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NEMA STANDARDS PUBLICATION

NEMA PE 7

COMMUNICATIONS TYPE BATTERY CHARGERS

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NEMA Standards Publication PE 7-1996

Communications Type Battery Chargers

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Foreword

This Standards Publication provides definitions, minimum requirements, and test methods for communications type battery chargers.

This Standards Publication was prepared by the Industrial Battery Charger Committee of the NEMA Power Electronics Section. During the preparation of this Standard, the Committee was composed of the following active participants:

Tony Cosentino—Power Conversion Products, Inc.
Don Henry—La Marche Manufacturing Company
John Mitchell—RELTEC
David Muhlrad—Ratelco Electronics, Inc.
Dan Skinner—Solidstate Controls Inc.
Grover Wilson—Prestolite Power Corporation

User needs and safety considerations were addressed during the preparation of this Standard. This Standard has been reviewed and approved by the Battery Council International, Chicago, Illinois.



To facilitate consideration by the International Electrotechnical Commission, this Standards Publication is written according to the IEC Directives for the drafting and presentation of international standards. Clauses 1 to 10 are normative (equivalent to the designation of "NEMA Standard"); any informative matter (equivalent to the designation of "Authorized Engineering Information") in these clauses is contained in notes or is so indicated. Annexes A and B are informative.

The NEMA Power Electronics Section will periodically review this Standard and revise it as necessary to reflect advancing technology. Proposed or recommended revisions should be submitted to:

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1300 North 17th Street, Suite 1847
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This Standards Publication was developed by the NEMA Power Electronics Section. Section approval of the standard does not necessarily imply that all section members voted for its approval or participated in its development. At the time it was approved, the Power Electronics Section was composed of the following members:

American Power Conversion—West Kingston, RI
Best Power, A Division of General Signal—Necedah, WI
Cyberex, Inc.—Mentor, OH
EPE Technologies Inc.—Palatine, IL
Georator Corporation—Manassas, VA
La Marche Manufacturing Company—Des Plaines, IL
Liebert Corporation—Irvine, CA
Power Paragon, Inc.—Anaheim, CA
Solidstate Controls Inc.—Columbus, OH
Toshiba International Corporation—Houston, TX

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Section 1
SCOPE

This Standards Publication covers stabilized constant-potential-type filtered or unfiltered battery chargers which are designed to supply direct-current power from an alternating-current source to charge a float-type battery and simultaneously power the connected telecommunication system load. These battery chargers provide transformer isolation of the direct-current output from the alternate-current input and are designed for stationary mounting and continuous operation.

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Section 2
NORMATIVE REFERENCES

The following normative documents contain provisions, which through reference in this text constitute provisions of this Standards Publication. By reference herein these publications are adopted, in whole or in part as indicated, in this Standards Publication.

ANSI C84.1-1989, *Electric Power Systems and Equipment–Voltage Ratings (60Hz)*

ANSI S1.4-1983, *Specification for Sound Level Meters*

ANSI S12.31-1990, *Precision Methods for the Determination of Sound Power Levels of Broad-Band Noise Sources in Reverberation Rooms*

ANSI S12.32-1990, *Precision Methods for the Determination of Sound Power Levels of Discrete-Frequency and Narrow-Band Noise Sources in Reverberation Rooms*

ANSI/IEEE 100-1992, *Dictionary of Electrical and Electronic Terms*

ANSI/IEEE 519-1993, *Guide for Harmonic Control and Reactive Compensation of Static Power Converters*

ANSI/IEEE C37.90.1-1989, *Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems*

ANSI/IEEE C62.41-1991, *Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits*

ANSI/NFPA 70-1994, *National Electrical Code*

The above listed standards may be obtained by contacting:

American National Standards Institute
11 West 42nd Street
New York, NY 10036

Code of Federal Regulations, Title 47, Part 15 (Federal Communication Commission), Subpart B, *Radio Frequency Devices – Unintentional Radiators*

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Section 3
DEFINITIONS

For the purposes of this Standards Publication the following definitions apply. Terms marked with an asterisk (*) are in accordance with ANSI/IEEE 100.

3.1 ambient operating-temperature range*: The range of environmental temperatures in which a battery charger [power supply] can be safely operated. For units with forced-air cooling, the temperature is measured at the air intake.

3.2 ampere-hour capacity: The number of ampere hours which a storage battery can deliver under specified conditions such as temperature, rate of discharge, and final voltage. The abbreviation AH, as used in this standards publication, is the ampere-hour capacity at the 8-hour rate at 25°C (77°F) if the lead-acid battery is discharged down to 1.75 volts per cell.

3.3 audible noise: The sound level produced by the battery charger, measured in decibels.

3.4 (storage) battery: A rechargeable electrochemical energy storage device that, when discharged, produces direct current electrical energy from a chemical reaction and can be recharged by reversing the chemical reaction with direct current electrical energy.

3.5 battery charger; rectifier: An apparatus which is capable of restoring the charge in storage batteries, or supplying charging power to a battery and, at the same time, supplying power to the connected load.

3.6 battery eliminator*: A device that provides direct-current energy from an alternating-current source in place of a battery.

3.7 c-message weighting: A noise weighting used in noise measuring sets to measure circuit noise power in dB referred to 1.0 picowatt (-90 dBm) which is 0 dBrn. The c-message weighting curve is shown in Figure 1.

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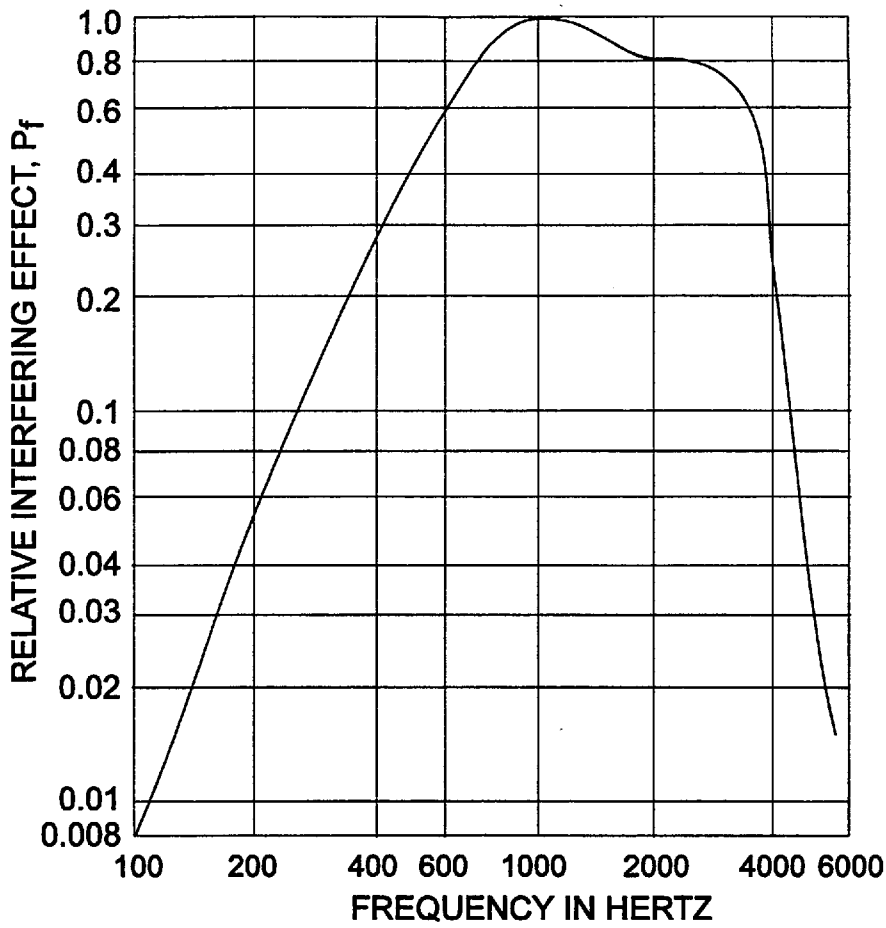

Figure 1 – C-message weighting curve

3.8 change of resistance method: The value of the temperature rise of a winding calculated from the formulae:

$$\Delta t = \frac{R_2 - R_1}{R_1} (234.5 + t_1) - (t_2 - t_1)$$ for a copper winding;

$$\Delta t = \frac{R_2 - R_1}{R_1} (225 + t_1) - (t_2 - t_1)$$ for an aluminum winding,

where:

Δt is the temperature rise (°C)
R_1 is the resistance of the winding at the beginning of the test (W)
R_2 is the resistance of the winding at the end of the test (W)
t_1 is the room temperature at the beginning of the test (°C)
t_2 is the room temperature at the end of the test (°C)

At the beginning of the test, the windings are at room temperature.

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It is recommended that the resistance of windings at the end of the test be determined by taking resistance measurements as soon as possible after switching off, and then at short intervals so that a curve of resistance against time can be plotted for ascertaining the resistance at the instant of switching off.

3.9 constant potential charge: A charge in which the voltage, or potential, at the output terminals of the battery charger is maintained at a constant value.

3.10 constant-voltage/constant-current crossover: The characteristic of a battery charger that automatically converts the mode of operation from voltage stabilization to current stabilization and vice versa, when the output current reaches a preset value.

3.11 (automatic) current limiting*: An overload protection mechanism that limits the maximum output current to a preset value, and automatically restores the output when the overload is removed.

3.12 dBrnc*: The decibels above reference noise (meter reading of measuring set using c-message weighting network).

3.13 dielectric tests*: Tests which consist of the application of a voltage higher than the rated voltage, for a specified time to assure the withstand strength of insulation materials and spacing. These various types of dielectric tests have been developed to allow selectively testing the various insulation components of a transformer, without overstressing other components; or to simulate transient voltages which transformers may encounter in service.

3.14 dielectric withstand strength: The specified voltage or potential gradient below which a dielectric material will continue to resist electrical current flow.

3.15 displacement power factor*: The ratio of the active power of the fundamental wave, in watts, to the apparent power of the fundamental wave in volt-amperes. This is the cosine of the phase angle by which the fundamental current lags the fundamental voltage. This is the power factor as seen in utility metering by watt-hour and varhour meters assuming that the ac voltages are sinusoidal.

3.16 distortion factor*: The ratio of the root-mean-square value of the harmonic content to the root-mean-square value of the nonsinusoidal quantity expressed in percent.

$$\text{Distortion Factor} = \left(\sqrt{\frac{\sum (\text{amplitude of all harmonics})^2}{(\text{amplitude of fundamental})^2}} \right) \times 100\%$$

3.17 efficiency*: The ratio of output power to input power expressed in percent, i.e.:

$$\text{Efficiency} = \frac{P_{out}}{P_{in}} \times 100\%$$

NOTE—This is an evaluation of power losses within the conversion equipment and may be also expressed as ratio of the output power to the sum of the output power and the power losses, and expressed in percent, i.e.:

$$\text{Efficiency} = \frac{P_{out}}{P_{out} + P_{losses}} \times 100\%$$

3.18 electromagnetic compatibility*: A measure of equipment tolerance to external electromagnetic fields.

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3.19 electromagnetic interference*: Impairment of a wanted electromagnetic signal by an electromagnetic disturbance.

3.20 equalizing charge: An extended charge, at an elevated voltage, to a measured end point that is given to a storage battery to insure the complete restoration of the active materials in all the plates of all the cells.

3.21 filter: Resistance-capacitance or inductance-capacitance networks which are arranged as low pass devices to attenuate the varying component that remains when alternating voltage is rectified.

3.22 floating charge: A method of operation for storage batteries in which a constant voltage which is sufficient to maintain an approximately constant state of charge is applied to the battery terminals.

3.23 forced-air cooling system*: An air cooling system in which heat is removed from the cooling surfaces of the rectifier by means of a flow of air produced by a fan or blower.

3.24 forced load sharing: Circuitry provided to cause (force) two or more chargers connected in parallel to share the load.

3.25 harmonic distortion*: The ratio of the effective value of all the harmonics to the effective value of the fundamental. Total harmonic distortion (THD) is expressed in percent by the following formulae:

$$THD = \frac{\sqrt{\sum_{n=1}^{\infty} E_n^2}}{E_1} \times 100\% \quad \text{for voltage;}$$

$$THD = \frac{\sqrt{\sum_{n=1}^{\infty} I_n^2}}{I_1} \times 100\% \quad \text{for current.}$$

3.26 I•T product: The inductive influence expressed in terms of the product of its root-mean-square (rms) magnitude in amperes (I) times its telephone influence factor (TIF).

3.27 inrush current*: The maximum root-mean-square or average current value, determined for a specified interval, resulting from the excitation of the charger with no connected load, with essentially zero source impedance, and with rated voltage.

3.28 load sharing: The operation of two or more chargers which are connected to a common direct current load and which are sharing the load proportionate to their output current ratings.

3.29 natural air cooling system; convection cooling system*: A cooling system in which the heat is removed from the cooling surfaces of the components only by the natural action of the ambient air.

3.30 nominal value*: The arbitrary reference value used to designate or identify a component, device, equipment, or parameter.

3.31 output voltage deviation; output voltage regulation: The excursion of the output voltage (E_{min} to E_{max}) resulting from changes in line, load, and temperature.

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$$Percent\ deviation = \pm \left(\frac{E_{max} - E_{min}}{E_{max} + E_{min}} \times 100\% \right)$$

3.32 overcurrent protection: Protection of the battery charger against excessive current.

3.33 parallel operation*: Operation of two or more chargers which are connected to a common direct-current load and which shall or shall not equally share the load.

3.34 power factor*: The ratio of the total watts input (total power input in watts) to the total volt-amperes input to the battery charger.

$$F_P = \frac{\sum watts\ per\ phase}{\sum RMS\ volt\text{-}amperes\ per\ phase}$$

$$= \frac{active\ power}{apparent\ power}$$

NOTES

1 This definition includes the effect of harmonic components of current and voltage, the effect of phase displacement between the current and voltage, and the excitation current of the transformer. Volt-amperes is the product of root-mean-square volts and root-mean-square amperes.

2 Measurements for rms voltage and rms current should be made at the alternating-current line terminals of the battery charger.

3 If the voltages have the same waveform as the corresponding currents, power factor becomes the same as phasor power factor. If the voltages and currents are sinusoidal and, for polyphase circuits, form symmetrical sets, then

$$F_P = \cos(\alpha - \beta)$$

where:

α = voltage phase angle;
β = current phase angle.

3.35 rating: A value, assigned by the manufacturer, for a specified parameter.

3.36 remote sensing: A means by which the charger maintains the stabilized value of output voltage at an external point (such as the battery or load) rather than at its output terminals. This may be accomplished by connecting the voltage sensing leads of the charger to the external point.

3.37 ripple voltage*: The alternating-voltage component of the unidirectional voltage from a direct current power supply arising from sources within the power supply.

3.38 root-mean-square value*: The square root of the average of the square of the value of the function taken throughout one period. Thus, if y is a periodic function of t, then:

$$Y_{rms} = \sqrt{\frac{1}{T}\int_a^{a+T} y^2 dt}$$

3.39 short circuit: A conductor placed across the output terminals of the charger that causes the charger output voltage to measure less than 1 volt.

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3.40 short-circuit current: The current supplied by the charger when the output terminals are short-circuited and rated input voltage is supplied to the battery charger.

3.41 telephone influence factor: For a voltage or current wave in an electric supply circuit, the ratio of the square root of the sum of the squares of the weighted root-mean-square values of all the sine wave components (including both fundamental and harmonics in alternating-current waves) to the unweighted root-mean-square value of the entire wave. This factor was formerly known as the telephone interference factor, a term still used occasionally when referring to values based on the original (1919) weighting curve.

3.42 temperature compensation: Circuitry that causes the battery charger to change output voltage with respect to temperature. The voltage change typically has a negative slope with respect to battery temperature.

3.43 test battery: A fully charged battery which has an ampere-hour capacity numerically equal to four times the rated output current of the charger.

3.44 three-phase circuit*: A combination of circuits energized by alternating electromotive forces which differ in phase by one-third of a cycle (120 degrees). In practice, the phases may vary several degrees from the specified angle.

3.45 zero-voltage battery: An overdischarged battery where the active materials are consumed producing a terminal voltage of less than 0.1 volts per cell with a connected resistive load equivalent to the 4-hour discharge rate.

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Section 4
ALTERNATING CURRENT (AC) INPUT CHARACTERISTICS

4.1 Rated AC voltages

The input voltage ratings shall be in accordance with Table 1 for 60-Hertz operation and in accordance with Table 2 for 50-Hertz operation. Unless otherwise specified, the range of values of 60-Hertz input voltages over which performance is specified shall be in accordance with ANSI C84.1, as shown in Table 1.

Table 1 – AC input voltage for 60-hertz chargers

Nominal (Volts)	Minimum (Volts)	Maximum (Volts)	+10% [1] (Volts)
120	106	127	132
208	184	220	228
240	212	254	264
277	245	293	305
480	424	508	528
575	508	600[2]	632[2]
600	530	635[2]	660[2]

[1] +10% line may be encountered outside the USA and Canada

[2] Certain kinds of control and protective equipment presently available have a maximum voltage limit of 600 Volts; the manufacturer or power supplier, or both, should be consulted to assure proper application.

Table 2 – AC input voltage for 50-hertz chargers

Nominal (Volts)	Minimum (Volts)	Maximum (Volts)
100	90	110
127	114	140
200	180	220
220	198	242
230	207	253
240	216	264
346	311	380
380	342	418
400	360	440
415	373	456

Contact the manufacturer for line voltages not shown in these tables.

4.2 Frequency

The nominal AC supply frequency shall be 50 Hz or 60 Hz. The input frequency range with or without an engine generator set shall be 60 Hz ± 3 Hz or 50 Hz ± 3 Hz.

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4.3 AC input current

AC input current is the root mean square (rms) value of the input current delivered to the charger under all rated operating conditions.

4.4 Maximum AC input current

Maximum AC input current is the maximum rms value of the input current delivered to the charger under all operating conditions within the manufacturer's specifications.

EXAMPLE – The maximum input current may occur at the DC output current limit setting while the rated input current occurs at the rated DC output current.

4.5 AC system grounding

The alternating current supply should be grounded in a manner permitted by the National Electrical Code (ANSI/NFPA 70) or by IEC standards where applicable.

4.6 Unbalance (three-phase AC supply)

The line-to-line input voltages to three-phase chargers shall not be unbalanced more than 5 percent, that is, the maximum voltage shall be no more than 105 percent of the minimum voltage. All voltages shall be within the limits of Tables 1 and 2.

4.7 Phase failure

The loss of any phase of the AC line voltage shall not damage the battery charger.

4.8 Input surge withstand capability

These surges may occur from line to line, line to neutral and line to ground. The battery charger shall meet the requirements of ANSI/IEEE C37.90.1 with both the oscillatory and fast transient wave forms with a 2500 volt peak.

NOTE—For applications where the charger may be subjected to higher surge levels, such as high lightning areas, it is recommended that the charger be tested to meet the requirements of ANSI/IEEE C62.41.

4.9 Power factor

NOTE—The charger should be designed to maximize the power factor. Power rating and circuit topology will affect the achievable power factor.

4.9.1 Requirement for power factor corrected chargers

A power factor corrected charger shall have a minimum power factor of 0.9 at full rated output power and nominal input voltage.

4.9.2 Displacement power factor

NOTE—In six-pulse and higher self-commutated converters, e.g., phase controlled SCR chargers, the displacement power factor is of more practical value than the "total" power factor. The displacement power factor only includes the fundamental frequency.

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4.10 Harmonic distortion

The charger should be designed to minimize the total harmonic distortion of the current waveform. Power rating and circuit topology may affect the achievable harmonic distortion.

Some charger technologies can act as non-linear type loads. In these cases input harmonics should be evaluated in accordance with ANSI/IEEE 519.

4.11 Electromagnetic Interference (EMI)

The charger shall meet the requirements for radiated and conducted EMI contained in FCC Rules and Regulations Part 15, Subpart B, Class A.

NOTE—The charger should meet the noise immunity requirements of Bellcore GR-1089-CORE, Issue 1, November 1994.

4.12 Low input voltage protection

The operation of the battery charger with line voltages below the minimum limits including zero shall not cause permanent damage to the battery charger. If protective devices are activated when a charger operates into a low/zero line voltage, this shall not result in any degradation of performance after proper voltage levels have been restored.

4.13 AC input protection

An overcurrent protection device shall be placed in all ungrounded AC input leads.

4.14 Inrush Current

The peak value of the inrush current measured on the input leads of the battery charger during turn-on shall be limited to prevent branch breakers from operating.

4.15 Telephone influence factor (TIF)

The TIF of the alternating current waveform shall have an I•T product less than 500 times the rms input current for all line and load conditions.

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Section 5
DIRECT CURRENT (DC) OUTPUT CHARACTERISTICS

5.1 General

The voltage ranges listed in 5.2 and 5.3 are broad in order to include all lead-acid and nickel-cadmium type batteries. The user may wish to contact the battery manufacturer for float and equalize voltages appropriate for the type battery being used. Other types of batteries may also be accommodated, however, the manufacturer should be consulted for correct voltage settings and the need for equalizing.

5.2 Output Voltage

The output voltage setting of a battery charger is dictated by the type of battery with which it is used and the number of cells being charged. For number of cells not shown, consult manufacturer. The nominal output voltage ratings are shown in Tables 3 and 4.

The values given in 5.3.2 for the equalize mode of operation should be used to determine the maximum voltage.

Table 5 shows some of the typical float and equalize voltages for various types of batteries.

Table 3 – Nominal output voltages for lead-acid batteries

Nominal Output Voltage (volts)	Number of Cells Lead-acid
12	6
24	12
48	24
64	32
72	36
120 or 130	60
240 or 260	120

Table 4 – Nominal output voltages for nickel-cadmium batteries

Nominal Output Voltage (volts)	Number of Cells[1] Nickel Cadmium
12	9-10
24	19-20
48	37-38
64	48-50
72	57-60
120 or 130	92-93
240 or 260	184-186

[1] Consult the manufacturer if another number of cells is part of a listed output voltage.

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Table 5 – Typical float/equalize voltages

Battery Type	Per Cell Voltage at 25°C[3] Float[2]	Equalize[2]
Lead-Antimony (1.210 S.G.)	2.15-2.17	2.33
Lead-Calcium (1.210 S.G.)	2.17-2.22	2.33[1]
Nickel-Cadmium	1.40-1.45	1.50-1.60
Nickel-Iron	1.50-1.55	1.60-1.65
Lead-Acid Valve Regulated		
(1.300 S.G.)	2.25-2.30	[1]
(1.290 S.G.)	2.25-2.30	[1]
(1.245 S.G.)	2.17-2.22	[1]

[1] Additional equalize charging is not normally recommended after initial charge. Consult battery manufacturer or the battery instruction manual for further recommendations.

[2] For certain applications higher voltage charging may be required. Consult battery manufacturer for further recommendations.

[3] Lower float voltages may be required in uncontrolled high temperature applications. Consult battery manufacturer for further recommendations.

5.3 Voltage Adjustment

Separate controls for float voltage and equalize voltage shall be provided to enable continuous adjustment of the level of DC output voltage over the following minimum voltage adjustment ranges.

5.3.1 Float Voltage Adjustment Range

The float voltage range per cell at nominal AC input voltage and half load at an ambient temperature of 77°F (25°C) shall be 2.15 to 2.35 for lead-acid type batteries. The float voltage range per cell at nominal AC input voltage and half load at an ambient temperature of 77°F (25°C) shall be 1.35 to 1.45 for nickel-cadmium batteries. Follow battery manufacturer's instructions for proper settings.

5.3.2 Equalize Voltage Adjustment Range

The equalize voltage range per cell at nominal AC input voltage and half load at an ambient temperature of 77°F (25°C) shall be 2.20 to 2.45 for lead-acid type batteries. The equalize voltage range per cell at nominal AC input voltage and half load at an ambient temperature of 77°F (25°C) shall be 1.50 to 1.60 for nickel-cadmium type batteries. Follow battery manufacturer's instructions for proper settings.

5.4 Performance Condition

All performance requirements stated in this clause shall be met by the charger with the test battery and load connected. For battery eliminator operation or operation without the battery, other performance characteristics may apply.

Remote sensing leads, when provided, shall be connected to the battery terminals.

5.5 Voltage deviation (regulation)

While the charger is subject to the AC input conditions specified in 4.1, applicable frequency variations specified in 4.2, and load variations of 0 percent to 100 percent, the DC output voltage should be maintained as described in 5.5.1 and 5.5.2.

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5.5.1 Float voltage deviation

When floating a battery within the range shown in 5.3.1 the deviation shall not exceed ±0.5 percent. (This is equivalent to a total deviation of 1.0 percent of the maximum or minimum voltage value.)

5.5.2 Equalize Voltage Deviation

When equalizing a battery within the range shown in 5.3.2 the deviation shall not exceed ±1.0 percent. (This is equivalent to a total deviation of 2.0 percent of the maximum or minimum voltage value.)

5.6 Temperature effects

The change of DC output voltage resulting from the change of operating ambient temperature as specified in 7.1 shall not exceed ±0.5 percent (equivalent to a total deviation of 1.0 percent of the maximum or minimum voltage value) of the output voltage setting. If output voltage is automatically adjusted to meet the battery requirements at various temperatures through the use of a temperature compensation device the above requirements need not be met.

The battery manufacturer should be consulted for the proper use of temperature compensation devices.

5.7 Current limiting

The charger shall limit the DC output current to the value above rated load at which it shall be capable of operating continuously while being subjected to the conditions of clause 4, with the connected lead-acid battery at a voltage of 1.75 volts per cell or nickel-cadmium battery at a voltage of 1.00 volt per cell. Such operation shall not cause the operation of any protective device or result in damage to the charger.

5.8 Abnormal load conditions

If protective devices are activated when a charger operates into a zero voltage battery, this shall not result in any degradation of performance after operation has been restored.

NOTE—The charger should be able to operate into and recover an undamaged zero voltage battery without activating protective devices. A zero voltage battery is not the same as short circuit.

5.9 Overcurrent protection

Means shall be provided to protect the output power circuits against overcurrents and fault conditions.

Short circuiting the output terminals may cause a protective device to operate.

5.10 Dynamic response

5.10.1 Step Load Change

Sudden changes in load current over the range of 10 to 90 or 90 to 10 percent of full load occurring within 2 milliseconds shall not result in an output voltage excursion of greater than ± 6 percent. No excursion of voltage shall result in activation of the overvoltage shutdown. The voltage shall return to and remain within the regulation limits specified within 300 milliseconds.

5.10.2 Input line change

Input line changes shall not result in transient behavior greater than the limits specified in 5.5.

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5.11 Start-up behavior

When tested in accordance with 9.1.16 energizing the charger with a connected load of 10 percent or more of the charger rating shall not result in output voltage greater than 106 percent of the voltage setting, shall not activate the overvoltage shutdown, and shall stabilize to within the deviation limits specified in 5.5 within 15 seconds. A fully charged test battery must be connected.

5.12 Output surge withstand

These surges may occur across the DC output terminal or from either DC output terminal to ground. The battery charger shall be tested in accordance to ANSI/IEEE C37.90.1 with both the oscillatory and fast transient wave forms with 2500 volt peak.

5.13 Output grounding

In applications where either the positive or negative output is grounded a single point grounding method is recommended. The grounding method must meet all code requirements.

5.14 Output noise

5.14.1 Ripple

The ripple voltage shall be measured in terms of rms voltage at the terminals of a connected test battery. The limits specified in Table 6 shall apply for charger output ranges from 0% to 100%. Filtered chargers shall be used for valve-regulated lead acid batteries.

Table 6 – Ripple voltage limits

Nominal Charger Voltage	Condition	Limit
12/24/48	Unfiltered on battery	1% V rms
	Filtered on Battery	30 mV rms
	Filtered off Battery	1% V rms
	Battery Eliminator	30 mV rms
120 or 130	Unfiltered on battery	2% V rms
	Filtered on Battery	100 mV rms
	Filtered off Battery	2% V rms
	Battery Eliminator	100 mV rms
240 or 260	Unfiltered on battery	2% V rms
	Filtered on Battery	200 mV rms
	Filtered off Battery	2% V rms
	Battery Eliminator	200 mV rms

5.14.2 Voice frequency weighted noise

The c-message weighted noise resulting from the output voltage waveform shall be expressed in units of dBrnc measured at the terminals of a connected test battery. The output noise shall not exceed 32 dBrnc for chargers with a nominal voltage rating of 48 volts DC or less. This requirement does not apply to chargers rated above 48 volts DC nominal.

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5.14.3 Peak to peak noise

The unweighted noise resulting from the output voltage waveform shall be expressed in terms of peak to peak voltage measured at the terminals of a connected test battery. For chargers with a nominal output rating of 48 volts or less the output noise voltage shall not exceed 1.0 percent peak to peak of the nominal battery voltage, or 250 millivolts peak to peak, whichever is greater, at a bandwidth from 0 MHz to 20 MHz.

5.15 Efficiency

NOTE—The charger should be designed to produce an efficiency that is high for the circuit topology that is used. The efficiency may be less for lower DC output voltages.

5.16 Electrical isolation

The input and output circuits shall be electrically isolated from each other and from the charger ground.

5.17 Parallel redundant performance protection

A blocking diode or overcurrent protection device (adequate to handle the short circuit capability of the test battery) shall be placed in the ungrounded output of the battery charger. This device will prevent a failed battery charger from shorting the battery and bringing down the whole system.

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Section 6
SUPERVISORY CONTROLS AND ALARMS

6.1 General

When supplied, the functions described in this section can be supplied by either the charger or a separate control/alarm panel unless otherwise stated. All alarm functions are indicated by an isolated form C contact unless otherwise stated. Visual indicators of alarms may also be included.

6.2 High output voltage shutdown

The high voltage shutdown shall produce a charger shutdown and lockout if the output voltage exceeds a preset value. The operating point of the high output voltage shutdown shall be adjustable from 2.2 to 2.5 volts per cell for lead acid and 1.5 to 1.7 volts per cell for nickel cadmium. This feature shall be provided by the battery charger, and is recommended for voltage sensitive loads.

NOTE—The high voltage shutdown may be designed to restart the charger up to two times after a shutdown prior to lockout. This is done to separate high voltage conditions caused by transients from high voltage conditions caused by charger faults. Such designs will turn off the charger output for a fixed time period, then restart the charger; and will only shutdown and lockout the charger if the high voltage condition recurs within a fixed (relatively short) time period.

6.3 Selective high voltage shutdown

The selective high voltage shutdown shall turn off and lock out the faulty charger in a system of parallel connected chargers. It shall shut down and lock out only the battery charger producing an output voltage exceeding a preset value. The operating point of the high output voltage shutdown shall be adjustable from 2.2 to 2.5 volts per cell for lead acid and 1.5 to 1.7 volts per cell for nickel cadmium.

NOTE—The selective high voltage shutdown may be designed to restart the charger up to two times after a shutdown prior to lockout. This is done to separate high voltage conditions caused by transients from high voltage conditions caused by charger faults. Such designs will turn off the charger output for a fixed time period, then restart the charger; and will only shutdown and lockout the charger if the high voltage condition recurs within a fixed (relatively short) time period.

6.4 High output voltage alarm

The high output voltage alarm shall provide an alarm when the output voltage goes above a preset value. The operating point of the high output voltage alarm shall be adjustable from 2.2 to 2.5 volts per cell for lead acid and 1.5 to 1.7 volts per cell for nickel cadmium.

6.5 Low output voltage alarm

The low output voltage alarm shall provide an alarm when the output voltage goes below a preset value. The operating point of the low output voltage alarm shall be adjustable from 1.7 to 2.2 volts per cell for lead acid and 1.0 to 1.4 volts per cell for nickel cadmium.

6.6 AC power failure alarm

The AC power failure alarm shall provide an alarm indication if the AC power fails causing the input voltage to drop to a low value. In a three-phase battery charger if it is desired to monitor all phases, a phase loss alarm is recommended. The AC power failure is not intended to operate at a precise voltage level but may operate at any voltage level below the AC input voltage range shown in 4.1.

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6.7 Battery charger failure alarm

A battery charger failure alarm indication shall be provided to indicate a battery charger failure. Typical battery charger failure conditions are: blown fuse, tripped circuit breaker, overvoltage shutdown, and no output voltage.

6.8 Low DC current alarm

Isolated form C contacts shall be provided for alarm indication when the output DC current decreases to a value less than 2 percent of the rated output current (unless otherwise specified).

NOTE—The low current alarm does not necessarily indicate a battery charger failure. Nuisance alarms may be caused when the charger rating significantly exceeds the load.

6.9 Other controls, alarms, and accessories

NOTE—Other controls and other alarms, audible and visual, may be available from the manufacturer. Some examples are shown in Table 7. Consult the manufacturer.

Table 7 – Other controls, alarms, and accessories

Audible Alarm	Equalize Timer	Low AC Voltage Alarm
Battery Charger OK Indicator	Forced Load Sharing	Output Voltage Test Jacks
Blocking Diode	High Temperature Alarm/Shutdown	Phase Loss Alarm

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Section 7
ENVIRONMENTAL REQUIREMENTS

7.1 Operating temperature

Battery chargers designed for natural or forced convection shall be capable of meeting all performance requirements when the inlet air temperature is in the range of 0°C to 50°C. Within this range the temperature shall not change at a rate exceeding 7.2°C per hour.

NOTE—If the battery charger is to be operated in an ambient temperature outside this range the manufacture should be consulted. In an uncontrolled outdoor environment, a -40°C to +65°C operating range is typical.

7.2 Audible Noise

The battery charger should be designed to keep audible noise to a minimum. The maximum audible noise level shall not exceed 65 dBa, measured 5 feet from any vertical surface. The power rating, circuit topology, and cooling techniques will affect the achievable noise level.

7.3 Storage

The battery charger shall not be damaged by extended storage at any temperature between -40°C to +85°C. The manufacture should be consulted regarding maintenance procedures (if any) following storage periods greater than six months.

7.4 Altitude

Battery chargers are intended to comply to all the requirements for installation in altitudes not exceeding 1000 meters. For installation at higher altitudes, the manufacture should be consulted.

NOTE—For operation at higher altitudes (above 1000 meters), it is recommended that the maximum ambient temperature be derated by 2°C per 300 meters as the altitude increases.

7.5 Humidity

The charger shall be capable of meeting performance standards in a humidity not to exceed 95% (without condensation).

7.6 Packaging, storage, and preservation

The charger, in its shipping container, shall be adequately protected from shipping, handling, and environmental conditions that would cause physical damage or degradation of the electrical performance. Testing of the charger packaging shall conform with current national and/or international standards, as applicable, to assure conformance with this requirement.

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7.7 Unusual service conditions

NOTE—This standard does not require the charger to be designed to meet the following unusual service conditions or to operate outside the ranges specified in this standard. These conditions may require specific design considerations and must be brought to the attention of the manufacturer if they exist:

a) Exposure to damaging fumes;
b) Exposure to vapors of oil or other substances;
c) Exposure to excessive moisture;
d) Exposure to steam;
e) Exposure to weather or dripping water;
f) Exposure to salt air;
g) Exposure to excessive dust;
h) Exposure to abrasive dust;
i) Exposure to abnormal vibration, shocks, or tilting during transportation or operation;
j) Exposure to unusual transportation or storage conditions;
k) Exposure to unusual electromagnetic fields;
l) Exposure to abnormal radiation;
m) Exposure to insects, vermin, or fungus;
n) Operation with switching or negative resistance loads;
o) Operation with non-sinusoidal input voltage;
p) Exposure to seismic conditions.

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Section 8
MECHANICAL DESIGN REQUIREMENTS

8.1 Mechanical design classifications

Charger mechanical design classifications shall be as described in 8.1.1 and 8.1.2.

8.1.1 Ventilation class 1

These chargers shall be designed for continuous duty with natural convection cooling. All subclauses of clause 8 apply except for 8.8.2.

8.1.2 Ventilation class 2

These chargers shall be designed for continuous duty using fans or cooling devices. All subclauses of clause 8 apply except for 8.8.1.

8.2 Serviceable components

Serviceable components shall be readily accessible and easily replaceable. Plug-in components shall be keyed or have other suitable provision to prevent incorrect assembly.

8.3 Mounting

All chargers of an appropriate physical size shall be designed for wall, rack, or rack cabinet mounting; and shall meet the parameters specified in 8.3.1 through 8.3.4. Chargers of a size inappropriate for wall, rack, or rack cabinet mounting shall be designed for floor mounting.

The design for all chargers shall be such that, except for installation, side, top, or bottom access shall not be required for normal maintenance and operation.

8.3.1 Mounting holes

Mounting holes for rack or rack cabinet mounting shall be in accordance with Figure 2.

NOTE—Closed slot mounting holes are preferred.

Charger mounting must match sufficient holes as shown in Figure 3 to assure adequate support.

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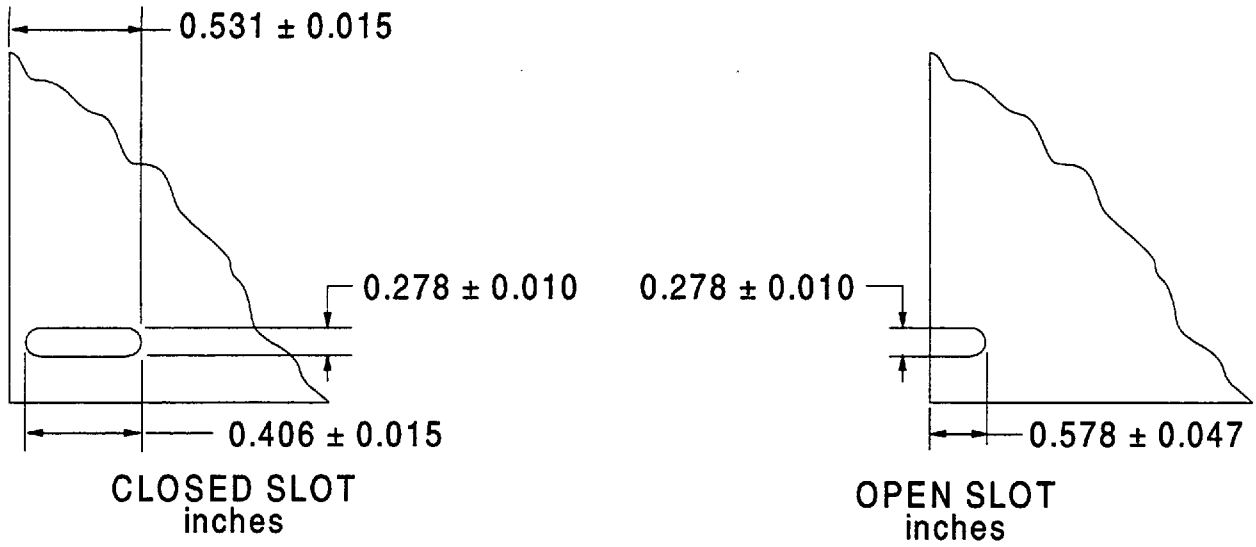

Figure 2 – Rack or rack cabinet mounting holes

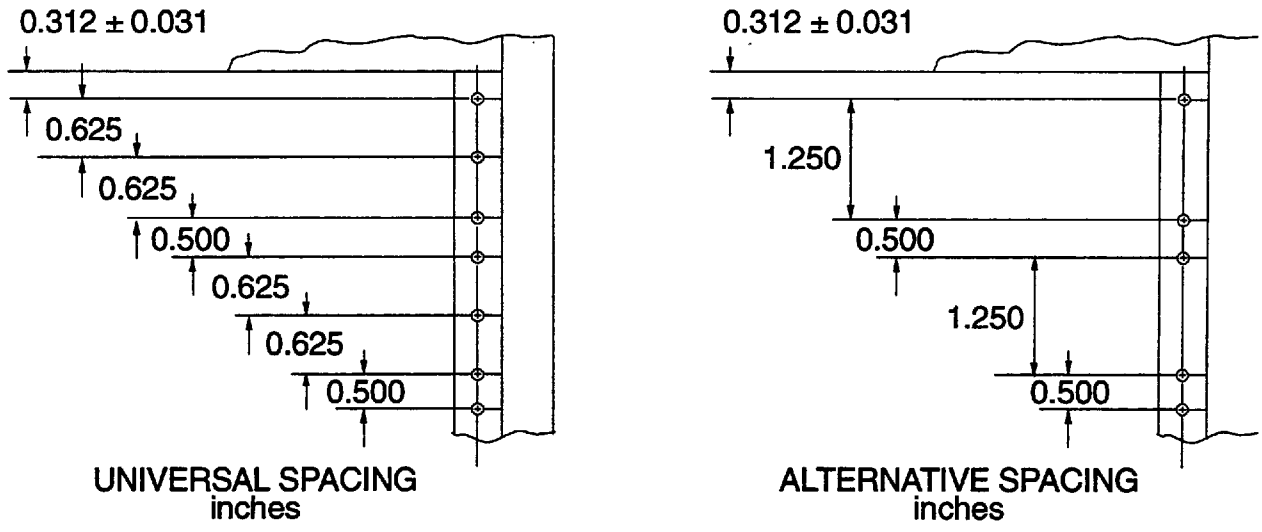

Figure 3 – Rack or rack cabinet hole spacing

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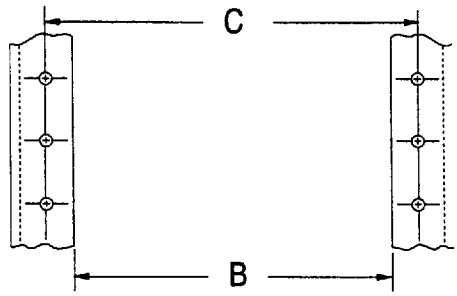

Figure 4 – Mounting hole centers and mounting rack inside dimensions

8.3.2 Mounting hole spacing

Preferred rack or rack cabinet hole spacing shall be in accordance with Figure 3. Clearance holes shall be 0.281 inches ± 0.003 inches. Threaded holes shall be for a No. 10 screw with 32 threads per inch, and for a No. 12 screw with 24 threads per inch as an alternative. The spacing tolerance between any two holes shall be ± 0.015 inches, with tolerance to be non-cumulative.

8.3.3 Mounting hole centers and mounting rack inside dimensions

Preferred rack or rack cabinet mounting hole centers and mounting rack inside dimensions shall be in accordance with Figure 4. Tolerances shall be ± 0.062 inches.

8.3.4 Charger width

Preferred dimensions shall be in accordance with Table 8 for rack or rack cabinet mounting. Tolerances shall be ± 0.062 inches.

Table 8 – Charger width dimensions

	Width (inches)	
Panel	**B [1]**	**C [1]**
19.000	17.750	18.312
23.000	21.750	22.312

[1] See Figure 4.

8.4 Nameplate marking

The following minimum information shall be given on the nameplate of the battery charger in letters which are 3.2 mm (1/8 inch) high or larger:

a. manufacturer's name, model number, and serial number;
b. rated DC output voltage, or number and type of cells, or both;
c. rated DC output current;
d. nominal AC supply voltage(s);
e. nominal AC supply frequency or frequency range;
f. number of supply phases;
g. AC input current (rated or maximum and must be so identified).

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8.5 Markings

All markings shall be legible and durable, and shall conform to the designations shown on supporting documentation.

8.5.1 Fuses

Current and voltage ratings or device type shall be marked as near as possible to all replaceable overcurrent protection devices.

8.5.2 Controls and indicators

Controls and indicators shall be marked with their function or an abbreviation of that function. The instruction manual shall describe control and indicator markings and functions.

8.5.3 Field wiring terminals

Field wiring terminals shall be marked to enable the user to properly and safely make all connections. Field wiring terminals include the cabinet ground, AC inputs, DC outputs, and alarm connections.

If multiple primary windings or taps are provided these shall be marked to permit proper connections.

8.5.4 Wires

Both ends of each wire not otherwise easily identifiable, shall be clearly identified either by color coding or numbering.

8.6 Field wiring terminals

Terminals intended for use by the equipment user (i.e., AC input, DC output, ground, remote controls, etc.) shall be of such size and design that they will accommodate the wiring specified in ANSI/NFPA 70 for the intended purpose.

The DC output terminals shall accommodate the wire size required to limit the voltage drop between the charger and the battery or load to 1 volt with 50 loop feet (i.e., 25 feet in each lead) of cable.

The battery charger manufacturer shall describe the voltage and current requirements of these terminations sufficiently to allow the user to properly select the type of wiring necessary, or, as an alternative, shall specify the classes, type, and sizes of wiring needed.

8.6.1 Enclosure service grounding

A separate grounding terminal shall be provided for connection of the AC input grounding conductor. The grounding terminal shall be conductively bonded to the inside of the charger enclosure (frame) near the AC input cable entry.

8.6.2 AC input cable entry

The charger cabinet shall be provided with a suitably sized entry hole or knockout located as near as possible to the internal connection terminals. If the charger is supplied with AC input cables, a strain relief shall be provided.

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8.6.3 DC output cable exit

The charger cabinet shall be provided with a suitably sized exit hole(s) or knockout(s) located as near as possible to the internal connection terminals. If the charger is supplied with DC output cables a strain relief shall be provided.

8.7 Wiring practices

Each bundle or harness shall be suitably supported along its length, particularly at points where a large portion of the bundle could tee off from the main stem. Harness to folding doors, swinging panels, and such, shall be given a reasonable length in which to twist rather than bend and shall be fixed at each end of the twist.

Conductors shall be adequately supported so that the requirements specified in 7.6 are met.

Insulation on wires and cables shall be compatible with environmental conditions.

8.8 Ventilation

8.8.1 Class 1 chargers

These chargers shall be cooled by natural convection and radiation. The enclosure shall be provided with adequate openings to permit sufficient air movement to avoid heat stagnation and to maintain allowable component temperatures. The charger will be installed and operated with the ventilation openings unobstructed.

Under normal operating conditions, the temperature of front panels and operator controls shall not exceed 65°C. Surfaces exceeding 65°C shall be marked with a suitable warning.

8.8.2 Class 2 chargers

These chargers shall allow the use of fans or cooling devices.

NOTE—The enclosure may be provided with openings to permit sufficient air movement to avoid heat stagnation and maintain allowable component temperatures.

Failure of the fan or cooling device, blocked openings or filters shall not allow a hazardous or destructive condition to develop.

Under normal operating conditions, the temperature of front panels and operator controls shall not exceed 65°C. Surfaces exceeding 65°C shall be marked with a suitable warning.

8.9 Component Temperatures

The temperature rise of all components shall not exceed the manufacturer's rating when subjected to the maximum ambient operating temperature specified in 7.1. All components must be rated to operate at the minimum temperature specified in 7.1. The total temperature of transformers and inductors shall not exceed the values given in Table 9.

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Section 9
TEST METHODS

9.1 Design tests (by type or model)

Design tests are those tests which are made to determine the performance characteristics of battery chargers and to demonstrate their conformance with this Standards Publication. They need not be repeated unless design changes are made that would affect the test results. Suitable test equipment shall be used for all tests if not specified in the test procedure. All design test results shall be recorded on an equipment test form. Design tests may include, but are not limited to, the following:

a. audible noise;
b. current limit;
c. dielectric;
d. dynamic response;
e. efficiency;
f. electromagnetic interference (EMI);
g. input current
h. inrush current;
I. input/output surge withstandability;
j. low input voltage protection;
k. phase failure
l. power factor
m. ripple voltage;
n. short circuit;
o. start-up behavior;
p. supervisory control;
q. component temperatures;
r. voltage adjustment;
s. voltage deviation (regulation);
t. telephone influence factor (TIF).

9.1.1 Audible noise

The battery charger shall be operated under all combinations of line voltages, output voltages, and load currents to determine the conditions which produce the highest audible sound. Measurements shall be made in accordance with ANSI S12.31 and ANSI S12.32 using a sound level meter which meets the requirements of ANSI S1.4. Measurements should be made at a distance of 5 feet from any vertical surface of the battery charger.

Noise tests shall be conducted in an environment where the ambient noise level is at least 10 dB (A - weighting) below the maximum measured noise level of the battery charger.

9.1.2 Current Limit

This test may be conducted with the battery disconnected. With the rated AC input voltage applied to the battery charger, the direct current output voltage shall be adjusted to its maximum equalize voltage in 5.3.2 and the load adjusted to full-load current. The load shall then be increased until the DC output voltage decreases to 1.75 volts per cell (1.00 volts per cell for nickel cadmium batteries). Sufficient measurements shall be taken to assure that protective devices will not operate and that damage will not occur to the battery charger. The measurements shall include the AC input and the DC output voltage

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and current. The input voltage shall be changed to minimum and maximum values specified in 4.1 and the measurements repeated.

9.1.3 Dielectric

A battery charger shall be capable of withstanding for 1 minute, without breakdown, the application of a 60-Hz sinusoidal test voltage with the battery charger at the maximum operating temperature which it reaches in normal use. A DC dielectric test can be used by applying the peak of the AC rating.

The test voltage as specified above shall be applied between the following points:

a. AC input terminals to ground;
b. AC input terminals to DC output terminals;
c. DC output terminals to ground.

The DC output terminals shall be shorted together and the AC input terminals shall be shorted together. Capacitors connected to ground and ground fault alarm circuits may be disconnected. Input and output contactors and relays shall be in their operating mode.

The insulation of primary circuits to ground and primary circuits to secondary circuits shall be capable of withstanding the application of 1000 volts plus twice the rated primary voltage. For secondary circuits operating at 50 volts or less, the insulation shall be capable of withstanding 500 volts between these circuits and ground. Secondary circuits operating at more than 50 volts shall withstand 1000 volts plus twice the maximum rated secondary circuit voltage between the circuits and ground.

9.1.4 Dynamic response

9.1.4.1 Load change

An optional test battery can be connected to the battery charger for this test. Sudden changes in load current over the range of 10% to 90% or 90% to 10% of full load occurring within 2 milliseconds shall not result in output voltage beyond the range of 94% to 106% of voltage setting. No excursion of voltage shall result in activation of the over voltage shutdown. The voltage shall return to, and remain, within the deviation limits specified in clause 5.5 in not more than 300 milliseconds.

9.1.4.2 Input voltage change

An optional test battery can be connected to the battery charger for this test. Sudden changes of up to 10% of rated input voltage shall not result in transient behavior greater than the limits specified in clause 5.5. The initial and final values shall be within the input voltage range shown in Tables 1 and 2.

9.1.5 Efficiency

The charger efficiency shall be determined by measuring the input watts at the AC input terminals by means of a wattmeter and by measuring the average values of the direct voltage and current at the output terminals. Unless otherwise specified by the manufacturer, the efficiency shall be taken at nominal float voltage, rated output current, and nominal input voltage. The battery charger shall be temperature stabilized for a sufficient time to permit temperatures within the unit to reach their steady-state values. The efficiency shall be calculated in accordance with the following formula:

$$\textit{Percent efficiency} = \frac{\textit{average output current} \times \textit{average output voltage}}{\textit{input watts}} \times 100\%$$

Unless otherwise stated, the input watts shall include the power requirements of all accessories.

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9.1.6 Electromagnetic interference (EMI)

The FCC regulations cover conducted and radiated EMI from electronic computing devices. A computing device is defined as any electronic device or system that intentionally generates and uses radio-frequency energy in excess of 10 kHz. The charger shall meet the requirements for radiated and conducted EMI contained in FCC Rules and Regulations Part 15, Subpart B Class A (for commercial equipment). It is recommended that this be done by a qualified EMI testing facility.

9.1.7 Input current

Input current shall be measured at rated values of low, nominal, and high AC line voltage at 0%, 20%, 40%, 60%, 80%, and 100% DC load current for both float and equalize modes. For three phase battery chargers at least two AC lines shall be monitored.

9.1.8 Inrush current

Whenever possible, the mains supply shall be from a power source with minimum protective short circuit capability consistent with the required input supply continuous rated current, including the switching device and wiring to the input terminals of the battery charger.

The mains supply shall be switched on to the battery charger input coincident with various angular points on the input voltage waveform in order to determine the worst case inrush current condition.

The inrush current test shall be performed after an absence of input voltage for more than 5 minutes and again after an absence of approximately 1 second. The measured value shall not exceed the manufacturers declared value.

Record all inrush current values on the equipment test report.

9.1.9 Input/output surge withstandability

The test circuit described in ANSI/IEEE C37.90.1 shall be used for this test. The battery charger used for this test shall be operating at full load with a test battery connected. During and after this test a surge voltage as described in ANSI/IEEE C37.90.1 shall be applied for a period of not less than 2 seconds to the charger as follows:

a. across each AC input phase;
b. from each AC input line to ground;
c. across the DC output terminals;
d. from each DC output terminal to ground.

The charger shall not exhibit any component damage. Following this test, there shall be no change in performance that exceeds specified tolerances.

9.1.10 Low input voltage protection

The AC input voltage to the battery charger shall be varied from the minimum value in 4.1 down to and including zero. Any protective devices that have operated shall be replaced or reset and the battery charger turned on. The battery charger shall show no degradation of performance after proper AC input voltages have been restored.

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9.1.11 Phase Failure

The battery may be removed for this test. Each input phase shall be removed in turn. The charger shall be tested over all rated input and output conditions. The battery charger may continue to operate or may turn off, but no damage shall occur.

9.1.12 Power factor

Input power factor shall be measured at low, nominal, and high line rated AC voltages at 0%, 20%, 40%, 60%, 80%, and 100% DC load for both float and equalize modes. Power factor measurements shall be made utilizing a power monitoring device which monitors one or more input phases. Record all power factor readings on the equipment test report.

9.1.13 Ripple voltage

Connect a test battery to the output of the battery charger. Connect a resistive load bank across the test battery. Connect a true rms-reading voltmeter (minimum 20 Hz to 10 kHz) response between the positive and negative terminals of the test battery. With the battery charger in the float mode, load the charger to its full load rating. Record the ripple reading on the equipment test report.

9.1.14 Short circuit

The battery shall be removed for this test.

A short circuit shall be placed across the output terminals of the battery charger. The battery charger shall be turned on and operated until the internal protection opens or constant temperatures are obtained (see 9.1.17). Upon removal of the short-circuit and the protective devices being reset or replaced, the output voltage shall return to normal without any degradation in performance.

9.1.15 Start-up behavior

An optional test battery can be connected to the battery charger for this test. The start-up behavior is the elapsed time between the application of input power and the attainment of output voltage to their nominal value stated in 5.2. With 10% of rated load connected to the charger, the output voltage shall not go above 106% of the output setting and shall not activate the overvoltage shutdown. The charger shall stabilize within the voltage deviation limits within 15 seconds.

9.1.16 Supervisory control circuits

When supplied, the supervisory control circuits and alarms shall be tested in accordance with the requirements in clause 6.

9.1.17 Component Temperatures

The battery charger shall be tested under worst case conditions of AC input voltage, DC output voltage, and load current as specified in 4.1 and 5.3. The operating conditions, at which each test is performed, shall be maintained constant until all component temperature rises have been stabilized.

The temperature of magnetic components shall not exceed the values given in Table 9. The temperature of all other components shall not exceed the manufacturer's rating when referred to an ambient operating temperature of 50°C (122°F). All measurements shall be made with any suitable temperature measuring device or technique (such as thermocouple method or resistance change method for transformer coils). The temperature shall be considered constant when three readings, taken at 15-minute intervals, indicate no further increase.

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Table 9 – Maximum Temperature Values for Transformers and Inductors

Class of Insulation	Maximum Temperature (Change of resistance)		Maximum Temperature Change of resistance)	
	°C	°F	°C	°F
105	90	194	95	203
130	110	230	120	248
155	135	275	140	284
180	150	302	160	320
200	165	329	175	347
220	180	356	190	374

9.1.18 Voltage adjustment

The AC input voltage shall be at the minimum value and the output current at one half the rated value. The float and equalize voltage adjustments shall cover the ranges in 5.3.1 and 5.3.2. The same results shall be met with the AC input voltage at its maximum value.

9.1.19 Voltage deviation (regulation)

This test shall be made at minimum and maximum rated floating and equalizing voltage settings. The battery charger shall be operated at the minimum, nominal, and maximum limits of line voltage and frequency specified in clause 4. while applying at least five increments of load from no-load to full-load. The DC voltage shall be measured at the output terminals of the charger except that, where remote sensing is required, the voltage shall be measured at the remote sense terminals.

From the values measured, the maximum (E_{max}) and the minimum (E_{min}) voltage values shall be determined. The maximum deviation, expressed as a percentage, shall be calculated as follows:

$$\textit{Percent deviation (regulation)} = \pm \left(\frac{E_{max} - E_{min}}{E_{max} + E_{min}} \times 100\% \right)$$

9.1.20 Telephone Influence Factor (TIF)

The battery charger shall be tested using the weighted noise test circuit shown in Figure 5 under the full range of input voltage and output power conditions. The TIF measurement expressed in terms of an I•T product is calculated by the following equation:

$$I \bullet T = n \times 10^{([N1-20.2]/20)}, \text{ or}$$

$$N1 - 20.2 = 20\log(I \bullet T/n)$$

where:

N1 is the noise reading using the C-message weighting;
n is the current transformer turns ratio.

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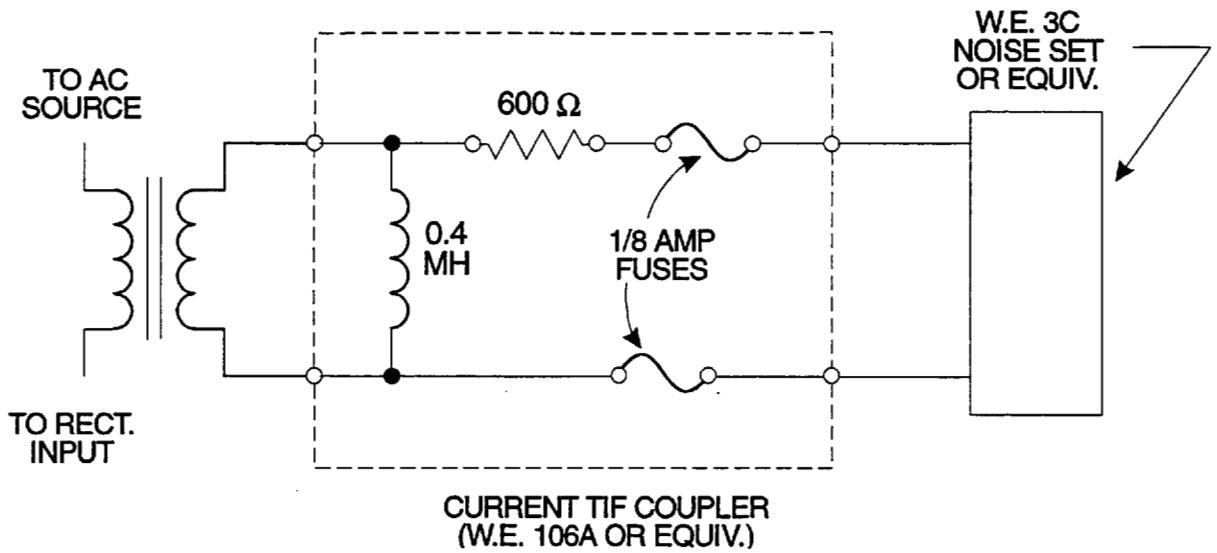

Figure 5 – Weighted noise test circuit

9.2 Production Tests

Production tests are those tests which are made at the discretion of the manufacturer on some or all production units for the purpose of maintaining quality and performance, and may include the following:

a. current limit;
b. dielectric;
c. voltage adjustment;
d. voltage deviation (regulation).

9.2.1 Current limit

With the rated AC input voltage applied to the battery charger, the DC output voltage shall be adjusted to its nominal value and the load adjusted to full load current. The load shall then be increased until the DC output voltage decreases to 1.75 volts per cell (1.00 volts per cell for nickel-cadmium batteries).

9.2.2 Dielectric

A battery charger shall be capable of withstanding for 1 minute, without breakdown, the application of a 60-Hz sinusoidal test voltage. A DC dielectric test can be used by applying the peak of the AC rating. As an alternative, 120% of the test voltage shall be applied for 1 second.

The test voltage as specified above shall be applied between the following points:

a. AC input terminals to ground;
b. AC input terminals to DC output terminals;
c. DC output terminals to ground.

The DC output terminals shall be shorted together and the AC input terminals shall be shorted together. Capacitors connected to ground and ground fault alarm circuits may be disconnected. Input and output contactors and relays shall be in their operating mode.

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The insulation of primary circuits to ground and primary circuits to secondary circuits shall be capable of withstanding the application of 1000 volts plus twice the rated primary voltage. For secondary circuits operating at 50 volts or less, the insulation shall be capable of withstanding 500 volts between these circuits and ground. Secondary circuits operating at more than 50 volts shall withstand 1000 volts plus twice the maximum rated secondary circuit voltage between the circuits and ground.

9.2.3 Voltage adjustment

The AC input voltage shall be at the nominal value and the output current at one half the rated nominal value. The float and equalize voltage adjustments shall cover the ranges in 5.3.1 and 5.3.2.

9.2.4 Voltage deviation (regulation)

This test shall be made at minimum and maximum rated floating and equalizing voltage settings. The battery charger shall be operated at the nominal value of line voltage and frequency specified in 4.1 and 4.2 while applying at least five increments of load from no-load to full-load. The DC voltage shall be measured at the output terminals of the charger except that, where remote sensing is required, the voltage shall be measured at the remote sense terminals.

From the values measured, the maximum (E_{max}) and the minimum (E_{min}) voltage values shall be determined. The maximum deviation, expressed as a percentage, shall be calculated as follows:

$$\textit{Percent deviation (regulation)} = \pm \left(\frac{E_{max} - E_{min}}{E_{max} + E_{min}} \times 100\% \right)$$

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Section 10
DOCUMENTATION

10.1 Instruction manuals

Instruction manuals shall be provided with every charger.

The manual shall include all the material shown in Table 10.

Table 10 – Instruction manuals

Item No.	Description
1	Charger specification to include, as a minimum: a) input and output voltage and current ratings; b) ripple voltage; c) output voltage regulation; d) current limit setting; e) input and output protection; f) controls; g) meters; h) maximum ambient temperature; I) other customer-specified requirements; j) charger size and weight
2	Installation instructions;
3	Circuit description, not at printed circuit board level;
4	High-level (above p.c. board level) schematic diagram;
5	Operating instructions;
6	Troubleshooting guide;
7	Recommended spare parts list.

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Annex A
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SAFETY

A.1 General

The protection of installation, operating, and service personnel from electrical and mechanical hazards is of prime importance. Design and manufacturing procedures which minimize such hazards shall be used when providing a product in accordance with this standards publication.

The user is required to properly train personnel involved in the installation, operation, and servicing of products built to meet this standard. This training should include safety procedures, general electrical and mechanical knowledge, general charger knowledge, and specific knowledge of the product.

This standard is a primarily a performance standard and, as such, does not provide complete coverage of all aspects of safety. The user is therefore encouraged to refer to the National Electrical Code and standards published by the Occupational Safety and Health Administration, Underwriter's Laboratories Inc., the Canadian Standards Association (such as CSA C22.2 No. 107.1), and other national and international safety standards organizations.

A.2 Safety agency certifications

Certain localities or applications may require a product to have a safety agency certification or to be locally certified prior to installation.

For purposes of this standard, chargers should meet the requirements of UL 1012.

A.3 Safety considerations

The following lists some of the areas of concern that need to be considered to meet safety objectives:

a. Construction;
   1. Cabinet strength;
   2. Accessibility to live and moving parts;
   3. Mounting;
b. Grounding;
c. Dielectric integrity;
d. Leakage currents;
e. Electrical spacings;
f. Markings;
   1. Cautionary labels and markings;
   2. Safety instructions;
      a) Grounding instructions;
   3. Operating instructions;
   4. Nameplate;
   5. Maintenance instructions;
   6. Moving and storage instructions;
g. AC and DC circuit protection;
h. Flammability;
I. Operation within component ratings;
   1. Temperatures;
j. Testing;
   1. Performance and ratings;
   2. Abnormal and fault conditions.

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Annex B
(informative)
BIBLIOGRAPHY

The following publications contain material relating to this Standards Publication:

ANSI/UL 1012-1994, *Power Units Other Than Class 2*

The above listed standard may be obtained by contacting:

American National Standards Institute
11 West 42nd Street
New York, NY 10036

CAN/CSA-C22.2 No. 107.1-M91, *Commercial and Industrial Power Supplies*

The above listed standard may be obtained by contacting:

Canadian Standards Association
178 Rexdale Boulevard
Etobicoke, Ontario M9W 1R3
Canada

NEMA PE 1-1992, *Uninterruptible Power Systems*

NEMA/BCI PE 6-199x, *Deep Cycle Battery Chargers*[1]

NEMA PE 5-1997, *Utility Type Battery Chargers*

NEMA TR 1-1993, *Transformers, Regulators, and Reactors*

The above listed standards may be obtained by contacting:

National Electrical Manufacturers Association
1300 North 17th Street
Rosslyn, VA 22209

Bellcore GR-1089-CORE, Issue 1, Nov. 1994, *Electromagnetic Compatibility and Electrical Safety Generic for Network Telecommunication Equipment*

[1] this document was still in draft stage at the time NEMA PE 7-1996 was published

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