UL 347

STANDARD FOR SAFETY

Medium-Voltage AC Contactors, Controllers, and Control Centers

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UL Standard for Safety for Medium-Voltage AC Contactors, Controllers, and Control Centers, UL 347

Seventh Edition, Dated November 23, 2020

Summary of Topics

This revision of ANSI/UL 347 dated September 30, 2022 includes the following changes in requirements:

– Restructuring of Scope; 1.1.1 – 1.1.5

– Chiller Duty or OEM Defined Duty for Motor Starting Reduced Voltage Autotransformers; 4.204.1.3, 6.5.5.104

– Wire Bending Space; 5.210.1, 5.210.2

– Requirement for Terminals; 5.206.1

– Temperature Test Following Short Time Capability Test; 6.5.1

– Revision of Table 2 to Add Higher Rated Insulation Systems

– Addition of Earthing Switch to UL 347; 3.4.104, Section 4.206, 5.10.207, 5.11.207, 5.12.203, 5.205.1.4, 6.101.3, Section 6.209, Figure 11

– Color Coding of Insulating Conductors; 5.205.1.4

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated February 11, 2022 and July 15, 2022.

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The most recent designation of ANSI/UL 347 as an American National Standard (ANSI) occurred on September 30, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

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Preface

This is the harmonized ANCE, CSA Group, and UL standard for medium-voltage ac contactors, controllers, and control centres. It is the third edition of NMX-J-564/106-ANCE, the third edition of CSA C22.2 No. 253:20, and the seventh edition of UL 347. This edition of NMX-J-564/106-ANCE supersedes the previous edition published on January 2016. This edition of CSA C22.2 No. 253 supersedes the previous edition published on January 2016. This edition of UL 347 supersedes the previous edition published on January 29, 2016. This harmonized standard has been jointly revised on September 30, 2022. For this purpose, CSA Group and UL are issuing revision pages dated September 30, 2022, and ANCE is issuing a new edition dated September 30, 2022.

This harmonized Standard was prepared by the Association of Standardization and Certification, CSA Group and Underwriters Laboratories Inc. The efforts and support of the medium-voltage control manufacturing industry and the CANENA Technical Harmonization Subcommittee THSC TC17 WG1 – Medium Voltage Controllers, which includes representatives of UL, CSA Group, ANCE, and North American medium voltage control manufacturers, are gratefully acknowledged.

This standard is considered suitable for use for conformity assessment within the stated scope of the standard.

The present Mexican Standard was developed by the CT GTD – Generación, Transmisión y Distribución from the Comité de Normalización de la Asociación de Normalización y Certificación, A.C., CONANCE, with the collaboration of the medium-voltage controller manufacturers and users.

This Standard was reviewed by the CSA Integrated Committee on Industrial Control, under the jurisdiction of the CSA Technical Committee on Industrial Products and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee.

Application of Standard

Where reference is made to a specific number of samples to be tested, the specified number is to be considered a minimum quantity.

Note: Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.

Level of harmonization

This Standard was prepared by comparing UL 347, existing CSA Group standards, and ANCE and IEC 60470-2000 requirements. These requirements were reviewed, compared, and, where possible, harmonized. Where harmonization was not possible due to local installation codes, the differing requirements are noted in the text of the document. When conflicts between existing North American and IEC practices existed, the practice in North America is retained.

This Standard is published as an equivalent standard for ANCE, CSA Group, and UL.

An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical national differences are allowed for codes and governmental regulations as well as those recognized as being in accordance with NAFTA Article 905, for example, because of fundamental climatic, geographical, technological, or infrastructural factors, scientific justification, or the level of protection that the country considers appropriate. Presentation is word for word except for editorial changes.

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Formatting

This Standard is formatted to facilitate comparison to IEC 60470:1999 requirements, and to IEC 60694:1996, which is the common clauses document to which IEC 60470 is subservient. Requirements are categorized and arranged in the clause numbering structure used for IEC 60470. Where the requirements in this Standard were equivalent to those in IEC 60470, the subclause was assigned the equivalent IEC subclause number. Where this Standard does not include a subclause equivalent to those in IEC 60470, the entry "[Vacant]" was shown for the IEC 60470 subclause number. Where this Standard includes a requirement not shown in IEC 60470, the subclause was assigned a number of a higher numerical value than those used in the IEC document.

Note: IEC 60470 has since been replaced by IEC 62271-106 and IEC 60694 has since been replaced by IEC 62271-1.

In order to simplify the cross-referencing of corresponding requirements, the following clause numbering system is used:

- The clauses follow the IEC 60470 (and IEC 60694) format for clauses 1 through 7.
- Subclauses numbered .1 through .99 (but not subdivisions, e.g., those numbered .1.1, .1.2, .1.3, etc.) correspond to subclauses in IEC 60470 (and IEC 60694).
- Subclauses numbered .101 through .199 correspond to subclauses in IEC 60470.
- Subclauses numbered .201 through .299 are CANENA requirements not found or numbered in IEC 60470.

The purpose of this Standard is to harmonize as far as practicable all rules and requirements of a general nature in order to obtain uniformity of requirements and tests throughout the corresponding range of equipment and to avoid the need for testing to different standards.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

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MEDIUM-VOLTAGE AC CONTACTORS, CONTROLLERS, AND CONTROL CENTERS

1 General

1.1 Scope

1.1.1 This standard is applicable to ac contactors applied at voltages in the range of 1 501V to 15kV, and metal-enclosed contactor-based controllers, control centers, and other control assemblies and associated equipment applied at voltages in the range of 751V to 15kV, designed for operation at frequencies of 50 or 60 Hz on three-phase systems. These requirements apply to equipment intended for use in ordinary (non-hazardous) locations and installed in accordance with the applicable local installation codes and standards (see Annex A, Item 1). These requirements, as modified by the applicable national standards for fire pump controllers, also apply to fire pump controllers (see Annex A, Item 2).

1.1.2 This standard also includes requirements for controllers intended for service entrance applications. (See Annex A, Item 3 and Clause 5.204.)

1.1.3 This standard also includes requirements for equipment incorporating solid state switching elements intended for starting, stopping, regulating, controlling, or protecting heating and other resistive loads, having ac voltage ratings in the range of 1501V to 15kV.

1.1.4 This standard also includes requirements for reduced-voltage solid-state controllers.

1.1.5 This standard does not apply to:

a) equipment for use in classified (hazardous) locations as defined in the applicable installation codes or standards;

b) components contained in contactors and contactor-based controllers for which individual component standards exist;

c) auxiliary low voltage control assemblies (see Annex A, Item 4);

d) equipment consisting solely of electronic or solid-state devices, circuits, or systems;

e) electronic variable speed motor controllers (power conversion equipment); and

f) controllers using only solid-state devices in the main circuit.

1.2 Normative references, component standards, and general requirements

1.2.1 General

Products covered by this standard shall comply with the reference installation codes and standards noted in Annex A.

For undated references to standards, such reference shall be considered to refer to the latest edition and all revisions to that edition up to the time when this standard was approved. For dated references to standards, such reference shall be considered to refer to the dated edition and all revisions published to that edition up to the time the standard was approved.

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1.2.2 Component standards

1.2.2.1 Components utilized in the products covered by this standard shall comply with the appropriate standards for these components and shall be used in accordance with their recognized ratings and other limitations of use (see Annex D). A component shall comply with the ANCE, CSA Group, or UL Standards as appropriate for the country where the product shall be used.

1.2.2.2 A component need not comply with a specific requirement that:

a) involves a feature or characteristic not needed in the application of the component in the product covered in this standard, or

b) is superseded by a requirement in this standard.

1.2.3 General requirements

1.2.3.1 Canadian requirements

In Canada, general requirements as indicated in Annex A, Item 5, are also applicable.

1.2.3.2 Units of measurement

The values given in SI (metric) units shall be normative. Any other values given shall be for information purposes only.

2 Normal and Special Service Conditions

2.1 Normal service conditions

Apparatus within the scope of this standard shall be capable of operation within its performance specifications under the following conditions:

a) For equipment that is cooled by air, either ventilated or nonventilated, the temperature of the air outside of the enclosure and the ambient temperature is above 0°C but does not exceed 40°C, and its average value, measured over a period of 24 h, does not exceed 35°C.

b) The equipment is located where:

i) the influence of solar radiation is not significant, such as indoors or similarly protected locations;

ii) the altitude does not exceed 1 000 m (3 300 ft);

iii) the ambient air is not significantly polluted by dust, smoke, corrosive and/or flammable gases, vapors, or salt (for Mexico refer to Annex A item 22); and

iv) the average value of the relative humidity, measured over a period of 24 h, does not exceed 95% non-condensing.

2.2 Special service conditions

2.2.1 Altitude

Installation at altitudes above 1000 m up to 3000 m is also recognized in this standard. Variations in the design will in some cases be required. For example, considerations should be made for temperature rise,

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insulation level, and mechanical parameters affected by lower ambient pressures. Manufacturers should be prepared to supply any de-rating factors to be applied to the normal service condition ratings and any necessary setting adjustments.

NOTE: Special conditions are in some cases also necessary for some types of operating mechanisms.

2.2.2 Solar radiation

If the effects of solar radiation are significant, the principles stated in Annex A, Item 11, may be used for guidance.

2.2.3 Evaluations and exceptions

Conditions that equipment will experience should be evaluated in terms of the manufacturer's designated ratings and limitations. Service conditions that are outside the limits described in Clause 2.1 should be called to the controller manufacturer's attention, since special construction or protection will in some cases be required.

3 Definitions

NOTE: Definitions that correspond to definitions in the International Electrotechnical Vocabulary (IEV) (IEC 60050-441) have been so identified with their corresponding IEV designation.

In Canada, the definitions that are contained in the Canadian Electrical Code, Part I shall apply.

3.1 General terms

3.1.101 **controller and controlgear:** A controller consists of a contactor, overload protection, a manual externally operated disconnector, and a short-circuit protective device, mounted and wired in an enclosure specifically designed and dimensioned for its application, in which all tests are conducted, and which may also include a grounding function. An auxiliary compartment may be provided if necessary to complete the function of the controller.

NOTE: “Controlgear” is a general term covering controllers and auxiliary equipment supplied with controller vertical sections and in medium-voltage control centers.

3.1.102 **overcurrent:** A current exceeding the rated continuous current.

NOTE: Overcurrents can result from motor starting, overload, short-circuit, or ground faults.

3.1.103 **short-circuit current (often called fault current):** An overcurrent resulting from a short-circuit due to a fault or an incorrect connection in an electric circuit. [IEC 60050-441:1984, 441-11-07]

3.1.104 **overload:** Operating conditions in an electrically undamaged circuit that cause an overcurrent. [IEC 60050-441:1984, 441-11-02]

3.1.105 **conductive part:** A part which is capable of conducting current, although it is not necessarily used for carrying current. [IEC 60050-441:1984, 441-11-09, modified]

3.1.106 **ambient air temperature:** The temperature, determined under prescribed conditions, of the air surrounding the complete switching device or fuse. [IEC 60050-441:1984, 441-11-13]

NOTE: For switching devices or fuses installed inside an enclosure, it is the temperature of the air outside the enclosure.

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3.1.201 **medium-voltage:** For this standard, ac voltage in the range of 1 501V to 15kV (in Canada, 751V to 15kV).

NOTE: The applicable installation codes will in some cases refer to this voltage range as “high-voltage.”

3.1.202 **medium-voltage compartment:** A compartment containing one or more medium-voltage components.

3.1.203 **low-voltage:** For this standard, ac voltage in the range of 50 to 1 500 V (in Canada, 30 to 750 V).

NOTE: The applicable installation codes refer to voltages above 600 Vrms (750 Vrms in Canada) as “high voltage”.

3.1.204 **low-voltage control compartment:** A compartment containing only low-voltage components.

3.1.205 **auxiliary compartment:** A compartment containing components and busing as needed to complete the functional requirements of an individual controller or a control center beyond the operational functions provided by individual controllers.

3.1.206 **line contactor:** Contactor whose line terminals are energized when the isolating means is closed.

3.1.207 **connected position of a drawout (withdrawable) element:** The position of a drawout (withdrawable) element in which it is fully connected to the main and secondary circuits.

3.1.208 **test position of a drawout (withdrawable) element:** The position of a drawout (withdrawable) element in which an isolating distance or segregation is established in the main circuit and in which the auxiliary circuits are connected. [IEC 60050-441:1984, 441-16-27, modified]

3.1.209 **Class E controller:** Class E controllers are intended for controlling and protecting medium-voltage electric motors or other electrical loads, including transformers, capacitors, resistive loads, and branch circuits.

3.1.210 **Class E1 controller:** Class E1 controllers utilize the main contactor to make and break all currents up to and including the breaking capacity of the controller.

3.1.211 **Class E2 controller:** Class E2 controllers utilize the main contactor to make and break load and operating overload currents and utilize medium-voltage fuses for interrupting fault currents that exceed the breaking capacity of the main contactor.

3.1.212 **medium-voltage control center (or control center):** A floor-mounted assembly of one or more enclosed vertical sections, principally containing controller(s) in medium-voltage compartments, and designed to provide power to more than one medium-voltage compartment by a common power bus.

NOTE: Also referred to as “controlgear”.

3.1.213 **assembly:** A combination of controllers or controlgear completely assembled with all internal electrical and mechanical interconnections. [IEC 60050-441:1984, 441-12-01, modified]

3.1.214 **barrier (or partition):** A part of an assembly separating one compartment from other compartments. [IEC 60050-441:1984, 441-13-05]

3.1.215 **blank space:** An unusable compartment containing no components or bus, and not intended for future installation of additional components.

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3.1.216 **space for future controller unit:** An empty compartment, suitable for future installation of a specified controller. This compartment does not include connections to power bus, but is suitable for future installation of connections to power bus.

3.1.217 **factory-prepared space for future controller unit:** A compartment suitable for future installation of a complete controller. This compartment includes connections to power bus.

3.1.218 **partially completed controller unit:** A compartment equipped as a complete controller, except without power fuses, CTs, and load-side power connections.

NOTE: These elements (power fuse rating, CT ratio, load-side power connections, etc.) are excepted, because they can only be sized correctly with specific motor data.

3.1.219 **spare controller unit:** A fully equipped (complete) controller, suitable for immediate use, with a specific rating, but without a specific controller (load) designation.

3.1.220 **clearance:** The distance between two conductive parts along a string stretched the shortest way between these conductive parts. [IEC 60050-441:1984, 441-17-31]

3.1.221 **control power transformer (CPT):** A transformer utilized to supply voltage for control circuits and auxiliary devices.

3.1.222 **ground (earth):** A conducting connection, whether intentional or accidental, by which an electric circuit or equipment is connected to the earth or to some conducting body of relatively large extent that serves in place of the earth.

NOTE: See Figure 8 for examples of the use of the terms “grounding” and “bonding”, with corresponding terms for Canada and Mexico.

3.1.223 **insulation class:** The classification of insulation materials for the purpose of establishing temperature limits for the use of the material.

3.1.224 **grounding kit:** A grounding terminal means intended to be field-connected or factory-installed, consisting of connectors (lugs) and hardware, such as bolts, studs, or screws, etc., and suitable for connecting a conductor 14 AWG (2.08 mm^2) or larger to equipment required to be grounded, which is in addition to the means for securing conduit or cable armor.

NOTE 1: It is not intended that a grounding kit consist merely of screws for direct attachment of grounding conductors.

NOTE 2: In Canada, a grounding kit can also be referred to as a bonding kit.

3.2 Assemblies of controlgear

[Vacant]

3.3 Parts of assemblies

[Vacant]

3.4 Switching devices

3.4.101 **switching device:** A device designed to make or break the current in one or more electric circuits. [IEC 60050-441:1984, 441-14-01]

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3.4.102 **mechanical switching device:** A switching device designed to close and open one or more electric circuits by means of separable contacts. [IEC 60050-441:1984, 441-14-02]

NOTE: Any mechanical switching device may be designated according to the medium in which its contacts open and close, e.g., air, SF_6, oil.

3.4.103 **isolating means (isolating switch or disconnector):** A mechanical switching device that provides, in the open position, isolating distance in the main circuit from the source of power. [IEC 60050-441:1984, 441-14-05, modified]

3.4.103.201 **service disconnecting means:** Isolating means that disconnects all conductors into a building or other structure from the service entrance conductors.

3.4.104 **grounding (earthing) switch:** A permanently installed mechanical three-pole open air switching device used to connect the load side of a de-energized medium voltage controller power circuit to ground (earth) for maintenance purposes.

3.4.105 **contactor:** A mechanical switching device having only one position of rest, operated otherwise than by hand, capable of making, carrying, and breaking currents under normal circuit conditions, including operating overload conditions. [IEC 60050-441:1984, 441-14-33]

3.4.106 **electromagnetic contactor:** A contactor in which the force for closing the normally open main contacts or for opening the normally closed main contacts is provided by an electromagnet.

NOTE: Unless otherwise identified, the term “contactor” as used in this standard refers to an “electromagnetic contactor”.

3.4.107 **vacuum contactor:** A contactor in which the main contacts open and close within a highly evacuated envelope.

3.4.108 **SF_6 contactor:** [Vacant]

3.4.109 **latched contactor:** A contactor, the moving elements of which are prevented by means of a latching arrangement from returning to the position of rest when the operating means are de-energized. [IEC 60050-441:1984, 441-14-34]

NOTE: The latching, and the release of the latching, can be mechanical, electromagnetic, pneumatic, etc.

3.4.110 **starter (motor controller):** A controller used to start and stop a motor.

3.4.110.1 **full-voltage starter:** A starter that connects the full line voltage across the motor terminals in one step.

3.4.110.2 **reversing starter:** A starter intended to cause the motor to reverse the direction of rotation by reversing the motor primary connections even when the motor is rotating.

3.4.110.3 **two-direction starter:** [Vacant]

3.4.110.4 **reduced-voltage starter:** A starter that reduces the starting voltage of the motor, and then transitions to full voltage. Reduced-voltage starters include autotransformer, reactor, solid-state, wye-delta, part winding, and wound-rotor starters.

3.4.110.5 **autotransformer starter:** A reduced-voltage starter that uses reduced voltages derived from an autotransformer to start a motor. It includes the necessary switching devices to provide full voltage.

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3.4.110.6 **rheostatic starter:** [Vacant]

3.4.110.7 **wound-rotor starter (or a rheostatic rotor starter):** [Vacant]

3.4.110.8 **reactor starter (often referred to as a primary reactor starter):** A starter that includes a reactor connected in series with the stator winding of an alternating current motor to furnish reduced voltage for starting. It includes the necessary switching devices to provide full voltage.

3.4.110.9 **electromagnetic starter (electromagnetic controller):** [Vacant]

3.4.110.10 **n-step starter:** [Vacant]

3.4.111 **controller, combination starter:** [Vacant]

3.4.112 **short-circuit protective device (SCPD):** A device intended to protect a circuit or parts of a circuit against short-circuit currents by interrupting them; in this standard, typically a medium-voltage fuse.

3.4.113 **Class C1:** A device with a low probability of restrike during capacitive current breaking as demonstrated by the type tests in Clause 6.109.

3.4.114 **Class C2:** A device with a very low probability of restrike during capacitive current breaking as demonstrated by the type tests in Clause 6.109.

3.4.201 **vacuum interrupter:** An interrupter in which the contacts open and close within a highly evacuated envelope.

3.4.202 **reduced-voltage solid state controller:** A controller that includes solid state devices connected in series with the stator winding of an alternating current motor to furnish reduced voltage for starting.

NOTE: It might or might not include the necessary mechanical switching devices to provide a bypass function.

3.4.203 **automatic bypass function:** A circuit that automatically shunts the solid state devices to provide full voltage to the output terminals.

NOTE: An automatic bypass function might or might not include provisions for automatic return of control to the solid state devices.

3.4.204 **solid state resistive load controller:** A Class E2 controller that includes solid state devices connected in series with a resistive load to provide control of power consumed by the resistive load, such as heaters.

NOTE: It might or might not include the necessary mechanical switching devices to provide a bypass function.

3.5 Parts of a controller

3.5.101 **pole of a switching device:** The portion of a controller associated exclusively with one electrically separated conducting path of its main circuit and excluding those portions which provide a means for mounting and operating all poles together.

NOTE: A switching device is called single-pole if it has only one pole. If it has more than one pole, it may be called multi-pole (two-pole, three-pole, etc.), provided that the poles are, or can be, coupled in such a manner as to operate together.

3.5.102 **main circuit:** All the current-carrying parts of a controller included in the medium-voltage circuit it is intended to open or close.

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3.5.103 **control circuit:** The circuit that carries the electric signals directing the performance of a control device, but does not carry the power that the device controls.

3.5.104 **auxiliary circuit:** All the conductive parts of controller that are intended to be included in a circuit, other than the main circuit and the control circuits of the device.

NOTE: Some auxiliary circuits fulfill supplementary functions, such as signalling, interlocking, etc., and, as such, can be part of the control circuit of another switching device.

3.5.201 **interlock (interlocking device):** A device that makes the operation of a movable element (e.g., a switching device, door, or the like) dependent upon the position or operation of one or more other movable elements. [IEC 60050-441:1984, 441-16-49, modified]

3.5.202 **drawout (withdrawable) element:** A removable part of controller that can be moved to one or more positions in which an isolating distance or a segregation between open contacts is established. [IEC 60050-441:1984, 441-13-09]

NOTE: The isolating distance or the segregation always relates to the main circuit, and in some cases refers to the auxiliary circuits or to control circuits.

3.5.203 **cover:** The unhinged portion of an enclosure that covers an opening.

3.5.204 **door:** A hinged portion of an enclosure that covers an opening.

3.5.205 **enclosure:** A surrounding case constructed to provide a degree of protection to personnel against incidental contact with the enclosed equipment and to provide a degree of protection to the enclosed equipment against specified environmental conditions.

NOTE: See also Annex A, Item 6.

3.5.206 **vertical section:** That portion of a medium-voltage control center assembly between two successive vertical delineations. A vertical section includes top, vertical side panels, front and rear doors or covers containing power bus, low-voltage and medium-voltage compartments, or other components as required for the intended application.

3.5.207 **power bus:** A conductor or group of conductors that serves as a source of supply to two or more power circuits within or between vertical sections.

3.5.208 **extendable power bus:** That portion of the power bus that is capable of being extended to connect two or more vertical sections.

3.5.209 **non-extendable power bus:** Those portions of the power bus that are not extendable and connect power circuits within a vertical section, with short direct terminations, to not more than three controllers.

3.6 Operation

3.6.101 **operation (of a mechanical switching device):** The transfer of the moving contact(s) from one position to an adjacent position. [IEC 60050-441:1984, 441-16-01]

NOTE 1: This can be a closing operation or an opening operation.

NOTE 2: If distinction is necessary, an operation in the electrical sense, e.g., make or break, is referred to as a switching operation, and an operation in the mechanical sense, e.g., close or open, is referred to as a mechanical operation.

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3.6.102 **operating cycle (of a mechanical switching device):** [Vacant]

3.6.103 **closing operation "C" (of a mechanical switching device):** An operation by which the device is brought from the open position to the closed position. [IEC 60050-441:1984, 441-16-08]

3.6.104 **opening operation "O" (of a mechanical switching device):** An operation by which the device is brought from the closed position to the open position. [IEC 60050-441:1984, 441-16-09]

3.6.105 **closed position (of a mechanical switching device):** The position in which the predetermined continuity of the main circuit of the device is secured. [IEC 60050-441:1984, 441-16-22]

3.6.106 **open position (of a mechanical switching device):** The position in which the predetermined clearance between open contacts in the main circuit of the device is secured. [IEC 60050-441:1984, 441-16-23]

3.6.107 **position of rest (of a contactor):** The position which the moving elements of the contactor take up when its electromagnet is not energized. [IEC 60050-441:1984, 441-16-24 modified]

3.6.108 **overload relay or release:** [Vacant]

3.6.109 **thermal overload relay or release:** [Vacant]

3.6.110 **current setting of an overload relay or release:** [Vacant]

3.6.111 **current setting range of an overload relay or release:** [Vacant]

3.6.112 **phase failure sensitive overload relay or release:** [Vacant]

3.6.113 **under-current (under-voltage) relay or release:** [Vacant]

3.6.114 **starting time (of a rheostatic starter):** [Vacant]

3.6.115 **starting time (of a reduced-voltage starter):** [Vacant]

3.6.116 **open transition (of an autotransformer starter):** [Vacant]

3.6.117 **closed transition (of an autotransformer starter):** [Vacant]

3.6.118 **inching (jogging):** [Vacant]

3.6.119 **plugging:** [Vacant]

3.7 Characteristic quantities

3.7.1 **isolating distance (gap):** The clearance between the line and load side contacts of the isolating means when in the open position.

3.7.2 **degree of protection:** The extent of protection provided by an enclosure against access to hazardous parts, against ingress of solid foreign objects, and/or ingress of water, and verified by standardized test methods (see Annex A Item 12).

3.7.101 **breaking current (of a switching device or a fuse):**

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3.7.102 **breaking capacity (of a switching device or a fuse):** A value of prospective current that a switching device or a fuse is capable of breaking at a stated voltage under prescribed conditions of use and behavior. [IEC 60050-441:1984, 441-17-08]

NOTE 1: The voltage to be stated and the conditions to be prescribed are dealt with in the relevant publications.

NOTE 2: For switching devices, the breaking capacity can be termed according to the kind of current included in the prescribed conditions, e.g., line charging breaking capacity, cable charging breaking capacity, single capacitor bank breaking capacity, etc.

3.7.103 **making capacity (of a switching device):** A value of prospective making current that a switching device is capable of making at a stated voltage under prescribed conditions of use and behavior. [IEC 60050-441:1984, 441-17-09]

NOTE: The voltage to be stated and the conditions to be prescribed are dealt with in the relevant specifications.

3.7.104 **take-over current:** See Clause 3.7.115.

3.7.105 **short-time withstand current:** The current that a circuit or a switching device in the closed position can carry during a specified short time under prescribed conditions of use and behavior. [IEC 60050-441:1984, 441-17-17]

3.7.106 **recovery voltage:** The voltage that appears across the terminals of a pole of a switching device or a fuse after the breaking of the current. [IEC 60050-441:1984, 441-17-25, modified]

NOTE: This voltage can be considered in two successive intervals of time, the first in which a transient voltage is superimposed on an essentially constant power-frequency voltage, followed by a second interval in which the power-frequency or the steady-state recovery voltage alone exists.

3.7.107 **transient recovery voltage (TRV):** The recovery voltage during the time in which it has a significant transient character. [IEC 60050-441:1984, 441-17-26]

NOTE 1: The transient recovery voltage can be oscillatory or non-oscillatory, or a combination of these, depending on the characteristics of the circuit and the switching device. It includes the voltage shift of the neutral of a polyphase circuit.

NOTE 2: The transient recovery voltage in three-phase circuits is, unless otherwise stated, that across the first pole to clear, because this voltage is generally higher than that which appears across each of the other two poles.

3.7.108 **power-frequency recovery voltage:** The recovery voltage after the transient voltage phenomena have subsided. [IEC 60050-441:1984, 441-17-27] See Figure 6.

3.7.109 **prospective current (of a circuit and with respect to a combination situated therein):** The current that would flow in the circuit if each pole of the combination were replaced by a conductor of negligible impedance. [IEC 60050-441:1984, 441-17-01, modified]

NOTE: For testing, the prospective current is determined by calibrating the test circuit with a short circuit placed directly across the incoming terminals of the test specimen.

3.7.110 **prospective peak current:** The peak value of a prospective current during the transient period following initiation. [IEC 60050-441:1984, 441-17-02, modified]

NOTE 1: For testing, the prospective current is determined by calibrating the test circuit with a short circuit placed directly across the incoming terminals of the test specimen.

NOTE 2: The definition assumes that the current is made by an ideal switching device, i.e. with instantaneous transition from infinite to zero impedance. For circuits where the current can follow several different paths, e.g., polyphase circuits, it further assumes that the current is made simultaneously in all poles, even if only the current in one pole is considered.

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3.7.111 **maximum prospective peak current (of an ac circuit):** The prospective peak current when initiation of the current takes place at the instant which leads to the highest possible value. [IEC 60050-441:1984, 441-17-04]

NOTE: For a multi-pole device in a polyphase circuit, the maximum prospective peak current refers to a single pole only.

3.7.112 **prospective breaking current (of a switching device or fuse):** [Vacant]

3.7.113 **minimum breaking current:** [Vacant]

3.7.114 **let-through current (sometimes called cut-off current):** The maximum instantaneous value of current attained during the breaking operation of a switching device or a fuse.

3.7.115 **take-over current:** The current coordinate of the intersection between the time-current characteristics of two overcurrent protective devices. [IEC 60050-441:1984, 441-17-16]

NOTE: Historically referred to as cross over current.

3.7.116 **minimum take-over current:** Current determined by the point of intersection of the time-current characteristics of the medium-voltage fuse and the contactor corresponding to:

a) the maximum break time plus, where applicable, the maximum operating time of an external overcurrent or ground-fault relay, and

b) the minimum pre-arcing time of the medium-voltage fuse.

See also Figure 7.

3.7.117 **maximum take-over current:** Current determined by the point of intersection of the time-current characteristics of the medium-voltage fuse and the contactor corresponding to:

a) the minimum opening time of the contactor, or minimum response time if operated by an overcurrent relay and/or time delay devices; and

b) the maximum operating time of the medium-voltage fuse of highest rated current.

See also Figure 7.

3.7.118 **maximum acceptable power dissipation:** [Vacant]

3.7.119 **fused short-circuit current:** [Vacant]

3.7.120 **applied voltage (for a switching device):** The voltage that exists across the terminals of a pole of a switching device just before the making of the current. [IEC 60050-441:1984, 441-17-24]

NOTE: This is normally the line-to-line voltage divided by 1.732.

3.7.121 **prospective transient recovery voltage (of a circuit):** [Vacant]

3.7.122 **opening time (of a contactor):** The opening time of a contactor is defined according to the tripping method as stated below, including any time-delay device forming an integral part of the contactor, adjusted to a specified setting:

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a) For an electromagnetic contactor, the opening time is the interval of time between the instant at which the control circuit initiates contactor opening and the instant when the arcing contacts have separated in all poles.

b) For a latched contactor, the opening time is the interval of time between the instant of energizing the opening release and the instant when the arcing contacts have separated in all poles.

3.7.123 **minimum opening time (of the contactor):** [Vacant]

3.7.124 **maximum opening time (of the contactor):** [Vacant]

3.7.125 **arcing time (of a pole or a fuse):** The interval of time between the instant of the initiation of the arc in a pole or a fuse and the instant of final arc extinction of that pole or the fuse. [IEC 60050-441:1984, 441-17-37]

3.7.126 **break time (of the contactor):** The interval of time between the beginning of the opening time of the contactor and the instant of final arc extinction in all poles.

3.7.201 **supply voltage:** The voltage to which the line terminals of a device are connected.

3.7.202 **creepage distance:** The shortest distance along the surface of an insulating material between two conductive parts.

3.7.203 **disruptive discharge:** The phenomena associated with the failure of insulation under electric stress; these include a collapse of voltage and the passage of current. The term applies to electrical breakdown in solid, liquid, and gaseous dielectrics, and combinations of these dielectrics.

3.7.204 **ultimate trip current:** The minimum value of continuously applied current that will cause an overload relay to operate (trip).

3.101 Fuses

3.101.1 **fuse:** A device that, by the melting and severing of its specially designed and proportioned components, opens the circuit in which it is inserted by breaking the current when this exceeds a given value for a sufficient time. The fuse comprises all the parts that form the complete device. [IEC 60050-441:1984, 441-18-01, modified]

3.101.2 **striker:** [Vacant]

3.101.3 **pre-arcing time:** The interval of time between the beginning of a current large enough to cause a break in the fuse-element(s) and the instant when an arc is initiated. [IEC 60050-441:1984, 441-18-21]

NOTE: Pre-arcing time is also referred to as melting time.

3.101.4 **total clearing time (sometimes called operating time):** The sum of the pre-arcing time and the arcing time. [IEC 60050-441:1984, 441-18-22, modified]

3.101.5 **joule integral (I^2t):** [Vacant]

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3.201 Medium-voltage fuse

3.201.1 **medium-voltage fuse:** A current-limiting fuse intended for use in medium-voltage circuits, capable of interrupting all currents from the rated maximum interrupting current down to the rated minimum interrupting current (where applicable).

NOTE: See Annex D, Item 23 , which categorizes different types of current-limiting fuses based on their minimum interrupting current capability:

a) Backup current-limiting fuse: a current-limiting fuse capable of interrupting all currents from its rated maximum interrupting current down to its rated minimum interrupting current.

b) Full-range current-limiting fuse: a current-limiting fuse capable of interrupting, under specified conditions, all currents from its rated maximum interrupting current down to the minimum continuous current that can cause the fusible element to melt.

c) General-purpose current-limiting fuse: a current-limiting fuse capable of interrupting all currents from its rated interrupting current down to the current that causes melting of the fusible element(s) in one hour or more.

3.201.2 **foldback action:** A protective feature (a type of overload protection) that may be incorporated in reduced-voltage solid-state controllers. When the load attempts to draw excessive overcurrent through the solid-state portion of the controller, this action reduces both output voltage and current to lower values so as to avoid damage to the solid-state portion of the controller.

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4 Controller and Control Center Ratings and Characteristics

A contactor, starter, or combination in the correct condition of maintenance and adjustment shall be able to withstand all the stresses that occur in service, provided that these do not exceed its rated characteristics.

The characteristics of a contactor, starter, or combination, including its operating devices and auxiliary equipment, that shall be used to determine the ratings are given in this clause.

Under this heading, consideration is also given to the characteristics which are not necessarily ratings but need to be taken into consideration in the specification and design stages.

The rating of a controller is dependent on the medium-voltage fuse used.

A Class E controller intended for use with non-motor loads, such as transformers or capacitors, will in some cases require special considerations not included in this standard.

Where preferred ratings are specified in this standard, these ratings are not restrictive; ratings other than preferred ratings may be specified. Ratings which are not specifically identified as preferred ratings are mandatory values.

4.1 Rated maximum voltage (U_r)

The rated maximum voltage indicates the upper limit of the highest voltage of the system voltage for which the device or assembly is intended. Standard values of rated voltages are 2.5 kV, 3.6 kV, 5.0 kV, 7.2 kV, 12.0 kV and 15.0 kV.

NOTE: Standard values of rated voltage in Mexico are 3.6 kV, 5.0 kV, and 7.2 kV.

4.1.201 Rated supply voltage (U_a)

The rated supply voltage is the voltage to which the line side of the controller is designed to be connected.

4.2 Rated insulation level (U_d), (U_p)

The rated insulation level is the impulse test voltage (BIL) (U_p) and the power-frequency withstand test voltage (U_d) from Table 1 that the controller is expected to withstand.

4.2.101 Rated rotor insulation level

[Vacant]

4.2.102 Rated starting voltage of an autotransformer controller (U_{tap})

The rated starting voltage of an autotransformer controller is the reduced voltage derived from the transformer.

Preferred values of rated starting voltage (U_{tap}) are 50%, 65%, or 80% of the rated supply voltage.

4.2.103 Rated starting voltage of a reactor starter (U_{tap})

The rated starting voltage of a reactor controller is the reduced voltage derived from the impedance of the reactor and the motor current before rotation.

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Preferred values of rated starting voltage (U_{tap}) are 50%, 65%, or 80% of the rated supply voltage.

4.3 Rated frequency (f_r)

The rated frequency is the supply frequency for which the device is designed and to which the other characteristic values correspond. The standard values of the rated frequency are 50 Hz and 60 Hz.

The preferred rated frequency is 60 Hz.

4.4 Rated continuous current and temperature rise

4.4.1 Rated normal current

[Vacant]

NOTE: See Clauses 4.4.101 and 4.4.201.

4.4.2 Temperature rise

The temperature rise of any part of a contactor or controller at an ambient air temperature not exceeding 40°C shall not exceed the limits of temperature rise specified in Table 2 when tested in accordance with Clause 6.5.

4.4.101 Rated continuous current (thermal current rating) (I_{th})

The rated continuous current (thermal current) is the maximum current carried on a continuous basis without the temperature rise of the various parts exceeding the limits specified in Table 2.

NOTE: Selection from the R10 series is not applicable.

4.4.201 Control center rated continuous current

Preferred ratings of extendable power bus are 800 A, 1 000 A, 1 200 A, 1 600 A, 2 000 A, and 3 000 A.

Ratings of non-extendable power bus shall equal or exceed the maximum continuous current of the connected loads.

The current rating of individual controllers, when grouped within a vertical section, may be less than the rating of the controller alone when tested in accordance with Clause 6.5.

4.5 Rated short-time withstand current (I_k)

The rated short-time withstand current is the maximum symmetrical rms value of the short-circuit current that the extendable power bus and ground bus can withstand. See Clause 4.7 for duration. See Clause 6.6.2 for test details.

The preferred values are 40 kA and 50 kA.

The non-extendable power bus is not required to have a short-time withstand current rating.

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4.6 Rated peak and momentary withstand current

4.6.1 Rated peak withstand current (I_p)

The rated peak withstand current is the prospective peak current associated with the first major loop of the rated short-time withstand current that the contactor, controller, and non-extendable power bus can withstand in the closed position during the fault interruption test.

The prospective peak current value shall be equal to 2.6 times (60 Hz) or 2.5 times (50 Hz or below) the rated short-time withstand current. See Clause 6.6.3 for test requirements.

The non-extendable power bus shall withstand the maximum peak let-through fault current among the connected assemblies.

4.6.2 Rated momentary withstand current

The rated momentary withstand current is the maximum total current that the extendable power bus and ground bus shall be required to withstand. The current shall be the value, including the dc component, at the major peak of the maximum cycle as determined from the envelope of the current wave of the maximum offset phase during a test period of at least 10 cycles.

The peak current value shall be equal to 2.6 times (60 Hz) or 2.5 times (50 Hz or below) the rated short-time withstand current. See Clause 6.6.2 for test requirements.

NOTE: The momentary current is expressed as the peak current.

The symmetrical current shall be the rated short-time withstand current.

The non-extendable power bus is not required to have a momentary withstand current rating.

4.7 Rated duration of short-circuit (t_k)

4.7.1 General

The rated duration of short-circuit is the interval of time for which a controller or control center can carry a current equal to its rated short-time withstand current.

4.7.2 Rated duration of short-circuit for extendable power bus

The standard value of rated duration of short-circuit is 10 cycles (0.167 s at 60 Hz).

If necessary, a value other than 10 cycles (0.167 s at 60 Hz) may be chosen. The recommended values are 0.5 s, 1 s, and 2 s.

4.7.3 Rated duration of short-circuit for non-extendable power bus

The rated duration of short-circuit withstand current is the clearing time of the medium-voltage fuse (for Class E2) or controller (for Class E1).

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4.8 Rated supply voltage of operating devices and of auxiliary and control circuits (U_a)

4.8.1 General

The supply voltage of closing and opening devices and auxiliary and control circuits shall be understood to mean the voltage measured at the circuit terminals of the apparatus itself during its operation, including, if necessary, the auxiliary resistors or accessories supplied or required by the manufacturer to be installed in series with it, but not including the conductors for the connection to the electricity supply.

4.8.2 Rated supply voltage (U_a)

Common values for the rated control circuit supply voltages are as follows:

Rated supply frequency	Canada United States	Mexico
60 Hz	120 V ac	127 V ac
50 Hz	230 V ac	NA
dc	125 V dc	125 V dc

4.8.3 Supply voltage range

The range of ac and dc power supply voltage in normal duty measured at the input of the auxiliary equipment (electronic controls, supervision, monitoring and communication) is 85% to 110%. See Clause 6.101.1 for test procedure.

4.9 Rated supply frequency of closing and opening devices and of control circuits

The standard values of rated supply frequency are dc, 50 Hz and 60 Hz.

4.10 Rated pressure of compressed gas supply for installation and/or operation

[Vacant]

4.101 Rated operational current or rated operational power (I_e)

[Vacant]

4.102 Rated duties

[Vacant]

4.103 Rated making and breaking capacities

A contactor shall be capable of making and breaking the maximum current at which the overload relays alone cause current interruption (take-over current). The rating is determined by the make and break capacity test described in Clause 6.102.

4.104 Utilization category

[Vacant]

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4.105 Mechanical endurance (standard and optional)

With respect to its endurance against mechanical wear, a contactor or starter is characterized by the number of no-load operating cycles (i.e. without current on the main contacts) that can be made before it becomes necessary to replace any parts.

The minimum number of operations for the required standard rating is 10 000 and shall be verified in accordance with the test described in Clause 6.101.2.

An optional rating above 10 000 may be provided. The preferred optional ratings, expressed in millions of operations, are 0.03, 0.1, 0.3, 1 and 3.

4.106 Electrical endurance

[Vacant]

4.107 Coordination with medium-voltage fuses

Class E2 controllers are characterized by the type, ratings, and characteristics of the power fuses. Current-limiting fuses, to be used to provide overcurrent delineation between the contactor(s) and medium-voltage fuses, shall be coordinated with the contactor. The contactor interrupting rating and breaking time shall be coordinated with the medium-voltage fuses such that the contactor does not attempt to interrupt currents above its breaking capacity.

The medium-voltage fuses shall preferably be located on the supply side of the controller, and shall have a short-circuit breaking capacity not less than the prospective current (symmetrical) under short-circuit conditions at its location.

The medium-voltage fuses shall not operate in place of the contactor for currents up to the maximum overload levels in normal service (including stalled current of the motor).

For additional coordination information, refer to Clauses 4.201 and 4.202.

4.108 Types and characteristics of automatic change-over devices and automatic acceleration control devices

[Vacant]

4.109 Types and characteristics of autotransformers or reactors

Autotransformers or reactors shall be characterized by:

a) the supply voltage;

b) the number of taps available for adjusting the starting torque and current;

c) the rated starting voltage (see Clauses 4.2.102 and 4.2.103);

d) the current they can carry for a specified duration;

e) the rated starting duty (see Clauses 4.204 and 4.204.1); and

f) the method of cooling (e.g., free air, forced air, liquid immersion).

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The autotransformer or reactor may be either built into the controller or provided separately.

4.110 Types and characteristics of the starting resistors for rheostatic motor starters

[Vacant]

4.111 Characteristics dependent on starter type

[Vacant]

4.112 Rated capacitive switching currents

A capacitive switching current rating is optional. The rating of a switching device for capacitive current switching shall include one or both of the following, where applicable:

a) Rated single capacitor bank breaking current and inrush making current.

b) Rated back-to-back capacitor bank breaking current and inrush making current.

The values of rated capacitive switching currents shall be given by the manufacturer.

Two classes of switching devices are defined according to their restrike performances:

• Class C1: low probability of restrike during capacitive current breaking as demonstrated by the type tests.

• Class C2: very low probability of restrike during capacitive current breaking as demonstrated by type tests.

NOTE 1: The probability is related to the performance during the series of type tests stated in 6.109.

NOTE 2: The same switching device may have different classes depending on the application.

4.112.1 Rated single capacitor bank breaking current

The rated single capacitor bank breaking current is the maximum capacitor current that the switching device shall be capable of breaking at its rated maximum voltage U_r under the conditions of use and behavior prescribed in this standard. This breaking current refers to the switching of a shunt capacitor bank where no shunt capacitors are connected to the source side of the switching device.

4.112.2 Rated back-to-back capacitor bank breaking current

The rated back-to-back capacitor bank breaking current is the maximum capacitor current that the switching device shall be capable of breaking at its rated maximum voltage U_r under the conditions of use and behavior prescribed in this standard.

This breaking current refers to the switching of a shunt capacitor bank where one or several shunt capacitor banks are connected to the source side of the switching device giving an inrush making current equal to the rated back-to-back capacitor bank inrush making current.

4.112.3 Rated single capacitor bank inrush making current

No rated values are defined. Inrush currents associated with single capacitor banks are not considered critical.

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4.112.4 Rated back-to-back capacitor bank inrush making current

The rated back-to-back capacitor bank inrush making current is the peak value of the current that the switching device shall be capable of making at its rated maximum voltage U_r and with a frequency of the inrush current. The values shall be given by manufacturer.

4.201 Characteristics of Class E2 controllers

4.201.1 Running overcurrent protective units for Class E2 controllers shall be selected to:

a) prevent continuous operation above the rated continuous current of the controller,

b) provide protection of branch circuit conductors and connected loads in accordance with Annex A, item 1; and

c) operate before any fuse melts at all currents below the rated minimum interrupting current of the power circuit fuses.

4.201.2 Power circuit fuses shall be selected to be able to:

a) permit repetitive switching of the load, with consideration given to inrush current and time, without damaging a fuse,

b) interrupt faults at or beyond the controller load terminals, and

c) continuously carry overload relay ultimate trip current.

4.201.3 Contactors shall be selected to:

a) continuously carry overload relay ultimate trip current, and

b) interrupt normal running currents and operating overload currents up to the rated minimum interrupting current of the power circuit fuses.

4.202 Fault-interrupting rating

The interrupting rating of a Class E controller is expressed in terms of the maximum symmetrical fault current and specific line-to-line voltage it can interrupt at the controller incoming line terminals, according the fault interruption test described in Clause 6.104.

Standard fault-interrupting ratings for Class E2 controllers, based on power fuse interrupting rating, are 40 kA and 50 kA rms symmetrical.

4.203 Control center short-circuit rating

The short-circuit rating of a control center is equal to the lowest of the:

a) fault-interrupting rating of the installed controllers;

b) rated short-circuit current of protective devices; or

c) the rated short-time withstand current of the extendable power bus.

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4.204 Starting duty of reduced-voltage starters

The locked-rotor current at full voltage is assumed to be 6 times full load current. Ratings shall be determined as follows:

4.204.1 The starting duties for motor starting autotransformers and reactors:

4.204.1.1 Medium duty: The starter shall be rated based on the following test sequence:

a) On 30 s off 30 s, repeat two times for a total of three on/off operations.

b) Rest one hour.

c) Repeat step (a).

4.204.1.2 Heavy duty: The starter shall be rated based on the following test sequence:

a) On 1 min off 1 min, repeat four times for a total of five on/off operations.

b) Rest two hours.

c) Repeat step (a).

4.204.1.3 Optional Duty: Optional duty includes a starting current, specified as a multiple of full load current, and a test sequence defined by the following parameters:

a) On time (in seconds).

b) Off time (in seconds).

c) Number of consecutive on/off operations.

d) Rest time (in hours).

e) Repeat step (a) through (d) for specified number of sequences.

Optional duty starters shall have their duty cycle capabilities clearly and completely marked on the nameplate and drawings.

4.204.2 The starting duty for reduced-voltage solid state starters:

Reduced voltage solid state starters shall have a rated starting duty. The preferred starting duty is medium duty in accordance with Clause 4.204.2.1. Optional starting duty may be assigned, using the format in accordance with Clause 4.204.2.2.

4.204.2.1 Medium duty: The starter shall be rated with current of 4 times the rated full load current and on the following test sequence:

a) On time of 30 s.

b) Off time of 30 s.

c) Repeat 2 times for a total of 3 consecutive on/off operations.

d) Rest 1 hour.

e) Repeat step (a), (b) and (c) for a total of two sequences.

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4.204.2.2 Optional Duty: Optional duty includes a starting current, specified as a multiple of full load current, and a test sequence defined by the following parameters:

a) On time (in seconds).

b) Off time (in seconds).

c) Number of consecutive on/off operations.

d) Rest time (in hours).

e) Repeat step (a) through (d) for specified number of sequences.

4.205 Duty rating for solid state resistive load controllers

4.205.1 Continuous duty (no bypass contactor)

The controller shall be capable of operating at its maximum rated continuous current continuously, without exceeding the temperature limits specified in Clause 6.5.5.201.

4.205.2 Intermittent duty (with or without bypass contactor)

The controller shall be capable of operating at its maximum rated continuous current for a duty as specified by the manufacturer and defined in a test sequence defined by the following parameters, without exceeding the temperature limits specified in Clause 6.5.5.201:

a) On time (in seconds or minutes).

b) Off time (in seconds or minutes).

c) Number of consecutive on/off operations.

d) Rest time (in hours).

e) Repeat step (a) through (d) for specified number of sequences.

4.206 Grounding switch characteristics

4.206.1 Grounding switch operating

Grounding switches shall be manually operated. Power operated devices may be used, providing they have provisions to be operated by hand.

Grounding switches shall have provisions to be padlocked in the closed position or shall have provisions to padlock the access to the operating means for the grounding switch such that the switch cannot be opened.

If the grounding switch has provisions for electrical operation, padlocking in the closed position shall prevent the switch from opening when an attempt is made to electrically open the switch.

4.206.2 Grounding switch mechanical endurance

A grounding switch shall be capable of performing 1000 operations without voltage on or current through the circuit.

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See Clause 6.101.3 for testing requirements.

4.206.3 Grounding switch electrical ratings

4.206.3.1 Grounding switches are intended to be used on de-energized power circuits.

Grounding switches shall have the following electrical ratings:

a) Rated maximum voltage for the line side terminals, when in the open position; and

b) Rated insulation level for the line side terminals, when in the open position.

These ratings shall be equal to or greater than the controller ratings.

See Clause 6.2 for testing requirements for these ratings.

4.206.3.2 A grounding switch that is intended to ground a load that may contain stored electrical energy, such as a capacitor bank, shall have the following additional manufacturer defined ratings:

a) Short time withstand current – The maximum symmetrical rms value of the prospective short-circuit current that the grounding switch can carry when in the closed position.

b) Short time withstand duration – The time the grounding switch can carry the rated short time withstand current, when in the closed position.

c) Peak closing current – The maximum value of prospective peak current, of a stored energy circuit, that the grounding switch could be closed into.

d) Peak making voltage – The maximum peak voltage, of a stored energy circuit, that the grounding switch could be closed into.

Grounding switches provided with closing ratings shall be constructed such that the contact operating speeds and pressure are independent of the operating speed of the manual handle.

See Clause 6.209 for testing requirements for these ratings.

4.206.4 Grounding switch construction

Vacuum or any other type of sealed switching devices are not suitable to be used as grounding switches.

5 Design and Construction

5.1 Requirements for liquids

[Vacant]

5.2 Requirements for gases

[Vacant]

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5.3 Provisions for protective grounding

5.3.201 Terms

The grounding and bonding terms are identified in Figure 8. The terms used in this standard are in accordance with the UL column in Figure 8. The corresponding CSA C22.1 Canadian Electrical Code, Part 1 (CE Code) terms and ANCE terms are also provided for information in Figure 8.

5.3.202 Grounding of exposed metal parts

An enclosure shall have provision for permanent and effective grounding of exposed non-current-carrying metal parts. The means for grounding shall consist of a ground bus or ground stud with provisions for the mounting of pressure terminal connectors acceptable for use with conductors of the size indicated in Table 3. At all points of connection between the ground bus or the equipment grounding conductor and the assembly, any nonconductive coating, such as paint, shall be removed or penetrated to provide a good electrical connection. Bolts or screws engaging at least two full threads in the penetrated metal shall be considered to have provided adequate penetration.

There shall be provision for permanently and effectively grounding a metal plate that covers uninsulated live parts. All dead metal parts that are likely to be touched by persons and are likely to become energized shall be grounded.

If the above requirements cannot be visually verified, the grounding provisions shall be tested in accordance with Clause 6.205.

In Canada, provision for grounding and bonding shall also comply with Annex A, Item 13.

5.3.203 Ground bus

A ground bus shall be provided for all controllers having extendable power bus, and for all assemblies consisting of multiple vertical sections.

When a ground bus is provided, it shall be of equivalent cross-sectional area to the conductors shown in column 2 or 3 of Table 3. Splice bars shall be provided for field splicing sections as needed.

When a ground bus is not provided, at least two terminals shall be provided on the frame or enclosure:

a) for an equipment-grounding conductor of a size in accordance with Table 3 to ground the control center frame; and

b) for an equipment-grounding conductor to bond all outgoing conduits to the enclosure frame. The second connection shall accommodate an equipment-grounding conductor in accordance with Table 3 corresponding to the largest branch circuit.

5.3.204 Provision for ground termination

Controllers shall include one of the following provisions for the termination of the grounding conductor associated with each incoming or outgoing circuit, or provision for field installation of wire connectors suitable for that purpose:

a) for each circuit, a suitable stud or bolt mounted on the grounding bus or controller structure, together with a standard complement of hardware to secure a suitable wire connector (the connector need not be furnished);

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