(5) 60-ampere, 250-volt, 3-phase, 3-pole, 4-wire and intended for use with 60-ampere, 250-volt, 3-phase, 3-pole, 4-wire receptacles and inlets, respectively

Informational Note: See UL 1686-2012, *Pin and Sleeve Configurations*, Figures C2.12 and C2.11, for complete details of the 30-ampere pin and sleeve receptacle configuration for refrigerated containers (TRUs) and for various configurations of 60-ampere pin and sleeve receptacles.

Transport refrigeration units (TRUs) are permitted to be supplied by 208-, 240-, or 480-volt, three-phase branch circuits. The current rating for these branch circuits cannot exceed 60 amperes. The connection to the TRU is accomplished using a flexible cord with a pin-and-sleeve-type cord connector that is connected to a flanged surface inlet mounted on the refrigerated box truck or refrigerated trailer. The flexible cords must be rated for wet locations, sunlight resistance, and extra-hard usage. The cords must have three insulated conductors to supply the three-phase power and one insulated and identified equipment grounding conductor. Section 626.31(C) specifies the type of receptacle(s) required at each truck parking space that is intended to accommodate refrigerated trucks or tractor-trailers.

ARTICLE

630 Electric Welders

Part I. General

630.1 Scope. This article covers apparatus for electric arc welding, resistance welding, plasma cutting, and other similar welding and cutting process equipment that is connected to an electrical supply system.

The two general types of electric welding are resistance welding and arc welding. Resistance welding, or "spot" welding, is the process of electrically fusing two or more metal sheets or parts. The metal parts are placed between two electrodes or welding points, and a high current at a low voltage is passed through the electrodes. The resistance of the metal parts to the flow of current heats them to a molten state, and a weld is made.

Arc welding is the butting of two metal parts, then striking an arc at the joint with a metal electrode (a flux-coated wire rod). The electrode itself is melted and supplies the extra metal necessary for joining the metal parts.

Article 630 also covers electrically supplied equipment associated with plasma cutting operations. This electrically powered equipment controls the flammable gas or gases used for cutting.

630.6 Listing. All welding and cutting power equipment under the scope of this article shall be listed.

N **630.8 Ground-Fault Circuit-Interrupter Protection for Personnel.** All 125-volt, 15- and 20-ampere receptacles for electrical hand tools or portable lighting equipment, supplied by single-phase branch circuits rated 150 volts or less to ground, installed in work areas where welders are operated shall have ground-fault circuit-interrupter protection for personnel.

Part II. Arc Welders

630.11 Ampacity of Supply Conductors. The ampacity of conductors for arc welders shall be in accordance with 630.11(A) and (B).

(A) Individual Welders. The ampacity of the supply conductors shall be not less than the I_{1eff} value on the rating plate. Alternatively, if the I_{1eff} is not given, the ampacity of the supply conductors shall not be less than the current value determined by multiplying the rated primary current in amperes given on the welder rating plate by the factor shown in Table 630.11(A) based on the duty cycle of the welder.

TABLE 630.11(A) *Duty Cycle Multiplication Factors for Arc Welders*

	Multiplier for Arc Welders	
Duty Cycle	**Nonmotor Generator**	**Motor Generator**
100	1.00	1.00
90	0.95	0.96
80	0.89	0.91
70	0.84	0.86
60	0.78	0.81
50	0.71	0.75
40	0.63	0.69
30	0.55	0.62
20 or less	0.45	0.55

(B) Group of Welders. Minimum conductor ampacity shall be based on the individual currents determined in 630.11(A) as the sum of 100 percent of the two largest welders, plus 85 percent of the third largest welder, plus 70 percent of the fourth largest welder, plus 60 percent of all remaining welders.

Exception: Percentage values lower than those given in 630.11(B) shall be permitted in cases where the work is such that a high-operating duty cycle for individual welders is impossible.

Informational Note: Duty cycle considers welder loading based on the use to be made of each welder and the number of welders supplied by the conductors that will be in use at the same time. The load value used for each welder considers both the magnitude and the duration of the load while the welder is in use.

Even under high-production conditions, the loads on transformer arc welders are considered intermittent. Therefore, the minimum ampacity of feeder conductors supplying several transformers (three or more) is permitted to be determined by applying the percentage values specified in 630.11(B). See also 630.31(B). The ampacity of the conductors is based on the I_{1eff} rating on the

welder rating plate. If the I_{1eff} rating is not available, a calculation is done by selecting the appropriate factor from Table 630.11(A) based on the type of welder and the duty cycle of the welder. The selected factor is then multiplied by the primary current rating from the welder rating plate to determine the minimum ampacity of the supply conductors.

630.12 Overcurrent Protection. Overcurrent protection for arc welders shall be as provided in 630.12(A) and (B). Where the values as determined by this section do not correspond to the standard ampere ratings provided in 240.6 or where the rating or setting specified results in unnecessary opening of the overcurrent device, the next higher standard rating or setting shall be permitted.

(A) For Welders. Each welder shall have overcurrent protection rated or set at not more than 200 percent of I_{1max}. Alternatively, if the I_{1max} is not given, the overcurrent protection shall be rated or set at not more than 200 percent of the rated primary current of the welder.

An overcurrent device shall not be required for a welder that has supply conductors protected by an overcurrent device rated or set at not more than 200 percent of I_{1max} or at the rated primary current of the welder.

If the supply conductors for a welder are protected by an overcurrent device rated or set at not more than 200 percent of I_{1max} or at the rated primary current of the welder, a separate overcurrent device shall not be required.

(B) For Conductors. Conductors that supply one or more welders shall be protected by an overcurrent device rated or set at not more than 200 percent of the conductor ampacity.

Informational Note: I_{1max} is the maximum value of the rated supply current at maximum rated output. I_{1eff} is the maximum value of the effective supply current, calculated from the rated supply current (I_1), the corresponding duty cycle (duty factor) (X), and the supply current at no-load (I_0) by the following equation:

$$I_{1eff} = \sqrt{I_1^2 X + I_0^2 (1 - X)} \qquad \textbf{[630.12(B)]}$$

Some arc welding machines have a welding range involving an excess secondary-current output capacity beyond that indicated by the secondary rating marked on the machines. This excess capacity (generally not more than 150 percent of the marked output capacity) is usually supplied by means of secondary taps in addition to the tap(s) intended for normal output current; the higher currents thus available are intended to provide for heavier welding work, including the use of larger-sized electrodes. This excess capacity is somewhat analogous to the inherent overload capacity of motors and transformers. Because the use of this excess current capacity and the overloading of welding machines, except for relatively short periods of time, could be hazardous, it should be undertaken with caution.

Calculation Example

A motor-generator-type electric arc welder has a nameplate primary current rating of 95 amperes and a duty cycle of 80 percent. Determine the minimum ampacity of the branch-circuit conductors and the maximum rating or setting for the branch-circuit overcurrent protective device (OCPD).

Solution

Step 1. Determine the minimum ampacity for the supply circuit conductors [630.11(A)]:

95 A × 0.91 (duty cycle factor) = 86.45 A

Copper THWN conductor selected from the 75°C column of Table 310.16: 3 AWG (100-A allowable ampacity)

Step 2. Determine the maximum rating of setting for the OCPD for the welder and the branch-circuit conductors [630.12(A) and (B)]:

95 A × 200% = 190 A

Next standard size OCPD: 200 A

Conclusion. The minimum conductor ampacity is 86.45 amperes, and the maximum rating or setting for the branch-circuit OCPD is 200 amperes. This rating or setting is the maximum permitted for a circuit supplying a single welder. However, the *NEC*® does not prohibit the use of a smaller-size OCPD, because that is a performance consideration related to the intended use of the welder.

Δ **630.13 Disconnecting Means.** A disconnecting means shall be provided in the supply circuit for each arc welder that is not equipped with a disconnect mounted as an integral part of the welder.

The disconnecting means shall be a switch, circuit breaker, or listed cord-and-plug connector, and its rating shall be not less than that necessary to accommodate overcurrent protection as specified in 630.12.

630.14 Marking. A rating plate shall be provided for arc welders giving the following information:

(1) Name of manufacturer
(2) Frequency
(3) Number of phases
(4) Primary voltage
(5) I_{1max} and I_{1eff}, or rated primary current
(6) Maximum open-circuit voltage
(7) Rated secondary current
(8) Basis of rating, such as the duty cycle

630.15 Grounding of Welder Secondary Circuit. The secondary circuit conductors of an arc welder, consisting of the electrode conductor and the work conductor, shall not be considered as premises wiring for the purpose of applying Article 250.

Informational Note: Connecting welder secondary circuits to grounded objects can create parallel paths and can cause objectionable current over equipment grounding conductors.

In theory and in accordance with the *NEC* definition in Article 100, the secondary circuit of an arc welder could be viewed as a *separately derived system*. However, the function of a welder is to create a high-current circuit between the electrode and the work surface. In the normal operation of an ac power distribution system, such an event would be considered a fault, and the operation of an overcurrent device to open the circuit and clear the fault is a fundamental concept of Articles 240 and 250. In the case of an arc welder, the opening of an overcurrent device is not intended unless the welding operation significantly exceeds the operating parameters of the welder. Grounding of a welder secondary terminal has the potential to cause excessive and potentially degrading parallel currents on power system equipment grounding conductors (EGCs).

This requirement clarifies that for the purposes of Article 250 — specifically, the requirements covering grounding of separately derived systems — the secondary circuit of a welder is not treated as premises wiring and is not required to be grounded as such. This removes any potential conflict where grounding in the welder secondary circuit occurs at the work object.

Part III. Resistance Welders

630.31 Ampacity of Supply Conductors. The ampacity of the supply conductors for resistance welders shall be in accordance with 630.31(A) and (B).

Informational Note: The ampacity of the supply conductors for resistance welders necessary to limit the voltage drop to a value permissible for the satisfactory performance of the welder is usually greater than that required to prevent overheating.

(A) Individual Welders. The ampacity of conductors for individual welders shall comply with the following:

(1) The ampacity of the supply conductors for a welder that can be operated at different times at different values of primary current or duty cycle shall not be less than 70 percent of the rated primary current for seam and automatically fed welders, and 50 percent of the rated primary current for manually operated nonautomatic welders.

(2) The ampacity of the supply conductors for a welder wired for a specific operation for which the actual primary current and duty cycle are known and remain unchanged shall not be less than the product of the actual primary current and the multiplier specified in Table 630.31(A) for the duty cycle at which the welder will be operated.

(B) Groups of Welders. The ampacity of conductors that supply two or more welders shall not be less than the sum of the value obtained in accordance with 630.31(A) for the largest welder supplied and 60 percent of the values obtained for all the other welders supplied.

Informational Note: Explanation of Terms

(1) The *rated primary current* is the rated kilovolt-amperes (kVA) multiplied by 1000 and divided by the rated primary voltage, using values given on the nameplate.

(2) The *actual primary current* is the current drawn from the supply circuit during each welder operation at the particular heat tap and control setting used.

(3) The *duty cycle* is the percentage of the time during which the welder is loaded. For instance, a spot welder supplied by a 60-Hz system (216,000 cycles per hour) and making 400 15-cycle welds per hour would have a duty cycle of 2.8 percent (400 multiplied by 15, divided by 216,000, multiplied by 100). A seam welder operating 2 cycles "on" and 2 cycles "off" would have a duty cycle of 50 percent.

TABLE 630.31(A) *Duty Cycle Multiplication Factors for Resistance Welders*

Duty Cycle (%)	Multiplier
50	0.71
40	0.63
30	0.55
25	0.50
20	0.45
15	0.39
10	0.32
7.5	0.27
5 or less	0.22

The ampacity of supply conductors for a welder that is not wired for a specific function (i.e., one operated at varying intervals for different applications, such as dissimilar metals or thicknesses) is permitted by 630.31(A)(1) to be 70 percent of the rated primary current for automatically fed welders and 50 percent of the rated primary current for manually operated welders. The rated primary current can be determined using the following equation with the values given on the welder nameplate:

$$\text{Related primary voltage} = \frac{\text{welder kVA} \times 1000}{\text{rated primary voltage}}$$

Where the actual primary current and the duty cycle are known, such as for a welder wired for a specific operation, the ampacity of the supply conductors is not permitted to be less than the product of the actual primary current (current drawn during weld operation) and the multiplier, as provided in Table 630.31(A), for the duty cycle at which the welder will be operated.

Calculation Example

A seam welder is set to draw current for 3 cycles and to be off for 4 cycles during every 7-cycle period. The welder's duty cycle is calculated as follows:

$$\frac{3}{7} \times 100\% = 42.9\% \text{ (duty cycle)}$$

The duty cycle is set for a specific operation by adjusting the controller for the welder. An instrument capable of measuring current impulses for 3 cycles (1/20 second) is required to measure the actual primary current as required by 630.31(A)(2) in order to size the conductors. For the sizing of supply conductors, voltage drop should be limited to a value permissible for the satisfactory performance of the welder.

630.32 Overcurrent Protection. Overcurrent protection for resistance welders shall be as provided in 630.32(A) and (B). Where the values as determined by this section do not correspond with the standard ampere ratings provided in 240.6 or where the rating or setting specified results in unnecessary opening of the overcurrent device, a higher rating or setting that does not exceed the next higher standard ampere rating shall be permitted.

(A) For Welders. Each welder shall have an overcurrent device rated or set at not more than 300 percent of the rated primary current of the welder. If the supply conductors for a welder are protected by an overcurrent device rated or set at not more than 200 percent of the rated primary current of the welder, a separate overcurrent device shall not be required.

(B) For Conductors. Conductors that supply one or more welders shall be protected by an overcurrent device rated or set at not more than 300 percent of the conductor ampacity.

630.33 Disconnecting Means. A switch or circuit breaker shall be provided by which each resistance welder and its control equipment can be disconnected from the supply circuit. The ampere rating of this disconnecting means shall not be less than the supply conductor ampacity determined in accordance with 630.31. The supply circuit switch shall be permitted as the welder disconnecting means where the circuit supplies only one welder.

630.34 Marking. A nameplate shall be provided for each resistance welder, giving the following information:

(1) Name of manufacturer
(2) Frequency
(3) Primary voltage
(4) Rated kilovolt-amperes (kVA) at 50 percent duty cycle
(5) Maximum and minimum open-circuit secondary voltage
(6) Short-circuit secondary current at maximum secondary voltage
(7) Specified throat and gap setting

Part IV. Welding Cable

630.41 Conductors. Insulation of conductors intended for use in the secondary circuit of electric welders shall be flame retardant.

Listed welding cable is intended to be used for the secondary circuits of electric welders and cannot be used as "building wire" for circuits operating at 1000 volts or less unless the cable is also one of the types covered in Table 310.4(1). The fine stranding allows for the flexibility necessary in manual and automatic welding operations. Terminals used with this type of cable must be suitable for use with the fine stranding used in this type of cable construction. See 110.14 for more information regarding terminations used with conductors having other than Class B or C stranding.

630.42 Installation. Cables shall be permitted to be installed in a dedicated cable tray as provided in 630.42(A), (B), and (C).

(A) Cable Support. The cable tray shall provide support at not greater than 150-mm (6-in.) intervals.

(B) Spread of Fire and Products of Combustion. The installation shall comply with 300.21.

(C) Signs. A permanent sign shall be attached to the cable tray at intervals not greater than 6.0 m (20 ft). The sign shall read as follows:

CABLE TRAY FOR WELDING CABLES ONLY

ARTICLE 640 Audio Signal Processing, Amplification, and Reproduction Equipment

Part I. General

640.1 Scope.

(A) Covered. This article covers equipment and wiring for audio signal generation, recording, processing, amplification, and reproduction; distribution of sound; public address; speech input systems; temporary audio system installations; and electronic organs or other electronic musical instruments. This also includes audio systems subject to Article 517, Part VI, and Articles 518, 520, 525, and 530.

Informational Note: Examples of permanently installed distributed audio system locations include, but are not limited to, restaurant, hotel, business office, commercial and retail sales environments, churches, and schools. Both portable and permanently installed equipment locations include, but are not limited to, residences, auditoriums, theaters, stadiums, and movie and television studios. Temporary installations include, but are not limited to, auditoriums, theaters, stadiums (which use both temporary and permanently installed systems), and outdoor events such as fairs, festivals, circuses, public events, and concerts.

Equipment covered by Article 640 includes amplifiers; public address (PA) systems and centralized sound systems used in schools, factories, businesses, stadiums, and similar locations; intercommunications devices and systems; and devices used for recording or reproducing voice or music. The scope is limited to equipment whose main function is the processing, distribution, amplification, and reproduction of audio frequency bandwidth signals. This limitation does not preclude equipment that uses