UL 674

STANDARD FOR SAFETY

Electric Motors and Generators for Use in Hazardous (Classified) Locations

UL Standard for Safety for Electric Motors and Generators for Use in Hazardous (Classified) Locations, UL 674

Sixth Edition, Dated July 29, 2022

Summary of Topics

This new edition of ANSI/UL 674 dated July 29, 2022 includes the following changes in requirements:

– Revisions for the use of electronic medium for required documentation.

– Revisions to include +60 °C and -60 °C explosion testing with test factors using precompression explosion testing equipment.

– Revisions to remove errors and omissions.

– Revisions to replace the oxygen-bomb aging test with the air-oven aging test.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated July 2, 2021 and January 28, 2022.

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CSA C22.2 No. 145:22
Fourth Edition

Underwriters Laboratories Inc.
UL 674
Sixth Edition

Electric Motors and Generators for Use in Hazardous (Classified) Locations

July 29, 2022

ANSI/UL 674-2022

Commitment for Amendments

This standard is issued jointly by the Association of Standardization and Certification (ANCE), the Canadian Standards Association (operating as “CSA Group”), and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the standard may be submitted to ANCE, CSA Group, or UL at anytime. Revisions to this standard will be made only after processing according to the standards development procedures of ANCE, CSA Group, and UL. CSA Group and UL will issue revisions to this standard by means of a new edition or revised or additional pages bearing their date of issue. ANCE will incorporate the same revisions into a new edition of the standard bearing the same date of issue as the CSA Group and UL pages.

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This Standard is subject to review within five years from the date of publication, and suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to inquiries@csagroup.org and include "Proposal for change" in the subject line: Standard designation (number); relevant clause, table, and/or figure number; wording of the proposed change; and rationale for the change.

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This ANSI/UL Standard for Safety consists of the Sixth Edition. The most recent designation of ANSI/UL 674 as an American National Standard (ANSI) occurred on July 29, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

The Department of Defense (DoD) has adopted UL 674 on November 6, 1987. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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Preface

This is the harmonized ANCE, CSA Group, and UL standard for Electric Motors and Generators for Use in Hazardous (Classified) Locations. It is the second edition of NMX-J-652-ANCE, the fourth edition of CSA C22.2 No. 145, and the sixth edition of UL 674. This edition of CSA C22.2 No. 145 supersedes the previous editions published in 1972, 1986 and 2011. This edition of UL 674 supersedes the previous edition published in 2011.

This harmonized standard was prepared by the Association of Standardization and Certification (ANCE), the Canadian Standards Association (CSA), and Underwriters Laboratories Inc. (UL). The efforts and support of the CANENA Technical Harmonization Committee are gratefully acknowledged.

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

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

Application of Standard

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

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

Level of harmonization

This standard uses the IEC format but is not based on, nor is it to be considered equivalent to, an IEC standard.

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

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

Reasons for differences from IEC

This standard provides requirements for electric motors and generators in accordance with the codes of Canada, Mexico, and the US. At present there is no IEC standard for electric motors and generators for use in accordance with these codes. Therefore, this standard does not employ any IEC standard for base requirements.

Interpretations

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

1 Scope

1.1 This standard applies to electric motors and generators or submersible and nonsubmersible sewage pumps and systems suitable for use in Class I, Division 1, Groups B, C and D, and Class II, Division 1, Groups E, F and G, hazardous (classified) locations as defined by CSA C22.1 *Canadian Electrical Code, Part I* (CE Code), the *National Electrical Code*, ANSI/NFPA 70 (NEC), and *NOM-001-SEDE*.

Note: In the US, the application “hazardous locations” is referred to as “hazardous (classified) locations”.

1.2 This standard covers the same type of electrical equipment indicated in 1.1 for installation and use in Class I, Zone 1, Groups IIA and IIB, IIB+H_2, and Zone 20 and 21 hazardous locations.

1.3 This standard also covers other rotating machinery such as, but not limited to, electric brakes, tachometers, encoders, and slip rings.

1.4 This standard does not address types of protection other than explosion-proof or dust-ignition-proof.

1.5 For Canada Only – This standard does not include Canadian energy efficiency or product performance requirements. For such requirements, see Annex A, item 19. It is possible that item 19 is referenced in whole or in part in federal, provincial, territorial, or local laws or regulations relating to energy efficiency or product performance. The appropriate governmental authorities should be consulted to confirm whether item 19 has been referenced in laws or regulations.

Note: This standard also does not include U.S. energy efficiency requirements for electric motors used in hazardous (classified) locations.

2 Conditions for Use

2.1 This standard covers motors and generators intended for use under the conditions specified in 2.2 – 2.6.

2.2 Normal ambient duty conditions are defined by the following:

a) An oxygen concentration not to exceed 21 % by volume.

b) A nominal barometric pressure of 101.4 kPa (14.7 psia) (1 atmosphere).

c) Temperature range of minus 25 °C to +40 °C.

d) Altitude not exceeding 1000 m (3281 ft).

In Canada, the normal ambient temperature is minus 50 °C to +40 °C.

2.3 Low ambient duty conditions are considered to be not less than minus 70 °C.

2.4 Products intended and marked for an ambient of lower than minus 25 °C shall be tested (e.g.: explosion pressure test) at 5 °C below the marked lower temperature.

In Canada, products intended and marked for an ambient of lower than minus 50 °C shall be tested (e.g.: explosion pressure test) at 5 °C below the marked lower temperature.

2.5 High ambient duty conditions are considered to be higher than +40 °C.

2.6 If a motor is rated for use in an ambient higher than +60 °C (+65 °C in Canada), the flame propagation test shall be performed at the marked temperature or greater.

3 Normative References

3.1 Products covered by this standard shall comply with the reference installation codes and standards noted in Annex A as appropriate for the country where the product shall be used. When the product is intended for use in more than one country, the product shall comply with the installation codes and standards for all countries where it is intended to be used.

In Canada, general requirements are as indicated in Annex A, item 18.

4 Dated and Undated References

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

5 Definitions

5.1 For the purposes of this standard, the following definitions apply.

5.2 AUTOMATIC RESET PROTECTOR – A device that incorporates a bimetal that is calibrated to open the motor circuit upon reaching a certain temperature and automatically closes the circuit once the bimetal has cooled to a lower temperature.

5.3 COMPONENT – Any device which can stand alone and does not require attachment to the motor or generator to comply with hazardous location requirements.

5.4 FLAT (PLAIN, FLANGED, CYLINDRICAL) JOINT – A joint where the path is flat and is not interrupted by steps or threads.

5.5 LABYRINTH JOINT FOR SHAFTS – A joint having at least two axial paths in series, interrupted by at least one radial path having a minimum length of 1.6 mm (0.06 inch).

5.6 MANUALLY RESET PROTECTOR – A device that incorporates a bimetal that is calibrated to open the motor circuit upon reaching a certain temperature and requires manual resetting to close the motor circuit again.

5.7 OPERATING ROD (SPINDLE) – A component of circular cross section used for transmitting control movements that may be rotary or linear or a combination of the two.

5.8 PORTABLE MOTOR – A portable motor is one that can be easily moved. A portable motor incorporates a cord and a plug. A submersible sewage-pump motor, with or without a flexible cord, is not considered a portable motor.

5.9 POWER SHAFT – A component of circular cross section used for transmitting rotary motion.

5.10 RABBET (STEPPED, SPIGOT) JOINT – A joint with two or more surfaces perpendicular to each other in the direction of the path.

5.11 SINGLE-OPERATION DEVICE – A device that incorporates a bimetal that is calibrated to open the motor circuit upon reaching a certain temperature and is resettable only by cooling to 10 °C lower than the minimum rated ambient of the motor, but not greater than minus 35 °C (minus 31 °F), or lower.

In Canada, a device that incorporates a bimetal that is calibrated to open the motor circuit upon reaching a certain temperature and is resettable only by cooling to 10 °C lower than the minimum rated ambient of the motor, but not greater than minus 60 °C (minus 76 °F), or lower.

5.12 THERMAL CUT-OFF – A device that will open a circuit when exposed for a sufficient length of time to a temperature at or above a specified functioning temperature. A thermal cut-off functions once only and will not reverse its function when the temperature is reduced below the functioning temperature.

6 Components

6.1 Except as indicated in 6.2, a component of a product covered by this standard shall comply with the requirements for that component. See Annex B for a list of standards covering components generally used in the products covered by this standard. A component shall comply with the ANCE, CSA, or UL Standards as appropriate for the country where the product shall be used.

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

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

b) Is superseded by a requirement in this standard.

7 Units of Measurement

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

8 Terminology

8.1 Where the term "motor" is employed in this standard, it shall be understood that the requirement also applies to a generator or a sewage pump motor.

8.2 The term sewage pump refers to both submersible and non-submersible types unless otherwise specified.

8.3 Paragraphs in this standard that apply to Class I, Class II, or Class I and II, locations are so identified by the following designations appearing after the subclause numbers: (I), (II), or (I, II).

9 Zone and Group Equivalency

9.1 Class I, Zone 1, Group IIA

9.1.1 Explosion-proof electrical equipment intended to be marked in accordance with 52.2 shall comply with all the requirements for explosion-proof electrical equipment for use in Class I, Group D hazardous (classified) locations.

9.2 Class I, Zone 1, Group IIB

9.2.1 Explosion-proof electrical equipment intended to be marked in accordance with 52.3 shall comply with all the requirements for explosion-proof electrical equipment for use in Class I, Group C hazardous (classified) locations.

9.3 Class I, Zone 1, Group IIB+H2

9.3.1 Explosion-proof electrical equipment intended to be marked in accordance with 52.4 shall comply with all the requirements for explosion-proof electrical equipment for use in Class I, Group B hazardous (classified) locations.

9.4 Zone 20 and 21

9.4.1 Dust-ignition-proof electrical equipment intended to be marked in accordance with 52.7 shall comply with all the requirements for dust-ignition-proof electrical equipment for use in Class II, Group E, F or G hazardous (classified) locations.

10 Enclosures

10.1 Material

10.1.1 (I, II) A motor enclosure shall be made of iron, steel, copper, brass, bronze, or aluminum or its alloys containing not less than 80 % aluminum. A metal such as zinc or magnesium, or their alloys, is not acceptable.

10.1.2 (I, II) To reduce the risk of percussion sparks all exposed metal parts of a portable motor or a cord-connected submersible sewage pump that can be struck by or strike against a foreign object shall be made of:

a) Brass, bronze, or aluminum for a portable motor; or

b) Brass or bronze for a cord connected submersible sewage pump motor.

10.1.3 (I, II) The shaft need not comply with this requirement.

10.1.4 (I, II) For a cord-connected submersible sewage pump provided with a guide-rail system that prevents the pump from contacting other objects while being raised or lowered into the wet pit, only metal parts that could contact the guide rail system and plumbing are required to be made of brass or bronze.

10.2 Porosity in castings

10.2.1 (I, II) Surface porosity not in the joint surface shall not be over 2.4 mm (3/32 inch) wide and not over 1.6 mm (1/16 inch) deep. These holes are not considered as affecting the minimum thickness except that the wall from the bottom of a hole to the opposite surface shall not be less than 3.2 mm (1/8 inch).

10.2.2 (I, II) Surface porosity in joint surfaces shall not be over 1.6 mm (1/16 inch) wide or 1.6 mm (1/16 inch) deep and shall be such that the specified widths of joints are provided, not including the porosity.

10.2.3 (I, II) The porosity level shall be no greater than level 6 as specified in Annex A, item 17.

10.3 Thickness

10.3.1 (I, II) Except as noted in 10.3.4, the minimum thickness of the enclosure walls shall not be less than that specified in Table 1.

10.3.2 (I, II) A machined or a threaded joint in the walls of a cast-metal enclosure, such as at the end-shield/stator-frame joint, shall have at least the thickness specified in Table 1 through the overlap with neither section less than 1.6 mm (1/16 inch) thick.

10.3.3 (I, II) For an enclosure consisting of different materials such as a steel stator frame and cast-iron end shields, the total thickness through the overlap shall not be less than the minimum required for either of the metals. A section through the overlap shall have a thickness of not less than 1.2 mm (3/64 inch) for a sheet-steel section and not less than 1.6 mm (1/16 inch) for a cast-metal section.

10.3.4 (I, II) For a tube-cooled (totally-enclosed, air-to-air cooled) motor in which the cooling tubes form part of the explosion-proof or dust-tight enclosure, the tubes may be copper, brass, aluminum, or steel, having a wall thickness of not less than 0.76 mm (0.030 inch) if:

a) The tubes are protected against external mechanical damage by an enclosure having a minimum thickness as specified in Table 1; and

b) The tubes are protected against the risk of electrical burn through by:

1) An insulating barrier at least 0.70 mm (0.028 inch) thick between the tubes and any electrical component that is subject to arcing;

2) A grounded metal barrier that will prevent any arcs from electrical parts from reaching the tubes; or

3) Location of components so that no arc from any electrical component, including internal wiring, can contact the tubes.

10.4 Strength

10.4.1 (I, II) The fluid handling section of a canned motor pump shall withstand a pressure equal to 1.5 times the operating pressure for 10 minutes without evidence of leakage into any electrical compartment.

10.4.2 (I) The motor enclosure strength shall be sufficient to withstand the stresses resulting from the Explosion Pressure Test of Clause 36.

10.4.3 (I) The ability of a motor enclosure to withstand internal explosion pressures with sufficient safety factor shall be determined either by calculations or by the Over Pressure Test on Enclosures of Clause 37. The safety factor used for calculations shall be that specified in Table 2.

10.4.4 (I) For a line of motors being covered by tests on a representative motor or motors, the required strength shall be based on the maximum internal explosion pressure recorded during the tests, or the pressure specified in Figure 1, whichever is higher. For a single motor (one frame size with one rating), the required strength shall be based on the maximum internal explosion pressure.

10.4.5 (I) The construction of a tube-cooled motor shall be such that the tubes cannot become dislodged from the main enclosure assembly. See Pull Test on Tubes of Clause 48.

11 Joints in Enclosure

11.1 General

11.1.1 (I, II) A joint in an enclosure shall be of the metal-to-metal type, and shall be flat, rabbet (stepped), labyrinth or threaded.

11.1.2 (I, II) A metal joint surface shall have an arithmetical average roughness of not more than 0.0064 mm (250 micro-inches) in accordance with the Annex A, item 14.

11.1.3 (I, II) A feeler gauge utilized to measure the clearances specified in these requirements shall be 3.2 mm to 12.7 mm (1/8 inch to 1/2 inch) wide.

11.1.4 (I, II) The clearance shall be considered to comply with the requirement if such a feeler gauge as described in 11.1.3 will not enter the joint for a distance of more than 3.2 mm (1/8 inch) at any point.

11.1.5 (I, II) In the case of cylindrical joints, the clearance shall be considered to comply with the requirement if the difference in the average diameters of the two parts does not exceed the clearance dimensions specified elsewhere in this standard for such a joint.

Note: The diameters shall be measured at four points equally spaced over a total of 135° (0°, 45°, 90°, 135°) around the circumference of both parts and averaged.

11.1.6 (I, II) The width of a joint shall be measured with the mating parts in their most unfavorable position.

11.1.7 (I, II) Except as noted in 11.2.3.1 – 11.2.3.3 and 11.4.3.1 – 11.4.3.3, the width of a joint shall be measured:

a) From the inside of the enclosure to all places around the joint, including the nearest edge of the bolt clearance hole and elsewhere if the bolt head is outside the enclosure; and

b) From the outside of the enclosure to all places around the joint, including the nearest edge of the bolt clearance hole if the bolt head is inside the enclosure.

11.1.8 (I, II) For a rabbet joint, a maximum chamfer of 2.4 mm (3/32 inch) may be provided at the corner to accept a 1.2 mm (1/16 inch) diameter "O" ring (if such an "O" ring is provided). The chamfer shall not reduce the minimum required metal-to-metal width of the joint.

11.1.9 (I, II) Joints in a terminal box shall comply with the requirements in Annex A, items 10 and 12.

11.1.10 (I, II) Joints in a switch enclosure shall comply with the requirements in Annex A, items 10 and 12.

11.2 Groups C and D locations

11.2.1 General

11.2.1.1 (I) Except as noted in Section 36, joints in a motor enclosure shall be as specified in Table 3, Table 5, or Table 6 (informative) as applicable.

11.2.1.2 (I) The minimum joint width in flat (plain) or rabbet (spigot) joints shall be in accordance with Table 3, Table 5, or Table 6 (informative) as applicable, except that the clearance (gap) may be larger providing the enclosure meets the flame propagation test with an additional safety factor applied to the test clearance (gap) in accordance with 36.6.

11.2.1.3 (I) The determination of free internal volume shall exclude the volume of any potting and/or sealing compound.

11.2.2 Threaded joints

11.2.2.1 (I) A threaded joint shall consist of the number of fully engaged threads specified in Table 7. Threads shall not be finer than specified in Table 7.

11.2.2.2 (I) The engagement between a threaded shaft (operating rod) and a tapped hole in an enclosure is considered to be a threaded joint.

11.2.3 Bolts in joint width

11.2.3.1 (I) A bolt may be located in the joint width provided that the requirements in Table 3, Table 5, and Table 6 (informative) as applicable, and the minimum effective joint width specified in Table 4 are met. See Figure 4.

11.2.3.2 (I) For a supplementary enclosure, such as a terminal box, device cover, and the like, or other part attached to the motor enclosure, a bolt may be located in the joint width if the joint construction complies with the requirements in 11.2.3.1. See Figure 4.

11.2.3.3 (I) The depth of tapping for the bolt mentioned in 11.2.3.1 and 11.2.3.2 shall permit nominal variations in standard bolt lengths to be accommodated. The use of washers shall be optional, but if used, the bolts shall be capable of securing the part tightly without the washers.

11.3 Group B locations

11.3.1 General

11.3.1.1 (I) The width of a joint in an enclosure having a free internal volume of not more than 0.5 dm^3 (30 cubic inches) shall not be less than 9.5 mm (3/8 inch). At a bolt hole, the width shall be measured from the inside edge to the nearest edge of the bolt clearance hole. The cover thickness at the joint flange shall not be less than 9.5 mm (3/8 inch). The clearance between the joint surfaces shall be less than 0.038 mm (0.0015 inch) or such that a 0.038 mm (0.0015 inch) feeler gauge will not enter the joint more than 3.2 mm (1/8 inch) at any point. See Figure 8.

11.3.1.2 (I) For an enclosure having a free internal volume of not more than 0.1 dm^3 (6 cubic inches), the clearance between the joint surfaces shall not be more than 0.10 mm (0.004 inch), and the cover thickness at the joint flange may be less than 9.5 mm (3/8 inch).

11.3.1.3 (I) The width of a joint in an enclosure having a free internal volume of more than 0.5 dm^3 (30 cubic inches) and not more than 1.6 dm^3 (100 cubic inches) shall not be less than 15.9 mm (5/8 inch). At a bolt hole, the width shall be measured from the inside edge to the nearest edge of the bolt clearance hole. The clearance between the joint surfaces shall be less than 0.038 mm(0.0015 inch) or such that a 0.038 mm (0.0015 inch) feeler gauge will not enter the joint more than 3.2 mm (1/8 inch) at any point. A rabbet joint shall have a total width of not less than 22.2 mm (7/8 inch), with neither section of joint being less than 9.5 mm (3/8 inch) wide. The diametrical clearance at the axial section of joint shall not be more than 0.064 mm (0.0025 inch), and the clearance at the radial or clamped section of joint shall not be more than 0.038 mm (0.0015 inch). See Figure 10.

11.3.1.4 (I) The width of a joint in an enclosure having a free internal volume of more than 1.64 dm^3 (100 cubic inches) and not more than 5.7 dm^3 (350 cubic inches) shall not be less than 25.4 mm (1 inch). At a bolt hole, the width shall be measured from the inside edge to the nearest edge of the bolt clearance hole. The clearance between the joint surfaces shall not be more than 0.038 mm (0.0015 inch).

11.3.2 Bolts in joint width

11.3.2.1 (I) A bolt is not prohibited from being located in the joint width of an enclosure having a free internal volume (air volume) of more than 1.6 and not more than 5.7 dm^3 (100 – 350 cubic inches) when it complies with the requirements in 11.3.2.2 and 11.3.2.3.

11.3.2.2 (I) A bolt is not prohibited from being located in a 25.4 mm (1 inch) or wider joint when the distance from the inside of the enclosure to the nearest edge of the clearance hole for the bolt is not less than 21.8 mm (55/64 inch), and the diametrical clearance between the bolt and the clearance hole is not more than 1.14 mm (0.045 inch), measured over the shank or the major diameter of the threads, for a length of not less than one-half the required width of joint. The distance from inside the enclosure to the edge of the nearest clearance hole is measured with the cover in the most unfavorable position. See 11.3.2.5 and Figure 9.

11.3.2.3 (I) All bolt holes in a joint width shall be bottomed or the bolts or screws for fastening a cover shall each engage at least five full threads in a tapped hole.

11.3.2.4 (I) A bolt in a joint width is not prohibited from being provided with a lock washer.

11.3.2.5 (I) The requirements in 11.3.2.1 – 11.3.2.3 apply, in general, to machine screws having a round cross section. Screws that form their own machine-type thread and have been investigated for securing enclosure parts are not prohibited from being located in the joint width when they comply with the requirements in 11.3.2.1 – 11.3.2.3, except for measurement of the bolt clearance. In determining the clearance between a thread forming screw and its clearance hole, the bolt dimension to be used is the minimum dimension of the cross section over the threads.

11.3.3 Threaded joints

11.3.3.1 (I) A threaded joint shall comply with the following:

a) For standard tapered pipe threads, not less than 5 fully engaged threads shall be provided; or

b) For parallel threads not finer than 1.27 mm pitch (20 threads per inch) the minimum number of threads required shall be not less than specified in Table 42 for the class of fit; or

c) For parallel threads not finer than 0.79 mm pitch (32 threads per inch) and tested as described in Explosion Tests – Class I Locations of Clause 36, the minimum number of threads required shall be not less than specified in Table 43.

11.4 Class II Locations

11.4.1 General

11.4.1.1 (II) Except as noted in 35.12, joints in a motor enclosure shall be as specified in Table 8 and Table 9, as applicable.

11.4.2 Threaded joints

11.4.2.1 (II) A threaded joint shall consist of at least 3 threads fully engaged. Threads shall not be finer than 0.79 mm pitch (32 threads per 1 inch).

11.4.3 Bolts in joint width

11.4.3.1 (II) At a metal-to-metal joint between an inner bearing cap and an end-shield, a bolt may be located in the required joint width if:

a) The bearing cap is secured by bolts or studs extending through the end-shield and engaging tapped holes in the bearing cap (see also 11.4.3.3);

b) The width of joint between the nearest edge of the clearance hole and the interior of the motor enclosure and the clearance between the joint surfaces complies with the requirements in 11.4.1.1;

c) The diametrical clearance between each bolt or stud and its clearance hole is not more than 1.14 mm (0.045 inch), measured over the shank or the major diameter of the threads, for a length of not less than 9.5 mm (3/8 inch); and

d) The width of the joint between the nearest edge of the clearance hole and the interior of the bearing chamber shall not be less than 2.8 mm (7/64 inch) with a clearance between the joint surfaces of not more than 0.05 mm (0.002 inch).

11.4.3.2 (II) The depth of tapping for the bolts or studs mentioned in 11.4.3.1 shall permit nominal variations in standard bolt lengths to be accommodated. The use of washers shall be optional, but if used, the bolts shall be capable of securing the part tightly without the washers.

11.4.3.3 (II) With respect to 11.4.3.1(a), if studs are used and they each engage at least 3 full threads in a tapped hole in the inner bearing cap and are mechanically secured against removal from the bearing cap, the hole need not be bottomed.

11.4.4 Through-bolts

11.4.4.1 (II) – For a through-bolt that secures the end shields and passes through the enclosure, the diametrical clearance between the unthreaded shank of the bolt and the clearance hole in the enclosure (or end shields) shall not be more than 0.25 mm (0.010 inch) for a length of not less than 12.7 mm (1/2 inch).

11.4.4.2 (II) – For a joint between a specially-machined nut and a machined surface on the end shield surrounding the bolt hole, the width of joint shall not be less than 4.8 mm (3/16 inch). The clearance at the joint shall not be over 0.05 mm (0.002 inch) for a 4.8 mm (3/16 inch) wide joint and not over 0.08 mm (0.003 inch) for a 6.4 mm (1/4 inch) wide joint. The width of joint shall be measured from the bolt clearance hole to the nearest outside edge of the nut. In addition, the nut shall fully engage not less than five threads of the through-bolt and a washer shall not be provided.

11.5 Class I and II Locations – Main poles and interpoles of D.C. motors

11.5.1 General

11.5.1.1 (I, II) A d-c motor for Class I, Group D, and Class II locations, with the main poles and interpoles fastened to the stator frame by bolts or studs, shall have a distance from the edge of the pole piece to the bolt hole in the motor frame of not less than 3.2 mm (1/8 inch) if the diametrical clearance between the bolt and bolt hole is not more than 0.58 mm (0.023 inch) for a distance of not less than 12.7 mm (1/2 inch) of the unthreaded bolt shank.

11.5.1.2 (I, II) The pole piece shall be tightly clamped against the interior of the motor frame with a clearance of not more than 0.10 mm (0.004 inch).

11.5.1.3 (I, II) A lock washer may be used with the bolt. Metal shims may be provided in the joint between a pole piece and the stator frame.

11.5.2 Brush holders

11.5.2.1 (I) A cap of a brush holder shall be provided with metal threads for engaging a metal brush holder mounted through the wall of the motor enclosure.

11.5.2.2 (I) For a motor for Class I locations the number and size of engaged threads shall be as specified in Table 7, and shall have a minimum length of thread-engagement of not less than 8 mm (5/16 inch) as specified in Table 43.

11.5.2.3 (II) For a motor for Class II locations, there shall be at least 3 full threads engaged, and the threads shall not be finer than 1.06 mm pitch (24 threads per 1 inch).

11.5.2.4 (I, II) The insulation provided between the brush holder and the enclosure, and on the brush-holder cap, shall be phenolic composition or the equivalent, and there shall be no exposed live parts. The joints between portions of a brush-holder assembly and between the assembly and the motor enclosure shall comply with the requirements specified for joints in the motor enclosure.

12 Holes in Enclosure

12.1 (I, II) Other than as noted in 12.5, a hole in an enclosure for securing a part, such as a nameplate or a switch, shall be bottomed.

12.2 (I) The remaining thickness at the bottomed hole shall be sufficient to withstand the internal explosion pressures as shown by calculations or by an over pressure test.

12.3 (I) Fastenings such as removable bolts, screws, and studs, shall not leave an opening in the enclosure wall when omitted. The minimum thickness of metal around the hole shall be not less than 3 mm (1/8 inch) or 1/3 of the diameter of the hole, whichever is greater. The minimum thickness of metal at the bottom of the hole shall be not less than 3 mm (1/8 inch) or 1/3 of the untapped diameter, whichever is greater.

12.4 (I, II) The remaining thickness at the bottomed hole shall not be less than 1.6 mm (1/16 inch) when closed by a screw.

12.5 (I, II) A hole in an enclosure may be through-hole when:

a) The hole is closed by a metal pin or part that is press-fitted in the hole for a length of at least 9.5 mm (3/8 inch) for Class I locations, and 4.8 mm (3/16 inch) for Class II locations. The pin or part shall be secured against removal by welding, peening, or the equivalent;

b) The hole is closed by solid and continuous welding of the pin or part that is installed in the hole; or

c) The hole is closed by a bolt or screw that:

1) Does not have more than 0.79 mm pitch (32 threads per inch);

2) Engages at least 5 full threads for Class I locations and at least 3 full threads for Class II locations. For a self-tapping screw, the number of threads engaged shall be measured when the screw is seated; and

3) Is secured against removal; and if the means for securing is not obvious, the bolt or screw shall withstand the following torques without loosening: for screw size No. 4, 2.8 N-m; No. 5, 4 N-m; No. 6, 4.5 N-m; No. 8, 8.5 N-m; and No. 10, 13.5 N-m.

13 Shaft Openings

13.1 General

13.1.1 (I, II) A shaft opening in a motor enclosure shall be of the metal-to-metal type. See 11.1.2 for the roughness requirements for the metal surfaces forming the path.

13.1.2 (I) Shaft openings in a motor enclosure shall be as specified in Table 10 or Table 12 for Class I, Group C motors, and in Table 11 or Table 12 for Class I, Group D motors. See Figure 2.

13.1.3 (I) The shaft openings specified in Table 10 to Table 12 shall be in addition to any protection offered by the ball bearings or sleeve bearings of the motor.

13.1.4 (I) The length of the shaft opening or path shall be determined by measuring only the metal-to-metal path. Oil or grease grooves with a maximum width of 6.4 mm (1/4 inch) and a maximum depth of 3.2 mm (1/8 inch) shall be acceptable. The total width of the oil or grease grooves (without any inlet or outlet openings) shall not be considered in measuring the effective metal path.

13.1.5 (I) The total actual length of a labyrinth shall be considered as equivalent in length to a straight metal path.

13.1.6 (I) An opening for oil or grease shall be located outside the path in order not to nullify its effectiveness.

13.1.7 (I) If the required shaft path is located between the bearing and the outer surface of the motor, an oil or grease opening shall not be provided unless the construction of the opening provides a length of path not less than that required at the shaft opening.

13.1.8 (I) If a path as specified in Table 10 to Table 12, is not provided in addition to the length of a sleeve bearing, the bearing shall have an overall length of not less than 31.8 mm (1-1/4 inches). The necessary oil openings and grooves may be provided in this 31.8 mm (1-1/4 inches) length of sleeve bearing, subject to tests. In addition, the flame path shall be either:

a) Around a radial shaft shoulder of not less than 3.2 mm (1/8 inch) with end-play limited by means of spring washers or the equivalent to less than 0.05 mm (0.002 inch) for a motor for Class I, Group D locations; or

b) Through a labyrinth with an offset not less than 1.6 mm (1/16 inch) [difference in diameters of at least 3.2 mm (1/8 inch)] through two 90° turns. See Figure 3. The labyrinth shall have a diametrical clearance of not more than 0.51 mm (0.020 inch) through a length of not less than:

1) 6.4 mm (1/4 inch) for a motor for Class I, Group D locations; and

2) 9.5 mm (3/8 inch) for a motor for Class I, Group C locations.

13.2 Groups F and G locations

13.2.1 (II) An outer shaft opening shall have a length of path and diametrical clearance between the shaft and its opening in accordance with Table 13.

13.2.2 (II) A motor provided with an inner shaft opening complying with dimensions specified in Table 14 may have shorter lengths of path and greater clearances at the outer shaft opening if the construction prevents the entrance of dust into the bearing chamber as determined by visual examination following the Dust-Penetration Test – Class II Locations of Clause 35.

13.2.3 (II) For grooves machined in the dust-tight path, the measurements shall be made overall without addition or subtraction of the grooves.

13.2.4 (II) A stationary oil seal may be used at an outer shaft opening if it is in addition to the shaft opening requirements specified in 13.2.1 – 13.2.3.

13.3 Group E locations

13.3.1 (II) The dimensions of a shaft opening in a motor for Group E locations shall not be less than those specified in 13.2.1 – 13.2.2 and shall be such as to prevent the entrance of metal dust into the bearing chamber, as determined by visual examination following the Dust-Penetration Test – Class II Locations of Clause 35.

13.3.2 (II) With reference to 13.3.1, a revolving seal or slinger forming an additional labyrinth path at the shaft opening is generally required to prevent the entry of metal dust into the bearing chamber. A revolving seal employed to prevent entrance of dust shall be made of brass, bronze, or aluminum.

14 Drain and Breather Plugs in Enclosure

14.1 (I, II) A drain plug and a breather plug shall:

a) Perform its intended function without removal of any part;

b) Be located or protected to reduce the likelihood of damage to the plug;

c) Be permanently attached to the enclosure; and

d) Be constructed of corrosion resistant material.

14.2 (I, II) The metal-to-metal joint between a drain plug or breather plug and the enclosure shall comply with the requirements specified for Joints in Enclosure of Clause 11.

14.3 (I) A drain plug or a breather plug shall prevent the passage of flames and sparks capable of igniting the surrounding flammable atmospheres, as in the requirements specified for Explosion Tests of Clause 36.

14.4 (II) A drain plug or breather plug shall prevent the entrance of dust as in the requirements specified for Dust-Penetration Tests of Clause 35.

15 Air-Gap Gauge Plugs in Enclosure

15.1 (I, II) An air-gap gauge plug may be provided if necessary. If provided, the plug shall comply with requirements for threaded joints as applicable in 11.2.2, 11.3.3, and 11.4.2.

16 Devices with Operating Rods or Spindles

16.1 (I) The path between an opening in an enclosure and an operating rod or spindle shall:

a) Be in accordance with Table 3 or Table 5 and Table 6 for cylindrical or rabbet joints; or

b) Comply with 11.2.2 or 11.3.3 for threaded joints.

16.2 (II) The path between an opening in an enclosure and an operating rod or spindle shall:

a) Conform to the requirements of Table 8; or

b) Be of the threaded type complying with the requirements in 11.4.2.

17 Protection Against Corrosion

17.1 General

17.1.1 (I, II) Iron and steel parts shall be protected against corrosion by painting, enamelling, galvanizing, sherardizing, plating, or other equivalent means. A coating of nitro-cellulose-base paint or enamel shall be free from runs, globules, or accumulations, and its composition shall be such that the paint is not likely to be ignited by impact or by the temperature on the surface to which it is applied.

17.1.2 (I, II) Surfaces of sheet-steel and cast-iron parts within an enclosure need not be protected against corrosion.

17.1.3 (I, II) Internal machined surfaces of a cast-iron stator frame, joint surfaces, shaft openings, bearings, laminations, and minor parts of iron or steel such as washers, screws, and the like, are not required to be protected against corrosion.

17.2 Submersible sewage-pump motor

17.2.1 (I) For a submersible sewage-pump motor, fasteners securing enclosure parts together shall be made of stainless steel or an equivalent corrosion-resistant material.

17.2.2 (I) For a submersible sewage-pump motor, joint surfaces shall be protected by "O" rings, gaskets, or seals located external to the joint fit to reduce the likelihood of the entrance of sewage that may corrode the surfaces. Shaft openings shall be provided with lip or mechanical seals located external to the shaft opening.

18 Materials Applied to Joint Surfaces

18.1 (I, II) Paint or sealing material shall not be applied to the contacting surfaces of a joint. A thin film of oil or grease may be applied to metal-joint surfaces before assembly.

18.2 (I, II) Joint surfaces may be electroplated. The metal plating shall not be more than 0.0076 mm (0.0003 inch) thick.

18.3 (I, II) Paint, paint over-spray, or thread sealant is permitted on conduit entry threads provided the entry passes the conduit entry electrical-resistance test of 41.3 and the gauging requirements of 19.1.1.4 after painting.

19 Field-Wiring Connections

19.1 Permanently connected motors

19.1.1 Connection for conduit

19.1.1.1 (I, II) Each motor shall have provision for connection to threaded rigid metal conduit, either directly or through a terminal box.

19.1.1.2 (I, II) Threaded conduit entries shall be of the modified National Standard Pipe Taper (NPT) thread, with thread form per Annex A, item 13. Additionally:

a) The taper shall be 1 mm per 16 mm (3/4 inch per foot); and

b) If an integral bushing (historically known as a conduit stop) is provided in the conduit opening of an enclosure for Class I, Group C or D locations, or both, NPS straight threads shall be permitted if there are a minimum of 5 full threads.

19.1.1.3 (I, II) Conduit entries shall not be smaller than trade size 1/2, nor larger than trade size 6; and must be provided with:

a) A minimum of 5 full threads for Class I locations; and

b) A minimum of 3-1/2 full threads for Class II locations.

19.1.1.4 (I, II) Conduit entries shall conform to Annex A, item 13, except that entries shall gauge flush to +3-1/2 turns beyond the L1 gauging notch, in lieu of the minus 1 to +1 turns.

19.1.1.5 (I, II) All male NPT threaded fittings shall have a threaded length not less than the L4 dimension in accordance with Annex A, item 13 from the end of the fitting to the face of a shoulder or to an interruption and shall gauge ±1 turn of the ring gauge from being flush with the end of the thread.

19.1.1.6 (I, II) If an integral bushing (historically known as conduit stop) is provided, it shall be smooth and well-rounded, having a throat or inner diameter as specified in Table 37.

19.1.1.7 (I, II) An attached conduit hub shall have a wall thickness, before threading, of not less than that of the corresponding trade-size conduit. The hub shall not depend upon friction alone to prevent it from turning, and shall withstand the torque specified in the Secureness Test on Conduit Hubs of Clause 40.

19.1.1.8 (I, II) A terminal box provided as part of the motor shall be acceptable for use in at least the same hazardous location Classes and Groups marked on the motor.

19.1.1.9 (I, II) A terminal box that encloses fixed motor terminals for field connection to the power-supply circuit shall be of sufficient size to provide spacings as specified in Table 24, and a useable volume of not less than that specified in Table 15.

19.1.1.10 (I, II) A terminal box that encloses wire-to-wire connections to the power-supply circuit to be made in the field shall have a dimension of opening in the cover and a usable volume of not less than that specified in Table 16 – Table 19.

19.1.1.11 (I) A conduit nipple used for enclosing the wiring leads shall fully engage at least 5 threads in the motor enclosure and shall be secured against turning, or it may be secured to the motor enclosure by a solid and continuous weld. The outer end of the nipple shall have a sufficient number of threads to engage at least 5 full threads.

19.1.1.12 (I) For a bolted-on box, the joint between the body of the box and the motor shall comply with the requirements in 11.1.9 and 11.2.3.1 – 11.2.3.2.

Note: The thickness of the box body flange may be less than the 9.5 mm (3/8 inch) as required for a 9.5 mm (3/8 inch) wide joint.

19.1.1.13 (I) A terminal box attached to the motor enclosure by a conduit nipple shall engage at least 5 full threads with the nipple.

19.1.1.14 (I) The dimensions of the metal-to-metal joint of a 12.7 mm (1/2 inch) conduit size swivel type conduit fitting shall be as specified in Table 20.

19.1.1.15 (II) A conduit nipple used for enclosing the wiring leads shall fully engage at least 3-1/2 threads in the motor enclosure and shall be secured against turning, or it may be secured to the motor enclosure by a solid and continuous weld. The outer end of the nipple shall have a sufficient number of threads to engage at least 3-1/2 full threads.

19.1.1.16 (II) For a bolted-on box, the joint between the body of the box and the motor shall comply with the requirements in 11.1.9 and 11.4.2 – 11.4.3.3.

19.1.1.17 (II) A terminal box attached to the motor enclosure by a conduit nipple shall engage at least 3-1/2 full threads with the nipple.

19.1.1.18 (II) The dimensions of the metal-to-metal joints of a 12.7 mm (1/2 inch) conduit size swivel type conduit fitting shall be as specified in Table 21.

19.2 Field wiring leads

19.2.1 (I, II) The requirements in 19.2 apply to wiring leads used to make connections in the field. A wiring lead includes a lead connected to an auxiliary device, but does not include thermocouple, resistance temperature detector (RTD), thermistor, resolver, or encoder leads.

19.2.2 (I, II) A wiring lead shall not be smaller than 0.82 mm^2 (18 AWG).

19.2.3 (I, II) The insulation of wiring leads shall be rated for the maximum temperatures to which the leads are subjected during operation of the motor at rated load.

19.2.4 (I) A submersible sewage-pump motor having provision for connection to conduit shall have field-wiring leads at least 3.2 m (10 feet, 6 inches) long.

19.2.5 (I) Wiring leads for motors with fractional horsepower ratings shall be Type TW oil- and gasoline-resistance wire, 90 °C (194 °F) neoprene-insulated wire, or wire with insulation having equivalent resistance to gasoline vapor.

19.2.6 (I) Wiring leads of an integral horsepower frame size motor having a fractional horsepower rating are not required to be of a gasoline-resistance type if the motor is permanently marked: "Not suitable for gasoline dispensing pumps."

19.2.7 (I) For a submersible sewage pump motor, the wiring leads are not required to be oil- and gasoline-resistant.

19.2.8 (I) For a submersible sewage pump motor, individual wiring leads or the jacket of a cord, when used, shall be resistant to water. Thermoplastic material is considered to comply with this requirement.

19.2.9 (I) The ampacity of wiring leads shall not be less than the maximum rated current of the motor.

19.2.10 (I) Wiring leads connected to an auxiliary device shall have an ampacity acceptable for the current they are intended to carry in accordance with Annex A, item 1, but shall not be smaller than specified in 19.2.2.

19.2.11 (I) Wiring leads passing through an external air chamber of a totally-enclosed, fan-cooled motor shall be enclosed and protected by an integrally cast, explosion-proof passage way, by rigid metal conduit, or the equivalent.

19.2.12 (I) Wiring leads for an auxiliary device shall be insulated for the highest voltage within the terminal box.

19.2.13 (I) Wiring leads shall be sealed where they pass into the motor case. A sealing compound shall be one that will form a tight fit, and that will neither soften nor crack under intended operation at rated load. A sealing compound shall not flow or creep at the operating temperature of the motor. A sealing compound that softens upon the application of heat shall have a softening point of not less than 93 °C (200 °F) for motors having Class A insulation, and 113 °C (236 °F) for motors having Class B insulation. Wiring leads of a Class F or a Class H insulated motor shall be sealed with a setting-type compound. Refer to Sealing Compounds Test in Clause 49.

19.2.14 (I) A determination of the softening point of a sealing compound shall be made in accordance with the Test specified in Annex A, Item 16.

19.2.15 (I) For a motor having a free internal volume of 1000 cm^3 (61 in^3)or less, the depth of seal shall not be less than 12.7 mm (1/2 inch). For a motor having a free internal volume of more than 1000 cm^3 (61 in^3), the depth of the seal shall not be less than 16 mm (5/8 inch) if the motor has frame-to-end-shield joints not exceeding 560 mm (22 inches) in internal length (circumference).

19.2.16 (I) For a motor having a free internal volume of more than 1000 cm^3 (61 in^3), and a frame-to-end-shield joints exceeding 560 mm (22 inches) in internal length (circumference), the depth of seal shall be as specified in Figure 6, but it shall not be less than the outside diameter of the largest lead wire. Depending on the compound, the size of lead wires, and the construction of the sealing well, a greater depth of sealing compound might be necessary to form a tight seal.

19.2.17 (I) For a nipple used to retain the lead wire sealing compound of a motor having a free internal volume of more than 1000 cm^3 (61 in^3), the depth of seal shall not be less than the internal diameter of the nipple, but not less than 16 mm (5/8 inch) deep. Depending on the compound and the size of the lead wires, a greater depth of sealing compound might be necessary to form a tight seal.

19.2.18 (I) Means shall be provided in the nipple to anchor the sealing compound. The completed lead wire seal shall withstand a hydrostatic test pressure of 4 times the applicable explosion pressure (see 10.4).

19.2.19 (I) The depth of a factory-installed seal anchored by mechanical means in a nipple may be less than the internal diameter of the nipple, but not less than 16 mm (5/8 inch).

19.2.20 (II) The ampacity of wiring leads shall not be less than the maximum rated current of the motor.

19.2.21 (II) Wiring leads connected to an auxiliary device (see 19.2.10) shall have an ampacity acceptable for the current they are intended to carry in accordance with Annex A, item 1, but shall not be smaller than specified in 19.2.2.

19.2.22 (II) Wiring leads passing through an external air chamber of a totally-enclosed, fan-cooled motor shall be enclosed and protected by an integrally cast, dust-ignition-proof passage way, by rigid metal conduit, or the equivalent.

19.2.23 (II) Wiring leads shall terminate in a terminal box that is integral with, or supplied with and attached to, the motor. The terminal box shall be acceptable for use in the same hazardous location Classes and Groups as the motor.

19.2.24 (II) A terminal box need not be provided if the lead wire seal complies with the requirements in 19.2.13 – 19.2.14, and 19.2.25 – 19.2.28.

19.2.25 (II) For a motor having a shaft height of not more than 140 mm (5-1/2 inches), the depth of the seal shall not be less than 11 mm (7/16 inch). For a motor having a shaft height of more than 140 mm (5-1/2 inches), the depth of the seal shall not be less than 16 mm (5/8 inch), or not less than the outside diameter of the largest wiring lead, which ever is greater.

19.2.26 (II) For a nipple used to retain the sealing compound, the depth of the seal shall not be less than the inside diameter of the nipple, or not less than 16 mm (5/8 inch), whichever is greater.

19.2.27 (II) The depth of the sealing compound in a nipple of 19 mm (3/4 inch) trade size and larger may be less than the inside diameter of the nipple, but not less than 16 mm (5/8 inch) if, upon investigation, it is found to provide the required sealing for the application.

19.2.28 (II) Depending on the compound, the size of the wires, and the construction of the sealing well, a depth of sealing compound greater than specified in 19.2.25 – 19.2.26 might be necessary to form a tight seal.

19.2.29 (II) For a seal, provided in addition to a terminal box complying with the requirements in 19.2.23 – 19.2.24, the seal need not comply with the requirements in 19.2.25 – 19.2.28.

19.3 Equipment grounding terminals and leads

19.3.1 (I, II) A motor provided with a terminal box shall be provided with an equipment grounding terminal in the box. The terminal shall be provided for wire-to-wire or fixed terminal connections, and shall be located so that connection to a field-installed equipment grounding conductor can be made within the same box used to enclose the power-supply connections.

19.3.2 (I, II) Where a terminal box has more than one assembly screw, stud, or equivalent securing means for attachment to the motor frame, one of these screws may be suitable for use as the grounding conductor securing means. If one of the assembly screws or studs is so used, a grounding lug shall be supplied to ensure the integrity of the joint.

19.3.3 (I, II) A means for attaching a terminal for a grounding conductor, such as a screw, a tapped hole, a nut and bolt combination, or the like, may be used provided:

a) The means is not likely to be removed during servicing; and

b) The means is located so that the addition of a terminal will not reduce electrical spacings in the terminal box to a value less than the applicable value in Table 24.

19.3.4 (I, II) Motors not supplied with a terminal box and having provision for connection to the power-supply by leads shall have a grounding lead provided as an integral part of the motor. The grounding lead shall be properly bonded to the frame of the motor and shall be brought out external to the motor through a sealed opening. This will allow the lead to be suitably enclosed and terminated by acceptable means inside a field-installed terminal box suitable for the location.

19.3.5 (I, II) An equipment grounding lead terminal, or stud, shall be bolted, welded, or otherwise securely bonded to the motor frame or supply connection box. The connection of the equipment grounding lead, terminal, or stud shall not rely upon solder, and shall be located so that it is unlikely to be disturbed during inspection of splices or routine servicing of the motor.

19.3.6 (I, II) An equipment grounding lead shall not be smaller than the equipment grounding conductor to be installed in accordance with Annex A, item 1.

19.3.7 (I, II) An equipment grounding terminal shall be capable of securing a conductor of the size required for the particular application in accordance with Annex A, item 1.

19.3.8 (I, II) The surface of an insulated lead intended for the connection of a field-installed equipment grounding conductor shall be green with or without one or more yellow stripes, and no other lead shall be so identified.

19.3.9 (I, II) An insulated grounding conductor larger than 13.3 mm^2 (6 AWG) may be identified by marking the exposed insulation with green tape or green adhesive labels.

19.3.10 (I, II) A wire-binding screw intended for the connection of an equipment grounding conductor shall have a green-colored head that is hexagonal, slotted, or both. A pressure wire connector or stud intended for connection of such a conductor shall be plainly identified, such as being marked "G", "GR", "GND", "GROUND", "GROUNDING", or the like, or by a marking on a wiring diagram provided on the motor. The grounding symbol illustrated in Figure 5 may be used as an identifying means; but, if used alone, the symbol shall be defined in the installation instructions provided with the motor.

19.3.11 (I, II) An equipment grounding stud intended to secure a field-installed pressure wire connector shall be provided with a nut to secure the connector. The stud shall be prevented from turning when the nut is tightened.

20 Cord-Connected Motors

20.1 General

20.1.1 (I, II) A portable motor shall be cord-connected. A submersible sewage-pump motor may be cord-connected. A submersible cord-connected sewage-pump motor may also be provided with an auxiliary flexible cord for control and monitor circuits.

20.1.2 (I, II) A cord-connected motor shall employ extra hard usage flexible cord with a grounding conductor in accordance with Annex A, item 1 and shall be constructed to permit replacement of the flexible cord.

20.1.3 (I, II) The enclosure that contains the connections between the flexible cord conductors and the motor terminals or leads shall comply with the requirements in 20.2.1 – 20.2.4 for Class I motors or 20.2.1 – 20.2.3 and 20.2.5 for Class II motors.

20.1.4 (I, II) The construction of the terminal enclosure shall be such that the temperature rise on the insulation and jacket of the cord does not exceed 35 °C (63 °F) when the motor is operated under full-load conditions.

20.1.5 (I, II) It is permissible for the rise to exceed 35 °C (63 °F) on the insulation and jacket of the cord if the cord used is rated more than 60 °C (140 °F) and if the portion of cord having a rise exceeding 35 °C (63 °F) is within an enclosure.

20.1.6 (I, II) If a power-supply cord is provided, the surface of the insulation of the equipment grounding conductor of the power-supply cord shall be green with or without one or more yellow stripes and no other conductor shall be so identified. The equipment grounding conductor shall be connected to the grounding terminal of the motor by means other than solder.

20.1.7 (I, II) If provided, the attachment plug shall be of the grounding type, acceptable for use in the same hazardous location Classes and Groups as the motor, and connected to the cord as intended.

20.1.8 (I, II) For a portable motor, the power-supply cord need not be provided if the motor is provided with instructions as required by 52.11.

20.2 Terminal enclosure

20.2.1 (I, II) The terminals for connection of the conductors of a flexible cord or cable shall be completely enclosed.

20.2.2 (I, II) If each terminal is of a type that provides a creepage and clearance spacing in accordance with Table 22, is insulated, and confines all strands of the conductor, the terminals shall be enclosed, but the explosion-proof or dust-ignition proof construction specified in Enclosures of Clause 10 and Joints in Enclosure of Clause 11 need not be provided.

20.2.3 (I, II) The entrance for the power-supply cord shall be closed with a molded-rubber, -neoprene bushing, or other suitable means, complying with the requirements in Accelerated Aging Tests on Bushings of Clause 42.

20.2.4 (I) Terminal enclosures not complying with 20.2.2 shall be explosion-proof.

20.2.5 (II) Terminal enclosures not complying with 20.2.2 shall be dust-ignition-proof.

20.3 Conductor seal

20.3.1 (I, II) A cord-connected motor, and a submersible sewage-pump motor, shall have the cord or cable sealed where they enter the enclosure housing the connections between the cord or cable conductors and the motor terminals or leads. The seal shall comply with the requirements in 19.2.13.

20.3.2 (I) The sealing material for a submersible sewage-pump motor shall be resistant to water. Epoxy resins are considered to be resistant to water.

20.4 Packing gland

20.4.1 (I, II) A packing gland (stuffing box) shall be provided at the cord entrance to a terminal enclosure that is constructed as described in 20.2.2.

20.4.2 (I, II) The packing material for the gland shall be polytetrafluoroethylene packing material having a diameter or thickness of not less than 2.4 mm (3/32 inch), or a material having similar characteristics. There shall be a sufficient amount of packing material to completely surround the cord and provide a tightly compressed seal when the packing gland is assembled. The depth of tightly compressed seal shall be at least 16 mm (5/8 inch). The construction and amount of packing shall be such that with the packing properly compressed, the compression nut still has a travel distance of at least 3.2 mm (1/8 inch) without interfering with parts other than packing material.

20.4.3 (I, II) The compression nut shall be mechanically secured against loosening by means of a setscrew or the equivalent.

20.4.4 (I, II) The diametrical clearance between the outer jacket of the power-supply cord and the surrounding cavity for packing material shall not exceed 3 times the diameter of the packing material. At each end of the cavity for the packing material, the diametrical clearance between the opening in the gland parts and the outer jacket of the cord shall not exceed:

a) 1.6 mm (1/16 inch) for packing material less than 6.4 mm (1/4 inch) diameter, or

b) 4.8 mm (3/16 inch) for packing material 6.4 mm (1/4 inch) diameter or larger.

20.4.5 (I, II) All metal surfaces of the packing gland and terminal enclosure adjacent to the cord shall be smooth and shall have rounded edges.

20.4.6 (I, II) If it is necessary to disassemble a packing gland to permit replacement of the power-supply cord, instructions shall be provided with each motor describing the intended assembly of the packing gland to the motor. See 52.10.

20.5 Strain relief

20.5.1 (I, II) A positive mechanical cord clamp shall be provided that:

a) Permits the power-supply cord to be readily replaced; and

b) Prevents stress at the cord connections within the terminal enclosure when subjected to the Cord-Pull Test of Clause 43.

If the cord clamp is threaded to the terminal enclosure, it shall form a tight engagement or shall be secured against turning or loosening by means of a setscrew or the equivalent. The clamp shall be smooth and free from sharp edges that could damage the jacket of the flexible cord.

20.5.2 (I, II) The cord clamp shall be in addition to the packing gland, or bushing.

20.5.3 (I) For a submersible sewage-pump motor, the cord-conductor seal described in 20.3.1 may be used in lieu of a cord clamp if it prevents strain on the connections when tested in accordance with the Cord-Pull Test of Clause 43.

20.6 Bonding for grounding

20.6.1 (I, II) All dead metal parts of a portable motor shall be electrically bonded to the terminal for the connection of the grounding conductor of the power-supply cord. See Electrical-Resistance Test of Clause 41.

20.6.2 (I, II) Dead metal parts that are not likely to become energized, such as a nameplate, need not be bonded if an investigation shows that accumulation of static electricity will not cause ignition of flammable or combustible materials classified as specified in Annex A, item 1, for the Classes and Groups involved.

20.7 Equipment grounding

20.7.1 (I, II) The terminal for the connection of an equipment grounding conductor shall have a permanent identification that is readily recognizable during installation and that is one of the following:

a) A terminal screw that is not removable and has a green-colored head that is hexagonal, slotted, or both;

b) A hexagonal green-colored nut that is not removable from a threaded terminal stud;

c) A visible pressure wire connector having a green-colored body or appendage that is not removable from the connector;

d) The grounding symbol illustrated in Figure 5, also see 20.7.3; or

e) A concealed pressure wire connector identified in accordance with 20.7.2.

20.7.2 (I, II) For a pressure wire connector at the equipment grounding terminal located within the insulating body and not readily visible, the wire-entrance hole for a connection to that terminal shall be identified by one of the following:

a) A distinct green-colored area immediately adjacent to the wire-entrance hole;

b) The letter or word "G", "GR", "GND", “GROUND", "GROUNDING", or "GREEN", distinctively marked immediately adjacent to the wire-entrance hole in letters not less than 1.6 mm (1/16 inch) high; or

c) The grounding symbol illustrated in Figure 5 marked adjacent to the wire entrance hole, also see 20.7.3.

20.7.3 (I, II) If the symbol mentioned in 20.7.1 and 20.7.2 is used alone, the symbol shall be defined in the installation instructions provided with the motor.

20.7.4 (I, II) A readily removable – not staked or otherwise held captive – part of an equipment grounding terminal, such as a setscrew or a clamping member, shall not be colored green or otherwise identified as part of the grounding terminal if such part may be interchanged with a similar part of another terminal on the device.

20.7.5 (I, II) The grounding member of the attachment plug and the grounding conductor of the power-supply cord and dead metal parts of a portable motor required to be bonded in accordance with 20.6.1 shall be electrically connected as determined by test.

20.8 Attachment of threaded parts

20.8.1 (I, II) Threaded parts forming explosion-proof or dust-ignition-proof joints in a terminal enclosure shall be secured against loosening by means of a setscrew or the equivalent located outside of the required threaded joint.

21 Assemblies of Equipment

21.1 General

21.1.1 (I, II) Electrical equipment, such as a generator, electric brake, tachometer, or a bearing thermostat, attached to an electric motor shall be suitable for at least the same hazardous location Class, Group, Division, and a suitable Temperature Class as the motor.

21.2 Electric brake

21.2.1 (I, II) For an electric brake marked to specify that the brake shall be mounted to the motor at the motor manufacturer's factory, the assembly to the motor shall comply with the requirements for joints in the enclosure and shaft openings in this standard.

22 External Fans and Fan Guards

22.1 Materials

22.1.1 (I, II) An external metallic fan shall be constructed of medium brass or aluminum, with a hardness not over Rockwell B66.

22.1.2 (I, II) An external non-metallic fan or guard shall be subjected to the Non-Metallic Fans and Fan Guards Tests of Clause 47.

22.2 Fan-cooled motor

22.2.1 (I, II) Unless the fan of a fan-cooled motor is provided with a guard as specified in 22.2.2 and 22.2.3 that protects against unintentional contact with blades, spokes, or other irregular surfaces of the fan or shaft, it shall be marked as specified in 52.13.

22.2.2 (I, II) For the purpose of these requirements, a guarded, fan-cooled motor is one in which all openings giving direct access to the fan are limited in size by the design of the structural parts, or by screens, grills, expanded metal, and the like.

22.2.3 (I, II) Except as noted in 22.2.4, an opening in a guard or an opening between the guard and the motor shall not permit the passage of a cylindrical rod 19 mm (0.75 inch) diameter, and a probe such as that shown in Figure 7 shall not contact the blades, spokes, or other irregular surfaces of the fan.

22.2.4 (I, II) An opening in a guard or an opening between the guard and the motor may be greater than 19 mm (3/4 inch) wide, but not greater than 38 mm (1-1/2 inch) wide, if the width is not more than 1/8 of the distance to the nearest moving part other than a smooth shaft.

23 Gasoline Submersible Motors

23.1 General

23.1.1 (I) A gasoline submersible motor shall comply with all the requirements given for motors for Class I, Group D locations in this standard.

23.2 Lubrication

23.2.1 (I) For a gasoline submersible motor lubricated by the surrounding product, the end turns of the windings shall be protected with potting compound or shall be sealed from the product.

23.3 Mechanical seal

23.3.1 (I) A mechanical seal construction conforming to the requirements in the Gasoline-Leakage Test, Clause 46, shall be provided at the lead-wire outlet, in addition to the lead seal requirements for motors for Class I locations given in this standard.

24 Leakage Detectors

24.1 Submersible sewage-pump motor

24.1.1 (I) A submersible sewage-pump motor shall be provided with a means of detecting the entrance of water into the enclosure. Instructions for making connections to the leakage-detection circuit shall be provided. There shall be a ready means for periodically testing the operation of the complete circuit, including the wiring to the leakage detectors inside the motor.

24.2 Cord-connected submersible sewage-pump motor

24.2.1 (I) A cord-connected submersible sewage-pump motor may utilize the equipment grounding conductor in the flexible cord as a return path for the leakage-detection circuit, if all of the following conditions are met:

a) The leakage-detection circuit is supplied by an isolating transformer;

b) The leakage-detection open-circuit voltage is 30 V rms, 60 V peak, 60 V dc or less;

c) The circuit current is 0.5 milliampere or less; and

d) The motor is permanently marked with the open-circuit voltage and current ratings of the leakage-detection circuit, and with an indication that the circuit must be an isolated-secondary circuit.

25 Maximum External Surface Temperatures

25.1 (I, II) During the normal and overload operating temperature tests, the exterior surface of a motor shall not exceed the marked operating temperature or temperature class (T-code) in Table 41. See Item (o) of 52.1.

25.2 (I) The marked operating temperature or temperature class (T-code) shall be based on operation in an ambient of 40 °C (104 °F) or higher marked ambient temperature, and on the highest external surface temperature obtained under all operating conditions, including full-load, overload, single-phasing, and locked-rotor operation.

25.3 (II) When operated under full-load and under all operating conditions, including overload, single-phasing, and locked-rotor operation, a motor shall not attain a temperature on any external surface higher than that specified in Table 23.

25.4 (II) The marked operating temperature or temperature class (T-code) shall be based on operation in an ambient of 40 °C (104 °F) or higher marked ambient temperature, and on the highest external surface temperature obtained under all operating conditions with dry or moist dust blanket, including normal full-load, overload, single-phasing, and locked-rotor operation.

25.5 (I, II) For an electric motor intended and marked for use where Class I and Class II conditions exist simultaneously, the marked operating temperature or temperature class (T-code) shall be based on temperatures attained when tested with dust. See 25.3 and 25.4.

26 Devices for Limiting External Surfaces Temperatures

26.1 (I, II) A temperature-limiting device shall be of the type that opens the motor circuit directly, or is connected to operate the controller in the motor circuit. See 52.15.

26.2 (I, II) A motor with an inherent overheating-protective device and marked "Thermally Protected" shall comply with Annex A, item 4 and for Class II the requirements of 26.5.

26.3 (I, II) For a replaceable thermal cut-off intended to prevent overheating of the external surface of the motor enclosure, the cut-off shall not be impaired by aging and shall open the motor circuit under the conditions described in the 72-Hour Locked Rotor Test in 32.6 and in the Arc-Rupturing Test for Thermal Cut-off Device in D.C. Motor Circuit in 39.1. A thermal cut-off complying with Annex A, Item 11 is not considered to be impaired by aging.

26.4 (I, II) A motor may be provided with a temperature-limiting device within the motor enclosure to limit external temperatures. The temperature-limiting device shall not open under full-load (or at service factor) operating conditions within its time rating, operating in air.

26.5 (II) A motor that may exceed the maximum temperatures specified in 25.3 shall be provided with a temperature-limiting device within the motor enclosure. The temperature-limiting device shall prevent external surface temperatures from exceeding the temperature specified in Table 23 when operated in the Dust-Penetration Test – Class II Locations of Clause 35, and the temperature with Dry-Dust Blanket Test – Class II Locations in 32.9 or with Moist-Dust Blanket Test – Group G locations in 32.10.

27 Spacings

27.1 Motors rated 1500 volts or less

27.1.1 (I, II) The spacing between field-wiring terminals of opposite polarity and between a field-wiring terminal and any other uninsulated metal part (dead or live) not always of the same polarity shall not be less than that specified in Table 24 and Table 25. See also 27.1.6 and 27.1.8.

27.1.2 (I, II) For an isolated dead metal part interposed between or in close proximity to:

a) Live parts of opposite polarity;

b) A live part and an exposed dead metal part; or

c) A live part and a dead metal part that may be grounded;

the spacing may be not less than 1.2 mm (3/64 inch) between the isolated dead metal part and any one of the other parts previously mentioned, if the total spacing between the isolated dead metal part and the two other parts is not less than the value specified in Table 24 or Table 25, whichever is applicable. See also 27.1.6 and 27.1.8.

27.1.3 (I, II) At terminal screws and studs to which connection may be made in the field by means of pressure wire connectors, soldering lugs, and the like, the spacings shall not be less than those specified in Table 24 when the connectors, lugs, and the like are in such position that minimum spacings (opposite polarity and to dead metal) exist when the terminals are turned 30° toward each other, or toward other uninsulated parts of opposite polarity or toward grounded metal parts. See also 27.1.7 and 27.1.9.

27.1.4 (I, II) A wiring terminal is considered to be a terminal to which a wire may be connected in the field, unless the wire and a means of making the connection (a pressure terminal connector, soldering lug, solder loop, crimped eyelet, and the like) are factory-assembled and provided as a part of the motor. See 27.1.7 and 27.1.9.

27.1.5 (I, II) Other than at field-wiring terminals, the spacing between uninsulated live parts of opposite polarity and between uninsulated live parts and a dead metal part that is exposed to contact by persons or that may be grounded shall not be less than the value specified in Table 25. See also 27.1.7 and 27.1.9. If an uninsulated live part is not rigidly fixed in position by means other than friction between surfaces or if a movable dead metal part is in proximity to an uninsulated live part, the construction shall be such that the required minimum spacing will be maintained.

27.1.6 (I, II) A capacitor that employs an internal interrupter to protect against expulsion of a flammable dielectric in the event of rupture of the enclosure shall have additional through-air expansion spacings in the axial direction to allow for movement of the terminals. The additional expansion spacing shall be at least 12.7 mm (1/2 inch) through air in addition to the applicable electrical spacings specified in Table 27.

27.1.7 (I, II) The spacing requirements in 27.1.1 – 27.1.5 do not apply to the inherent spacings of a component of the motor, such as a temperature-limiting device or a snap switch. Such spacings are judged on the basis of the requirements for the component in question. The spacing requirements in these paragraphs do apply between a component live part and adjacent metal parts. For a repulsion motor, a repulsion-induction motor, or a repulsion-start-induction motor, the spacing requirements do not apply to the commutator, the brush assembly, and the jumpers that short-circuit the brushes. Any uninsulated conductor of the rotor circuit is regarded as a dead metal part with respect to the stator circuit, and the appropriate spacing is required between uninsulated stator and rotor conductors.

27.1.8 (I, II) The spacings between parts of the motor and a temperature-limiting device mounted within the motor enclosure shall not be less than that specified in Table 28. See 27.1.9.

27.1.9 (I, II) An insulating barrier, as described in 27.1.10 – 27.1.13, may be provided as part of, or in lieu of, the spacings specified in 27.1.1 – 27.1.5 and 27.1.7.

27.1.10 (I, II) An insulating barrier or liner used as the sole separation between an uninsulated live part and a grounded dead metal part, including the enclosure, or between uninsulated live parts of opposite polarity, shall be of material that is acceptable for the mounting of uninsulated live parts and is not less than 0.71 mm (0.028 inch) thick.

Note: (I, II) Fiber having a thickness of not less than 0.71 mm (0.028 inch) may be used as the sole separation between the enclosure and an uninsulated metal part electrically connected to a grounded-circuit conductor, if the fiber is not exposed to an operating temperature of more than 90 °C (194 °F).

27.1.11 (I, II) Barriers as referred to in 27.1.9 do not pertain to slot liners or slot cells in the motor insulation system.

27.1.12 (I, II) An insulating barrier or liner used in addition to an air space in lieu of the required spacing through air shall not be less than 0.71 mm (0.028 inch) thick. If the barrier or liner is of fiber, the air space shall not be less than 0.8 mm (1/32 inch), and if the barrier or liner is of material not acceptable for the mounting of uninsulated live parts, the air space provided shall be adequate for the application.

27.1.13 (I, II) A barrier or a liner used in addition to not less than one-half the required spacing through air may be less than 0.71 mm (0.028 inch) thick, but not less than 0.33 (0.013 inch) thick, if the barrier or liner is of material that is:

a) Acceptable for the mounting of uninsulated live parts;

b) Of adequate mechanical strength if exposed or otherwise subject to mechanical damage;

c) Reliably held in place; and

d) Located so that it will not be affected adversely by operation of the equipment in service.

27.1.14 (I, II) Insulating material having a thickness less than that specified in 27.1.10 and 27.1.12 may be used if it has equivalent properties.

27.2 Motors rated more than 1500 volts

27.2.1 (I, II) In a motor rated more than 1500 V, there shall be no uninsulated live parts with spacings less than those given in Table 26.

28 Test Voltages and Test Conditions

28.1 (I, II) The performance of a motor shall be investigated by subjecting representative samples to all the applicable tests described in Variable-Frequency Inverter-Drive Motors of Clause 30 and Temperature Tests – General of Clause 31.

28.2 (I, II) Except as noted in 28.3, for the tests described in Temperature Tests – General of Clause 31 the motor shall be mounted in the intended operating position, when possible, and coupled to a generator, dynamometer, or other loading equipment, and operated at rated frequency and at full rated load or service factor load based on the voltage specified in Table 29.

28.3 (I, II) When an integral horsepower d-c motor is tested as described in 32.10.3 – 32.10.6, such tests may be conducted using a d-c power supply that:

a) Is capable of starting the motor under full load, with starting equipment, if necessary;

b) Maintains the supply voltage specified in Table 29 at the motor terminals when the motor is operated as described in 28.4; and

c) Under locked-rotor conditions, maintains an armature current that is ten times the rated full-load current of the motor at a voltage that may be other than that specified in Table 29.

28.4 (I, II) With regard to the requirements in Normal Temperature Test in 32.1, rated load is considered to exist when the motor is loaded to at least:

a) For a motor other than service-factor duty motor:

1) Rated horsepower; or

2) Marked full load amperes if the motor does not have a horsepower rating or the horsepower can not be measured during testing;

b) For a service-factor duty motor:

1) Rated horsepower times service factor; or

2) Marked full load amperes times service-factor if the motor does not have a horsepower rating or the horsepower cannot be measured during testing; and

c) For a line of motors, as specified in (a) or (b), as applicable, or higher if necessary to attain rated temperature rise on the windings when the motor is operated in air.

28.5 (I, II) For fan-duty and air-over motors with temperature-limiting devices full rated-load shall be determined as follows:

a) A fan-duty or air-over motor with a temperature-limiting device intended to limit external surface temperatures shall be operated at full-rated voltage with no load.

b) If the temperature-limiting device opens, the motor shall be operated at a reduced voltage with no load until the point is found where the temperature-limiting device does not open. Ninety percent of the measured current value shall be considered the normal full-load condition for the temperature tests.

c) If the temperature-limiting device does not open when the motor is operated at full voltage with no load, the load shall be increased gradually until the temperature protection opens. The trip current shall be noted. The no-load current shall be compared to 90 % of the value of the trip current. The higher of the two values shall be considered the normal full-load condition for the temperature tests.

28.6 (I, II) The tests described in Temperature Tests – General, Clause 31, may be conducted at any ambient temperature in the range 10 °C – 40 °C (50 °F – 104 °F). Maximum surface temperatures measured in a test conducted in an ambient less than 40 °C shall be increased by the amount of the difference between the lower ambient and 40 °C. For ambients greater than 40 °C, the test ambient shall not be less than the marked ambient minus 30 °C.

28.7 (I, II) In the U.S., a motor that is not provided with a temperature-limiting device shall be tested at an ambient of 10 °C – 40 °C (50 °F – 104 °F) or at rated ambient if higher than 40 °C.

28.8 (I, II) In the U.S., for a motor with a temperature-limiting device, the normal-load tests shall be conducted at 40 °C (104 °F) or at a higher ambient if the motor is so rated.

29 Instrumentation – Temperature Measurements

29.1 (I, II) Temperatures shall be measured by thermocouples as necessary to determine the maximum external surface temperature.

29.2 (I, II) Thermocouples shall be located at various points on the outside of the motor enclosure and at other points where temperature measurements are required.

30 Variable-Frequency Inverter-Drive Motors

30.1 (I, II) A motor intended for use with variable-frequency inverter drives shall comply with the requirements in accordance with Annex A, item 9, and in this standard:

a) Throughout the marked frequency range; and

b) With each type of inverter with which the manufacturer specifies that the motor can be used; for example, voltage-source inverter (VSI), current-source inverter (CSI), and pulse-width modulated inverter (PWM).

30.2 (I, II) Testing with each type of inverter is not necessary if it can be determined that testing with one type of inverter is also representative of operation with another type or types of inverter.

31 Temperature Tests – General

31.1 (I, II) The temperature tests to which a motor shall be subjected depends upon whether a temperature-limiting device is provided for the purpose of limiting the external surface temperatures and, if provided, the type of temperature-limiting device as specified in Table 30. For an air-over or fan-duty motor with a temperature-limiting device, also see 28.5.

31.2 (I, II) When the machine is provided with a temperature-limiting device used for the purpose of limiting the external surface temperature, the protective device shall not be defeated for the tests.

31.3 (I, II) A motor shall be subjected to the applicable tests described in 32.1 – 32.10 and shall not exceed the limits specified in Maximum External Surface Temperature of Clause 25 during operation. This maximum temperature shall also not be exceeded in the interval after the motor is disconnected from the circuit, whether disconnected manually or by an integral temperature-limiting device, if provided.

31.4 (I, II) Single-phase operation may be omitted and locked-rotor operation may be conducted at marked locked-rotor current and time for a motor that is:

a) Rated higher than 600 V;

b) Provided with a temperature-limiting device that limits external temperatures under a gradual running overload condition; and

c) Permanently marked in accordance with 52.21.

32 Temperature Tests on Sinewave Power for Single Speed or Multi-Speed Motors

32.1 Normal temperature test

32.1.1 (I, II) The motor shall be connected to a generator, dynamometer, or other loading equipment. A continuous-duty rated motor shall be operated at the voltage specified in Table 29 and at full-rated load or service-factor load, if so marked, until thermal equilibrium occurs. An intermittent-duty motor shall be operated at the voltage specified in Table 29 at full-rated load or service-factor load, if so marked, and at the rated duty cycle until the maximum temperatures are attained. A short-time-duty motor shall be operated at full-rated load or service-factor load, if so marked, for the rated duty-time. A torque motor shall be operated under locked-rotor conditions.

32.2 Running-overload test

32.2.1 (I, II) A motor that is provided with a temperature-limiting device in the motor circuit or control circuit intended to limit the external surface temperature shall be connected and operated as described in 32.1, except the load shall be gradually increased until the temperature-limiting device trips. A short-time-duty motor shall be operated at full rated load or service-factor load until the temperature-limiting device trips; if the temperature stabilizes without the device tripping, the load shall be gradually increased until it does trip.

32.3 Running-overload to burnout test

32.3.1 (I, II) A motor that is not provided with a temperature-limiting device shall be connected and operated as described in 32.1 until normal-load temperatures are reached. The load shall then be gradually increased until burnout occurs or the temperature no longer increases.

32.4 Single-phasing test

32.4.1 (I, II) A multi-phase motor that is provided with a temperature-limiting device in the motor circuit or control circuit intended for the purpose of limiting the external surface temperatures shall be connected and operated as described in 32.1 until normal-load temperatures are reached. The motor shall then be subjected to single-phasing operation until the temperature-limiting device opens or equilibrium temperatures are attained. The single-phasing test shall be conducted three times using a different combination of two or three phases for each test.

32.4.2 (I, II) The single-phasing test need be performed only once using one combination of two of the three leads if a 3-phase protector in the motor circuit is used.

32.5 Locked-rotor test

32.5.1 (I, II) A motor that is provided with a temperature-limiting device in the control circuit intended for the purpose of limiting the external surface temperatures and which is not marked with a safe stall time shall be operated as described in 32.1 until normal-load temperatures are reached. The rotor of the motor shall then be locked and the motor operated until:

a) The temperature-limiting device opens or the motor reaches thermal equilibrium.

32.5.2 (I, II) A rotor limited motor for which a safe stall time is specified by the manufacturer and marked on the nameplate shall be operated as described in 32.1 until normal-load temperatures are reached. The rotor of the motor shall then be locked and the motor operated until the safe stall time is reached or until the temperature-limiting device trips, if the motor is provided with a device to limit the external surface temperatures.

32.6 72-Hour locked-rotor test

32.6.1 (I, II) A motor that is provided with a temperature-limiting device in the motor circuit intended for the purpose of limiting the external surface temperatures shall be operated as described in 32.1 until normal-load temperatures are reached. The rotor of the motor shall then be locked. A motor with an automatically reset temperature-limiting device shall be permitted to cycle on-and-off for 72 hours. A motor with a manually reset temperature-limiting device shall be operated as rapidly as possible until maximum temperatures are reached, or for a maximum of 10 cycles of operation, whichever occurs first. A motor provided with a thermal cut-off shall be subjected to at least three locked-rotor tests with a new cut-off being used for each test.

32.7 Locked-rotor endurance test

32.7.1 (I, II) – A motor that is provided with a temperature-limiting device in the motor circuit shall be connected to a power-supply circuit of 100 – 110 % of the voltage specified in Table 29. The enclosure of the motor shall be connected to ground through a 30-ampere cartridge fuse. The rotor of the motor shall be locked and the motor operated as described in 32.7.2 or 32.7.3 depending on whether the temperature-limiting device is automatic or manually operated.

32.7.2 (I, II) – A motor with an automatically reset temperature-limiting device shall be operated for 15 days. There shall be no permanent damage to the motor, including excessive deterioration of the insulation.

32.7.3 (I, II) – An automatically reset temperature-limiting device may permanently open the circuit before 15 days of operation if:

a) It is specifically intended to do so; and

b) Testing of three samples show that it will do so consistently and without grounding to the motor frame, damage to the motor, or evidence of any risk of fire.

32.7.4 (I, II) – A manually reset temperature-limiting device shall open the motor circuit for 50 operations without damage to the motor or itself. The temperature-limiting device shall reclose as quickly as it can be made to do so after each opening of the circuit. There shall be no permanent damage to the motor, including excessive deterioration of the insulation.

32.8 Air test

32.8.1 (I, II) The motor shall be subjected to the tests in Table 30.

32.8.2 (I, II) When performing the Normal Temperature Test in 32.1, any temperature-limiting device installed for the purpose of limiting surface temperatures provided with the motor shall not trip.

32.9 Dry-dust blanket test

32.9.1 (II) The motor shall be installed in a test chamber as described in 35.5 and operated under normal load while exposed to the circulating dust/air atmospheres until the blanket of dust on the motor is stabilized.

32.9.2 (II) The motor shall then be subjected to the tests specified in Table 30.

32.9.3 (II) When performing the Normal Temperature Test described in 32.1, the load for the test shall be the same as that when tested in air. The test is concluded when either:

a) Thermal equilibrium occurs;

b) A temperature-limiting device intended for the purpose of limiting the external surface temperature trips, provided the difference between the rates of rise of the winding temperature and frame temperature does not exceed 3 °C per hour at the time of trip, or the load shall be reduced and the test repeated; or

c) Burnout occurs if no temperature-limiting device is provided.

32.9.4 (II) During tests, the dust in contact with the motor enclosure shall not ignite or discolor (from heat) and the temperature of the exterior surface of the motor enclosure shall not exceed the temperature specified in Table 23.

32.9.5 (II) For a motor intended for Class II, Group F, Group G, Groups F and G, or Groups E, F and G locations, the tests shall be conducted with grain dust. If the motor is intended for Class II, Group E locations only, the tests shall be conducted with magnesium or grain dust.

32.9.6 (II) The tests with moist-dust in 32.10 may be performed in lieu of testing with dry-dust, except when the motor is intended for Class II, Group E locations only.

32.10 Moist-dust blanket test – Group G locations

32.10.1 (II) A motor for Class II, Group G locations shall be subjected to the Temperature Tests specified in Table 30 with the motor packed with moisture-laden dust consisting of approximately 45 % finely-sifted grain dust and 55 % water, by weight.

32.10.2 (II) The moisture-laden dust shall be packed on the motor to the approximate accumulated depths attained in the Dry-Dust Blanket Temperature Test in 32.9 and allowed to dry.

32.10.3 (II) To obtain maximum external surface temperatures, a motor without a device for limiting the external surface temperature shall be operated as described in 28.2, except that a d-c motor may be operated as described in 28.3. The supply voltage shall be as specified in Table 29.

32.10.4 (II) The motor shall then be subjected to the tests specified in Table 30.

32.10.5 (II) When performing the Normal Temperature Test described in 32.1 the load for the test shall be the same as that when tested in air. The test is concluded when either:

a) Thermal equilibrium occurs;

b) A temperature-limiting device intended for the purpose of limiting the external surface temperature trips, provided the difference between the rates of rise of the winding temperature and frame temperature does not exceed 3 °C per hour at the time of trip, or the load shall be reduced and the test repeated; or

c) Burnout occurs if no temperature-limiting device is provided.

32.10.6 (II) The temperatures on the exterior surfaces of the motor shall not exceed 165 °C (329 °F) under all operating conditions specified in Table 30. This maximum temperature shall not be exceeded in the interval after the motor is disconnected from the circuit, whether disconnected manually or by an integral temperature-limiting device, if provided.

32.10.7 (II) The dust in contact with the motor shall not char or ignite during the test.

33 Temperature Tests for Variable-Frequency Inverter-Drive Motors

33.1 Normal temperature test

33.1.1 (I, II) A continuous-duty rated motor shall be operated at the voltage specified in Table 29 and at full rated load or service-factor load, if so marked, until thermal equilibrium occurs. For an intermittent-duty motor, the motor shall be operated at the voltage specified in Table 29 at the full-rated load or service-factor load, if so marked, and at the rated duty cycle until the maximum temperature is attained. A short-time duty motor shall be operated at full-rated load or service-factor load, if so marked, for the rated-duty time. A torque motor shall be operated under locked-rotor conditions.

33.1.2 (I, II) The test in 33.1.1 shall be performed at rated load or service-factor load, if so marked, for each of the following frequencies which is applicable to the markings for the motor:

a) The highest frequency for any marked variable torque range;

b) The lowest and highest frequency for any marked constant torque range;

c) The lowest and highest frequency for any marked constant horsepower range; and

d) Any other frequency necessary to demonstrate motor performance for other types of torque-speed profile.

33.2 Running-overload test

33.2.1 (I, II) A motor that is provided with a temperature-limiting device in the motor circuit or control circuit intended to limit the external surface temperature shall be connected and operated as described in 33.1.1 at each frequency identified in 33.1.2, except the load shall be gradually increased until the temperature-limiting device trips. A short-time-duty motor shall be operated continually at full-rated load or service-factor load, if so marked, until the temperature-limiting device trips; if the device does not trip, the load shall be gradually increased until it does trip.

33.3 Running-overload to burnout test

33.3.1 (I, II) A motor that is not provided with a temperature-limiting device shall be connected and operated as described in 33.1.1 at the lowest test frequency identified in 33.1.2 until normal-load temperatures are reached. The load is then to be gradually increased until burnout occurs. The frequency shall be increased if necessary to obtain overload conditions. The inverter must be of sufficient rating to provide the motor overload requirement.

33.3.2 (I, II) The test may be conducted using a 60 Hertz fixed frequency sinusoidal power supply, if the device is so rated, with any external fan being removed, with the agreement of all concerned.

33.4 Locked-rotor test

33.4.1 (I, II) If the motor is provided with a temperature-limiting device intended for the purpose of limiting the external surface temperature, the motor is intended for use in a multi-motor drive system or for use with an inverter of sufficient size to provide locked-rotor conditions, and the motor was not subjected previously to the Locked-Rotor Test in 32.5, then the motor shall be tested under locked-rotor using a Sinewave power source following the procedure in 32.5.

33.5 Air test

33.5.1 (I, II) The motor shall be subjected to the tests specified in Table 30.

33.5.2 (I, II) When performing the Normal Temperature Test in 33.1, any temperature-limiting device installed for the purpose of limiting surface temperatures provided with the motor shall not trip.

33.6 Dry-dust blanket test

33.6.1 (II) The motor shall be installed in a test chamber as described in 35.5 and operated under normal load while exposed to the circulating dust/air atmospheres until the blanket of dust on the motor is stabilized.

33.6.2 (II) The motor shall then be subjected to the tests specified in Table 30.

33.6.3 (II) When performing the Normal Temperature Test described in 33.1 the load for the test shall be the same as that when tested in air. The test is concluded when either:

a) Thermal equilibrium occurs;

b) A temperature-limiting device intended for the purpose of limiting the external surface temperature trips, provided the difference between the rates of rise of the winding temperature and frame temperature does not exceed 3 °C per hour at the time of trip, or the load shall be reduced and the test repeated; or

c) Burnout occurs if no temperature-limiting device is provided.

33.6.4 (II) During this test, the dust in contact with the motor enclosure shall not ignite or discolor (from heat) and the temperature of the exterior surface of the motor enclosure shall not exceed the temperature specified in Table 23.

33.6.5 (II) For a motor intended for Class II, Group F, Group G, Groups F and G, or Groups E, F and G locations, the tests shall be conducted with grain dust. If the motor is intended for Class II, Group E locations only, the tests shall be conducted with magnesium or grain dust.

33.6.6 (II) The tests with moist-dust in 33.7 may be performed in lieu of testing with dry-dust, except when the motor is intended for Class II, Group E locations only.

33.7 Moist-dust blanket test – Group G locations

33.7.1 (II) A motor for Class II, Group G locations shall be subjected to Temperature Tests with the motor packed with moisture-laden dust consisting of approximately 45 % finely-sifted grain dust and 55 % water, by weight.

33.7.2 (II) The moisture-laden dust shall be packed on the motor to the approximate accumulated depths attained in the Dry-Dust Blanket Temperature Test and allowed to dry.

33.7.3 (II) To obtain maximum external surface temperatures, a motor without a device for limiting the external surface temperature shall be operated as described in 28.2. The supply voltage shall be as described in Table 29.

33.7.4 (II) The motor shall then be subjected to the tests specified in Table 30.

33.7.5 (II) When performing the Normal Temperature Test described in 33.1 the load for the test is that corresponding to the torque level for rated load when the motor was tested in air. The test is concluded when either:

a) Thermal equilibrium occurs;

b) A temperature-limiting device intended for the purpose of limiting the external surface temperature trips, provided the difference between the rates of rise of the winding temperature and frame temperature does not exceed 3 °C per hour at the time of trip, or the load shall be reduced and the test repeated; or

c) Burnout occurs if no temperature-limiting device is provided.

33.7.6 (II) The temperatures on the exterior surfaces of the motor shall not exceed 165 °C (329 °F) under all operating conditions specified in Table 30.

33.7.7 (II) The dust in contact with the motor shall not char or ignite during the test.

34 Dielectric-Voltage Withstand Test

34.1 (I, II) A motor shall withstand without breakdown the application of a voltage test potential between live parts and dead-metal parts. If the motor is equipped with an auxiliary device, such as a thermostat or a heater, the auxiliary device circuit shall also withstand without breakdown the application of a voltage test potential between live parts and dead-metal parts.

34.2 (I, II) The voltage test potential values shall be in accordance with Condition A of Table 40.

34.3 (I, II) The test equipment, the output of which can be varied, shall have a voltmeter to measure directly the applied output potential.

34.4 (I, II) The motor shall be at room ambient temperature or higher.

34.5 (I, II) The Dielectric Voltage Withstand Test of the motor winding is conducted by applying the required voltage test potential between the power leads and the motor enclosure with all auxiliary device circuits grounded to the enclosure.

34.6 (I, II) The applied voltage test potential shall be increased from zero until the required test value is reached, and shall be held at the value for 1 minute. The increase in the applied potential shall be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter.

35 Dust-Penetration Test

35.1 (II) A motor for Class II locations shall be subjected to the Dust-Penetration Test described in 35.3 – 35.10. Also see 35.12.

35.2 (I, II) A dust-penetration test is not required if:

a) The motor is for use in Class II, Group F, Group G, or both, in addition to Class I;

b) The joints in the motor enclosure comply with the requirements in Annex C; and

c) The Class I shaft openings are located to the outside of the bearing chambers and have a diametrical clearance of not more than 0.41 mm (0.016 inch) for a 25.4 mm (1 inch) length of path and not more than 0.56 mm (0.022 inch) for a 38.1 mm (1-1/2 inch) length of path with proportional intermediate values.

35.3 (II) The motor shall exclude dust. The dust in contact with the enclosure shall not ignite or become charred as determined by a color change of the dust.

35.4 (II) For grain dust, a barely visible film of dust may enter the bearing housing if there is no excessive heating of the bearing and an inner shaft path complying with Table 14 is provided between the bearing and the interior of the motor.

35.5 (II) The motor shall be installed in a test chamber of a size sufficient to permit thermal equilibrium of the motor at rated load, see 32.1 and 33.1, and to permit free circulation of the dust-air mixture around the motor during the test. The test chamber shall be provided with a cover and with dust-air inlet and outlet connections.

35.6 (II) During this test, the motor shall be operated as described in 32.1 and 33.1, while exposed to a circulating dust-air atmosphere in the test chamber. The motor then shall be allowed to cool to ambient temperature. This procedure shall be repeated for 6 cycles of operation and for at least 30 hours.

35.7 (II) Grain dust consisting of wheat or corn dust, or both, that has passed through a 150 micron (100 mesh) wire cloth shall be used in the test if the motor is for use in Class II, Group F, Group G, or Groups F and G locations.

35.8 (II) Magnesium dust, all of which has passed through a 250 micron (60 mesh) wire cloth, 66 % of which has passed through a 150 micron (100 mesh) wire cloth, 22 % of which has passed through a 75 micron (200 mesh) wire cloth, shall be used in the test, if the motor is for use in Class II, Group E, Groups E and F, Groups E and G, or Groups E, F and G locations.

35.9 (II) As an alternative to the use of magnesium dust in 35.8, a dust known as 140-mesh silica flour commercially may be used. The purity of the test-dust shall be 97 % to 99 % SiO_2 and having composition and particle size as follows:

a) 100 % has passed through an 150 mm (100 mesh) ASTM sieve;

b) 98 % of which has passed through an 106 mm (140 mesh) ASTM sieve;

c) 90 % of which has passed through a 75 mm (200 mesh) ASTM sieve; and

d) 75 % of which has passed through a 45 mm (325 mesh) ASTM sieve.

35.10 (II) Where silica flour, see (35.9), is used, the procedure shall be as follows:

a) The test-dust shall be maintained in suspension inside the test chamber by an air velocity of between 30.5 and 152.4 m/min; and

b) The dust density shall be maintained between 3.6 and 8.9 g/m^3.

35.11 (II) The wire cloth specified in 35.7 – 35.9 shall conform to the dimensional requirements of Standard Specification for Wire-Cloth Sieves for Testing Purposes in accordance with Annex A, item 15.

35.12 (II) A motor that has joints that do not comply with the requirements in Joints in Enclosures, Section 11, shall be tested as described in 35.3 – 35.10, except that:

a) The joint widths shall be reduced to 75 % of the minimum to be provided in production; and

b) The joint clearances shall be increased to 150 % of the maximum to be provided in production.

36 Explosion Test

36.1 General

36.1.1 (I) An electric motor having joints and shaft openings complying with Joints in Enclosure of Clause 11 and Shaft Openings of Clause 13 shall be subjected to explosion tests to determine:

a) The maximum explosion pressure effects of the gas-air mixtures specified in Table 31;and

b) The flame propagation effects of the gas-air mixtures specified in Table 32 or Table 33.

36.1.2 (I) Explosion tests are not required if the motor construction complies with the following:

a) The joints in the enclosure are of the threaded, cylindrical, or rabbet type that comply with the requirements in Annex C;

b) The shaft openings comply with the requirements in Annex C;

c) There are no internal fans;

d) There are no through holes in or over the stator frame core or in the rotor;

e) The enclosure complies with the strength requirement in 10.4;

f) The motor is not intended for use at an ambient temperature lower than minus 25 °C (minus 13 °F) nor higher than 65 °C (149 °F); and

g) There are no normally arcing electrical parts within the enclosure.

36.1.3 (I) For the explosion tests, the motor shall be installed in a test chamber provided with inlet and outlet connections to the lines carrying the explosive mixture. The motor enclosure shall be provided with pressure-recording devices, spark plugs, and connections to the inlet and outlet lines carrying the explosive mixtures.

36.2 Explosion pressure test

36.2.1 (I) The explosive mixture shall be allowed to flow into the motor enclosure until all of the original air has been displaced. The flow shall be stopped and the valves at the inlets and outlets to the motor shall be closed. The mixture shall then be ignited inside the motor.

Products intended and marked for an ambient of lower than minus 25 °C shall be tested at 5 °C ±5 °C below the marked lower temperature.

In Canada, products intended and marked for an ambient of lower than minus 50 °C shall be tested at 5 °C ±5 °C below the marked lower temperature.

36.2.2 (I) Ignition of the explosive gas-air mixture shall be by either the use of:

a) A spark plug (or plugs); or

b) A normally arcing electrical device (e.g., a starting switch, a line switch, or other arcing and sparking devices installed within the motor enclosure).

36.2.3 (I) The explosion pressure of each ignition of the explosive gas-air mixture shall be recorded.

36.2.4 (I) Terminal boxes having provisions for connection to 1-1/2 and smaller trade size conduit shall be tested with the lengths of conduit specified in Table 34 if the compartment does not contain components capable of initiating an internal explosion due to arcing, sparking or thermal effects under normal conditions.

36.2.5 (I) Terminal boxes, tested without lengths of conduits, shall be marked in accordance with 52.1(p) which requires field-installed conduit sealing fittings.

36.2.6 (I) During the explosion pressure tests:

a) The enclosure shall withstand the internal explosion pressure without damage that may weaken the integrity of the enclosure; and

b) Internal fans, air deflectors, and other parts, shall not be permanently distorted.

36.3 Low-ambient explosion pressure tests

36.3.1 (I) For explosion-proof equipment specified and marked for use at ambient temperatures lower than minus 25 °C (minus 50 °C in Canada), the explosion tests shall be determined by one of the following methods:

a) For explosion-proof equipment specified and marked for use at ambient temperatures lower than minus 25 °C (minus 50 °C in Canada), the explosion tests shall be performed at 5° lower than the rated minimum ambient temperature, ±5 °C (±9 °F). When the ambient specified is such that common materials within the Group are not flammable, a test temperature shall be specified that represents the minimum temperature at which the test gasses shown in Table 31 remain gasses, or

b) The reference pressure shall be determined at room ambient temperature using the defined test mixture(s), but at increased pressure. The absolute pressure of the test mixture (P) shall be calculated by the following formula, using T_a in °C:

$$P = 100\left[\frac{293}{(T_a,\ \min + 273)}\right] \text{(kPa)}$$

or

$$P = 14.6959\left[\frac{293}{(T_a,\ \min + 273)}\right] \text{(psi)}$$

36.4 Flame propagation test

36.4.1 (I) The explosive mixture shall be allowed to flow into the motor enclosure and the surrounding test chamber until all of the original air has been displaced. The flow shall be stopped and the valves at the inlets and outlets to the motor and test chamber shall be closed. The mixture shall then be ignited inside the motor.

36.4.2 (I) A motor for Class I, Group B locations that has flat or rabbet type joints shall be tested with the joints reduced to 75 % of the minimum production joint width and the joints shimmed to give a clearance of 50 % more than the maximum production clearance.

36.4.3 (I) A motor for Class I, Group B locations that has threaded joints shall be tested with a threaded engagement of 75 % of the total number of engaging threads to be used, and the lateral clearance at the threaded joints shall be the maximum obtainable in production, including maximum manufacturing tolerances.

36.4.4 (I) A motor for Class I, Group B locations that has a free internal volume greater than 0.5 dm^3 (30 cubic inches) and has a shaft passing through the enclosure shall be tested with the metal-to-metal shaft path reduced to 75 % of the total path length.

36.4.5 (I) Ignition of the explosive gas-air mixture shall be by the use of a spark plug (or plugs).

36.4.6 (I) The enclosure shall prevent the passage of flame or sparks that may ignite the surrounding explosive atmosphere during the flame propagation tests.

36.5 Elevated ambient flame propagation tests

36.5.1 For explosion-proof equipment specified and marked for use at ambient temperatures greater than 60 °C (65 °C in Canada), flame propagation tests shall be conducted under one of the following conditions:

a) At a temperature not less than the specified maximum ambient temperature; or

b) At normal ambient temperature using the defined test mixture at increased pressure according to the factors in Table 36; or

c) At normal atmospheric pressure and temperature, but with the test gap increased by the factors noted in Table 36.

These tests are in addition to the explosion tests required to determine compliance with 36.2 and 36.4.

36.5.2 All test sample joints shall be based upon the manufacturers maximum specified gap, and tested with the minimum specified joint length. Specially prepared test samples having modified joint lengths, gaps and engagements shall be employed. For Group B test factors per 36.4.2, 36.4.3 or 36.4.4, as applicable, shall be introduced into the test pressure or test gap in addition to the test factors above.

36.6 Exceptions for non-standard joints

36.6.1 (I) The joint clearance (gap) may be larger than that required in Joints in Enclosure of Clause 11 and Shaft Openings of Clause 13, provided the enclosure meets the flame propagation test in 36.4 with the gap increased as follows:

a) Increase the test gap to 180 % of the design maximum gap instead of 150 % of the design maximum gap when testing in accordance with Table 32; or

b) Increase the test gap to at least 120 % of the design maximum gap instead of the design maximum gap when testing in accordance with Table 33.

37 Over Pressure Test on Enclosures

37.1 (I) An enclosure shall withstand for at least 10 seconds, without rupture or permanent distortion, an Over Pressure Test (applied hydrostatically) based on the internal explosion pressure as specified in 10.4.3. The safety factor shall be as specified in Table 35.

37.2 (I) The over pressure test may be omitted if calculations indicated a factor of safety as specified in 10.4.3 for the enclosing parts and bolts based on the explosion pressure specified in 10.4.4 and the tensile strength of the materials.

37.3 (I) The hydrostatic pressure shall be gradually applied until the required internal pressure is reached. Gaskets or other acceptable means may be used if necessary to prevent leakage of water during application of pressure.

38 Dynamic Pressure Test

38.1 For explosionproof enclosures not subject to pressure piling and intended for routine testing during production, the Dynamic Pressure Test shall be permitted as an alternative to the Hydrostatic Pressure Test. The dynamic tests shall be carried out in such a way that the maximum pressure to which the enclosure is subjected is 1.5 times the reference pressure.

38.2 The test shall be made once except for Group B, in which case the test shall be made three times with each gas mixture as follows:

– Group D: 4.6 ±0.3 % propane

– Group C: 8 ±0.5 % ethylene

– Group B: 31 ±1 % hydrogen

38.3 Following the test, there shall be no permanent deformation or damage and joints shall not be permanently enlarged.

38.4 (I, II) The fluid handling section of a canned motor pump shall withstand a pressure equal to 1.5 times the operating pressure for 10 minutes without evidence of leakage into any electrical compartment.

39 Tests on Temperature-Limiting Devices for Limiting External Surface Temperature

39.1 Arc-rupturing tests for thermal cut-off device in D.C. motor circuit

39.1.1 (I, II) In addition to the test specified in 32.6, a d-c motor provided with a thermal cut-off connected directly in series with the windings of the motor shall be subjected to an arc-rupturing test. At least three cut-offs, in turn, shall be connected in series with only the shunt winding of the motor. With the shunt-winding circuit connected to an electrical supply, the ambient air temperature shall be gradually increased until the cut-off operates. There shall be no burning of the cut-off and no striking of an arc to ground.

39.2 Temperature-limiting device in the motor-control circuit

39.2.1 (I, II) There shall be no electrical or mechanical failure or any undue burning, pitting or welding of the contacts of a temperature-limiting device when subjected to the test specified in 39.3 – 39.5.

39.3 Overload test

39.3.1 (I, II) A temperature-limiting device shall be subjected to 50 cycles of operation (break only) at one of the overload-test voltages and using the associated electromagnet load as specified in Table 38. A new sample may be used for each overload-test potential for which the device is rated.

39.4 Endurance test

39.4.1 (I, II) A temperature-limiting device shall be subjected to 10,000 cycles of operation (break only). The test voltage and the associated electromagnet load shall be as specified in Table 38. A new sample may be used for each endurance-test potential for which the device is rated. However, each device shall be subjected to the appropriate Overload Test before the Endurance Test is conducted. A device that has been tested for 6,000 cycles of make-and-break operation is considered to comply with this requirement.

39.5 Calibration test

39.5.1 (I, II) A temperature-limiting device shall be calibrated in accordance with the requirements covering the component. The device shall be calibrated both before and after the Overload Test and Endurance Test.

40 Secureness Test on Conduit Hubs

40.1 (I, II) A conduit hub not integrally cast with a metal enclosure shall withstand the torque specified in Table 39 applied to a short length of rigid metal conduit threaded into the hub of the enclosure in the intended manner, without turning in the enclosure and without stripping of any threads.

41 Electrical-Resistance Test

41.1 (I, II) The resistance of the grounding path between the terminal for connection of the grounding conductor of the power-supply cord and dead metal parts of a portable motor required to be bonded in accordance with 20.6 shall not exceed 0.1 ohm.

41.2 (I, II) The resistance may be determined by any convenient method except that if unacceptable results are recorded, either a direct or alternating current of 15 Amperes shall be passed from the grounding terminal to all dead metal parts required to be bonded in accordance with 20.6, and the resulting drop in potential shall be measured between these two points. The resistance in ohms shall be determined by dividing the drop in potential in volts by the current in amperes passing between the two points.

41.3 (I, II) For threaded joint surfaces, where paint or coating is applied, the potential drop between two points located across the point when 50 Amperes of direct or alternating current are passed between them shall result in a calculated resistance that is no greater than 0.003 ohm. For a conduit opening, one point shall be on the enclosure and the other on a length of conduit connected to the opening and located 1.6 mm (1/16 inch) from the enclosure.

42 Accelerated-Aging Test on Bushings

42.1 A molded-rubber or -neoprene bushing provided at the cord entrance to the terminal enclosure of portable equipment shall be exposed in an air oven for 70 hours at 100 °C ±2 °C (212 °F ±3.6 °F). See the Standard for Gaskets and Seals, UL 157, for oven aging conditions for service temperatures exceeding 60 °C (140 °F). The bushing shall not have a change in hardness of more than ten numbers.

42.2 Either the complete molded-rubber or -neoprene bushing or representative material specimen shall be tested. The hardness of the rubber or neoprene shall be determined as the average of five readings with a gauge such as a Rex hardness gauge or Shore durometer. The bushing shall then be exposed in an air oven for 70 hours at 100 °C ±2 °C (212 °F ±3.6 °F).

42.3 The bushing or specimen shall be removed from the oven and then cooled at room temperature for at least 4 hours. The hardness shall be determined again as the average of five readings. The difference between the original average hardness reading and the average reading taken after exposure in an air oven is the change in hardness.

43 Cord-Pull Test

43.1 (I, II) A portable motor shall be subjected to the Cord-Pull Test described in 43.2 and 43.3. As a result of the test, there shall not be:

a) A displacement of 2.4 mm (3/32 inch) or more of the conductors, conductor insulation, or outer jacket of the flexible cord inside the motor from its original position;

b) Any damage to the cord insulation, such as a cut, rip, or tear; or

c) Any damage to the motor that could adversely affect compliance with the requirements in this standard.

43.2 (I, II) The motor shall be tested with each size and type of flexible cord that the manufacturer specifies may be used with the motor. The cord shall be cut cleanly at a right angle to its major axis and installed in the portable motor so that the end of the jacket is located in its intended position as if the conductors were to be connected to the terminals. However, there shall be no stripping of insulation and no connection to terminals. The position of the flush end of the conductor, insulation, fillers, and jacket inside the motor is intended to provide an indicating means of cord displacement after the application of the test force.

43.3 (I, II) The motor shall be mounted in a fixed position and a direct pull shall be applied for 1 minute between the cord and the motor. The force applied shall be 665 N (150 pounds) for a motor rated 30 Amperes or less and 1,330 N (300 pounds) for a motor rated more than 30 Amperes. After 1 minute the force is to be removed and any displacement of the conductors, conductor insulation or outer jacket of the flexible cord inside the motor from its original position is to be measured.

44 Rough-Usage Test

44.1 (I, II) A cord-connected motor not provided with base or stand shall be subjected to a rough-usage test. The motor, terminal enclosure and the cord clamp shall not be impaired nor shall threaded engagements be loosened during this test.

44.2 (I, II) The motor shall be suspended in a vertical position, with cord clamp up, by means of a short loop formed from a heavy solid wire. The power-supply cord shall be removed from the motor and one end of the wire loop shall be connected to the motor at its cord clamp. The other end of the wire loop shall be extended through a screw eye secured to a solidly mounted vertical board, 50.8 mm (2 inches) thick. The free end of the motor shall be pulled away from the board and then allowed to swing back against the board or a wooden block secured to the board for 9,000 times at a rate of about 50 times per minute. The horizontal distance of swing shall be about 150 mm (6 inches).

44.3 (I, II) Following this test, the motor shall be subjected to the Dielectric Voltage Withstand Test specified in Clause 34.

45 Drop Test

45.1 (I, II) A drop test shall be conducted on a cord-connected motor, such as portable motors, that could be dropped while being handled. The hazardous location integrity of the motor enclosure, terminal enclosure, and the cord clamp shall not be impaired, based on a visual inspection, when the motor is dropped to a concrete floor ten times from a height of 0.9 m (3 feet).

45.2 (I, II) For the first five drops, the motor, with cord connected as in service, shall be allowed to fall freely in a manner that would be the case if the device were to fall from a horizontal platform to the floor. In the remainder of the test, the motor with cord shall be held at various angles about 0.9 m (3 feet) above the concrete floor and then dropped to the floor.

45.3 (I, II) Following this test, the motor shall be subjected to the Dielectric Voltage Withstand Test specified in Clause 34.

46 Gasoline-Leakage Test

46.1 (I) The mechanical seal provided at the lead-wire outlet of a gasoline submersible motor that is lubricated by the surrounding product shall prevent leakage at a pressure of 520 kPa (75 psig) or 150 % maximum closed discharge pressure of the pump, whichever is higher. The pressure shall be applied for 168 hours. "O" rings and other parts made of organic materials shall be subjected to appropriate tests to determine their reliability.

47 Non-Metallic Fans and Fan Guards Test

47.1 General

47.1.1 (I, II) A non-metallic fan or fan guard shall comply with the requirements in 47.2 or 47.3.

47.2 Conductivity test

47.2.1 (I, II) When tested as described in 47.2.2 – 47.2.6, the measured resistance of the fan or guard shall not exceed 1 megohm.

47.2.2 (I, II) Three samples of the fan or guard shall be provided with conductive pads at various locations on the samples. The pads shall be located:

a) At points as far away as possible from the points at which the fan or guard is mounted to grounded metal;

b) At intermediate points; and

c) At other points that may result in high resistance to ground because of the configuration of the part being tested.

47.2.3 (I, II) The conductive pads shall be metal foil about 2 cm^2 (0.3 $inch^2$) and attached to the samples by a thin film of petrolatum or similar material.

47.2.4 (I, II) Ground point electrodes shall be provided on the samples at a point or points on the part where it is mounted to grounded metal; for example, the ground point electrode on a fan could consist of a piece of metal tubing installed in the opening that fits over the motor shaft. For a fan guard, screws with washers shall be installed in holes for mounting screws.

47.2.5 (I, II) The resistance shall be measured between the ground point electrodes and the conductive pads after the samples have been conditioned for at least 48 hours at a relative humidity of 50 ±10 %.

47.2.6 (I, II) The resistance shall be measured with an ohmmeter that has an effective internal resistance of 100,000 ±10,000 ohms. The open-circuit potential shall be 500 V dc and the short-circuit current shall be 5 mA.

47.3 Accumulation of static electricity test

47.3.1 General

47.3.1.1 (I, II) When required by 47.1.1, a non-metallic fan or guard shall comply with either the requirements of 47.3.2 or 47.3.3.

47.3.2 Method A

47.3.2.1 (I, II) Any fan or guard shall have a surface resistivity of 1 Gohm or less at 23 °C (73 °F) and 50 % relative humidity as defined by the material specifications or as determined by the test in 47.3.2.2.

47.3.2.2 (I, II) The resistance shall be tested on the guard or fan or on a section of the guard or fan. Two parallel electrodes 1 mm (0.04 inch) in width, 100 mm (4 inches) in length, 10 mm (0.4 inch) apart shall be centered on a 150 mm by 60 mm (6 by 2.4 inch) sample. The sample shall be cleaned with distilled water, then with isopropyl alcohol, then once more with distilled water before being dried. Untouched by bare hands, it shall be conditioned for 24 hours at 23 °C (73 °F) and 50 % relative humidity. The test shall be carried out under the same conditions. A direct voltage of 500 ±10 Vdc shall be applied for one minute. The resistance is the quotient of the direct voltage applied at the electrodes to the total current flowing between them when the direct voltage has been applied for one minute.

47.3.3 Method B

47.3.3.1 (I, II) No sparks shall be observed when a grounded metal sphere is brought into gradual contact with the fan or guard after it has been electrostatically charged.

47.3.3.2 (I, II) Three samples of the fan or guard with ground point electrodes as described in 47.2.4 shall be conditioned for at least 48 hours at a relative humidity of 25 ±10 %.

47.3.3.3 (I, II) Immediately after removal from the low-humidity chamber, the samples shall be supported by means of insulators in a room having a relative humidity not more than 35 % and having all sources of light, other than electrical sparks, eliminated. The ground point electrodes shall be grounded. An electrostatic charge shall be sprayed on nonconductive parts of the product using a Van de Graaf generator limited to 5,000 V.

47.3.3.4 (I, II) A 9.5 mm (3/8 inch) diameter grounded metal sphere shall be brought into gradual contact with the nonconductive area of the sample.

48 Pull Test on Tubes

48.1 (I) The tubes in a tube-cooled motor shall be subjected for 1 minute to a direct pull determined in accordance with 48.2. The tubes shall not become dislodged and the joints between the tubes and the end rings shall not be damaged or become permanently distorted.

48.2 (I) Three samples shall be tested. The direct pull used for the test shall be calibrated using the formula:

$$L = [(D_o^2 - D_i^2 - N \cdot d^2)(P)(F)] / 4N$$

In which:

L is the pull-test force in N (pounds);

D_o is the outside diameter of end ring in m (inches);

D_i is the inside diameter of end ring in m (inches);

N is the number of tubes;

d is the outside diameter of tubes in m (inches);

P is the maximum explosion pressure or the pressure from Figure 1, whichever is higher, in Pa (psi);and

F is the safety factor of 4.

49 Sealing Compounds Test

49.1 (I) A sealing compound used in Class I equipment shall be subjected to the tests described in 49.2 – 49.8 to determine its resistance to chemicals.

49.2 (I) The resistance to crushing of the sealing compound shall be determined on as-received specimens and specimens exposed to chemical vapors. The crushing force after exposure shall be at least 85 % of the value determined using as-received samples. In addition, changes in dimensions and weight after exposure shall be determined. Shrinkage or loss of weight of more than 1 % or an increase in weight or swelling that changes the intended properties of the sealing compound does not meet the intent of the requirement. See 49.8.

49.3 (I) Cylindrical specimens 12.7 mm (1/2 inch) in diameter and 19.1 mm (3/4 inch) long shall be used for the tests. At least 81 specimens are required – six for each chemical and three for as-received tests. The samples shall be of uniform size and shape, having both ends perpendicular to the side of the cylinder.

49.4 (I) The specimens shall be exposed for 168 hours (7 days) at 20 °C – 25 °C (68 °F – 77 °F) to saturated vapors in air of the chemicals specified below:

a) Acetic Acid (Glacial);

b) Acetone;

c) Ammonium Hydroxide (20 % by weight);

d) ASTM reference fuel C;

e) Diethyl Ether;

f) Ethyl Acetate;

g) Ethylene Dichloride;

h) Furfural;

i) n-Hexane;

j) Methyl Ethyl Ketone;

k) Methanol;

l) 2-Nitropropane; and

m) Toluene.

49.5 (I) During and after the exposure, the specimens shall be observed for discoloration, swelling, crazing, cracking, leaching, or dissolving.

49.6 (I) After the exposure, three specimens from each chemical exposure shall be weighed and measured immediately after removal from the chemical vapor.

49.7 (I) The other three exposed specimens and the as-received specimens shall be placed between two parallel plates and crushed with a compression-testing machine having a crosshead speed of 2.54 mm (0.1 inch) per minute. The load shall be applied perpendicular to the axis of the cylindrical specimens and the compressive force required to crack and break the specimens shall be recorded.

49.8 (I) As an alternative, tests to determine resistance of the sealing compound to chemicals shall be conducted on a complete sample or subassembly representative of the construction that incorporates the sealing compound as intended in the final assembly, without cable or conductors. These tests shall consist of explosion and hydrostatic pressure tests in accordance with Explosion Tests in Clause 36, and Over Pressure Test on Enclosures in Clause 37, on the complete sample after the sample has been exposed to the chemicals specified in 49.4.

50 Low Ambient-Duty Motors

50.1 General

50.1.1 (I, II) These requirements apply to motors that are intended and marked for use in a prevailing ambient temperature lower than minus 25 °C (minus 13 °F) but not lower than minus 70 °C (minus 94 °F).

50.1.2 In Canada, these requirements apply to motors that are intended and marked for use in a prevailing ambient temperature lower than minus 50 °C (minus 58 °F) but not lower than minus 70 °C (minus 94 °F).

50.1.3 (I, II) A motor intended for use in a low ambient temperature shall comply with the applicable requirements in Clauses 31 – 49, supplemented by, and in some cases modified by, the requirements given in 50.2 – 50.4 and in Section 51.

50.2 Construction

50.2.1 (I, II) At the rated low ambient, thermal contraction of enclosure parts shall not result in a decrease in the length of joints or shaft paths or an increase in joint or shaft path clearances such that the joints or shaft openings do not comply with requirements for Joints in Enclosure of Clause 11 and Shaft Openings of Clause 13. Compliance is determined by conducting the explosion test in Clause 50.3.

50.2.2 (I) In determining the strength of the enclosure in accordance with the requirements in 10.4.2, consideration shall be given to any reduction in the tensile strength of the enclosure over the ambient temperature range.

50.3 Explosion test

50.3.1 (I) The Explosion Pressure Test in 36.2, shall be conducted with the motor at 5 °C less than the rated low ambient temperature in addition to the explosion tests at room temperature.

50.4 Drop test on lead seal

50.4.1 (I, II) Three samples representative of the lead seal (for example, sealing-well section or pipe nipple) shall be tested.

50.4.2 (I, II) The samples shall be conditioned for 24 hours at 5 °C less than the rated low ambient temperature. Immediately after the conditioning, each sample shall be dropped to a concrete floor ten times from a height of 0.9 m (3 feet).

50.4.3 (I, II) The lead seal shall not crack.

51 Manufacturing and Production Tests – Dielectric Voltage-Withstand Test

51.1 Dielectric Voltage-Withstand Test

51.1.1 (I, II) Each motor shall withstand without electrical breakdown, as a routine production-line test, the application of a potential at a frequency within the range of 40 – 70 Hertz:

a) Between the primary wiring, including connected components, and motor enclosure; and

b) Between live parts of an auxiliary device and the motor enclosure.

51.1.2 (I, II) The production-line test potential applied to each motor shall be in accordance with either Condition A or Condition B of Table 40 for the applicable motor rating. The full test potential shall be applied for the full time specified in Table 40.

51.1.3 (I, II) The test potential may be applied gradually until the full test potential is attained, except that for the 1 second test (Condition B) the full test potential may be applied immediately at the beginning of the test.

51.1.4 (I, II) The motor may be in a heated or unheated condition for the test.

51.1.5 (I, II) The test shall be conducted when the motor is complete (fully assembled). It is not intended that the motor be unwired, modified, or disassembled for the test.

51.1.6 (I, II) A part, such as a snap cover or a friction-fit knob that would interfere with conducting the test need not be in place.

51.1.7 (I, II) The test may be conducted before final assembly if the test represents that for the completed motor.

51.1.8 (I, II) A motor employing a solid-state component that is not relied upon to prevent a risk of electric shock and that can be damaged by the dielectric potential may be tested before the component is electrically connected provided that a random sampling of each day's production is tested at the potential specified in Table 40. The circuitry may be rearranged for the purpose of the test to reduce the likelihood of solid-state-component damage while retaining representative dielectric stress of the circuit.

51.1.9 (I, II) The test equipment shall include a means of indicating the test potential, an audible or visual indicator of electrical breakdown, and either a manually reset device to restore the equipment after electrical breakdown or an automatic feature that rejects any unacceptable unit.

51.1.10 (I, II) If the output of the test-equipment transformer is less than 500 VA, the equipment shall include a voltmeter in the output circuit to indicate the test potential directly.

51.1.11 (I, II) If the output of the test equipment transformer is 500 VA or more, the test potential may be indicated by:

a) A voltmeter in the primary circuit or in a tertiary-winding circuit;

b) A selector switch marked to indicate the test potential; or,

c) In the case of equipment having a single test-potential output, by a marking in a readily visible location to indicate the test potential.

When marking is used without an indicating voltmeter, the equipment shall include a positive means, such as an indicator lamp, to indicate that the manual reset switch has been reset following a dielectric breakdown.

51.1.12 (I, II) During the test, the primary switch shall be in the "ON" position, both sides of the circuit under test shall be connected together and to one terminal of the test equipment, and the second test-equipment terminal shall be connected to accessible dead metal.

51.1.13 (I, II) A product (resistive, high-impedance winding, or the like) having circuitry not subject to excessive secondary-voltage build-up in case of electrical breakdown during the test may be tested:

a) With a single-pole primary switch, if used, in the "OFF" position; or

b) With only one side of the circuit connected to the test equipment when the primary switch is in the "ON" position or when a primary switch is not used.

51.1.14 (I, II) The primary switch is not required to be in the "ON" position if the testing means applies full test potential between the circuit under test and dead metal parts with the switch not in the "ON" position.

51.2 Grounding-Continuity Test

51.2.1 (I, II) The manufacturer shall determine by routine production-line test that the grounding member of the attachment plug, if provided or the grounding conductor of the power-supply cord is electrically connected to dead metal parts of a cord-connected motor.

52 Markings

52.1 (I, II) A motor shall have a metal nameplate marked with the following information:

a) Manufacturer's or private labeler's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified.

b) Catalogue designation or equivalent.

c) Rated volts and full-load amperes. For a multi-speed motor, full-load amperes for each speed, except shaded pole and permanent split capacitor motors for which amperes are required only for maximum speed.

d) Rated full-load speed.

e) Rated temperature rise or the insulation system class.

f) Rated ambient temperature.

g) Time rating. The preferred time rating shall be 5, 15, 30, or 60 minutes, or continuous. Alternatively, the time rating may be 1/12, 1/4, 1/2, or 1 hour, or 24 hours.

h) Rated kW (horsepower) if 0.093 kW (1/8 horsepower) or more. For a multi-speed motor 0.093 kW (1/8 horsepower) or more, rated kW (horsepower) for each speed, except shaded pole and permanent split capacitor motors 0.093 kW (1/8 horsepower) or more where rated 0.093 kW (horsepower) is required only for maximum speed. For a torque motor, see 52.14.

i) Locked-rotor indicating code letter, or actual locked-rotor current, if an a-c motor (other than a polyphase wound-rotor motor) rated 0.37 kW (1/2 horsepower) or more.

j) Secondary volts and full-load amperes if a wound-rotor induction motor.

k) For a-c motors, rated frequency and for polyphase motors the number of phases.

l) For a motor for use with variable-frequency inverter drives: The type or types of inverters, motor load characteristics, and the frequency range; for example, "PWM – Constant Torque – 6 to 60 Hertz". All motor base performance values in (c) through (k) are to correspond to rated sine-wave operation. Additional markings for inverter operation may be included.

m) For a d-c motor, the words "direct current" or "d-c", and the winding type (for example, "Straight shunt, stabilized shunt, compound, series, or permanent magnet"). A fractional horsepower d-c motor, 178 mm (7 inches) or less in diameter, need not be marked with the winding type.

n) Designation of the hazardous location in which the motor is intended to be used: for example, "Class ___, Group ____". A motor that has been investigated and found acceptable for exposure to Class I and Class II location conditions at the same time shall be marked with the following or equivalent wording: "Suitable for simultaneous use in Class I, Group _____ and Class II, Group _____ locations".

o) The maximum external operating temperature or temperature class (T code) as indicated in Table 41. The operating temperature or temperature class (T code) shall be on the nameplate near the marking required by Item (n). It shall be identified as "Operating Temperature _____", "Temperature Class _____", or the equivalent. Motors having maximum external operating temperature of not more than 100 °C (212 °F) need not have this marking.

p) Terminal boxes that have been tested without lengths of conduit per 36.2.5 shall be marked with the following, or equivalent: "Caution: Seal entries within ...LL... of Enclosure." The dimension "...LL..." shall be determined during the explosion pressure testing.

q) The date or other dating period of manufacture not exceeding any three consecutive months. The date of manufacture may be abbreviated, or may be in a nationally accepted conventional code or in a code affirmed by the manufacturer, provided that the code:

1) Does not repeat in less than 20 years; and

2) Does not require reference to the production records of the manufacturer to determine when the product was manufactured.

52.2 (l) In addition to the marking requirement in 52.1(n), equipment that has been investigated and found to comply with the requirements for Class I, Group D locations may additionally be marked Class I, Zone 1, Group IIA.

52.3 (I) In addition to the marking requirement in 52.1(n), equipment that has been investigated and found to comply with the requirements for Class I, Group C locations may additionally be marked Class I, Zone 1, Group IIB.

52.4 (I) In addition to the marking requirement in 52.1(n), equipment that has been investigated and found to comply with the requirements for Class I, Group B locations may additionally be marked Class I, Zone 1, Group IIB+H2.

52.5 (I) Equipment marked Group IIB may also be marked Group IIA.

52.6 (I) Equipment marked Group IIB+H2 may also be marked IIA.

52.7 (II) In addition to the marking requirement in 52.1(n), equipment that has been investigated and found to comply with the requirements for Class II, Group E, F or G locations may additionally be marked Zone 20 or 21.

52.8 (I, II) The metal nameplate referred to in 52.1 shall be permanently attached to the motor by means such as drive pins or drive screws. An adhesive-attached nameplate may be used if it complies with the requirements specified in the standard for marking and labelling systems. Intended usage of the motor and the atmosphere in which it shall be used are considered when evaluating an adhesive-attached plate.

52.9 (I, II) Each cord-connected motor shall be provided with marking instructions regarding replacement of the power-supply cord. These instructions shall be legible and permanent. These instructions may be a paper label if located within the terminal compartment and protected from mechanical damage.

52.10 (I, II) Each cord-connected motor employing a packing gland that has to be disassembled during cord replacement shall be provided with marking instructions describing its installation and replacement.

52.11 (I, II) A cord-connected motor that is produced without power-supply cord or the attachment plug attached shall be provided with instructions regarding the installation of these components. The instructions shall include all required information regarding the type of cord and the attachment plug that must be provided.

52.12 (I, II) A single-phase capacitor motor having a capacitor, or capacitors, external to the motor enclosure shall be provided with a diagram indicating the intended connections. If the capacitor is not mounted in an explosion-proof or dust-ignition-proof enclosure, the diagram shall indicate that the capacitor shall be mounted outside of the hazardous location.

52.13 (I, II) A fan-cooled motor that does not comply with the requirements for guarding in 22.2, shall be marked "Fan Not Guarded". This marking shall be on the nameplate or permanently marked on the motor in some other manner.

52.14 (I, II) A torque motor shall be marked as indicated in 52.1, except that the locked-rotor torque shall replace the rated horsepower.

52.15 (I, II) A motor provided with a temperature-limiting device for limiting external surface temperatures that does not open the motor circuit directly shall be supplied with instructions or a wiring diagram, or both, for the temperature-limiting device circuit on a plate or tag. The wiring diagram or instructions shall include the ratings of the temperature-limiting device and the identification of the leads, and shall indicate that a manual, momentary start switch is required. If the load controlled by the temperature-limited device is likely to exceed the values specified in Table 38, the wiring diagram shall show the use of an intermediate control-circuit relay.

52.16 (I, II) A motor provided with auxiliary equipment, such as heaters or a temperature-limiting device not relied upon to limit external surface temperatures, shall be supplied with instructions or a wiring diagram, or both, for the auxiliary-device circuit on a plate or tag. The instructions or wiring diagram shall include the rating of the auxiliary device and the identification of the leads.

52.17 (I, II) If automatic restarting of a motor could result in injury to persons, the motor shall be provided with information indicating that it can be restarted automatically. The information may be included with the installation instructions. The marking "Thermally Protected" on a motor that complies with the requirements for thermally protected motors is considered sufficient information. A motor intended to be immersed in a fluid, such as gasoline, during intended operation would not be considered a type of motor that could cause injury to persons as a result of automatic restarting.

52.18 (I, II) If a manufacturer produces or assembles motors or generators at more than one factory, each finished motor or generator shall have a distinctive marking by which it may be identified as the product of a particular factory.

52.19 (I) A submersible sewage-pump motor with provision for conduit connection shall be provided with instructions that recommend the use of corrosion-resistant conduit, such as stainless steel.

52.20 (I) A submersible sewage-pump motor provided with a flexible cord shall be permanently marked with instructions for cord replacement. If specific assemblies are needed for cord replacement, information on the availability and ordering of the assemblies shall be included. As an alternative, the motor may be permanently marked, "See instruction manual for cord replacement", or the equivalent, with the required information contained in the instructions accompanying each motor.

52.21 (I, II) A motor that is tested in accordance with 31.4 shall be permanently marked with detailed information on the use of:

a) A single-phasing monitor; or

b) The maximum locked-rotor current and time, or the like.

53 Installation Instructions

53.1 General

53.1.1 Motors shall be provided with documentation that includes all the instructional material required by this standard.

53.2 Electronic medium for required instructions

53.2.1 The required instructional material of this standard may be provided additionally or alternatively by electronic media under the following conditions:

a) Where all required instructional material is provided by electronic media, there shall be marking on the apparatus that contains the international symbol (Reference No. 0434B of ISO 7000), along with the document number, revision level and location of the electronic documentation (e.g. URL, QRcode).

b) Where only some of the required instructional material is provided by electronic media and some is printed:

1) there shall be marking on the apparatus that contains the international symbol ⚠ (Reference No. 0434B of ISO 7000), along with the document number, revision level and location of the electronic documentation (e.g. URL, QRcode); and

2) the printed instructions provided with the apparatus shall clearly identify that additional information is available electronically, along with the document number, revision level and location of this electronic documentation (e.g. URL, QRcode).

3) for small electrical apparatus where some or all of the instructional material is to be provided by electronic media, and where there is limited space for both the international symbol ⚠ (Reference No. 0434B of ISO 7000) and the document number, revision level and location of the electronic documentation (e.g. URL, QRcode):

i) the international symbol ⚠ (Reference No. 0434B of ISO 7000) shall be marked on the apparatus; and

ii) printed instructions shall be provided with the apparatus that, as a minimum, indicates the document number, revision level and location of the electronic documentation (e. g. URL, QRcode).

NOTE: When electronic documentation is referenced either on the device or on the printed instructions, the location given can be the specific location for the required instructions (e. g. direct link to the specific instructions), or can be a more general location. (e.g. the URL for the overall manufacturer's website). It is the manufacturer's responsibility to assure that the location of the required instructions is accessible by the user.

53.2.2 Alternatively, the reference to the document number and revision level on the marking can be excluded if the location of the electronic documentation marked on the apparatus (e.g. URL, QRcode) involves an electronic search feature that makes the required documentation available by entering specific information that is required to be marked on the apparatus, such as any combination of model number, part number, serial number, date code, or other unique identifier.

53.2.3 Where a QRcode is used to provide the required instructional material, and the QRcode contains all required instructional material (as opposed to merely referencing a URL that contains required instructional material), a document number and revision level need not be indicated.

53.2.4 Where some or all of the required instructional material is provided by electronic media, the required instructional material shall be available in printed format upon request of the user.

NOTE 1: Where required instructional material, especially drawings, is provided in an electronic documentation format, consideration should be given by the manufacturer to its viewability and print capability by the user.

NOTE 2: Electronic media are permitted for required instructions as part of national and international standards, however other constraints may apply in certain market places (e.g. the European Commission's Standing Committee for the ATEX Directive has taken the view that at least the safety related parts of the instructions in respect of ATEX should be supplied in paper form).

Table 1
Minimum Thickness of Enclosure Walls

Maximum enclosure dimensions		Minimum thickness[a], mm (inch)		
Internal Length[b] of Joints, mm (inch)	Area[c,d] dm² (in²)	Cast brass, bronze, copper, or malleable iron	Cast iron, or aluminum[e]	Sheet steel[f]
330 (13)	15 (233)	2.36 (0.093)	3.18 (0.125)	1.47 (0.058)
560 (22)	31 (480)	2.36 (0.093)	3.18 (0.125)	1.47 (0.058)
760 (30)	40 (620)	2.36 (0.093)	3.18 (0.125)	2.36 (0.093)
1525 (60)	97 (1500)	3.18 (0.125)	4.75 (0.187)	3.18 (0.125)

Table 1 Continued on Next Page

Table 1 Continued

Maximum enclosure dimensions		Minimum thickness[a], mm (inch)		
Internal Length[b] of Joints, mm (inch)	Area[c,d] dm² (in²)	Cast brass, bronze, copper, or malleable iron	Cast iron, or aluminum[e]	Sheet steel[f]
Over 1525 (60)	Over 97 (1500)	4.75 (0.187)	6.35 (0.250)	4.75 (0.187)

[a] The basis behind the thickness values is to delay electrical burn-through until protective devices can function.

[b] Circumference of frame/end-shield Joint.

[c] This area is not the total area, but the area of each enclosure part such as the end-shield or the stator frame.

[d] The area of an end-shield is considered to be the area of a circle.The area of a stator frame is considered to be the area of a cylinder.

[e] Includes sand-cast, permanent-mould, and die-cast aluminum and sheet aluminum.

[f] A motor intended for installation where not subjected to mechanical or physical damage, such as with or without a supplementary enclosure, may have a thickness of not less than 1.07 mm (0.042 inch).

Table 2
Safety Factors for Calculations to Determine Strength of Enclosure for Class I Locations

Material of enclosure or part	Safety factor for calculations
Cast metal	5
Fabricated steel	4
Bolt	3

Table 3
Maximum Width of Joint and Maximum Clearance for Group C Motor Enclosures

Width of joint L mm (inch)	Maximum gap, mm (inch) for free internal volume of enclosure, V cm³ (inch³)				
	V < 100 (6)	100 < V < 500 (30)	500 < V <2000 (122)	2000 < V < 5000 (305)	V > 5000 (305)
Straight (flat and cylindrical) and rabbet joints					
6 (0.25) ≤ L < 9.5 (0.375)	0.10 (0.004)	a	a	a	a
9.5 (0.375) ≤ L < 12.5 (0.5)	0.10 (0.004)	0.05 (0.002)	0.04 (0.0016)	a	a
12.5 (0.05) < L < 25 (1)	0.10 (0.004)	0.10 (0.004)	0.10 (0.004)	0.08(0.003)	0.08 (0.003)
25 (1) ≤ L	0.10 (0.004)	0.10 (0.004)	0.10 (0.004)	0.10 (0.004)	0.10 (0.004)
Operating-rod (spindle) joints[b]					
6 (0.25) ≤ L < 9.5 (0.375)	0.10 (0.004)	a	a	a	a
9.5 (0.375) ≤ L < 12.5 (0.5)	0.10 (0.004)	0.10 (0.004)	0.10 (0.004)	0.08 (0.003)	a
12.5 (0.5) ≤ L < 25 (1)	0.10 (0.004)	0.10 (0.004)	0.10 (0.004)	0.08 (0.003)	0.08 (0.003)
25 (1) ≤ L	0.10 (0.004)	0.10 (0.004)	0.10 (0.004)	0.10 (0.004)	0.10(0.004)

Table 3 Continued on Next Page

Table 3 Continued

Width of joint L mm (inch)	Maximum gap, mm (inch) for free internal volume of enclosure, V cm^3 ($inch^3$)				
	V < 100 (6)	100 < V < 500 (30)	500 < V <2000 (122)	2000 < V < 5000 (305)	V > 5000 (305)

Notes:

For SI unit conversions: 1 inch = 25.4 mm

1 $inch^3$ = 16.4 cm^3

[a] Construction not permitted.

[b] For cylindrical and operating-rod joints, the maximum gap is the diametrical difference.

Table 4
Class I Locations Minimum Flame Path at Bolt Holes Groups C and D Motor Enclosures

Required minimum width (L) of joint per Table 3 or Table 5		Minimum effective (l) flame path	
mm	(in)	mm	(in)
6	(0.236)	6	(0.236)
9.5	(0.374)	8	(0.315)
12.7	(0.500)	8	(0.315)
19	(0.749)	9.5	(0.374)
Over 19	(0.749)	12.7	(0.500)

Table 5
Minimum Width of Joint and Maximum Clearance for Group D Motor Enclosures (Metric units)

Width of joint, L	Maximum clearance mm for free internal volume of enclosure cm^3				
mm	V ≤ 100	100 < V ≤ 500	500 < V ≤ 1650	1650 < V ≤ 5750	V > 5750
Straight (flat and cylindrical) and rabbet joints[b]					
6 ≤ L < 9.5	0.15	a	a	a	a
9.5 ≤ L < 13	0.15	0.08	0.08	0.08	0.08
13 ≤ L < 19	0.15	0.15	0.10	0.10	0.10
19 ≤ L < 25	0.15	0.15	0.15	0.10	0.10
25 ≤ L	0.20	0.20	0.20	0.20	0.20
Operating-rod (spindle) joints[b]					
6 ≤ L < 9.5	0.15	a	a	a	a
9.5 ≤ L < 13	0.15	0.08	0.08	0.08	0.08
13 ≤ L < 19	0.15	0.15	0.10	0.10	0.10
19 ≤ L < 25	0.15	0.15	0.15	0.10	0.10
25 ≤ L	0.20	0.20	0.20	0.20	0.20

[a] Construction does not meet the intent of the requirement.

[b] For operating-rod (spindle) joints, axial sections of rabbet joints, and cylindrical joints, the maximum gap is the diametrical clearance.

Table 6
(informative)
Minimum Width of Joint and Maximum Clearance for Group D Enclosures
(English units)

Width of joint, L inch	Maximum clearance inch for free internal volume of enclosure $inch^3$				
	V ≤ 6	6 < V ≤ 30	30 < V ≤ 100	100 < V ≤ 350	V > 350
Straight (flat and cylindrical) and rabbet joints[b]					
0.25 ≤ L < 0.375	0.006	a	a	a	a
0.375 ≤ L < 0.500	0.006	0.003	0.003	0.003	0.003
0.500 ≤ L < 0.75	0.006	0.006	0.004	0.004	0.004
0.75 ≤ L < 1.0	0.006	0.006	0.006	0.004	0.004
1.0 ≤ L	0.008	0.008	0.008	0.008	0.008
Operating-rod (spindle) joints[b]					
0.25 ≤ L < 0.375	0.006	a	a	a	a
0.375 ≤ L < 0.500	0.006	0.003	0.003	0.003	0.003
0.500 ≤ L < 0.75	0.006	0.006	0.004	0.004	0.004
0.75 ≤ L 1.0	0.006	0.006	0.006	0.004	0.004
1.0 ≤ L	0.008	0.008	0.008	0.008	0.008

[a] Construction does not meet the intent of the requirement.

[b] For operating-rod (spindle) joints, axial sections of rabbet joints, and cylindrical joints, the maximum gap is the diametrical clearance.

Table 7
Class I Locations Thread Engagement for Groups B, C, and D Motor Enclosures

Maximum diameter of threaded section, mm (in)	Maximum number of threads per 25.4 mm (1 in)	Minimum number of threads engaged
No limit	20	5
9.5 (0.374)	24	5
Over 9.5 (0.374)	24	6
	28	7
	32	8

Table 8
Class II Locations Dimensions of Joints in Groups E, F, and G Motor Enclosures Flat and Cylindrical Joints

Minimum joint width, mm (in)	Maximum gap, mm (in)
4.8 (0.189)	0.05 (0.002)
6.4 (0.252)	0.08 (0.003)
9.5 (0.374)	0.10 (0.004)
12.7 (0.500)	0.13 (0.005)
16 (0.630)	0.15 (0.006)
19 (0.749)	0.18 (0.007)
22.2 (0.875) or wider	0.20 (0.008)

Table 9
Class II Locations Dimensions of Joints in Groups E, F, and G Motor Enclosures Rabbet Joints

Minimum total joint width, mm (in)	Minimum width of radial section, mm (in)	Maximum gap at radial section, mm (in)	Maximum gap at axial section, mm (in)
4.8 (0.189)	1.2 (0.047)	0.05 (0.002)	0.10 (0.004)
6.4 (0.252)	1.2 (0.047)	0.08 (0.003)	0.15 (0.006)

Table 10
Class I, Group C Shaft Openings in Motor – Straight Joints

Free internal volume, V cm^3 (in^3) Circumference of joint[a], Φ mm (in)	Dimensions of joints, mm (in)		
	Minimum length of joints (A)	Maximum diametrical clearance (B minus E)	
		Sleeve bearings	Ball bearings
V ≤ 100 (6.102)	6.4 (0.25)	0.20 (0.008)	0.30 (0.012)
and	12.7 (0.5)	0.25 (0.010)	0.41 (0.016)
Φ ≤ 810 (31.91)	25.4 (1)	0.30 (0.012	0.46 (0.018)
	38.0 (1.50)	0.41 (0.016)	0.61 (0.024)
V ≤ 2000 (122.04)	12.7 (0.5)	0.20 (0.008)	0.30 (0.012)
and	25.4 (1)	0.25 (0.010)	0.41 (0.016)
Φ ≤ 810 (31.91)	38.0 (1.5)	0.30 (0.012)	0.46 (0.018)
V ≤ 6000 (366.12)	12.7 (0.5)	0.15 (0.006)	0.20 (0.008)
and	25.4 (1)	0.20 (0.008)	0.30 (0.012)
Φ ≤ 2290 (90.23)	38.0 (1.5)	0.25 (0.010)	0.41 (0.016)
Note: [a] Circumference of frame/end-shield joint.			

Table 11
Class I, Group D Shaft Openings in Motor – Straight Joints

Free internal volume, V cm^3 (in^3) Circumference of joint[a], Φ mm (in)	Dimensions of joints, mm (in)		
	Minimum length of joint (A)	Maximum diametrical clearance (B minus E)	
		Sleeve bearings	Ball bearings
V ≤ 100 (6.102)	6.4 (0.25)	0.20 (0.008)	0.30 (0.012)
and	12.7 (0.5)	0.25 (0.010)	0.41 (0.016)
Φ ≤ 810 (31.91)	25.4 (1)	0.30 (0.012)	0.46 (0.018)
	38.0 (1.50)	0.41 (0.016)	0.61 (0.024)
V ≤ 2000 (122.04)	12.7 (0.5)	0.20 (0.008)	0.30 (0.012)
and	25.4 (1)	0.25 (0.010)	0.41 (0.016)
Φ ≤ 810 (31.91)	38.0 (1.50)	0.30 (0.012)	0.46 (0.018)
V ≤ 6000 (366.12)	12.7 (0.5)	0.20 (0.008)	0.30 (0.012)
and	25.4 (1)	0.53 (0.021)	0.64 (0.025)
Φ ≤ 810 (31.91)	31.8 (1.25)	0.58 (0.023)	0.69 (0.072)
	38.0 (1.50)	0.64 (0.025)	0.76 (0.030)

Table 11 Continued on Next Page

Table 11 Continued

Free internal volume, V cm³ (in³) Circumference of joint[a], Φ mm (in)	Dimensions of joints, mm (in)		
	Minimum length of joint (A)	Maximum diametrical clearance (B minus E)	
		Sleeve bearings	Ball bearings
	44.5 (1.75)	0.69 (0.072)	0.76 (0.030)
	51.0 (2.01)	0.74 (0.029)	0.76 (0.030)
V ≤ 6000 (366.12)	38.0(1.50)	0.64 (0.025)	0.76 (0.030)
and Φ ≤ 2290 (90.23)	63.5 (2.50)	0.76 (0.030)	0.76 (0.030)

Notes:

[a] Circumference of frame/end-shield joint.

2) For Φ greater than 2290 (90.23), see Table 12.

Table 12
Class I, Groups C and D Shaft Openings in Motors – Labyrinth Joints[a]

Free internal volume, V cm³ (in³) Circumference of joints[b], Φmm (in)	Minimum length of joint, mm (in)				Minimum difference in diameters of labyrinth sections (D minus E)	Maximum diametrical clearance of each section (B minus E and C minus D)
	Total (A plus F)	At one labyrinth section (F)	At other labyrinth section (A)	At any labyrinth section		
V ≤ 6000 (366.12)	28.6 (1.14)	3.2 (0.126)	25.4 (1)	–	3.2 (0.126)	0.53 (0.021)
and	35.0 (1.38)	3.2 (0.126)	31.8 (1.25)	–	3.2 (0.126)	0.58 (0.023)
Φ ≤ 810 (31.91)	41.3 (1.63)	3.2 (0.126)	38.0 (1.50)	–	3.2 (0.126)	0.64 (0.025)
	47.6 (1.88)	3.2 (0.126)	44.5 (1.75)	–	3.2 (0.126)	0.69 (0.072)
	54.0 (2.13)	3.2 (0.126)	51.0 (2.01)	–	3.2 (0.126)	0.74 (0.029)
V ≤ 6000 (366.12)	41.3 (1.63)	3.2 (0.126)	38.0 (1.50)	–	6.4 (0.252)	0.64 (0.025)
and	66.7 (2.63)	3.2 (0.126)	63.5 (2.50)	–	6.4 (0.252)	0.76 (0.030)
Φ ≤ 2290 (90.23)						
V > 6000 (366.12)	51.0[c] (2.01)	–	–	6.4[c] (0.252)	6.4 (0.252)	0.64 (0.025)
and	76.0[c] (3.00)	–	–	25.4[c] (1)	6.4 (0.252)	0.76 (0.030)
Φ > 2290 (90.23)						

Notes:

[a] The labyrinth joint shall consist of at least 2 axial sections.

[b] Circumference of frame/end-shield joint.

[c] The minimum labyrinth-path dimensions shall be provided with the rotor in any position permitted by the end-play of the shaft. The adjacent sections of the path shall not be more than 20 mm (0.80 inch) apart at any position permitted by that end-play.

– : Not applicable.

Table 13
Class II, Groups E, F and G Outer Shaft Openings in Motors

Minimum length of joint, mm (in)	Maximum diametrical clearance, mm (in)
12.7 (0.5)	0.25 (0.01)
25.4 (1)	0.41 (0.016)
38.0 (1.5)	0.56 (0.022)
Note: Proportional intermediate values are permitted.	

Table 14
Class II, Groups F and G Inner Shaft Openings in Motors

Minimum length of joint, mm (in)	Maximum diametrical clearance, mm (in)	
	Ball bearings	Sleeve bearings
25.4 (1)	0.53 (0.021)	0.53 (0.021)
31.8 (1.25)	0.58 (0.023)	0.58 (0.023)
38.0 (1.5)	0.64 (0.025)	0.64 (0.025)
44.5 (1.75)	0.69 (0.027)	0.69 (0.027)
51.0 (2)	0.74 (0.029)	0.74 (0.029)
63.5 (2.50)	0.76 (0.030)	0.76 (0.030)
(31.8 (1.25) + 3.2 (0.126)) Labyrinth	–	0.51 (0.020)
Note:– Not applicable.		

Table 15
Terminal Compartments for Rigidly Mounted Motor Terminals

Power supply conductor size[a], mm² (AWG)	Minimum acceptable usable volume per power-supply conductor, cm³ (cubic inches)
2.1 (14) and smaller	16(1)
3.3 and 5.3 (12 and 10)	20 (1-1/4)
8.4 and 13.3 (8 and 6)	37 (2-1/4)
[a] Based on copper supply conductors having a temperature rating of 60 °C (140 °F).	

Table 16
Field Wiring Compartment for AC and DC Motors 279 mm (11 inches) or Less in Diameter

Rating of motor kW (horsepower)	Field wiring compartment	
	Minimum dimension of field wiring compartment opening, mm (inches)	Minimum usable volume, cm³ (cubic inches)
kW ≤ 0.75 (Hp ≤ 1[a)])	41 (1.625)	170 (10.5)
0.75 < kW ≤ 2.2 (1 < Hp ≤ 3[a)])	44 (1.75)	275 (16.8)
2.2 < kW ≤ 5.6 (3 < Hp ≤ 7.5)	50 (2)	365 (22.4)

Table 16 Continued on Next Page

Table 16 Continued

Rating of motor kW (horsepower)	Field wiring compartment	
	Minimum dimension of field wiring compartment opening, mm (inches)	Minimum usable volume, cm^3 (cubic inches)
5.6 < kW ≤ 11.2 (7.5 < Hp ≤ 15)	64 (2.5)	595 (36.4)

[a] For a field wiring compartment partially or wholly integral with the frame or end shield, the minimum dimension of cover opening is not specified and the volume of the field wiring compartment per wire-to-wire connection may be not less than 18 cm^3 (1.1 cubic inch) for a motor rated 1 horsepower or less, or 23 cm^3 (1.4 cubic inch) for a motor rated 1 < Hp ≤ 3.

Table 17
Field Wiring Compartment for AC Motors Over 279 mm (11 inches) in Diameter

Maximum full-load current for 3-phase motors with maximum of 12 leads[a]	Minimum dimension of field wiring compartment opening,		Minimum usable volume,	
	mm	(inches)	cm^3	(cubic inches)
0 – 45	64	(2.5)	595	(36.4)
46 – 70	84	(3.3)	1265	(77)
71 – 110	102	(4.0)	2295	(140)
111 – 160	127	(5.0)	4135	(252)
161 – 250	152	(6.0)	7380	(450)
251 – 400	178	(7.0)	13775	(840)
401 – 600	203	(8.0)	25255	(1540)

[a] Auxiliary leads for such items as brakes, thermostats, space heaters, or exciting fields are not required to be evaluated when their current-carrying area does not exceed 25 % of the current-carrying area of the motor power leads.

Table 18
Field Wiring Compartment for Direct Current Motors Over 279 mm (11 inches) in Diameter

Maximum full-load current for DC motors with maximum of 6 leads[a]	Minimum dimension of field wiring compartment opening,		Minimum usable volume,	
	mm	(inches)	cubic inches	(cm^3)
0 – 68	64	(2.5)	425	(26)
69 – 105	84	(3.3)	900	(55)
106 – 165	102	(4.0)	1640	(100)
166 – 240	127	(5.0)	2950	(180)
241 – 375	152	(6.0)	5410	(330)
376 – 600	178	(7.0)	9840	(600)
601 – 900	203	(8.0)	18040	(1100)

[a] Auxiliary leads for such items as brakes, thermostats, space heaters, or exciting fields are not required to be evaluated when their current-carrying area does not exceed 25 % of the current-carrying area of the motor power leads.

Table 19
Minimum* Size of Terminal Boxes for Insulated Terminations

Voltage†	Maximum full load current, Ampere	Minimum* usable volume, cm³	minimum* usable volume, (in³)	Minimum dimension, mm (in)	Minimum centerline distance‡, mm (in)
2 400	160	2 950	(180.009)	125 (4.925)	–
	250	5 400	(329.508)	150 (5.91)	–
	400	9 800	(597.996)	180 (7.092)	–
	600	18 000	(1098.36)	205(8.077)	320 (12.608)
	900§	32 800	(2001.45)	205 (8.077)	320 (12.608)
	1 500§	64 500	(3935.79)	355 (13.987)	510 (20.094)
4 200	160	32 800	(2001.45)	205 (8.077)	320 (12.608)
	700	91 800	(5601.63)	355 (13.987)	410 (16.154)
	1 000§	131 000	(7993.62)	405 (15.957)	510 (20.094)
	1 500§	176 000	(10739.52)	510 (20.094)	635 (25.019)
	2 000§	220 000	(13424.4)	560 (22.064)	635 (25.019)
7 200	260	91 800	(5601.63)	355 (13.987)	510 (20.094)
	680	131 000	(7993.62)	405 (15.957)	635 (25.019)
	1 000§	154 000	(9397.08)	460 (18.124)	635 (25.019)
	1 500§	190 000	(11593.8)	510 (20.094)	635 (25.019)
	2 000§	235 000	(14339.7)	560 (22.064)	720 (28.368)
12 000**	250	505 000	(30815.1)	560 (22.064)	635 (25.019)
	680	600 000	(36612)	635 (25.019)	720 (28.368)
	1 000	720 000	(43934.4)	700 (27.58)	720 (28.368)
	1 500	826 000	(50402.52)	700 (27.58)	720 (28.368)
	2 000	925 000	(56443.5)	700 (27.58)	820 (32.308)
13 800**	400	720 000	(43934.4)	560 (22.064)	720 (28.368)
	900	826 000	(50402.52)	635 (25.019)	820 (32.308)
	1 500	925 000	(56443.5)	700 (27.58)	820 (32.308)
	2 000	1 025 000	(62545.5)	780 (30.732)	820 (32.308)
18 000**	500	1 066 000	(65047.32)	635 (25.019)	820 (32.308)
	850	1 200 000	(73224)	700 (27.58)	950 (37.43)
	1 300	1 325 000	(80851.5)	780 (30.732)	950 (37.43)
23 000	500	1 700 780	(103781.5956)	780 (30.732)	950 (37.43)
	1 000	2 064 000	(125945.28)	860 (33.884)	1 100 (43.34)
	1 500	2 400 000	(146448)	950 (37.43)	1 100 (43.34)
28 000	500	2 400 000	(146448)	950 (37.43)	1 100 (43.34)
	1 000	2 900 000	(176958)	1 050 (41.37)	1 250 (49.25)
	1 500	3 500 000	(213570)	1 150 (45.31)	1 250 (49.25)
34 000	500	2 900 000	(176958)	1 050 (41.37)	1 250 (49.25)

* The minimum size of terminal boxes containing surge capacitors, surge arresters, current transformers, or potential transformers shall be determined on the basis of individual consideration.

† For 750 V and less see Table 2.

Table 19 Continued on Next Page

Table 19 Continued

Voltage†	Maximum full load current, Ampere	Minimum* usable volume, cm^3	minimum* usable volume, (in^3)	Minimum dimension, mm (in)	Minimum centerline distance‡, mm (in)
‡ Minimum distance from the entrance plate for the conduit entrance to the centerline of the motor leads.					
§ Starting inrush currents can require leads be supported to limit their movement.					
**Terminal boxes at these voltages can require supported cable.					

Table 20
Class I, Group C and D Locations Dimensions of Joints in Swivel-Type Conduit Fittings

Minimum total width of joint, mm (inch)	Minimum width of clamped radial section, mm (inch)	Maximum clearance at radial section, mm (inch)	Minimum width of axial section, mm (inch)	Maximum diametrical clearance at axial section, mm (inch)
9.5 (3/8)[a]	3.2 (1/8)	0.038 (0.0015)	6.4 (1/4)	0.08 (0.003)
12.7 (1/2)[a]	3.2 (1/8)	0.038 (0.0015)	9.5 (3/8)	0.10 (0.004)
9.5 (3/8)[b]	–	–	9.5 (3/8)	0.08 (0.003)

Notes:
[a] This is the rabbet joint between the fitting and the machined joint surfaces at the lead wire seal of the motor.
[b] This is the joint between the hole in the fitting and the unthreaded portion of the screw that secures the fitting to the motor.

Table 21
Class II Locations Dimensions of Joints in Swivel-Type Conduit Fittings

Minimum total width of joint, mm (inch)	Minimum width of clamped radial section, mm (inch)	Maximum clearance at radial section, mm (inch)	Minimum width of axial section, mm (inch)	Maximum diametrical clearance at axial section, mm (inch)
4.8 (3/16)[a]	1.2 (3/64)	0.05 (0.002)	1.2 (3/64)	0.10 (0.004)
6.4 (1/4)[a]	1.2 (3/64)	0.08 (0.003)	1.2 (3/64)	0.15 (0.006)
4.8 (3/16)[b]	–	–	4.8 (3/16)	0.05 (0.002)
6.4 (1/4)[b]	–	–	6.4 (1/4)	0.08 (0.003)

Notes:
[a] This is the rabbet joint between the fitting and the machined joint surfaces at the lead wire seal of the motor.
[b] This is the joint between the hole in the fitting and the unthreaded portion of the screw that secures the fitting to the motor.

Table 22
Minimum Spacings for Cord-Connected Motors Rated 0 – 600 V Maximum

Parts involved	Minimum Spacing, mm (inch)	
	Through air	Over surface
Between uninsulated live parts of opposite polarity;	4.8 (3/16)	4.8 (3/16)

Table 22 Continued on Next Page

Table 22 Continued

Parts involved	Minimum Spacing, mm (inch)	
	Through air	Over surface
Between any uninsulated live part and grounded metal part other than the enclosure; or Between any uninsulated live part and exposed metal part which is isolated (insulated).		
Between any uninsulated live part and the walls of a metal enclosure.	6.4 (1/4)	6.4 (1/4)

Table 23
Class II Locations Maximum External Surface Temperature

Class II, Group	Under all operating conditions
E	200 °C (392 °F)
F	200 °C (392 °F)
G	165 °C (329 °F)[a]

[a] See tests with moist-dust blanket – Class II, Group G locations in 32.10.

Table 24
Spacings at Field-Wiring Terminals

Potential involved, (volts)	Minimum spacing, mm (inch)			
	Between wiring terminals		Between terminal and other un-insulated metal parts not always of the same polarity[a]	
	Over surface	Through air	Over surface	Through air
0 – 250	6.4 (0.250)	6.4 (0.250)	6.4 (0.250)	6.4 (0.250)
251 – 600	9.5 (0.375)	9.5 (0.375)	9.5 (0.375)	9.5 (0.375)
601 – 1000	9.5 (0.375)	9.5 (0.375)	9.5 (0.375)	9.5 (0.375)
1001 – 1500	19.0 (0.750)	19.0 (0.750)	19.0 (0.750)	19.0 (0.750)

[a] Applies to the sum of the spacings involved where an isolated dead metal part is interposed.

Table 25
Spacings at Other Than Field-Wiring Terminals, Pilot-Circuit Temperature-Limiting Devices, or Motor-Circuit Temperature-Limiting Devices

Potential involved, (volts)	Parts involved	Minimum spacings, mm (inch)			
		Motor diameter 178 mm (7 inch) or less		Motor diameter more than 178 mm (7 inch)[a]	
		Over surface	Through air	Over surface	Through air
0 – 125	• Commutator or collector rings of a motor.	1.6 (0.062)	1.6 (0.062)	4.8 (0.187)[b]	3.2 (0.125)[b]
	• Elsewhere in motor.	2.4 (0.094)[c]	2.4 (0.094)[c]	6.4 (0.250)[b,d]	3.2 (0.125)[b,d]

Table 25 Continued on Next Page

Table 25 Continued

Potential involved, (volts)	Parts involved	Minimum spacings, mm (inch)			
		Motor diameter 178 mm (7 inch) or less		Motor diameter more than 178 mm (7 inch)[a]	
		Over surface	Through air	Over surface	Through air
126 – 250	• Commutator or collector rings of a motor.	1.6 (0.062)	1.6 (0.062)	4.8 (0.187)[b]	4.8 (0.187)[b]
	• Elsewhere in motor.	2.4 (0.094)	2.4 (0.094)	6.4 (0.250)[b,d]	6.4 (0.250)[b,d]
251 – 600	• Commutator or collector rings, and live parts of the brush rigging, of a motor.	6.4 (0.250)	6.4 (0.250)	9.5 (0.375)	6.4 (0.250)
	• Elsewhere in motor.	6.4 (0.250)[d]	6.4 (0.250)[d]	9.5 (0.375)[d,f]	9.5 (0.375)[d,f]
601 – 1000	• Commutator or collector rings, and live parts of the brush rigging, of a motor.	–	–	9.5 (0.375)	12.7 (0.500)
	• Elsewhere in motor.	–	–	9.5 (0.375)	12.7 (0.500)
1001 – 1500	• Commutator or collector rings, and live parts of the brush rigging, of a motor.	–	–	19.0 (0.750)	34.9 (1.375)
	• Elsewhere in motor.	–	–	19.0 (0.750)	34.9 (1.375)

[a] This is the diameter, measured in the plane of the laminations, of the circle circumscribing the stator frame, excluding lugs, fins, boxes, and the like, used solely for motor mounting, cooling, assembly, or connection.

[b] Spacings of not less than 2.4 mm (3/32 inch) are acceptable throughout a universal motor.

[c] For a motor rated 1/3 horsepower (0.249 kW) or less, these spacings may be not less than 1.6 mm (1/16 inch).

[d] Film-coated wire is considered to be an uninsulated live part. However, a spacing of not less than 2.4 mm (3/32 inch), over surface and through air, between film-coated wire, rigidly supported and held in place on a coil, and a dead metal part is acceptable.

[e] Through air spacings involving a collector ring may be not less than 3.2 mm (1/8 inch).

[f] Spacings not less than 6.4 mm (1/4 inch) are acceptable between live parts and dead metal parts (1) within a subassembly, and (2) between parts in different subassemblies, of the following types only:

1) A terminal board not intended for field wiring;

2) Centrifugally operated (1) starting, (2) auxiliary, and (3) interlock switches;

3) A starting relay; and

4) A capacitor.

This applies only to subassemblies mounted on or inside a motor.

Table 26
Minimum Spacings for Bare Live Parts Over 1500 V

Parts involved		Minimum spacings, mm (in)					
		Between bare live parts of opposite polarity		Between bare live parts and non-current carrying metal		Between bare live parts and removable metal enclosures	
	Maximum volts	Through air	Over surface	Through air	Over surface	Through air	Over surface
Wiring terminals for installer	2 400*	25 (0.985)	50 (1.97)	25 (0.985)	50 (1.97)	25 (0.985)	50 (1.97)
	4 200	50 (1.97)	88 (3.467)	50 (1.97)	88 (3.467)	50 (1.97)	88 (3.467)
	7 200	100 (3.94)	125 (4.925)	100 (3.94)	125 (4.925	100 (3.94)	125 (4.925
	12 000	125 (4.925)	160 (6.30)	125 (4.925)	160 (6.30)	125 (4.925)	160 (6.30)
	13 800	150 (5.91)	200 (7.88)	150 (5.91)	200 (7.88)	150 (5.91)	200 (7.88)
	18 000	175 (6.895)	250 (9.85)	175 (6.895)	250 (9.85)	175 (6.895)	250 (9.85)
	23 000	305 (12.02)	460 (18.12)	305 (12.02)	460 (18.12)	305 (12.02)	460 (18.12)
	28 000	405 (15.96)	620 (24.43)	405 (15.96)	620 (24.43)	405 (15.96)	620 (24.43)
	34 000	455 (17.93)	690 (27.19)	455 (17.93)	690 (27.19)	455 (17.93)	690 (27.19)

* Spacings shall be measured with cable connectors in place.

Notes:

(1) The above spacings apply to rigid constructions in which spacings will not be reduced by more than 10 % by mechanical or electrical stresses when the machine is energized.

(2) These clearances are for machines operating at altitudes not exceeding 1000 m (3281 ft). For each 300 m (984 ft) rise in altitude in excess of 1000 m (3281 ft), add 3 % to the tabulated spacings.

(3) For line to neutral only, use the maximum voltage divided by 3 for each entry in this table.

(4) For 1500 V and less, see Table 24 and Table 25.

(5) The clearances in this table may be reduced through the use of insulating barriers, provided that proof of performance is substantiated by dielectric tests.

Table 27
Minimum Acceptable Spacings at Capacitor Terminals

Motor rating, (V)	Expansion spacing, mm (inch)	Electrical spacing[a], mm (inch)	Total spacing[a], mm (inch)
0 – 300	12.7 (1/2)	1.6 (1/16)	14.3 (9/16)
301 – 600	12.7 (1/2)	3.2 (1/8)	15.9 (5/8)

[a] An insulating liner or barrier as mentioned in 27.1.9 may be used in lieu of the required electrical spacing; however, at least 12.7 mm (0.50 inch) expansion spacing shall be provided.

Table 28
Spacings at Motor-Circuit and Pilot-Circuit Temperature-Limiting Devices

Parts involved and voltage[a]	Minimum spacings, mm (inch)					
	Not larger than 0.25 kW (1/3 horsepower)		Larger than 0.25 kW (1/3 horsepower) but not larger than 0.75 kW (1 horsepower)		Larger than 0.75 kW (1 horsepower)	
	Through air	Over surface	Through air	Over surface	Through air	Over surface
A. Between an uninsulated live part and uninsulated live part of opposite polarity or an exposed dead metal part other than the enclosure:						
0 – 150 volts	1.6 (1/16)	1.6 (1/16)	1.6 (1/16)	2.4 (3/32)	3.2 (1/8)	6.4 (1/4)
151 – 300 volts	1.6 (1/16	2.4 (3/32)	1.6 (1/16)	2.4 (3/32)	6.4 (1/4)	6.4 (1/4)
301 – 600 volts	3.2 (1/8)	6.4 (1/4)	3.2 (1/8)	6.4 (1/4)	6.4 (1/4)	6.4 (1/4)
B. Between an uninsulated live part and the enclosure, if of other than sheet metal:						
0 – 150 volts	1.6 (1/16)	1.6 (1/16)	1.6 (1/16)	2.4 (3/32)	12.7 (1/4)	12.7 (1/4)
151 – 300	1.6 (1/16)	2.4 (3/32)	1.6 (1/16)	2.4 (3/32)	12.7 (1/4)	12.7 (1/4)
301 – 600 volts	3.2 (1/8)	6.4 (1/4)	3.2 (1/8)	6.4 (1/4)	12.7 (1/4)	12.7 (1/4)
C. Between an uninsulated live part and a sheet-metal enclosure, including a cap or cover:						
0 – 300 volts	3.2 (1/8)	6.4 (1/4)	3.2 (1/8)	6.4 (1/4)	12.7 (1/4)	12.7 (1/4)
301 – 600	6.4 (1/4)	9.5 (1/4)	6.4 (1/4)	9.5 (1/4)	12.7 (1/4)	12.7 (1/4)

[a] The voltage specified is that of the motor-circuit or the pilot-circuit temperature-limiting device.

Table 29
Voltage for Tests

Voltage rating of motor[a], (Volts)	Test potential[b], (Volts)
110 – 120 ac	120 ac
208 ac	208 ac
220 – 240 ac	240 ac
265 – 277 ac	277 ac
440 – 480 ac	480 ac
550 – 600 ac	600 ac
110 – 125 dc	125 dc
220 – 250 dc	250 dc

[a] If the rating of the motor does not fall within any of the specified voltage ranges or is more than 600 V, it shall be tested at 100 – 105 % of its rated voltage.

[b] These test potentials are based on a 60 Hertz supply. If the rating of the motor is other than 60 Hertz, the test potential shall be rated voltage at that frequency.

Table 30
Temperature tests

Hazardous locations	Power source	Type of temperature limiting device	Normal temperature		Running overload			Running overload to burnout			Single phasing			Locked rotor			72-Hour locked rotor		
			I-A	D-D	I-A	D-D	M-D	I-A	D-D	M-D	I-A	D-D	M-D	I-A	D-D	M-D	I-A	D-D	M-D
Class I, Groups C and D	Sinewave	None	X					X											
		In Motor Circuit	X		X						X						X		
		In Control Circuit	X		X						X			X					
	Inverter	None	X					X											
		In Control Circuit	X		X									X					
Class II, Groups E and F	Sinewave	None	X	X					X										
		In Motor Circuit	X	X		X						X						X	
		In Control Circuit	X	X		X						X			X				
	Inverter	None	X	X					X										
		In Control Circuit	X	X		X									X				
Class II, Group G	Sinewave	None	X	X						X									
		In Motor Circuit	X	X			X						X						X
		In Control Circuit	X	X			X						X			X			
	Inverter	None	X	X						X									
		In Control Circuit	X	X			X									X			

I-A = In Air

D-D = Dry Dust

M-D = Moist Dust

Table 31
Gas-Air Mixtures for Maximum Pressure Tests

Class I, Group	Test gas	Percentage of gas in air (test range)	With motor running		With motor at standstill	
			Location of ignition at	Number of ignitions	Location of ignition at	Number of ignition
B	Hydrogen	15 – 35	Drive End	10	Drive End	10
			Non-Drive End	10	Non-Drive End	10
C	Ethylene	4 – 9	Drive End	10	Drive End	10
			Non-Drive End	10	Non-Drive End	10
D	Propane	3 – 7	Drive End	10	Drive End	10
			Non-Drive End	10	Non-Drive End	10
Note: To determine the maximum pressure effects, the location of pressure monitoring could be at the drive-end, the non-drive-end, or both ends, at the discretion of the testing body.						

Table 32
Gas-Air Mixtures for Flame Propagation Tests Joints Enlarged by a Factor of 1.5

Class I, Group	Test gas	Percentage of gas in air	With motor at standstill	
			Location of ignition at	Number of ignitions
B	Hydrogen	27 ±1	Drive End	5
			None-Drive End	5
C	Ethylene	6.5 ±0.5	Drive End	5
			Non-Drive End	5
D	Propane	4.2 ±0.1	Drive End	5
			None-Drive End	5
Note: Alternatively, in lieu of enlarging the joints with a factor 1.5, the test mixtures in accordance with Table 33 may be used.				

Table 33
Gas-Air Mixtures for Flame Propagation Tests Without Factor Applied to Joints

Class I, Group	Test gas	Percentage of gas in air	With motor at standstill	
			Location of ignition at	Number of ignitions
B	Hydrogen	40 ±1	Drive End	5
			None-Drive End	5
	Oxygen	9.5 ±1		
C	Hydrogen	37 ±1	Drive End	5
			None-Drive End	5
D	Hydrogen	55 ±1	Drive End	5
			None-Drive End	5
Note: Alternatively, in lieu of using hydrogen/air mixtures with an inherent factor 1.5, the test mixtures in accordance with Table 32 and with the joints enlarged by a factor of 1.5 may be used.				

Table 34
Lengths of Rigid Metal Conduit for Explosion Pressure Tests on Terminal Boxes

Conduit trade size, mm (in)	Class I, Group	Length of conduit, m (ft)
Less than 60.3 (2)	B,C	1.5 (5) 3.0 (10) 4.5 (15)
Less than 60.3 (2)	D	0.6 (2)

Notes:

1) Notwithstanding Table 31 – Explosion Pressure Tests, the number of ignitions shall be 10 for each length of conduit.

2) Lengths of conduit may be omitted in the Flame Propagation Tests.

3) Notwithstanding Table 32 and Table 33 – Flame Propagation Tests, the total number of ignitions shall be 5.

Table 35
Class I Locations Safety Factors for Over-Pressure Tests to Determine the Strength of an Enclosure

Enclosure or part material	Safety factor for over-pressure test
Cast Metal	4
Fabricated Steel	3[a]
Bolt	3

[a] The enclosure shall withstand a hydrostatic pressure of at least twice the maximum required pressure without permanent distortion and at least three times the maximum required pressure without rupture.

Table 36
Test factors to increase pressure or joint test gap

Temperature up to °C	Group B 27.5 % H_2 7.5 % C_2H_2	Group C 37 % H_2	Group D 55 % H_2	Minimum Number of Tests[a]
60*	1.00	1.00	1.00	5
70	1.11	1.04	1.05	5
80	1.13	1.05	1.06	5
90	1.15	1.06	1.07	5
100	1.16	1.06	1.08	5
110	1.18	1.07	1.09	5
120	1.20	1.08	1.10	5
130	1.22	1.09	1.11	5

[a] The tests are carried out five times with each test mixture. For equipment intended for Group B, only the test with the hydrogen-air mixtures is required.

* 65 °C in Canada