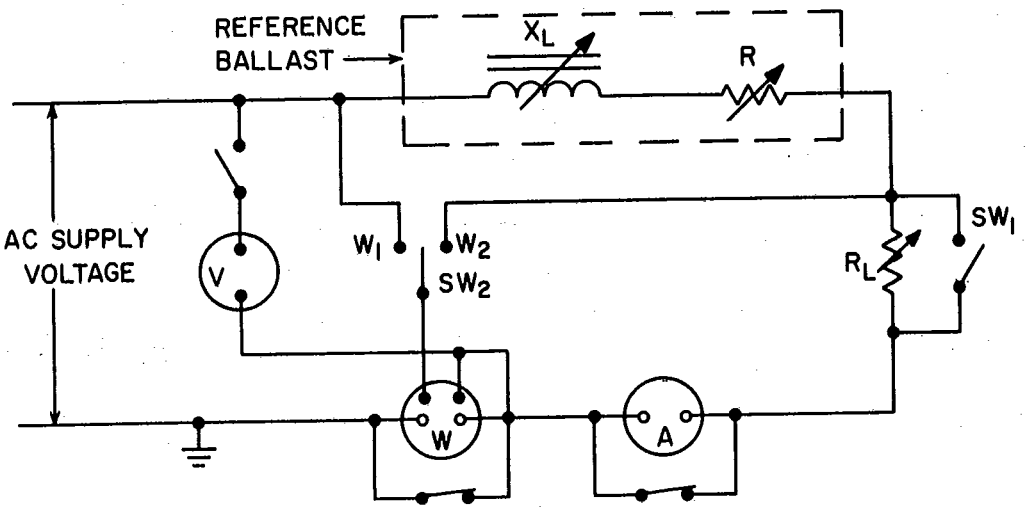


NOTE: Current terminals of instruments are shown as o. Potential terminals of instruments are shown as ●.

Fig. A4
Circuit for Alternate Method of Power-Factor Measurement
Normal-Power-Factor Wattmeter Included in Reference-Ballast Impedance (Z_{RB})

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APPENDIX



NOTE: Current terminals of instruments are shown as o. Potential terminals of instruments are shown as ●.

Fig. A5
Circuit for Alternate Method of Power-Factor Measurement
Ammeter Included in Reference-Ballast Impedance (Z_{RB})

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Appendix B

Measurement and Adjustment of the Impedance and Power-Factor Characteristics of a Reference Ballast – Guide for the Use of the Preferred Method

Although the specifications to which a reference ballast must conform have been fully stated in the standard, it may also be helpful to outline in more detailed manner the calculations and measurements that would be needed to set up a reference ballast in compliance with these specifications.

In the following example it should be noted that (1) the preferred method of measuring the power factor, as covered in 8.7.1, will be followed; and (2) the instrument current coils will not be included in the reference ballast impedance. It will be assumed that the reference ballast is to consist of an adjustable reactor and a variable resistor connected in series.

The required value of impedance and the corresponding reference current at which it is to be measured should be obtained from the applicable American National Standard for the Dimensional and Electrical Characteristics of Fluorescent Lamps – Rapid-Start Types, ANSI C78.1-1978 and C78.1a-1980. In this example, the values used are those shown for the 40-watt T-12 rapid-start lamp. These values are:

Impedance:	439 ohms
Reference current:	0.430 ampere
Power factor:	0.075 ± 0.005 (see 6.5)

Example:

Step 1. Calculate the voltage (V_Z) that is to be impressed on the test circuit:

$V_Z = I_R \times Z_{RB}$
$V_Z = 0.430 \times 439 = 188.8$ volts

Step 2. With R at a moderate value, X_L at its maximum value, and an impressed voltage of 188.8 volts, reduce X_L until the reference current (0.430 ampere) is obtained.

Step 3. Calculate the required wattage loss for power factors of 0.07 and 0.08:

$W = V_Z \times I_R \times \text{pf}$
$W_{0.07} = 188.8 \times 0.430 \times 0.07 = 5.7$ watts
$W_{0.08} = 188.8 \times 0.430 \times 0.08 = 6.5$ watts

Step 4. For the purpose of this example it will be assumed that the instrument connections are such that the power consumed in the wattmeter potential coil is 1 watt. This must then be added to each of the values calculated in step 3. It will further be assumed that the voltmeter will be removed from the circuit each time the wattmeter is being read; hence it will not be necessary to make any adjustments for the power consumed by the voltmeter.

Step 5. With the applied voltage remaining at 188.8 volts, read the wattmeter. If the deflection is less than 6.7 watts (5.7 + 1.0), R should be increased to bring it into the range of 6.7 to 7.5 watts. If the wattmeter reading is in excess of 7.5 watts (6.5 + 1.0), R should be reduced until the wattmeter deflection is within the calculated range.

Step 6. Readjust X_L as in step 2 to provide a current of 0.430 ampere with 188.8 volts applied.

Step 7. Recheck the wattmeter reading. If the deflection is between the previously mentioned 6.7 and 7.5 watts, no further adjustment of R is required. If necessary, however, repeat steps 2 and 5 alternately until neither X_L nor R requires further adjustment.

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Appendix C

Description of and Guide for an Alternate Method of Measurement and Adjustment of the Impedance and Power-Factor Characteristics of a Reference Ballast

C1. General

The alternate procedure mentioned in 8.7.2 and described in this Appendix is recommended only if a high-quality low-power-factor wattmeter of suitable range is not available. The method described herein utilizes the same normal-power-factor wattmeter used to measure lamp power in the reference ballast circuit when the reference ballast is connected either to an operating lamp or to a dummy-load resistor (R_L) having an equivalent impedance.

Since in this method the power consumed by the reference ballast is determined as a small difference between two much larger quantities (input and output power readings), it is not as accurate as the preferred method given in 8.7.1 and for which an example is shown in Appendix B.

C2. Measurement Methods

The circuit connections needed are as shown in Fig. C1. With the instruments connected as shown, the impedance of the ammeter and wattmeter current coil will be excluded from the reference-ballast impedance. If either or both of these instrument coils are to be included in the ballast impedance, the circuit should be modified as indicated in Appendix A and the appropriate corrections applied to the instrument readings. In addition to the usual instrument switches, two other switches are required. Switch SW_1 shorts out the dummy-load resistor or lamp during the adjustment of the impedance of the reference ballast. Switch SW_2 transfers the wattmeter potential coil from the input to the output circuit.

The resistor shown as R_L may be either an operating lamp or a resistor adjusted to substitute for the lamp. If the resistor is used, its value must be such that when the reference ballast is adjusted to its proper impedance, the specified value of the reference current will be obtained in the circuit.

If an operating lamp is used instead of a dummy-load resistor, this may result in an increase in the power consumed in the reference ballast or in errors in the power measurements due to the nonsinusoidal waveshape of the lamp current, or both. Further, if successive adjustments are required for X_L and R (steps 5, 6, and 7 in the following example), employment of a lamp in position R_L will increase the time required to adjust the impedance and power factor since it will be necessary to allow the test lamp to stabilize after each adjustment of X_L and R before meaningful power measurements can be taken.

When the wattage readings are being taken, the line voltmeter and the ammeter may be left in the circuit. No correction is needed for the line voltmeter, the ammeter, or the wattmeter current coil since these affect both the input and the output measurements to the same degree. The power consumed by the wattmeter potential coil, however, must be calculated and subtracted from each wattmeter reading since it will not be the same for the two measurements.

The power consumed by the reference ballast is the difference between the input and the output wattage. The ballast power factor is the ratio of this wattage value to the product of the current and voltage. A measurement of the voltage was obtained as part of the impedance measurement covered in 8.6.

The required value of impedance and the correspond- reference current at which it is to be measured should be obtained from the applicable American National Standard for the Dimensional and Electrical Characteristics of Fluorescent Lamps – Rapid-Start Types, ANSI C78.1-1978 and C78.1a-1980. In the following example, the values used are those shown for the 40-watt T-12 rapid-start lamp. These values are:

Impedance:	439 ohms
Reference current:	0.430 ampere
Power factor:	0.075 ± 0.005 (see 6.5)

Example:

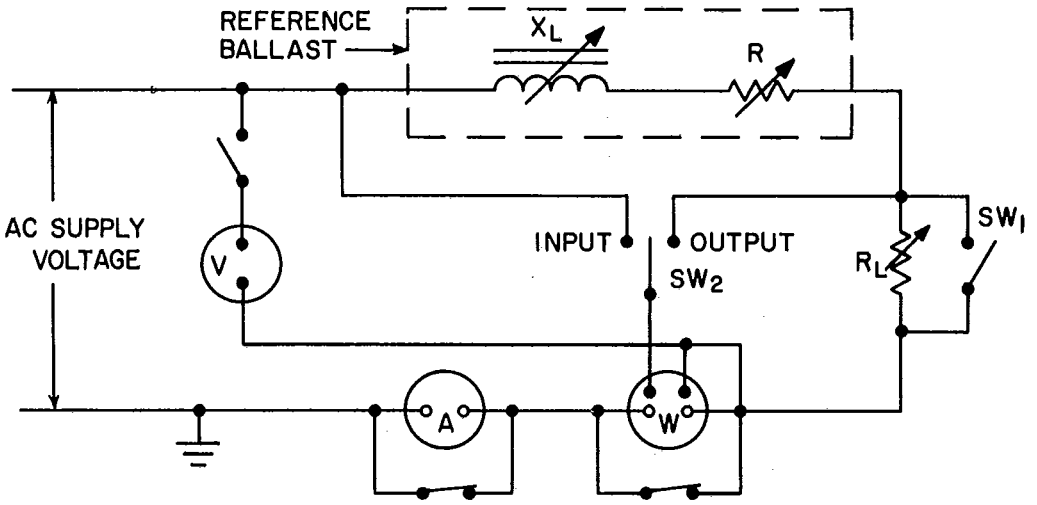
Step 1: Calculate the voltage (V_Z) that is to be impressed on the test circuit:

$$V_Z = I_R \times Z_{RB}$$
$$V_Z = 0.430 \times 439 = 188.8 \text{ volts}$$

Step 2. Set X_L at its maximum and R at a moderate value. Place SW_1 in the closed position and SW_2 in the open position. With a voltage of 188.8 volts applied to the circuit, reduce X_L until the lamp reference current (0.430 ampere) is obtained.

Step 3. Calculate the required watt loss for power

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NOTE: Current terminals of instruments are shown as o. Potential terminals of instruments are shown as •.

Fig. C1
Circuit for Alternate Method of Power-Factor Measurement When High-Quality Low-Power-Factor Wattmeter Is Not Available

factors of 0.07 and 0.08:

$$W = V_Z \times I_R \times \text{pf}$$
$$W_{0.07} = 188.8 \times 0.430 \times 0.07 = 5.7 \text{ watts}$$
$$W_{0.08} = 188.8 \times 0.430 \times 0.08 = 6.5 \text{ watts}$$

In this method the power consumption of the wattmeter should not be added to the preceding values. Instead, individual corrections as indicated in step 5 should be applied to the readings of input power and output power.

Step 4. Change SW_1 to the open position. This results in either an actual lamp circuit or else a simulated lamp circuit (if a resistor is being used as the load). If the resistor-type circuit is being used, set R_L to a value approximately equal to the reference-lamp voltage divided by the reference current. If a lamp is being used as the load, its operating voltage should be approximately equal to that of a reference lamp. The impressed voltage V (regardless of the type of load used for R_L) should be approximately equal to the specified reference-ballast input voltage (236 volts). This voltage should be adjusted until the proper reference current (0.430 ampere) is obtained.

Step 5. With the current held at the reference-current value, read the input power and the load power. Note that the correction for the power consumed by the wattmeter potential coil must be calculated for each of the two conditions since different potentials are involved. To determine the correction (E^2/R) for the output measurement, it is necessary to measure the voltage impressed on the wattmeter potential coil when SW_2 is in the "output" position. The instrument used to determine this potential should not be in the circuit during the readings of output power. Each E^2/R correction should be subtracted from the appropriate wattmeter reading. If the "corrected input" minus the "corrected output" power is within the range calculated in step 2, no further adjustment is required. If the power consumed is less than the calculated value, R should be increased. Conversely, if the power consumed is greater than the calculated value, R should be decreased.

Step 6. Readjust X_L as in step 2 to provide a current of 0.430 ampere with 188.8 volts applied.

Step 7. Recheck the wattage readings as in step 5. If the difference between input power and load power is within the previously calculated range (step 3), no further adjustment is required for R. If necessary, however, repeat steps 2 and 5 until neither X_L nor R requires further adjustment.

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