American National Standard

for Fluorescent Lamps – Guide for Electrical Measurements

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American National Standard for Fluorescent Lamps – Guide for Electrical Measurements

Secretariat

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American National Standard

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Contents

Foreword (This foreword is not part of American National Standard C78.375-1991.)

This standard supersedes *American National Standard guide for electrical measurements of fluorescent lamps*, ANSI C78.375-1984.

There have been some changes from the 1984 edition in order to bring the publication into conformity with present practice.

Suggestions for improvement of this standard will be welcome. They should be sent to the Secretariat, C78.2 Subcommittee, National Electrical Manufacturers Association, 2101 L Street, NW, Washington, DC 20037.

This standard was processed and approved for submittal to ANSI by the Accredited Standards Committee on Electric Lamps, C78. Committee approval of this 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:

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American National Standard for Fluorescent Lamps – Guide for Electrical Measurements

1 Scope

This standard describes the procedures to be followed and the precautions to be observed in obtaining uniform and reproducible measurements of the electrical characteristics of fluorescent lamps under standard conditions when operated on alternating-current (ac) circuits. These methods are applicable both to lamps having hot cathodes – either switch-start (preheat-start), rapid-start (continuously heated cathodes), or instant-start – and to lamps of the cold-cathode variety.

The electrical characteristics usually measured are lamp current, lamp voltage, and lamp power. In the case of rapid-start lamps, the power measurements may include both the arc watts[1)] and the cathode watts. Total lamp power will then be the sum of arc watts and cathode watts.

The methods noted in this standard apply to fluorescent lamps operated at common power-line frequencies (50 and 60 Hz). Other methods may be needed for operation of lamps at high frequencies, and these are under consideration.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ANSI C78.1-1978, C78.1a-1980, C78.1b-1986, C78.1c-1985, and C78.1d-1988, *Dimensional and electrical characteristics of fluorescent lamps – Rapid-start types*

ANSI C78.2-1978 and C78.2a-1988, *Dimensional and electrical characteristics of fluorescent lamps – Preheat-start types*

ANSI C78.3-1978 and C78.3a-1985, *Dimensional and electrical characteristics of fluorescent lamps – Instant-start and cold-cathode types*

ANSI C82.3-1983, *Reference ballasts for fluorescent lamps*

3 Electrical supply characteristics

3.1 Voltage waveshape

The ac voltage supply, throughout the full test range, shall have a waveshape such that the root-mean-square (rms) summation of the harmonic components shall not exceed 3% of the fundamental.

3.2 Voltage regulation

The line voltage shall be as steady and as free from sudden changes as possible. For best results, the voltage shall be regulated to within ±0.1%. If adequate automatic regula-

1) *Arc watts* is the term used for the power consumed by the discharge only and does not refer to any power that may be supplied to the lamp cathodes from a separate voltage source.

tion is not available, accurate measurements shall be obtained by constant checking and readjustment.

NOTE – If the static type of voltage stabilizer is used, it is particularly important to check the waveshape to see that it meets the specification given in 3.1.

3.3 Supply-source impedance

The supply source shall have sufficient power capacity and a sufficiently low impedance, compared with the ballast impedance, to ensure that the voltage to the lamp-ballast combination does not vary by more than 2%, with the lamp-ballast combination in and out of the circuit.

4 Ambient conditions for lamp measurements

4.1 General

Certain electrical characteristics, and also the light output, of fluorescent lamps are appreciably affected by variations in ambient temperature and by air movement along the bulb surface. These parameters are controlled by methods specified in 4.2, 4.3, and 4.4.

4.2 Temperature

The room in which measurements are being taken shall be maintained at an ambient temperature of 25°C ± 1°C. (The preferred tolerance may be as exact as ±1/2°C.) This temperature shall be measured at a point at least 1 but not more than 3 ft from the lamp and at the same height as the lamp. For lamps burned in a base-up position, the height is defined as the midpoint of a plane, bisecting the vertical axis of the lamp. The temperature-measuring device shall be shielded from the lamp or radiation from any other source. Care shall be taken, however, to prohibit the lamp-bulb wall temperature from increasing above normal, as might happen in small enclosures or with the use of baffles to restrict air movement.

4.3 Drafts

Drafts shall be avoided and constant care shall be exercised to keep air movement to the lowest possible velocity while measurements are being taken. (Air movement during lamp measurements shall ideally be less than 1 ft/min, but movement of up to 5 ft/min is still acceptable.)

Fluorescent lamps of the higher-current types (800 milliamperes and above) are more sensitive to air movement and temperature than those of the lower-current types and may require additional precautions. For example, when light output of these highly loaded lamps is being measured, special shielding, such as fine wire mesh or cheesecloth, may be placed near the lamps in order to obtain reproducible comparative data.

4.4 Lamp position

To ensure stabilized and uniform air convection over the lamp surface, lamps shall be operated in the following positions when measurements are being taken.

Lamp type	Operating position[2]
Linear	Horizontal
Circular	Horizontal
Single-ended compact	Base-up or horizontal[3]
U-shaped	Horizontal

5 Ballasts

5.1 Reference ballasts

When the electrical characteristics of a fluorescent lamp are being measured for rating purposes, the lamp shall be operating in conjunction with a reference ballast. (The use of a ballast having differing characteristics, even though of the same impedance, can significantly alter the electrical characteristics of the lamp.) The general characteristics of reference ballasts are described in ANSI C82.3-1983. The specific values of impedance, refer-

[2] Note that some lamp manufacturers may specify a certain horizontal orientation that, according to their specifications, would help stabilize the lamp and ensure maximum light output. This is particularly true of lamps having a noncircular cross section.

[3] Check the appropriate American National Standard for lamps, or if not available, check the manufacturer's literature.

ence current, and rated input voltage for the reference ballasts corresponding to each lamp size are given in the respective lamp standards, ANSI C78.1-1978, C78.1a-1980, C78.1b-1986, C78.1c-1985, C78.1d-1988, C78.2-1978, C78.2a-1988, C78.3-1978, and C78.3a-1985.

5.2 Nonstandard lamp types

If readings are to be taken on a lamp of a size for which no standard exists, the ballast shall comply with the general requirements of ANSI C82.3-1983. The impedance of the ballast should be such that the open-circuit voltage will, for switch-start and rapid-start lamps, be at least twice the lamp voltage, and for instant-start lamps, at least three times the lamp voltage.

5.3 Other ballasts

For special purposes, the electrical characteristics of lamps when they are operated by other than reference ballasts may need to be determined. Where this is done, such results shall be considered meaningful only for the particular ballast and circuit for which they were obtained and not directly comparable with data taken on a reference ballast.

6 Circuits

6.1 Measurement Circuit

The measurement circuit employed for fluorescent lamps is shown in figures 1(a) through 1(g). The reference ballasts used for lamp measurement are of the series-reactor type and do not include a step-up transformer. In many cases, a separate step-up transformer is needed to provide the input voltage required by the reference ballast.

6.2 Instrument connections

Figure 1(a) shows the method of connecting instruments into the circuit. The voltmeter 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 can be removed from the circuit when it is not being read. These switches shall have low resistance and shall be well maintained to preserve this property. If knife switches are used, a bypass lead at the hinged end of each switch should be used.

Reference ballasts may be set up either with or without the impedances of the ammeter or wattmeter current coils, or both, included in the measured ballast characteristics. Either procedure is satisfactory, but it is important that instrument corrections be determined for the particular method being used (see clause 10). If the ammeter or wattmeter current coils, or both, are included in the ballast impedance, these instrument coils shall be left in the circuit at all times.

Figure 1(b) shows the method of connecting into the circuit an instrument capable of measuring and displaying wattage, current, and voltage. The potential element of the instrument is connected on the lamp side of the current measuring element. A switch provides a means of measuring either lamp or input voltage of the reference circuit with the same potential element. An auxiliary voltmeter, V_2, can be used if monitoring input and lamp voltage simultaneously is desirable. Corrections to compensate for the presence of the measuring elements in the circuit can be calculated from the impedance specification data provided by the manufacturer of the instrument, or they can be determined by using switches to remove instruments from the circuit. (See clause 9.) Usually this type of multifunction instrument has negligible effect on the circuit and does not require corrections. Some units have internal or automatic burden compensation.

Satisfactory results can be obtained using the circuit shown in either figure 1(a) or 1(b); however, the latter offers the advantage of simplicity, reducing the number of separate instruments and in most cases eliminating the need for correction.

6.3 Preheat-start lamps

For preheat-start lamps, the complete circuit needed is a combination of figures 1(a or b) and 1(c) (or, alternatively, figures 1(a or b) and 1(d)). If the starting switch is normally shunted by a capacitor when the lamp is being started, this capacitor shall be disconnected before readings of lamp characteristics are taken. If the starter and starting capacitor are integral to the lamp, then measurements are taken with these components in the circuit.

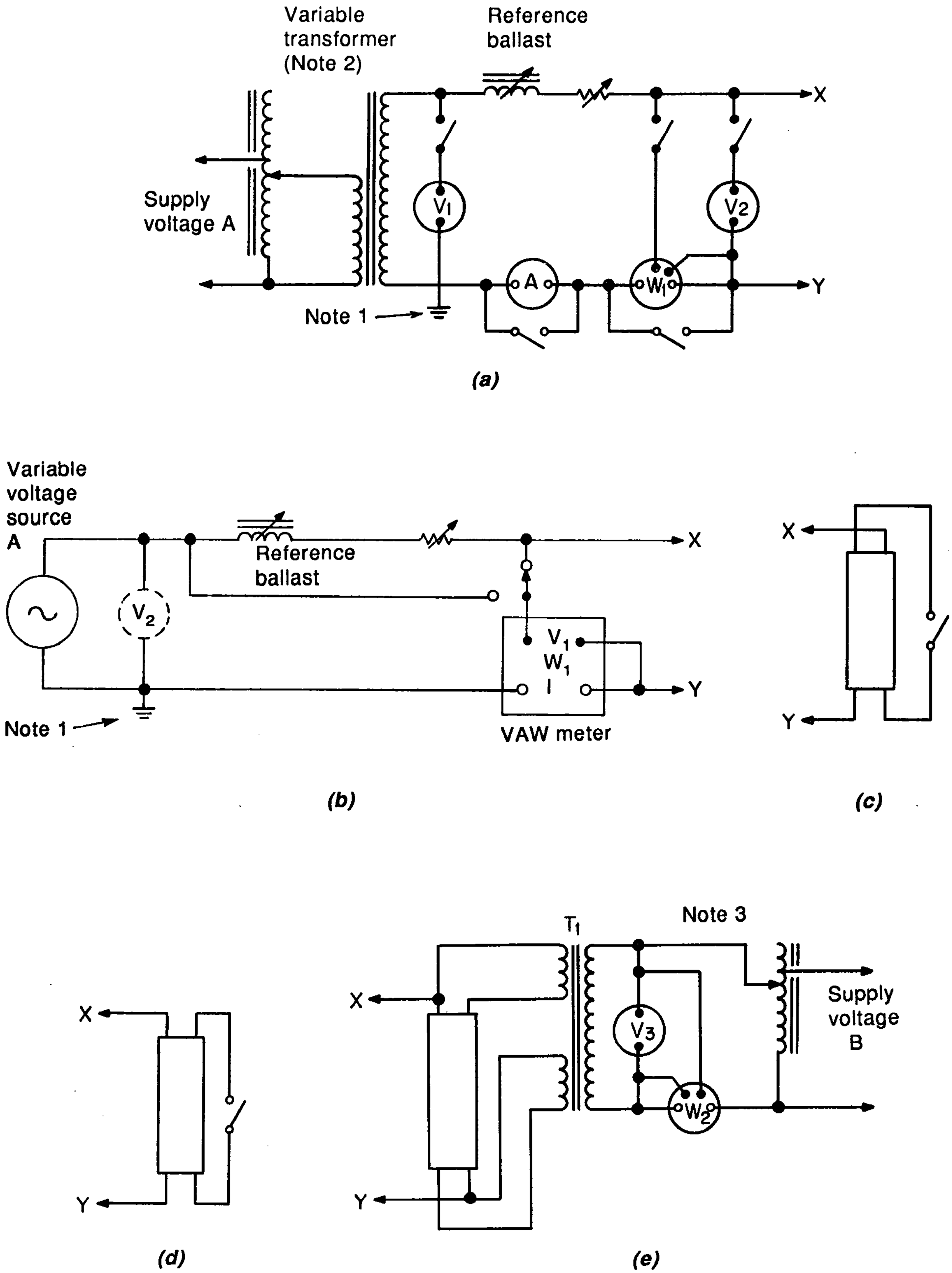
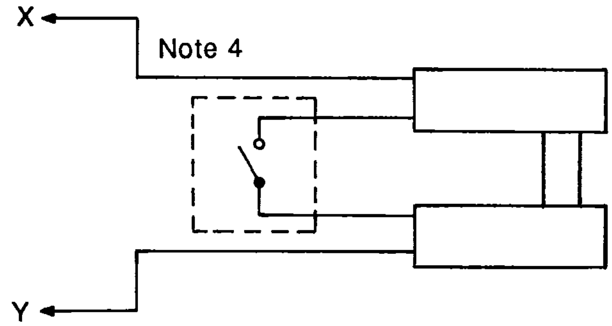
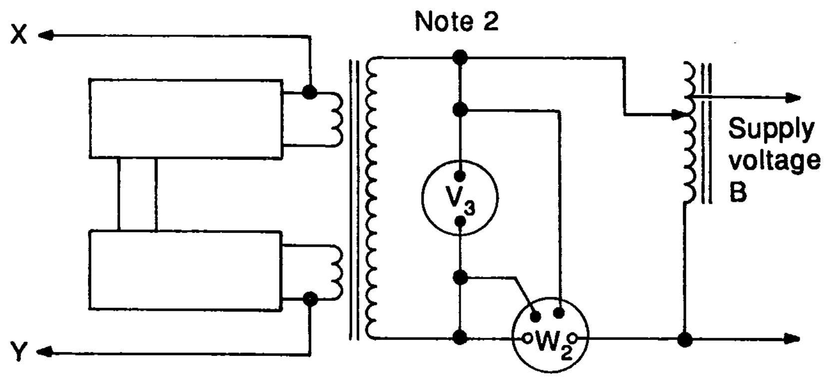


Figure 1 – Measurement circuit for fluorescent lamps



(f)



(g)

NOTES

1 This side of the circuit shall be the one connected to ground if a grounded supply system is used.

2 The transformer shown at this point in the circuit is often necessary in order to obtain the open-circuit voltage required by the reference ballast for certain sizes of lamps. Either an autotransformer or a double-sound transformer can be used.

3 The transformer supply voltage B shall come from the same line (and the same phase if a three-phase supply is being used) as the reference ballast supply voltage A. Unless the precaution is observed, the subtractive polarity of the cathode windings may not actually be obtained.

4 Current terminals of the instrument are shown as ○. Potential terminals of instruments are shown as ●.

5 The starting circuit may be integral to the test lamp and may include a shunt capacitor.

Figure 1 *(concluded)*

6.4 Instant-start lamps

For instant-start lamps, the connections shall be the same as for preheat-start lamps, except that the starting circuit is omitted.

6.5 Rapid-start lamps

For rapid-start lamps, the reference ballast circuit to be used is a combination of figures 1(a or b) and 1(e). This arrangement provides separate low-voltage sources of cathode heat and allows the lamp to operate in its normal manner.

The cathode voltage may be supplied from a suitable transformer (or two separate transformers) having known losses. The cathode transformer windings shall be so connected to the rest of the circuit that their voltage subtracts from the voltage supplied by the reference ballast circuit itself. The points *X* and *Y*, therefore, shall be the points of maximum potential difference at the lampholder terminals, and the arc shall operate across the lamp between these two points. The power consumed by the cathodes in an operating lamp shall be that indicated by wattmeter W_2, less the transformer loss. The power consumed by the lamp discharge shall be indicated by wattmeter W_1 and is usually referred to as arc watts. The total lamp power is the sum of W_1 and W_2.

The low-voltage cathode heating transformer(s), T_1 in figure 1(e), may be either two separate transformers or a single transformer having two secondary windings. These transformers shall be of high quality, have good regulation (less than 5%), and have a current capacity several times the actual current required. They shall also have low losses to minimize the effect that any error in the measurement of these losses would have on the total lamp watts.

The center values of cathode voltage shall be 3.6 volts for the regular rapid-start lamps and 8.5 volts for the high-resistance cathode lamps (that is, preheat-start lamps), some of which may at times be operated with ballasts of the rapid-start type. Where a 3.6-volt output is required, a regular 6.3-volt filament transformer operated at a reduced primary voltage should be used so that an output of 3.6 volts is obtained. Where an output of 8.5 volts is needed, a nominal 12.6-volt filament transformer may be used satisfactorily.

6.6 Calibration of cathode heating transformers

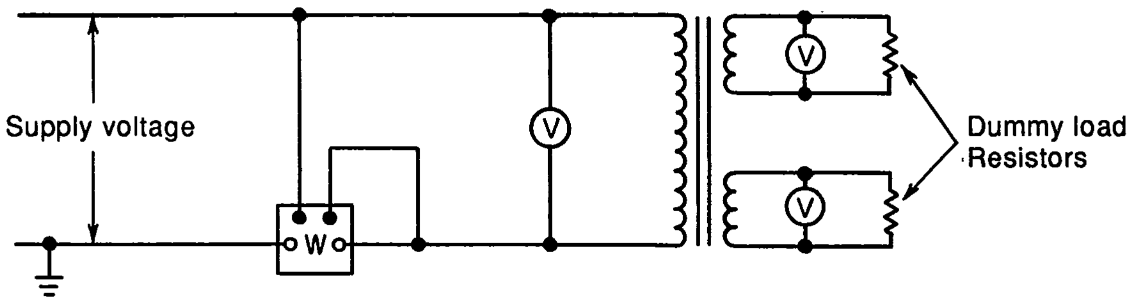
Each cathode transformer (or pair of transformers) shall be individually calibrated to determine the power loss that will exist during normal operation. This power loss will, of course, vary with the current to be supplied to the particular type of cathode involved. These loss values, however, shall be determined only once for a given transformer for each cathode type. The appropriate transformer losses can be applied to the measurements of the various types of lamps.

It is also desirable to obtain a voltage calibration on each transformer; that is, to determine the primary voltage that shall be set in order to obtain the desired secondary output voltage. This calibration, although not entirely essential, makes it possible to use primary voltage settings in all routine work, thus avoiding the need for constant use of the more fragile low-range thermocouple voltmeters.

The circuit used in making the calibration is shown in figure 2. Each secondary winding shall be connected to a dummy load resistor having the electrical characteristics specified for the particular cathode type involved. The primary voltage shall be adjusted so that the average of the two secondary voltages is 3.6 volts (or 8.5 volts in the case of high-resistance cathode lamps), and the value of primary voltage is then recorded. This calibration shall be repeated for any other cathode types with which the transformer is to be used.

The power loss in the transformer (core loss and I^2R loss considered together) shall also be determined for each load condition. The loss shall be measured by the circuit described for voltage calibration. With the primary voltage again set so as to give the specified voltage (that is, 3.6 volts or 8.5 volts) across the secondary load, the power input shall be read. The loss in the transformer may be calculated as the wattage input reading minus the instrument correction (for the two potential circuits) and also minus the power absorbed by the load resistors. This power in the load resistors can be calculated as E^2/R for each of the windings.

Since the total wattage to be read is likely to be below 10 watts, a low-range wattmeter shall be used.



NOTE – Current terminals of instruments are shown as O. Potential terminals of instruments are shown as ●.

Figure 2 – Circuit for the calibration of cathode transformers

The transformer loss is assumed to be constant for all lamps having the same cathode resistance, and no allowance shall be made for the slight differences resulting from variations in the actual cathodes.

To make a measurement of lamp cathode power, the lamp is operated in the normal manner on the reference ballast with the lamp connections shown in figure 1(f). Primary voltage V_3 is adjusted as previously determined to give the proper voltage on the cathodes, and the input power is read on W_2. Cathode power is then equal to the input power minus the transformer losses previously determined.

An electronic variable power source may be used to supply cathode heating and a separate voltmeter and wattmeter may be used to take measurements on each cathode. However, as in the case of using transformers, the cathode voltage must subtract from the voltage supplied by the reference ballast to ensure that points *X* and *Y* will be the points of maximum potential difference at the lampholder terminals.

6.7 Circuit grounding

In all of the wiring diagrams shown in this standard, the side containing the instrument's current coil is shown connected to the ground. 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 already grounded at some other potential (for example, a 120/240, three-wire supply with the mid-point grounded), the grounded connection as shown in these diagrams shall not be used, but in such cases other arrangements shall then be made to minimize shock hazard.

7 Lamp connections

7.1 Preheat-start lamps

Linear lamps of the preheat-start type are provided with two contact pins at each end of the lamp. One pin at each end is connected to the operating circuit (at points *X* and *Y*, figure 1(a)), and the remaining two pins are connected to the starter circuit. Single-ended compact lamps usually have an internal starting circuit. The two available contact pins are connected to the operating circuit at points *X* and *Y*, figure 1(a or b).

For consistent results, each lamp shall always be operated with the same two pins connected to the operating circuit. This requirement shall apply not only during the operation of the lamp while measurements are being taken but also during all other periods of operation prior to the time of measurement.

For linear lamps, one pin at each end of the lamp should be marked to indicate the operating circuit. It is strongly recommended that the crossover scheme, shown in figure 1(b) be followed. The parallel system, shown in figure 1(d), if consistently followed, will also give satisfactory results, but the use of two different systems may cause difficulties wherever cross-checks between different laboratories are involved.

7.2 Instant-start and cold-cathode lamps

No marking is needed for these lamps.

7.3 Rapid-start lamps

Rapid-start lamps shall have the same marking of pins as that described for preheat-start lamps, and the marked pins shall always be connected to the same point in the operating circuit. For a reference-ballast circuit, these points are marked *X* and *Y* in figure 1(a or c) and 1(e). For a commercial ballast circuit, where each lamp is connected to four of the leads from the ballast, the marked pins shall be connected to those two leads having the highest potential difference.

For single-ended compact lamps with four pins arranged in one plane, it is strongly recommended that connecting the two outside pins to the operating circuit as shown in figure 1(g) be followed as a standard procedure.

8 Lamp stabilization

8.1 Linear, circular, and U-shaped lamps

Before any measurements are taken, the lamp shall be operated long enough to attain stabilization and temperature equilibrium. For lamps intended for use at 800 milliamperes (mA) or less, a period of 15 minutes of continuous operation usually is sufficient to accomplish stabilization and temperature equilibrium, but it is better to rely on periodic checks of lamp lumens or lamp volts, or both, rather than merely on elapsed time. When these values stop drifting, the lamp has reached equilibrium. In the case of those lamps with special mercury temperature control areas, such as the 1500-mA lamps, the stabilization process is likely to be more complicated. These lamps reach a pseudostabilization condition in 30 minutes, but should be operated at least 24 hours for T-12 lamps and 150 hours for configured lamps to ensure complete stabilization. This procedure shall be repeated whenever the mercury position is disturbed by lamp motion. If the lamp is turned off without being disturbed, 2 hours of operation should be sufficient for restabilization.

If lamps are warmed up on one ballast and then transferred to a different ballast for electrical measurement, an additional period of operation in the measurement circuit is usually necessary to bring the lamp to equilibrium. The length of the additional operating period can be kept to a minimum by transferring the lamp without extinguishing it and also by using reference ballasts in the warm-up circuit. If the lamp is extinguished during transfer, or if the warm-up ballast does not match the measurement ballast, the additional operating time in the measurement circuit will be longer, possibly as long as 5 or 10 minutes.

Lamp manufacturers' initial ratings shall be based on lamps that have operated (aged) 100 hours, unless otherwise specified in the lamp standards in the ANSI C78.1 series.

8.2 Single-ended compact lamps

Single-ended compact fluorescent lamps are generally more difficult to stabilize for measurements than conventional linear or circular lamps. The electrical and photometric properties are highly dependent on the mercury vapor pressure within the discharge tube. This, in turn, is affected by the location of the mercury within the lamp.

8.2.1 Prestabilization procedure

Lamps should be initially operated for 15 hours at rated voltage ±5%. They must be in a base-up position. Ambient temperature should not exceed 40°C to ensure that excess mercury condenses in the coolest parts of the lamp. If lamps are aged in the base-up position and care is taken to physically handle the test lamps according to clause 8.2.2, Lamp circuit transfer, then the prestabilization requirement will have been met during the aging period and stabilizing the lamp again prior to taking measurements is not necessary.

Some lamp types, particularly lamps without cold chambers, may not require 15 hours of operation to sufficiently stabilize for photometric measurements. Five hours may be an adequate period. Only experience in testing a particular lamp type will determine a minimum stabilization time that will result in reproducible measurements. Unless experience permits otherwise, the 15-hour prestabilization period is recommended.

For a method of reducing the prestabilization time of test lamps with cold chambers, see annex A.

8.2.2 Lamp circuit transfer

Because of the time required for prestabilization, it is usually desirable to operate lamps at a separate location from the measurement equipment, thus permitting measurements on other lamps to be taken concurrently. In this case, the test lamp is extinguished at the end of the prestabilization period and then transferred to the test position. As it is moved from one location to the other, it is important to keep the test lamp in the same physical orientation (e.g., base up) as maintained during prestabilization. Care must be taken to avoid shaking or bumping the lamp during transfer, as this could cause mercury to dislodge from the cool zones. The lamp will be less sensitive to movement if it is allowed to cool down for 15 minutes before being transferred to the photometric equipment.

If the prestabilization location is physically the same as the measurement location but the lamp is prestabilized on one ballast and electrically switched over to a different ballast or variable reactor for measurement, an additional period of operation in the measurement circuit is necessary to restabilize the lamp.

Before any measurements are taken, lamps should be operated long enough to obtain restabilization and temperature equilibrium. A period of 15 minutes of continuous operation is usually sufficient. However, it is better to rely on periodic checks of lumens, lamp volts, or both, rather than elapsed time. For lamps with integral ballasts, it will not be possible to measure and monitor lamp volts.

8.2.3 Aging

Although lamp aging can be done in any position, prestabilization and photometric and electrical testing of single-ended compact fluorescent lamps must be done with the lamp in a base-up position unless otherwise specified by the lamp manufacturer. This is due to the fact that the mercury vapor pressure and, therefore, the light output and electrical parameters may vary with the operating position. Aging single-ended compact fluorescent lamps in the specified position will eliminate the need for a separate prestabilization period.

8.3 Abnormal behavior

Lamps that show swirling or other abnormal behavior shall not be considered to be stabilized for measurement purposes. Swirling can usually be detected by the naked eye. However, there are also invisible or incipient swirls that can affect electrical measurements. These can usually be located by running a small permanent magnet along the length of the lamp. Any incipient swirling will be evidenced by a perceptible brightening at the spot where the swirling exists. Turning the lamp off for approximately 15 seconds and restarting often eliminates the trouble. The lamp shall then be restabilized before measurements are made.

Starting of preheat fluorescent lamps with inadequate cathode preheating is conducive to lamp swirling. The use of a manual switch, bypassed by an appropriate capacitor, usually results in more stable operation than starting with the conventional glow-switch type of starter.

9 Instruments

9.1 Accuracy

Instruments that have a guaranteed accuracy commensurate with the requirements of the test shall be selected. Scale calibration shall be used to obtain reasonable accuracy of results. Instruments shall be chosen so that the deflection to be read will be in the upper one-third of the scale, if possible.

9.1.1 Linear and circular lamps

For linear and circular lamps, ammeters and voltmeters shall have accuracies of not less than ±1/2%, up to 800 Hz. Wattmeters shall have accuracies of not less than ±3/4%, up to 800 Hz and down to at least 50% power factor. These specified performances to higher frequencies are necessary to correctly evaluate the distorted waveforms present in the lamp circuits.

9.1.2 Single-ended compact lamps

Because of the small bulb diameter of the single-ended compact fluorescent lamp, the distortion is greater than found in more conventional, larger-diameter lamps. This is true of both the voltage and current waveform. Therefore, the harmonic content is a greater percent of the input fundamental, a significant portion of which can be comprised of components even above 1000 Hz.

It is recommended that ammeters and voltmeters have accuracies better than ±1/2% up to 2000 Hz, and wattmeters ±3/4% up to 2000 Hz. Power factor for these instruments should not exceed 20%, and should preferably be 5% or lower.

9.2 Impedance limitations

To reduce the disturbance to the circuit caused by the presence of the instruments, high potential-circuit impedance and low current-circuit impedance shall be achieved.

Instruments connected in parallel with the lamp shall never draw more than 1% of the rated lamp current.

Instruments connected in series with the lamp shall have an impedance such that the voltage across the instrument current coil does not exceed 2% of the rated lamp voltage.

Potential-circuit amplifiers having high input impedance and an accurately controlled gain may be inserted to avoid corrections owing to disturbance of the lamp circuit. The output of such amplifiers shall faithfully reproduce the input voltage with respect to rms value (or a multiple thereof), wave shape, and phase relation.

9.3 RMS measurements

The voltage across a fluorescent lamp has a distorted wave shape that departs considerably from a true sine wave. Therefore, the instruments used in lamp circuits shall be of a type whose deflection depends upon rms values. Instruments with scales calibrated in rms values and deflections based on average or peak values shall not be used.

9.4 General characteristics of ac instruments

The characteristics of different types of instruments are given in 9.4.1 through 9.4.7.

9.4.1 Electrodynamic instruments

Electrodynamic instruments give an indication proportional to rms values, and they can be designed for accurate measurements over a moderate range of frequency. Most electrodynamic instruments have fairly low potential-circuit and high current-circuit impedances, but designs are available with characteristics that are within allowable limits for fluorescent lamp circuits. Most electrodynamic instruments can be calibrated by means of reversed reading on direct current (dc), and they maintain calibration well. However, in certain varieties of these instruments, the hysteresis loss is high enough so that calibration by direct current alone may not always be reliable. In such cases, the instruments shall be calibrated on alternating current.

9.4.2 Electrostatic instruments

In most designs, the indication of electrostatic instruments are accurate over a wide frequency range and their potential-circuit impedances are very high. Their deflection torque is very low and they therefore require a relatively long time to reach a steady deflection. They are also subject to zero shift.

9.4.3 Iron-vane instruments

Iron-vane instruments give an indication proportional to rms values, and they can be designed for use over a moderate frequency range. As in electrodynamic types, a design with impedances that are within the allowable limits shall be chosen. Theoretically, these instruments should be calibrated only on alternating current because hysteresis occurs to some degree in the vane. Practically, however, the hysteresis in modern instruments is often so small that direct-current calibration can be used with satisfactory results.

9.4.4 Thermal instruments

The indication of thermal instruments is proportional to rms values. These instruments are accurate over a wide frequency range and their potential-circuit and current-circuit impedances are usually within required limits. However, their calibration depends rather critically upon instrument temperature, the change being from 0.1% to 0.3% per degree Celsius. Therefore, the instrument temperature shall remain uniform and constant, and the instrument shall be calibrated at the same temperature at which it is used.

9.4.5 Rectifier instruments

The indication of rectifier instruments is proportional to average values. These instruments, therefore, shall not be used to measure the rms value of a distorted wave.

9.4.6 Electronic true rms analog instruments

Most electronic instruments respond to peak or average waveform values, making them unsuitable for these measurements, even if the scale is calibrated to read rms. There are, however, a number of true rms electronic instruments available. Electronic voltmeters usually have the great advantage of a high input impedance, so that their effect upon circuit conditions is negligible. Accuracy is good, providing the manufacturer's specified ambient temperature limitations and corrections are observed. These instruments may also provide a dc output proportional to the meter deflection that they might be used in automated circuits with printed readouts.

Care shall be exercised, however, when these instruments are used to measure distorted waveforms, since the permissible overload is limited by both rms and peak values. Most required measurements can be made without difficulty.

9.4.7 True rms digital instruments

The general characteristics of these instruments are similar to those given in 9.4.6. They do, however, have a number of added features that may justify in some cases the added cost. Among these features are the following:

- The digital readout decreases the possibility of reading error and speeds the reading time;
- Instrument accuracy may be greatly increased;
- These instruments are available with autoranging so that all or most of the necessary measurements might be taken with a single instrument coupled by switches to properly locate voltage and current probes.

9.4.8 Instrument protection against transients

The instruments described in 9.4.6 and 9.4.7 often are much more subject to damage by transient voltages and currents produced when the circuits are first turned on or when circuits are switched than the instruments described in 9.4.1 through 9.4.5. Therefore, some form of protection against transients should be included in these instruments. Since these instruments vary in design and type, there is no simple way to protect all of them, and it is therefore best to inquire of the manufacturer for the most suitable means of protection in the specific circuits in which they will be used.

10 Corrections to compensate for the presence of instruments in the lamp circuit

10.1 General

In measuring electrical values in fluorescent lamp circuits, it is usually necessary to take into account the change in the circuit caused by the instrument. The restoration-of-light method shall be the basic method used to determine the required corrections.

With this method, a suitable photoelectric cell is used to measure lamp luminance (photometric brightness). The output of the cell may be read on a low-resistance galvanometer, microammeter, or other suitable indicating device having a sensitivity comparable to that of the electrical instruments used. The cell shall be so located that it sees the central portion of the lamps, and it shall be baffled to prevent its being influenced by extraneous room light. The procedure is as follows:

a) Set the proper rated line voltage across the lamp and reference ballast;

b) Note the lamp luminance as indicated by the photoelectric cell reading;

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

d) Readjust the line voltage until the output of the photoelectric cell is the same as before the instrument was inserted;

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

f) Remove the instrument from the circuit and recheck Steps (a) and (b). The photocell indication should agree with that originally obtained;

g) The difference between the instrument indication recorded in (e) and that recorded in (c) 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 lamp size.

It should be noted that the reading for only one instrument at a time can be obtained by the foregoing procedure. Also, instrument scale correction shall still be applied and, for a wattmeter, the power taken by its potential circuit (E^2/R) shall be subtracted from the correction obtained.

The exact procedure to be followed also depends upon whether or not the instrument current coils are to be included in the reference ballast impedance. The procedure is somewhat different for each of the three instruments in the lamp circuit, as outlined in 10.2 through 10.4.

10.2 Correction for lamp ammeter reading

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

If the current coils have not been included in the reference ballast impedance, the ammeter correction shall be obtained by the restoration-of-light method. The ammeter shall not be left in the circuit while readings of other instruments are being taken.

10.3 Correction for lamp voltmeter reading

Regardless of which procedure is followed for the current coils, the correction for the voltmeter reading shall be obtained by using the restoration-of-light method. The voltmeter shall not be left in the circuit while readings of other instruments are being taken.

10.4 Correction for wattmeter reading

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 shall be made for the presence of this coil. The correction for the presence of the potential coil may be obtained by using the restoration-of-light method and then subtracting the power in the potential circuit E^2/R. Sometimes, the increase in watts when the lamp luminance is restored is very nearly equal to the decrease when E^2/R is subtracted. When this condition prevails, it is then possible in routine work to omit both corrections and use the wattmeter readings directly. (An instrument scale correction still shall be made.)

If the current coils have not been included in the reference ballast impedance, the correction for both the current and potential coils may be determined at the same time by the restoration-of-light method. The power in the potential circuit, E^2/R, shall be subtracted from the reading obtained.

Annex A
(informative)

Procedure for accelerated prestabilization

NOTE – This information is not intended to be a specific recommended procedure but is presented as reference information to more fully acquaint the user with some alternative methods of photometric measurements on single-ended compact fluorescent lamps. Because of the wide range of potential applications for these lamps, it is felt that there exists a strong interest in expanding or modifying the measurement procedure in order to obtain additional information on electrical and photometric characteristics.

In making measurements on lamps with cold chambers, a 15-hour prestabilization time may be impractical. This time can be reduced to several hours if, during operation, the cold chambers are momentarily cooled by contact with a liquid coolant that is below 20°C. An ice bath is suitable for this purpose. The procedure is most effective if the main body of the test lamp is surrounded by an insulating material to raise the wall temperature of the lamp.

The test lamp must first be warmed up for several minutes to near-operating temperature so as to raise the mercury vapor pressure. The coolant is placed in contact with the cold chambers or tips of the lamp long enough to cause mercury to condense at this location. This will typically take between 5 and 10 seconds. The tips of the lamp should then be wiped dry of any residual coolant and the lamp allowed to reach its normal operating temperature. This procedure must usually be repeated several times. When the prestabilization time has been sufficient, the light output will drop to a very low level as the tips of the lamp are in contact with the coolant.

Because the design of single-ended compact lamps may vary significantly and experience to date is limited, experimentation with a particular lamp type and cooling process is necessary if reproducible results are to be obtained.