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NEMA STANDARDS PUBLICATION NO. EW 7

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Electric Arc Welding Power Sources for the Non-Professional Operator

NEMA

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

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EW 7

ELECTRIC ARC WELDING POWER SOURCES FOR THE NON-PROFESSIONAL OPERATOR

Published by:

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Foreword

The standards in this publication represent the technical judgement of the Arc Welding Section with respect to the performance, and construction of electric arc welding power sources. These standards are based upon sound engineering principles, research, records of tests, and field experience. The standards cover both installation and manufacturing criteria obtained from manufacturers and users.

To obtain input, publication copies of the proposed standard were sent to a number of individuals and organizations in the public and private sectors having an interest in or responsibility for the purchase, testing, application, use, or inspection of this product category. Comments and suggestions received during the draft stage resulted in a number of substantive changes being made in this publication.

As future major revisions to this publication are proposed, appropriate individuals and organizations will be canvassed.

The values stated in U.S. customary (inch) units are to be regarded as the standard. Calculated SI (millimeter) equivalents of the U.S. customary (inch) units (in several places in the publication) have been included. The SI units of measurement are those adopted by the General Conference on Weights and Measures (CGPM) as the International System of Units (Systeme Internationale D'Unites) and are sometimes referred to as the "modern metric system."

Proposed or recommended revisions to this Standards Publication should be submitted to:

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National Electrical Manufacturers Association
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Purpose

This NEMA Standards Publication is adopted in the public interest to provide a standard for performance and construction and to assist buyers in selecting and obtaining the proper product for their particular needs.

Recommended safe practices intended to prevent personal injury and property damage arising out of the installation and use of this equipment are covered more completely in other related safety publications such as the Manufacturer's Instructions; ANSI/NFPA 70, the *National Electrical Code*; ANSI/AWS Z49.1, *Safety in Welding and Cutting*; AWS Publication C5.6-79, *Recommended Safe Practices for Gas-Metal Arc Welding.* (See 1.1, Referenced Standards.)

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Scope

This Standards Publication defines minimum mechanical and electrical construction and performance requirements applying to constant current arc welding power sources for manual shielded metal arc welding by non-professional operators. These power sources are designed to have a maximum OCV of 50 volts ac or 80 volts dc and will operate properly only with electrodes designed to operate at these open circuit voltages. The characteristics of these welding power sources may not provide the levels of performance necessary to use the broad-range of electrodes available in industry.

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ELECTRIC ARC WELDING POWER SOURCES FOR THE NON-PROFESSIONAL OPERATOR

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 and are available from the organizations listed below.

American National Standards Institute (ANSI)
1430 Broadway
New York, NY 10018

Z49.1-1988	*Safety in Welding and Cutting*
C57.12.90-1987	*American National Standard Distribution Power, and Regulating Transformers, Test Code for Liquid Immersed*

American Welding Society (AWS)
550 N.W. Le Jeune Road, P.O. Box 351040
Miami, FL 33135

C5.6-1979	*Recommended Safe Practices for Gas-Metal Arc Welding*

Institute of Electrical and Electronics Engineers (IEEE)
345 E. 47th St.
New York, NY 10017

112-1984	*Standard Test Procedure for Polyphase Induction Motors and Generators*
113-1985	*Guide on Test Procedures for DC Machines*
117-1974(R1985)	*Standard Test Procedure For Evaluation of Systems of Insulating Materials for Random-wound AC Electric Machinery*
304-1977	*Test Procedure Evaluation and Classification of Insulation System for DC Machines*

National Electrical Manufacturers Association (NEMA)
2101 L Street, N.W.
Washington, DC 20037

ANSI/NEMA CB1-1984	*Brushes For Electrical Machines*
WD1-1983	*General Requirements for Wiring Devices*

National Fire Protection Association (NFPA)
Batterymarch Park
Quincy, MA 02269

ANSI/NFPA 70-1987	*National Electrical Code*

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Underwriters Laboratories Inc.
333 Pfingsten Road
Northbrook, IL 60062

ANSI/UL94-1985 — *Test For Flammability of Plastic Materials for Parts in Devices and Appliances*

ANSI/UL 551-1987 — *Transformer-Type Arc Welding Machines*

1.2 DEFINITIONS

AC TRANSFORMER ARC WELDING POWER SOURCE

An ac transformer arc welding power source utilizes a transformer having isolated primary and secondary windings with the associated control and indicating devices required to produce an alternating current suitable for arc welding.

NEMA Standard 1-11-1989.

ASSOCIATED ELECTRICAL ATTACHMENTS

Associated electrical attachments are those electrical controls, cables, accessories, and such, attached to the arc welding power source to facilitate control, function, or operation and that are external to the power source enclosure.

NEMA Standard 1-11-1989.

AUXILIARY POWER SUPPLY

An auxiliary power supply is a separate source of power available to the operator, which is provided by the arc welding power source for purposes other than supplying power to the welding arc.

NEMA Standard 1-11-1989.

CONSTANT CURRENT ARC WELDING POWER SOURCE

A constant current arc welding power source is a power source that has means for adjusting the load current and that has a static volt ampere curve that tends to produce a relatively constant load current. The load voltage, at a given load current, is responsive to the rate at which a consumable electrode is fed into the arc.

NEMA Standard 1-11-1989.

DUTY CYCLE

Duty cycle, expressed in percent, is the ratio of arc time to total time.

For the purpose of these standards, the time period of one complete test cycle shall be 10 minutes. (For example, in the case of a 60 percent duty cycle, load shall be applied continuously for 6 minutes and shall be off for 4 minutes.)

NEMA Standard 1-11-1989.

EFFICIENCY

The efficiency of an arc welding power source is the ratio of the power output at the welding terminals to the total power input. Unless otherwise specified, the efficiency shall be given when the power source is operated at rated output.

NEMA Standard 1-11-1989.

ELECTRIC POWERED ARC WELDING POWER SOURCE

An electric powered arc welding power source is a power source designed for arc welding that obtains its input power from an external electrical power supply.

NEMA Standard 1-11-1989.

ENCLOSURE

An arc welding power source enclosure is the surrounding case or housing constructed to provide a degree of protection to personnel against incidental contact with energized and moving parts and to provide a degree of protection to the power source against damage that will adversely affect its operation.

NEMA Standard 1-11-1989.

ENGINE GENERATOR ARC WELDING POWER SOURCE

An engine generator arc welding power source is a power source that consists of an engine mechanically connected to a generator designed for arc welding.

NEMA Standard 1-11-1989.

FRAME

The frame of an arc welding power source is a supporting structure provided to increase the strength and rigidity of the enclosure, and to provide means for mounting the various parts of the power source, or both.

NEMA Standard 1-11-1989.

HAND-HELD ASSEMBLY

An assembly or device that is designed to be supported and manipulated by hand during use.

NEMA Standard 1-11-1989.

INPUT CURRENT

Input current is the amperage drawn from the electrical power supply to operate an arc welding power source.

NEMA Standard 1-11-1989.

INPUT RATING

For an arc welding power source operating from an electrical power supply, the input rating consists of the rated input voltage(s), number of phases, rated frequency(s), and the input current when the power source is delivering rated output.

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JACK
A female contact device designed to mate with a jack plug to establish an electrical connection.
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JACK PLUG
A male device, usually associated with welding lead(s), that is inserted into a jack to establish an electrical connection of the welding circuit.
NEMA Standard 1-11-1989.

LIVE PART
A live part is a part at a potential different from ground, which could render an electrical shock.
NEMA Standard 1-11-1989.

LOAD CURRENT
The load current is the amperage flowing in the welding circuit when a load is applied to the welding terminals.
NEMA Standard 1-11-1989.

LOAD VOLTAGE
Load voltage is the voltage between the welding terminals of the arc welding power source when load current is flowing in the welding circuit.
NEMA Standard 1-11-1989.

NON-PROFESSSIONAL OPERATOR
A non-professional operator is one who does not weld in the performance of his/her vocation and has little or no formal training in arc welding.
NEMA Standard 1-11-1989.

OPEN CIRCUIT VOLTAGE
Open circuit voltage is the voltage between the welding terminals of the arc welding power source when no load current is flowing in the welding circuit.
NEMA Standard 1-11-1989.

RATED FREQUENCY
Rated frequency (expressed in hertz) is the supply voltage frequency at which an arc welding power source is designed to operate.
NEMA Standard 1-11-1989.

RATED INPUT VOLTAGE
The rated input voltage is the supply voltage(s) at which an arc welding power source is designed to operate.
NEMA Standard 1-11-1989.

RATED LOAD CURRENT
The rated load current is the load current at rated output.
NEMA Standard 1-11-1989.

RATED LOAD SPEED
The rated load speed of an arc welding power source is the rotational speed at which an arc welding generator is designed to operate when delivering rated output.
NEMA Standard 1-11-1989.

RATED LOAD VOLTAGE
Rated load voltage is the load voltage at rated output.
NEMA Standard 1-11-1989.

RATED OUTPUT
The rated output of an arc welding power source shall consist of a designated limit of output or capacity expressed as rated load voltage, rated load current, and rated duty cycle when the power source is operated at rated input voltage(s) and rated frequency(s), or at rated load speed.
NEMA Standard 1-11-1989.

SHIELDED METAL ARC WELDING (SMAW)
An arc welding process that produces coalescence of metals by heating them with an arc between a covered metal electrode and the workpieces. Shielding is obtained from decomposition of the electrode covering. Pressure is not used, and filler metal is obtained from the electrode.
NEMA Standard 1-11-1989.

SLOPE OF THE STATIC VOLT AMPERE CURVE
The slope of the static volt ampere curve is the ratio of load voltage change to the change in load current expressed in volts per 100 amperes.
NEMA Standard 1-11-1989.

STATIC VOLT AMPERE CHARACTERISTICS
The static volt ampere characteristics is the curve or family of curves which gives the steady state load voltage of an arc welding power source as ordinate, plotted against the steady state load current as abscissa.
NEMA Standard 1-11-1989.

WELDING CIRCUIT
The welding circuit consists of all attachments connected to the welding terminals of the arc welding power source.
NEMA Standard 1-11-1989.

WELDING LEADS
Welding leads conduct the welding power from the welding terminals to the welding arc.
NEMA Standard 1-11-1989.

WELDING TERMINALS
Welding terminals are those terminals of an arc welding power source which furnish welding power.
NEMA Standard 1-11-1989.

WORK LEAD
A work lead is the welding lead between one of the welding terminals of the arc welding power source and the work.
NEMA Standard 1-11-1989.

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Section 2
GENERAL

2.1 SUITABILITY OF OPERATION

The characteristics of an arc welding power source conforming to these standards shall be such that a non-professional operator can, by following the manufacturer's recommended installation and operating procedures, weld satisfactorily within the specified operating range of the power source and with the welding process for which it is intended to be used.

NEMA Standard 1-11-1989.

2.2 SERVICE CONDITIONS

Service conditions, other than those specified as usual, may have some detrimental effect on the arc welding power source. Such effect depends upon the degree of departure from usual operating conditions and the severity of the environment to which the power source is exposed. Of principal concern are unusual service conditions which may cause abnormal deterioration of the insulation system, electrical breakdown, or mechanical wear, resulting in premature failure. The manufacturer of the power source should be consulted for further information regarding any unusual service conditions.

Authorized Engineering Information 1-11-1989.

2.3 USUAL SERVICE CONDITIONS

An arc welding power source constructed in accordance with these standards shall be capable of operation, when the following conditions prevail:

1. Where the ambient temperature is in the range of 0°C to 40°C;
2. Where the altitude is between sea level and 3300 feet (1000 meters);
3. When exposed to gases and dust only to the extent of those normally produced by the welding arc;
4. When the input line voltage varies within the range of ±10 percent of input line voltage rating of the arc welding power source; and
5. Where the base of a power source is within 15 degrees of horizontal.

NEMA Standard 1-11-1989.

2.4 UNUSUAL SERVICE CONDITIONS

Examples of unusual service conditions are exposure to:

1. Combustible or conducting dusts;
2. Chemical fumes or flammable gases;
3. Rain, steam, or oil vapor;
4. Vermin infestation or atmosphere conducive to the growth of fungus;
5. Very dirty, corrosive, explosive, or abrasive environment;
6. High radiant or conducted heat;
7. Abnormal shock or vibration;
8. Nuclear radiation;
9. Severe weather conditions;
10. Seacoast and shipboard conditions;
11. Continuous average relative humidity above 90 percent or below 10 percent; or
12. Altitudes in excess of 3300 feet (1000 meters).

Authorized Engineering Information 1-11-1989.

2.5 INSTALLATION AND OPERATION

Arc welding power sources shall be installed and operated in accordance with the *National Electrical Code,* state and local codes as applicable, the manufacturers instructions, and applicable safety specifications.

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Section 3
CONSTRUCTION REQUIREMENTS – MECHANICAL CONSIDERATIONS

3.1 FRAME AND ENCLOSURE

An arc welding power source shall be so formed and assembled that it will have the strength and rigidity necessary to withstand the normal service to which it is likely to be subjected without increasing its shock, fire, or other hazard. An arc welding power source shall be provided with a case or cabinet that shall enclose all current carrying parts and hazardous moving parts (such as motors, pulleys, belts, fans, gears, and such) except that the following need not be enclosed:

1. A flexible supply cord or cable and welding leads; and
2. Ungrounded output terminals for the connection of welding leads, jack plugs, jacks, or similar parts connected to the output circuit and limited in open circuit voltage in accordance with 5.3 if they are suitably protected against unintentional contact.

NEMA Standard 1-11-1989.

Protection of the output terminals will usually be afforded if: (a) jacks and uninsulated current carrying parts of the power source, including the specified output terminal lugs in the case of threaded type connections, are recessed behind the vertical plane of the access opening; (b) an uninsulated current carrying part of the power source is recessed for a distance not less than one half of the minimum dimension of the opening behind which the current carrying part is located; or (c) a hinged cover, or a protective guard or cover, which is removable only by the use of tools, with smooth edged slots or openings for the cable is provided over the terminals.

Authorized Engineering Information 1-11-1989.

3.2 ENCLOSURE CONSTRUCTION

3.2.1 An enclosure shall be constructed of either sheet metal, cast metal, or a nonmetallic material. If the enclosure is constructed from sheet metal, the thickness shall not be less than that given in Tables 3-1 or 3-2 (see also 3.2.2). These tables are based on a uniform deflection of the enclosure surface for any given load concentrated at the center of the surface regardless of metal thickness. The thickness of a cast metal enclosure shall be not less than that given in Table 3-3. If the enclosure is constructed of nonmetallic material, the material shall conform to Class 94V-0 of ANSI/UL 94, *Test for Flammability of Plastic Materials for Parts in Devices and Appliances.* The enclosure shall have a mechanical strength at least equivalent to a sheet metal enclosure constructed in accordance with Table 3-1 or 3-2.

NEMA Standard 1-11-1989.

3.2.2 The thickness of sheet metal in an area where provision is made for connection of a wiring system in the field shall not be less than 0.053 inch (1.35 mm) if uncoated steel, 0.056 inch (1.42 mm) if galvanized steel and not less than 0.075 inch (1.91 mm) for aluminum, copper, and brass.

NEMA Standard 1-11-1989.

3.2.3 Construction of the power source enclosure shall be such that there are no sharp projections or edges on the exposed exterior surfaces of the enclosure that are likely to cause accidental injury to personnel.

NEMA Standard 1-11-1989.

3.2.4 Among the factors to consider in determining the suitability of an enclosure are its: (1) physical strength, (2) resistance to impact, (3) moisture absorptive properties, (4) combustibility, (5) resistance to corrosion, (6) resistance to distortion at temperatures to which the enclosure may be subjected under conditions of normal or abnormal use, and (7) resistance to ignition from electrical sources. For a nonmetallic enclosure, all of these factors are considered with respect to thermal aging.

Authorized Engineering Information 1-11-1989.

3.2.5 With reference to Tables 3-1 and 3-2, a supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and has sufficient torsional rigidity to resist the bending moments that may be applied to the surface of the enclosure when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure that is as rigid as one built with a frame of angles or channels.

Authorized Engineering Information 1-11-1989.

3.2.6 Construction considered to be without supporting frame includes: (a) single sheet with single formed flanges (formed edges), (b) a single sheet that is corrugated or ribbed, (c) an enclosure surface loosely attached to a frame (for example, with spring clips), or (d) an enclosure formed or fabricated from sheet metal.

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3.2.7 The minimum thickness of an enclosure without supporting frame may be less than shown in Tables 3-1,

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3-2, and 3-3 if the enclosure is so reinforced that if subjected to bending and torsion forces, its strength and rigidity are shown to be not less than the corresponding properties of an enclosure of the same maximum length and width having the required thickness of metal.

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3.3 OPENINGS IN ENCLOSURES

The suitability of an opening in the enclosure of an arc welding power source shall be determined in accordance with 3.3.1 or 3.3.2, except that for engine powered power sources, the suitability of the openings shall be determined in accordance with 3.3.3. Any part of the outer enclosure that is intended to be opened or removed without the use of tools by the user of the equipment (to permit the attachment of accessories, to allow access to means for making operating adjustments, or for other reasons) shall be opened or removed prior to examination.

3.3.1 Openings in Other Than Hand-Held Arc Welding Power Source Assemblies

1. An opening that will not permit entrance of an 0.750 inch (19 mm) diameter rod shall be suitable if a 0.500 inch (12.7 mm) diameter (D) probe, illustrated in Figure 3-1, cannot be made to touch film-coated wire, uninsulated live part(s), hazardous moving part(s) or any combination thereof, when it is inserted with a one pound force (4.45 N) through the opening.

NEMA Standard 1-11-1989.

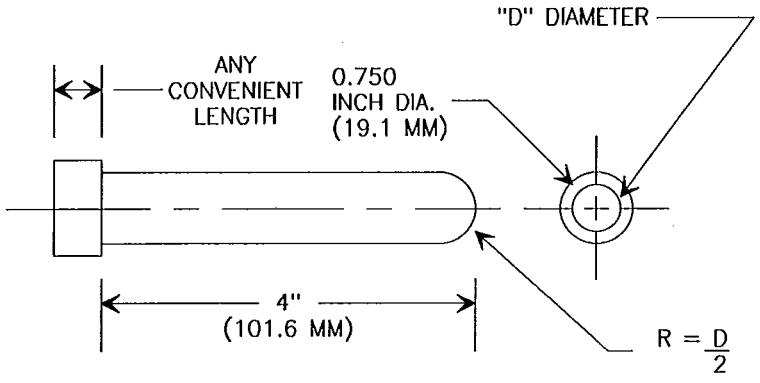

Figure 3-1
PROBE

2. An opening that will permit entrance of a 0.750 inch (19 mm) diameter rod shall be suitable if there is no film-coated wire, uninsulated live part(s), hazardous moving part(s) or any combination thereof; (1) less than X inches (X mm) from the perimeter of the opening, and; (2) within the volume generated by projecting the perimeter X inches (X mm) normal to its plane when X equals five times the diameter of the largest diameter rod (but not less than 4 inches (101.6 mm) that can be inserted through the opening. See Figure 3-2.

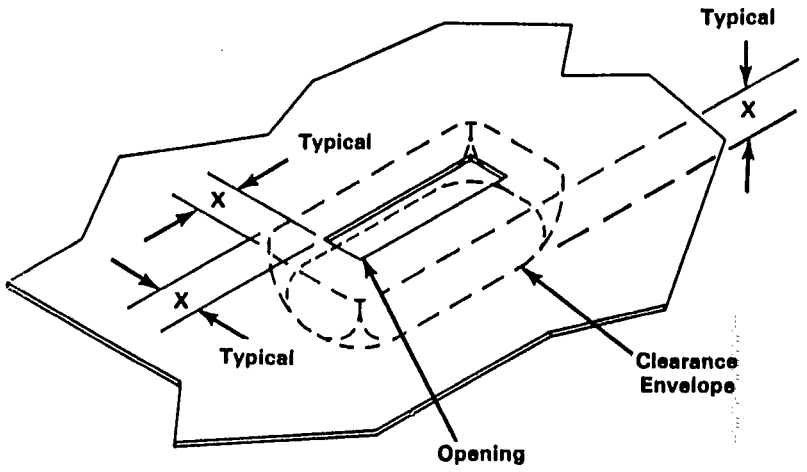

Figure 3-2
ENCLOSURE OPENING

3.3.2 Openings in Hand Held Arc Welding Power Source Assemblies

An opening in a hand-held assembly shall be suitable if a 0.375 inch (9.5 mm) diameter (D) probe, illustrated in Figure 3-1, when inserted into the opening to a maximum of 1 inch (25.4 mm) cannot be made to touch any film-coated wire, uninsulated live part(s), hazardous moving part(s), or any combination thereof.

3.3.3 Openings in Engine Powered Power Sources

Openings in the enclosures for engine powered power sources shall provide protection in accordance with 3.3.1 and 3.3.2. Where in service access to the equipment is required and enclosure protection cannot reasonably be assured, a label calling attention to any potential hazard shall be prominently displayed on the equipment.

NEMA Standard 1-11-1989.

3.4 CORROSION PROTECTION

All metallic parts shall be painted, plated, or otherwise protected against corrosion if the deterioration of such unprotected parts would be likely to result in a hazardous condition.

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3.5 BRUSHES

Brushes shall be in accordance with ANSI/NEMA Standards Publication No. CB 1, *Brushes for Electrical Machines.*

NEMA Standard 1-11-1989.

3.6 JERK AND DROP TESTS

3.6.1 Jerk Test

If an eye or lug is provided for the purpose of lifting an assembled arc welding power source, such device shall be capable of withstanding a free fall jerk test. This test shall be made with the power source equipped with all associated attachments (excluding trailers, carts, and wheel running gears) that are likely to be installed and, in the case of engine powered power sources, completely serviced and ready for operation.

The unit shall be suspended from a rigid member by a chain or cable attached to the lifting eye or lug, and it shall be positioned for a direct free fall. The chain or cable suspension assembly shall be arranged to provide for a free fall of at least 6 inches (152 mm) before the unit is caught in suspension bringing the full force of the fall to bear on the lifting eye or lug. Three such falls shall be made.

NEMA Standard 1-11-1989.

3.6.2 Drop Test

An assembled arc welding power source equipped with all associated attachments (excluding trailers, carts, and wheel running gear) that are likely to be installed and, in the case of engine powered power sources completely serviced and ready for operation, shall be capable of withstanding a drop test. This test shall consist of three drops onto a hard and rigid surface from a height of not less than 6 inches (152 mm). These drops shall be so arranged that each drop shall strike on a bottom edge different from that of any other drop.

3.6.3 Test Conformance

After the above tests, the power source shall still conform to the provisions of this standard, other than the foregoing 3.6.1 and 3.6.2, in all respects even though there may be some deformation of the structural parts of enclosure.

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Table 3-1
MINIMUM THICKNESS OF SHEET METAL FOR ENCLOSURES – CARBON STEEL OR STAINLESS STEEL

Without Supporting Frame(a)				With Supporting Frame or Equivalent Reinforcing (b)				Minimum Thickness			
Maximum Width(c), Inches (mm)		Maximum Length(d) of Supported Edge, Inches (mm)		Maximum Width(c), Inches (mm)		Maximum Length, Inches (mm)		Uncoated, Inches (mm)		Zinc Coated Inches (mm)	
4.0	(102)	Not limited		6.25	(159)	Not limited					
4.75	(121)	5.75	(146)	6.75	(171)	8.25	(210)	0.020	(0.51)	0.023	(0.58)
6.0	(152)	Not limited		9.5	(241)	Not limited					
7.0	(179)	8.75	(222)	10.0	(254)	12.5	(318)	0.026	(0.66)	0.029	(0.74)
8.0	(203)	Not limited		2.0	(305)	Not limited					
9.0	(229)	11.5	(292)	13.0	(330)	16.0	(406)	0.032	(0.81)	0.034	(0.86)
12.5	(318)	Not limited		19.5	(495)	Not limited					
14.0	(356)	18.0	(457)	21.0	(533)	25.0	(635)	0.042	(1.07)	0.045	(1.14)
18.0	(457)	Not limited		27.0	(686)	Not limited					
20.0	(508)	25.0	(635)	29.0	(737)	36.0	(914)	0.053	(1.35)	0.056	(1.42)
22.0	(559)	Not limited		33.0	(838)	Not limited					
25.0	(635)	31.0	(787)	35.0	(889)	43.0	(1092)	0.060	(1.52)	0.063	(1.60)
25.0	(635)	Not limited		39.0	(991)	Not limited					
29.0	(737)	36.0	(914)	41.0	(1041)	51.0	(1295)	0.067	(1.70)	0.070	(1.78)
33.0	(838)	Not limited		51.0	(1295)	Not limited					
38.0	(965)	47.0	(1194)	54.0	(1372)	66.0	(1676)	0.080	(2.03)	0.084	(2.13)

(a) See 3.2.6

(b) See 3.2.5

(c) The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

(d) Not limited applies only if the edge of the surface is flanged at least 0.500 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use.

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Table 3-2
MINIMUM THICKNESS OF SHEET METAL FOR ENCLOSURES – ALUMINUM, COPPER, OR BRASS

Without Supporting Frame(a)				With Supporting Frame or Equivalent Reinforcing (b)				Minimum Thickness	
Maximum Width(c), Inches (mm)		Maximum Length(d) of Supported Edge, Inches (mm)		Maximum Width(c), Inches (mm)		Maximum Length, Inches (mm)		Uncoated, Inches (mm)	
3.0	(76)	Not limited		7.0	(179)	Not limited			
3.5	(90)	4.0	(102)	8.5	(216)	9.5	(241)	0.023	(0.58)
4.0	(102)	Not limited		10.0	(254)	Not limited			
5.0	(127)	6.0	(152)	10.5	(267)	13.5	(343)	0.029	(0.74)
6.0	(152)	Not limited		14.0	(356)	Not limited			
6.5	(165)	8.0	(203)	15.0	(381)	18.0	(457)	0.036	(0.91)
8.0	(203)	Not limited		19.0	(483)	Not limited			
9.5	(241)	11.5	(292)	21.0	(533)	25.0	(635)	0.045	(1.14)
12.0	(305)	Not limited		28.0	(711)	Not limited			
14.0	(356)	16.0	(406)	30.0	(762)	37.0	(940)	0.058	(1.47)
18.0	(457)	Not limited		42.0	(1067)	Not limited			
20.0	(508)	25.0	(635)	45.0	(1143)	55.0	(1397)	0.075	(1.90)
25.0	(635)	Not limited		60.0	(1524)	Not limited			
29.0	(737)	36.0	(914)	64.0	(1626)	78.0	(1981)	0.095	(2.41)
37.0	(939)	Not limited		87.0	(2210)	Not limited			

(a) See par. 3.2.6

(b) See par. 3.2.5

(c) The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

(d) Not limited applies only if the edge of the surface is flanged at least 0.500 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use.

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Table 3-3
MINIMUM THICKNESS OF CAST METAL FOR ENCLOSURES

Dimensions or Location or Area Involved	Minimum Thickness			
	Cast Metal Other Than Die-Cast		Die-Cast Metal	
	Inches	(mm)	Inches	(mm)
Area of 24 square inches (154.8 = square cm) or less and having no dimension greater than 6 inches (152 mm)	0.125	(3.18)	0.062[a]	(1.59)
Area greater than 24 inches squared (154.8 cm squared) or having any dimension greater than 6 inches (152 mm)	0.125	(3.18)	0.094	(2.38)
At a threaded conduit hole	0.250	(6.15)	0.250	(6.35)
At an unthreaded conduit hole	0.125	(3.18)	0.125	(3.18)

[a]The area limitation for metal 0.062 inch (1.59 mm) thick can be obtained by the provision of suitable reinforcing ribs subdividing a larger area.

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Section 4
CONSTRUCTION REQUIREMENTS – ELECTRICAL CONSIDERATIONS

4.1 POWER SUPPLY CONNECTION – GENERAL

Where power supply conductors pass through an opening in a barrier or enclosure, the edges of the opening shall be smoothly rounded or shall be provided with a secured and smooth rounded bushing.

The ampacity used for conductor selection shall be calculated from the following equation:

$$I_r = \sqrt{I_a^2 d + I_b^2 (1-d)}$$

Where:

I_r = Ampacity requirements in amperes.

I_a = Nameplate input current at rated voltage and at rated output.

I_b = Input current at rated input voltage and at no load

$$d = \frac{\text{Rated Duty Cycle (Percent)}}{100}$$

When a flexible cord is used for power supply connection, it shall be sized in accordance with Table 4-1. Where wiring terminals or terminal leads are provided, they shall be suitable for the connection of power supply conductors which are sized in accordance with Table 4-2.

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Table 4-1
CONDUCTOR SIZE OF CORDS

Required Ampacity (I_r) [a]		Conductor Size, AWG
Two Conductor	Three Conductor	
10	7	18
13	10	16
18	15	14
25	20	12
30	25	10
40	35	8
55	45	6
70	60	4

[a] The ampacities are applicable to current carrying conductors in accordance with Table 400-5 of the **1987 National Electrical Code.** The ampacities listed above are based upon a 30°C ambient temperature. A conductor used for equipment grounding is not considered to be a current carrying conductor.

Table 4-2
SIZE OF INSULATED COPPER CONDUCTORS (Not More Than Three Conductors in Raceway or Cable)

Required Ampacity (I_r)[a]	Conductor Size, AWG
15	14
20	12
30	10
50	8
65	6

[a] The ampacities in Table 4-2 are based upon 75°C temperature rating of conductors with ampacities in accordance with Table 310-16 of the **1987 National Electrical Code.** Ampacities listed above are based upon a 30°C ambient temperature. A conductor used for equipment grounding is not considered to be a current carrying conductor.

4.2 POWER SUPPLY BY FLEXIBLE CORD

When a flexible cord is used as a part of the power source for power supply connection, it shall be a type S, SO, ST, STO, SJ, SJO, SJT, SJTO, or SPT-3 flexible cord. Such flexible cords shall not be less than 5 feet (1.52 meters) in length as measured from the strain relief provided at the enclosure of the power source to the attachment plug terminal provided for connection to the power supply receptacle.

A power source that has wheels, casters, or other obvious means of mobility shall be equipped with a flexible cord. An attachment plug shall be provided on the flexible cord and it shall be selected to conform to NEMA Standards Publication No. WD 1, *General-Purpose Wiring Devices,* for the input voltage and current rating of the power source. The attachment plug terminating the flexible cord shall be of the grounding type. When a power source is provided with a switch or circuit breaker that complies with the requirements of 4.10.3, the rating of the attachment plug shall not be less than 75 percent of the input current rating of the power source.

Flexible cords shall be provided with strain relief so that an external pulling force, as specified in Table 4-3, exerted for one minute on the flexible cord from any direction will not be transmitted to the terminals, splices, or internal wiring of the power source.

Means shall be provided to prevent the flexible cord from being pushed into the enclosures through the cord entry hole if such displacement is likely to: (1) subject the cord to mechanical damage, (2) expose the cord to

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a temperature higher than that for which it is intended, or (3) reduce spacings (such as to a metal strain relief clamp) below those specified in Table 4-5.

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Table 4-3
EXTERNAL PULLING FORCE

Wire Size	Pulling Force	
AWG	Lbs.	N
16–18	35	155.9
12–14	50	222.4
10–Larger	100	444.8

4.3 POWER SUPPLY BY PERMANENT WIRING SYSTEM

If a power source is not provided with a flexible cord for power supply connection, it shall be provided with input wiring terminals or input terminal leads which shall be enclosed and accessible only by means of tools. A hole, knockout, or fitting shall be provided to facilitate connection to a permanent wiring system. The diameter and the size of the flat surface surrounding a hole or knockout shall conform to Table 4-4.

NEMA Standard 1-11-1989.

4.4 GROUNDING

All exposed noncurrent carrying conductive parts, which might become energized under the rigors of normal use and handling shall have metal-to-metal contact or shall be otherwise electrically bonded together and connected to a common grounding means.

The grounding means shall be all of the following:

1. A part of the power source;
2. Used only for grounding purposes;
3. Unlikely to be disassembled during operation or servicing;
4. Of adequate size for the grounding conductor as specified in accordance with Table 250-95 and article 250-51(2) of the *1987 National Electrical Code;* and
5. Located in the vicinity of the supply connections.

The grounding means shall be a metal stud, binding post, pressure connector, binding screw, uninsulated or insulated leads, internally threaded boss, or equivalent means. Solder alone shall not be relied upon as a means for grounding connections.

When the grounding means is an insulated lead, it shall have a green colored surface with or without one or more yellow stripes. In all other cases, the grounding means shall be identified by green coloring or by a legible marking with the symbols or , alternatively, with the letter(s) G, GR, GRD, GND or GROUND.

NEMA Standard 1-11-1989.

4.5 CORROSION PROTECTION

When materials subject to corrosion, such as iron, steel, or aluminum, etc., are used as part of the wiring terminal or grounding means, such parts shall be plated or otherwise protected to maintain the integrity of the electrical connection.

NEMA Standard 1-11-1989.

4.6 OUTPUT PROVISIONS

4.6.1 Welding Leads

Welding leads supplied with the power source shall be of a size sufficient to limit the temperature to 85°C or to the temperature rating of the cable insulation, whichever is less, when operated at the rated load current and duty cycle of the power source.

When welding leads are supplied as integral parts of the power source, the attachment of such leads shall be so constructed to withstand an external pull, exerted for 1 minute from any direction, as specified in Table 4-3, without reducing electrical spacings below those specified in Table 4-5, or causing damage to any internal parts of the power source. However, the pull applied to the welding leads need not be more than that specified for the flexible cord used for the power supply connection.

Table 4-4
DIAMETER OF KNOCKOUT OR HOLE FOR CONDUIT AND WIDTH OF SURROUNDING FLAT SURFACE

Size of Supply Conductor, AWG		Trade Size Conduit Nom.	Knockout Clearance Hole					
			Minimum		Nominal		Maximum	
Single Phase	Three Phase		Inches	(mm)	Inches	(mm)	Inches	(mm)
14–10	14–10	½	0.859	(21.82)	0.875	(22.22)	0.906	(23.01)
8	8	¾	1.094	(27.79)	1.109	(28.17)	1.141	(28.98)
6–4	6–4	1	1.359	(34.52)	1.375	(34.92)	1.406	(35.17)
3–1	3–2	1¼	1.719	(43.66)	1.734	(44.04)	1.766	(44.86)

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Table 4-5
SPACINGS IN ARC WELDING POWER SOURCES[a]

r.m.s. Voltage Between Parts Involved (d, e)	At Wiring Terminals (b,c)				At Other Than Wiring Terminals							
					To other than Enclosure Walls				To walls of a metal enclosure (f, g)			
	Through Air		Over Surface		Through Air		Over Surface		Through Air		Over Surface	
	In.	(mm)	In.	(mm)	In.	(mm)	In.	(mm)	In.	(mm)	In.	(mm)
0 – 50	1/2	(12.7)	1/2	(12.7)	1/8	(3.18)	1/8	(3.18)	1/2	(12.7)	1/2	(12.7)
51 – 150	1/2	(12.7)	1/2	(12.7)	1/8	(3.18)	1/4	(6.35)	1/2	(12.7)	1/2	(12.7)
151 – 300	1/2	(12.7)	1/2	(12.7)	1/4	(6.35)	3/8	(9.53)	1/2	(12.7)	1/2	(12.7)
301 – 600	1	(25.4)	1	(25.4)	3/8	(9.53)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)

[a] Values do not apply to a turn of wire on a coil or to spacings between (1) two conductors of a coil, (2) a coil and its core, and (3) a coil and any other part of opposite polarity including the crossover lead. The spacings given in Table 4-5 do not apply to wiring devices (snap switches, lampholders, etc.), motors, printed circuit boards, potted circuits and devices, or other accessories for which there are standards established for such components.

[b] Wiring terminals are considered to be terminals to which supply connections are made in the field.

[c] The spacing between screw type terminals of opposite polarity shall be not less than 0.250 inch (6.35 mm) if the terminals are in the same plane.

[d] When the repetitive peak voltage on which the device is used is more than 1.5 times the rms volts, the peak voltage shall be divided by 2 to obtain an equivalent rms rating in volts.

[e] For grounded power systems, such as three phase four wire systems, the clearance and creepage distances to ground shall be governed by voltage to ground.

[f] A metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is likely to reduce clearance and creepage distances between the metal piece and uninsulated live parts or film coated wire.

[g] For subassembly enclosures where clearance and creepage distances are rigidly maintained and when mounted inside another enclosure, the distances for "to other than enclosure walls" shall be permitted instead of "to walls of metal enclosure" but in no case shall they be less than 0.100 inch (2.54 mm).

At locations where a welding lead passes through an opening in a barrier, or enclosure, the opening shall be smoothly rounded or shall be provided with a secured and smoothly rounded bushing.

NEMA Standard 1-11-1989.

4.6.2 Welding Terminals

Terminals of the power source provided for the connection of welding leads shall be constructed to withstand an external pull, exerted for 1 minute from any direction, as specified in Table 4-3, without reducing the electrical spacings below those specified in Table 4-5 or without permanently deforming the terminals or adjacent parts. However, the pull applied to the welding terminals need not be more than that specified for the flexible cord used for the power supply connection. In the case of a jack plug, the plug can pull free of its jack with the application of a lesser pull.

Threaded connections used for the connection of welding leads shall withstand a torque as given by the following equation without reducing internal spacings below those given in Table 4-5 or without permanently deforming the terminals or adjacent parts:

$$T = 100 \times D^2 \text{ (customary units)}$$
$$T = 0.0175 \times D^2 \text{ (SI units)}$$

Where:
T = Torque in lb.-ft. (n.m).
D = Thread major diameter in inches (mm).

The welding terminals shall not exceed 60°C temperature rise when the power source is operated at rated-load current and duty cycle. When temperature testing, the welding leads connected to the welding terminals shall be in accordance with 4.6.1. Threaded connections used to hold the welding leads shall be tightened to a minimum torque as given in the following equation:

$$T = 60 \times D^2 \text{ (customary units)}$$
$$T = 0.0105 \times D^2 \text{ (SI units)}$$

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4.7 INTERNAL WIRING REQUIREMENTS

4.7.1 Insulated Conductors

When internal wiring consists of insulated conductors, they shall be selected for the particular application with

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respect to the temperature, current, voltage, exposure to oil or grease, and other conditions of service to which they are likely to be subjected.

The wiring shall be so arranged or protected that no damage to the conductor insulation will occur from contact with any rough, sharp, or moving part.

All joints and connections shall be mechanically secured and shall provide electrical contact without mechanical strain on the conductor.

NEMA Standard 1-11-1989.

4.7.2 Uninsulated Conductors

When uninsulated conductors are used within an enclosure, they shall be so supported that the spacings given in Table 4-5 shall be maintained.

NEMA Standard 1-11-1989.

4.7.3 Insulating of Live Parts

Insulating washers, bushings, sheets, and such for the mounting of or insulation of live parts shall not be functionally damaged by the temperature to which they will be subjected during operation at rated load under usual service conditions.

NEMA Standard 1-11-1989.

4.8 SPACINGS

The minimum spacing between any uninsulated live part and another live, grounded, or isolated conductive part shall not be less than those shown in Table 4-5.

NEMA Standard 1-11-1989.

4.9 CLASSIFICATION OF INSULATION SYSTEMS

An insulation system is an assembly of insulating materials in association with the conductors and the supporting structural parts of an arc welding power source. Insulation systems are divided into classes according to the thermal endurance of the system for temperature rating purposes.

Insulation systems shall be classified as Class 105, Class 130, Class 155, Class 180, Class 200, or Class 220. Each insulation system is one that by experience or accepted test can be shown to have suitable thermal endurance when operating at the limiting temperature specified in temperature rise Tables 5-2 and 5-3.

The term "experience," as used in this paragraph, means successful operation for a long time under actual operating conditions of power sources designed with a temperature rise at or near the temperature rating limit.

The term "accepted test," as used in this paragraph, means a test on a system or model system that simulates the electrical, thermal, and mechanical stresses occurring in service.

Where appropriate to the construction, tests shall be made in accordance with the following applicable IEEE Test Procedures:

1. *Standard Test Procedure For Evaluation of Systems of Insulating Materials for Random-wound AC Electric Machinery,* IEEE Publication No. 117.
2. *Test Procedure Evaluation and Classification of Insulation System for DC Machines,* IEEE Publication No. 304.

For other constructions for which tests have not been standardized, similar procedures shall be permitted to be used if it is shown that they properly discriminate between service proven systems known to be different.

When evaluated by an accepted test, a new or modified insulation system shall be compared to an insulation system on which there has been substantial service experience.

If a comparison is made on a system of the same class, the new system shall have equal or longer thermal endurance under the same test conditions; if the comparison is made with a system of a lower temperature class, it shall have equal or longer thermal endurance at an appropriately higher temperature. When comparing systems of different classes, an appropriately higher temperature shall be considered to be 25°C per class higher than the temperature for the base insulation system class.

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4.10 REQUIREMENTS FOR SPECIFIC COMPONENTS

4.10.1 Transformers

A power source transformer supplying welding current shall have the secondary winding(s) electrically isolated from the primary winding(s) when the power source is designed to be operated from power supply lines.

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4.10.2 Capacitors

A capacitor, provided as part of a power source and connected across the power supply lines or a winding of the transformer providing welding current, shall be: (a) housed within the power source enclosure, or (b) housed in an enclosure or container that meets all of the applicable provisions of this standard. If a capacitor contains an insulating liquid, its container shall not leak under usual service conditions. If the liquid is flammable, the quantity shall be limited to 1 quart and the capacitor shall be protected against rupture of its container.

A capacitor shall be provided with automatic discharging means capable of reducing the potential across the capacitor to 50 volts within the time necessary to gain access to any current carrying part not in the output circuit of the machine after disconnecting the machine. If the potential across the capacitor exists at the blade

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of a disconnected attachment plug, the time of access is considered to be 2 seconds.

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4.10.3 Switches and Control Devices

A switch, contactor, controller, or circuit breaker used to energize the power source shall perform satisfactorily for 6000 cycles of operation at a rate of 6 cycles per minute with the device making and breaking the input current(s) at rated input voltage(s) of the power source when operated at rated load current. If such a device is known by prior testing or documentation to be suitable for the application, it need not be retested. Opening of the primary supply interrupting device employed in an arc welding power source shall disconnect all ungrounded supply conductors. Means shall be provided to indicate if this interrupting device has been turned on or off.

Exception: Control transformers having isolated windings that provide operating voltage for the primary supply interrupting device are not covered by this paragraph.

NEMA Standard 1-11-1989.

4.10.4 Operating Controls

A suitable means shall be provided for adjusting the output of an arc welding power source over the welding range specified by the manufacturer. Provision shall be made for indicating the approximate output setting of the power source expressed as load current, or by an arbitrary reference scale.

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4.10.5 Marking of Connections and Operating Controls

All welding terminal connections, tap connections, and operating controls shall be plainly and permanently marked to designate their purpose and correct usage.

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4.11 OUTPUT REGULATING TAPS

When load current regulating tap switches are provided, they shall have established contact positions. Switches, brushes, or sliding type contacts shall not, if left between two contact positions, short circuit any winding turns unless tests show that such short circuiting will not cause temperature rises exceeding those specified in 5.6.

When load current regulating taps involve the use of jack plugs and jacks, or equivalent means, external to the enclosure, the voltages at these locations shall not exceed those for welding terminals given in 5.3. Any flexible conductor used shall be suitable for welding service. Whatever means provided shall conform to the requirements of 3.1 regarding recessing or protection.

NEMA Standard 1-11-1989.

4.12 AUXILIARY POWER SUPPLY

4.12.1 Receptacles

A supply receptacle intended for providing power to 115 or 230 volt auxiliary equipment such as wire feeders, drills, grinders, and such, shall be of the grounding type, and the grounding contact of the receptacle shall be electrically connected to the enclosure of the power source. The current and voltage rating of the auxiliary power supply shall be marked at the receptacle location.

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4.12.2 Protection

When supplied, a fuse(s) or circuit breaker(s) that protects the auxiliary power supply circuit shall be capable of interrupting the auxiliary power supply circuit. The current rating of a fuse shall be marked at the fuseholder location.

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4.12.3 Auxiliary Power Supply Circuit

An auxiliary power supply circuit shall be electrically isolated from the input power supply.

NEMA Standard 1-11-1989.

4.13 SHORT CIRCUIT OF WELDING CIRCUIT

An arc welding power source shall not become a fire or shock hazard as a result of a short circuit of the welding circuit.

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Protection of the power source against short circuit current may be accomplished by means of the branch circuit protection, provided at the time of installation, in accordance with Article 630 of the *1987 National Electrical Code,* official local codes and the manufacturer's recommendations.

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Section 5
RATING AND PERFORMANCE

5.1 INPUT RATING OF ELECTRIC POWERED ARC WELDING POWER SOURCES

The preferred input voltages and frequencies shall be one or more of the following:

60 Hertz: 115, 200, and 230 volts.

50 Hertz: 220 volts.

The input current(s) of an electric powered arc welding power source supply shall be determined at the rated output when rated input voltage(s) and rated frequency(s) are applied.

For power sources with regulating taps, the input current(s) shall be determined under the conditions which result in the maximum input current when the output is the rated load current at the rated load voltage of the power source.

The actual input current(s) determined shall not vary from the input current(s) shown on the nameplate by more than 10 percent.

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5.2 POWER FACTOR CORRECTION

When power factor correction is provided, the corrected value shall be measured at rated load, rated input voltage(s), and frequency(s). The corrected value shall not be less than 75 percent unless the corrected value is specified on the nameplate.

NEMA Standard 1-11-1989.

5.3 OPEN CIRCUIT VOLTAGE

The open circuit voltage of an arc welding power source, using a voltmeter within the range of 100 ohms/volt and 1,000 ohms/volt, shall not exceed the following when rated input voltage is applied or when an electric powered arc welding power source is operated at maximum rated no load speed:

1. AC arc welding power source . . . . . 50 volts rms
2. DC arc welding power source . . . . . 80 volts rms

NEMA Standard 1-11-1989.

5.4 RATED OUTPUT

Power sources shall have a rated output in load current and load volts in accordance with Column 1 of Table 5-1. They shall be capable of providing the range of load current at the load voltage as shown in Table 5-1 when:

1. The welding terminals are connected to a resistance load having a power factor of 0.99 or higher.
2. An engine-powered power source is operated at rated load speed.
3. Rated input voltage at rated frequency is applied to the electric-powered power source.
4. The temperature rise in 5.6 is not exceeded.
5. An electric powered power source shall have a duty cycle of 10 percent to 20 percent, expressed in increments of 2 percent. An engine powered power source shall have a duty cycle of 20 percent to 100 percent, expressed in increments of 10 percent.

For an arc welding power source having an ac output, the load current and load voltage shall be expressed as rms values. For an arc welding power source having a dc output, the load current and load voltage shall be expressed as average values.

For arc welding power sources producing both an ac an dc output, the ac rated output and the dc rated output shall be permitted to be different.

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5.5 NO LOAD OPERATION

Arc welding power sources shall be capable of operating continuously at no load at any output setting without exceeding the temperature rises specified in 5.6.

NEMA Standard 1-11-1989.

5.6 TEMPERATURE RISE

When an arc welding power source, is operated at rated load speed or with rated input voltage at rated frequency applied, is connected to a resistance load (0.99 power factor or higher), and is operated:

a. At rated load current(s) and load voltage(s) (See 6.1) at rated duty cycle and;
b. At the maximum output setting(s) at the specified duty cycle until constant temperatures are attained, the temperature rise of the various parts shall not exceed the values given in Tables 5-2 and 5-3. Auxiliary power supplies intended to be used while welding shall be loaded to their rating.

In the case of power sources with output regulating taps in either the input circuit, the output circuit, or both, the temperature shall be measured with tap selections that will produce the highest temperatures at rated output or below.

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Table 5-1
OUTPUT RATINGS

Column 1 Rated Output[a]	Column 3 Minimum Output Setting[c]		Column 3 Maximum Output Setting	
Load Current	Load Voltage	Load Current	Load Voltage	Load Current
75 through 230[b]	25	40	20	Same as rated output given in Column 1

[a]The measured load current at rated load voltage shall not be less than 95 percent of the rated load currents shown on the nameplate.

[b]Expressed in multiples of 5.

[c]Load current, load voltage or both, shall be permitted to be less than, but they shall not be more than the values listed in the table.

Table 5-2
MAXIMUM TEMPERATURE RISE FOR ENGINE POWERED ARC WELDING GENERATORS

	Class of Insulation Systems			
	105	130	155	180
1. Armature windings, multilayer field windings, and all windings other than those covered in item 2[a]				
By thermometer method[b]	50°C	70°C	90°C	110°C
By resistance method	60°C	85°C	110°C	135°C
2. Single layer windings consisting of exposed uninsulated or film-coated conductors[a]				
By thermometer method[b]	60°C	85°C	105°C	130°C
By resistance method	65°C	90°C	115°C	140°C
3. Cores and mechanical parts in contact or adjacent to insulation – by thermometer method[b]	50°C	70°C	90°C	110°C
4. Commutators – by thermometer method[b]	65°C	85°C	85°C	85°C
5. For the temperature rise of electrical parts, other than generators, see Table 5-3.				

[a]Where two methods of temperature measurement are listed, a temperature rise within the values listed in Table 5-2, measured by either method, demonstrates conformity with this standard.

[b]A thermocouple shall be permitted to be substituted for a thermometer where applicable. (For test procedures, see Section 6. For the description of classes of insulation systems, see 4.9.)

Table 5-3
MAXIMUM TEMPERATURE RISE FOR COMPONENTS OTHER THAN ARC WELDING GENERATORS

Method of Temperature Determination[a]	Class of Insulation					
	105	130	155	180	200	220
Resistance	70°C	90°C	115°C	135°C	155°C	170°C
Applied Thermocouple	80°C	100°C	125°C	150°C	170°C	190°C

Metallic parts in contact with any kind of insulation shall not attain a temperature in excess of that allowed for the adjacent insulation.

For the temperatures of welding leads and welding terminals, see 4.6.

Where standards exist for components that specify temperatures different from the values given in this Table, those components shall be tested to the applicable standard.

[a] A temperature rise within the values listed in Table 5-3, measured by either method, demonstrates conformity with this standard. For coils, transformer windings, and reactors, the resistance method of temperature determination is preferred.

For the description of classes of insulation systems, see 4.9.
For test procedures, see Section 6.

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Section 6
TEMPERATURE TESTS

6.1 TESTING PROCEDURES FOR ARC WELDING POWER SOURCES

When power sources are tested for temperature rise in accordance with 5.9, the load current shall be maintained.

For arc welding sources having a duty cycle rating less than 100 percent, the test shall be conducted by starting and stopping the welding circuit in the manner in which the power source is designed to be used. All temperatures shall be measured at the end of the load period after constant temperatures are attained.

NEMA Standard 1-11-1989.

6.2 THERMOMETER METHOD OF TEMPERATURE DETERMINATION

6.2.1 Definition

The thermometer method consists of determining temperature by mercury or spirit thermometers or other suitable temperature measuring instruments* that shall be applied to the hottest parts accessible to ordinary mercury thermometers without alteration of the structure.

NEMA Standard 1-11-1989.

*When the thermometer method of temperature determination is called for, it is intended that the temperature measuring instrument used shall indicate substantially the same temperature as would be obtained by a liquid in glass thermometer in the same location.

6.2.2 Measurement

When temperature measurements of motor generator and engine powered arc welding power sources are made by the thermometer method, the tests shall be made, except as indicated in 6.1, 6.8, and 6.9, in accordance with the latest revision of the following applicable test codes:

1. *Test Procedure for Polyphase Induction Motors and Generators,* IEEE Publication No. 112.
2. *Guide on Test Procedures for DC Machines,* IEEE Publication No. 113.

NEMA Standard 1-11-1989.

6.3 RESISTANCE METHOD OF TEMPERATURE DETERMINATION

6.3.1 Definition

The resistance method consists of determining temperature by comparison of the resistance of a winding at the temperature to be determined with the resistance at a known temperature.

NEMA Standard 1-11-1989.

6.3.2 Measurement

When temperature measurements of arc welding power sources are made by the resistance method, the tests shall be made, except as indicated in 6.1, 6.8, and 6.9, in accordance with the following applicable test codes:

1. *Test Procedure for Polyphase Induction Motors and Generators,* IEEE Publication No. 112.
2. *Distribution Power, and Regulating Transformers, Test Code for Liquid Immersed,* ANSI/IEEE Publication No. C57.12.90.

NEMA Standard 1-11-1989.

6.3.3 Determination of Average Measured Temperature by the Resistance Method

The average measured temperature of either a copper or aluminum winding shall be determined by the following equation:

$$t_h = \frac{R_h}{R_c}(K + t_c) - K$$

Where:
t_h = temperature of winding in degrees celsius when R_h was measured
t_c = temperature of winding in degrees celsius when R_c was measured
R_h = hot resistance, ohms
R_c = cold resistance, ohms
K = for copper = 234.5
for aluminum = 225

NEMA Standard 1-11-1989.

6.4 APPLIED THERMOCOUPLE METHOD OF TEMPERATURE DETERMINATION

6.4.1 Definition

The applied thermocouple method consists of determining temperature by thermocouples or other suitable temperature measuring instruments of comparable size applied to the hottest parts accessible to thermocouples in locations that are normally inaccessible to liquid in glass thermometers.

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Depending upon the thickness of the insulation separating them from current carrying conductors, thermocouples may give readings comparable to those obtained by the resistance method or may give the considerably lower readings characteristic of the thermometer method. Accordingly, in the measurement of winding temperatures by the use of thermocouples, the method will be defined as the "applied thermocouple

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method" only if the thermocouples are applied directly to the conductors or are separated from the metallic circuit only by the integrally applied insulation of the conductor itself.

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6.4.2 Measurement

When temperature measurements of arc welding power sources are made by the applied thermocouple method, the tests shall be made, except as indicated in 6.1, 6.8, and 6.9, in accordance with ANSI/IEEE Publication No. C57.12.90.

NEMA Standard 1-11-1989.

6.5 DETERMINATION OF AMBIENT TEMPERATURE

When temperature measurements are made, the ambient temperature shall be determined by at least three thermocouples, or thermometers, spaced uniformly around the arc welding power source under test. They shall be located at approximately one half the height of the power source and at a distance of 3 to 6 feet (1 to 2 meters) from the power source and shall be protected from drafts and abnormal heating.

NEMA Standard 1-11-1989.

6.6 COOLING AIR TEMPERATURE DURING TESTS

Temperature tests shall be made at any cooling air temperature, preferably not below 10°C. It shall be assumed that the temperature rise is the same for all cooling air temperatures between the limits of 10°C and 40°C.

NEMA Standard 1-11-1989.

6.7 OMISSION OF TEMPERATURE TEST ON DUPLICATE APPARATUS

A temperature test shall not be required when a record of test made on a duplicate unit in accordance with these standards can be furnished.

NEMA Standard 1-11-1989.

6.8 CORRECTION OF TEMPERATURE TO TIME OF SHUTDOWN

Whenever a sufficient time has elapsed between the instant of shutdown and the time of final temperature measurement to permit the temperature to fall, suitable corrections shall be applied so as to obtain as nearly as practicable the temperature at the instant of shutdown. One acceptable method to determine approximate temperature at the instant of shutdown is by plotting a curve, with temperature readings as ordinate and time as abscissa, and extrapolating back to the instant of shutdown.

In cases where successive measurements show increasing temperatures after shutdown, the highest value shall be taken.

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Section 7
HIGH POTENTIAL TESTS

7.1 HIGH POTENTIAL TESTS

At the time of manufacture, each new and completely assembled arc welding power source shall be capable of passing the high potential test described in this Section.

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7.2 TEST VOLTAGE

The ac rms test voltage for all arc welding power sources shall be 1000 volts plus twice the rated voltage of the circuit under test except for the alternative voltages specified for production line testing in 7.7. The frequency of all test voltages shall be 50 to 60 hertz, and the wave shape shall be essentially sinusoidal.

Repeated application of the high potential test voltage is not recommended. (This sentence is approved as Authorized Engineering Information.) If it becomes necessary to subject the arc welding power source to a subsequent high potential test, the test voltage shall be 85 percent of the appropriate test voltage applicable to the circuit under test.

NEMA Standard 1-11-1989.

7.3 DURATION OF APPLICATION OF TEST VOLTAGE

The test voltage for arc welding power sources shall be applied continuously for a period of 1 minute except for the alternative time periods specified for production line testing.

NEMA Standard 1-11-1989.

7.4 POINTS OF APPLICATION OF TEST VOLTAGE

Except for the production line testing specified in 7.7.2, the test voltage shall be successively applied between the input circuit of the arc welding power source and the metal frame and case; between the output circuit and the metal frame and case; and between other circuits such as control or auxiliary circuits and the metallic frame and case. All windings and circuits not under test and the core and other noncurrent carrying parts shall be connected to the metallic frame and case. Any electrical circuit that is isolated from the high potential test voltage by a switch, relay, or contactor shall be tested separately, or the switch, relay, or contactor shall be closed.

Alternatively, all circuits shall be tested by successively applying the test voltage directly between any two circuits and between any circuit and the metallic frame and case.

For purposes of high potential testing, an electric circuit consists of all windings and other live parts that are conductively connected to each power input terminal, to each output terminal of the welding power source, or to each terminal of any auxiliary or control receptacle or terminal. See 7.6.

NEMA Standard 1-11-1989.

7.5 TEMPERATURE AT WHICH HIGH POTENTIAL TESTS ARE TO BE MADE

High potential tests shall be made at room temperature or at any higher temperature attained during testing up to rated load operating temperature of the arc welding power source.

NEMA Standard 1-11-1989.

7.6 HIGH POTENTIAL TEST PROCEDURE FOR COMPONENTS AND ACCESSORIES

Except for the production line testing specified in 7.7.2, devices that do not fall within the scope of this publication but for which there are standards for high potential tests, such as meters, rectifiers, capacitors, lamp holders, switches, fractional horsepower motors, electronic equipment, ground detectors, etc., and that require lower test voltages than those called for in this publication, shall be grounded, short circuited or disconnected before the high potential tests are made on the arc welding power source.

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7.7 PRODUCTION LINE HIGH POTENTIAL TESTING

One of the two tests specified in 7.7.1 and 7.7.2 shall be used in production line testing as an alternative to the 1 minute high potential test specified in 7.2, 7.3, and 7.4.

7.7.1 Arc welding power sources for which the test voltage is 2,500 volts or less shall be tested in accordance with 7.2 through 7.6 except that the test voltage shall be 1.2 times the one minute test voltage and the test time reduced to one second.

7.7.2 For this alternative test all of the following tests shall be made:

1. Prior to final assembly in the power source, components such as transformers, reactors (including saturable), magnetic amplifiers, motors, rectifier assemblies, and any other devices that are intended to be electrically connected to the input power supply manufactured inhouse shall be tested in accordance with 7.2 and 7.3. Application of the test voltage to such a device shall be be-

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tween its input connected parts and its metal frame or mounting bracket parts.

2. Internally connected circuits that are not accessible during usual operation need not be tested; however, if such circuits derive their power from transformers connected to the input power supply, these transformers shall be tested in accordance with 7.7.2.1.

3. The completely assembled power source shall be tested at 1000 volts for 1 minute or 1200 volts for 1 second in accordance with 7.2 through 7.5.

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During the test, circuitry employing solid state components or other electronic circuits may be electrically bypassed or alternately connected to minimize the likelihood of damage to these components.

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Section 8
EFFICIENCY AND POWER FACTOR FOR ELECTRIC POWERED ARC WELDING POWER SOURCES

8.1 METHOD OF DETERMINING EFFICIENCY AND POWER FACTOR

8.1.1 Conditions for Test

1. *Input*

The efficiency and input power factor of an arc welding power source shall be determined at rated input voltage, at rated frequency, and measured input current.

2. *Output*

Efficiency and input power factor shall be determined at rated output when the power source is connected to a resistance load having a power factor of 0.99 or higher.

3. *Temperature*

The efficiency and input power factor shall be measured just prior to the conclusion of the temperature test.

4. *Miscellaneous Losses*

The power consumed by resistors, reactors, stabilizers, ventilating blowers, field and control rheostats, and other components, including separately excited fields and control windings, performing an essential function in the operation of the arc welding power source and included as an integral part of the power source shall be included in the determination of the efficiency and input power factor.

NEMA Standard 1-11-1989.

8.1.2 Efficiency

The efficiency of an arc welding power source shall be determined from simultaneous measurements of input power and output power.

NEMA Standard 1-11-1989.

8.1.3 Input Power Factor

The input power factor of an arc welding power source shall be determined from simultaneous measurements of input current, rated input voltage, and watts. Alternatively, a power factor meter shall be used.

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Section 9
NAMEPLATE MARKING AND INSTRUCTIONS FOR USE

9.1 NAMEPLATE MARKING

The following minimum information, where applicable, shall be given on the nemaplate(s) of an arc welding power source.

1. Manufacturer's type designation and/or identification number;
2. "NEMA EW 7";
3. Maximum open circuit voltage (5.3);
4. Rated load volts;
5. Rated load amperes;
6. Duty cycle at rated load;
7. Maximum rated speed of generator in rpm at no load;
8. Rated frequency(s) of power supply.
9. Number of phases of power supply;
10. Rated input voltage(s) of power supply;
11. Input current(s) amperes at rated load output (see 5.1);
12. Engine speed in rps at no load if internal part of the power source is different from 9.1, item 7;
13. Power factor value as required in 5.2;
14. Information for proper electrodes.

NEMA Standard 1-11-1989.

9.2 INSTRUCTIONS FOR USE

Each welding power source shall be delivered with an instructon sheet including the following:

1. General description of the welding power source;
2. Definitions and explanation of output rating(s) including limitation of current load duty cycle;
3. Limitations of use and the welding capability of the welding power source and explanation of thermal protection where relevant;
4. Input power supply connections including wire size, fuse, and/or circuit breaker rating where relevant;
5. Type and size of welding cables;
6. Requirements for the connection of the work lead;
7. Correct operation of the control device(s) and any indicators;
8. Safety requirements relating to the welding power source (e.g. cooling);
9. Safety requirements relating to welder's clothing and accessories (e.g. insulating glove, mask, and protective eye filters, ventilation);
10. Isolation of electrode holders when not in use (e.g. proper storage, removal of electrode);
11. Warning against potential hazards (e.g. electric shock, arc rays, fumes);
12. Warning against use in certain environments (e.g. rain, damp or wet conditions, flammable surroundings, flammable products, restricted movements);
13. Warning against welding on containers that have held flammables (e.g. tanks, barrels, drums, pipes);
14. The meanings of graphical symbols;
15. Maintenance instruction;
16. A list of replacement spare parts.

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NEMA STANDARDIZATION

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 purchasers 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. *(Standardization Policies and Procedures, p. 1)*

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, construction, dimensions, tolerances, safety, operating characteristics, performance, rating, testing, and the service for which they are designed.
(Standardization Policies and Procedures, p. 2)

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.8)

Categories of Standards

National Electrical Manufacturers Association Standards are of two classes:

1. NEMA Standard, which relates to a product, process, or procedure commercially standardized and subject to repetitive manufacture, which standard has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon;
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, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote thereon.

(Standardization Policies and Procedures, pp. 7 & 16)

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 been approved by at least two-thirds of the members of the Subdivision eligible to vote on the standard.
(Standardization Policies and Procedures, pp. 7 & 16)

Official Standards Proposal

An Official Standards Proposal is an official draft of a proposed standard which is formally recommended to an outside organization(s) for consideration, comment, and/or approval, and which has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon.
(Standardization Policies and Procedures, pp. 7 & 16)

Identification of Status

Standards in NEMA Standards Publications are identified in the foreword or following each standard as "NEMA Standard" or "Suggested Standard for Future Design." These indicate the status of the standard. These words are followed by a date which indicates when the standard was adopted in its present form by the Association.

The material identified as "Authorized Engineering Information" and "Official Standards Proposal" is designated similarly.

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ARC WELDING SECTION
OF THE
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

MEMBER COMPANIES

Alloy Rods Corporation
Hanover, PA 17331

Century Manufacturing Company
Minneapolis, MN 55431

C K Systematics, Inc.
Auburn, WA 98002

ESAB Welding Products, Inc.
Chicago, IL 60632

Hobart Brothers Company
Troy, OH 45373

Hypertherm, Incorporated
Hanover, NH 03755

The Lincoln Electric Company
Cleveland, OH 44117

L-TEC Welding & Cutting Systems
Florence, SC 29501

Miller Electric Mfg. Company
Appleton, WI 54912

National Standard Company
Niles, MI 49120

Pow Con Inc.
San Diego, CA 92126

Sandvik Steel Company
Welding and Wire Division
Scranton, PA 18501

Stoody Deloro Stellite, Inc.
St. Louis, MO 63105

Teledyne McKay
York, PA 17405-1509

Thermadyne Industries, Inc.
St. Louis, MO 63105

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