ANSI C78.386 89 ■ 0724150 0005722 8 ■

American National Standard

for Electric Lamps –

Mercury Lamps – Methods of Measuring Characteristics

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ANSI®
C78.386-1989
Revision of
ANSI C78.386-1983

American National Standard
for Electric Lamps –

Mercury Lamps – Methods of Measuring Characteristics

Secretariat

National Electrical Manufacturers Association

Approved February 20, 1989

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Foreword

(This Foreword is not part of American National Standard C78.386-1989.)

In the process of measuring lamp characteristics during the development of standards for mercury lamps, Subcommittee C78-4 on High Intensity Discharge Lamps spent a good deal of time and effort on methods of testing, instruments used, and conditions in which mercury lamps are held. Much valuable information was collected. To make the electrical characteristics given in the American National Standards on mercury lamps more useful, it was decided to prepare a standard on the methods of measurement. The original standard was approved by ANSI in 1965, the first revision in 1971, and the second in 1982.

This, the third revision, includes a number of technical changes. Lamp stabilization is more explicitly defined, and the circuit in Figure 4 and the procedure for testing have been modified to include a commercial ballast for lamp warmup. The Appendix on General Characteristics of ac Instruments has been removed, since the information it contained is now obsolete.

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

This standard was processed and approved for submittal to ANSI by Accredited Standards Committee on Electric Lamps, C78. 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 C78 Committee had the following members:

T. A. Pickett, Chair
A. C. Rousseau, Vice-Chair
Vicki Schofield, Secretary C78

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Wilger Liaison Company, Inc	G. M. Plank, Jr

The personnel of Subcommittee C78-4 on High Intensity Discharge Lamps and Subcommittee C82-2 on High Intensity Discharge Lamp Ballasts, which developed this standard, included the following:

R. D. Munson, Chair C78-4
Ted Yahraus, Chair C82-2
Vicki Schofield, Secretary C78

William Alexander
William Alling
Warren Anderson
Ernest Birnstein
Peter Bleasby
B. Bolt
Anthony DiNiro
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Contents

SECTION PAGE

1. Scope and Purpose 5

2. Referenced and Related Standards 5
   2.1 Referenced American National Standards 5
   2.2 Related Standards 5

3. Measurement of Lamp Voltage, Current, and Power 5
   3.1 General 5
   3.2 Power Supply 5
   3.3 Ambient Conditions 5
   3.4 Ballasts 6
   3.5 Circuits and Equipment Grounding 6
   3.6 Lamp Position 7
   3.7 Lamp Stabilization 8
   3.8 Instruments 8
   3.9 Corrections to Compensate for the Presence of Instruments in the Lamp Circuit 8

4. Measurement of Lamp Current Crest Factor 9
   4.1 General 9
   4.2 Method A – Peak-Reading Voltmeter and rms Ammeter 10
   4.3 Method B – Oscilloscope and rms Ammeter; Oscilloscope, Current Probe, and rms Ammeter 10
   4.4 Measurement of Lamp Current Crest Factor during Lamp Warm-up 10

5. Measurement of Starting Voltage 10
   5.1 General 10
   5.2 Conditioning of Lamps for Starting Test 11
   5.3 Test Equipment and Power Supply 11
   5.4 Procedures 11

6. Measurement of Warm-up Time 12
   6.1 General 12
   6.2 Test Conditions 12
   6.3 Selection and Handling of Lamps 12
   6.4 Procedure 12

7. Testing Lamps at Maximum Permissible Voltages across Lamp Terminals 12
   7.1 General 12
   7.2 Circuit for Measurement 13
   7.3 Procedure 13

8. Measurement of Maximum Bulb and Base Temperature 13
   8.1 General 13
   8.2 Procedures 13

9. Measurement of Extinction Voltage 14

Figures

Fig. 1 Reference Ballast Circuit for Mercury Lamps 6
Fig. 2 Circuit for Measurement of Lamp-Current Crest Factor 7
Fig. 3 Circuit for Measurement of Starting Voltage and Warm-up Time 11
Fig. 4 Circuit for Measurement of Maximum Voltage Limitation 15

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American National Standard for Electric Lamps –

Mercury Lamps – Methods of Measuring Characteristics

1. Scope and Purpose

1.1 This standard describes the procedures to be followed and the precautions to be observed in measuring the characteristics of mercury lamps as specified in American National Standards covering these lamps. (See Section 2.)

1.2 It is the purpose of this standard to outline methods of measurement that will make it possible to obtain reproducible and basically accurate measurements of mercury lamp characteristics.

1.3 Deviations from the procedures given in this standard are permissible for production or other testing, provided that the methods used give results in substantial agreement with the methods given herein. In case of doubt, reference shall be made to the specified methods to establish the validity of the results obtained by any alternate procedure.

2. Referenced and Related Standards

2.1 **Referenced American National Standards.** This standard is intended to be used in conjunction with the following American National Standards. When these standards are superseded by a revision approved by the American National Standards Institute, Inc, the revision shall apply.

ANSI C78.25-1983 (R1988), Electric Lamps – Method of Measuring Lamp-Base Temperature Rise

ANSI C78.40-1985, Mercury Lamps – Specifications

ANSI C82.5-1983 and supplement ANSI C82.5a-1984, Reference Ballasts for High-Intensity Discharge Lamps

ANSI MC96.1-1982, Temperature Measurement Thermocouples

ANSI/UL 496-1986, Safety Standard for Edison Base Lampholders

2.2 **Related Standards.** The standard listed here is for information only and is not essential for the completion of the requirements of this standard.

ANSI C82.9-1988, High-Intensity Discharge and Low-Pressure Sodium Lamps, Ballasts, and Transformers – Definitions

3. Measurement of Lamp Voltage, Current, and Power

3.1 **General.** This section covers the measurement of lamp current, voltage, and power for mercury lamps as measured on a reference ballast supplied by a sinusoidal voltage input.

3.2 **Power Supply**

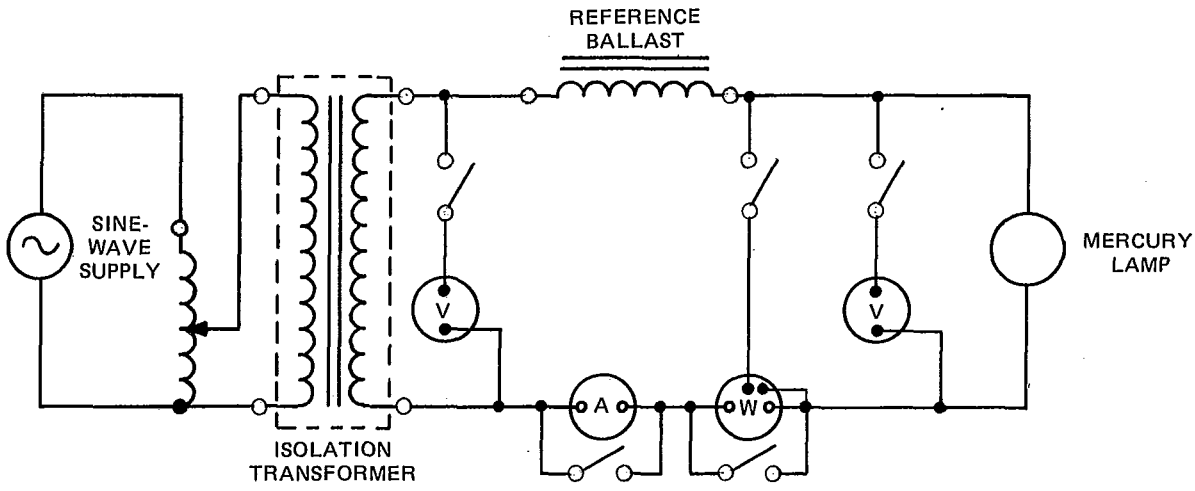
3.2.1 **Wave Shape.** The ac power supply shall have a voltage wave shape such that the root-mean-square (rms) summation of the harmonic components will not exceed 3% of the fundamental.

3.2.2 **Voltage Regulation.** The line voltage should be as steady and as free from changes as possible. For best results, the voltage shall be regulated to within ±0.5%. If adequate automatic regulation is not available, constant checking and readjustments are essential if accurate measurements of lamp characteristics are to be obtained.

3.2.3 **Power Source Impedance.** The power supply impedance, as measured at the point where the reference ballast and lamp are connected, shall not exceed 2% of the reference ballast impedance. This requires that variable autotransformers or other voltage transformation devices have a kVA rating of at least five times the normal lamp wattage to ensure compliance with the preceding requirements.

3.3 **Ambient Conditions.** The ambient in which the lamp is operated shall be maintained at 25°C ± 5°C and shall be draft-free.

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NOTE: Current terminals of instruments are shown as ○. Potential terminals of instruments are shown as ●.
WARNING: Refer to 3.5.4 through 3.5.9 for circuit and equipment grounding procedures.

Fig. 1
Reference Ballast Circuit for Mercury Lamps

3.4 Ballasts

3.4.1 When the electrical characteristics of a mercury lamp are being measured, the lamp shall be operated with a reference ballast of the appropriate rating. The use of a ballast having different characteristics (even though of the same impedance) can materially alter the electrical characteristics of the lamp. For the proper reference ballast to be used, refer to the appropriate lamp data sheets in ANSI C78.40-1985, C82.5-1983, and C82.5a-1984.

3.4.2 If electrical readings are to be taken on a lamp of a size for which no American National Standard exists, the ballast used shall be one complying with the general requirements for high-intensity discharge-lamp reference ballasts and having an impedance appropriate for the lamp.

3.4.3 For special purposes, it may be desirable to determine the electrical characteristics of lamps when they are operated by other than reference ballasts. Where this is done, such results are meaningful only for the particular ballast and circuit with which they are obtained.

3.4.4 When the electrical characteristics of a lamp are to be obtained at nominal lamp wattage, the lamp shall be operated with its reference ballast. The nominal wattage level is achieved by adjustment of the input voltage to the reference ballast. The input voltage shall not, however, be adjusted below the minimum necessary for stable lamp operation.

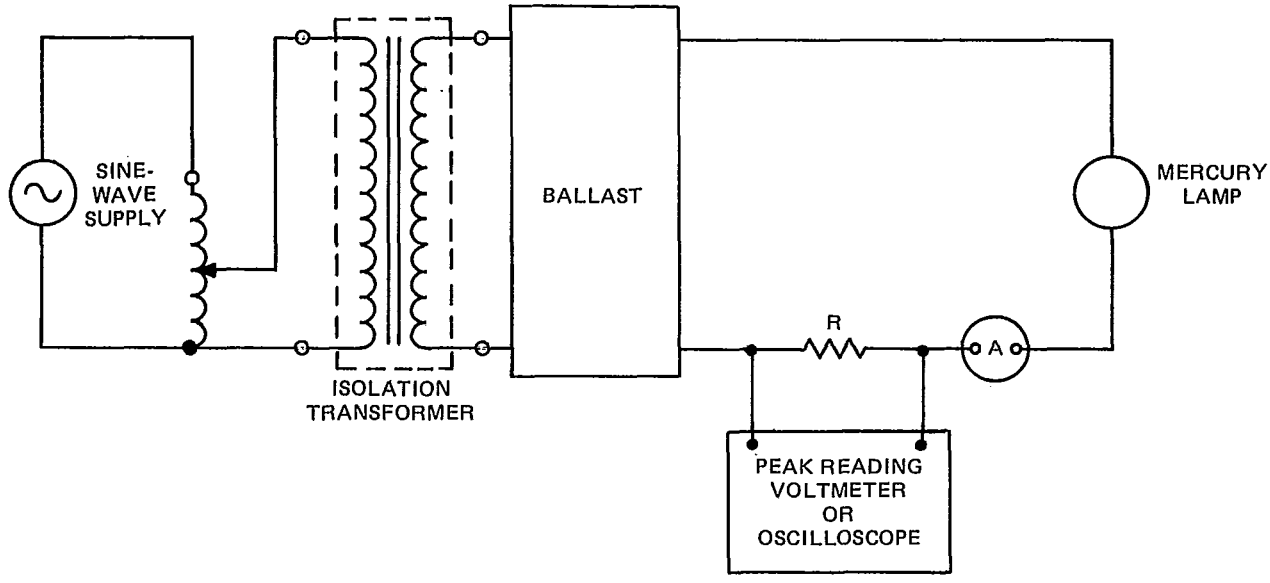
3.5 Circuits and Equipment Grounding

3.5.1 An acceptable operating circuit for a mercury lamp is shown in Fig. 1. The reference ballasts used for lamp measurement are the series-reactor type and do not include step-up transformers. In many cases, a separate transformer may be needed to provide the line voltage required by the reference ballast.

3.5.2 The method of connecting the instruments in the circuit is shown in Fig. 1. In this method, the voltmeter that measures lamp voltage and the potential element of the wattmeter are connected on the lamp side of the current-measuring instruments. Switches shall be provided so that each instrument element can be removed from the circuit when the instrument is not being read. These switches shall have a maximum resistance of 0.01 ohm, as determined by the operating volt-amp method (Vrms/Irms), and shall be well maintained to preserve this property.

3.5.3 Reference ballasts may be set up either with or without the impedance of the ammeter and wattmeter current coils included in the measured ballast characteristics. Either procedure is satisfactory, but it

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WARNING: Refer to 3.5.4 through 3.5.9 for circuit and equipment grounding procedures.

Fig. 2
Circuit for Measurement of Lamp-Current Crest Factor

is important that instrument corrections be determined for the particular method being used (see 3.9). If the impedances of the ammeter and wattmeter current coils are included in the ballast impedance, these instrument coils shall be left in the circuit at all times.

3.5.4 In order to minimize the possibility of electrical shock, it is essential that careful attention be paid to the proper grounding of the electrical circuit and certain instruments that may be used. It is especially important to make sure that electronic or other instruments having exposed metal cases always have the exposed metal parts connected to ground.

3.5.5 In the circuit shown in Fig. 1, the power supply is a two-wire system connected to the test circuit through an isolation transformer. The power supply used may or may not have one of the phase conductors at ground potential; either type of supply can be used satisfactorily, since the isolation transformer separates the measurement circuit from the power source. The instrument side of the measurement circuit may be grounded, or, if all instrument terminals are adequately insulated, it may be left "floating" (that is, with neither side connected to ground).

3.5.6 Oscilloscopes and peak-reading voltmeters, as shown in Figure 2, usually have to have one of the input terminals at ground potential. The use of the isolation transformer, described in 3.5.5, allows connection of any part of the test circuit to ground.

3.5.7 To minimize electrical shock hazard, it is essential that the exposed metal case of the oscilloscope or any other instrument *always be connected to ground.*

3.5.8 To eliminate the possibility of ground loops, it is essential that a *single* ground connection be used to ground the exposed metal case of the instrument, the instrument input terminal, and the measurement circuit.

3.5.9 Wherever the circuit permits, the lampholder shell shall be connected to the grounded side of the measurement circuit.

3.6 Lamp Position

3.6.1 Reference ballast impedance values have been standardized only for vertical and horizontal operation. For lamp measurements, the lamp shall be operated in either the vertical or horizontal position. If a lamp is marked to designate a specific operating position (verti-

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cal base-up, vertical base-down, or horizontal), it shall be tested in that position.

3.6.2 If the lamp is operated in a horizontal position, the arc will increase its length slightly because of the upward curvature of the arc stream. The amount of the increase depends on various factors such as the dimensions of the arc tube, the accuracy with which main electrodes are centered, etc. Since the electrodes are usually not perfectly centered, the electrical characteristics (voltage, current, and power) of the lamp may vary as the lamp is rotated about its axis. For this reason, when operating a lamp in the horizontal position, the value for the horizontal reading shall be obtained by burning the lamp with the arc tube in the tip-up position.

3.7 Lamp Stabilization

3.7.1 General. The stabilization requirements of 3.7.2 are applicable to any lamp, regardless of its accumulated burning time. The requirements are general but should be adhered to unless other instructions are given by the lamp manufacturer. The stabilization requirements do not supplant the initial 100-hour lamp-seasoning requirements for reference measurements.

3.7.2 Stabilization Requirements

(1) Before any measurements are taken, the lamp shall be operated until the performance characteristics are stable. Stabilization is determined by monitoring the electrical characteristics of the lamp after 15-20 minutes of operation until a change of 1% or less is observed in three successive measurements over a 15-minute period.

(2) If a lamp is warmed up on one ballast and then transferred without extinguishing to a reference ballast for measurement, an additional period of burning in the measurement circuit is usually necessary to bring the lamp to equilibrium. The length of the additional burning period can be kept to a minimum if the ballast used for warm-up operates the lamp at essentially the same power at which the lamp operates from the reference ballast. Stabilization is determined as in 3.7.2(1).

3.8 Instruments

3.8.1 Accuracy. Instruments shall be selected that have an accuracy equal to or better than 0.75% over a minimum frequency range of 40 to 1000 Hz. Scale calibration is essential to obtain accurate results.

3.8.2 Impedance Limitations

3.8.2.1 High potential-circuit impedance and low current-circuit impedance are desirable in order to reduce the disturbance to the circuit caused by the presence of the instruments.

3.8.2.2 Instruments connected in parallel with the lamp shall not draw more than 3% of the rated lamp current. If corrections for the presence of the instrument in the circuit (see 3.9) are to be avoided, this current drain shall be limited to a maximum of 1.5% of the rated lamp current.

3.8.2.3 Instruments connected in series with the lamp shall have (unless their impedance has been included as part of the reference ballast impedance) an impedance such that the voltage drop does not exceed 2% of rated lamp voltage. If corrections for the presence of the instrument in the circuit (see 3.9) are to be avoided, this voltage drop shall be limited to a maximum of 0.75% of the rated lamp voltage. In those cases where the impedance of the instrument is included as part of the reference-ballast impedance, these restrictions do not apply and no correction need be made to compensate for the presence of the instrument in the circuit.

3.8.3 Root-Mean-Square (rms) Measurements. The voltage across a mercury lamp has a distorted wave shape that departs considerably from a true sine wave shape. Therefore, the instruments used in the lamp circuits shall be of a type whose deflection depends upon the rms value of the wave. Instruments whose scales are calibrated in rms values but whose deflections depend upon average or peak values shall not be used.

3.9 Corrections to Compensate for the Presence of Instruments in the Lamp Circuit

3.9.1 General. If the electrical measuring instruments used in a mercury lamp circuit have impedances within the limits specified in 3.8 (that is, for potential coils a current drain not exceeding 1.5% of rated lamp current, and for current coils a voltage drop not exceeding 0.75% of rated lamp volts), it will not be necessary to make any corrections to compensate for the presence of the instrument in the circuit.

If the instrument impedances do not meet the above restrictions, corrections may be needed and the magnitude of these corrections can usually be determined by the restoration-of-light method. The accuracy of this method is somewhat dependent upon the stability of the light output of the particular lamp being measured, but the method will normally be useful wherever the correction to be determined exceeds approximately 1% of the electrical value being measured. The restoration-of-light method can be used for measurements on reference ballasts or on any ballast on which lamp characteristics will vary significantly with changes in line voltage.

3.9.2 Restoration-of-Light Method. The restoration-of-light method is one in which a suitable photoelectric cell and meter are used to measure the relative light output of the lamp. The photoelectric cell should be

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one that has been selected and calibrated to determine that its spectral response, linearity, and fatigue characteristics meet the requirements of the test. The test should be made with the lamp in an integrating sphere or enclosure. The procedure is as follows:

(1) Set the proper rated line voltage across the lamp and reference ballast.

(2) Note the lamp relative light output as indicated by the photoelectric-cell reading.

(3) Insert the instrument (ammeter, voltmeter, or wattmeter) and, with line voltage held constant, observe and record the instrument indication.

(4) Readjust the line voltage until the output of the photoelectric cell is stabilized at the same readings as before the instrument was inserted.

(5) Record the reading of the instrument under this new condition; within very close limits, this value will be the same as would have been obtained at rated line voltage if the instrument did not alter the lamp circuit.

(6) Remove the instrument from the circuit and recheck (1) and (2) above. The photoelectric-cell-output indication should agree with that originally obtained.

(7) The difference between the instrument indication recorded in (5) and that recorded in (3) may be used as an instrument correction to be added to (or subtracted from) observations made when holding rated line voltage. This correction, of course, applies only for that particular instrument when used with that size of lamp.

It should be noted that the reading for only one instrument at a time can be obtained by the foregoing procedure. Also, instrument scale corrections must still be applied. For a wattmeter, the power taken by its potential circuit (E^2/R) shall be subtracted from the correction that has been determined. (This assumes that the wattmeter coils have been connected as shown in Fig. 1).

The exact procedure to be followed also depends upon whether the instrument current coils are or are not included in the reference ballast impedance. The procedure is somewhat different for each of the three instruments in the lamp circuit as outlined in 3.9.3, 3.9.4, and 3.9.5.

3.9.3 Correction for Lamp Ammeter Reading

3.9.3.1 If the impedances of the current coils have been included in the measured impedance of the reference ballast, no correction is needed for the presence of this instrument (that is, the restoration-of-light method should not be used). The ammeter shall be left in the circuit at all times.

3.9.3.2 If the impedances of the current coils have not been included in the reference-ballast impedance, and if the voltage drop across the ammeter exceeds 0.75% of rated lamp voltage, the ammeter correction should be obtained by the restoration-of-light method. The ammeter should not be left in the circuit while readings of other instruments are being taken.

3.9.4 Correction for Lamp Voltmeter Reading. Regardless of which procedure is followed for the current coils, the correction for the voltmeter reading, if one is needed, is obtained by using the restoration-of-light method. The voltmeter should not be left in the circuit while readings of other instruments are being taken.

3.9.5 Correction for Lamp Wattmeter Reading

3.9.5.1 If the current coils have been included in the measured reference-ballast impedance, the wattmeter current coil shall be left in the circuit at all times and no correction need be made for the presence of this coil. The correction for the presence of the potential coil (if a correction is needed) may be obtained by using the restoration-of-light method and then subtracting the power (E^2/R) in the potential circuit. (This assumes wattmeter connections as shown in Fig. 1.)

3.9.5.2 If the current coils have not been included in the reference-ballast impedance, the correction for both the current and potential coils (if corrections are needed) may be determined at the same time by the restoration-of-light method. The power in the potential coil (E^2/R) must be subtracted from the correction obtained. (Again, this assumes wattmeter connections as shown in Fig. 1.) The wattmeter potential coil and current coil should not be left in the circuit while readings of other instruments are being taken.

3.9.5.3 The increase in wattage when the light output is restored will sometimes be very nearly equal to the decrease when E^2/R is subtracted; when this is so, it is then possible in routine work to omit both corrections and to use the wattmeter readings directly. (An instrument scale correction, of course, must still be made.)

3.9.5.4 In some cases it may be desirable to connect the lamp wattmeter so that its potential coil is on the input side of the current coil (instead of on the output side as shown in Fig. 1). If this is done, then the procedures recommended in 3.9.5.1 and 3.9.5.2 should be modified by subtracting the loss in the current coil (I^2/R) instead of the loss in the potential coil.

4. Measurement of Lamp Current Crest Factor

4.1 General. Limits of current crest factor are given in the appropriate lamp data sheets found in ANSI C78.40-1985.

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4.1.1 Methods of Measurement. The following two methods can be used to measure current crest factor:

Method A – Peak-reading voltmeter and rms ammeter

Method B – Oscilloscope and rms ammeter; or oscilloscope, current probe, and rms ammeter

The accuracy of the test method depends on the instrumentation. The use of an analog oscilloscope can limit the accuracy of Method B to approximately 5% of the measured value. This accuracy can be improved by calibrating the system with a sine-wave current of approximately the same peak current as the value to be measured. A digitizing oscilloscope, with high resolution, can be used to measure the peak current without the need for system calibration. With a CRT readout this instrument combines the best features of Methods A and B.

4.1.2 General Circuit. A generalized circuit is shown in Fig. 2. Other instruments may be needed to ensure that the lamp-ballast combination is operating as desired. The principles of circuits and equipment grounding as outlined in 3.5.4 through 3.5.9 shall be followed in setting up this circuit.

The ammeter should read true rms current and should maintain rated accuracy up to a frequency of at least 1000 Hz.

The resistance R should be noninductively wound; it must not change resistance during measurements. Its resistance shall be accurately known, and the value shall be such that when it is carrying rated lamp current the voltage across it will not exceed 0.50% of rated lamp voltage. A resistance of 0.100 ohm, rated at 15 amperes, is commonly used.

To obtain true and accurate instrument readings, care should be taken to ensure that effects from stray electromagnetic radiation emanating from ballast components are kept to a minimum.

4.2 Method A – Peak-Reading Voltmeter and rms Ammeter

(1) Place a calibrated, peak-reading voltmeter across R, as shown in Fig. 2.

(2) With the lamp operating as desired, read the rms current, as indicated by the ammeter, and the peak volts across R. The two readings should be taken close together in time.

(3) The peak current may be found as follows: Record the peak volts across R, either directly from the meter reading or (as is usually the case) by dividing the peak-to-peak reading by 2. Then divide the peak volts by R to obtain peak current in amperes.

(4) To obtain crest factor, divide peak amperes by rms amperes.

4.3 Method B – Oscilloscope and rms Ammeter; Oscilloscope, Current Probe, and rms Ammeter

4.3.1 Oscilloscope and rms Ammeter

(1) Connect an oscilloscope, calibrated in volts per unit of vertical deflection, across the resistor R, as shown in Fig. 2.

(2) With the lamp operating as desired, read the rms current as indicated by the ammeter, and find the peak volts across R by measuring the height of the wave trace from peak to peak; to find peak height, divide by 2. (If the trace height is measured in centimeters, multiply the peak height by the sensitivity of the oscilloscope in volts per centimeter to determine peak volts.) The two readings should be taken close together in time.

(3) The peak current may be found as follows: Divide peak volts by R to obtain peak current in amperes.

(4) To obtain the crest factor, divide peak amperes by rms amperes.

4.3.2 Oscilloscope, Current Probe, and rms Ammeter

(1) Resistor R is eliminated from the circuit in Fig. 2.

(2) With the lamp operating as desired, read the rms current as indicated by the ammeter. With the current probe connected to the oscilloscope, as defined by the probe instructions, clamp the probe around one of the lamp lead wires. The oscilloscope will be calibrated in amperes per unit of vertical deflection. Find the peak current through the lamp by measuring the height of the wave trace from peak to peak, and divide this value by 2. The two readings should be taken close together in time.

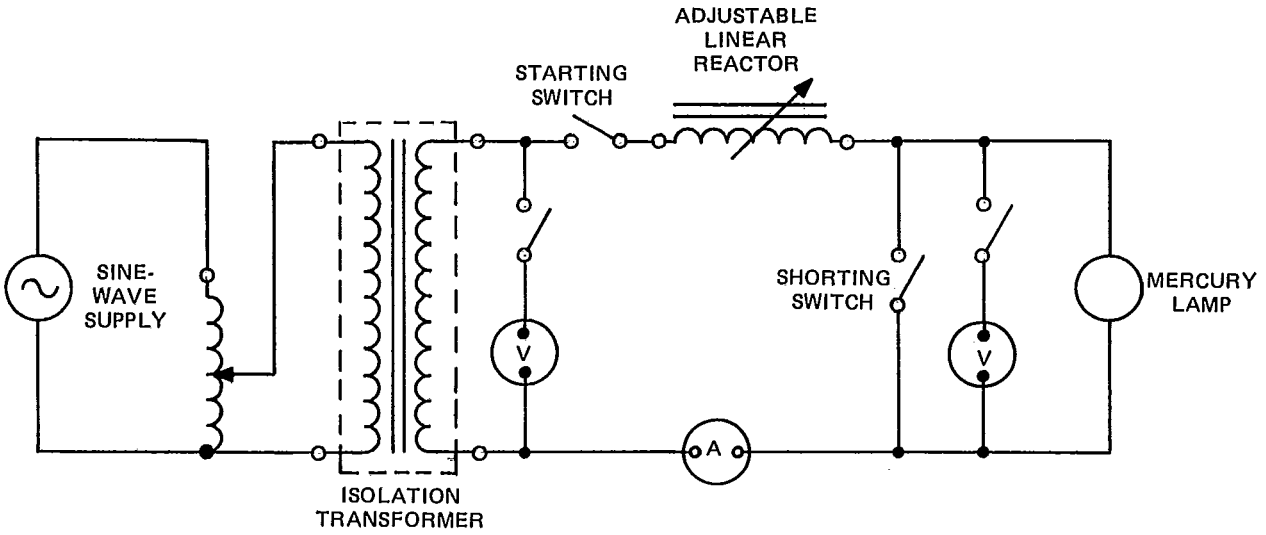
(3) To obtain the crest factor, divide peak amperes by rms amperes.

4.4 Measurement of Lamp Current Crest Factor during Lamp Warm-up. The methods for making this measurement are the same as those described in 4.1 through 4.3, except that the readings of rms amperes and peak current must be made within 5 to 15 seconds after the lamp arc has struck.

5. Measurement of Starting Voltage

5.1 General. In any group of lamps of a given type the starting voltage can vary considerably from one lamp to another. Therefore, if the starting-voltage characteristics of a large group of lamps (such as a batch of lamps offered for sale or a manufacturer's whole production of a given type) are to be determined, it is necessary to test a fairly large sample of lamps; this sample shall be so selected as to be representative of the total quantity.

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Fig. 3
Circuit for Measurement of Starting Voltage and Warm-up Time

Most starting-voltage tests are made using a power source having essentially a sinusoidal voltage wave shape. In ANSI C78.40-1985, however, starting requirements for other voltage wave shapes having crest factors higher than the square-root of 2 are established. Therefore, it may be necessary to check lamp starting on these nonsinusoidal wave shapes.

In the case of mercury lamp ballasts, open-circuit voltage wave shapes having crest factors up to 2.0 may be encountered.

5.2 Conditioning of Lamps for Starting Test

(1) Regardless of whether the mercury lamp is new or has been tested previously for starting, it shall be seasoned for at least 20 minutes at room temperature. Seasoning, as defined in this section, refers to the aging of a lamp by operating it within ±10% of the wattage obtained when operating it on a reference ballast. This seasoning requirement does not supplant the initial 100-hour lamp-seasoning requirement set forth in ANSI C78.40-1985 under General Information. Lamp position for starting test is not critical.

(2) Before testing at a given temperature, the lamps shall remain at the test temperature for a minimum of 6 hours, preferably overnight. The test chamber shall be maintained at the given temperature throughout the duration of the test.

5.3 Test Equipment and Power Supply

(1) Refer to Fig. 3 for the test circuit. The principles of circuit and equipment grounding, as outlined in 3.5.4 through 3.5.9, shall be followed in setting up this circuit.

(2) Usually a power supply having a sinusoidal voltage wave shape will be used. In most cases the normal public-utility voltage supply is satisfactory for this purpose, provided that voltage regulators do not introduce distortion. In those cases where a nonsinusoidal power supply is intentionally used, a curve shall be plotted to show the peak voltage for each value of rms voltage over the range that will be employed in the test. Both rms and peak-reading voltmeters are required to secure data for such a curve.

(3) The power supply, up to and including the isolation transformer, shall have a capacity of at least five times the normal lamp-current rating.

(4) The voltmeter shall read rms volts and shall have resistance of not less than 100 ohms per volt.

(5) An adjustable linear reactor shall be used for Procedure B in 5.4.2.

5.4 Procedures

5.4.1 Procedure A. Procedure A shall be used to determine whether or not a lamp will start at the minimum ballast open-circuit voltage specified in ANSI

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C78.40-1985. The switch-start method shall be used.

(1) With the starting switch open, set the open-circuit voltage to the minimum ballast open-circuit voltage specified in the appropriate lamp data sheets in ANSI C78.40-1985.

(2) Close the shorting switch to short out the lamp socket and then close the starting switch. Adjust the reactor to give rated lamp current at the chosen voltage.

(3) Open the lamp-starting switch, open the shorting switch, and then reclose the starting switch.

(4) Record the lamp as starting if the voltage across it drops to about 20 volts within 30 seconds. If the voltage remains high or does not fall to a steady low value, record the lamp as nonstarting; it has failed to meet the standard.

5.4.2 Procedure B. Procedure B shall be used to determine the minimum starting voltage of a lamp. The switch start-step voltage method shall be used.

(1) With the starting switch open and the lamp in the socket, set the open-circuit voltage at a value at which the lamp is *not* expected to start at the test temperature.

(2) Close the shorting switch to short out the lamp socket and then close the starting switch. Adjust the reactor to give rated lamp current at the chosen voltage.

(3) Open the lamp-starting switch, open the shorting switch, and then reclose the starting switch.

(4) Record the lamp as starting if the voltage across it drops to about 20 volts within 10 seconds. If the voltage remains high or does not fall to a steady low value, record the lamp as nonstarting.

(5) After testing the lamp at the lowest applied voltage, increase the open-circuit voltage by 5 volts for a 100 volt or lower nominal lamp; by 10 volts for a 125–135 volt nominal lamp; or by 20 volts for a 265 volt nominal lamp. Repeat steps (2), (3), and (4) for the lamp that did not start at the lower voltage. Continue to increase test voltage in 5-, 10-, or 20-volt increments (whichever is appropriate for the lamp being tested) until the lamp starts. A minimum time of 2 minutes shall elapse between successive applications of voltage.

(6) Before testing at another temperature, observe the precautions outlined in 5.2(1) and (2).

6. Measurement of Warm-up Time

6.1 General. The method described in this section is intended as an evaluation of the lamp itself and is independent of the effects of commercial luminaires and ballasts. Refer to Fig. 3 for the recommended test circuit. The test equipment and power supply requirements referred to in 5.3 shall apply.

The established requirements for lamp warm-up time are stated in the appropriate lamp data sheets in ANSI C78.40-1985.

6.2 Test Conditions

(1) A lamp shall be tested in the operating position most adverse to warm-up for the particular lamp design being tested (but not, of course, in a position in which the lamp was not intended to operate).

(2) A lamp shall be tested in still air, and precautions shall be taken to avoid having drafts in the vicinity of the lamp.

(3) If the lamp is tested in an enclosure, the enclosure shall be one that is approximately cubical in shape with a volume of not less than one cubic foot for each 12 watts of lamp power.

(4) The power-supply circuit shall be capable of maintaining the current at the specified value throughout the warm-up period.

6.3 Selection and Handling of Lamps

(1) Regardless of whether the mercury lamp has been previously stabilized, it shall be restabilized for at least 20 minutes at room temperature according to the requirements in 3.7.2.

(2) Before testing, the lamp shall remain at the test temperature for a minimum of 6 hours, preferably overnight.

6.4 Procedure

(1) The lamp shall be operated at the constant current specified in the appropriate lamp data sheets in ANSI C78.40-1985. Constant current shall be maintained by varying the line voltage.

(2) Warm-up time shall be measured from the moment the arc strikes to the time when the lamp voltage reaches 95% of the minimum specified lamp operating voltage for the lamp position employed in the test.

7. Testing Lamps at Maximum Permissible Voltages across Lamp Terminals

7.1 General. If a lamp is to be tested for its ability to withstand specific maximum voltages across its terminals, the lamp shall first be made inoperative. For the purpose of this particular test, the simplest way to render a lamp inoperative is first to allow the arc tube to reach normal operating temperature and then shut off the lamp for a few seconds so that the gas in the arc tube will deionize. The power can then be reapplied, but the lamp will not restart for a minute or two, even at 2000 volts (although glow may be established between the starting electrode and its adjacent main elec-

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trode). Refer to ANSI C78.40-1985 for the voltages (rms and peak) that a lamp is required to withstand. These standards also give the length of time that the test voltage is to be applied.

7.2 Circuit for Measurement. The circuits to be used are shown in Fig. 4. Circuit I is used to supply the specified rms test voltage. Circuit II supplies the specified peak voltage. Circuit III utilizes a commercial ballast to warm up the lamp. The principles of circuit and equipment grounding as outlined in 3.5.4 through 3.5.9 shall be followed in setting up these circuits.

7.3 Procedure. While referring to Fig. 4, perform the following procedure:

(1) With ganged switch S3 in position 1 as shown in Fig. 4 (with warmup circuit inoperative and no lamp in the socket), close ammeter switch, close voltmeter switch, and close switch S1. Set the rms voltage to the value specified in the appropriate lamp standard as indicated by the voltmeter. Open the ammeter switch, open the voltmeter switch, close the shorting switch, and adjust the linear reactor (Circuit I) for the rated lamp current. Open the shorting switch, close the ammeter switch, close the voltmeter switch, and readjust the rms voltage if necessary. Open switch S1.

(2) With switch S1 open, no lamp in the socket, and ganged switch S3 in position 1 as shown in Fig. 4 (warmup circuit inoperative), close ammeter switch, close voltmeter switch, and close switch S2. Set the peak voltage to the value specified in the appropriate lamp standard as indicated by the peak-reading voltmeter, or oscilloscope connected at the voltmeter position (Circuit III in Fig. 4). Close the shorting switch, open the voltmeter switch, open the ammeter switch, and adjust the linear reactor in Circuit II to provide a short-circuit current of 1 ampere or less but high enough for visual detection of an arc in the lamp. Open the shorting switch, close the voltmeter switch, close the ammeter switch, and readjust the peak voltage if necessary. Open switch S2, open the ammeter switch, and open the voltmeter switch.

(3) Insert the test lamp in the socket. Close the ammeter switch and change switch S3 to position 2. Then allow the lamp to warm up (usually about 10 minutes).

(4) When the lamp has warmed up, set switch S3 to position 1. After five seconds, close switch S2 and leave it closed for 1 second; then reopen it.

(5) Immediately close switch S1. Leave it closed until the lamp restarts and then reopen it. While the test voltages are being applied in steps (4) and (5), there may be a small arc between the starting electrode and its adjacent main electrode. This is normal. If an arc occurs in any other place in the lamp, the lamp will have failed the test.

8. Measurement of Maximum Bulb and Base Temperature

8.1 General. Maximum permissible values of bulb and base temperature shall be in accordance with ANSI C78.40-1985.

8.2 Procedures

8.2.1 Thermocouple Method for Bulb Temperature

(1) Thermocouple wire shall be size 30 AWG and shall conform with the requirements of "special" thermocouples as listed in ANSI MC96.1-1982, Table 8, "Initial Calibration Tolerances for Thermocouples." Thermocouples and methods of attachment shall be arranged to absorb a minimum of energy. The effects of radiant energy on the thermocouple can be minimized by taking readings after the lamp has been extinguished and extrapolating back to time-zero.

(2) The contact pressure of the thermocouple junction against the glass shall be sufficient to ensure that no further pressure affects the temperature.

(3) If the instrument used does not have room-temperature compensation adjustments, an ice-water bath shall be used for the reference junction.

(4) Since reaching temperature equilibrium may require considerable time, readings shall be taken at 15-minute intervals until at least three consecutive readings are the same.

(5) It may be necessary to measure a number of points on the bulb in order to locate the maximum temperature.

8.2.2 Thermocouple Method for Base Temperature

(1) For base temperature measurements, refer to ANSI C78.25-1983.

(2) Where base temperatures are being measured with lamps in a luminaire to evaluate the luminaire's effect on the base temperature, it is obvious that a metal sleeve cannot be used. In such cases, the thermocouple shall be attached directly to the base-shell itself, as close as possible to the junction of the base-shell with the glass bulb.

(3) The stipulations of 8.2.1(1), (3), and (4) also apply to base temperature measurements.

8.2.3 Infrared-Radiation Method for Bulb Temperature

(1) The instrument used shall be sensitive only to radiation over a wavelength which is (a) not transmitted

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by glass, so as to avoid contribution from hot components within the lamp bulb, especially the arc tube; and is (b) not absorbed by atmospheric components. For practical purposes, this is limited to the wavelength range 4.8 micrometers to 5.6 micrometers for bulb thickness down to 0.7 mm.

(2) To this method of measurement, 8.2.1(4) and (5) are applicable.

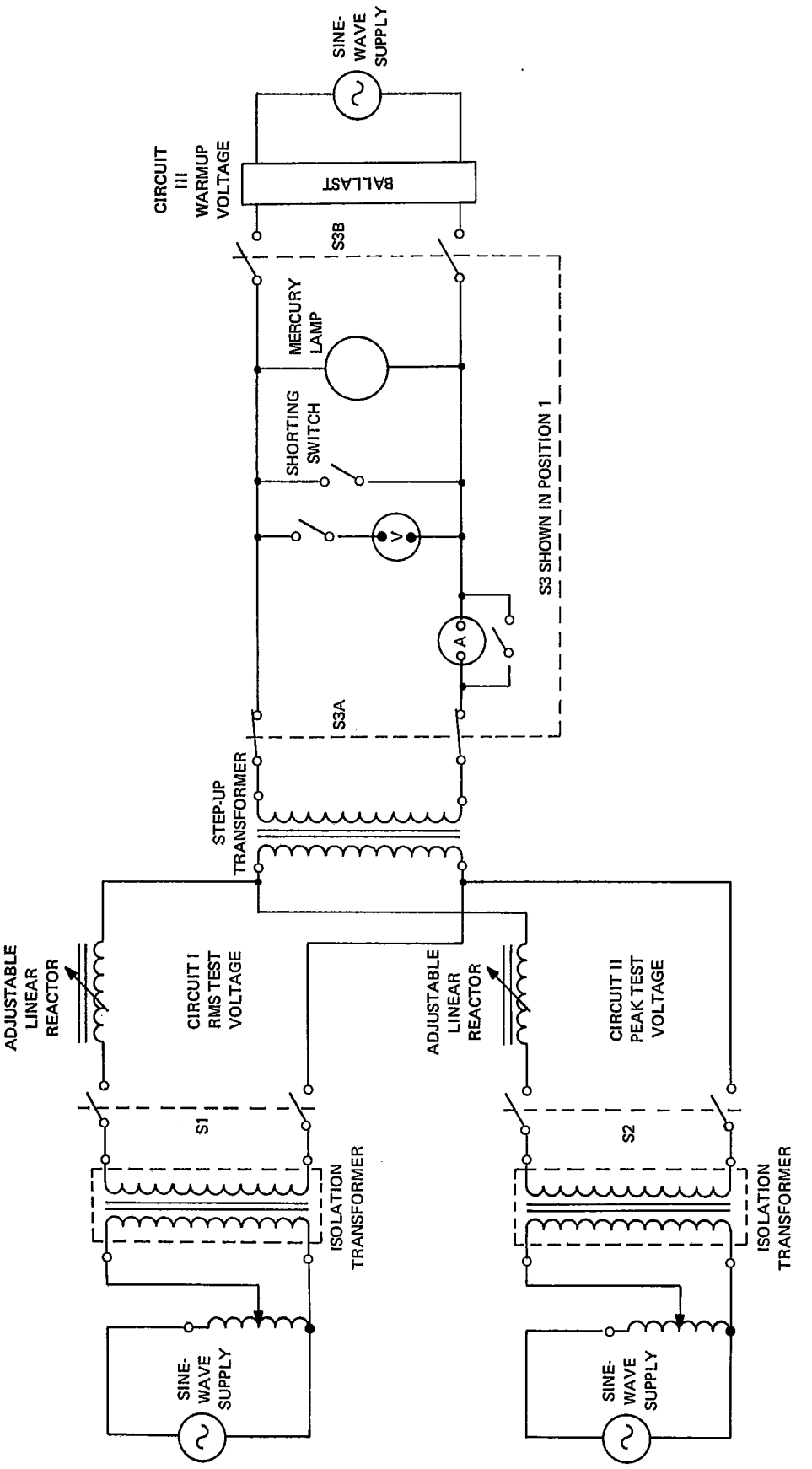
(3) Commercial instruments may differ; the procedures outlined in the manufacturer's operating manual should be followed.

9. Measurement of Extinction Voltage

(To be developed.)

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NOTES:
(1) For setting Circuit I the voltmeter should be an rms meter. For Circuit II the instrument should be a peak-reading voltmeter or oscilloscope.
(2) Position 1 of switch S3 is S3A closed and S3B open. Position 2 of switch S3 is S3A open and S3B closed.
(3) Current terminals of instruments are shown as ○. Potential terminals of instruments are shown as ●.

CAUTION: Neither switch S1 nor S2 should be closed when switch S3 is in position 2.

WARNING: Refer to 3.5.4 through 3.5.9 for circuit and equipment grounding procedures.

Fig. 4
Circuit for Measurement of Maximum Voltage Limitation

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