



IEEE Standard for Control Cabinets for Power Transformers

STANDARDS

IEEE Power and Energy Society

Developed by the
Transformers Committee

IEEE Std C57.148™-2020
(Revision of
IEEE Std C57.148-2011)



IEEE Standard for Control Cabinets for Power Transformers

Developed by the

Transformers Committee
of the
IEEE Power and Energy Society

Approved 24 September 2020

IEEE SA Standards Board

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Abstract: Requirements for the design and construction of control cabinets on power transformers are covered by this standard.

Keywords: cabinet, circuit, component, construction, control cabinet, controls, current transformer, design, IEEE C57.148™, layout, manufacture

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Introduction

This introduction is not part of IEEE Std C57.148-2020, IEEE Standard for Control Cabinets for Power Transformers.

This standard, first published in 2011, was developed to provide requirements for the design and manufacture of control cabinets for Class I and Class II power transformers. It contained options to cover the various types of components that could be provided, the various types of cooling classes that may be employed, and the various site-specific or user-specified requirements that may exist for the transformer

In this latest revision of the standard, the document was updated to current IEEE styles, general revisions were made, and experience gained from its first five years of use were included. In addition, a new clause on drawing requirements was added, the clause on standard cabinet construction was rearranged for clarity, and a new clause on digital communication and telemetry and a companion clause were added to [Annex B](#).

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1. Overview

1.1 Scope

This standard will provide minimum and optional function, layout, and construction requirements for standard control cabinet designs. It will also include a coding system for specifying standard control cabinets with the required options. This standard ~~applies~~ ~~will apply~~ to Class ~~I~~ ~~1~~ and Class ~~II~~ ~~2~~ power transformers and ~~does~~ ~~will~~ not apply to distribution or padmount design transformers.

1.2 Purpose

This document ~~provides~~ ~~will provide~~ users and manufacturers with a set of standard designs that can be easily specified. The document should greatly reduce the engineering time required by manufacturers to create and by users to review control cabinet designs.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{1,2}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI/ASME B1.1, Unified Inch Screw Threads (UN and UNR Thread Form).³⁴

ANSI Z55.1, Gray Finishes for Industrial Apparatus and Equipment (R1973).⁴²

¹The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

²The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

³⁴ASME publications are available from the American Society of Mechanical Engineers, <https://www.asme.org/>.

⁴²ANSI Z55.1 (R1973) has been withdrawn; however, copies can be obtained from the Sales Department, American National Standards Institute, <http://www.ansi.org/>.

DIN EN 50022, Specification for low voltage switchgear and control-gear for industrial use.
Mounting rails.

Top hat rails 35 mm wide for snap-on mounting of equipment.⁵

IEC ~~Publication~~ 60529, ~~Classification of~~ Degrees of Protection Provided by Enclosures ([IP codes](#)).⁶³

IEEE Std C37.2™, IEEE Standard for Electrical Power System Device Function Numbers, Acronyms, and ~~Contact~~ Designations.^{784,5}

IEEE Std C57.12.00™, IEEE Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.

IEEE Std C57.12.10™, IEEE Standard Requirements for Liquid-Immersed Power Transformers.

¹⁰IEEE Std C57.13TM, IEEE Standard Requirements for Instrument Transformers.

ISO 262, ISO General purpose metric screw threads—Selected sizes for screws, bolts, and nuts.⁹⁶

⁵This DIN publication is available from <https://www.din.de/en/about-standards>.

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⁵~~IEEE publications are available at <http://standards.ieee.org/>.~~

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NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).¹⁰~~7~~

NFPA 70[®], National Electrical Code[®] (NEC[®]).^{11,12}~~8~~

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary: Glossary of Terms & Definitions* should be consulted for terms not defined in this clause.¹³~~9~~

arc fault circuit interrupter (AFCI): A device intended to provide protection from the effects of arc faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc fault is detected.

Class I power transformer: Power transformers that are not categorized as Class II, as defined in IEEE Std C57.12.00.

¹⁰NEMA publications are available from the National Electrical Manufacturers Association (<http://www.nema.org/>).

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¹³IEEE Standards Dictionary Online is available at: <http://dictionary.ieee.org>. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

~~⁷This NEMA publication is available at <http://shop.ieee.org/>.~~

~~⁸National Electrical Safety Code and NESC are both registered trademarks and service marks of the Institute of Electrical and Electronics Engineers, Inc.~~

~~⁹The IEEE Standards Dictionary: Glossary of Terms & Definitions is available at <http://shop.ieee.org/>.~~

Class II power transformer: Power transformers with high-voltage windings rated for 115 kV nominal system voltage and above, and also power transformers with high-voltage windings rated 69 kV through 115 kV nominal system voltage, having a top nameplate rating of at least 15 000 kVA for three-phase transformers or 10 000 kVA for single-phase transformers, as defined in IEEE Std C57.12.00.

control cabinet: The primary cabinet(s) on a Class I or Class II transformer that contains the control panels for relay, metering, alarms, cooling controls, auxiliary power, and related circuits for user connection to the related systems in the substation.

control cabinet designer: The engineer or designer responsible for designing the layout and circuitry in the control cabinet.

continuous hinge ~~piano hinge~~: A long hinge with one continuous pin, attached along the full available lengths of a door and frame. Also referred to as a piano ~~continuous~~ hinge.

Deutsches Institut für Normung e.V. (German Institute for Standardization) (DIN) rail: A standard 35-mm-wide metal rail used to mount terminals, circuit breakers, and other types of devices (as specified in DIN EN 50022).

ethylene-tetrafluoroethylene (ETFE): A modified compound used for wire and cable insulation and jackets.

fluorinated ethylene propylene (FEP): A compound used for wire and cable insulation and jackets.

ground fault circuit interrupter (GFCI ~~GFI~~): A device intended ~~commonly used~~ for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds established values ~~or some circuits by fast tripping for differential current in the neutral and phase wires of a circuit.~~

machine tool wire: A flexible, stranded wire with a polyvinylchloride (PVC) insulation and jacket compound.

manufacturer: The organization that constructs or supplies the device or equipment.

positive temperature coefficient (PTC) heater: A type of heater that provides self-regulating temperature control resulting from the thermal-resistive properties of the ceramic materials used for the heating elements.

supplier: Refers to the transformer manufacturer when the control cabinet has been ~~ordered~~ [supplied](#) by the transformer manufacturer, or refers to the control cabinet manufacturer when the control cabinet has been ordered directly from the control cabinet manufacturer by the user.

switchboard wire [\(SIS\)](#): A flexible, stranded, tin-coated wire, with a cross-linked polyethylene [\(XLP\)](#) insulation and jacket compound.

user: The organization, or representative of the organization, who specifies and orders the purchase of the transformer and/or control cabinet and will own and operate the transformer and/or control cabinet when it is received and placed in service. As used in the introductory sections before the Contents, the term refers to the user of this standard.

wire raceway: A channel, with or without a cover, designed to contain and route wires and cables adjacent to terminal blocks and other devices.

3.2 Acronyms and abbreviations

[Transformer cooling classes referenced in this document: The following acronyms as defined in C57.12.00 are referenced in this document as generic examples of transformers with control circuits and components utilizing fans and/or pumps. For transformers with alternate insulating liquids K or L, references or requirements for cooling classes with the O insulating liquid designation in this Standard shall apply to K or L insulating liquids respectively. In the same way, for transformers with cooling classes with alternate external cooling medium W, references or requirements herein for cooling classes with the A external cooling medium shall apply to transformers with cooling classes with W external cooling mediums.](#)

~~AWG~~ ~~— American Wire Gauge~~

~~CT~~ ~~— current transformer~~

DIN ~~Deutsches Institut für Normung e.V. (German Institute for Standardization)~~

ETFE ~~ethylene tetrofluoroethylene~~

FEP ~~fluorinated ethylene propylene~~

GFI ~~ground fault interrupter~~

MTW ~~machine tool wire~~

OEM ~~original equipment manufacturer~~

ODAF Insulating liquid with fire point < 300°C, ~~oil~~ directed flow, ~~air~~ forced air

OFAF Insulating liquid with fire point < 300°C, forced flow, ~~oil~~ forced air ~~forced~~

ONAF Insulating liquid with fire point < 300°C, ~~oil~~ natural flow, ~~air~~ forced air

ONAN Insulating liquid with fire point < 300°C, natural flow, ~~oil~~ natural air ~~natural~~

SIS ~~switchboard wire~~

XLP ~~cross linked polyethylene~~

4. Cabinet-ordering specifications

This standard includes requirements that are intended to provide a basic, standard design. This standard also provides options on many aspects of the design and construction. Additionally, the user may specify and require other options. A standard checklist ~~sample ordering form~~ is included in Annex B to provide a convenient and complete method of communicating the user's ~~purchaser's~~ selection of standard design, standard options, or users' options for all aspects of the control cabinet.

5. Standard cabinet construction

5.1 General

The following standard cabinet construction requirements shall apply to all control cabinets covered under this standard.

Note that references herein to the National Electric Code[®] (NEC[®]) (NFPA 70[®]) are not intended to include the complete NEC as a normative reference. All references to the NEC in this standard are specific to the topic covered in the clauses containing the references only, and any other NEC requirements not referenced in this document do not apply to control cabinets covered under this standard.

5.2 Cabinet-housing criteria

Unless specified otherwise, the complete cabinet shall be constructed for outdoor use to meet or exceed the NEMA 3 ~~R~~ designation as detailed in NEMA 250, [similar to an IP63 Ingress Protection designation as detailed in IEC 60529](#).

For special application environments such as corrosive or chemical atmospheres, marine or explosion proof requirements, the appropriate NEMA, [IEC](#) or [other](#) ~~IEC~~ designations shall be specified by the user. The NEMA Type performance requirements are defined in NEMA 250 ~~“Enclosures for Electrical Equipment (1000 Volts Maximum)”~~. The IEC designations are defined in IEC 60529 ~~“Degrees of Protection Provided by Enclosures (IP)”~~.

Cabinets with gross weight greater than 20 kg (44.1 lb) shall have provisions for lifting and a sufficient number of external tabs for the purpose of bolting to the transformer. Additional external brackets for mounting gauges shall be specified by the transformer manufacturer or user.

Cabinet mounting provisions ~~shall~~ ~~must~~ meet the specified requirements of the user or supplier, respectively, depending on who orders the cabinet from the manufacturer. One such requirement is the ability to accommodate vibration suppressors or similar mounting hardware. Unless specified otherwise by the user or supplier, the control cabinet shall be designed ~~designer should design the cabinet~~ to be mounted on the transformer with not less than a 200 mm (7.9 in) air space between the back of the cabinet and the transformer tank wall.

5.3 Cabinet dimensions

Cabinet height and depth shall be such that all switches, circuit breakers, fuses, device display panels, and all similar components that require operation, adjustment, or inspection during normal operation may be operated from a readily accessible place. The center of the grip of the operating handle shall not be more than 2.0 m (6 ft 7 in) above the floor or working platform. ~~can be comfortably reached by a person of average height (approximately 1.7 m, or 5 ft 7 in) when standing at the plane of the door.~~ The mounted location of the control cabinet should be determined by the supplier based on user specifications, transformer foundation design, shipping limitations, and other considerations. Unless otherwise specified by the user, the bottom of the control cabinet shall not be less than 0.5 m (19.7 in) above the ground or work platform ~~location~~ where a worker would be ~~be~~ standing in front of the control cabinet ~~on the ground or on a work platform~~ when the transformer is set on its foundation. The bottom of the control cabinet ~~, and~~ shall not be below the base of the transformer. Unless specified otherwise by the user, the control cabinet designer shall assume that the elevation of the location where a technician would stand in front of the control cabinet in order to work in the cabinet shall be the same elevation as the base of the transformer.

5.4 Cabinet construction materials

Cabinets, doors, and hardware shall be of sturdy construction, and capable of operation under usual service conditions for transformers as specified in IEEE Std C57.12.00 for the expected life of the transformer, without bending or warping.

Unless specified otherwise by the user, [or agreed upon by the user and manufacturer](#), all cabinets shall be constructed of cold-rolled carbon steel with the minimum sheet metal thickness, based on the overall outside cabinet dimensions with doors closed, as shown in Table 1.

Table 1—Sheet metal thickness requirements

Length	Height	Minimum sheet metal thickness
Not greater than 762 mm (30 in), and	Not greater than 762 mm (30 in)	1.51 mm (0.0598 in or 16 gauge)
Greater than 762 mm (30 in) but not greater than 1524 mm (60 in), or	Greater than 762 mm (30 in) but not greater than 1219 mm (48 in)	1.90 mm (0.0747 in or 14 gauge)
Greater than 1524 mm (60 in), or	Greater than 1219 mm (48 in)	2.67 mm (0.105 in or 12 gauge)

Note that the minimum sheet metal thickness shall apply if either the length or the height, or both length and height, fall within the dimensional range for that sheet metal thickness. For example, a cabinet with a length of 700 mm and a height of 700 mm would require a minimum 1.51 mm sheet metal thickness. A cabinet with a length of 700 mm and a height of 800 mm would require a minimum 1.9 mm sheet metal thickness (see Table 1).

For special environmental applications where carbon steel cabinets are not suitable, either the environmental conditions or other materials, such as stainless steel, aluminum, polymeric, or special coatings, must be specified by the user.

5.5 Compartment styles and welding

~~Unless specified otherwise by the user or chosen by the control cabinet designer,~~ Cabinets shall have a single compartment with one or two doors. If user specifications require [or allow](#) isolated cabinet sections, ~~or if the control cabinet designer chooses to provide isolated~~ sections, cabinets may be constructed with internal compartments separated by steel barriers, with doors for each compartment. All external metal joints and seams shall be fully welded to prevent trapped water and corrosion. Intermittent welds on internal metal joints are acceptable, provided the metal surface preparation and finish coatings protect exposed metal from corrosion.

5.6 General cabinet layout

In general, ~~one-door and two-door~~ cabinets shall be organized in an orderly and logical manner to ~~reduce~~ minimize the risk of wiring errors. ~~All secondary wiring for any current transformer shall be connected to the same terminal block and not divided among multiple terminal blocks. Stacks of DIN rail terminals shall be equipped with dividers or installed with spaces between terminals for each current transformer and connected in the same manner.~~

To the extent practical within the available cabinet dimensions, current transformer terminal blocks should be arranged with all current transformers for each phase in a common row or column. Current transformer terminal blocks shall also be grouped by location and function and arranged within each group by stacking order. All secondary wiring for any current transformer shall be connected to the same terminal block and not divided among multiple terminal blocks. Stacks of Deutsches Institut für Normung e.V—German Institute for Standardization (DIN) rail terminals shall be equipped with dividers or installed with spaces between terminals for each current transformer and connected in the same manner.

Cooling control, alarm, and trip-circuit terminal blocks that provide the user's connections shall be arranged in a vertical or rectangular configuration similar to the general layout examples shown in Figure A.3.

Terminal block and test-switch locations shall provide adequate room between groups of columns of terminal blocks for orderly wire routing, troubleshooting, and any user's cable routing and connections.

The user or supplier may provide a standard layout design that meets these requirements, or the cabinet layout may be organized with the locations and minimum dimensions as shown ~~on~~ in Figure A.1, Figure A.2, and Figure A.3. Cabinet areas in the figures are approximate and can be expanded or contracted to accommodate the terminals and devices in any particular cabinet. Terminals and devices may be added or deleted as required.

Unless specified otherwise, the following requirements apply to all specified future or provisional components.

Current transformer terminal blocks and any optional test switches shall be provided for all installed and future provisional current transformers. Terminal blocks for control wiring shall include not less than 20% extra terminal blocks for DIN rail type and rounded to the closest number for molded block type but not less than four extra full-size terminal blocks, for future wiring requirements. The backplate shall include at least 10% provision space reserved for future devices. See 8.4.4 for extra power terminal requirements.

5.7 Rain sheds

The cabinet shall be constructed to reduce ~~minimize~~ the ingress of water from the cabinet top when the doors are opened. Acceptable solutions include a sloped cabinet top or shield above the cabinet top to shed rainwater away from the doors toward the back of the cabinet, or a water guard or barrier fitted to the front edge of the top of cabinet ~~cover~~ or doorways.

5.8 Fixed back and side panels

To reduce ~~minimize~~ the number of penetrations through the cabinet shell, controls components shall not be mounted directly to the inner surfaces of the cabinet. Components shall be mounted on rigid steel panels with a thickness not less than the cabinet material thickness. The panel shall be ~~that are attached to and~~ spaced a minimum of 12 mm (0.5 in) from the inner side or back walls of the cabinet. Openings and holes in the fixed panels shall be suitable for the secure mounting of components such as relays, ~~components~~, terminals, and DIN rail.

5.9 Swing panels

If additional panel surface is needed for mounting ~~controls~~ components, or if components need to be mounted on a panel inside the cabinet, swing panels may be used. Swing panels are flat steel panels vertically hinged and attached to the inside walls of the cabinet. With the external door of the cabinet open, the swing panel, complete with its mounted components, shall be capable of being opened through the main door opening to allow access to the fixed panels inside the cabinet. Swing panels shall have latching mechanisms to secure the panel in the closed position. Swing panels shall be capable of being opened a minimum of 90 degrees and be equipped with a mechanism to secure the panel in the open position. All exposed energized terminals rated for a potential Vac > 120 Vac ~~150 V~~ or Vdc > 48 Vdc ~~V~~ on the back side of swing panel shall be fully protected with a removable, fire-resistant ~~retardant~~, transparent shield, or other means, to reduce ~~minimize~~ the risk of accidental contact.

5.10 Doors, hardware, and gaskets

Cabinets shall be equipped with vertically hinged doors consisting of two or more hinges, or a continuous ~~piano~~ hinge, and be capable of opening a minimum of 90 degrees. ~~If the hinges are mild steel,~~ All exposed edges shall be completely welded to the door and cabinet to provide a full-weather seal.

The doors shall be equipped with corrosion-resistant handled latching mechanisms that secure the door to the cabinet at two or more points. ~~A combination of a handle and door clamps may be used for small control cabinets.~~ The handles or doors shall be suitable to be locked with a padlock fitting the dimensions listed in Figure 1 to be provided by the user. Unless specified otherwise, door handles shall not be equipped with integral key locks.