



ANSI C82.1-2004
Revision of ANSI C82.1-1997

American National Standard

for lamp ballast—

**Line Frequency Fluorescent
Lamp Ballast**

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Revision of C82.1-1997

American National Standard

Approved: November 19, 2004 Secretariat: ANSLG -National Electrical Manufacturers Association

For Lamp Ballast –

Line Frequency Fluorescent Lamp Ballast

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FOREWORD (This Foreword is not part of American National Standard C82.1-2004.)

Suggestions for improvement of this standard will be welcome. They should be sent to Secretariat C82 Committee, American National Standard Lighting Group (NEMA), 1300 North 17th Street, Suite 1847, Rosslyn, VA 22209.

This standard was processed and approved for submittal to ANSI by the Accredited Standards Committee on Lamp Ballasts, C82, and its Working Group C82-1. Approval of the standard does not necessarily imply that all working group members voted for its approval.

This standard is a revision of ANSI C82.1-1997 and supercedes the aforementioned standard and all supplements. Information concerning the approval of this standard is based on the documents listed in the table below:

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1. Scope

This standard is intended to cover ballasts which have rated open-circuit voltages of 2000 volts¹ or less and are intended to operate lamps at a frequency of 50 Hz or 60 Hz.² This comprises ballasts for hot-cathode fluorescent lamps, either switch-start (preheat-start), rapid-start (continuously heated cathodes), modified rapid start (cathode cutout), or instant-start, and also ballasts for cold-cathode fluorescent lamps, used primarily for lighting purposes, which come within this voltage range. The ballast and lamp combinations covered by this specification normally are intended for use in room ambient temperatures of 10°C to 40°C. At ambient temperatures outside this range, certain special operating characteristics may be required.

2. Normative References

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 When these standards are superseded by a revision approved by the American National Standards Institute, Inc., the revision shall apply: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/NFPA 70 *National Electrical Code*

ANSI C78.81-2003 *Double-capped Fluorescent Lamps – Dimensional and Electrical Characteristics*

ANSI C78.901-2001 *Single base Fluorescent Lamps – Dimensional and Electrical Characteristics*

ANSI C82.2-2002 *Fluorescent Lamp Ballasts - Methods of Measurement*

ANSI C82.3-2002 *Reference Ballasts for Fluorescent Lamps*

ANSI C82.11-2002 *High Frequency Fluorescent Lamp Ballasts*

ANSI C82.13-2002 *Definitions –for Fluorescent Lamps and Ballasts*

ANSI/UL 935-2001 *Standards for Safety - Fluorescent Lamp Ballasts*

1. See ANSI/NFPA 70 or related standards for requirements for various voltage classifications.

2. See ANSI C82.11-2002 for high frequency fluorescent ballast specifications.

3. Definitions

See ANSI C82.13 for related definitions.

4. Ballast Marking

4.1 Marking

Ballasts shall be marked to indicate the supply voltage and frequency, the input current, the manufacturer, the ballast type designation, and the number, type, and wattage or current of fluorescent lamps the ballast shall operate.

4.1.1 Power Factor. Ballasts operating with an average power factor of 90% or above shall be labeled as high-power factor type. Ballasts of the corrected type and operating at a power factor of less than 90% shall indicate the average operating power factor. Ballasts of the uncorrected type need not be marked for power factor.

4.1.2 Open-Circuit Voltage. The value of the open-circuit voltage, when over 300 volts, shall be marked.

4.1.3 Required Grounding. All ballasts providing voltages in excess of 150 volts shall be marked to indicate that the ballast case must be grounded.

4.1.4 Supplementary Marking. Except for single-lamp series-reactor type ballasts, supplementary marking shall be included to indicate the correct point of connection for various leads. Any necessary restrictions or conditions concerning operation of a ballast shall be so indicated as part of the supplementary marking.

4.2 Color Coding of Ballasts Leads

4.2.1 Line Leads. The following color coding shall be used for the line leads of ballasts:

- (1) On ballasts with only one line lead, such as the series-reactor type, the lead shall be *black*.
- (2) On ballasts with two line leads, when one lead connects to a neutral wire, that lead shall be *white or natural gray* and the other shall be *black*.³
- (3) On ballasts with two line leads, which connect to ungrounded supply lines, both leads shall be *black*.

³ For single identification of single lamp ballast leads in switching schemes, a 15% or less white tracer stripe may be used on the black lead.

4.2.2 Lamp Leads. The following color coding is for the lamp lead of ballasts:

- (1) On single-lamp series-reactor type ballast, the lamp lead shall be *blue*.
- (2) An unprotected version of a single-lamp series reactor type ballast, the lamp lead shall have the option to be *black*.
- (3) On a single-lamp or multi-lamp ballast (except series-reactor type) where lamps are operated independently and lamp currents are essentially in phase with each other, the lamp leads shall be *blue*.
- (4) On multi-lamp ballast, where a lead-lag type circuit is used, the leading-lamp lead shall be *red*, and the lagging-lamp lead shall be *blue*.
- (5) On ballasts with a compensator winding, compensator leads shall be yellow-blue tracer or *yellow*.⁴
- (6) On a two-lamp instant-start ballast of the series-sequence type, lamp leads shall be *red* and *blue*, respectively. Circuit arrangements shall be such that *red and white* leads are connected to respective ends of one lamp and *black and blue* leads to the other lamp. If the circuit arrangement is such that both lamps do not connect back to the line leads, this paragraph shall be followed insofar as possible.
- (7) On a single-lamp ballast of the continuously heated cathode type (rapid-start), the leads to that lamp cathode operated at the maximum voltage with reference to either of the line leads shall be *red*. The leads to the cathode at the other extreme of voltage relative to the red cathode shall be *blue*.
- (8) On multi-lamp ballast of the series-sequence continuously heated cathode type (rapid-start), the leads to that cathode operated at the maximum voltage with reference to either of the line leads, shall be *red*. The leads to the cathode at the other extreme of voltage relative to the *red* shall be *blue*. For two-lamp ballasts, the leads to the pair of common cathodes shall be either *yellow-blue* tracer or *yellow*.⁵

When more than two lamps are involved, the leads to each cathode or pair of cathodes, beginning at the high voltage (or *red*) end, shall have colors used in the order shown in Table 1.

4 Choice is given depending upon the type of wire utilized by the manufacturer and its ability to be distinguished from white.

5 Choice is given depending upon the type of wire utilized by the manufacturer and its ability to be distinguished from white.

4.2.3 Other Ballast Types. Ballasts not covered by 4.2.1 and 4.2.2 shall comply with these requirements insofar as possible.

Table 1
Color Coding for Multi-lamp Ballasts Leads

3-Lamp*	4-Lamp*	5-Lamp*	6-Lamp*
Red	Red	Red	Red
Yellow	Yellow	Yellow	Yellow
Blue/White 50/50	Blue/White 50/50	Blue/White 50/50	Orange
Blue	Brown	Brown	Blue/White
	Blue	Orange	Orange/Black
		Blue	Brown
			Blue
*C78 specifications for more than three lamps in series are not available at present.			

5. Ballast Performance

5.1 General

Measurements necessary to determine ballast performance shall be made in accordance with ANSI C82.2.

5.2 Starting Conditions

5.2.1 Starting. For satisfactory lamp starting, a ballast, when operated at any voltage between 90% and 110% of its rated primary voltage and at rated frequency, shall provide the starting characteristics specified in ANSI C78.81, C78.901.

When ballasts are designed to operate lamps in parallel circuits, the relevant requirements shall be met for each separate lamp, both with and without lamps operating or preheating in other circuits.

5.2.2 Fixture and Circuit Grounding. Rapid-start lamps, and switch-start (preheat-start) lamps when operated in circuits of the rapid-start type, require a starting aid consisting of a metal strip (usually a conventional part of the fixture), the surface of which shall be at least 1 inch (25 mm) wide. This surface shall extend essentially the full length of the lamp and *shall be connected to ground*. The distance from the starting aid to the bulb wall, as measured in a direction normal to the surface of the starting aid, shall be specified in appropriate C78 lamp standards.

Ballasts circuits and connections (including ground connections) shall be such that the potential difference between the starting aid and one of the cathodes of each lamp will be greater than the minimum specified in ANSI C78.81, C78.901.

(If operation on ungrounded power supplies is contemplated, the necessary starting-aid potential should be maintained regardless of accidental grounds on either side of line. In some types of circuits this may require the use of a two-winding transformer.)

5.2.3 Required Starting Current. Instant-start types of ballasts shall meet the requirements for starting currents as listed in 5.2.3.1 through 5.2.3.3.

If the normal wiring of the ballast being tested is such that the primary circuit of the ballast is normally closed by the insertion of lamps into the lamp holders, the primary circuit shall be completed by some other means when these tests are being made.

5.2.3.1 Single-Lamp Ballasts. With the specified test resistor (see Table 2) connected to the ballast in place of the lamp, the rms current through the resistor, at any supply voltage between 90 % and 110% of rated voltage, shall not be less than that shown in Table 2.

5.2.3.2 Multi-lamp Ballasts. Multi-lamp ballasts, other than those covered in 5.2.3.3, shall meet the following requirements, which apply to *each lamp position*: With specified test resistor (see Table 2) connected to the ballast in place of one of the lamps, and with all other positions connected to reference lamps, the rms current through the resistor, at any supply voltage between 90% and 110% of rated voltage, shall not be less than the value shown in Table 2.

In addition, if one or more of the lamp positions are such that it can start and operate a lamp (not necessarily at rated current) *without* lamps in the other positions, the resistor current in this position shall also meet the specifications given in Table 2 *without* lamps in the other circuits.

Table 2
Required Starting Current for Instant-Start Ballasts

Lamp Size	Lamp Operating Current (mA)	Test Resistor* (ohms)	Minimum Starting Current (mA)
42-inch T-6	120	3000	75
	200	3000	90
	300	3000	100
64-inch T-6 and 72-inch T-8	120	4000	75
	200	4000	90
	300	4000	100
96-inch T-8	120	5000	75
	200	5000	90
	300	5000	100
40 W T-12 IS	425	2750	100
48-inch T-12	425	2750	100
72-inch T-12	425	3400	100
96-inch T-12	425	4000	100
40 W T-171S	425	2750	100

*The values given in this column include the resistance of the ammeter and should be held within +/- 2%.

5.2.3.3 Other Multi-lamp Ballasts. Two-lamp series-sequence type ballasts for the operation of any of the types of lamps shown in Tables 3 and 4 shall be tested with two resistors as specified in Tables 3 and 4. These resistors shall be connected in the ballast circuit as specified in the tables, and the current through the specified measurement resistor, at any supply voltage between 90% and 110% of rated voltage, shall not be less than that shown in the appropriate table.

Table 3
Required Starting Current for Two-Lamp Series-Sequence Type Ballasts for 96-inch T-12 Instant-Start Lamps

Resistor Value (ohms)		Minimum Current through the 4000-Ohm Resistor (mA)
No. 1 Lamp Position (Red-White Leads)	No. 2 Lamp Position (Blue-Black Leads)	
4000	9000	90
1200	4000	100

Table 4
Required Starting Current for Two-Lamp Series-Sequence Type Ballasts
for 48-Inch T-12, 40 Watt T-12,
or 40-Watt T-17 Instant-Start Lamps

Resistor Value (ohms)		Minimum Current through the 2750-Ohm Resistor (mA)
No. 1 Lamp Position (Red-White Leads)	No. 2 Lamp Position (Blue-Black Leads)	
2750	750	90
750	2750	100

5.3 Ballast Output

A ballast shall provide the operating characteristics given in 5.3.1 and 5.3.2 when connected to any specified complement of reference lamps.

5.3.1 Switch-Start and Instant-Start Ballasts. Ballasts of these types shall deliver not less than the power specified in Table 5 to a reference lamp, as measured in percent of the power and current delivered to the same lamp by a reference ballast. The lamp current shall not exceed the maximum value specified in the lamp standard, C78.81 or C78.901. Both the reference ballast and the ballast under test shall be operated at their rated voltage and frequency.

Power and current measurements of the ballast under test shall be made when it is connected to a full complement of reference lamps.

Table 5
Minimum Ballast Factor
for Switch-Start and Instant-Start Ballasts

Ballast Types	Percent of Values Delivered by Reference Ballast
	Ballast Factor (Power)
Switch-Start	Not < 92.5
Instant-Start	Not < 92.5
Instant-Start 60W/96T12/SP*	Not < 85.0
Compact Fluorescent	Not < 92.5

*A ballast is rated for use with both 75W/96T12/SP and 60W/96T12/SP lamps and meets the 75W/96T12/SP operation need not be tested with a 60 watt lamp.

5.3.2 Rapid-Start Ballasts. Rapid-start ballasts shall provide the operating characteristics given in 5.3.2.1 and 5.3.2.2 when connected to a full complement of normally-operating lamps.

5.3.2.1 Ballast Factor. With rated voltage applied to the primary of the ballast, the light output delivered by a reference lamp shall be equal to the light output delivered by the same reference lamp when operated on its reference ballast at its rated primary voltage, subject to the minimum values in Table 6.

The maximum light output shall be limited by the maximum permissible lamp current as specified in 5.3.2.2.

Table 6
Minimum Ballast Factor for Rapid Start Circuits

Lamp Type	Minimum Ballast Factor (Light) Output (percent)
<i>Linear Lamps</i>	
4, 6, 8WT5	90
14WT8	90
15WT8	90
14, 15, 20WT20	90
17, 25, 32, 40WT8	92.5
30, 40WT10, 40WT12	92.5
*34WT12	85
0.800A and 1.0A T12	95
**95W T12-0.800 A	88
1.5A T12 and PG17	95
<i>Circular Lamps</i>	
20WT9	90
22, 32, 40WT9	90
32WT10	90
40WT10	90
<i>U-Shaped lamps</i>	
16, 24, 32WT8	92.5
40WT12	92.5
<i>Single-based Lamps with 2G11 bases 18W, 24-27W, 36-39W, 40W</i>	92.5
*A ballast that is rated for use with both a 40-watt and a 34-watt lamp and meets the 40-watt lamp requirements need not be tested with a 34-watt lamp.	
**A ballast that is rated for use with both 113 and 95 watt lamp and meets the 113 watt lamp operation need not be tested with a 95 watt lamp.	

5.3.2.2 Lamp Current. With rated voltage applied to the primary of the ballast, the lamp current in a reference lamp shall not exceed the value specified in the lamp standard, C78.81 or C78.901.

5.3.3 Ballasts for compact self-supporting lamps.

Ballasts for compact self-supporting fluorescent lamps shall deliver current to a reference lamp within the limits specified in the lamp standard, C78.901.

5.4 Cathode Preheating Current

Ballasts designed for the operation of switch-start lamps shall provide preheating current within the limits required by ANSI C78.81 and C78.901.

When ballasts are designed to operate more than one lamp, each circuit shall meet this requirement, both with and without lamps operating or preheating in the other circuits.

5.5 Regulation

5.5.1 Ballasts for Rapid-Start Lamps. Ballasts for rapid-start lamps shall, at 90% and 110% of rated line voltage, operate a reference lamp at a level of light output of the same not less than 75% or greater than 125%, respectively, of the light output of the same lamp when it is operated with the same ballast at *rated* primary voltage.

5.5.2 Ballasts for Switch-Start Lamps and Instant-Start Lamps. Ballasts for switch-start lamps and instant-start lamps shall, at 90% and 110% of rated line voltage, deliver to a reference lamp not less than 85% or more than 115%, respectively, of the power delivered by a reference ballast to the same lamp at corresponding voltages.

5.5.3 Ballasts for Compact Fluorescent Lamps. Ballasts for compact fluorescent lamps shall, at 90% and 106% of rated line voltage, deliver to a reference lamp not less than 75% nor more than 115% current, respectively, of the current delivered by a reference ballast at rated voltage and frequency.

5.6 Operating-Current Waveshape

5.6.1 Normal Operating Conditions. With rated voltage applied to the primary of the ballast, the current Waveshape supplied to a warmed-up reference lamp shall have a crest factor (ratio of peak current to RMS current) that does not exceed the values shown on the appropriate lamp standard, C78.81 or C78.901.

5.7 Supplementary Cathode Heating

5.7.1 Switch-Start Ballasts. Switch-start ballasts shall not furnish a current greater than 100% of the arc discharge current to any cathode terminal of a lamp in normal operation.

5.7.2 Rapid-Start Ballasts. Rapid-start ballasts shall provide supplementary cathode heating as follows: (1) When two cathodes are supplied from a common winding, they shall be connected in parallel. (2) The cathode heating voltage shall be measured using a dummy load resistor. All cathode windings must be loaded during this measurement. With the rated voltage applied to the primary of the ballast, the cathode heating windings shall deliver voltages to the dummy load resistors within the limits shown on the appropriate lamp data sheets. (3) When reference lamps are in normal operation at rated primary voltage, the voltage across any cathode shall be within the limits shown on the appropriate lamp data sheets.

5.7.3 Modified Rapid-Start Ballasts. Rapid-start ballasts shall provide supplementary cathode heating as follows: (1) When two cathodes are supplied from a common winding, they shall be connected in parallel. (2) The cathode heating voltage shall be measured using a dummy load resistor. All cathode windings must be loaded during these measurements. With the rated voltage applied to the primary of the ballast, the cathode heating windings shall deliver voltages to the dummy load resistors within the limits shown on the appropriate lamp data sheets. (3) When reference lamps are in normal operation at rated primary voltage, the voltage across any cathode is reduced or removed after the lamp is in full operation.

5.8 Voltage across Starter Terminals.

Ballasts for switch-start lamps, when operated at any voltage between 90% and 110% of their rated primary voltage and at rated frequency, shall meet the requirements of 5.8.1 and 5.8.2.

5.8.1 Voltage - with Reference Lamps. When operating reference lamps the ballasts shall not furnish at the starter terminals a voltage in excess of the value listed in Table 7. This limit applies when the lamps are first lighted and after they have warmed up.

5.8.2 Voltage - with Deactivated Lamps. When connected to non-reference lamps having one or both cathodes deactivated, the ballast shall not furnish at the starter terminals a voltage in excess of the value listed in Table 7.

Table 7
Maximum RMS Volts
Across Starter Terminals

Lamp Rating (watts)	Normal Lamp	Deactivated Lamp
4,6,8,14,15,20	70	*
30,40	128	265
32,90	95	*
*To be Determined		

5.9 Radio-Interference Suppression.

Fluorescent lamps may be a source of electromagnetic radiation at radio frequencies. Several means are available for suppressing the interference caused by such radiation. The starters for use with switch-start lamps shall contain capacitors which assist in this suppression.

Switch-start ballasts which contain a compensating winding shall include a capacitor of 0.0048 μF (minimum) connected across such winding. Instant-start ballasts, with the exception of ballasts for operating slim-line lamps at 120 mA, shall contain 0.008 μF (minimum) capacitors (low-inductance) for this purpose, either connected across each lamp or across the line, or both. Further suppression of conducted radio interference may be obtained through the use of the delta-capacitor or the inductor-inductor type of filter at the line connection of the ballast.

5.10 Ballast Safety.

Ballast shall comply with ANSI/UL 935.

6. Design Center Voltages⁶

The following voltages are the design center input voltage for fluorescent lamp ballasts:

Table 8
Design Center Voltages

120	127	208	220	240	254	277	347	440	480
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

⁶ See ANSI/NFPA 70 or related standards for maximum voltage-to-ground limitations and ground requirements.

7. Application Requirements

7.1 Limits for Contact Resistance.

Even relatively small resistance in series with the cathode of the rapid-start lamp, because of the low heater-circuit voltage, may seriously interfere with the lamp starting or operation. The added resistance in any cathode circuit shall not exceed at any time the following values:

Table 9
Maximum Contact Resistance

Lamp Type (mA)	Maximum Added Resistance Any Cathode Circuit (ohms)
500 or less	0.5
800 (high output)	0.2
1500	0.2

7.2 Operating Temperature Limits

The service installation must be designed so that the temperature at the hottest spot on the ballast case shall not exceed 90°C under actual operating conditions.

7.3 Supply Voltage Limits

7.3.1 Average Voltage. The average voltage of the supply system should not depart more than -7.5 % or more than + 5 % from the primary voltage rating shown in the ballast label.

7.3.2 Voltage Excursions. For satisfactory ballast operation, the supply voltage excursions must not exceed +/- 10% of the ballast primary rating.

7.4 Equipment Grounding

Exposed non-current-carrying metal part of fluorescent lamp ballasts (such as the ballast case) shall be grounded if the open-circuit voltage of the ballast exceeds 150 volts.

7.5 Audible Sound Level

Noise is an inherent characteristic of electromagnetic devices and cannot be completely eliminated.

Care should be exercised in the selection of the ballast location and the method of mounting because ballast noise can be amplified by reflections from surrounding objects and by resonance of the mechanical mounting and electrical connections. This unintentional amplification can make the ballast appear to produce considerably more noise than the generated by the ballast. The ballast or luminaire manufacturer, or both, should be consulted for specific recommendations for a quiet installation.