CSA B44.1:19/ASME A17.5-2019
National Standard of Canada
American National Standard

Elevator and escalator electrical equipment

ASME
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REVISED APRIL 2019

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Revision History

CSA B44.1:19/ASME A17.5-2019, Elevator and escalator electrical equipment

Errata — April 2019
Outside back cover

Standards Update Service

CSA B44.1:19/ASME A17.5-2019
February 2019

Title: *Elevator and escalator electrical equipment*

To register for e-mail notification about any updates to this publication
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The **List ID** that you will need to register for updates to this publication is **2425951**.

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National Standard of Canada
American National Standard

CSA B44.1:19/ASME A17.5-2019
Elevator and escalator electrical equipment

Published in February 2019 by CSA Group
A not-for-profit private sector organization
178 Rexdale Boulevard, Toronto, Ontario, Canada M9W 1R3
1-800-463-6727 • 416-747-4044

Visit the CSA Group Online Store at store.csagroup.org

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The American Society of Mechanical Engineers (ASME)
Two Park Avenue
New York, NY 10016-5990 USA
www.asme.org

ISBN 978-0-7918-7307-6

This Standard is available for public review on a continuous basis. This provides an opportunity for additional public input from industry, academia, regulatory agencies, and the public at large.

Published in February 2019 by CSA Group
A not-for-profit private sector organization
178 Rexdale Boulevard
Toronto, Ontario, Canada M9W 1R3
www.csagroup.org

ICS 91.140.90
ISBN 978-1-4883-1263-2

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Preface

This is the sixth edition of CSA B44.1/ASME A17.5, *Elevator and escalator electrical equipment*. It supersedes the previous editions published in 2014, 2011, 2004, 1996, and 1991.

The purpose of this Standard is to reduce the risk of injury to persons and damage to property from fire and electrical shock. To this end, it is a safety Standard for the design and construction of equipment to be used in conformity with the rules of the applicable elevator and electrical codes (i.e., ASME A17.1/CSA B44 and CSA C22.1, *Canadian Electrical Code, Part I*, or ANSI/NFPA 70).

This Standard arose from the need to have identical Canadian and U.S. requirements for this equipment, thereby enabling manufacturers to have their products certified by an approved testing laboratory in Canada or the United States and to have the certification ratified for acceptance in either country.

In 1986, an ad hoc committee on the certification of electrical equipment consisting of jurisdictional authorities, representatives of Canadian and U.S. testing laboratories, and Canadian and U.S. manufacturers began to develop a draft for submission to the ASME A17 Standards Committee on Elevators and Escalators and the CSA Technical Committee on the Elevator Safety Code. Its initial investigation consisted of a review of the industrial control Standards CSA C22.2 No. 14 and UL 508. These Standards could not be used as such, due to the differences in the application of industrial control equipment and elevator equipment. It was recognized that industrial control equipment normally operates continuously for a low number of operations (about 3000/year) and at full-load current. In contrast, elevator control equipment operates intermittently for a high number of operations (about 500 000/year), and at up to 200 to 250% of full-load current in order to accelerate a mass. Further, elevator equipment is usually protected by either a locked machine room or a hoistway. The applicable portions of CSA C22.2 No. 14 and UL 508 were then reviewed and adapted to elevator equipment. (Grateful acknowledgement is made to Underwriters Laboratories Inc. for the use of UL 508.) Where there were differences between the UL and CSA Group Standards, the more stringent requirements were used.

This Standard has been approved by the CSA Technical Committee on the Elevator Safety Code and the ASME A17 Standards Committee on Elevators and Escalators. It is the intent of these committees to maintain a single harmonized Standard by coordinating their procedures for revising and interpreting this Standard. To this end, interpretations and revisions of this Standard will not be issued without the approval of both committees.

Changes to this edition include:

a) update to Clause 2.1, Reference publications;
b) update to Clause 2.2, Definitions;
c) update to Clause 6.4.2;
d) update to Clause 6.7;
e) update to Clause 7.1.1;
f) update to Clause 17.3;
g) update to Clauses 18.2 and 18.3;
h) addition of Clause 19.3.10, Verification of electronic motor overload protection test;
i) update to Clause 19.4.4.1;
j) addition of Clause 19.4.12, Electronic motor overload protection test;
k) addition of Clause 19.4.13, Short-circuit test;

l) update to Clause 19.6.1;
m) update to Clause 19.7.1;
n) update to Clause 20, Marking;
o) update to Table 12, Minimum conductor spacings (creepage and clearance) for printed circuit boards;
p) update to Table 17, Sequence of tests for solid-state ac motor controllers;
q) update to Table 18, Maximum permissible temperature rises;
r) update to Table 19, Sequence of tests for power-conversion equipment;
s) update to Annex B, CSA Group and ASME elevator and escalator publications; and
t) addition of Annex C, French marking translations.

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

This Standard was prepared by the CSA B44.1/ASME A17.5 Joint Committee on Elevator and Escalator Electrical Equipment, under the jurisdiction of the CSA Technical Committee on the Elevator Safety Code, the CSA Strategic Steering Committee on Mechanical Industrial Equipment Safety, and the ASME A17 Standards Committee on Elevators and Escalators, and has been formally approved by the CSA Technical Committee and the ASME A17 Standards Committee.

This Standard has been developed in compliance with Standards Council of Canada requirements for National Standards of Canada. It has been published as a National Standard of Canada by CSA Group.

This Standard was approved as an American National Standard by the American National Standards Institute (ANSI) on February 15, 2019.

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CSA B44.1:19/ASME A17.5-2019
Elevator and escalator electrical equipment

1 Scope

1.1

The requirements of this Standard apply to the following electrical equipment for elevators, escalators, moving walks, dumbwaiters, material lifts, and elevating devices for persons with physical disabilities (platform lifts and stairway chairlifts):

a) motor controllers;
b) motion controllers;
c) operation controllers;
d) operating devices; and
e) all other electrical equipment not listed/certified and labelled/marked according to another product safety standard or code.

The equipment specified in this Standard is intended for installation in accordance with the *Canadian Electrical Code, Part I* (CSA C22.1) and the *National Electrical Code* (ANSI/NFPA 70), whichever is applicable.

Note: *Controllers (i.e., motion, motor, and operation controllers) are defined in CSA B44 and ASME A17.1.*

1.2

The electrical equipment covered by this Standard is intended

a) to be connected to supply circuits at a nominal system voltage of 600 V or less;
b) for internal voltages that are not more than 1500 V;
c) for use in non-hazardous locations in accordance with the rules of the applicable electrical codes; and
d) for use in an ambient temperature no greater than 40 °C.

Note: *This Standard does not include requirements for equipment intended for use in an ambient temperature above 40 °C. Additional investigation of the equipment will be required when equipment is to be used in ambient temperature above 40 °C.*

1.3

The object of this Standard is to reduce the risk of injury to persons and damage to property from fire and electrical shock by presenting requirements for the proper design, the good construction, and the high quality of work of the equipment listed in Clause 1.1.

1.4

This Standard does not apply to devices that are rated for connection to extra-low-voltage Class 2 supply circuits as defined in the applicable electrical code.

Note: *Extra-low-voltage circuits are circuits that have a voltage of not more than 30 V rms or 42.4 V peak.*

1.5

In this Standard, "shall" is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; "should" is used to express a recommendation or that which is advised but not required; and "may" is used to express an option or that which is permissible within the limits of the standard.

Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material.

Notes to tables and figures are considered part of the table or figure and may be written as requirements.

Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

1.6

The values given in SI units are the units of record for the purposes of this Standard. The values given in parentheses are for information and comparison only.

2 Reference publications, definitions, and abbreviations

2.1 Reference publications

This Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below, including all amendments published thereto.

CSA Group

B355-09 (R2013)
Lifts for persons with physical disabilities

C22.1-12
Canadian Electrical Code, Part I

CAN/CSA-C22.2 No. 0-10 (R2015)
General requirements — Canadian Electrical Code, Part II

C22.2 No. 0.2-93 (R2013)
Insulation coordination

CAN/CSA-C22.2 No. 0.4-04 (R2013)
Bonding of electrical equipment

CAN/CSA-C22.2 No. 0.17-00 (R2013)
Evaluation of properties of polymeric materials

CAN/CSA-C22.2 No. 4-04 (R2009)
Enclosed and dead-front switches

C22.2 No. 5-13
Molded-case circuit breakers, molded-case switches and circuit-breaker enclosures

C22.2 No. 14-13
Industrial control equipment

C22.2 No. 66.3-06 (R2011)
Low voltage transformers — Part 3: Class 2 and Class 3 transformers

CAN/CSA-C22.2 No. 94.2-07 (R2012)
Enclosures for electrical equipment, environmental considerations

C22.2 No. 235-04 (R2013)
Supplementary protectors

C22.2 No. 60950-1-07 (R2016)
Information technology equipment — Safety — Part 1: General requirements
Note: *Binational standard, with ANSI/UL 60950-1.*

ASME (The American Society of Mechanical Engineers)/CSA Group
ASME A17.1-2016/CSA B44-16
Safety code for elevators and escalators

ANSI/ASME (American National Standards Institute/The American Society of Mechanical Engineers)
ANSI/ASME A18.1-2014
Safety Standard for Platform Lifts and Stairway Chairlifts

ANSI/IEEE (American National Standards Institute/Institute of Electrical and Electronics Engineers)
ANSI/IEEE 4-1995
Standard Techniques for High-Voltage Testing

ANSI/NFPA (American National Standards Institute/National Fire Protection Association)
ANSI/NFPA 70-2014
National Electrical Code

ANSI/UL (American National Standards Institute/Underwriters Laboratories Inc.)
50E (2007)
Enclosures for Electrical Equipment, Environmental Considerations

94 (2013)
Standard for Test for Flammability of Plastic Materials for Parts in Devices and Appliances

98 (2004)
Enclosed and Dead-Front Switches

489 (2013)
Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

840 (2005)
Standard for Safety for Insulation and Coordination Including Clearances and Creepage Distances for Electrical Equipment

5085-3 (2006)
Low Voltage Transformers — Part 3: Class 2 and Class 3 Transformers

60950-1 (2007)
Information Technology Equipment — Safety — Part 1: General Requirements

NEMA (National Electrical Manufacturers Association)

ICS 19-2002 (R2007)
Guide for Diagrams, Devices Designations, and Symbols for Industrial Controls and Systems

UL (Underwriters Laboratories Inc.)

508 (2013)
Standard for Industrial Control Equipment

746C (2004)
Standard for Polymeric Materials — Use in Electrical Equipment Evaluations

796 (2010)
Standard for Printed Wiring Boards

1077 (2005)
Supplementary Protectors for Use in Electrical Equipment

2.2 Definitions

The following definitions shall apply in this Standard:

bonding — a low impedance path obtained by permanently joining all non-current-carrying metal parts to ensure electrical continuity and having the capacity to conduct safely any current likely to be imposed on it.

clearance distance — the shortest distance in air between two conductive parts.

comparative tracking index (CTI) — a rating which provides an indication of the material's ability to withstand carbonization due to low level electrical current on the surface of the material.

conformal coating — a protective covering applied on a printed circuit board capable of conforming to the configuration of objects coated, used to increase the dielectric voltage-withstand capability between conductors and/or to protect against environmental conditions.

control circuit — a circuit that carries the electric signals directing the performance of a controller, but which does not carry the main power circuit.

controller — a device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected.

controller, motor, manual — a motor controller operated only by direct manual means.

controller, motor, solid-state — a motor controller designed to make and/or break the current in a motor circuit by means of the controlled conductivity of a semiconductor.

creepage distance — the shortest distance along the surface of a solid insulating material between two conductive parts.

enclosure — the outer cabinet that completely encloses live parts of an electrical apparatus to prevent personnel from accidentally contacting energized parts and to protect the equipment from physical damage.

enclosure, fire — a part of the equipment intended to minimize the spread of fire or flames from within.

enclosure environmental rating — an enclosure rating signifying compliance with defined environmental construction and performance requirements.

live parts — conductive components intended to be energized during operation.

motor circuit — the circuit that carries the main power for a motor.

motor control circuit — the control circuit associated with a motor controller.

opposite polarity — with respect to spacing and insulation requirements of this standard, a difference in potential between two points, such that shorting of these two points would result in a condition involving an over current; rupturing of printed wiring-board traces, components, or fuses; or similar results.

overcurrent — any current in excess of the rated current of equipment or the ampacity of a conductor resulting from abnormal conditions. It may result from overload, short circuit, or ground fault.

overcurrent device — a device capable of automatically opening an electric circuit, under both predetermined overload and short-circuit conditions, either by fusing of metal or by electromechanical means.

overcurrent protective device — see definition for **overcurrent device**.

overload — a condition that causes equipment or circuitry to exceed its effective-current (RMS) rating over its rated duty cycle. Overload currents flow within the complete intended path. Overload conditions may result from excessive mechanical or electrical loading.

overload relay — a device employed to protect motors from damage due to overheating caused by excessive current flow over a period of time by causing the motor controller to interrupt the motor current.

overvoltage category — a grouping of products based on typical installed location with respect to overvoltage protection and available energy.

pigtails — a length of wire, one end of which is pre-connected at the equipment manufacturer's location. The free end is intended for connection during final installation.

pilot duty — the rating assigned to a relay or switch that controls the coil of another relay, contactor, or other similar load.

power-conversion equipment — equipment that supplies power to control a motor(s) at a frequency or voltage which is different from the input supply.

primary battery — a battery which is the sole source of power for the circuit where the circuit does not include any recharging circuitry.

printed circuit board — a board produced from rigid or flexible industrial laminate material that provides point-to-point connections and/or printed components in a predetermined arrangement.

printed wiring board — see definition for **printed circuit board**.

protection, ground-fault — a means of detecting and interrupting a ground fault current at a level less than the current required to operate the circuit overcurrent device.

protection, overcurrent, branch circuit — a device capable of providing protection for service, feeder, branch circuits and equipment over the full range of overcurrents between its rated current and its interrupting rating.

protection, overcurrent, supplementary — a device intended to provide limited overcurrent protection for specific applications and utilization equipment. This limited protection is in addition to the protection provided in the required branch circuit by the branch-circuit overcurrent protective device.

protection, overload, motor — the protection required for motor circuits that will operate to prohibit excessive heating due to running overloads and failure to start.

protection, short-circuit, branch circuit — a device capable of providing short circuit protection for feeder and branch circuits and equipment, over the range of overcurrent above its rated overload current up to its rated interrupting current.

protective device — a device used to protect an electrical circuit from an abnormal condition.

short-circuit — unintended impedance placed directly across an electrical circuit to another element of the same circuit, to another circuit or to ground. Short-circuit currents do not flow within the complete intended path. Short-circuit conditions result from abnormal connections and do not include normal leakage currents.

transformer, class 2 — a transformer complying with ANSI/UL 5085-3 or CSA C22.2 No. 66.3.

transformer, isolating — a transformer having no electrical connection between the primary and secondary windings.

transient suppression device — a component or assembly of components that limits the transient voltage, such as a voltage clamping device, a transformer with isolated windings, or a suitably located damping impedance or a combination of these devices.

transient voltage not limited — a condition wherein an apparatus or circuit does not employ a component or assembly that limits the peak transient voltage.

transient voltages, known and controlled (transient voltage limited) — a condition wherein an apparatus or circuit employs a suitable component or assembly that limits the peak transient voltage to a specified value.

wire bending space — a space opposite field wiring terminals or any other space in which it is intended that field wiring may be bent or offset.

wire binding screw — a screw used to fasten an unprepared conductor that is looped around the shank of the screw and secured under the head of the screw or a prepared conductor that is assembled about the screw shank and retained by the head of the screw.

wiring, field — wiring terminated at the equipment in the final installation and that is subjected to the requirements for wiring as specified in the applicable installation code.

wiring, internal — wiring located within the equipment, installed under controlled conditions, at the equipment manufacturer's location.

wiring terminal — an assembly that establishes a connection of one or more conductors by means of mechanical pressure.

wiring terminal, field — a wiring terminal intended for field wiring connection.

2.3 Abbreviations

The following abbreviations shall apply in this Standard:

Abbreviation	Unit
A	ampere
ac	alternating current
AWG	American wire gauge
°C	degree Celsius
CTI	comparative tracking index
dc	direct current
deg	degree (angle)
°F	degree Fahrenheit
ft	foot
ft-lbf	foot pound force
h	hour
hp	horsepower
Hz	hertz
in	inch
J	joule
K	kelvin
kcmil	kilo circular mil
kg	kilogram
kV	kilovolt
kVA	kilovolt ampere
lb	pound (mass)
lbf	pound (force)
lbf-in	pound force inch
mm	millimetre

Abbreviation	Unit
µs	microsecond
N	newton (force)
Nm	newton metre (torque)
rms	root mean square
s	second
V	volt
VA	volt-ampere

3 Construction

3.1

Electrical components used in control equipment shall be suitable for the intended application and shall be either

a) certified to the requirements of the pertinent standards covering such components; or
b) specifically evaluated for the intended use.

3.2

Components for electronic circuits such as solid-state devices (SCRs, diodes, etc.), resistors, and capacitors for which there are no appropriate standards may be accepted as components based on examination (quality of work, electrical spacings, etc.) and testing.

3.3

Circuits incorporated in elevator equipment that are intended for direct connection to a hard-wired telecommunication network shall comply with the requirements of CAN/CSA-C22.2 No. 60950-1 and ANSI/UL 60950-1, Clause 6.

Note: *Examples of a telecommunication network are*

a) *a public switched telephone network;*
b) *a public data network;*
c) *an integrated services digital network (ISDN); and*
d) *a private network with electrical interface characteristics similar to the examples in Items a), b), and c).*

4 Enclosure construction

4.1 General

4.1.1

The enclosure of control equipment shall be constructed and assembled so that it will have the strength and rigidity necessary to resist the abuses to which it is likely to be subjected, without resulting in a hazard due to reduction of spacings, loosening or displacement of parts, or other serious defects.

4.1.2

An enclosure shall be constructed so as to reduce the risk of unintentional contact with enclosed electrical devices.

4.2 Thickness of cast-metal enclosures for live parts

4.2.1

A cast-metal enclosure shall be made of malleable iron, die-cast metal, or permanent mould cast aluminum, brass, bronze, or zinc.

4.2.2

Other than as permitted in Clause 4.2.3, cast-metal enclosures shall be

a) not less than 2.4 mm (0.094 in) thick for an area that is greater than 15 500 mm^2 (24 in^2) or that has a dimension greater than 150 mm (6 in);
b) not less than 1.6 mm (0.063 in) thick for an area that is 15 500 mm^2 (24 in^2) or less and that has no dimensions greater than 150 mm (6 in). The area limitation may be obtained by the provision of suitable reinforcing ribs subdividing a larger area; and
c) not less than 3.2 mm (0.125 in) at reinforcing ribs, door edges, and unthreaded conduit entries.

4.2.3

Thicknesses less than those required by Clause 4.2.2 shall be permitted if the enclosure complies with the following requirements:

a) the crushing resistance test of Clause 19.11 of this Standard;
b) the impact test of Clause 19.5 of this Standard, except that the energy required for the ball impact is 13.56 J (10.0 ft-lbf) for all sizes; and
c) the conduit connection tests of CSA C22.2 No. 14 or UL 508.

4.3 Thickness of sheet-metal enclosures for live parts

4.3.1

Except as specified in Clause 4.3.2, the thickness of sheet-metal enclosures shall be not less than that specified in Tables 1 and 2, except that at the points at which a wiring system will be connected, uncoated steel shall be at least 0.78 mm (0.032 in) thick, zinc-coated steel at least 0.88 mm (0.034 in) thick, and non-ferrous metal at least 1.16 mm (0.045 in) thick.

4.3.2

The thickness of sheet metal for enclosures at points other than those at which a wiring system will be connected need not comply with the thickness requirements of Clause 4.3.1 if the enclosure complies with the compression and deflection test requirements in Clauses 19.8 and 19.9.

Note: *Tables 1 and 2 are based on a uniform deflection of the enclosure surface for any given load concentrated at the centre of the surface, regardless of metal thickness.*

4.3.3

With reference to Tables 1 and 2, a supporting frame shall consist of a structure of angles, channels, or folded rigid sections of sheet metal. This structure shall be rigidly attached to and shall have essentially the same outside dimensions as the enclosure surface and sufficient torsional rigidity to resist the bending moments that may be applied by the enclosure surface when it is deflected. A structure that is

as rigid as one built with a frame of angles or channels is considered to have equivalent reinforcing. Constructions without a supporting frame shall be considered to include

a) a single sheet with single-formed flanges or formed edges;
b) a single sheet that is corrugated or ribbed;
c) an enclosure surface loosely attached to a frame (e.g., with spring clips); and
d) an enclosure surface having an unsupported edge.

5 Doors and covers

5.1

A part of the enclosure, such as a door or a cover, shall be provided with the means, such as latches or screws, to firmly secure it in place. Snap-on covers of 0.1 m^2 (155 in^2) or less shall be permitted for signal fixtures operating at 30 V rms, or 42 V peak, or less, provided they meet the test requirements of Clause 6.16 of CSA C22.2 No. 14 or Clause 9 of UL 508.

5.2

Barriers shall be installed to prevent contact with live parts if inadvertent contact with bare live parts during normal service and adjustment operation is considered probable.

Note: *Troubleshooting or the replacement of fuses is not considered a normal service adjustment operation with respect to control equipment, but the resetting of overload devices, adjustment of timers or switches, etc., are considered normal service operations.*

5.3

Equipment enclosures containing any portion of the motor controller, that have markings in accordance with Clause 20.23 are designed to be located outside machinery spaces, machine rooms, control spaces, or control rooms and shall comply with all the following:

a) access to the interior of the enclosure shall only be via door(s), or panel(s) that is (are) non-removable except with the use of tools or a key;
b) door(s) or panel(s) shall require a key to open;
c) door(s) or panel(s) shall remain mechanically attached to the enclosure when opened;
d) door(s) or panel(s) shall be self-locking, such that a key is required to reopen the door(s) or panel(s) after closing; and
e) door(s) or panel(s) shall not be self-closing.

Note: *The key is required to meet the security requirements of ASME A17.1/CSA B44.*

6 Polymeric enclosures

6.1

Polymeric enclosures shall comply with the conduit connection test of CSA C22.2 No. 14 or UL 508.

6.2

The thickness of a polymeric enclosure shall be such that the enclosure is sufficiently rigid to support the device and components that will be mounted on it.

6.3

6.3.1

Polymeric enclosure material shall be rated 5 VA (in accordance with CAN/CSA-C22.2 No. 0.17 or ANSI/UL 94) or the enclosures shall comply with the requirements of Clause 6.3.2 of this Standard after testing in accordance with Clause 6.3.3 or 6.3.4 of this Standard.

6.3.2

To fulfill the requirements of the tests specified in Clause 6.3.3 or 6.3.4

a) the enclosure material shall not continue to burn for more than 60 s after the fifth application of the test flame;
b) particles shall not drip from the test sample at any time during the test; and
c) the material shall not be destroyed in the area of the test flame to the extent that the integrity of the enclosure is affected as determined by Clauses 4.1, 4.2, and 7.1.

6.3.3

Enclosure material shall

a) fulfill the requirements of the 125 mm (5.0 in) flame test, "Flame Test B — Flame Test for Combustion-Resistant Materials", in Appendix D, Clause D.2, of CAN/CSA-C22.2 No. 0.17, except that the maximum burning time after each application shall be 60 s; and
b) not ignite within 15 s when subjected to the hot-wire ignition test of CAN/CSA-C22.2 No. 0.17 or ANSI/UL 94.

6.3.4

Enclosures shall be tested in accordance with the 125 mm (5.0 in) flame test, "Flame Test A — 125 mm Flame Test", in Clause D.1 of CAN/CSA-C22.2 No. 0.17 or the flame test for combustion-resistant materials in ANSI/UL 94.

6.4

6.4.1

Polymeric enclosure materials outside a protective or fire enclosure (decorative) shall be classified HB or better.

Note: *See CAN/CSA-C22.2 No. 0.17 or ANSI/UL 94 for identification of the material classifications.*

6.4.2

A non-metallic plug or other closure means assembled to a sheet-metal box as part of the enclosure shall be considered acceptable under any one of the following conditions:

a) The maximum area is 645 mm^2 (1.0 in^2) and the closure material is classified as V-0, V-1, or V-2.
b) The maximum area is 645 mm^2 (1.0 in^2), the closure material is classified as HB, and the closure complies with the flame test requirements in Clause 6.3.
c) The maximum area is 5800 mm^2 (9 in^2), the closure material is classified as V-0, V-1, V-2, or HB, and the closure material is used as a pilot light lens.
d) The area is more than 645 mm^2 (1.0 in^2), the closure material is classified as V-0, V-1, V-2, or HB, and the closure means complies with the flammability test of Clause 6.3 and impact test requirements in Clause 6.5.
e) The closure material is classified as V-0, V-1, V-2, or HB, and the closure material is used as a lens for a pilot light, lantern, position and/or direction indicator, operating devices, or other visual

signaling device where voltage to ground is limited to 30 V_{rms} or 42.4 V peak and the current is limited to 5 A maximum for voltages up to 20 V_{rms}, or (100/V) A maximum for voltages over 20 V_{rms} up to 30 V_{rms}.

Note: *See CAN/CSA-C22.2 No. 0.17 or ANSI/UL 94 for identification of the material classifications.*

6.5

Samples of equipment shall be subjected to the impact tests described in Clauses 19.5.1 and 19.5.2. The impact shall not

a) reduce spacings below the minimum acceptable values;
b) make any bare live parts or internal wiring accessible to contact;
c) have an undue adverse effect on the insulation; and
d) produce any other condition that can increase the risk of shock, fire, or damage to the equipment.

6.6

An enclosure employing insulating material, either wholly or in part, shall be provided with a suitable bonding means to ensure continuity of grounding between all conduit openings and any external metal parts that can become energized. The suitable bonding means shall be either completely fitted to the product or provided as separate parts for field installation. An enclosure designed for field assembly of the bonding means shall be provided with complete instructions to ensure proper installation. The instructions shall include the identification of the parts (see Clause 20.6) and their method of installation.

6.7

Notwithstanding Clause 6.6, bonding shall not be required for enclosures of end-of-line auxiliary devices where there are no exposed metal parts that can become energized and where, if necessary, the enclosures are marked to indicate that only one conduit is to be connected to the enclosure.

Note: *Examples of auxiliary devices include, but are not limited to, limit switches and push-button switches.*

6.8

A separate bonding conductor shall be copper, a copper alloy, or other material suitable for use as an electrical conductor. Ferrous metal parts in the grounding path shall be suitably protected against corrosion by enamelling, galvanizing, plating, or other equivalent means. A separate bonding conductor shall

a) be protected from mechanical damage or be located within the confines of the outer enclosure or frame; and
b) not be secured by a removable fastener used for any purpose other than bonding. The ends of the bonding conductor shall be in metal-to-metal contact with the parts to be bonded.

6.9

The size of a separate component bonding conductor shall be not less than that specified in Table 3 or the size of the conductor supplying the component, whichever is smaller. Notwithstanding this requirement, the bonding conductor may be of smaller size than that specified in Table 3 but not less than the size of the conductor supplying the component, provided that the bonding complies with the requirements of the applicable bonding and grounding standards.

7 Openings in enclosures

7.1 Requirements for all enclosures

7.1.1

To reduce the likelihood of unintentional contact involving a risk of electric shock from an uninsulated live part or film-coated wire, or a risk of injury to personnel from a moving part, an opening in an enclosure shall comply with either of the following:

a) for an opening that has a minor dimension (see Clause 7.1.4) less than 25.4 mm (1.0 in), such a part or wire shall not be contacted by the probe illustrated in Figure 1; or
b) for an opening that has a minor dimension of 25.4 mm (1.0 in) or more, such a part or wire shall be distanced from the opening as specified in Table 4.

7.1.2

The probe mentioned in Clause 7.1.1 and illustrated in Figure 1 shall be applied to any depth that the opening will permit. It shall be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the enclosure.

7.1.3

The probe mentioned in Clauses 7.1.1, 7.1.2, and 7.1.4 shall be used as the measuring instrument to judge the accessibility provided by an opening. The probe shall not be used as an instrument to judge the strength of a material. The probe shall be applied with a force sufficient to ensure full insertion but not greater than 11 N.

7.1.4

With reference to the requirements in Clause 7.1.1, the minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that can be inserted through the opening.

7.1.5

Other than as described in Clause 7.1.6, electrical equipment shall be so constructed that molten or flaming particles cannot fall to the surface on or over which the equipment is mounted.

7.1.6

Coverings may be omitted from the bottom of a floor-mounted enclosure that is marked in accordance with Clause 20.12 if

a) the enclosure extends to the floor, with live parts mounted in the enclosure in accordance with Table 5; or
b) the control equipment is rated 600 V or less, the equipment enclosure is not marked in accordance with Clause 20.23, the enclosure is within 152 mm (6.0 in) of the floor, and the bare live parts of the device are not less than 152 mm (6.0 in) above the lower edge of the enclosure.

7.1.7

The diameter of the wires of a screen shall be not less than 1.3 mm (0.051 in) if the screen openings are 320 mm^2 (0.5 in^2) or less in area, and shall be not less than 2.06 mm (0.0811 in) for larger screen openings.

7.1.8

Perforated sheet steel and sheet steel employed for expanded metal mesh shall be not less than 1.07 mm (0.042 in) thick for mesh openings or perforations 320 mm² (0.5 in²) or less in area, and shall be not less than 2.03 mm (0.080 in) thick for larger openings. In a small device, where the indentation of a guard enclosure will not alter the clearance between uninsulated, movable, live parts and grounded metal so as to adversely affect the performance or reduce spacings below the minimum values specified in Table 5, expanded metal mesh not less than 0.51 mm (0.020 in) thick may be employed, provided that

a) the exposed mesh on any one side or surface of the device has an area of not more than 46 500 mm² (72 in²) and has no dimension greater than 305 mm (12 in); or
b) the width of an opening is not greater than 88 mm (3.5 in).

7.1.9

Glass covering an observation opening and forming a part of the enclosure shall be reliably secured in such a manner that it cannot be readily displaced in service and it provides mechanical protection for the enclosed parts. Glass covering an opening not more than 100 mm (4 in) in any dimension shall be not less than 1.4 mm (0.055 in) thick, and glass covering an opening having no dimension greater than 305 mm (12 in) shall be not less than 2.92 mm (0.115 in) thick. Glass used to cover larger openings shall be of the clear safety type or wire-reinforced type.

7.2 Requirements for equipment enclosures marked in accordance with Clause 20.23

Equipment enclosures containing any portion of the motor controller that have markings in accordance with Clause 20.23 designed to be located outside machinery spaces, machine rooms, control spaces, or control rooms shall comply with the following:

a) there shall be no opening accessible to the public after installation;
b) Clause 7.1.6 shall not apply; and
c) in addition to the requirements in Clause 7.1.9, all glass covering an observation opening or forming a part of an enclosure shall be of the clear safety type or the wire-reinforced type.

8 Wire-bending space

8.1

The wire-bending space at a field wiring terminal shall be measured from the centre of the conductor opening on the face of the wire connector to the enclosure wall opposite the terminal, in the line in which the wire leaves the connector when the connector is at the smallest angle to the perpendicular of the enclosure wall that it can assume without defeating any reliable means provided to prevent it from turning. A connector shall not be directed toward a corner or a recess in an enclosure to obtain the required bending space. The wire-bending space shall be as specified in Table 6.

8.2

If a wire is restricted by a barrier or obstruction from being bent in a single 90° or S bend between the terminal and any permitted enclosure entrance point, the wire-bending space shall be measured from the end of the barrier or obstruction to the wall towards which the wire is directed, in a line perpendicular to the wall.

8.3
A barrier, shoulder, or the like shall be disregarded when the measurement is being made if it does not reduce the radius to which the wire must be bent.

8.4
The wire size used to determine the wire-bending space shall be determined as described in CSA C22.2 No. 14 or UL 508.

9 Enclosures with environmental ratings
Enclosures with an environmental rating shall comply with the requirements of CAN/CSA-C22.2 No. 94.2 or ANSI/UL 50E.

10 Protection against corrosion
Ferrous metals shall be suitably protected against corrosion as required by CAN/CSA-C22.2 No. 0 or UL 508.

11 Insulating material

11.1
Material for the support of an uninsulated live part shall be porcelain, phenolic, cold-moulded composition, unfilled nylon, melamine, melamine-phenolic, urea formaldehyde, or other material found acceptable for the support of an uninsulated live part.

These materials shall withstand the most severe conditions likely to be met in service.

11.2
The insulation material shall be classified as V-0, V-1, V-2, or HB.

Note: *See CAN/CSA-C22.2 No. 0.17 or ANSI/UL 94 for identification of the material classifications.*

11.3
Insulating material, including barriers between parts of opposite polarity and material that can be subject to the influence of the arc formed by the opening of a switch, shall be suitable for the particular application. Materials shall not be adversely affected by the overload and endurance tests.

11.4
A printed circuit board and any coating material that is provided shall not increase the flammability of the assembly.

12 Protective devices

12.1 Overcurrent protection
Protective devices shall be provided for motor branch circuit overcurrent protection, ground-fault protection, and motor running overload protection where required by the applicable electrical code.

12.2 Number, arrangement, and ratings or settings of protective devices

12.2.1
The number, arrangement, and ratings or settings of protective devices used in control equipment shall be in accordance with the requirements of the applicable electrical code.

12.2.2
If a controller has a short circuit rating of greater than 10 000 A, all branch circuit fuseholders shall be provided with rejection features to prohibit the use of Class H fuses.

12.3 Supplementary overcurrent protection
Supplementary overcurrent protection shall not be used as a substitute for required branch circuit overcurrent devices or in place of required branch circuit protection.

12.4 Disconnecting means

12.4.1
When provided as part of the controller, a disconnecting means shall comply with Clauses 12.4.2 through 12.4.9.

12.4.2
A single throw knife switch shall be mounted so that gravity will not tend to close it.

12.4.3
A single throw knife switch shall be connected so that the blades will be de-energized when the switch is open unless the switch is designed so that all live parts are protected against unintentional contact when the switch is in the open position and the controller enclosure door or cover is open.

12.4.4
A disconnecting means provided as a branch circuit disconnect, a local controller disconnect or a motor disconnect shall be operable from outside the controller enclosure and shall be capable of being locked in the open position, independent of the controller door position. The provision for locking or adding a lock to the disconnecting means shall be installed on or at the switch or circuit breaker used as the disconnecting means and shall remain in place with or without the lock installed. Portable means for adding a lock to the switch or circuit breaker shall not be permitted as the means required to be installed at and remain with the equipment.

12.4.5
If an interlock is provided between the door or cover and a switching mechanism of a disconnecting means, provision for circumventing the interlock for inspection purposes while the switch is in the ON position shall be permitted.

12.4.6
Handle positions shall be marked as specified in Clause 20.7.

12.4.7

A disconnecting means shall open all ungrounded conductors of the source that it disconnects. One pole shall be permitted to disconnect a permanently grounded conductor, provided that the disconnecting means is designed so that the pole in the grounded conductor cannot be opened without disconnecting all conductors of the circuit in the same operation.

12.4.8

If a controller includes a manual motor controller that can be locked or sealed in the open position, this manual motor controller shall be tested, approved and marked as "Suitable For Motor Disconnect". When this device is provided, the locking means shall meet the requirements of Clause 12.4.4.

Notes:

1) *A manual motor controller is a horsepower rated switching device, with an operating mechanism, such as a pushbutton or operating handle, that is intended to be operated manually to open or close the contacts to control a motor.*
2) *Unless specifically tested, approved and marked as "Suitable for Motor Disconnect", a manual motor controller has not been investigated for use as a disconnecting means to isolate the load from the line. The presence of a locking or sealing means could improperly imply that the manual controller is suitable for isolation or other lockout/tagout purposes.*

12.4.9

12.4.9.1

When provided as part of the controller, a disconnecting means supplied to comply with CSA C22.1, Rule 38-051, or ANSI/NFPA 70, Section 620.51 shall comply with Clauses 12.4.9.2 through 12.4.9.8.

12.4.9.2

A disconnecting means shall be a fusible switch complying with the requirements of CAN/CSA-C22.2 No. 4 or ANSI/UL 98, or a circuit breaker or molded case switch complying with the requirements of CSA C22.2 No. 5 or ANSI/UL 489.

12.4.9.3

The disconnecting means shall be operable from outside the controller enclosure and shall be capable of being locked in the open position, independent of the controller door position. The provision for locking or adding a lock to the disconnecting means shall be installed on or at the switch or circuit breaker used as the disconnecting means and shall remain in place with or without the lock installed. Portable means for adding a lock to the switch or circuit breaker shall not be permitted as the means required to be installed at and remain with the equipment.

12.4.9.4

The disconnecting means shall open all ungrounded main power supply conductors for

a) the drive motor and its ventilation and control circuits; and
b) control valve operating magnets.

The disconnecting means shall be designed so that no pole will be independently operated under normal service conditions.

12.4.9.5
Where motor branch circuit short-circuit and ground-fault protection is provided as part of the disconnecting means, the entire assembly shall be separately enclosed within the controller enclosure, or the assembly shall be located in a separate compartment.

12.4.9.6
Uninsulated parts that remain energized with the disconnecting means in the open position shall be protected against unintentional contact when the enclosure door or cover is open.

12.4.9.7
Where multiple drive machines are connected to a single elevator, escalator, moving walk or pumping unit, there shall be one disconnecting means that disconnects
a) all the drive motors, their ventilation and control circuits; and
b) all the control valve operating magnets.

The disconnecting means shall be designed so that no pole will be independently operated under normal service conditions.

12.4.9.8

12.4.9.8.1
The disconnecting means shall disconnect the elevator from both the emergency or standby power system and the normal power system.

Where an additional power source that allows movement of the car is connected to the load side of the disconnecting means, the disconnecting means shall be provided with an auxiliary contact. The auxiliary contact shall meet the requirements of Clause 12.4.9.8.2.

12.4.9.8.2
An auxiliary contact for the disconnecting means shall be positively opened mechanically, and the opening shall not be solely dependent on springs.

12.5 Power from more than one source
Where a controller includes a disconnecting means and parts of the controller remain energized from a source other than the one disconnected, a marking shall be provided in accordance with Clause 20.24.

13 Protection of control circuits

13.1 Control circuit conductor protection
Conductors of control circuits that are connected to the load side of the motor branch circuit short-circuit protective device (common control) and that extend beyond the control equipment enclosure shall be protected against overcurrent, in accordance with their ampacities, by protective devices located within the controller; otherwise, the controller shall be marked in accordance with Clause 20.20. Additional protection or additional marking shall not be required if the rating or setting of the intended motor branch circuit short-circuit protective device is not more than 300% of the ampacity (15 A minimum) of the control circuit conductors.

13.2 Control circuit transformer protection

13.2.1

A control circuit transformer shall be provided with one or more of the following types of overcurrent protection:

a) individual overcurrent devices located in the primary circuit that are rated or set as specified in Table 7;
b) secondary circuit protection rated or set at not more than 125% of the rated secondary current of the transformer, with the protection of the primary feeder circuit rated or set at not more than 250% of the rated primary current of the transformer; or
c) coordinated thermal overload protection arranged to interrupt the primary circuit, provided that the primary circuit overcurrent device is rated or set at a current of not more than
   i) six times the rated current of the transformer for transformers having not more than 6% impedance; or
   ii) four times the rated current of the transformer for transformers having more than 6% but less than 10% impedance.

13.2.2

Notwithstanding Clause 13.2.1, overcurrent protection need not be provided if the

a) transformer supplies a Class 2 circuit;
b) transformer is rated less than 50 VA and is an integral part of the motor controller, and there is no fire hazard (emission of flame or molten material) with a short-circuit on the secondary;
c) primary feeder circuit overcurrent device provides the required protection; or
d) protection is provided by other means that comply with the applicable electrical code.

13.2.3

Notwithstanding Clause 13.2.1 b), if the rated secondary current of the transformer is 2 A or more, the current rating of the secondary overcurrent device may be as indicated in line 2 or 3 of Table 7, as applicable.

13.2.4

If the rated primary current of the transformer is 9 A or more and 125% of this current does not correspond to a standard rating of a fuse or non-adjustable circuit breaker, the next higher standard rating of protective device shall be used.

13.2.5

A control transformer and its primary and secondary conductors may be protected by overcurrent devices located in the primary circuit, provided that the

a) transformer is single-phase and has only a two-wire (single voltage) secondary;
b) maximum value of an intended overcurrent device is determined in accordance with Clause 13.2.1; and
c) maximum value of an intended overcurrent device as determined in Item b) does not exceed the value of the overcurrent device obtained from Table 7 for the secondary conductor multiplied by the secondary-to-primary voltage ratio of the transformer.

13.2.6

A supplementary protector complying with Clause 13.3 h) is permitted to be used as the primary circuit protector for transformers supplying power only for control circuits, as required by Clause 13.2.1.

13.3 Use of supplementary protectors in control circuits

Supplementary protectors shall be permitted to be used in the protection of control circuits if

a) they are suitable for general industrial use as determined by Table 1 of CSA C22.2 No. 235 or as indicated by Use Group (UG) A of UL 1077;
b) they are a type suitable for the function intended (i.e., under-voltage trip, over-voltage trip, overload trip etc.);
c) their short-circuit rating is adequate for the circuit in which they are used;

Note: *That is, a 2 kA minimum for a control circuit with an external source or when supplied by an internal single-phase control transformer as determined by the following formula:*
(transformer VA rating)/(Vs × z)
where
Vs = the secondary voltage of the transformer, V
z = the impedance of the transformer, %

d) the contact rating is suitable to interrupt rated overload currents, as specified by the assigned OL codes and voltage ratings. See Table A.3 of Annex A for an explanation of OL code applications;
e) the supplementary protector has a short-circuit application code of U3, U1a, or C1a. See Table A.1 of Annex A for an explanation of U and C code applications;
f) the line side overcurrent protection is provided in accordance with the manufacturer's literature when the supplementary protector has a short-circuit rating code of C1a;
g) the appropriate level of protection is provided, where the supplementary protector is intended to protect a component or circuit from overheating due to overload. See Table A.2 of Annex A for an explanation of TC code applications; and
h) a supplementary protector used as the primary protection of a control transformer has a short-circuit current rating (SC) of U3, TC3, OL1.

Note: *Power transformers are required to be protected in accordance with the local electrical codes. See CSA C22.1 or ANSI/NFPA 70 for definition of "control circuit".*

14 Internal wiring

14.1

Insulated conductors shall be types suitable for the service intended with respect to voltage, temperature, and grouping. Conductors shall be not smaller than No. 24 AWG, and the temperature rating shall be not less than 90 °C unless investigation proves the suitability of other conductors.

Notes:

1) *The requirements of this Clause apply only to the wiring furnished on or in control equipment. They do not apply to the supply wiring that is run to control equipment, to motors, or to other apparatus.*
2) *For motor and control circuit applications, the use of Tables 8 and 9 as a guide in selecting conductor sizes for control equipment can obviate the need to perform a temperature test on the wire. Conductor sizes for other applications (e.g., heating loads) are subject to investigation.*

14.2

Notwithstanding Clause 14.1, conductors smaller than No. 24 AWG may be used for wiring of printed circuit boards and interconnecting wiring between electronic modules and sub-assemblies.

14.3

Conductors in an assembly intended for use in a complete enclosure shall be insulated for the highest voltage normally occurring between such conductors unless

a) the wires are grouped so as to segregate the several voltages; or

b) the circuits involving the wires rated at the lower voltage(s) do not extend beyond the complete enclosure.

14.4

Wires shall be supported or secured or otherwise run in suitable raceways so that they will not come into contact with moving parts or rest on sharp edges or projections that can cause abrasion of the insulation. Wires shall be of flexible or extra-flexible construction where they make connections to electrical equipment mounted on a hinged door. If the flexing section of the wiring is liable to come into contact with grounded metal parts, that portion of the wiring shall be given additional protection by wrapping of tape or the equivalent or by enclosure in non-metallic flexible tubing or conduit.

14.5

Internal wiring shall not be in contact with bare live parts of opposite polarity or with bare live parts of other circuits.

14.6

A bare conductor, including pigtails and coil leads, if it is not covered by acceptable insulating sleeving or tubing, shall be supported so that the spacings required elsewhere in this Standard will be maintained.

15 Wiring terminals and leads

15.1

Control equipment shall be provided with wiring terminals or leads for connection of conductors having an ampacity not less than the largest of the following:

a) the ampere rating of the equipment;
b) 125% of the full-load motor current specified in Table 10 or 11 for the horsepower rating or, in the case of power-conversion equipment in which the input current is different from motor full-load current, 125% of maximum rated input current;
c) 125% of the resistive ampere rating of the devices intended to control fixed electric space-heating equipment loads; and
d) for equipment controlling a direct-current motor intended to be operated from a rectified single-phase power supply
   i) 190% of full-load current if a half-wave rectifier is used; or
   ii) 150% of full-load current if a full-wave rectifier is used.

Note: *Item d) does not apply if the product is marked in accordance with Clause 20.19.*

15.2

A device having a current rating or an hp rating with a full-load motor-running current as specified in Table 10 or 11 shall be provided with wiring terminals or leads for connections to wire of a size determined in accordance with the applicable electrical code. The size shall be based upon a wire suitable for a temperature of 60 °C for a rating of 100 A or less, and upon a wire suitable for 75 °C for a rating greater than 100 A. The type of insulation is not specified.

Note: *Higher-temperature-rated field-installed conductors are permitted provided that the higher-rated conductors have a cross-sectional area no smaller than the cross-sectional area that would be required if 60 °C or 75 °C conductors were used. See Clause 20.2 a) v).*

15.3
A lead that is intended to be spliced to a circuit conductor in the field shall be not smaller than No. 24 AWG, and the insulation, if of rubber or thermoplastic, shall be not less than 0.8 mm (0.031 in) thick.

15.4
Terminal parts for field wiring connections shall conform to the requirements of CAN/CSA-C22.2 No. 0 or UL 508, except that for a No. 10 AWG or smaller conductor, the terminal to which wiring connections are made may consist of clamps or binding screws, and a terminal plate with upturned lugs or the equivalent to hold the wires in position.

15.5
A wire-binding screw to which field wiring connections are made shall be not smaller than No. 8, except that a No. 5 screw may be used at a terminal intended only for connection of a No. 14 AWG or smaller conductor and a No. 6 screw may be used at a terminal intended only for connection of a No. 12 AWG or smaller conductor.

15.6
A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.76 mm (0.030 in) thick for a No. 14 AWG or smaller wire, and not less than 1.27 mm (0.050 in) thick for a wire larger than No. 14 AWG. There shall be not fewer than two full threads in the plate. Two full threads shall not be required if fewer threads result in a secure connection in which the threads will not strip upon application of a 2.3 Nm (20 lbf-in) tightening torque.

15.7
A terminal plate formed from stock having the minimum required thickness specified in Clause 15.6 may have the metal extruded at the tapped hole for the binding screw to provide two full threads.

15.8

15.8.1
Control equipment intended for cord connection to the power supply shall be provided with a suitable length, size, and type of hard-usage cord (see CSA C22.1), junior hard service cord (see ANSI/NFPA 70), extra-hard-usage cord (see CSA C22.1), hard service cord (see ANSI/NFPA 70), or the equivalent permitted by the applicable elevator or electrical code, which shall terminate in an appropriate attachment plug.

15.8.2
Strain relief shall be provided so that a mechanical stress on the cord will not be transmitted to terminals, splices, or internal wiring. At the point at which the cord passes through the enclosure wall, protection shall be provided to prevent cord abrasion. The equipment shall withstand damage to the cord or conductors and shall withstand, without displacement, the test specified in Clause 19.10.

16 Electrical spacings

16.1

Except as required by Clause 16.2 or as permitted by Clause 16.27, electrical spacings in control equipment shall be not less than those specified in Table 5. On printed circuit boards, the spacings of Table 12 may apply.

16.2

The electrical spacings in control equipment in which transient voltages are known and controlled by a suitable transient suppression device shall be not less than those specified in Table 13, except the spacings at a field wiring terminal shall be in accordance with Table 5 and Clause 16.12.

Surge suppressors of the metal oxide varistor type shall not be permitted as overvoltage protection for the purpose of the reduction of electrical spacing in equipment and circuits that operate in the primary circuit.

16.3

The transient suppression device specified in Clause 16.2 shall prevent peak transient voltages from exceeding 300% of the instantaneous peak working voltage or 300 V, whichever is greater. See Clause 19.7.

16.4

With reference to the requirements in Clauses 16.2 and 16.3, control equipment shall have provision for the maintenance of clean, dry electrical surfaces, such as a suitable conformal coating on a printed circuit board, or shall have other means of protecting equipment from atmospheres containing dust.

16.5

The spacing at a field wiring terminal shall be measured with wire connected to the terminal as in service. The connected wire for a programmable controller shall be the size that is normally required for the equipment rating. The connected wire for all devices other than a programmable controller shall be the next larger size than that normally required for the equipment rating if the terminal will accommodate it or if the equipment is not marked to restrict its use.

16.6

The spacings specified in Group B of Table 5 shall apply to

a) devices rated 1 hp or equivalent FLA or less, 720 VA or less (break pilot duty), or not more than 15 A at 51 to 150 V, 10 A at 151 to 300 V, or 5 A at 301 to 600 V, or any combination thereof;
b) the same devices as described in Item a) when multi-pole and controlling more than one load, provided that the total load connected to the line at one time does not exceed 2 hp, 1440 VA, or have a current rating greater than 30 A at 51 to 150 V, 20 A at 151 to 300 V, or 10 A at 301 to 600 V, and provided also that the loading on any one pole does not exceed its marked rating; and
c) manual motor controllers rated 1 hp and less.

16.7

The spacings in Group C of Table 5 apply to devices rated at 300 V or less and 1 hp or less or 2000 VA or less per pole.

Note: *A switching device may also have a supplementary current rating (per pole) of 15 A or less at 51 to 150 V or 10 A at 151 to 300 V, or both.*

16.8

The spacings of Group C of Table 5 shall also apply to magnetically operated switches that are not rated in horsepower and that have current ratings per pole not greater than 15 A at 51 to 150 V or 10 A at 151 to 300 V, or both.

16.9

Spacings between traces of different potentials on a printed circuit board are not required to comply with Table 12 when all of the following conditions are met:

a) The spacings are used in a circuit where power is limited by a transformer, rectifier, voltage divider, or similar device that derives power from a primary circuit, and where the short-circuit limit between conductors of the secondary circuit or between conductors and ground is 1500 VA or less.
Note: *The short-circuit volt ampere limit is the product of the open-circuit volts and the short-circuit amperes, and these are rms values in an ac circuit.*
b) The spacings are not used for circuits containing electrical protective devices as defined in ASME A17.1/CSA B44, ASME A18.1, and CSA B355.
c) The printed circuit board has a flammability rating of V-0.
d) The printed circuit board base material has a minimum comparative tracking index (CTI) of 100 V.
e) The traces do not involve separate isolated circuits.
f) The equipment complies with the “Printed Wiring Board Abnormal Operation Test” specified in CSA C22.2 No. 14 or UL 508.

16.10

A motor controller rated more than 1 hp at 151 to 300 V and complying with the spacings specified in Group A of Table 5 for such rating may have an additional rating of 1 hp or less at 301 to 600 V. See also Clause 16.6 for multi-pole devices.

16.11

A motor controller rated more than 1 hp at 51 to 150 V and complying with the spacings specified in Group A of Table 5 for such rating may have an additional rating of 1 hp or less at 151 to 300 V. See also Clause 16.6 for multi-pole devices.

16.12

In a circuit involving voltages of 50 V or less, other than as noted in Clause 16.14, spacings at field wiring terminals may be 3.2 mm (0.125 in) through air and 6.3 mm (0.248 in) over surface; spacings elsewhere may be 1.6 mm (0.063 in) through air or over surface, provided that the insulation and clearances between such circuits and any circuits of more than 50 V are in accordance with the requirements for the higher voltage circuit. Spacings are not specified for a circuit involving a voltage of not more than 30 V and supplied by

a) a primary battery;
b) a standard Class 2 transformer; or
c) a suitable combination of transformer and fixed impedance having output characteristics in compliance with those required for a Class 2 transformer.

16.13

For a pilot light consisting of a lampholder in series with a dropping resistor or connected to an autotransformer, the spacings shall be

a) not less than 1.2 mm (0.047 in) between bare live parts of opposite polarity at or within a lampholder (an inherent lampholder spacing) rated 250 V or less and not less than 3.2 mm (0.125 in) for a lampholder rated more than 250 V;
b) not less than those specified in Table 5 or in Clause 16.12 between uninsulated live parts of opposite polarity (other than at or within the lampholder), based on the normal operating voltage existing between such parts; and
c) not less than those specified in Table 5 between bare live parts and grounded parts, exposed non-current-carrying metal parts, or the enclosure, based on the line voltage of the pilot light circuit.

16.14

In a series circuit, the spacings between resistor terminals, transformer taps, and the like shall be based on the normal operating voltage existing between such parts.

16.15

In a push-button switch, selector switch, limit switch, or the like, opposite polarity shall not be considered to exist on any one pole, including switches with double-throw arrangements, but opposite polarity shall be considered to exist between poles and between live parts on adjacent units unless the parts in question are connected to the same line terminal or conductor or marked to indicate the same polarity.

16.16

The spacings at fuses and fuseholders, measured with the fuses in place, shall be determined using fuses that have the maximum standard dimensions, and the spacings shall be not less than those specified in Group A of Table 5.

16.17

A ceramic, vitreous-enamel, or similar coating shall not be acceptable as insulation in place of spacings unless, upon investigation, the coating is found to be uniform, reliable, and otherwise suitable for the purpose.

16.18

If contact arms, blades, etc., in a motor controller remain connected to the motor load terminals when in the OFF position, the spacing from such parts in the OFF position to the enclosure or to exposed non-current-carrying metal parts that are isolated and/or insulated shall be not less than 3.2 mm (0.125 in) plus the spacings required otherwise.

16.19

Enamelled or similar film-coated wire shall be considered to be a bare live part when determining compliance with the spacing requirements in this Standard.

16.20

An insulating barrier or liner used as the sole separation between a bare live part and a grounded non-current-carrying metal part, including the enclosure, or between bare live parts of opposite polarity shall be of a material that is suitable for the mounting of bare live parts and shall be not less than 0.71 mm (0.028 in) thick. Fibre less than 0.71 mm (0.028 in) thick may be used as the sole separation

between the enclosure and an uninsulated metal part electrically connected to a grounded circuit conductor.

16.21

An insulating barrier or liner that is used in addition to an air space in place of the required spacing through air shall be not less than 0.71 mm (0.028 in) thick.

If the barrier or liner is of fibre, the air space shall be not less than 0.8 mm (0.031 in). If the barrier or liner is of other material that is not suitable for the support of bare live parts, an acceptable air space shall be provided for the application.

A barrier or liner that is used in conjunction with an air space that is not less than 1/2 of the required spacing through air may be less than 0.71 mm (0.028 in) thick but not less than 0.33 mm (0.013 in) thick if the barrier or liner

a) is of a material that is suitable for the mounting of bare live parts;
b) has the necessary mechanical strength if exposed or otherwise likely to be subjected to mechanical abuse;
c) is reliably held in place; and
d) is located so that it will not be adversely affected by operation of the equipment in service.

16.22

Insulating material having a thickness less than that specified in Clauses 16.20 and 16.21 may be used if, upon investigation, it is found to be suitable for the particular application.

16.23

Gaskets or seals, if used to obtain the required spacings, shall be subject to investigation to determine their effectiveness in service. They shall be mounted so that they are not liable to be readily damaged and shall be securely held in position.

16.24

For an enclosure not provided with conduit openings or knockouts, spacings of not less than the minimum specified in Clause 16.1 shall be provided between bare live parts and a conduit bushing installed at any location likely to be used during installation. Permanent marking on the enclosure, a template, or a full-scale drawing furnished with the device may be used to limit such locations.

16.25

When measuring a spacing between a bare live part and a bushing installed in the knockout, it shall be assumed that the bushing has the dimensions specified in Table 14 and there is a single locknut installed on the outside of the enclosure.

16.26

16.26.1

Except as required in Clause 16.26.2, the spacings in a component device, such as a snap switch, lampholder, etc., supplied as part of control equipment, other than in a motor circuit or motor control circuit, shall be not less than the minimum spacings required for the component device or the spacings specified in Table 5, whichever are smaller.

16.26.2
Fuseholders shall meet the spacing requirements in Table 5.

16.27

16.27.1
As an alternative to the spacing requirements specified in Clauses 16.1 to 16.26 of this Standard, clearances and creepage distances shall be permitted to be evaluated in accordance with the requirements in CSA C22.2 No. 0.2 or ANSI/UL 840 that are described in Clause 16.27.4 of this Standard.

16.27.2
The clearance between an uninsulated live part and the wall of a metal enclosure, including fittings for conduit or armoured cable, shall be as specified in Table 5.

16.27.3
The clearance and creepage distance at field wiring terminals shall be in accordance with the requirements in Clauses 16.5 to 16.8 and Table 5.

16.27.4
In conducting evaluations in accordance with the requirements in CSA C22.2 No. 0.2 or ANSI/UL 840, the following guidelines shall be used:

a) Unless specified elsewhere in this Standard, the pollution degree shall be considered to be pollution degree 3.
b) Equipment that operates in the direct line of the source of power to the load equipment shall be considered to be Overvoltage Category II.
c) Pollution degree 2 may be considered to exist on a printed circuit board between adjacent conductive material covered by any coating that provides an uninterrupted covering over at least one side and the complete distance up to the other side of conductive material.
d) Any printed circuit board that complies with the requirements in UL 796 shall be considered to provide a minimum comparative tracking index (CTI) of 100. The materials listed in Clause 11.1 of this Standard or any material that complies with the requirements of Section 22 of UL 796 shall be considered to provide a minimum CTI of 175.
e) In order to fulfill the requirements for coatings of printed circuit boards used to achieve pollution degree 1 in accordance with CSA C22.2 No. 0.2 or ANSI/UL 840, a coating shall comply with the requirements of Section 47 of UL 746C.
f) Pollution degree 1 may also be achieved at a specific printed circuit board location by application of at least a 0.79 mm (0.031 in) thick layer of silicone rubber or by potting, without air bubbles, in epoxy or potting material.
g) The evaluation of clearances to determine equivalence with through-air spacing requirements may be conducted in accordance with Clause 4.1 of CSA C22.2 No. 0.2 or ANSI/UL 840, Paragraph 4, regarding Clearance A (Equivalency).
h) The evaluation of clearances and creepage distances shall be conducted in accordance with the requirements in Clauses 4.2 and 4.2 of CSA C22.2 No. 0.2 or Paragraph 5 and requirements on creepage distance in ANSI/UL 840.
i) The phase-to-ground rated system voltage used in the determination of clearances shall be the equipment-rated supply voltage rounded to the next higher value (see Table 2 of CSA C22.2 No. 0.2 or Table 5.1 in ANSI/UL 840) for all points on the supply side of an isolating transformer or all points on the entire product if no isolating transformer is provided. The system voltage used in the

evaluation of secondary circuitry may be interpolated with interpolation continued across the table for the rated impulse withstand voltage peak and clearance.

j) Determination of the dimensions of clearance and creepage distances shall be conducted in accordance with the requirements of CSA C22.2 No. 0.2 or ANSI/UL 840.

17 Grounding

17.1

Control equipment shall comply with CAN/CSA-C22.2 No. 0.4 or UL 508.

17.2

Provision for bonding and grounding of control equipment shall be provided by terminations in enclosures in accordance with Clause 17.3.

17.3

Grounding terminations shall be provided for at least the following number of grounding conductors:

a) in power device enclosures, one grounding conductor for each incoming and each outgoing power circuit based on one circuit for three poles or less and one circuit for each additional three poles or less, plus one grounding conductor for the control circuit where applicable;

b) in cast enclosures for power devices that have provision for only one conduit entry, one grounding conductor; and

c) in auxiliary device enclosures, one grounding conductor.

Note: *Examples of auxiliary devices include, but are not limited to, limit switches and push-button switches.*

17.4

The maximum number of conductors on each termination shall be in accordance with Table 15.

17.5

For determining the suitability of the grounding termination, the grounding conductor size shall be

a) No. 14 AWG copper or No. 12 AWG aluminum for control circuits and auxiliary devices; or

b) selected from Table 16 for power circuits and devices.

17.6

Means shall be provided to facilitate grounding of the secondaries of control circuit transformers.

18 Printed circuit boards

18.1

Printed circuit boards shall comply with applicable printed circuit board requirements and shall be classed V-0, V-1, and V-2.

Note: *See CAN/CSA-C22.2 No. 0.17 or ANSI/UL 94 for identification of the material classifications.*

18.2

Notwithstanding Clause 18.1, a printed circuit board powered from an isolated secondary circuit of a Class 2 transformer or in an isolated secondary circuit of a transformer operating at not more than

30 V_{rms} or 42.4 V_{peak} and having a maximum capacity of 100 VA need not be classed as minimum V-2 and may be classed HB.

Note: *See CAN/CSA-C22.2 No. 0.17 or ANSI/UL 94 for identification of the material classifications.*

18.3

If a printed circuit board is intended for connection only in circuits operating at not more than 30 V_{rms} or 42.4 V_{peak}, and having a maximum capacity of 100 VA, the only requirement for the printed circuit board material is a minimum flammability rating of HB.

19 Tests

19.1 General

The temperature, overload, endurance, overvoltage, undervoltage, short-circuit, calibration, and dielectric strength tests of CSA C22.2 No. 14 or UL 508 shall be conducted as necessary, as well as the applicable tests of Clauses 19.2 to 19.11 of this Standard.

19.2 Endurance

19.2.1

Other than as noted in Clauses 19.2.2 and 19.2.3, electromagnetic devices (e.g., armature, across-the-line, reduced voltage) that directly control an elevator's ac or dc drive motors shall perform acceptably when subjected to an endurance test that involves making and breaking two times the current corresponding to the horsepower rating of the device for 500 000 operations. For dc-rated devices, the load shall be a non-inductive resistive load. For ac-rated devices, the load shall have a power factor of 0.4 to 0.5. The cycle rate shall be 1 s on and 9 s off, except that the number of cycles per minute may be increased at the manufacturer's option. The endurance test shall be conducted following the overload test of Clause 19.1.

19.2.2

A controller that has the device's coil circuit interlocked or sequenced such that in normal operation the device does not make or break current shall be tested as described in Clause 19.2.1, except the test current shall only be applied during the last five operations.

19.2.3

Electromagnetic devices used in wind turbine tower elevators and elevating devices for people with physical disabilities (platform lifts and stairway chairlifts) shall perform acceptably when subjected to the applicable endurance test of CSA C22.2 No. 14 or UL 508. The endurance test shall be required for across the line motor starting and devices rated in horsepower, including following the electrical endurance cycles with 5000 no-load mechanical operations.

19.2.4

All other devices shall perform acceptably when subjected to the applicable endurance test of Clause 19.1.

19.3 Solid-state ac motor controller tests

19.3.1 General

The performance of a solid-state motor controller shall be investigated by subjecting a representative sample or samples in commercial form to the tests indicated in Clause 19.3. Tests shall be conducted in the sequence specified in Table 17. Consideration shall be given to heat-sink capability, solid-state device ratings, and other criteria when determining which samples to use for testing a line of similarly constructed controllers.

19.3.2 Test voltage

Tests shall be conducted at rated frequency at a test voltage not less than 120, 208, 240, 277, 480, or 600 V, as appropriate for the voltage rating, except that the tests in Clauses 19.3.3 and 19.3.4 may be conducted at a voltage between 90 and 110% of the voltage specified if the current load is adjusted to produce the maximum normal heating and if the power semiconductors are capable of conduction as intended at the test voltage.

19.3.3 Temperature test

19.3.3.1

When operating in the normal mode resulting in maximum heating and as described in Clauses 19.1 and 19.3.3.2, solid-state motor controllers shall not

a) attain a temperature high enough to constitute a risk of fire;
b) adversely affect any materials or components employed in the device; or
c) exceed, at stabilized temperature, the temperature rises specified in Table 18.

19.3.3.2

For the purpose of evaluating the temperature limit of the material, insulating material that is used at the junction in lieu of required spacings shall be considered to be at the junction temperature. To determine the insulating material temperature, reference temperatures (i.e., case, tab, heat-sink, or similar) shall be measured and the junction temperature shall be calculated based on the semiconductor manufacturer's power dissipation and thermal data.

19.3.4 Dielectric voltage withstand test

The dielectric voltage withstand test described in Clause 19.1 shall be conducted immediately after the temperature test with the sample at stabilized temperature and, where necessary, the power semiconductor (in the power circuit) shorted. If placement of thermocouples can adversely affect the results of the dielectric voltage withstand test, the test may be conducted on a sample without thermocouples that has been operated as specified for the temperature test until the temperature has stabilized.

19.3.5 Overvoltage and undervoltage tests

A control that employs an electromagnet shall comply with the overvoltage and undervoltage tests described in Clause 19.1.

19.3.6 Overload and endurance tests

A solid-state motor controller shall comply with the overload and endurance tests for reduced-voltage motor starting or across-the-line motor starting, as appropriate, in accordance with CSA C22.2 No. 14 or UL 508.

19.3.7 Exception

Notwithstanding Clause 19.3.6, the endurance test need not be conducted if the test current is the same as the rated current or if there is no inrush current.

19.3.8 Short-circuit test

19.3.8.1 Compliance

Solid-state motor controllers shall comply with the following after the test described in Clauses 19.3.8.3 to 19.3.8.6:

a) The cotton indicator shall not have ignited.
b) The fuse connected between the live pole and the enclosure or equipment dead metal shall not have opened.
c) The door or cover shall not be blown open, and it shall be possible to open the door or cover. Deformation of the enclosure is acceptable but shall not result in the accessibility of live parts as determined by the use of the rods specified in Clauses 19.8 and 19.9.
d) Wires shall not be pulled out of connectors, and the wire insulation shall not burn out.

19.3.8.2 Selection of samples

A sufficient number of samples considered representative of a product line shall be subjected to short-circuit tests. Representative samples shall be selected on the basis of such features as configuration and ratings.

19.3.8.3 Test procedures

19.3.8.3.1

Open equipment shall be tested in an enclosure judged to be representative of that likely to be encountered when the equipment is in service. Tests may be conducted without an enclosure and considered equivalent to tests conducted using an enclosure if such testing is agreeable to those concerned. If tests are to be conducted without an enclosure, surgical cotton shall be placed on a wire cage that surrounds and is close to the equipment under test so as to closely simulate the intended enclosure.

19.3.8.3.2

The enclosure or grounded metal parts of open equipment shall be connected through a non-time-delay, 30 A cartridge fuse to the live pole judged least likely to arc to ground. The fuse shall have an interrupting rating at least equal to the short-circuit-withstand test current in the short-circuit test of Clause 19.1. The connection shall be made to the load side of the limiting impedance by a No. 10 AWG copper wire 1.2 to 1.8 m (4 to 6 ft) long.

19.3.8.3.3

Notwithstanding Clause 19.3.8.3.2, the connection of the enclosure or grounded metal parts of open equipment may be made with No. 12 or 14 AWG copper wire if the branch-circuit conductors are No. 12 or 14 AWG, respectively.

19.3.8.4 Equipment in an outer enclosure

When testing equipment inside an outer enclosure, surgical cotton shall be placed at all openings, handles, flanges, joints, or the like, on the outside of the enclosure.

19.3.8.5 Protective devices

A short-circuit protective device that has not been investigated and determined to be reliable shall be defeated during the test.

19.3.8.6 Test circuit conditions

The test circuit conditions for the short-circuit shall be as described in Clause 19.1.

19.3.9 Breakdown of components test

19.3.9.1

A solid-state motor controller under test shall comply with the requirements in Clause 19.4.11.

19.3.9.2

With reference to Clause 19.3.9.1, each of the following conditions shall be unacceptable:

a) asymmetrical switching other than half-wave;
b) half-wave operation for a single-phase controller rated less than 5 hp; and
c) the transmitting of one cycle or more of voltage source to the motor with the control in the OFF position, thus permitting possible rotation of a de-energized motor.

19.3.10 Verification of electronic motor overload protection test

A solid-state motor controller with integral electronic motor overload protection shall comply with the requirements of Clause 19.4.12 and be marked in accordance with Clause 20.21.2 a). Drives not incorporating integral electronic overload protection shall be marked in accordance with Clause 20.21.2 b) or 20.21.3.

19.4 Power-conversion equipment

19.4.1 General

19.4.1.1

The performance of power-conversion equipment shall be investigated by subjecting a representative sample or samples in commercial form to the tests described in Clauses 19.4.1.2 to 19.4.11. The tests shall be as specified in Table 19 and shall be conducted in the sequence outlined in that table. Consideration shall be given to heat-sink design, solid-state device ratings, and other design criteria when selecting samples to use for testing a line of similarly constructed devices.

19.4.1.2

Tests shall be conducted at rated frequency and a test voltage not less than 120, 208, 240, 277, 480, or 600 V, as appropriate for the voltage rating, except that the tests in Clauses 19.4.2.1 to 19.4.2.3 may be conducted at a voltage between 90 and 110% of the voltage specified if the load current is adjusted to produce the maximum normal heating.

19.4.1.3

Power-conversion equipment intended to control a variable-speed motor load shall be tested controlling

a) a load equivalent to that of a motor with voltage, frequency, and current ratings corresponding to the marked rating; or
b) a test motor capable of being loaded to the values specified.

19.4.1.4

Notwithstanding Clause 19.4.1.3, the test motor may be simulated by a passive load consisting of resistive or inductive loads.

19.4.2 Temperature test

19.4.2.1

When operating in the normal mode resulting in maximum heating, power-conversion equipment shall not attain a temperature high enough to

a) constitute a risk of fire;
b) adversely affect any materials or components employed in the device; or
c) exceed, at stabilized temperatures, the temperature rises specified in Table 18.

19.4.2.2

For insulating materials at semiconductor junctions that are used in lieu of required spacings, see the requirements in Clause 19.3.4.

19.4.2.3

The size of a conductor that represents field wiring in the temperature test shall be based on the rms value of the current.

19.4.3 Dielectric voltage withstand test

The dielectric voltage withstand test described in Clause 19.1 shall be conducted immediately after the temperature test with the sample at stabilized temperature. If placement of thermocouples can adversely affect the results of the dielectric voltage withstand test, the test may be conducted on a sample without thermocouples that has been operated as specified in the temperature test until the temperature has stabilized.

19.4.4 Operation tests

19.4.4.1

During and upon completion of the operation tests in Clauses 19.4.5 to 19.4.10 and 19.4.12, the power-conversion equipment shall be electrically and mechanically operable, and there shall be no evidence of a risk of fire or electrical shock. The fuse specified in Clause 19.4.4.2 shall not open, and the surgical cotton specified in Clause 19.3.8.3.1 or 19.3.8.4, whichever is applicable, shall not glow or flame.

19.4.4.2

To assess the risk of electric shock, the outer enclosure (if any) and grounded or exposed dead metal parts shall be connected through a 30 A fuse to the supply circuit pole least likely to arc to ground. For grounded control circuits, the enclosure and grounded or exposed dead metal parts shall be connected through the 30 A fuse to ground. To assess the risk of fire, the procedures specified in Clauses 19.3.8.3.1 to 19.3.8.4 shall be followed.

19.4.4.3

Before all operation tests, the test sample shall be mounted, connected, and operated as described in the temperature test in Clauses 19.4.1 and 19.4.2.

19.4.5 Normal operation

19.4.5.1

Power-conversion equipment that has a rheostat, a potentiometer, or a similar device intended for operator control shall be subjected to 100 operations under the most severe normal conditions for which the control is intended.

19.4.5.2

The procedure described in Clause 19.4.5.1 is intended to demonstrate the ability of the device to control and sequence the circuit under normal conditions of operation. For motor loads, this includes starting and running with the motor loaded to full load at normal speed.

19.4.6 Contactor overload

A contactor that has the coil circuit interlocked or sequenced in such a way that in normal operation the contactor does not make or break load current shall be tested at the maximum current permitted by the current-limiting control, if provided, but at least at 150% of full-load current. Five operations shall be conducted.

19.4.7 Single phasing

Three-phase power-conversion equipment shall be operated with one line disconnected at the input. The disconnected line shall be the one determined to be the line to which any protective devices are the least responsible. The test shall be conducted by disconnecting one line with the power-conversion equipment operating at maximum normal load and shall be repeated by initially energizing the device with one lead disconnected.

19.4.8 Inoperative blower motor

Power-conversion equipment having forced ventilation shall be operated at rated load with inoperative blower motor(s) until the test is terminated by a protective device or until the temperature stabilizes.

19.4.9 Clogged filter

Enclosed power-conversion equipment having filtered ventilation openings shall be operated with the openings blocked to represent clogged filters. The test shall be conducted initially with the ventilation openings blocked approximately 50%. The test shall be repeated with the ventilation openings fully blocked until terminated by a protective device or until the temperature stabilizes.

19.4.10 Current-limiting control

Power-conversion equipment incorporating a current-limiting control shall be operated with the load increased to cause the power-conversion equipment to operate in the current-limiting mode. If the current-limiting control is adjustable, it shall be adjusted to the setting producing the most severe results. The duration of the test shall not exceed the maximum time required for operation of the overload protective device or system supplied or specified on the marking required by Clause 20.21.

19.4.11 Breakdown of components

19.4.11.1

There shall be no emission of flame or molten metal nor ignition of cotton loosely placed over all openings of ventilated equipment or totally surrounding open devices when passive devices such as

capacitors and resistors or solid-state components such as transistors and diodes are short- or open-circuited.

19.4.11.2

Notwithstanding Clause 19.4.11.1, the test shall not be required

a) if circuit analysis indicates that no other component or portion of the circuit will be damaged as a result of the assumed open-circuiting or short-circuiting of a component;
b) on power semiconductor devices if equivalent testing is accomplished during short-circuit tests; or
c) for components complying with requirements applicable to the component.

19.4.12 Electronic motor overload protection test

19.4.12.1

Power conversion equipment incorporating integral electronic overload protection shall comply with the electronic motor overload protection test and be marked in accordance with Clause 20.21.2 a). Drives not incorporating integral electronic overload protection shall be marked in accordance with Clause 20.21.2 b) or 20.21.3.

19.4.12.2

One representative sample of equipment provided with electronic motor overload protection shall be tested.

19.4.12.3

The motor overload protection shall operate in accordance with the following conditions:

a) ultimately at 100% of the rated tripping current;
b) within 8 min
   i) at 200% of the rated tripping current; or
   ii) when the overload protection operates prior to reaching 200% overload; and
c) within 20 s
   i) at 600% of the rated tripping current; or
   ii) when the overload protection operates prior to reaching 600% overload.

19.4.12.4

For accuracy, overload protective circuitry or software programs shall be reset to their zero or starting value after each test specified in Clause 19.4.12.3. Where provided, thermal protective devices shall be cooled to ambient after each test.

19.4.12.5

The current limit setting shall be adjusted to its highest rated value that can be obtained at the motor full-load ampere setting.

19.4.12.6 Electronic motor over-temperature protection test

19.4.12.6.1

Power conversion equipment incorporating integral electronic over-temperature protection shall comply with the electronic motor over-temperature protection test as specified in Clauses 19.4.12.6.2 to 19.4.12.6.8. Power conversion equipment not incorporating integral electronic over-temperature protection shall be marked in accordance with Clause 20.21.3 or 20.21.8.

19.4.12.6.2

With the thermal memory reset, the drive shall be operated and an overload condition introduced. The elapsed time between the start of the overload condition and the operation of the overload protection shall be recorded.

19.4.12.6.3

After the operation of the over-temperature protection, the drive shall be restarted and the same overload condition introduced. The elapsed time between the start of the overload condition and the operation of the overload protection shall be recorded and shall be less than the time recorded in Clause 19.4.12.6.2.

19.4.12.6.4

With the thermal memory reset, the drive shall be operated and an overload condition introduced. The elapsed time between the start of the overload condition and the operation of the overload protection shall be recorded.

19.4.12.6.5

After the operation of the over-temperature protection as specified in Clause 19.4.12.6.4, power shall be removed from the drive until all control logic functions cease to operate, with the exception of those intentionally powered by a source independent of the supply mains, such as a battery.

19.4.12.6.6

Power shall be restored to the drive and the drive shall be restarted and the same overload condition introduced. The elapsed time between the start of the overload condition and the operation of the overload protection shall be recorded and shall be less than the time recorded in Clause 19.4.12.6.4.

19.4.12.6.7

With the thermal memory reset, the output of the drive shall be adjusted such that it will operate at 20% of rated speed and an overload condition shall then be introduced. The elapsed time between the start of the overload condition and the operation of the overload protection shall be recorded.

19.4.12.6.8

With the thermal memory reset, the output of the drive shall be adjusted such that it will operate at 10% of rated speed and an overload condition shall then be introduced. The elapsed time between the start of the overload condition and the operation of the overload protection shall be recorded and shall be less than the time recorded in Clause 19.4.12.6.7.

19.4.13 Short-circuit test

The power conversion equipment shall comply with the requirements specified in Clause 19.3.8.

19.5 Impact test

19.5.1

Each of three samples of the equipment shall be subjected to an impact test on any surface that can be exposed to a blow during normal use or during installation. For an enclosure having no surface area exceeding 25 800 mm² (40 in²), the impact shall be 6.78 J (5.0 ft-lbf), produced by dropping a steel sphere 51 mm (2.0 in) in diameter and weighing 0.53 kg (1.17 lb) from a height of 1300 mm (51 in). For an enclosure having any surface area greater than 25 800 mm² (40 in²), the impact shall be 13.56 J

(10.0 ft-lbf), produced by dropping a steel sphere 51 mm (2.0 in) in diameter and weighing 0.53 kg (1.17 lb) from a height of 2600 mm (102 in). The impact shall not result in any of the conditions specified in Clause 6.5. Tests shall be conducted at any ambient temperature within the range of 10 to 40 °C (50 to 104°F).

19.5.2

Each of three samples of the equipment shall be cooled to 0 °C (32°F) and maintained at that temperature for 3 h. Immediately following removal from the cold chamber, the sample shall be subjected to the impact test described in Clause 19.5.1.

19.6 Printed circuit board coatings

19.6.1 General

For printed circuit boards that rely on a coating for reduction of spacings in accordance with Table 12, the suitability of the coating shall be determined by subjecting three samples to the tests specified in Clauses 19.6.2 to 19.6.5.

19.6.2 Dielectric strength (new samples)

The samples shall be conditioned by flexing them slightly four times to simulate conditions that can normally be expected.

A voltage of 1000 V plus twice the rated voltage shall be applied for 1 min without breakdown between adjacent printed circuits where there are reduced spacings.

19.6.3 Dielectric strength (aged samples)

The same samples shall then be conditioned again by maintaining them at 90 ± 1 °C (194 ± 2°F) for 96 h and then flexing them as described in Clause 19.6.2.

They shall then be subjected to the dielectric strength test described in Clause 19.6.2.

19.6.4 Dielectric strength (after humidity conditioning)

The same samples shall then be conditioned again by maintaining them at 23 ± 1 °C (73 ± 2°F) and 96 ± 2% relative humidity for 96 h and then flexing them as described in Clause 19.6.2.

They shall then be subjected to the dielectric strength test described in Clause 19.6.2.

19.6.5 Adhesion

Following the tests described in Clauses 19.6.2 to 19.6.4, the samples shall be investigated for adhesion of the coating to the board by scraping or cutting. The coating shall not flake.

19.7 Transient-voltage-surge suppression

19.7.1

A transient voltage limited circuit as specified in Clauses 16.2 and 16.3 and Table 12 shall withstand without breakdown a single 1.2 × 50 µs full-wave impulse with a crest value of 5.0 kV (see ANSI/IEEE 4). The transient voltage surge shall not exceed 300% of the peak working voltage or 300 V, whichever is greater, and the equipment shall be operational upon completion of the test.

19.7.2

The equipment shall be connected to a single-phase source of supply, operating at rated voltage, with the output of the impulse generator connected across the equipment.

19.8 Compression

19.8.1

As required by Clause 4.3.2, an enclosure constructed of metal that is thinner than that specified in Tables 1 and 2 shall be reinforced so that its deflection is not more than that of a reference sheet-metal enclosure of the maximum length and width constructed of the minimum required sheet-metal thickness.

19.8.2

The enclosure shall rest on a flat, unyielding horizontal surface. A vertical force shall be applied at any point on the surface of the enclosure except for the door or cover, using a flat face of a steel bar having a 13 mm (0.5 in) square cross-section. Force shall be applied to the end, the side, and the rear walls of each enclosure. The value of the force and the limit of deflection, both of which shall be measured and recorded, are not specified, but the force on each wall of both the test and reference enclosures shall be sufficient to result in a measurable deflection of the test enclosure.

19.9 Deflection

19.9.1

As required by Clause 4.3.2, a drawn, embossed, flanged, or similarly strengthened door, front, or cover made of metal having a thickness less than that specified in Tables 1 and 2 shall not deflect inward more than 6.4 mm (0.25 in) when a vertical force of 445 N (100 lbf) is applied at any point on the door, front, or cover.

19.9.2

The force shall be applied through a flat face of a steel bar having a 13 mm (0.5 in) square cross-section. The test shall be conducted with the door, front, or cover mounted on the box in the intended manner, and the enclosure placed with its back on a flat, unyielding horizontal surface.

19.10 Cord pullout

As required by Clause 15.8.2, a direct pull of 156 N (35 lbf) shall be applied to the cord for 60 s. Supply connections within the equipment, if provided, shall be disconnected from terminals or splices during the test.

19.11 Crushing resistance test

19.11.1

Three samples of equipment shall be supported on the mounting side by a fixed rigid supporting surface, in the position that is recommended by the manufacturer. Crushing force shall be applied to the exposed surfaces of the enclosure. The compression force shall be applied by flat surfaces each 102 by 254 mm (4 by 10 in). Each force applicator shall exert 440 N (100 lbf) on the sample for 1 min. As many applicators shall be applied as the sample can accommodate, up to a maximum of 8, based upon an arrangement of applicators as indicated in Figure 2.

19.11.2

The test shall be considered successful if at the conclusion none of the following occur:

a) Spacings are reduced below the minimum acceptable values.
b) Bare live parts or internal wiring are made accessible to contact.
c) Breakage, cracking, rupture, and the like produce an adverse effect on the insulation.
d) Any other condition occurs that would increase the likelihood of electric shock or fire, or both, during use of the equipment.

20 Marking

20.1

Where a product is intended for use in Canada, equipment shall additionally be marked in French in accordance with Annex C.

20.2

Electrical equipment shall be legibly marked in accordance with Item a) and, where applicable, with Items b) and c) as well:

a) The marking for a certified assembly shall be in the form of a nameplate permanently attached to the assembly. The marking for a certified component shall be permitted to be in the form of a permanently attached nameplate or shall be made by permanent silk-screening or hot stamping, or by other permanent and legible means. The marking shall specify the following:
   i) indication of certification, which shall include "CSA B44.1/ASME A17.5";
   ii) the manufacturer's name, trademark, or a file number by which the organization responsible for the product may be identified;
   iii) the complete electrical rating as described in Clause 20.4;
   iv) the catalogue number, type, or equivalent for identification of the product; and
   v) the temperature rating of the field-installed conductors for which the unit has been investigated, except that devices rated 30 A or less, or horsepower-rated devices having equivalent current rating of 24 A or less (see Tables 11 and 20), which have been tested when wired with 60 °C or 60/75 °C conductors, need not be marked.

   Equipment shall be permitted to be additionally marked to indicate that higher-temperature-rated field-installed conductors are permitted provided that the higher rated conductors have a cross-sectional area no smaller than the cross-sectional area that would be required if 60 °C or 75 °C conductors were used.

   Note: *Examples of markings include*
   a) *"Use 60 C wire only";*
   b) *"Use 60 C/75 C wire only"; and*
   c) *"Size wire per ampacity for 60 C/75 C".*

b) Permanent or temporary (removable, "throw-away" labels or strip-off adhesive) nameplates shall be used to specify
   i) instructions as to the method of installation to be followed or precautions to be observed when installing; and
   ii) details of parts supplied loose to be fitted together during installation.

c) Separate drawings or manuals specifying installation information, setting and adjustments, wiring diagrams, etc., shall be provided where this data cannot be included in the assembly due to lack of space. This information may be provided separately or be installed in a permanent-type pocket

located inside one or all of the compartments. If all of the information is located in one compartment, the door concerned shall be marked to indicate the location of the pocket.

Notes:

1) *Individual components are not required to be marked if the entire assembly is marked.*
2) *Wiring temperature ratings are only in SI (metric) units as this is the industry standard.*

20.3

Electrical equipment for use with either copper or aluminum conductors shall be marked Cu-Al or the equivalent.

20.4

Unless otherwise indicated, electrical equipment shall be rated in volts, full-load amperes, volt-amperes, or any combination thereof. The rating shall indicate whether the equipment is for direct or alternating current. The rating of ac equipment shall include the number of phases and, if necessary, the frequency, except that the rating of equipment obviously intended for single-phase use only need not include the phase rating.

20.5

The rating of an auxiliary device shall

a) be in the form of a contact rating code designation in accordance with Tables 20 and 21;
b) be in volts, amperes, and inrush amperes; or
c) indicate the voltage and contain the words “standard duty” or “heavy duty”, or the abbreviation “SD” or “HD”, as applicable.

20.6

Marking on polymeric enclosures shall consist of the following or equivalent wording*:

CAUTION: BONDING BETWEEN CONDUITS MUST BE PROVIDED.

* *See Annex C for equivalent French wording.*

20.7

Manual switching means shall be clearly marked with the words “ON” and “OFF” or with symbols* to indicate the ON and OFF positions of switches or controls that have such positions unless the construction or application of the switch or control is such that marking is unnecessary.

* *Symbols for ON and OFF are “I” and “O”, respectively.*

20.8

Electrical equipment that is energized by more than one source and that does not have means for disconnecting all ungrounded conductors within a single enclosure or compartment shall be permanently marked on the outside with the following or equivalent wording*:

WARNING: MORE THAN ONE LIVE CIRCUIT. SEE DIAGRAM.

* *See Annex C for equivalent French wording.*

Note: *This Clause does not apply to circuits of extra-low voltage.*

20.9

The voltage, and amperage rating and the fuse manufacturer, and type designation of fuses used to provide overcurrent protection in control circuits shall be permanently and legibly marked adjacent to

the fuseholder. When the fuse is identified by a class designation (e.g., Class CC, RK5, etc.), the fuse manufacturer and type designation may be replaced by the class designation (e.g., “1 A, 300 V, Class CC”).

Alternatively, this information is permitted to be marked in a permanent table or diagram readily visible in the equipment. When this method is used, the table or diagram shall also identify each fuse with a unique identifier that is also permanently marked adjacent to each fuseholder.

20.10

Electrical equipment provided with screw-type terminals for field wiring connections shall be identified using the designation that is given in the wiring diagram. In addition, contactors, relays, switches, overloads, and power resistors shall be identified using the designations that are given in the wiring diagram.

20.11

An oil tank shall be marked to indicate the proper oil level.

20.12

Enclosures with open bottoms in accordance with Clause 7.1.6 shall be marked with the following or equivalent wording*:

WARNING: WHEN MOUNTING ON OR OVER A COMBUSTIBLE SURFACE, A FLOOR PLATE OF AT LEAST 1.43 mm (0.056 in) GALVANIZED OR 1.6 mm (1/16 in) UNCOATED STEEL EXTENDING AT LEAST 150 mm (6 in) BEYOND THE EQUIPMENT ON ALL SIDES MUST BE INSTALLED.

* *See Annex C for equivalent French wording.*

This marking need not be permanent.

20.13

A control device that is shipped in a “knocked-down” condition for assembly in the field shall have the separate pieces identified to ensure proper assembly.

20.14

A live heat sink or other part likely to be mistakenly identified as dead metal and exposed to persons shall be marked with the following or equivalent wording*:

CAUTION: RISK OF ELECTRIC SHOCK — PLATES [or other wording describing the type of part] ARE LIVE — DISCONNECT POWER SUPPLY BEFORE SERVICING.

* *See Annex C for equivalent French wording.*

The marking shall be located on the live part so as to make the risk known before the part is likely to be touched.

20.15

Elevator control equipment incorporating components in the motor branch circuit shall be marked with the following:

SUITABLE FOR USE ON A CIRCUIT CAPABLE OF DELIVERING NOT MORE THAN _____ rms SYMMETRICAL AMPERES, _____ VOLTS MAXIMUM.

The ampere rating shall not be more than the value for which the elevator control equipment being marked was tested or the lowest short-circuit rating of any component connected to a branch circuit.

20.16

An overload relay that has a replaceable current element, or control equipment incorporating such an overload relay, shall be permanently marked with the following or equivalent wording*:

WARNING: THE OVERLOAD RELAY MUST BE REPLACED IF BURNOUT OF THE CURRENT ELEMENT OCCURS.

* *See Annex C for equivalent French wording.*

20.17

Where more than one grounding conductor No. 6 AWG or smaller is to be terminated in a single- or multi-conductor terminal that will accept a range of conductor sizes, the following marking or equivalent wording shall appear adjacent to the grounding terminal:

TWIST WIRES TOGETHER BEFORE INSERTING IN TERMINAL.

If the terminal is suitable for both copper and aluminum conductors, the following additional marking or equivalent wording shall also appear adjacent to the grounding terminal:

CU-AL, COPPER WIRES MUST NOT BE MIXED WITH ALUMINUM WIRES IN THE SAME TERMINAL HOLE.

20.18

20.18.1

A cautionary marking shall be prefixed with the word “CAUTION”* or “WARNING”*, as applicable, in letters not less than 3.2 mm (0.125 in) high. The remaining letters of such marking, unless specified otherwise in individual marking requirements, shall not be less than 1.6 mm (0.063 in) high.

* *See Annex C for equivalent French wording.*

20.18.2

Markings prefixed with the words “CAUTION”* or “WARNING”* shall be provided in both English and French. Other markings shall be in English and may be in other languages.

* *See Annex C for equivalent French wording.*

20.19

A control with dc motor ratings that does not comply with the requirements of Clause 15.1 d) i) shall be marked with the following or equivalent wording*:

WARNING: DO NOT CONNECT TO A CIRCUIT SUPPLIED BY A SINGLE-PHASE, HALF-WAVE RECTIFIER.

A control that does not comply with the requirements of Clause 15.1 d) ii) shall be marked with the following or equivalent wording*:

WARNING: DO NOT CONNECT TO A CIRCUIT SUPPLIED BY A SINGLE-PHASE RECTIFIER OF THE HALF-WAVE OR FULL-WAVE TYPE.

* *See Annex C for equivalent French wording.*

20.20

With reference to the requirements in Clause 13.1, unless control circuit overcurrent protection is provided in the equipment, a permanent marking shall be provided on the controller or controller wiring diagram to indicate that such protection is sometimes necessary.

20.21

20.21.1

In addition to the applicable markings of Clauses 20.2 to 20.20, power-conversion equipment shall be marked as described in Clauses 20.21.2 to 20.21.8.

20.21.2

Marking for motor overload protection shall be as follows:

a) Electrical equipment incorporating internal overload protection for the motor load and not requiring external or remote overload protection shall be marked to indicate the degree of protection provided. The marking shall indicate the protection level as a percentage of the full-load current. If the protection level is adjustable, the marking shall be provided with instructions for adjustment.

b) Equipment not incorporating internal overload protection for the motor load and intended for use with external or remote overload protection shall be marked to indicate that such protection is required.

20.21.3

Electrical equipment intended to be used with motors that have thermal protectors in or on the motors shall be marked to

a) indicate that the motors are required to have integral thermal protection; and

b) identify the proper connection and the rating of the load imposed by the equipment on the protector contacts.

The rating shall be in volts and amperes, except it shall be in volts or volt-amperes if the load is electromagnetic. The marking shall also indicate alternating or direct current.

20.21.4

Electrical equipment shall be marked to indicate the specific size, catalogue number, and manufacturer for replacement fuses. The equipment marking shall indicate at least one acceptable type fuse.

20.21.5

Electrical equipment that is required to be connected to a supply source with a specific overcurrent protective device as specified in Clause 19.4.10 shall be marked to indicate the necessary protective device.

20.21.6

Markings in accordance with Clauses 20.21.2 to 20.21.5 may be provided on wiring diagrams or in instruction manuals that are supplied with the equipment and referenced on the nameplate or a similar marking that is permanently attached and visible after installation.

20.21.7

Power-conversion equipment that does not incorporate overspeed protection shall be so marked.

20.21.8

Power conversion equipment not incorporating electronic over-temperature protection shall be so marked.

20.22

Controllers for elevating devices for people with physical disabilities (platform lifts and stairway chairlifts) shall be marked with the following or equivalent wording*:

CONTROLLER FOR ELEVATING DEVICES FOR PEOPLE WITH PHYSICAL DISABILITIES.

or

CONTROLLER FOR PLATFORM LIFTS AND STAIRWAY CHAIRLIFTS.

* *See Annex C for equivalent French wording.*

20.23

Equipment enclosures complying with both Clauses 5.3 and 7.2 shall be permitted to be marked with the additional indicator “AGP”. This marking shall be readily visible on the inside of the enclosure.

20.24

Where a controller includes a disconnecting means and parts of the controller remain energized from a source other than the one disconnected (see Clause 12.5) a warning sign shall be mounted on or next to the disconnecting means. The sign shall be clearly legible and shall read as follows or use equivalent wording*:

WARNING: PARTS OF THE CONTROLLER ARE NOT DE-ENERGIZED BY THIS SWITCH.

* *See Annex C for equivalent French wording.*

20.25

Controllers for wind turbine towers elevators shall be marked with the following or equivalent wording*:

CONTROLLER FOR WIND TURBINE TOWER ELEVATORS.

* *See Annex C for equivalent French wording.*

Table 1
Thickness of sheet metal for enclosures — Carbon steel or stainless steel
(See Clauses 4.3.1 to 4.3.3, 19.8.1, and 19.9.1.)

Without supporting frame*				With supporting frame or equivalent reinforcement*					
Maximum width†		Maximum length‡		Maximum width†		Maximum length‡		Minimum acceptable thickness, mm (in)	
mm	(in)	mm	(in)	mm	(in)	mm	(in)	Uncoated	Metal-coated
102	(4.0)	Not limited		159	(6.25)	Not limited		0.52 (0.020)	0.59 (0.023)
121	(4.75)	146	(5.75)	172	(6.75)	210	(8.25)		
152	(6.0)	Not limited		241	(9.5)	Not limited		0.68 (0.026)	0.75 (0.029)
178	(7.0)	222	(8.75)	254	(10.0)	318	(12.5)		
203	(8.0)	Not limited		305	(12.0)	Not limited		0.81 (0.032)	0.88 (0.034)
228	(9.0)	292	(11.5)	330	(13.0)	406	(16.0)		
318	(12.5)	Not limited		495	(19.5)	Not limited		1.07 (0.042)	1.16 (0.045)
356	(14.0)	457	(18.0)	533	(21.0)	635	(25.0)		
457	(18.0)	Not limited		686	(27.0)	Not limited		1.35 (0.053)	1.43 (0.056)
508	(20.0)	635	(25.0)	737	(29.0)	914	(36.0)		
559	(22.0)	Not limited		838	(33.0)	Not limited		1.52 (0.060)	1.62 (0.063)
635	(25.0)	787	(31.0)	889	(35.0)	1092	(43.0)		
635	(25.0)	Not limited		991	(39.0)	Not limited		1.70 (0.067)	1.79 (0.070)
737	(29.0)	965	(38.0)	1041	(41.0)	1295	(51.0)		
838	(33.0)	Not limited		1295	(51.0)	Not limited		2.03 (0.080)	2.14 (0.084)
965	(38.0)	1194	(47.0)	1372	(54.0)	1676	(66.0)		
1067	(42.0)	Not limited		1626	(64.0)	Not limited		2.36 (0.093)	2.47 (0.097)
1194	(47.0)	1499	(59.0)	1727	(68.0)	2134	(84.0)		

(Continued)

Table 1 (Concluded)

Without supporting frame*				With supporting frame or equivalent reinforcement*					
Maximum width†		Maximum length‡		Maximum width†		Maximum length‡		Minimum acceptable thickness, mm (in)	
mm	(in)	mm	(in)	mm	(in)	mm	(in)	Uncoated	Metal-coated
1321	(52.0)	Not limited		2032	(80.0)	Not limited		2.74 (0.108)	2.85 (0.112)
1524	(60.0)	1680	(66.0)	2134	(84.0)	2616	(103.0)		
1600	(63.0)	Not limited		2464	(97.0)	Not limited		3.12 (0.123)	3.23 (0.127)
1854	(73.0)	2286	(90.0)	2616	(103.0)	3226	(127.0)		

* *See Clause 4.3.3.*

† *The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.*

‡ *"Not limited" applies only if the edge of the surface is flanged at least 12.7 mm (0.5 in) or fastened to adjacent surfaces not normally removed in use.*

Table 2
Thickness of sheet metal for enclosures — Aluminum, copper, or brass
(See Clauses 4.3.1 to 4.3.3, 19.8.1, and 19.9.1.)

Without supporting frame*				With supporting frame or equivalent reinforcement*				Minimum acceptable thickness	
Maximum width†		Maximum length‡		Maximum width†		Maximum length‡			
mm	(in)	mm	(in)	mm	(in)	mm	(in)	mm	(in)
76	(3.0)	Not limited		178	(7.0)	Not limited			
89	(3.5)	102	(4.0)	216	(8.5)	241	(9.5)	0.58	(0.023)
102	(4.0)	Not limited		254	(10.0)	Not limited			
127	(5.0)	152	(6.0)	267	(10.5)	343	(13.5)	0.74	(0.029)
152	(6.0)	Not limited		356	(14.0)	Not limited			
165	(6.5)	203	(8.0)	381	(15.0)	457	(18.0)	0.91	(0.036)
203	(8.0)	Not limited		483	(19.0)	Not limited			
241	(9.5)	292	(11.5)	533	(21.0)	635	(25.0)	1.14	(0.045)
305	(12.0)	Not limited		711	(28.0)	Not limited			
356	(14.0)	406	(16.0)	762	(30.0)	940	(37.0)	1.47	(0.058)
457	(18.0)	Not limited		1067	(42.0)	Not limited			
508	(20.0)	635	(25.0)	1143	(45.0)	1397	(55.0)	1.91	(0.075)
635	(25.0)	Not limited		1524	(60.0)	Not limited			
737	(29.0)	914	(36.0)	1626	(64.0)	1981	(78.0)	2.41	(0.095)
940	(37.0)	Not limited		2210	(87.0)	Not limited			
1067	(42.0)	1346	(53.0)	2362	(93.0)	2896	(114.0)	3.10	(0.122)

(Continued)

Table 2 (Concluded)

Without supporting frame*				With supporting frame or equivalent reinforcement*				Minimum acceptable thickness	
Maximum width†		Maximum length‡		Maximum width†		Maximum length‡			
mm	(in)	mm	(in)	mm	(in)	mm	(in)	mm	(in)
1321	(52.0)	Not limited		3124	(123.0)	Not limited			
1524	(60.0)	1880	(74.0)	3302	(130.0)	4064	(160.0)	3.89	(0.153)

** See Clause 4.3.3.*
† The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.
‡ "Not limited" applies only if the edge of the surface is flanged at least 12.7 mm (0.5 in) or fastened to adjacent surfaces not normally removed in use.

Table 3
Size of bonding conductor
(See Clause 6.9.)

Rating of circuit not exceeding, A	Size of bonding conductor		Size of metallic conduit or pipe, in	Size of electrical metallic tubing, in
	Copper wire, AWG	Aluminum wire, AWG		
15	14	12	1/2	1/2
20	12	10	1/2	1/2
30	10	8	1/2	1/2
40	10	8	1/2	1
60	10	8	3/4	1
100	8	6	1	1-1/4
200	6	4	1-1/4	1-1/2
300	4	2	1-1/4	1-1/2
400	3	1	2-1/2	2-1/2
500	2	0	2-1/2	2-1/2
600	1	00	3	4
800	0	000	4	4
1000	00	0000	4	4
1200	000	250 kcmil	6	—
1600	0000	350 kcmil	—	—
2000	250 kcmil	400 kcmil	—	—
2500	350 kcmil	500 kcmil	—	—
3000	400 kcmil	600 kcmil	—	—
4000	500 kcmil	800 kcmil	—	—
5000	700 kcmil	1000 kcmil	—	—
6000	800 kcmil	1250 kcmil	—	—

Table 4
Minimum acceptable distance from an opening to a part that can involve a risk of electric shock or injury to persons
(See Clause 7.1.1.)

Minor dimension of opening, mm (in)*	Minimum distance from opening to part, mm (in)
25.4 (1.00)	165.0 (6.5)
31.8 (1.25)	190.0 (7.5)
38.1 (1.50)	318.0 (12.5)
47.6 (1.87)	394.0 (15.5)
54.0 (2.12)	444.0 (17.5)
†	762.0 (30.0)

* *See Clause 7.1.4.*
† *More than 54.0 mm (2.12 in) but not more than 152.0 mm (6 in).*

Table 5
Minimum spacings for live parts

(See Clauses 7.1.6, 7.1.8, 16.1, 16.2, 16.6 to 16.8, 16.10, 16.11, 16.13, 16.16, 16.26, 16.27.2, and 16.27.3.)

Group		Nominal voltage involved, V	Minimum spacings, mm (in)			
			Between bare live parts of opposite polarity and between bare live parts and grounded metal parts other than the enclosure		Between bare live parts and the walls of metal enclosures, including fittings for conduit or armoured cable*	
			Clearance	Creepage	Clearance	Creepage
A	Control apparatus*	51–150	3.0 (0.12)†	6.3 (0.25)	12.7 (0.50)	12.7 (0.50)
		151–300	6.3 (0.25)	9.4 (0.37)	12.7 (0.50)	12.7 (0.50)
		301–600	9.4 (0.37)	12.7 (0.50)	12.7 (0.50)	12.7 (0.50)
		601–1000	14.0 (0.55)	21.6 (0.85)	20.3 (0.80)	25.4 (1.00)
		1001–1500	17.8 (0.70)	30.5 (1.20)	30.5 (1.20)	41.9 (1.65)
B	Devices having limited ratings‡	51–150	1.5 (0.06)†	1.5 (0.06)†	6.3 (0.25)	6.3 (0.25)
		151–300	1.5 (0.06)†	3.0 (0.12)†	6.3 (0.25)	6.3 (0.25)
		301–600	4.6 (0.18)†	9.4 (0.37)	12.7 (0.50)	12.7 (0.50)
C	Other small devices‡	51–150	3.0 (0.12)†	6.3 (0.25)	6.3 (0.25)	6.3 (0.25)
		151–300	6.3 (0.25)	6.3 (0.25)	6.3 (0.25)	6.3 (0.25)

** For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is likely to reduce spacings between the metal piece and uninsulated live parts.*

† The spacing between wiring terminals of opposite polarity and the spacing between a wiring terminal and a grounded non-current-carrying metal part shall be not less than 6.3 mm (0.25 in) if short-circuiting or grounding of such terminals can result from projecting strands of wire.

‡ Spacings for components or equipment rated at voltages below 51 V are not specified but they shall be the subject of investigation.

Notes:

1) *When measuring oversurface spacing, any slot, groove, or similar feature that is 0.33 mm (0.013 in) wide or less in the contour of insulating material shall be disregarded.*
2) *When measuring spacings, an air space of 0.33 mm (0.013 in) or less between a live part and an insulating surface shall be disregarded.*

Table 6
Wire-bending space at the terminal of enclosed motor controllers
(See Clause 8.1.)

Size of wire*, AWG or kcmil (mm²)		Minimum bending space, terminal to wall, mm (in)		
		Wires per terminal		
		1	2	3
14–10	(2.1–8.3)	—	—	—
8–6	(8.4–13.3)	38 (1-1/2)	—	—
4–3	(21.2–26.7)	51 (2)	—	—
2	(33.6)	64 (2-1/2)	—	—
1	(42.4)	76 (3)	—	—
1/0	(53.5)	127 (5)	127 (5)	178 (7)
2/0	(67.4)	152 (6)	152 (6)	191 (7-1/2)
3/0	(85)	178 (7)	178 (7)	203 (8)
4/0	(107.2)	178 (7)	178 (7)	216 (8-1/2)
250	(127)	203 (8)	203 (8)	229 (9)
300	(152)	254 (10)	254 (10)	279 (11)
350	(177)	305 (12)	305 (12)	330 (13)
400	(203)	305 (12)	305 (12)	356 (14)
500	(253)	305 (12)	305 (12)	381 (15)
600	(304)	356 (14)	406 (16)	457 (18)
700	(355)	356 (14)	406 (16)	508 (20)
750–800	(380–405)	457 (18)	483 (19)	559 (22)
900	(456)	457 (18)	483 (19)	610 (24)

* *The wire size shall be based on Clause 15.1 b).*

Table 7
Maximum acceptable rating of overcurrent device
(See Clauses 13.2.1, 13.2.3, and 13.2.5.)

Rated primary current, A	Maximum rating of overcurrent protective device expressed as a percentage of the transformer primary current rating
Less than 2	300
2 to less than 9	167
9 or more	125*

** The next highest standard rating may be used if 125% of the current does not correspond to a standard rating of fuse or non-adjustable circuit breaker.*

Table 8
Allowable ampacities of insulated copper conductors inside elevator electrical equipment enclosures (based on a maximum room ambient temperature of 40 °C)
(See Clause 14.1.)

	Conductors with 90 °C insulation		Conductors with 105 °C insulation	
Conductor size, AWG	In non-ventilated enclosure	In ventilated enclosure	In non-ventilated enclosure	In ventilated enclosure
Column 1	Column 2	Column 3	Column 4	Column 5
24	1	2	1	2
22	2	3	2	3
20	3	4	3	4
18	4	6	4	6
16	6	9	6	9
14	9	13	10	15
12	12	17	15	22
10	18	27	22	35
8	31	47	35	55
6	45	67	52	80
4	61	91	71	108
3	70	104	80	121
2	80	120	90	140
1	94	141	107	164

(Continued)

Table 8 (Concluded)

Conductor size, AWG	Conductors with 90 °C insulation		Conductors with 105 °C insulation	
	In non-ventilated enclosure	In ventilated enclosure	In non-ventilated enclosure	In ventilated enclosure
Column 1	Column 2	Column 3	Column 4	Column 5
0	110	164	133	190
00	128	191	148	221
000	148	221	171	257
0000	173	258	200	300

Table 9
Ampacity correction factors for multiple conductor groupings
(See Clause 14.1.)

Number of conductors	Correction factor
1 to 3	1.00
4 to 6	0.80
7 to 24	0.70
25 to 42	0.60
43 and more	0.50

Table 10
Full-load motor-running currents in amperes corresponding to various ac horsepower ratings
(See Clauses 15.1 and 15.2.)

Horse-power	110–120 V			220–240 V			440–480 V			550–600 V		
	Single-phase	2-phase	3-phase	Single-phase	2-phase	3- phase	Single-phase	2-phase	3-phase	Single-phase	2-phase	3-phase
1/10	3.0	—	—	1.5	—	—	—	—	—	—	—	—
1/8	3.8	—	—	1.9	—	—	—	—	—	—	—	—
1/6	4.4	—	—	2.2	—	—	—	—	—	—	—	—
1/4	5.8	—	—	2.9	—	—	—	—	—	—	—	—
1/3	7.2	—	—	3.6	—	—	—	—	—	—	—	—
1/2	9.8	4.0	4.0	4.9	2.0	2.0	2.5	1.0	1.0	2.0	0.8	0.8
3/4	13.8	4.8	5.6	6.9	2.4	2.8	3.5	1.2	1.4	2.8	1.0	1.1
1	16.0	6.4	7.2	8.0	3.2	3.6	4.0	1.6	1.8	3.2	1.3	1.4
1-1/2	19.0	9.0	10.4	10.0	4.5	5.2	5.0	2.3	2.6	4.0	1.8	2.1
2	24.0	11.8	13.6	12.0	5.9	6.8	6.0	3.0	3.4	4.8	2.4	2.7
3	34.0	16.6	19.2	17.0	8.3	9.6	8.5	4.2	4.8	6.8	3.3	3.9
5	56.0	26.4	30.4	28.0	13.2	15.2	14.0	6.6	7.6	11.2	5.3	6.1
7-1/2	80.0	38.0	44.0	40.0	19.0	22.0	21.0	9.0	11.0	16.0	8.0	9.0
10	100.0	48.0	56.0	50.0	24.0	28.0	26.0	12.0	14.0	19.0	10.0	11.0
15	135.0	72.0	84.0	68.0	36.0	42.0	34.0	18.0	21.0	27.0	14.0	17.0
19	—	94.0	108.0	88.0	47.0	54.0	44.0	23.0	27.0	35.0	19.0	22.0
25	—	118.0	136.0	110.0	59.0	68.0	55.0	29.0	34.0	44.0	24.0	27.0
30	—	138.0	160.0	136.0	69.0	80.0	68.0	35.0	40.0	54.0	28.0	32.0
40	—	180.0	198.0	176.0	90.0	104.0	88.0	45.0	52.0	70.0	36.0	41.0
50	—	226.0	260.0	216.0	113.0	130.0	108.0	56.0	65.0	86.0	45.0	52.0

(Continued)

Table 10 (Concluded)

Horse-power	110–120 V			220–240 V			440–480 V			550–600 V		
	Single-phase	2-phase	3-phase	Single-phase	2-phase	3- phase	Single-phase	2-phase	3-phase	Single-phase	2-phase	3-phase
60	—	—	—	—	133.0	154.0	—	67.0	77.0	—	53.0	62.0
75	—	—	—	—	166.0	192.0	—	83.0	96.0	—	66.0	77.0
100	—	—	—	—	218.0	248.0	—	109.0	124.0	—	87.0	99.0
125	—	—	—	—	—	312.0	—	135.0	156.0	—	108.0	125.0
150	—	—	—	—	—	360.0	—	156.0	180.0	—	125.0	144.0
190	—	—	—	—	—	480.0	—	198.0	240.0	—	167.0	192.0
250	—	—	—	—	—	602.0	—	—	302.0	—	—	242.0
300	—	—	—	—	—	—	—	—	361.0	—	—	289.0
350	—	—	—	—	—	—	—	—	414.0	—	—	336.0
400	—	—	—	—	—	—	—	—	477.0	—	—	382.0
500	—	—	—	—	—	—	—	—	590.0	—	—	472.0

Notes:

1) *To obtain full-load currents for 190 and 198 V motors, increase corresponding 220–240 V ratings by 15% and 10%, respectively.*
2) *To obtain full-load currents for 265 and 277 V motors, decrease corresponding 220–240 V ratings by 13% and 17%, respectively.*
3) *These values of motor full-load current are for guidance only. Where exact values are required (e.g., for motor protection), always use those appearing on the motor nameplate.*
4) *These values of motor full-load current are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Motors built for especially low speed or high torques may require more current, and multi-speed motors will have full-load current varying with speed, in which case the nameplate current rating shall be used.*
5) *For 90% and 80% power factor, multiply the above figures by 1.1 and 1.25, respectively.*

Table 11
Full-load motor-running currents in amperes corresponding to various dc horsepower ratings

(See Clauses 15.1, 15.2, and 20.2.)

Horse-power	90 V	110–120 V	180 V	220–240 V	500 V	550–600 V
1/10	—	2.0	—	1.0	—	—
1/8	—	2.2	—	1.1	—	—
1/6	—	2.4	—	1.2	—	—
1/4*	4.0	3.1	2.0	1.6	—	—
1/3	5.2	4.1	2.6	2.0	—	—
1/2	6.8	5.4	3.4	2.7	—	—
3/4	9.6	7.6	4.8	3.8	—	1.6
1	12.2	9.5	6.1	4.7	—	2.0
1-1/2	—	13.2	8.3	6.6	—	2.7
2	—	17.0	10.8	8.5	—	3.6
3	—	25.0	16.0	12.2	—	5.2
5	—	40.0	27.0	20.0	—	8.3
7-1/2	—	58.0	—	29.0	13.6	12.2
10	—	76.0	—	38.0	18.0	16.0
15	—	110.0	—	55.0	27.0	24.0
20	—	148.0	—	72.0	34.0	31.0
25	—	184.0	—	89.0	43.0	38.0
30	—	220.0	—	106.0	51.0	46.0
40	—	292.0	—	140.0	67.0	61.0
50	—	360.0	—	173.0	83.0	75.0
60	—	—	—	206.0	99.0	90.0
75	—	—	—	255.0	123.0	111.0
100	—	—	—	341.0	164.0	148.0
125	—	—	—	425.0	205.0	185.0
150	—	—	—	506.0	246.0	222.0
200	—	—	—	675.0	330.0	294.0

** The full-load current for a 1/4 hp, 32 V dc motor is 8.6 A.*

Table 12
Minimum conductor spacings (creepage and clearance) for printed circuit boards*

(See Clauses 16.1, 16.9, 19.6.1, and 19.7.1.)

	Transient voltage not limited				Transient voltage limited			
	Coated†		Uncoated		Coated†		Uncoated	
Volt‡ ac rms or dc	mm	(in)	mm	(in)	mm	(in)	mm	(in)
50	0.18	(0.007)	0.85	(0.033)	0.025	(0.001)	0.04	(0.002)
100	0.25	(0.009)	1.00	(0.039)	0.10	(0.004)	0.16	(0.006)
125	0.28	(0.011)	1.05	(0.041)	0.16	(0.006)	0.25	(0.009)
150	0.32	(0.012)	1.10	(0.043)	0.25	(0.009)	0.40	(0.015)
200	0.42	(0.016)	1.40	(0.055)	0.40	(0.015)	0.63	(0.025)
250	0.56	(0.022)	1.80	(0.070)	0.56	(0.022)	1.00	(0.039)
320	0.75	(0.029)	2.20	(0.087)	0.75	(0.029)	1.60	(0.061)
400	1.00	(0.039)	2.80	(0.110)	1.00	(0.039)	2.00	(0.079)
500	1.30	(0.051)	3.60	(0.142)	1.30	(0.051)	2.50	(0.098)
630	1.80	(0.070)	4.50	(0.177)	1.80	(0.070)	3.20	(0.126)
800	2.40	(0.094)	5.60	(0.219)	2.40	(0.094)	4.00	(0.157)
1000	3.20	(0.126)	7.10	(0.279)	3.20	(0.126)	5.00	(0.197)

* *The base material shall have a minimum CTI of 100.*
† *The coating shall comply with the requirements of Clause 19.6. Internal layers of PCBs shall be considered coated.*
‡ *Between the traces where spacing is measured.*

Table 13
Minimum acceptable spacings for equipment for which transient voltages are known and controlled
(See Clause 16.2.)

Short-circuit power	Peak working voltage	Minimum spacing, mm (in)						
		Between bare live parts of opposite polarity, and between bare live parts and grounded parts other than the enclosure or exposed metal parts				Between any bare live parts and the walls of a metal enclosure, including fittings for conduit or armoured cable*		
		Through air or oil		Over surface		Through air	Over surface	
More than 10 kVA for use where transient voltages are known and controlled	0–50	0.76	(0.030)	0.76	(0.030)	12.7† (0.50)	6.3	(0.25)
	51–225	1.90	(0.075)	2.50	(0.100)	12.7 (0.50)	12.7	(0.50)
	226–450	3.80	(0.150)	5.10	(0.200)	12.7 (0.50)	12.7	(0.50)
	451–900	7.60	(0.300)	10.10	(0.39)	12.7 (0.50)	12.7	(0.50)
More than 500 VA but not more than 10 kVA‡	0–30	0.76	(0.030)	0.76	(0.030)	12.7† (0.50)	6.3	(0.25)
	31–50	0.76	(0.030)	0.76	(0.030)	12.7† (0.50)	6.3	(0.25)
	51–225	1.52	(0.060)	1.52	(0.060)	12.7 (0.50)	12.7	(0.50)
	226–450	2.50	(0.100)	2.50	(0.100)	12.7 (0.50)	12.7	(0.50)
	451–900	5.10	(0.200)	5.10	(0.200)	12.7 (0.50)	12.7	(0.50)
500 VA or less‡	0–36	0.30	(0.012)	0.30	(0.012)	12.7† (0.50)	6.3	(0.25)
	37–72	0.40	(0.016)	0.40	(0.016)	12.7† (0.50)	6.3	(0.25)
	73–100	0.76	(0.030)	0.76	(0.030)	12.7† (0.50)	6.3	(0.25)
	101–225	1.14	(0.045)	1.14	(0.045)	12.7 (0.50)	12.7	(0.50)
	226–450	1.52	(0.060)	1.52	(0.060)	12.7 (0.50)	12.7	(0.50)
	451–900	2.50	(0.100)	2.50	(0.100)	12.7 (0.50)	12.7	(0.50)

** A metal piece attached to the enclosure shall be considered to be part of the enclosure if deformation of the enclosure is likely to reduce spacings between the metal piece and uninsulated live parts. Spacings specified for parts other than enclosure walls shall be acceptable for metal walls of a sub-assembly mounted inside another enclosure if spacings in the sub-assembly are rigidly maintained.*

† Where deflection of an enclosure wall cannot reduce the through-air spacing to the enclosure wall, the spacing through air may be 6.3 mm (0.25 in).

(Continued)

Table 13 (Concluded)

‡ *Maximum short-circuit power is the product of the open-circuit voltage and the short-circuit current available at the supply terminals when protective devices are bypassed.*

Notes:

1) *When measuring an over-surface spacing, any slot, groove, or similar feature that is 0.33 mm (0.013 in) wide or less in the contour of insulating material shall be disregarded.*
2) *When measuring spacings, an air space of 0.33 mm (0.013 in) or less between a live part and an insulating surface shall be disregarded.*