

**665.26 Grounding and Bonding.** Bonding to the equipment grounding conductor or inter-unit bonding, or both, shall be used wherever required for circuit operation, and for limiting to a safe value radio frequency voltages between all exposed non-current-carrying parts of the equipment and earth ground, between all equipment parts and surrounding objects, and between such objects and earth ground. Such connection to the equipment grounding conductor and bonding shall be installed in accordance with Article 250, Parts II and V.

**Informational Note:** Under certain conditions, contact between the object being heated and the applicator results in an unsafe condition, such as eruption of heated materials. Grounding of the object being heated and ground detection can be used to prevent this unsafe condition.

Because of stray currents between units of equipment or between equipment and the ground, bonding presents special problems at radio frequencies. Special bonding requirements are particularly needed at dielectric heating frequencies (100 to 200 megahertz) because of the differences in radio frequency potential that can exist between the equipment and surrounding metal units or other units of the installation. Bonding has been accomplished by placing all units of the equipment on a flooring or base consisting of a copper or aluminum sheet, then thoroughly bonding by soldering, welding, or bolting. Such special bonding holds the radio frequency resistance and reactance between units to a minimum, and any stray circulating currents flowing through the bonding will not cause a dangerous voltage drop.

The operator can be protected from high radio frequency potentials by shielding at dielectric heating frequencies. Interference with radio communications systems at such high frequencies can be eliminated by totally enclosing all components in a shielding of copper or aluminum.

**665.27 Marking.** Each heating equipment shall be provided with a nameplate giving the manufacturer's name and model identification and the following input data: line volts, frequency, number of phases, maximum current, full-load kilovolt-amperes (kVA), and full-load power factor. Additional data shall be permitted.

## ARTICLE

# 668

## Electrolytic Cells

**668.1 Scope.** This article applies to the installation of the electrical components and accessory equipment of electrolytic cells, electrolytic cell lines, and process power supply for the production of aluminum, cadmium, chlorine, copper, fluorine, hydrogen peroxide, magnesium, sodium, sodium chlorate, and zinc.

Not covered by this article are cells used as a source of electric energy and for electroplating processes and cells used for the production of hydrogen.

**Informational Note No. 1:** In general, any cell line or group of cell lines operated as a unit for the production of a particular metal,

gas, or chemical compound may differ from any other cell lines producing the same product because of variations in the particular raw materials used, output capacity, use of proprietary methods or process practices, or other modifying factors to the extent that detailed *Code* requirements become overly restrictive and do not accomplish the stated purpose of this *Code*.

**Informational Note No. 2:** See IEEE 463-2013, *Standard for Electrical Safety Practices in Electrolytic Cell Line Working Zones*, for further information.

Within a cell line working zone, both an electrolytic cell line and its direct current (dc) process power-supply circuit are treated as an individual machine supplied from a single source, even though they might cover acres of space, have a load current in excess of 400,000 amperes dc, or have a circuit voltage in excess of 1000 volts dc. The cell line process current passes through each cell in a series connection, and the load current cannot be subdivided the way it can in the heating circuit of a resistance-type electric furnace. Because a cell line is supplied by its individual dc rectifier system, the rectifier or the entire cell line circuit is de-energized by removing its primary power source.

In some electrolytic cell systems, the terminal voltage of the process supply can be significant. The voltage to ground of exposed live parts from one end of a cell line to the other is variable between the limits of the terminal voltage. Hence, operating and maintenance personnel and their tools are required to be insulated from ground.

## 668.3 Other Articles.

**(A) Lighting, Ventilating, Material Handling.** Chapters 1 through 4 shall apply to services, feeders, branch circuits, and apparatus for supplying lighting, ventilating, material handling, and the like that are outside the electrolytic cell line working zone.

**(B) Systems Not Electrically Connected.** Those elements of a cell line power-supply system that are not electrically connected to the cell supply system, such as the primary winding of a two-winding transformer, the motor of a motor-generator set, feeders, branch circuits, disconnecting means, motor controllers, and overload protective equipment, shall be required to comply with all applicable sections of this *Code*.

**(C) Electrolytic Cell Lines.** Electrolytic cell lines shall comply with the provisions of Chapters 1 through 4 except as amended in 668.3(C)(1) through (C)(4).

**(1) Conductors.** The electrolytic cell line conductors shall not be required to comply with Articles 110, 210, 215, 220, and 225. See 668.12.

**(2) Overcurrent Protection.** Overcurrent protection of electrolytic cell dc process power circuits shall not be required to comply with the requirements of Article 240.

**(3) Grounding.** Except as required by this article, equipment located or used within the electrolytic cell line working zone or associated with the cell line dc power circuits shall not be required to comply with Article 250.



**(4) Working Zone.** The electrolytic cells, cell line attachments, and the wiring of auxiliary equipment and devices within the cell line working zone shall not be required to comply with Articles 110, 210, 215, 220, and 225. See 668.30.

Informational Note: See 668.15 for equipment, apparatus, and structural component grounding.

#### 668.10 Cell Line Working Zone.

**(A) Area Covered.** The space envelope of the cell line working zone shall encompass spaces that meet any of the following conditions:

- (1) Is within 2.5 m (96 in.) above energized surfaces of electrolytic cell lines or their energized attachments
- (2) Is below energized surfaces of electrolytic cell lines or their energized attachments, provided the headroom in the space beneath is less than 2.5 m (96 in.)
- (3) Is within 1.0 m (42 in.) horizontally from energized surfaces of electrolytic cell lines or their energized attachments or from the space envelope described in 668.10(A)(1) or (A)(2)

**(B) Area Not Covered.** The cell line working zone shall not be required to extend through or beyond walls, floors, roofs, partitions, barriers, or the like.

#### 668.11 Direct-Current Cell Line Process Power Supply.

**(A) Not Grounded.** The direct-current cell line process power-supply conductors shall not be required to be grounded.

**(B) Metal Enclosures Grounded.** All metal enclosures of power-supply apparatus for the direct-current cell line process operating with a power supply over 50 volts shall be grounded by either of the following means:

- (1) Through protective relaying equipment
- (2) By a minimum 2/0 AWG copper grounding electrode conductor or a conductor of equal or greater conductance

**(C) Grounding Requirements.** The grounding electrode connections required by 668.11(B) shall be installed in accordance with 250.8, 250.10, 250.12, 250.68, and 250.70.

#### 668.12 Cell Line Conductors.

**(A) Insulation and Material.** Cell line conductors shall be either bare, covered, or insulated and of copper, aluminum, copper-clad aluminum, steel, or other suitable material.

**(B) Size.** Cell line conductors shall be of such cross-sectional area that the temperature rise under maximum load conditions and at maximum ambient shall not exceed the safe operating temperature of the conductor insulation or the material of the conductor supports.

**(C) Connections.** Cell line conductors shall be joined by bolted, welded, clamped, or compression connectors.

#### 668.13 Disconnecting Means.

**(A) More Than One Process Power Supply.** Where more than one direct-current cell line process power supply serves the same cell line, a disconnecting means shall be provided on the cell line circuit side of each power supply to disconnect it from the cell line circuit.

**(B) Removable Links or Conductors.** Removable links or removable conductors shall be permitted to be used as the disconnecting means.

#### 668.14 Shunting Means.

**(A) Partial or Total Shunting.** Partial or total shunting of cell line circuit current around one or more cells shall be permitted.

**(B) Shunting One or More Cells.** The conductors, switches, or combination of conductors and switches used for shunting one or more cells shall comply with the applicable requirements of 668.12.

**668.15 Grounding.** For equipment, apparatus, and structural components that are required to be grounded in accordance with Article 668, Article 250, Part III, for a local grounding electrode system shall apply, except a water pipe electrode shall not be required to be used. Any electrode or combination of electrodes described in 250.52 shall be permitted.

#### 668.20 Portable Electrical Equipment.

**(A) Portable Electrical Equipment Not to Be Grounded.** The frames and enclosures of portable electrical equipment used within the cell line working zone shall not be grounded.

*Exception No. 1: Where the cell line voltage does not exceed 200 volts dc, these frames and enclosures shall be permitted to be grounded.*

*Exception No. 2: These frames and enclosures shall be permitted to be grounded where guarded.*

**(B) Isolating Transformers.** Electrically powered, hand-held, cord-connected portable equipment with ungrounded frames or enclosures used within the cell line working zone shall be connected to receptacle circuits that have only ungrounded conductors such as a branch circuit supplied by an isolating transformer with an ungrounded secondary.

**(C) Marking.** Ungrounded portable electrical equipment shall be distinctively marked and shall employ plugs and receptacles of a configuration that prevents connection of this equipment to grounding receptacles and that prevents inadvertent interchange of ungrounded and grounded portable electrical equipment.

#### 668.21 Power-Supply Circuits and Receptacles for Portable Electrical Equipment.

**(A) Isolated Circuits.** Circuits supplying power to ungrounded receptacles for hand-held, cord-connected equipment shall be



electrically isolated from any distribution system supplying areas other than the cell line working zone and shall be ungrounded. Power for these circuits shall be supplied through isolating transformers. Primaries of such transformers shall operate at not more than 1000 volts between conductors and shall be provided with proper overcurrent protection. The secondary voltage of such transformers shall not exceed 300 volts between conductors, and all circuits supplied from such secondaries shall be ungrounded and shall have an approved overcurrent device of proper rating in each conductor.

**(B) Noninterchangeability.** Receptacles and their mating plugs for ungrounded equipment shall not have provision for an equipment grounding conductor and shall be of a configuration that prevents their use for equipment required to be grounded.

**(C) Marking.** Receptacles on circuits supplied by an isolating transformer with an ungrounded secondary shall be a distinctive configuration, shall be distinctively marked, and shall not be used in any other location in the plant.

### 668.30 Fixed and Portable Electrical Equipment.

**(A) Electrical Equipment Not Required to Be Grounded.** Alternating-current systems supplying fixed and portable electrical equipment within the cell line working zone shall not be required to be grounded.

**(B) Exposed Conductive Surfaces Not Required to Be Grounded.** Exposed conductive surfaces, such as electrical equipment housings, cabinets, boxes, motors, raceways, and the like, that are within the cell line working zone shall not be required to be grounded.

**Δ (C) Wiring Methods.** Auxiliary electrical equipment such as motors, transducers, sensors, control devices, and alarms, mounted on an electrolytic cell or other energized surface, shall be connected to premises wiring systems using any of the following:

- (1) Multiconductor hard usage cord.
- (2) Wire or cable in suitable raceways or metal or nonmetallic cable trays. If metal conduit, cable tray, armored cable, or similar metallic systems are used, they shall be installed with insulating breaks such that they do not cause a potentially hazardous electrical condition.

**(D) Circuit Protection.** Circuit protection shall not be required for control and instrumentation that are totally within the cell line working zone.

**(E) Bonding.** Bonding of fixed electrical equipment to the energized conductive surfaces of the cell line, its attachments, or auxiliaries shall be permitted. Where fixed electrical equipment is mounted on an energized conductive surface, it shall be bonded to that surface.

**668.31 Auxiliary Nonelectrical Connections.** Auxiliary nonelectrical connections, such as air hoses, water hoses, and

the like, to an electrolytic cell, its attachments, or auxiliary equipment shall not have continuous conductive reinforcing wire, armor, braids, and the like. Hoses shall be of a nonconductive material.

### 668.32 Cranes and Hoists.

**(A) Conductive Surfaces to Be Insulated from Ground.** The conductive surfaces of cranes and hoists that enter the cell line working zone shall not be required to be grounded. The portion of an overhead crane or hoist that contacts an energized electrolytic cell or energized attachments shall be insulated from ground.

**(B) Hazardous Electrical Conditions.** Remote crane or hoist controls that could introduce hazardous electrical conditions into the cell line working zone shall employ one or more of the following systems:

- (1) Isolated and ungrounded control circuit in accordance with 668.21(A)
- (2) Nonconductive rope operator
- (3) Pendant pushbutton with nonconductive supporting means and having nonconductive surfaces or ungrounded exposed conductive surfaces
- (4) Radio

**668.40 Enclosures.** General-purpose electrical equipment enclosures shall be permitted where a natural draft ventilation system prevents the accumulation of gases.

## ARTICLE 669

## Electroplating

**669.1 Scope.** This article applies to the installation of the electrical components and accessory equipment that supply the power and controls for electroplating, anodizing, electropolishing, and electrostripping. For purposes of this article, the term *electroplating* shall be used to identify any or all of these processes.

Because of the extremely high currents and low voltages normally involved, conventional wiring methods cannot be used in electroplating, anodizing, electropolishing, and electrostripping processes. Section 669.6 permits the use of bare conductors supported from insulators in systems exceeding 50 volts direct current (dc). Some systems in the aluminum anodizing process have potentials up to 240 volts. Warning signs in accordance with 669.7 are required to be posted to indicate the presence of bare conductors.

**669.3 General.** Equipment for use in electroplating processes shall be identified for such service.

**669.5 Branch-Circuit Conductors.** Branch-circuit conductors supplying one or more units of equipment shall have an ampacity