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STANDARDS PUBLICATION/NO. PE 5

nema

Utility Type Battery Chargers

NEMA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION ■ 2101 L STREET, N.W., WASHINGTON, D.C. 20037

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PE 5

UTILITY TYPE BATTERY CHARGERS

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Foreword

This Standards Publication provides definitions, minimum requirements, and testing methods for utility battery charging equipment.

This Standards Publication provides practical information concerning the construction, test, performance, and safety of utility type battery chargers. The performance and safety tests included in this document form a part of the attempt to provide protection for the operator, the battery, and the battery charger.

This Standards Publication is reviewed periodically by the Power Electronics Section of NEMA for any revisions necessary to keep it up to date with advancing technology.

In the preparation of this Standards Publication, input of users and other interested parties has been sought and evaluated. Inquiries, comments, and proposed or recommended revisions should be submitted to the concerned NEMA product subdivision by contacting:

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National Electrical Manufacturers Association
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Washington, DC 20037

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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 to power the connected direct current system load. This standard also covers those chargers that are used to power the direct current load directly with the battery eliminated.

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UTILITY TYPE BATTERY CHARGERS

Section 1

REFERENCED STANDARDS AND DEFINITIONS

1.1 REFERENCED STANDARDS

The following publications are adopted in whole or in part as indicated, by reference in this Standards Publication.

American National Standards Institute
1430 Broadway
New York, NY 10018

ANSI C84.1-1982	*Voltage Ratings for Electric Power Systems (60 Hz)*
ANSI S1.4-1983	*Sound Level Meters, Specification for*
ANSI S1.31-1980	*Broad-Band Noise Sources in Reverberation Rooms, Precision Methods for the Determination of Sound Power Levels of*
ANSI S1.32-1980	*Discrete-Frequency and Narrow-Band Noise Sources in Reverberation Rooms, Precision Methods for the Determination of Sound Power Levels of*
ANSI Z53.1-1979	*Safety Color Code for Marking Physical Hazards*
ANSI/IEEE C37.90a-1974	*Surge Withstand Capability (SWC) Test*
ANSI/IEEE 100-1984	*IEEE Standards Dictionary of Electrical and Electronic Terms*
ANSI/NFPA 70-1984	*National Electrical Code*

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IB 6-1983	*Material Handling (Industrial Truck) Battery*
PE 7-1985	*Communication Type Battery Chargers*
PE 1-1983	*Uninterruptible Power Systems*
TR 1-1980	*Transformers, Regulators, and Residential Controls*

1.2 DEFINITIONS

The terms listed in this section are defined as applied in this Standards Publication. Definitions marked with an asterisk (*) are in accordance with ANSI/IEEE 100-1984.

1.2.1 Ambient Temperature

The temperature of the medium, such as air or water, that is used to cool the apparatus.

NEMA Standard 11-14-1985.

1.2.2 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.

NEMA Standard 11-14-1985.

1.2.3 Audible Noise

The sound level produced by the battery charger, measured in decibels.

NEMA Standard 11-14-1985.

1.2.4 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.

NEMA Standard 11-14-1985.

1.2.5 Battery Charger

An apparatus which is capable of restoring the charge in storage batteries.

NEMA Standard 11-14-1985.

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1.2.6 Charge*

The conversion of electrical energy into chemical energy within a battery.

NEMA Standard 11-14-1985.

1.2.7 Charger Efficiency

The output in watts divided by the input in watts, expressed in percent.

NEMA Standard 11-14-1985.

1.2.8 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.

NEMA Standard 11-14-1985.

1.2.9 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.

NEMA Standard 11-14-1985.

1.2.10 Current Limit

The function that maintains a current within its prescribed value.

NEMA Standard 11-14-1985.

1.2.11 Dielectric Tests*

Tests which consist of the application of a voltage higher than the rated voltage for a specified time to verify the dielectric withstand strength of insulation materials and spacing.

NEMA Standard 11-14-1985.

1.2.12 Dielectric Withstand Strength

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

NEMA Standard 11-14-1985.

1.2.13 Equalizing Charge

A charge, at an elevated voltage, to a 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.

NEMA Standard 11-14-1985.

1.2.14 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.

NEMA Standard 11-14-1985.

1.2.15 Floating

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.

NEMA Standard 11-14-1985.

1.2.16 Influence Quantity

Any quantity external to a battery charger, which affects its output quantities.

NEMA Standard 11-14-1985.

1.2.17 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.

NEMA Standard 11-14-1985.

1.2.18 Nominal Value

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

NEMA Standard 11-14-1985.

1.2.19 Output Voltage Deviation (Regulation)*

The excursion of the output voltage (E_{min} to E_{max}) resulting from changes in influence quantities (sometimes referred to as regulation).

$$\text{Percent Deviation (Regulation)} = \frac{E_{max} - E_{min}}{E_{max} + E_{min}} \times 100$$

NEMA Standard 11-14-1985.

1.2.20 Overcurrent Protection

Protection of the battery charger against excessive current, including short-circuit current.

NEMA Standard 11-14-1985.

1.2.21 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.

NEMA Standard 11-14-1985.

1.2.22 Power Factor

The ratio of the total input in watts to the total input in volt amperes.

NEMA Standard 11-14-1985.

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1.2.23 Rating

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

NEMA Standard 11-14-1985.

1.2.24 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 shall be accomplished by connecting the voltage sensing leads of the charger to the external point.

NEMA Standard 11-14-1985.

1.2.25 Ripple Voltage

Ripple voltage is the alternating-voltage component of the unidirectional voltage from a direct current power supply arising from sources within the power supply.

NEMA Standard 11-14-1985.

1.2.26 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.

NEMA Standard 11-14-1985.

1.2.27 Stabilized Charger

A battery charger which contains means to minimize deviations in the output quantities caused by changes in the influence quantities.

NEMA Standard 11-14-1985.

1.2.28 Test Battery

A fully charged battery, which has an ampere-hour rating of four times the rated output current of the charger.

NEMA Standard 11-14-1985.

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Section 2

ALTERNATING CURRENT (AC) INPUT CHARACTERISTICS

2.1 RATED AC VOLTAGES

The input voltage ratings of utility type chargers shall be in accordance with Table 2-1. 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 2-1.

NEMA Standard 11-14-1985.

Table 2-1
AC INPUT VOLTAGE

Nominal (Volts)	Minimum (Volts)	Maximum Volts
120	106	127
208	184	220
240	212	254
277	245	293
480	424	508
575	508	600*

*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.

Authorized Engineering Information 11-14-1985.

2.2 AC INPUT CURRENT

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

NEMA Standard 11-14-1985.

2.3 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.

NEMA Standard 11-14-1985.

2.4 AC SYSTEM GROUNDING

The alternating current supply should be grounded in a manner permitted by the ANSI/NFPA 70-1984.

Authorized Engineering Information 11-14-1985.

2.5 UNBALANCE (THREE-PHASE)

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 shown in Table 2-1.

NEMA Standard 11-14-1985.

2.6 INPUT SURGE WITHSTAND CAPABILITY

The input circuits of the charger shall withstand the surge test as specified in 8.13.

NEMA Standard 11-14-1985.

2.7 FREQUENCY

The nominal ac supply frequency shall be 50 Hz or 60 Hz. The tolerance on each shall be ± 5 percent.

NEMA Standard 11-14-1985.

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Section 3

DIRECT CURRENT (DC) OUTPUT CHARACTERISTICS

3.1 GENERAL

The voltage ranges listed in 3.2, 3.3, and 3.4, are broad in order to include all lead-acid types and nickel-cadmium batteries. The user may wish to contact the battery manufacturer for floating and equalizing voltages appropriate for the type of battery being used. Other types of batteries may be accommodated. However, the manufacturer should be consulted for correct voltage setting.

Authorized Engineering Information 11-14-1985.

3.2 OUTPUT VOLTAGE

The output voltage of a battery charger is dictated by the type of battery with which it is used and the number of cells being charged. The nominal output voltage should be as shown in Table 3-1.

The values given in 3.4 for the equalizing mode of operation should be used to determine the maximum voltage.

Authorized Engineering Information 11-14-1985.

Table 3-1
NOMINAL OUTPUT VOLTAGE

Nominal Output Voltage	Number of Cells	
Volts	Lead-Acid	Nickel-Cadmium
12	6	9-10
24	12	19-20
48	24	37-38
120	60	92-93
240	120	184-186

3.3 FLOATING VOLTAGE RANGES

The floating voltage ranges per cell at an ambient temperature of 77 °F (25 °C) shall be:

Lead-Acid Type.....2.15-2.25 volts
Nickel-Cadmium.....1.35-1.45 volts

NEMA Standard 11-14-1985.

3.4 EQUALIZING VOLTAGE RANGES

The equalizing voltage ranges per cell at an ambient temperature of 77 °F (25 °C) shall be:

Lead-Acid Type.....2.25-2.40 volts
Nickel-Cadmium.....1.50-1.60 volts

NEMA Standard 11-14-1985.

3.5 PERFORMANCE CONDITION

All performance requirements shall be met by the charger with the battery, and load connected.

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

NEMA Standard 11-14-1985.

3.6 VOLTAGE ADJUSTMENT RANGE

Controls shall be provided to enable continuous adjustment of the level of dc output over the following ranges:

Floating Voltage Adjustment Range

The range for this control at nominal ac input voltage and half-load shall be as shown in 3.3, times the number of series-connected cells for which the charger is intended. Follow battery manufacturer's instructions for proper voltage setting.

Equalizing Voltage Adjustment Range

When provided, the range of this control, at rated ac input voltage and half load, shall be as shown in 3.4, times the number of cells for which the charger is intended. Follow battery manufacturer's instructions for proper voltage setting.

NEMA Standard 11-14-1985.

3.7 VOLTAGE DEVIATION (Regulation)

While the charger is being subjected to the ac input conditions specified in 2.1 and 2.4, applicable frequency variations specified in 2.7, and load variations of 0 to 100 percent, the dc output voltage shall be maintained as follows:

Floating Voltage Deviation (Regulation)

When float charging a battery at a voltage as shown in 3.3, times the number of cells for which the charger is intended, the deviation shall not exceed ± ½ percent.

Equalizing Voltage Deviation (Regulation)

When equalize charging a battery at a voltage as shown in 3.4, times the number of cells for which the charger is intended, the deviation shall not exceed ±1 percent.

NEMA Standard 11-14-1985.

3.8 EFFECT OF TEMPERATURE CHANGE (ALL OTHER CONDITIONS CONSTANT)

The change of dc output voltage, resulting from the change of operating ambient temperature as specified in

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5.1, shall not exceed ± ½ percent of the output voltage setting. If output voltage is automatically adjusted to meet the battery requirements at various temperatures, the above requirement need not be met.

NEMA Standard 11-14-1985.

3.9 CURRENT LIMITING

The charger shall limit the dc output current to the value above rated at which it shall be capable of operating continuously while being subjected to the conditions of Section 2, with the connected lead-acid battery at a voltage level of 1.75 to 2.40 volts per cell or nickel-cadmium battery at a voltage of 1.00 to 1.60 volts per cell. Such operation shall not cause the operation of any protective device or result in damage to the charger.

NEMA Standard 11-14-1985.

3.10 ABNORMAL LOAD CONDITIONS

The charger should be able to operate into a zero battery voltage without activating protective devices.

Authorized Engineering Information 11-14-1985.

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

NEMA Standard 11-14-1985.

3.11 OVERCURRENT PROTECTION

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

NEMA Standard 11-14-1985.

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

Authorized Engineering Information 11-14-1985.

3.12 DYNAMIC RESPONSE

Load Change

When tested according to 8.12, the voltage shall return to, and remain, within the deviation limits specified in 3.7 in not more than 2 seconds. No excursion of voltage shall result in activation of the overvoltage shutdown.

Input Voltage Change

Input voltage shall not result in transient behavior greater than the limits specified in 3.7.

NEMA Standard 11-14-1985.

3.13 START-UP BEHAVIOR

When tested according to 8.12, energizing the charger with a connected load, which is 10 percent of nominal output, shall not result in output voltage greater than 110 percent of the voltage setting, shall not activate the overvoltage shutdown and shall stabilize to within the deviation limits specified in 3.7 within 15 seconds. A fully charged test battery or equivalent resistor-capacitor network must be connected.

NEMA Standard 11-14-1985.

3.14 OUTPUT SURGE WITHSTAND

The output circuits of the charger shall withstand the surge test as specified in 8.13.

NEMA Standard 11-14-1985.

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Section 4

SAFETY REQUIREMENTS

4.1 BATTERY CHARGER ENCLOSURES

The enclosure shall be constructed in such a manner that, in normal use, it shall meet the safety requirements outlined in this section. The enclosure shall completely house all current-carrying parts other than input and output leads.

A door or cover providing access to uninsulated live parts shall have means for holding it securely in place. A door or cover providing access to overcurrent protective devices or other parts, whose normal functioning requires renewal or replacement, shall be hinged, sliding, or similarly attached to prevent the door or cover from being easily removed. Opening the door or removing the cover shall require the use of a tool.

The enclosure shall be constructed to minimize the possibility of adjustment or tampering by unauthorized personnel. Potentiometers and rheostats which are used to adjust or vary the output characterisitic of the battery charger shall be guarded or be of the lockable type or shall require a tool for access.

Ventilating openings in an enclosure (including perforated holes, louvers, and openings protected by means of wire screening, expanded metal, or perforated covers) shall conform to requirements shown in Table 4-1. Electrical spacings shall conform to dimensions shown in Table 4-2.

All enclosures which are composed of wire mesh, perforated screens, grille work, or a combination thereof shall be provided with a supporting frame or other means which is rigid enough to prevent the mesh, screens, or grille work from being deformed and making contact with live parts under normal use.

If non-ferrous or non-metallic materials are used they shall have strength equivalent to the specified metal.

NEMA Standard 11-14-1985.

Table 4-1
VENTILATION OPENINGS

	Closest live part to any opening Up to 101.6 mm (4 inches)	Closest live part to any opening Greater than 101.6 mm (4 inches)
Minimum rod diameter that will not pass through any opening	12.7 mm (½ inch)	19.1 mm (¾ inch)
Minimum wire size for screened opening	1.5 mm (0.059 inch)	2.5 mm (0.100 inch)
Minimum thickness for expanded steel mesh and perforated steel ventilation opening	1.1 mm (0.042 inch)	2.5 mm (0.100 inch)

Table 4-2
ELECTRICAL SPACINGS

Potential Involved Volts, RMS	Through Air MM	Through Air In.	Over Surface MM	Over Surface In.
50 or less	1.6	1/16	1.6	1/16
51-150	3.2	1/8	6.4	1/4
151-300	6.4	1/4	9.5	3/8
301-600	9.5	3/8	12.7	1/2

4.2 ELECTRICAL SPACINGS

Spacings between live parts of different potentials (except on printed circuit board assemblies operating below 151 volts rms) and spacings between live and dead metal parts, shall not be less than specified in Table 4-2.

NEMA Standard 11-14-1985.

4.3 MARKINGS

External precautionary markings or labels on battery chargers shall be readily visible to the operator and permanently attached.

Battery chargers which are not equipped with input or output cords, cables, plugs or connectors, shall have their connecting cables (if supplied) or their input and output terminals sufficiently and permanently identified or

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marked so that the charger is properly connected for service. If multiple transformer primary windings or taps are incorporated in the battery charger, these leads or terminals shall also be properly identified or marked to permit proper connection.

A marking that is required to be permanent shall be molded, die-stamped, paint-stencilled, stamped, etched-on-metal, or another method that is permanently secured or be indelibly stamped on a pressure sensitive label.

Interconnecting wiring (other than printed wiring on circuit boards) shall be either numbered in a permanent and legible manner at both ends of each wire or color coded to facilitate servicing and trouble-shooting of the battery charger. Terminals and terminal blocks for use by the equipment user (i.e., remote control, and so forth) shall be permanently marked or identified in such a manner as to enable the user to make proper connections.

The polarity of the output shall be plainly identified by (1) the abbreviations "POS" and "NEG", or (2) the sign "+" for positive and "−" for negative, or (3) color coding of "red" for positive and "black" for negative.

The ac input power terminals or point of entry of the battery charger shall be labeled or tagged to indicate the original factory setting of the ac input voltage.

Replaceable overcurrent protection devices shall be identified by permanently affixed markings or labels indicating current ratings as near as possible to the device(s).

NEMA Standard 11-14-1985.

4.4 PRECAUTIONARY LABELING

4.4.1 Signal Words

A signal word is used to draw attention to the presence and degree of a hazard or hazards. There should be three recognized signal words. In descending order of severity they are:

a. *DANGER*—The signal word DANGER should be used to call attention to immediate or imminent hazards which if not avoided will result in immediate, serious, personal injury or loss of life.

b. *WARNING*—The signal word WARNING should be used to call attention to potential hazards which could result in personal injury or loss of life.

c. *CAUTION*—The word CAUTION should be used to call attention to hazards which could result in personal injury or damage to equipment.

The signal word should be printed so that it is the dominant word in the labeling and it should be in capital letters. Where one or more signal words could be used, because of multiple hazards, only the signal word corresponding to the class of greatest hazard should be used.

When red, orange, and yellow are associated with the signal words DANGER, WARNING, and CAUTION respectively, the colors should conform to ANSI Z53.1-1979.

Authorized Engineering Information 11-14-1985.

4.4.2 Symbol

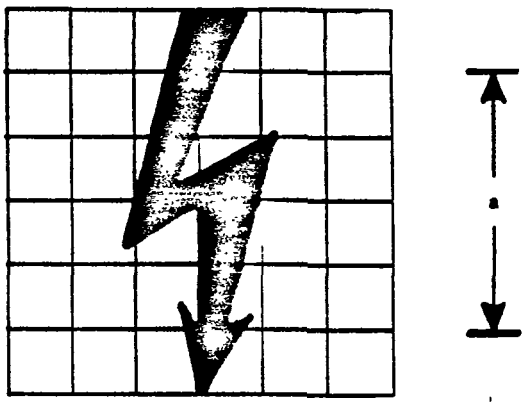
The symbol denoting hazard of electrical shock or burn shall be as shown in Figure 4-1. The use of the symbol on the front of the battery charger is not intended to rule out the use of other labels or markings either internal or external, which are required to comply with this standard, other nationally recognized standards, laws, or regulations.

NEMA Standard 11-14-1985.

4.4.3 Size of Letters

The signal words shall be 3.2 mm (⅛ inch) high or larger; the remaining words shall be no less than 1.6 mm (1/16 inch) high.

NEMA Standard 11-14-1985.



SYMBOL PROPORTION
HEIGHT = 1.48a
WIDTH = 0.58a

Figure 4-1
SYMBOL DENOTING HAZARD OF ELECTRICAL SHOCK OR BURN

4.5 PRECAUTIONARY LABEL (TEXT) INSTRUCTIONS

4.5.1 Shock Hazard Labels

A battery charger shall have a precautionary label indicating the presence of potentially lethal voltage with minimum wording, as shown in Figure 4-2.

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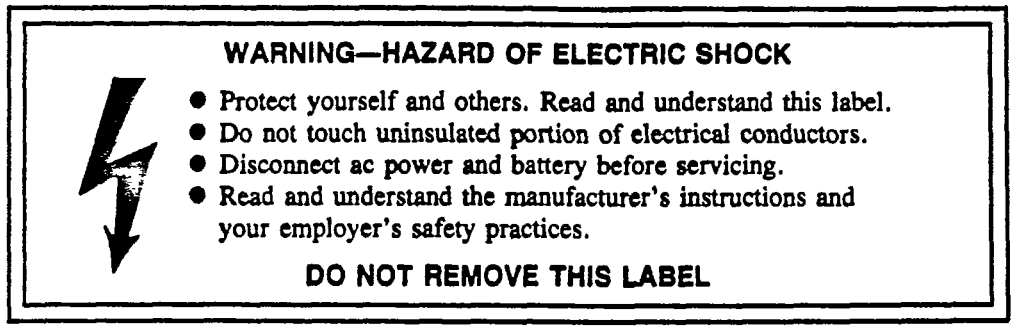

Figure 4-2
PRECAUTIONARY LABEL—TEXT

4.5.2 Grounding Label

The battery charger shall be permanently marked with the following wording or equivalent, which will be readily visible to the electrical installer:

WARNING, ELECTRIC SHOCK CAN KILL. Install and ground the charger in accordance with ANSI/NFPA 70-1984, using the grounding screw terminal. Before installing or operating, see instruction manual.

NEMA Standard 11-14-1985.

4.5.3 Field Wiring Label

If the wires in a terminal box or component of a charger intended for field wiring connections can attain a temperature higher than 60 °C during normal operation, the charger shall be marked:

"For supply and load connections use wire suitable for _____ °C, or equivalent at or near the point at which the connections are to be made."

Chargers intended for 120V ac operation containing an overcurrent protection device in only one line shall have the unprotected line marked "neutral".

NEMA Standard 11-14-1985.

4.6 NAMEPLATE MARKING

The following minimum information shall be given on the nameplate of the battery charger in letters which are 3.2 mm (⅛ inch) high or larger:

1. Manufacturer's name, model number, and serial number
2. Rated dc output voltage, or number and type of cells, or both
3. Rated dc output current
4. Nominal ac supply voltage(s)
5. Nominal ac supply frequency(ies)
6. Number of supply phases.
7. AC input current (maximum or rated and must be so identified).

NEMA Standard 11-14-1985.

4.7 OPERATING CONTROLS

All operating controls shall be identified with permanently affixed legends. Letters shall be 3.2 mm (⅛ inch) high or larger and shall be so placed on the battery charger so that they are readily visible.

NEMA Standard 11-14-1985.

4.8 INSTRUCTION MANUAL

An instruction manual shall be provided with each charger and shall include at least safety instructions and other minimum information as specified in Table 9-1.

NEMA Standard 11-14-1985.

4.9 POTENTIALLY LETHAL SHOCK HAZARDS

Higher voltages present a greater potential for a lethal shock hazard; therefore, efforts should be made to reduce the accessibility to such voltages.

Voltages exceeding 42.4V peak are considered to be dangerous and necessary precautions should be taken.

Authorized Engineering Information 11-14-1985.

4.10 TRANSFORMER CONSTRUCTION

The transformer shall have its primary winding electrically isolated from its secondary winding and shall be varnish impregnated and baked to exclude moisture. Each class of insulation shall operate within its design temperature limits as indicated in Table 4-3.

Means shall be taken to prevent the possibility of primary voltage being present in the secondary circuit. This shall be accomplished by either of the following:

a. Coil winding methods which provide insulation or physical separation between input and output circuits.
b. A grounded electrostatic or Faraday shield placed between the primary and secondary windings. This shield shall be made of copper or aluminum and shall have at least the ampacity of the primary conductor if the primary conductor is smaller than No. 6 AWG. If the primary conductor is No. 6 AWG or larger, the shield shall have an ampacity of a least 50 percent of the primary conductor. If foil is used, it shall have a thickness of not less than 0.25mm (0.010 inch).

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The insulating materials used within the transformer at the points described below shall have dielectric stength rating equal to or greater than 5000 volts (volts per mil rating multiplied by thickness).

a. Between the primary and secondary windings
b. Between the primary windings and the core
c. Between the secondary windings and the core
d. At cross over points between high and low potential windings
e. At the interface between the shield and adjacent coils

The same temperature rise limitations shall be used for properly applied aluminum connections. Aluminum shall not be placed on direct contact with silver or copper, without treatment to prevent galvanic corrosion.

The values given in Table 4-4 shall not apply to transformers, diodes, or fuses, or to their connections.

Primary leads shall be separated from secondary leads and dead-metal parts by spacings shown in Table 4-2 or shall be provided with insulation having a minimum rating of 5000 volts.

NEMA Standard 11-14-1985.

Table 4-3
INSULATING MATERIALS

Class of Insulating Material	Limit of Hottest-Spot Temperature Rise, Degrees C*†	Limit of Hottest-Spot Total Temperature Degrees C*†
90	40	90
105	55	105
130	80	130
155	105	155
180	130	180
220	170	220

4.11 AC AND DC CIRCUIT PROTECTION

The charger shall be provided with protection against overload and short-circuit in each ac input power line except the neutral line on 120V ac connected charger when marked according to 4.5.3.

It is the responsibility of the user to provide protection for the ac input lines.

The charger shall also be provided with protection against overload, short-circuit, and reverse battery connection in at least one of the two output leads.

Protective devices shall limit fault and overload currents to prevent damage to the charger.

NEMA Standard 11-14-1985.

4.12 FIELD WIRING TERMINALS

Terminals intended for use by the equipment user (i.e., ac input, dc output, remote controls, and so forth) shall be of such size and design that they will accommodate the wiring specified in the ANSI/NFPA 70-1984 for the intended purpose. In addition, the dc output terminal lugs shall accommodate the wire size required to limit the voltage drop between the rectifier and the battery or load to 1 volt, with 50 loop feet (i.e., 25 feet in each lead).

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.

NEMA Standard 11-14-1985.

4.13 ENCLOSURE SERVICE GROUNDING

A separate, clearly identified grounding terminal shall be provided for the 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. All non-current-carrying metal parts of the battery charger shall be conductively connected to this grounding terminal or to the battery charger enclosure (frame) to ensure their grounding integrity. The grounding terminal and any grounding stud used in conjunction with the grounding terminal shall have a current-carrying capacity not less than that of the required ac

Table 4-4
ENCLOSURES, BUSES, AND CONNECTIONS

Item	Limit of Hottest-Spot Temperature Rise, Degrees C*	Limit of Hottest-Spot Total temperature Degrees C*
Buses and Connections with:		
Bare untreated, bolted copper-to-copper connecting joints	55	105
Silver-surfaced or equivalent connecting joints	55	105
Connections with Insulated Cables		
Copper-to-copper connecting joints	20	70
Silver-surfaced or equivalent connecting joints	35	85
Enclosures	25	75

*Higher connection temperatures corresponding to the temperature rating of the cable should be applicable where cables with higher temperature insulation are used. (Total temperatures are limited to a maximum of 105°C.)

† These temperature limits for insulating materials may not apply to insulation in circuit breakers or other devices. For temperature limitation on appropriate device standards.

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input grounding conductor. The grounding terminal shall be sized to accommodate the required ac input grounding conductor as shown in Table 4-5.

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Table 4-5
SIZE OF EQUIPMENT GROUNDING CONDUCTORS FOR GROUNDING INTERIOR RACEWAY AND EQUIPMENT

Maximum Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Amperes	AWG Size	
	Copper	Aluminum or Copper-Clad Aluminum
15	14	12
20	12	10
30	10	8
40	10	8
60	10	8
100	8	6

4.14 AC INPUT CABLE ENTRY

The charger cabinet shall be provided with an entry hole or knockout located as near as possible to the internal connection terminals. If the charger is supplied with ac input cable, a strain relief shall be included.

NEMA Standard 11-14-1985.

4.15 DC OUTPUT CABLE EXIT

The charger cabinet shall be provied with an exit hole(s) or knockout(s) located as near as possible to the internal connection terminals to accommodate the required strain relief. If the charger is supplied with dc output cable(s), a strain relief(s) shall be included.

NEMA Standard 11-14-1985.

4.16 WIRING CONNECTORS OR TERMINALS

All crimp-type connectors shall be in keeping with the wires to which they are attached and shall be crimped with the proper type of compression tool. Open fork terminals, if used, shall be of the type that assist in preventing the terminations from slipping off the terminal and creating a possible hazard.

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4.17 DIELECTRIC WITHSTAND

The charger shall be capable of withstanding the dielectric test specified in 8.2.

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Section 5

ENVIRONMENTAL REQUIREMENTS

5.1 OPERATING TEMPERATURE

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° to 50 °C (32° to 122 °F). Within this range, the temperature shall not change at a rate exceeding 7.2 °C (13 °F) per hour.

NEMA Standard 11-14-1985.

5.2 STORAGE

The charger shall not be damaged by extended storage at any temperature between −40 °C (−40 °F) and 85 °C (185 °F).

NEMA Standard 11-14-1985.

The manufacturer should be consulted regarding maintenance procedures (if any) following storage periods greater than 6 months.

Authorized Engineering Information 11-14-1985.

5.3 ALTITUDE

Chargers shall meet all performance requirements at altitudes not exceeding 1000 meters (3300 feet).

NEMA Standard 11-14-1985.

5.4 HUMIDITY

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

NEMA Standard 11-14-1985.

5.5 VIBRATION

The charger, in its shipping container, shall be capable of withstanding vibration normally encountered in shipping without physical damage or degradation of the electrical performance.

NEMA Standard 11-14-1985.

5.6 SHOCK

The charger, in its shipping container, shall be capable of withstanding the shock involved when one edge of the container is dropped 6 inches (152.4 mm) while the opposite edge is resting on the ground, or a full drop of 2 inches (50.8 mm) on any surface without physical damage or degradation of the electrical performance.

NEMA Standard 11-14-1985.

5.7 UNUSUAL SERVICE CONDITIONS

Unusual service conditions may require specific design considerations and the following unusual service conditions should be brought to the attention of the manufacturer:

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. Operation at ambient temperature below 0 °C (32 °F) or above 50 °C (122 °F)
m. Operation at altitudes above 1000 meters (3300 feet)
n. Exposure to abnormal radiation
o. Exposure to insects, vermin, or fungus
p. Operation with switching or negative resistance loads
q. Operation without a battery

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Section 6

SUPERVISORY CONTROLS

6.1 SUPERVISORY CONTROLS

When supplied, the following supervisory controls shall perform as stated below:

6.1.1 DC Output Failure Alarm

Isolated form "C" contacts shall be provided to indicate loss of charger dc output for any reason, such as, transformer failure, blown fuse(s), rectifier failure, or any shutdown.

NEMA Standard 11-14-1985.

6.1.2 Low DC Voltage Alarm

Isolated form "C" contacts shall be provided for alarm indication of dc output voltage below a preset adjustable level. The minimum voltage adjustment range for pickup and dropout shall be 1.7 to 2.2 volts per cell for lead-acid and 1.00 to 1.40 volts per cell for nickel-cadmium battery times the number of series-connected cells for which the charger is intended. The operating voltage shall not vary by more than ½ percent over the charger ambient temperature range specified in 5.1. This alarm shall operate within ¼ percent of the adjusted value for a minimum of 6 months without adjustment.

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6.1.3 High DC Voltage Alarm

The high dc voltage alarm shall provide isolated form "C" contacts for alarm indication of a dc voltage above a preset adjustable level. The minimum voltage adjustment ranges for pickup and dropout shall be 2.2 to 2.5 volts per cell for lead-acid and 1.50 to 1.70 volts per cell for nickel-cadmium battery times the number of series-connected cells for which the charger is intended. The operating voltage shall not vary by more than ½ percent over the charger ambient temperature range specified in 5.1. This alarm shall operate within ¼ percent of the adjusted value for a minimum of 6 months without adjustment.

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6.1.4 High DC Voltage Shutdown

The overvoltage shutdown shall produce a charger shutdown and lockout if the output voltage exceeds a preset value. The minimum voltage adjustment range for shutdown shall be adjustable from 2.2 to 2.5 volts per cell for lead-acid and 1.50 to 1.70 volts per cell for nickel-cadmium battery times the number of series-connected cells for which the charger is intended.

NEMA Standard 11-14-1985.

6.1.5 Selective High DC Voltage Shutdown

The selective high dc voltage shutdown is intended to shut down the faulty charger in a system of parallel connected chargers. It shall shutdown and lockout only the charger producing an output voltage exceeding a preset value. The operating point adjustability shall be the same as specified in 6.1.4.

NEMA Standard 11-14-1985.

6.1.6 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).

NEMA Standard 11-14-1985.

6.1.7 AC Power Failure Alarm

Isolated form "C" contacts shall be provided for alarm to indicate loss of power.

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It is not intended to operate at a precise voltage level but may operate at any voltage below the ac input operating range shown in Table 2-1.

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Section 7

COMPONENT REQUIREMENTS

7.1 GENERAL

All component parts of the charger shall be operated within their design ratings.

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7.2 MINIMUM COMPONENTS

The charger shall contain the following minimum parts:

a. Semiconductor rectifying elements
b. Transformer (two winding type) to electrically isolate the battery being charged from the ac source

The temperature rise of tranformer shall conform to the values shown in Table 4-3. Temperature rise limits apply for any combination of voltage and load and shall be measured in accordance with applicable NEMA standards: IB 6-1983, PE 7-1985, PE 1-1983, and TR 1-1980.

c. Output voltage adjustment control
d. Enclosure in accordance with 4.1
e. Input and output protective devices as described in 4.11

NEMA Standard 11-14-1985.

7.3 ADDITIONAL COMPONENTS

If the charger contains additional parts, they shall meet the following requirements:

a. Electrolytic Capacitor—Electrolytic capacitors shall not be subjected to any steady-state, dc working voltage, or ripple current exceeding 85 percent of the manufacturer's capacitor rating.
b. DC Meters—Average responding type meters shall be used to monitor the output voltage and current.
c. Other Magnetic Components—When furnished, these components shall meet the temperature rise requirements specified in Table 4-3.
d. Relays—All control and alarm relays shall be provided with dust covers.
e. Transient Surge Suppression—Suppressors (if required) shall be provided to protect the semiconductors from the transient overvoltage surges specified in 2.6 and 3.14—surge withstand capability.
f. Adjustment Controls—Adjustment controls shall be provided for independently adjusting the floating and equalizing voltage levels and a means to change from the float mode to the equalize mode of operation and vice versa.

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Section 8

TEST METHODS

8.1 GENERAL

All dc meters used in these tests should be of the average responding type.

Tests are divided into two categories:

8.1.1 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. Design tests may include but are not limited to the following:

1. Dielectric Test (see 8.2)
2. Voltage Adjustment Test (see 8.3)
3. Temperature Rise Test (see 8.4)
4. Current-Limit Test (see 8.5)
5. Short-Circuit Test (see 8.6)
6. Voltage Deviation (Regulation) Test (see 8.7)
7. Efficiency Measurement (see 8.8)
8. Power Factor Measurement (see 8.9)
9. Ripple Voltage Measurement (see 8.10)
10. Audible Noise Test (see 8.11)
11. Dynamic Response Test (see 8.12)
12. Input and Output Surge Withstandability Test (see 8.13)

8.1.2 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:

1. Dielectric Test (see 8.2)
2. Voltage Adjustment Test (see 8.3)
3. Current-Limit Test (see 8.5)
4. Ripple Voltage Measurement (see 8.10)

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8.2 DIELECTRIC TEST

A battery charger shall be capable of withstanding for 1 minute, without breakdown, the application of a 60 Hertz sinusoidal test voltage with the battery charger at the maximum operating temperature which it reaches in normal use. As an alternative, 120 percent of the specified test voltage shall be applied for 1 second.

The charger shall be tested by one of the following types of test equipment or equivalent:

1. A 500 volt-ampere or larger transformer with voltmeter.
2. A less than 500 volt-ampere transformer having output voltmeter, audible and visual indication of breakdown, and reset button.

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

a. AC input terminals to dead-metal parts.
b. AC input terminals to dc output terminals.
c. DC output terminals to dead-metal parts.

For these tests, all semiconductors, capacitors, and sensitive control components shall be short-circuited; printed circuit control boards shall be removed and ground fault alarm circuits shall be disconnected from the case. Contactors and relays shall be in their operating mode.

The insulation of primary circuits to dead-metal parts 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 withinstanding 500 volts between these circuits and dead-metal parts. Secondary circuits operating at more than 50 volts shall withstand 1000 volts plus twice the maximum rated secondary circuit voltage between the circuits and dead-metal parts. The leakage current for these test voltages shall not exceed 0.75 milliampere on cord connected chargers and 5.0 milliamperes on all other chargers.

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8.3 VOLTAGE ADJUSTMENT TEST

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 given in 3.6.

NEMA Standard 11-14-1985.

8.4 TEMPERATURE RISE TEST

The battery charger shall be operated in its worst case rated mode until there is no further rise in the temperature of any component. The temperature rise shall not exceed the values given in Tables 4-3 and 4-4.

If a mode of operation other than a maximum output current would result in a greater temperature rise in any component, the charger shall be operated in that mode other than that specified above until the maximum temperature rise of that component is ascertained.

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The load shall be resistive, with a battery connected in parallel to provide the required current.

The temperature shall be considered constant when three readings, taken at 15-minute intervals with a thermocouple bridge or thermometer are identical. The actual temperature rise of a component is the difference between the constant final operating temperature thus obtained and the ambient temperature of the cooling medium.

NEMA Standard 11-14-1985.

8.5 CURRENT-LIMIT TEST

The battery charger shall be resistively loaded to check for compliance with 3.9.

NEMA Standard 11-14-1985.

8.6 SHORT-CIRCUIT TEST

A short-circuit shall be placed across the output terminals of the battery charger. The charger shall be capable of withstanding the short-circuit condition either by means of the current limit feature or operation of an output circuit breaker or a fuse. Upon removal of the short-circuit and the resetting of the circuit breaker or replacement of the fuse, the output voltage shall return to normal without any immediate or future degradation in the performance of the battery charger. The battery shall be removed for this test.

NEMA Standard 11-14-1985.

8.7 VOLTAGE DEVIATION (REGULATION) TEST

This test shall be made at minimum and maximum rated floating and equalizing voltage settings. The battery charger shall be operated at the minimum and maximum limits of line voltage specified in 2.1 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 battery 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:

$$\text{Percent Deviation (Regulation)} = \frac{E_{max} - E_{min}}{E_{max} + E_{min}} \times 100$$

NEMA Standard 11-14-1985.

8.8 EFFICIENCY MEASUREMENT

The efficiency of a battery charger shall be determined by measuring the total power at the ac input terminals by means of wattmeter(s) and by measuring the values of the dc voltage and current at the output terminals at maximum rated output voltage, rated output current and nominal input voltage.

From the rated values thus measured, the efficiency shall be calculated in accordance with the following:

$$\text{Efficiency Percent} = \frac{\text{DC Volt-Ampere Output}}{\text{Input Watts}} \times 100$$

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

NEMA Standard 11-14-1985.

8.9 POWER FACTOR MEASUREMENT

The power factor for single-phase chargers shall be measured under the conditions as specified in 8.8 and shall be calculated as follows:

$$\text{Power Factor, Percent} = \frac{\text{Input Watts} \times 100}{\text{rms Input Volt-Amperes}}$$

For single-phase chargers, the input watts shall be measured with a suitable wattmeter and the voltamperes shall be calculated from the measurements of the true rms input voltage and the true rms input current, using rms responding meters.

For a balanced three-phase source and load, the input power factor shall be measured under the conditions as specified in 8.8 and calculated as follows:

$$\text{Power Factor, Percent} = \frac{\text{Input Watts}}{\sqrt{3} \times \text{Line to Line Volts} \times \text{Line Current}} \times 100$$

where the line to line volts and line current are rms values, measured with rms responding meters.

NEMA Standard 11-14-1985.

8.10 RIPPLE VOLTAGE MEASUREMENT

Measurements of ripple voltage shall be taken at the terminals of a fully charged battery. A variable resistive load shall be connected to the test battery or equivalent resistor-capacitor network terminals to cover the power rating of the battery charger. Ripple voltage shall be expressed in terms of an rms value or as a percentage of the measured dc output voltage of the battery charger, or both.

The test shall be performed at a minimum and maximum rated float and equalize voltages. The worst case of ripple voltage recorded for ac input voltage variations within the ranges given in 2.1, Table 2-1, and within the power rating of the battery charger shall be the significant value.

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8.11 AUDIBLE NOISE TEST

The battery charger shall be operated under all combinations of line voltages, output voltage, and load current to determine the conditions which produce the highest audible sound level. Measurements shall be made in accordance with ANSI S1.31-1980 and ANSI S1.32-1980, using a sound level meter which meets the requirements of the ANSI S1.4-1983. This test shall be made with the battery connected. Measurements shall be made at a distance of 5 feet from each of the four sides of the charger.

NEMA Standard 11-14-1985.

8.12 DYNAMIC RESPONSE TEST

Load Change

With a test battery or equivalent resistor-capacitor network connected sudden changes in load current over the range of 20 to 100 percent or 100 to 20 percent of full load shall not result in output voltage beyond the range of 94 to 106 percent of voltage setting. No excursion of voltage shall result in activation of the overvoltage shutdown. The voltage shall return to, and remain, within the deviation limits specified in 3.7 in not more than 2 seconds.

Input Voltage Change

With a test battery or equivalent resistor-capacitor network connected, sudden changes of up to 10 percent of rated input voltage shall not result in transient behavior greater than the limits specified in 3.7. The initial and final values shall be within the input voltage range shown in Table 2-1.

NEMA Standard 11-14-1985.

8.13 INPUT AND OUTPUT SURGE WITHSTANDABILITY TEST

The test circuit described in ANSI/IEEE C37.90a-1974 shall be used for this test.

The battery charger used for this test shall be operating at 50°C (122°F) at full load with a test battery or equivalent resistor-capacitor network connected. A surge voltage as described in ANSI/IEEE C37.90a shall be applied for a period of not less than 2 seconds to the charger as follows:

- Across each ac input phase
- From each ac input line to ground
- Across the dc output terminals
- From each dc output terminals to ground

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

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Section 9

DOCUMENTATION

9.1 GENERAL

Instruction manuals and test reports shall be made available for all chargers.

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9.1.1 Instruction Manuals

The manual shall include all the material shown in Table 9-1.

NEMA Standard 11-14-1985.

9.1.2 Test Reports

Certified copies of the design (type) and production tests shall be available.

NEMA Standard 11-14-1985.

Table 9-1
INSTRUCTION MANUALS

Item No.	Description
1	Charger specification, as a minimum, shall include the following: (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, and (i) other customer-specified requirements
2	Installation instructions
3	Circuit description
4	Schematic diagram
5	Operating instructions
6	Trouble shooting guide
7	Replaceable parts list

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Section 10

APPLICATION DATA FORM

The following form was developed to assist the purchaser in providing the technical and engineering information needed by the manufacturer in order that he may comply with the purchaser's requirements.

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BATTERY CHARGER APPLICATION DATA FORM

1. AC Loads (Describe Type): _____
_____

2. DC Input Voltage: Nominal_____, Maximum_____, Minimum_____,
Frequency_____ Hz ±_____ Hz
Phases desired_____
Input power factor_____%
Charger efficiency_____%

3. (a) Battery Type: Lead-acid type_____, Nickel-cadmium_____,
Other (specify)_____

(b) Capacity: _____ Ampere hours at _____
hour rate to _____ volts per cell.

(c) Number of Cells: _____

4. Charge-Discharge Cycle: Ampere hours removed from battery during power failure_____.
Allowable recharge time _____ hours.

5. External Load on Charger During Recharge Period: Amperes minimum _____ Amperes maximum _____.
Describe duty cycle _____.

6. External Load on Charger When Battery is Fully Recharged: Amperes minimum _____. Amperes maximum _____.

7. Output Voltage Range
(a) Floating _____ volts minimum to _____ volts maximum

(b) Equalizing _____ volts minimum to _____ volts maximum

8. Voltage Regulation: ± _____ percent/volts from _____ amperes minimum to _____ amperes maximum with an ac input voltage variation of ± _____ % and input frequency variation of ± _____ %.

9. Current Limiting: _____ amperes maximum.

10. Maximum Allowable Ripple Voltage at Full Load: _____ volts rms.

11. Environment: Air temperature around charger _____ °C minimum,
_____ °C maximum, altitude _____ feet.
Atmospheric conditions—Dry _____, Humid _____,
Fungus _____, Corrosive _____,
Other (Specify) _____

12. Ventilation: (Specify) _____

13. Protection: Input (describe) _____
Output (describe) _____
Surge Protection (describe) _____

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BATTERY CHARGER APPLICATION DATA FORM (Continued)

14. Meters: Voltmeter _____ Other _____.
Specify: case size, scale length, accuracy, type, and so forth
Ammeter _____ range,
accuracy _____ % of full scale.

15. Mounting: Wall _____, Floor _____ Relay rack size _____
Portable _____, Other (Specify) _____

16. Maximum Dimensions: Height _____, Width _____, Depth _____,

17. Type of Finish: _____

18. Other Requirements:

_____ 0 to 24 hour equalizing timer
_____ 0 to 72 hour equalizing timer
_____ Ground detector switch (voltmeter)
_____ Ground detector lights
_____ Ground detector alarm relay
_____ AC power failure alarm relay*
_____ DC low-voltage alarm relay*
_____ DC high-voltage alarm relay*
_____ DC high-voltage shutdown circuit*
_____ DC high- and low-voltage alarm relay*
_____ Charger failure (loss of output) relay*
_____ Low dc current alarm relay*
_____ AC pilot light
_____ Dripproof construction
_____ AC line filter
_____ Parallel operation (describe) _____
_____
_____ Load sharing

*Specify time delay, if any.

19. Any Other Information:

_____
_____
_____
_____
_____

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NEMA STANDARDIZIATION BACKGROUND

The purpose of NEMA standards, their classification, and status are set forth in certain clauses of the NEMA *Standardization Policies and Procedures* manual and are referenced below:

Purpose of Standards

National Electrical Manufacturers Association Standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser and to assist the purchaser in selecting and obtaining the proper product for their particular needs. Existence of a National Electrical Manufacturers Association Standard does not in any respect preclude any member or nonmember from manufacturing or selling products not conforming to the standard.

Definition of a Standard

A standard of the National Electrical Manufacturers Association defines a product, process, or procedure with reference to one or more of the following: nomenclature, composition, dimensions, tolerances, safety, operating characteristics, performance, rating, testing, and the service for which they are designed.

(Standardization Policies and Procedures, p. 1)

Dimensions

Where dimensions are given for interchangeability purposes, alternate dimensions satisfying the other provisions of the Standards Publication may be capable of otherwise equivalent performance.

(Standardization Policies and Procedures, p. 6)

Categories of Standards

National Electrical Manufacturers Association Standards are of three classes, which have received the affirmative vote of at least two-thirds of the Subdivision votes cast in the affirmative or negative:

1. NEMA Standard, which relates to a product, process, or procedure commercially standardized and subject to repetitive manufacture.
2. Suggested Standard for Future Design, which may not have been regularly applied to a commercial product, but which suggests a sound engineering approach to future development.
3. Adoptive Standard, which is adopted in whole or in part from the standards of another organization, either domestic, regional, or international.

(Standardization Policies and Procedures, pp. 5)

Authorized Engineering Information

Authorized Engineering Information consists of explanatory data and other engineering information of an informative character not falling within the classification of NEMA Standard or Suggested Standard for Future Design, which standard has received the affirmative vote of at least two-thirds of the Subdivision votes cast in the affirmative or negative.

(Standardization Policies and Procedures, pp. 5)

Identification of Status

Standards in NEMA Standards Publications are identified as "NEMA Standard," "Suggested Standard for Future Design," or "Adoptive Standard." These indicate the status of the standard. A statement incorporating the auxiliary verb "shall" indicates that compliance with a requirement is mandatory for compliance with the standard. These classes of standards are identified in the foreword or throughout the text.

The material identified as "Authorized Engineering Information" is designated similarly. Statements incorporating other auxiliary verbs such as "should," "may," etc. refer to the authorized engineering information and not to procedures required for compliance with the standard.

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POWER ELECTRONICS SECTION
OF THE
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
MEMBER COMPANIES

Bicron Electronics Co.
Canaan, CT 06018

C & D Batteries Division
An Allied Company
Plymouth Meeting, PA 19462

Cyberex Inc.
Mentor, OH 44060

Dual-Lite, Inc.
Newton, CT 06470

McGraw-Edison Company
Belleville, NJ 07109

Emerson Electric Company
Industrial Controls Division
Santa Ana, CA 92702

Exide Electronics Corp.
Raleigh, NC 27658

General Electric Company
Power Deliver Division
King of Prussia, PA 19406

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International Power Machines Corporation
Mesquite, TX 75149

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Des Plaines, IL 60018

Liebert Corporation
Programmed Power Division
Sunnyvale, CA 94086

Lorain Products
Div. of Reliance Electric Co.
Lorain, OH 44052

Pulskota Electric Co.
Worth, IL 60482

Power Conversion Products, Inc.
Crystal Lake, IL 60014

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