# IEEE Standard for Electrical Safety Practices in Electrolytic Cell Line Working Zones

## IEEE Industry Applications Society

Sponsored by the
Petroleum and Chemical Industry Committee

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# IEEE Standard for Electrical Safety Practices in Electrolytic Cell Line Working Zones

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Approved 6 December 2006

**IEEE-SA Standards Board**

**Abstract:** Means for improved safeguarding of personnel while operating or maintaining equipment located in electrolytic cell line working zones are provided. Included are related requirements for equipment and electrical conductor installations. The general types of electrolytic cells covered include, but are not limited to, the direct current cells used in the production of aluminum, cadmium, sodium chlorate, chlorine, copper, fluorine, hydrogen peroxide, magnesium, sodium, and zinc.
**Keywords:** cell line working zone, electrical conductor installations, electrical safety, electrolytic cell line

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## Introduction

**This introduction is not part of IEEE Std 463-2006, IEEE Standard for Electrical Safety Practices in Electrolytic Cell Line Working Zones.**

In 1974 the Electrical Cell Line Working Group of the Petroleum and Chemical Industry Committee prepared a trial-use standard for Electrical Safety Practices in Electrolytic Cell Line Working Zones. Comments on the trial-use standard were incorporated into a full-use IEEE standard, which was published as IEEE Std 463-1977. The standard was developed to provide electrical safety practices for the unique conditions of the working areas of electrolytic cell installations. It defines the extent of the area covered and sets forth means of improved safeguarding of personnel in the area. The means are based on many years of successful experience in the industry.

This standard covers conditions that are different from the those general safety requirements in electrical installations stated in IEEE Std 141™-1993, IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (*The Red Book*) [B1],[a] and IEEE Std 142™-1991, IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (*The Green Book*) [B3]. The standard was used as a source document for Article 668, Electrolytic Cells, of the National Electrical Code® (NEC®) (NFPA 70-2005) and Chapter 3, Safety Requirements for Special Equipment, of the Standard for Electrical Safety in the Workplace (NFPA 70E-2004).

This standard must be applied with judgment. The requirements are of necessity general to cover the widely varied conditions of electrolytic cell areas. The selection of safeguards must include consideration of the nature and exposure of an electrical hazard as well as avoid unnecessary restriction of operation of the plant.

In 2005, a working group was formed for the purpose of reviewing and updating the standard.

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[a] The numbers in brackets correspond to those of the bibliography in Annex B.

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## CONTENTS

# IEEE Standard for Electrical Safety Practices in Electrolytic Cell Line Working Zones

## 1. Overview

Means of improved safeguarding of personnel while operating or maintaining equipment located in electrolytic cell line working zones are provided. Included are related requirements for equipment and electrical conductor installations. The general types of electrolytic cells covered include, but are not limited to, the direct current cells used in the production of aluminum, cadmium, sodium chlorate, chlorine, copper, fluorine, hydrogen peroxide, magnesium, sodium, and zinc.

### 1.1 Scope

This standard covers means of improved safeguarding of personnel while operating or maintaining equipment located in electrolytic cell line working zones. Included are related requirements for equipment and electrical conductor installations. The general types of electrolytic cells covered include, but are not limited to, the direct current (dc) cells used in the production of aluminum, cadmium, sodium chlorate, chlorine, copper, fluorine, hydrogen peroxide, magnesium, sodium and zinc.

This standard does not cover the following:

a) Any electrical equipment that is neither part of the electrolytic process equipment nor installed or used in the cell line working zone

b) Electroplating and anodizing facilities

c) AC cells or furnaces

d) Electrothermal process furnaces

e) Arc furnaces

f) Melting or heat treating facilities

g) Cells for hydrogen production

h) Cells used as a source of electric energy

### 1.2 Purpose

The purpose of this standard is to provide methods for practical improved safeguarding of personnel operating or maintaining equipment in electrolytic cell line working zones from electrical hazards. The cell line working zone is defined in Clause 5.

This standard permits alternate methods such as establishing and maintaining safety procedures if they accomplish the same objectives.

## 2. Normative references

There are no normative references.

## 3. Definitions

For the purposes of this standard, the following terms and definitions apply. *The Authoritative Dictionary of IEEE Standards, Seventh Edition* [B1] should be referenced for terms not defined in this clause.

**3.1 bond:** A reliable connection to ensure required electrical conductivity between metal parts.

**3.2 cell line:** An assembly of electrically interconnected electrolytic cells supplied from a dc power source.

**3.3 cell line voltage:** The dc voltage applied to the positive and negative bus supplying power to a cell line.

**3.4 cell voltage:** The dc voltage between the positive and negative terminals of one electrolytic cell.

**3.5 electrical hazard:** A condition where contact or equipment failure can result in electrical shock, arc flash burn, thermal burn, or blast.

**3.6 electrolytic cell:** A receptacle or vessel in which electrochemical reactions are caused by applying electrical energy for the purpose of refining or producing materials.

**3.7 ground:** A conducting connection, whether intentional or accidental, between an electric circuit or equipment and the earth, or to some conducting body that serves in place of earth.

**3.8 guarded:** Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casing, barriers, rails, screens, mats, or platforms to remove the likelihood of approach or contact by persons or objects to a point of danger.

**3.9 insulated:** Separated from other conducting surfaces by a dielectric, offering a high resistance to the passage of current. Air space is also a dielectric.

NOTE—When any object is said to be insulated, it is understood to be insulated for the conditions to which it is normally subjected. Otherwise, it is considered uninsulated, within the purpose of this definition.[1]

**3.10 isolated:** Not readily accessible to persons unless special means for access is used.

**3.11 isolation transformer:** A transformer used to electrically separate one circuit from another.

**3.12 qualified:** Having training and experience in recognizing and avoiding electrical hazards in the cell line working zone.

**3.13 safeguard:** A precautionary measure or requirement, or a technical plan to prevent accidents.

**3.14 work practices for improved safety:** Operating and maintenance procedures effective in minimizing the risk of accidents.

[1] Notes in text, tables, and figures are given for information only, and do not contain requirements needed to implement the standard.

## 4. Description of electrolytic cell lines

Electrolytic cell lines differ widely in size and in physical and electrical characteristics, even for the same type process. One cell line may operate at less that 25 volt dc and another at more than 1500 volt dc depending on the type and number of cells. Also, one cell line may operate at a few thousand ampere dc and another at over 400 000 ampere dc.

Electrolytic cell lines may be located indoors or outdoors, may be in a wet or dry environment, may have conductive or nonconductive floor surfaces, and may be electrically connected to auxiliary equipment such as pumps, motors, piping, and steelwork at elevations above and/or below the cells.

Electrolytic cell line installations and their associated power sources, electrical conductors, auxiliary equipment, and attachments are custom designed for each installation.

## 5. Cell line working zone

A cell line working zone is the space envelope wherein operation or maintenance is normally performed on or in the vicinity of exposed energized surfaces of electrolytic cell lines or their attachments. The space envelope of the cell line working zone includes any space:

a) Within 2.5 m (96 in) above energized surfaces of electrolytic cell lines or their energized attachments.

b) 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).

c) Within 1.1 m (42 in) horizontally from energized surfaces of electrolytic cell lines or their energized attachments, or from the space envelope described in item a) and item b).

The cell line working zone shall not be required to extend through or beyond walls, floors, roofs, ceilings, partitions, barriers, or the like.

## 6. Improved safeguarding of personnel from electrical hazards within the cell line working zone

Operation and maintenance of most electrolytic cell lines routinely require personnel to contact exposed, electrically energized surfaces such as electrolytic cells, their energized attachments and bus. The potential electrical hazards presented by these energized surfaces can be minimized by the selection of appropriate safeguards.

Exposed energized surfaces of cells and attachments in themselves do not create electrical hazards. However simultaneous contact between surfaces operating at different potentials (including ground) could create an electrical hazard. Therefore safeguards shall be provided for personnel within the cell line working zone.

Safeguards shall be provided by one or a combination of the means described in 6.1 through 6.8. In some cell line installations, certain safeguards are inherent due to building size, equipment spacing, component type, materials of construction, etc.

## 6.1 Insulation

Insulation shall be a properly designed system for energized and/or grounded surfaces utilizing non-conductive materials. Non-conductive material shall include glass, porcelain, epoxy coating, rubber, fiberglass, plastic, and when dry, such materials as concrete, tile, brick, and wood.

## 6.2 Guards

Guards shall be mechanical devices such as covers, casings, barriers, rails, screens, mats, and platforms that prevent approach or contact with electrically energized or grounded surfaces.

## 6.3 Voltage equalization

Voltage equalization shall be permitted by bonding a conductive surface to an electrically energized surface, either directly or through a resistance, so that there is insufficient voltage to create an electrical hazard.

## 6.4 Isolation

Isolation shall be the placement of equipment or items in locations so that personnel are unable to simultaneously contact exposed conductive surfaces.

## 6.5 Physical clearance

Physical clearance shall be a substantially safe working distance designed to minimize safety risks that may be less than that defined for the cell line working zone.

## 6.6 Personal protective equipment

— Personal protective equipment (PPE) shall include one or more of the following as determined appropriate for the conditions:

— Shoes, boots, or overshoes for wet service

— Shoes for dry service

— Gloves for wet service

— Gloves for dry service

— Sleeves for wet service

— Sleeves for dry service

— Electrically insulated head protection

— Eye protection with non-conductive frames

— Faceshield (polycarbonate or similar non-melting type)

— Other PPE as required

### 6.7 Work practices for improved safety

Work practices for improved safety shall be developed, used, and enforced for removing electrical hazards not alleviated by the methods described in 6.1 through 6.6.

### 6.8 Additional requirements

In addition to the preceding safeguards, the following general requirements apply:

a) Personnel permitted to work in the cell line working zone shall be qualified by periodic training and instruction as to what electrical hazards exist and what safeguards are provided in the areas of their assigned duties.

b) Normal entrances into a cell line working zone shall be marked with conspicuous warning signs that forbid entry by unqualified persons.

c) Protective devices and equipment shall be periodically verified to ensure they are in proper working condition.

d) Personal protective equipment shall be periodically tested by methods consistent with the exposure of the wearer to electrical hazards.

### 6.9 . Pacemakers and metallic implants

**Persons with implanted pacemakers, ferromagnetic medical devices, or other electronic devices vital to life shall not be permitted in cell areas unless written permission is obtained from the person's physician.**

**WARNING**

**The American Conference of Government Industrial Hygienists (ACGIH) recommends that persons with implanted pacemakers should not be exposed to magnetic flux densities above 10 gauss.**

## 7. Cell line working zone installations

### 7.1 Power supply circuits

#### 7.1.1 Fixed electric equipment

Alternating current (ac) power systems supplying fixed electrical equipment within the cell line working zone shall not be required to be grounded.

Circuit protection shall not be required for control and instrumentation totally within the cell line working zone.

Control and instrumentation wiring entering or leaving the cell line working zone requires special design consideration since the wiring may transfer cell potential to other areas.

Insulation shall be rated not less than cell line voltage **or ac power system voltage, whichever is greater,** where insulated conductors are exposed to cell line to ground voltage.

### 7.1.2 Portable electric equipment

AC power systems supplying power to portable cord-connected equipment used within cell line working zone shall:

a) Be ungrounded and have an approved overcurrent device of proper rating in each conductor.

b) Be supplied by isolation transformers.

   1) Primary voltage shall operate at no more than 600 V between conductors and shall be provided with proper overcurrent protection.

   2) Secondary voltage

      i) Shall not exceed 600 V between conductors for non-hand-held portable cord-connected equipment.

      ii) Shall not exceed 300 V between conductors for hand-held cord-connected equipment.

c) Use only special ungrounded single receptacles with a unique pole configuration and distinctive marking to prevent their use with equipment required to be grounded. These receptacles shall be used only in the cell line of the facility.

NOTE—If more than one receptacle is powered from the same circuit, use of two or more portable tools simultaneously may introduce hazardous circulating direct currents under abnormal conditions (e.g., multiple tool or cord insulation failures).

## 7.2 Electric equipment

### 7.2.1 Fixed electric equipment

Conductive surfaces such as electrical equipment housings, cabinets, boxes, motors, raceways, and similar equipment within the cell line working zone shall not be required to be grounded.

Bonding of fixed electrical equipment to the energized conductive surfaces of the cell line, its attachments, or auxiliaries shall be permitted.

Motors, transducers, sensors, control and alarm devices, and other auxiliary electrical devices mounted on an electrolytic cell or other energized surface shall be connected by one of the following means:

a) Multi-conductor, hard-service jacketed cord.

b) Wire or cable in suitable raceways. Exposed metal conduit, cable tray, armored cable, or similar metallic systems shall be installed with electrical insulating breaks so they do not create an electrical hazard.

c) Open wiring on insulators. Bare wire shall be used where temperatures exceed the rating of available insulated wire.

d) Equipment using optical isolation. Insulating breaks shall be provided where this equipment is electrically conductive.

### 7.2.2 Portable electric equipment

NOTE—The order of preference for the energy source for portable hand-held equipment is 1) battery powered, 2) pneumatic, 3) portable generator, and 4) ungrounded electrical receptacle.

The frames and enclosures of portable equipment used within an energized cell line working zone shall not be grounded.

*Exception #1:* Where the cell line voltage does not exceed 200 volt dc, the frames and enclosures shall be permitted to be grounded, if the frames and enclosures are guarded.

Ungrounded cord-connected portable electrical equipment (including hand-held) used exclusively in the cell line working zone shall be distinctively marked and shall employ plugs to connect with ungrounded receptacles of item c) in 7.1.2.

*Exception #2:* Standard hand-held ungrounded or grounded portable electrical tools and equipment shall be permitted to be used when a second isolation transformer or portable generator (see 7.3) is placed within the cell line working zone to which these hand-held tools are connected (Figure 1). The configuration of this transformer shall include the following:

a) Primary winding shall not be grounded and shall include cord and plug with the unique connector to mate with the ungrounded receptacles of item c) in 7.1.2.

b) The neutral leg of the secondary winding of the isolation transformer shall be bonded to the chassis (frame) of the transformer. The isolation transformer chassis will be the zero-voltage reference.

c) The secondary winding shall have an approved overcurrent device of proper rating.

d) Receptacles on secondary winding are standard for use with ungrounded or grounded cord and plug connected portable electrical tools and equipment. The receptacle ground pin socket(s) shall be bonded to the chassis of the transformer.

e) The isolation transformer shall be mounted in a non-conductive enclosure and base to insure isolation of the transformer from earth (building structure) potential.

f) The isolation transformer shall be used in the cell line working zone only.

g) The isolation transformer enclosure shall be clearly labeled as “Ungrounded Primary” and “For use in the cell line working zone only” and uniquely color coded.

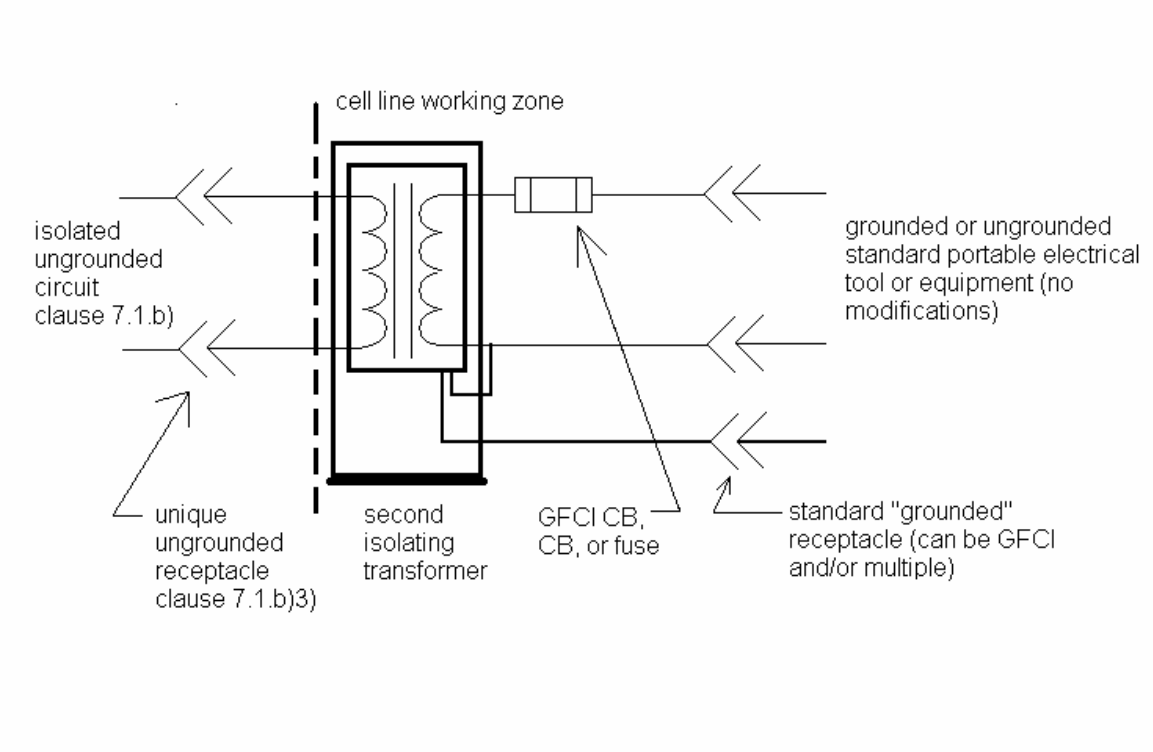


**Figure 1— Isolation Transformer**

NOTE—If the second isolation transformer is bonded to the cell line, then the power tool or equipment shall only be used in areas at the same dc potential of the transformer chassis. This is to minimize the risk of hazardous circulating currents between the tool and the transformer if they are at different potentials.

A ground fault circuit interrupter (GFCI) shall be used to protect the operator. If the second isolation transformer secondary is not equipped with a GFCI receptacle, a portable GFCI shall be used.

## 7.3 Portable generators used to supply temporary power in the cell line working zone

A generator can only be installed and connected in the cell line working zone if the generator frame is isolated from earth potential. The generator shall be permitted to supply power to standard hand-held ungrounded or grounded portable tools and equipment under the following conditions:

a) The work for the tool or equipment is within the cell line working zone.

   1) The tool and generator frame shall be considered to be at cell line potential.

   2) The generator shall not be grounded and shall be placed as close to the work as possible.

      NOTE—If the generator is bonded to the cell line, then the power tool or equipment shall only be used in areas at the same dc potential of the generator frame to minimize the risk of hazardous circulating currents between the tool and the generator.

   3) A ground fault circuit interrupter (GFCI) shall be used to protect the operator. If the generator is not equipped with a GFCI receptacle, a portable GFCI shall be used. The "ground" terminal of the receptacle shall be bonded to the generator frame.

### 7.4 Arc-welding machines (electrically powered)

When arc-welding machines are used to weld on energized cell line equipment, bonding requirements are as follows:

a) When a machine is placed within the cell line working zone, the machine frame shall be ungrounded and bonded to the cell line electrically close to the point of work. The cell line working zone shall be considered extended to include the welding machine and a substantially safe working distance (see 6.5) around the machine [1.1 m (42 in) horizontal and 2.5 m (96 in) vertical].

b) When a machine is placed outside the cell line working zone, the machine frame shall not be bonded to the cell line nor shall it be grounded. A "DANGER—CELL LINE VOLTAGE" sign shall be placed on the machine and the machine shall be temporarily guarded while leads are connected to the cell line

### 7.5 Cranes and hoists

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.

Crane or hoist controls that may introduce electrical hazards into the cell line working zone shall employ one or more of the following systems:

a) Insulated and ungrounded control circuits in accordance with 7.1

b) Pendant push-button with non-conductive supporting means and having either non-conductive surfaces or ungrounded exposed conductive surfaces

c) Wireless controls

d) Non-conductive rope operator

### 7.6 Non-electrical components

Air hoses, water hoses, and other auxiliary non-electrical connections to an electrolytic cell, its energized attachments, or auxiliary equipment shall not have continuous conductive reinforcing wires, armors, braids, or other similar materials. Hoses shall be constructed of a non-conductive material suitable for use with the cell line voltage.

## 8. Cell and cell line circuit grounding

The dc cell line process power supply conductors shall not be required to be grounded.

## 9. Enclosures

General purpose electric enclosures shall be permitted where a natural draft ventilation system prevents accumulation of gases.

# Annex A

(informative)

## Typical cell line working zone applications of safeguards where electrical hazards exist

A person is working on an energized cell. Manual contact is required to make adjustments and repairs. The exposed energized cell surfaces and ground are likely to create an electrical hazard. Safeguards can be provided in several different ways:

a) A permanent or temporary insulating surface on which the person stands.

b) Modification to the design of the installation provides an ungrounded conductive surface on which the person stands. If this conductive surface is bonded to the cell, the electrical hazards are minimized and improved safety provided.

c) Protective boots isolate the person's feet from the floor and provide improved safety from the electrical hazard.

d) Protective gloves isolate the person's hands from the energized cell and provide improved safety.

e) If the work task cause severe deterioration, wear, or damage to protective equipment, both protective gloves and boots may be required.

f) Work practice for improved safety. If protective boots are worn, then the person shall not make long reaches over the energized (or grounded) surfaces because his elbow or body may bypass the safeguard. If such movements are necessary, protective sleeves, protective mats, or special tools shall be used.

g) Instruction on the nature of electrical hazards and proper use and condition of safeguards provides improved personnel safety.

h) An electrolytic cell "grounding" device can be used to equalize the cell line potential to ground potential at the task location.

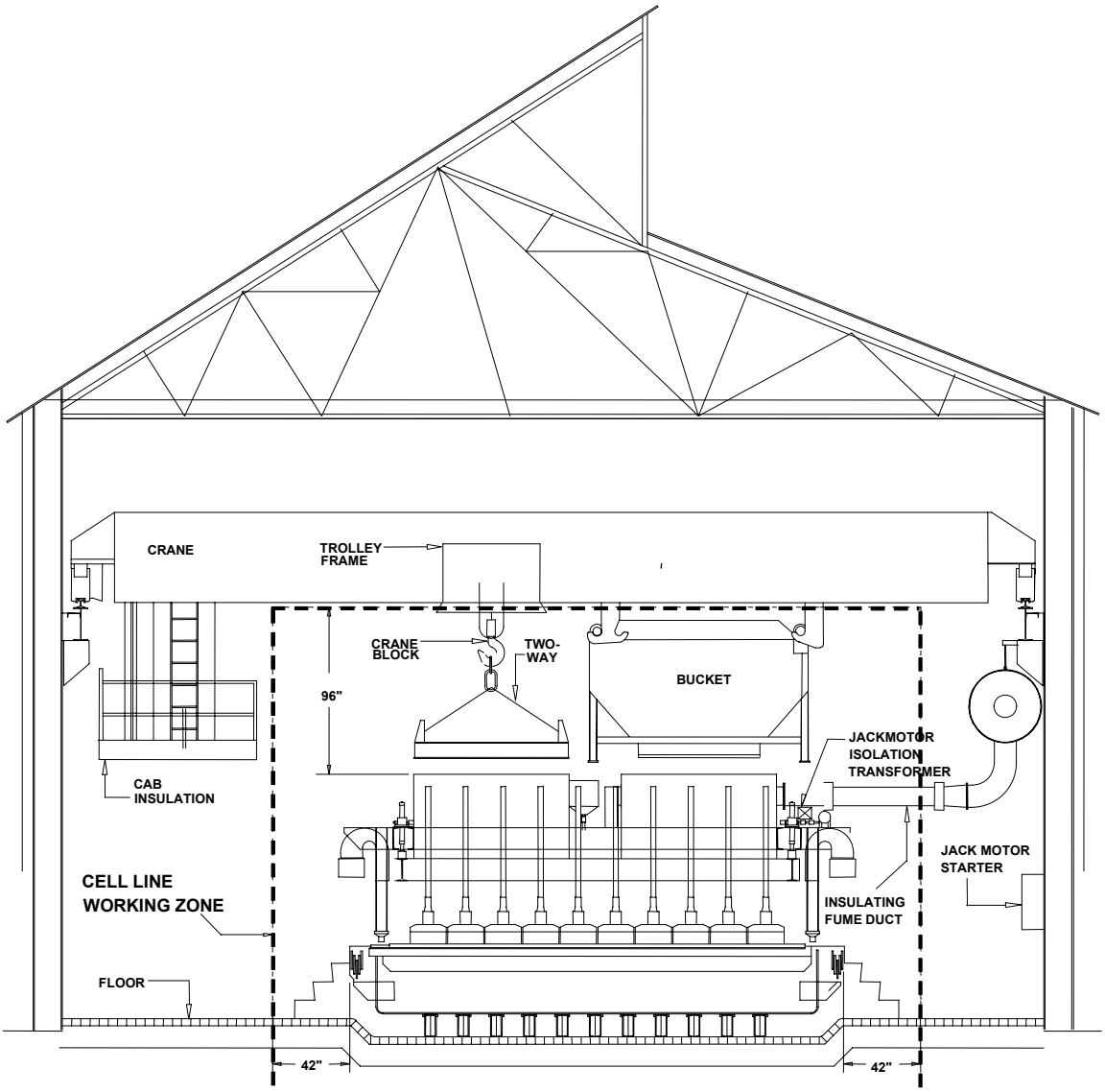


**Figure A.1— Typical cell line working zone (shown in dashed line)**

NOTE—As per ANSI/NFPA 70 Article 668-10 [B4]. Cell line working zone is 2.5 m (96 in) above and below if applicable and 1.1 m (42 in) horizontal from energized surfaces of potlines or their energized attachments.

# Annex B

(informative)

# Bibliography

[B1] IEEE 100, *The Authoritative Dictionary of IEEE Standards Terms,* Seventh Edition.

[B2] IEEE Std 141-1993, IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (*The Red Book*®).[2, 3]

[B3] IEEE Std 142-1991, IEEE Recommended practice for Grounding of Industrial and Commercial Power Systems (*The Green Book*®).

[B4] NFPA70-2005, National Electric Code.[4]

[B5] NFPA 70E-2004, Electrical Safety Requirements for Employee Workplaces.

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