STANDARD for SAFETY

INTRINSICALLY SAFE ELECTRICAL CIRCUITS AND EQUIPMENT FOR USE IN HAZARDOUS LOCATIONS

UNDERWRITERS' LABORATORIES, INC.®
TESTING FOR PUBLIC SAFETY
Underwriters' Laboratories, Inc., founded in 1894, is chartered as a not-for-profit organization without capital stock, under the laws of the State of Delaware, to establish, maintain, and operate laboratories for the examination and testing of devices, systems, and materials.

A complete description of the organization, purposes, and methods of Underwriters' Laboratories, Inc. is given in a separate pamphlet entitled "Testing For Public Safety."

An enumeration of all the Laboratories' Standards is given in a catalog of "Standards for Safety" and in each of the following publications:

- Electrical Construction Materials List
- Electrical Appliance and Utilization Equipment List
- Hazardous Location Equipment List
- Fire Protection Equipment List
- Building Materials List
- Gas and Oil Equipment List
- Accident, Automotive, and Burglary Protection Equipment Lists
- Marine Products List
- Classified Products Index
- Supplement to Lists and Indexes

A copy of the current issue of any of the above-mentioned publications may be obtained upon request.
STANDARD FOR INTRINSICALLY SAFE ELECTRICAL CIRCUITS AND EQUIPMENT FOR USE IN HAZARDOUS LOCATIONS

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FOREWORD

A. This Standard represents the judgment of Underwriters' Laboratories, Inc., as to the basic requirements for the construction and performance of the products to be Listed under this category. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of the Standard by a manufacturer is one of the conditions of the continued Listing of the manufacturer's product. Underwriters' Laboratories, Inc., however, assumes no responsibility for the effect of such observance or nonobservance by the manufacturer upon the relations between the manufacturer and any other party or parties arising out of the sale or use of the product or otherwise.

C. A product which complies with these requirements will not necessarily be eligible for Listing if, when examined and tested, it is found to have other features which impair the result contemplated by these requirements.

D. A product employing materials or having forms of construction differing from those detailed in these requirements may be examined and tested according to the intent of the requirements, and if found to be substantially equivalent may be Listed.

E. Many tests required by the Standards of Underwriters' Laboratories, Inc., are inherently hazardous. Underwriters' Laboratories, Inc., neither assumes nor accepts any responsibility for any injury or damage that may occur during or as the result of tests, wherever performed, whether performed in whole or in part by the manufacturer or the Laboratories, and whether or not any equipment, facility, or personnel for or in connection with the test is furnished by the manufacturer or the Laboratories.

SCOPE

1. These requirements cover intrinsically safe electrical circuits and equipment rated 600 volts or less, for installation and use in hazardous locations in accordance with the National Electric Code.

2. These requirements also apply to instruments intended to be installed in panels except that the requirements for field wiring connections may be modified if appropriate for the particular application.

3. This Standard applies to battery-operated radio devices, to telemetering equipment, and to process control equipment including instruments for measurement, recording, and/or control of process variables, and to auxiliary devices used therewith such as primary elements, converters, transducers, and valve operators.

4. This Standard also applies to classifications, such as medical and dental equipment and industrial control equipment, in regard to requirements pertaining to intrinsic safety, only. For such classifications, all requirements, other than intrinsic safety, are those applicable to the classification.

5. Portable hand-held, battery-operated equipment is not considered suitable for investigation with respect to use in Division 2 locations since accidental dropping of the equipment could place it in a Division 1 location.

GLOSSARY

6. Intrinsically Safe Equipment and Wiring – Equipment and wiring incapable of releasing sufficient electrical or thermal energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture in its most easily ignited concentration. Abnormal conditions include accidental damage to any field wiring, electrical components (except protective components as described in paragraph 278), application of overvoltage adjustment, and maintenance operation, and other similar conditions. The hazardous mixture is to be at one atmosphere pressure, at normal room ambient (40°C maximum), and is to have not more than 21 percent oxygen present (not oxygen enriched) unless the equipment is intended for operation under other than these conditions.
7. Intrinsically safe equipment generally is part of a system where portions of the interconnected units can be located in an ordinary location area, a Class I or Class II, Division 2 area, or a Class I or II, Division 1 area. Nonintrinsically safe portions of the system installed in Division 1 areas are to comply with the requirements for that area.

8. Intrinsically safe equipment may also consist of a single piece of apparatus where a portion of the circuitry is not intrinsically safe. In equipment of this type, the enclosures housing components which are not intrinsically safe are to be of the explosion-proof and/or dust-ignition-proof type suitable for the hazardous area classes and groups involved except as noted in paragraph 313.

9. Division 2 Equipment and Wiring - Equipment which in its normal operating condition will not ignite a specific hazardous atmosphere in its most easily ignited concentration. The circuits may include sliding or make-and-break contacts which release insufficient energy to cause ignition. Circuits not containing sliding or make-and-break contacts may operate at energy levels potentially capable of causing ignition under fault conditions.

10. Class I Locations - Locations in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Class I locations may be further subdivided into Division 1 and Division 2 locations.

11. Class I, Division 1 Locations - Locations (1) in which hazardous concentrations of flammable gases or vapors exist continuously, intermittently, or periodically under normal operating conditions; (2) in which hazardous concentrations of such gases or vapors may exist frequently because of repair or maintenance operation or because of leakage; or (3) in which breakdown or faulty operation of equipment or processes which might release hazardous concentration of flammable gases or vapors might also cause simultaneous failure of electrical equipment.

12. Class I, Division 2 Locations - Locations (1) in which volatile flammable liquids or flammable gases are handled, processed, or used, but in which the hazardous liquids vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment; (2) in which hazardous concentrations of gases or vapors are normally prevented by positive mechanical ventilation, but which might become hazardous through failure or abnormal operation of the ventilating equipment; or (3) which are adjacent to Class I, Division 1 locations, and to which hazardous concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

13. Class II Locations - Locations which are hazardous because of the presence of combustible dusts. Class II locations may further be subdivided into Division 1 locations and Division 2 locations.

14. Class II, Division 1 Locations - Locations (1) in which combustible dust is or may be in suspension in the air continuously, intermittently, or periodically under normal operating conditions, in quantities sufficient to produce explosive or ignitable mixtures; (2) where mechanical failure or abnormal operation of machinery or equipment might cause such mixtures to be produced, and might also provide a source of ignition through a simultaneous failure of electrical equipment, operation of protection devices, or from other causes; or (3) in which dusts of an electrically conducting nature may be present.

15. Class II, Division 2 Locations - Locations in which combustible dust will not normally be in suspension in the air, or will not be likely to be thrown into suspension by the normal operation of equipment or apparatus, in quantities sufficient to produce explosive or ignitable mixtures, but (1) where deposits or accumulations of such dust may be sufficient to interfere with safe dissipation of heat from electrical equipment or apparatus, or (2) where such deposits or accumulations of dust on, in, or in the vicinity of electrical equipment might be ignited by arcs, sparks or burning material from such equipment.

16. Faults - A fault is any abnormal condition which, alone or in combination with others, may affect the electrical characteristics of the circuit. Faults are either obvious or nonobvious.

17. Obvious Fault - An obvious fault is indicated by an audible or visible signal, abnormal meter reading, or malfunctioning of the equipment necessitating correction before proceeding with further operation of the equipment. This may also include equipment that does not give a direct indication or alarm, but does indicate malfunction through the indicating means of companion equipment.

18. Nonobvious Fault - A nonobvious fault is not evident to the user in the normal operation of the equipment.
19. Isolated Limited-Energy Low-Voltage Circuits — A circuit classified as an isolated limited-energy low-voltage circuit (herein after referred to as a low-voltage circuit) involves a potential of not more than 42.4 volts peak supplied by:
   A. An energy-limiting Class 2 transformer (see paragraph 254);
   B. A nonenergy-limiting Class 2 transformer and a suitable over-current protective device. The protective device is (1) not to be of the automatic reclosing type, (2) to be trip-free from the reclosing mechanism, and (3) not to be readily interchangeable with a device of a different rating;
   C. A suitable combination of an isolated transformer secondary winding and a fixed impedance which complies with all the performance requirements for an energy-limiting Class 2 transformer except for the tests specified in paragraphs 260-263;
   D. A dry cell battery having output characteristics no greater than those of an energy-limiting Class 2 transformer; or
   E. A suitable combination of a rechargeable battery and a fixed impedance which complies with all of the performance requirements for an energy-limiting Class 2 transformer.

20. With reference to Item C of paragraph 19 more than one circuit may be supplied by a single transformer secondary winding if each circuit is limited by a separate fixed impedance.

21. Isolated Limited-Energy Secondary Circuit — A circuit classified as being isolated and of limited energy is one derived from an isolated secondary winding of a transformer having a maximum capacity of 100 volt-amperes and an open circuit secondary voltage rating not exceeding 600 volts.

22. Line-Voltage Circuits — A circuit classified as line-voltage involves a potential of not more than 600 volts and has circuit characteristics in excess of those described for a low-voltage circuit or an isolated limited secondary circuit.

23. A circuit derived from a source of supply classified as a line-voltage circuit by connecting resistance in series with the supply circuit as a means of limiting the voltage occurrence is not considered to be low-voltage or an isolated-secondary circuit.

24. Battery-Powered Circuits — A battery-powered circuit having voltage and energy output in excess of those described in paragraph 19 is judged under the same requirements as a line-voltage circuit.

25. Battery-powered apparatus employing rechargeable batteries is judged under the requirements for line-voltage powered equipment if:
   A. The battery charger is an integral part of the apparatus; and
   B. The input to the battery charger has characteristics in excess of those specified in paragraph 19.

GENERAL

26. The apparatus shall employ materials that are suitable for the particular use and shall be made and finished with the degree of uniformity and grade of workmanship practicable in a well-equipped factory.

27. A component of the apparatus shall comply with the requirements for that component, except that the requirements may be modified if appropriate for the particular application.
PART I
GENERAL REQUIREMENTS
(SEE PART II FOR
REQUIREMENTS PERTAINING TO
INTRINSICALLY SAFE
CIRCUITS ONLY)

CONSTRUCTION

Enclosure For Ordinary Locations
Or Intrinsically Safe Equipment For Use In
Division 1 Locations

28. The apparatus shall be so formed and assembled that it will have the strength and rigidity necessary to resist the abuses to which it is liable to be subjected, without increasing its fire hazard due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

29. The apparatus shall be provided with an enclosure of material suitable for the particular application, which shall house all electrical parts that may present a fire, shock, or accident hazard under any condition of use. See paragraph 31.

30. Enclosures of individual electrical components, outer cabinets, and combinations of the two are taken into consideration in applying the requirement in paragraph 29.

31. A portion of an overall enclosure may be omitted if the apparatus is designed to be so installed in conjunction with other equipment that the latter will complete the enclosure, and suitable installation instructions are provided.

32. Among the factors taken into consideration when acceptability of an enclosure is being judged are (1) physical strength, (2) resistance to impact, (3) moisture absorptive properties, (4) combustibility, (5) resistance to corrosion, (6) resistance to distortion at temperatures to which the enclosure may be subjected under conditions of normal or abnormal use, (7) resistance to solvents as covered by the hazardous area group classification, and (8) resistance to the generation of dangerous static charges. For a nonmetallic enclosure, all of these factors are considered with respect to thermal aging.

Cast-Metal Enclosures

33. Unless metal of lesser thickness has been found acceptable when the enclosure is judged under considerations such as those mentioned in paragraph 32, cast-metal enclosures shall have thicknesses not less than given in Table 1.

Table 1 effective March 30, 1973

<table>
<thead>
<tr>
<th>Maximum Area of Any Surface in Square Inches</th>
<th>Maximum Volume in Cubic Inches</th>
<th>Minimum Thickness of Cast Metal in Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>24</td>
<td>1/16</td>
</tr>
<tr>
<td>6</td>
<td>36</td>
<td>3/32</td>
</tr>
<tr>
<td>30</td>
<td>620</td>
<td>3/32</td>
</tr>
<tr>
<td>60</td>
<td>1500</td>
<td>1/8</td>
</tr>
<tr>
<td>More than 60</td>
<td>1500</td>
<td>3/16</td>
</tr>
</tbody>
</table>

a The thickness at openings for conduit is to be not less than 1/8 inch at plain openings and not less than 1/4 inch at threaded openings except for enclosures of malleable iron having a volume of 100 cubic inches, or less, the thickness may not be less than 3/32 inches for a plain opening.

Table 1 effective March 30, 1973

Sheet-Metal Enclosures

34. The thickness of a sheet-metal enclosure shall be not less than that indicated in Table 2, except that uncoated steel shall be not less than 0.032-inch thick (No. 20 MSG), zinc coated steel shall be not less than 0.034-inch thick (No. 20 GSG), and nonferrous metal shall be not less than 0.045-inch thick (No. 16 AWG) at points at which conduit or armored cable is to be connected. For cast-metal enclosures see paragraph 33.

35. The reinforcement indicated in Table 2 need not consist of a complete frame for all edges, but should employ a sufficient number of reinforcing members to provide additional support for all surfaces.

Wiring Openings

36. A knockout in a sheet-metal enclosure shall be reliably secured but shall be capable of being removed without undue deformation of the enclosure.
TABLE 2
THICKNESS OF SHEET METAL FOR ENCLOSURES

<table>
<thead>
<tr>
<th>Maximum Area of Any Surface in Square Inches</th>
<th>Maximum Dimension in Inches</th>
<th>Minimum Thickness of Sheet Metal in Inches&lt;sup&gt;d&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Without Supporting Frame</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zinc-Coated</td>
</tr>
<tr>
<td>6&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3</td>
<td>0.023</td>
</tr>
<tr>
<td>36</td>
<td>8</td>
<td>0.023</td>
</tr>
<tr>
<td></td>
<td>(22)</td>
<td>(22)</td>
</tr>
<tr>
<td>90</td>
<td>12</td>
<td>0.034</td>
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<tr>
<td></td>
<td>(20)</td>
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<tr>
<td>135</td>
<td>18</td>
<td>0.045</td>
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<tr>
<td></td>
<td>(18)</td>
<td>(18)</td>
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<tr>
<td>360</td>
<td>24</td>
<td>0.056</td>
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<tr>
<td></td>
<td>(16)</td>
<td>(16)</td>
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<tr>
<td>1200</td>
<td>48</td>
<td>0.070</td>
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<tr>
<td></td>
<td>(14)</td>
<td>(14)</td>
</tr>
<tr>
<td>1500</td>
<td>60</td>
<td>0.097</td>
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<tr>
<td>More than 1500</td>
<td>—</td>
<td>0.126</td>
</tr>
<tr>
<td></td>
<td>(10)</td>
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</tr>
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<sup>a</sup> The figures in parenthesis are the Galvanized Sheet Gauge (GSG) numbers (for zinc-coated steel), the Manufacturers' Standard Gauge (MSG) numbers (for uncoated steel), and the American Wire Gauge (AWG) numbers (for copper, brass, or aluminum) that provide the specified minimum thickness of metal.

<sup>b</sup> Including stainless steel.

<sup>c</sup> Volume of enclosure not more than 12 cubic inches.

37. A knockout shall be provided with a flat surrounding surface adequate for proper seating of a conduit bushing, and shall be located so that installation of a bushing at any knockout likely to be used during installation will not result in spacings between uninsulated live parts and the bushing of less than those required in this Standard.

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

39. In measuring a spacing between an uninsulated live part and a bushing installed in the knockout referred to in paragraphs 37 and 38, it is to be assumed that a bushing having the dimensions indicated in Table 3 is in place, in conjunction with a single lock nut installed on the outside of the enclosure.

40. If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or if an equivalent construction is employed, there shall be not less than three nor more than five threads in the metal, and the construction of the device shall be such that a suitable conduit bushing can be properly attached. If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall be not less than three and one-half threads in the metal and there shall be a smooth, well-rounded inlet hole for the conductors which shall afford protection to the conductors equivalent to that provided by a standard conduit bushing and which shall have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

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41. An enclosure threaded for support by rigid conduit shall provide at least five full threads for engaging with the conduit.

42. Clamps and fasteners for the attachment of conduit, electrical metallic tubing, armored cable, nonmetallic flexible tubing, nonmetallic-sheathed cable, service cable, etc., which are supplied as a part of an enclosure shall comply with the requirements for outlet boxes and fittings.

Ventilating Openings

43. If an enclosure houses fuses or any portion of a circuit breaker, other than the operating handle, ventilating openings shall not be provided unless the construction affords containment of electrical fault disturbances equivalent to that provided by an enclosure complying with the requirements in paragraphs 92–94.

44. The requirement in paragraph 43 is not applicable to a fuse or a circuit breaker provided with a separate nonventilated enclosure within an enclosure, or to a fuse or a circuit breaker employed in a low-voltage or isolated limited-energy circuit.

45. For ventilating openings the following requirements shall apply:

A. The compartment or that part of an enclosure which contains field-wiring splices in the line-voltage circuit shall not be provided with ventilating openings.

B. The ventilating opening shall be necessary to prevent the attainment of excessive temperatures on components of the device, as determined by a temperature test with the opening blocked.

C. The ventilating opening shall not be located in the mounting surface of the enclosure.

D. The ventilating opening shall not be located in the bottom surface of the enclosure unless the conditions of use necessitate such ventilation and it can be shown by test that electrical disturbances will be contained.

E. The nearest portion of a ventilating opening shall be above the bottom of the enclosure and away from the wall mounting surface by a distance equal to one quarter of the enclosure height and depth, respectively, or 1 inch, whichever is the least.

F. There shall be no emission of flame or molten metal, or other manifestation of fire hazard, during the normal tests, as well as during abnormal tests such as transform-er burnout and burnout of relays with blocked armature, on the apparatus.

G. Unless the construction of a device provided with forced ventilation is such that there is no direct path between live parts and the outlet opening, burnout tests, in addition to those mentioned in item F, shall be conducted to determine that there is no emission of flame or molten material through that opening.

H. Air from a ventilating opening (either forced or otherwise) shall not be directed into a duct or into a concealed space in a building, shall not be directed against the mounting surface, and shall not be directed so that a disturbance would be propagated to other equipment.

I. Ventilating openings in an enclosure, including perforated holes, louvers, and openings protected by means of wire screening, expanded metal, or perforated covers, shall be of such size or shape to conform to the requirements in paragraphs 46 and 47.

46. An opening that will not permit entrance of a 3/4-inch-diameter rod is acceptable if a probe as illustrated in Figure 1 cannot be made to touch any uninsulated live part (other than one in a low-voltage circuit) when inserted through the opening.

47. An opening that will permit entrance of a 3/4-inch-diameter rod is acceptable under the conditions described in Figure 2.
The opening is acceptable if, within the enclosure, there is no uninsulated live part or enamel-insulated wire (other than those in a low-voltage circuit) (1) less than X inches from the perimeter of the opening, as well as (2) within the volume generated by projecting the perimeter X inches normal to its plane. X equals five times the diameter of the largest diameter rod that can be inserted through the opening, but is to be less than 4 inches.

Other Openings

48. The smaller dimension (width) of an opening in an enclosure around a dial, adjusting knob, lever, handle, pointer, or the like shall be not more than 1/8 inch for any setting or position of the dial, knob, etc.

49. Except as permitted for ventilating openings or in paragraph 48, the enclosure shall have no open holes other than:

A. No more than four unused holes may be provided in an enclosure which is intended for mounting various components inside the enclosure. The largest dimension of each such opening shall not be greater than 5/32 inch (No. 8 screw diameter).

B. No more than four holes, 1/8 inch or less in diameter, may be provided for the escape of air or drainage of paint during the painting process if they are located as close to the corners of the enclosure as possible, preferably at the rear of the enclosure.

C. The drainage opening in a rainproof enclosure shall not exceed 1/4 by 1/4 inch.

D. No more than four enclosure mounting holes shall be provided for enclosures up to and including line 4 of Table 2. Six holes may be provided for lines 5 and 6, and eight holes may be provided for lines 7 and 8. Four of the holes for lines 1 through 3 may be keyhole slots having the configuration illustrated in Figure 3. Four of the holes for lines 4 through 8 may be keyhole slots, the dimensions of which are not specified. Their size will be judged with respect to the enclosure dimensions and configuration.

E. An opening for passage of a capillary tube, air pipe, bellows, or other necessary mechanism shall result in an unclosed portion of the opening not larger than 1/16 inch.

50. A plate or plug for an unused conduit opening or other hole in the enclosure shall have a thickness not less than (1) 0.014 inch for steel or 0.019 inch for nonferrous metal for a hole having a 1/4-inch maximum dimension and (2) 0.027-inch steel or 0.032-inch nonferrous metal for a hole having a 1-3/8-inch maximum dimension. A closure for a larger hole shall have a thickness equal to that required for the enclosure of the device or a standard knockout seal shall be used. Such plates or plugs shall be securely mounted.

Screen Covered Openings

51. The wires of a screen shall be not less than No. 16 AWG if the screen openings are 1/2 square inch or less in area, and shall be not less than No. 12 AWG for larger screen openings.

52. Except as noted in paragraph 53, perforated sheet steel and sheet steel employed for expanded metal mesh shall have an average thickness of (1) 0.042 inch (0.045 inch if zinc coated) if the mesh opening or perforations are 1/2 square inch or less in area, and (2) 0.080 inch (0.084 inch if zinc coated) for larger openings.
53. In a small device where the indentation of a guard or enclosure will not alter the clearance between uninsulated, movable, live parts and grounded metal so as to affect performance adversely or reduce spacings below the minimum values given in Table 6, expanded metal mesh of uncoated steel not less than 0.021-inch thick (No. 24 MSG) and of zinc-coated steel not less than 0.024-inch thick (No. 24 MSG) may be employed, provided that:

A. The exposed mesh on any one side or surface of the device so protected has an area of not more than 72 square inches and has no dimension greater than 12 inches, or

B. The width of an opening so protected is not greater than 3-1/2 inches.

Windows

54. Glass covering an observation opening and forming a part of the enclosure shall be reliably secured in such a manner that it cannot be readily displaced in service, and shall provide adequate mechanical protection for the enclosed parts. Glass for an opening not more than 4 inches in any dimension shall be 1/16-inch thick (minimum 0.055 inch); and glass for an opening having no dimension greater than 12 inches shall be 1/8-inch thick (minimum 0.115 inch). Glass used to cover a larger opening shall have adequate mechanical strength and shall otherwise be suitable for the purpose.

55. A transparent material other than glass employed as a covering over an opening in an enclosure shall be investigated to determine if it has adequate mechanical strength and is otherwise suitable for the purpose.

56. An enclosure of insulating material shall be of such thickness and so formed that it will protect operating parts against mechanical injury.

Rainproof Enclosures

57. An enclosure intended for outdoor use shall exclude a beating rain. The enclosure shall be provided with external means for mounting, except that internal means for mounting may be employed if designed to prevent water from entering the enclosure. Hinges and other attachments shall be resistant to corrosion. Metals shall not be used in combinations such as to cause galvanic action which will adversely affect any part of the device. There shall be provision for drainage of the enclosure.

Paragraph 57 effective March 30, 1973

58. A gasket of an elastomeric or thermoplastic material or a composition gasket utilizing an elastomeric material employed to make an enclosure rainproof shall be adequately resistant to aging.

59. A hole for conduit shall be threaded unless it is located wholly below the lowest terminal lug, or other live part within the enclosure when the enclosure is mounted in the intended position.

60. An enclosure of sheet steel having an average thickness less than 0.120 inch (No. 10 MSG) shall be:

A. Galvanized by the hot-dip process after forming and assembly;

B. Made from hot-dipped sheets;

C. Provided with a metallic coating at least the equivalent of zinc applied by the hot-dip process; or

D. Protected from corrosion by some other finish that has been found by investigation to be suitable for the purpose.

61. An enclosure made of sheet steel having an average thickness of 0.120 inch (No. 10 MSG) or more may be formed from either hot-dipped or electroplated sheets, or may be protected from corrosion by some other finish that has been found by investigation to be suitable for the purpose. A cadmium coating shall not be less than 0.001-inch thick. Except as noted in paragraph 62, a zinc coating shall be such that a sample of the coated steel will not show a fixed deposit of copper after four one minute immersions in the copper sulphate solution used in the Precece test.

62. If zinc-coated sheet steel has, in addition, a coat of alkyd-resin or other suitable paint, the zinc coating need not comply with the concluding requirement in paragraph 61, provided that an unpainted sample of the coated steel does not show a fixed deposit of copper after three one minute immersions in the copper sulphate solution. If two or more coats of such paint are employed, the unpainted sample need withstand only two one minute immersions without showing a fixed deposit of copper.

Enclosure for Class I, Division 2 Locations, Groups A, B, C, and D

63. An enclosure for equipment for use in Class I, Division 2, Groups A, B, C, and D locations shall comply with the requirements in paragraphs 28-62, and also with paragraphs 64-66.
64. All arcing or sparking parts such as switches, circuit breakers, starters, fuses, ballasts with protective devices sensitive to current, temperature, pressure, etc., shall be housed in an enclosure complying with Class I, Division 1, requirements unless (1) the interruption of current occurs within a hermetically sealed enclosure, (2) the current interrupting contacts are oil immersed and investigated for use in Class I, Division 2 locations, or (3) the contacts are in circuits which under normal conditions do not release sufficient energy to ignite the hazardous atmosphere under consideration.

65. An enclosure is considered to be hermetically sealed if there are no openings in the enclosure and:

A. All joints in a metal enclosure are sealed against the entrance of a gas or spirit by continuous welding, brazing, or soldering,

B. All joints in a glass enclosure are sealed against the entrance of a gas or spirit by fusing.

66. Except for a conduit hub integrally cast with an enclosure, a conduit hub shall (1) have a wall thickness before threading not less than that of the corresponding trade size conduit; (2) not depend upon friction alone to prevent its turning; and (3) be capable of withstanding the torque specified in paragraph 252.

Enclosure for Class II, Div. 2 Locations, Group G

67. The enclosure for equipment for use in Division 2 locations shall comply with the requirements given in paragraphs 28-42, 54-62, and 66 and also with paragraphs 68-75.

68. Electrical components shall be totally enclosed to minimize or exclude the entrance of dust and to prevent the escape of sparks or other hot particles.

69. Two basic types of enclosures can be considered. See paragraphs 70 and 73.

70. An enclosure that is of the gasketed type and is intended to exclude the entrance of dust shall be tested as indicated in paragraphs 236-238 and 248-251. The gaskets shall comply with paragraph 71. The width of joints and the maximum joint clearances are not specified.

71. If a gasket is used, it shall be formed of material acceptable for the purpose such as woven-asbestos or plant-fiber sheet packing material. Gaskets of elastomeric or thermoplastic material may be used if they are adequately resistant to aging as determined by the accelerated aging tests described either in paragraph 270 or in paragraph 271, as appropriate.

72. Gaskets which are employed to make an enclosure dust-tight shall be mechanically secured or captive, if they are at a joint which is opened for wiring or for maintenance purposes.

73. An enclosure that is not of the gasketed type and is intended to minimize the entrance of dust shall be tested as indicated in paragraphs 236-238.

74. All control devices such as switches, circuit breakers, starters, fuses, ballasts, etc., shall be, mounted within a gasketed type enclosure which will exclude dust as indicated in paragraph 70.

75. Equipment which is designed to exclude dust as described in paragraph 70 shall have provision for connection of threaded rigid conduit, only.

Mounting

76. Provision shall be made for securely mounting a permanently connected device of other than the free standing type to a supporting surface. Bolts, screws, or other parts used for mounting a device shall be independent of those used for securing component parts of the device to the frame, base, or panel.

Strength of Parts

77. A pressure-actuated device employing a bourdon tube, a flexible-metal bellows, a diaphragm, or the like that is rated for 300 or more pounds per square inch gauge and is not contained within an enclosure shall withstand for one minute without bursting a hydraulic pressure equal to four times the maximum marked operating-pressure rating of the device.

78. To determine if a part complies with the requirement of paragraph 77, a sample is to be subjected to a hydrostatic-pressure test. The sample is to be filled with water to exclude air and is to be connected to a suitable hydraulic pump. The pressure is to be raised gradually to the required test pressure. Except as indicated in paragraphs 79-84, the sample is to withstand the test pressure for one minute without leakage or rupture.

79. Leakage at a gasket or fitting during the hydrostatic-pressure test is not considered to constitute failure unless it occurs at a pressure of 50 percent or less of the required test pressure.
80. Where leakage occurs during the test, the test is to be continued to four times the maximum working pressure, test equipment permitting, or suitable modifications may be made, if the leakage is due to external fittings, to permit completion of the test.

81. A bourdon tube, a flexible-metal bellows, a diaphragm, or the like that is provided with an enclosure shall comply with the requirements in paragraph 77 or shall:
   A. Withstand for 1 minute without visible leakage a hydraulic pressure in accordance with the second column of Table 4; and
   B. Be subjected to a hydraulic pressure for 1 minute equal to four times the maximum marked operating-pressure rating of the device, except as noted in paragraph 83.

82. In determining compliance with Item B of paragraph 81, there is to be no dangerous rupture. Bourdon tubes, diaphragms, or bellows may split if there are no flying objects outside the enclosure. Joints or gaskets may fail, but the result is acceptable if the four times pressure value is reached and maintained for 1 minute. A leaking gasket or flexible member may be replaced by a stronger nonfunctional one, such as a diaphragm replaced by a heavier disc to permit the four times pressure value to be reached so that the strength of the structure can be demonstrated.

83. With reference to paragraph 82, if leakage becomes excessive so that the four times pressure cannot reasonably be reached, i.e., the part functions as if it had a rupture disc, the part is acceptable if:
   A. A pressure in accordance with the third column in Table 4 is reached;
   B. No dangerous flying objects results; and
   C. It can be demonstrated by test (which may be at a low pressure) or otherwise that the outer enclosure can either relieve a pressure equal to the maximum marked operating-pressure rating of the device without dangerous rupture or can withstand a pressure equal to the maximum marked operating pressure rating.

84. A pressure vessel, an air filter, a piston operator, or similar device shall perform acceptably when subjected to hydrostatic-strength tests consistent with the intended use unless the vessel is marked with the boiler-construction-code symbol of the American Society of Mechanical Engineers.

<table>
<thead>
<tr>
<th>Marked Maximum Operating-Pressure Rating</th>
<th>Test Pressure for Item A of paragraph 81</th>
<th>Test Pressure for Item A of paragraph 83</th>
</tr>
</thead>
<tbody>
<tr>
<td>300-2000 psig</td>
<td>Two Times rated(^d) pressure</td>
<td>Three Times rated(^d) pressure</td>
</tr>
<tr>
<td>Over 2000-10,000 psig</td>
<td>1.75 times rated(^d) pressure plus 500 psi</td>
<td>2.5 times rated(^d) pressure plus 1000 psi</td>
</tr>
<tr>
<td>Over 10,000-25,000 psig</td>
<td>1.3 times rated(^d) pressure plus 5000 psi</td>
<td>1.5 times rated(^d) pressure plus 11,000 psi</td>
</tr>
</tbody>
</table>

\(^d\)Marked maximum operating-pressure rating.

Operating Mechanism

85. The assembly of the apparatus shall not be affected adversely by the vibration of normal operation. If screws and nuts serve to attach operating parts to movable members, they shall be upset or otherwise located to prevent loosening under the conditions of actual use. The operating mechanism shall not subject manually operated switch parts to undue strain.

86. The position of an operating handle shall be marked, if necessary, as a guide for proper operation.

Casualty Hazards

87. Moving parts, such as rotors of motors, and gears, shall be suitably enclosed or guarded to adequately reduce the likelihood of injury to persons.

88. With reference to the requirement in paragraph 87, the degree of protection required of the enclosure depends upon the general design and intended use of the machine. The factors to be taken into consideration in judging the acceptability of exposed moving parts are (1) the degree of exposure, (2) the sharpness of the moving parts, (3) the likelihood of accidental contact with the moving parts, (4) the speed of movement of those parts, and (5) the likelihood of fingers, arms, or clothing being drawn into the moving parts (such as at points where gears mesh, or where moving parts close in a pinching or shearing action).
Overcurrent- and Overload-Protective Devices

89. The construction of intrinsically safe equipment incorporating a fuseholder and the location of fuses in other than a low-voltage circuit, the normal function of which requires renewal, shall be such that fuses will be readily accessible, when the switch contacts are open, so that they may be replaced without a person touching any live part. The electrical arrangement of a single-throw switch shall be such that, if properly connected, fuse terminals will be dead when the switch contacts are open.

90. A control-circuit fuse is not considered to require renewal as a normal function under any of the following conditions:

A. The fuse and control-circuit load (other than a fixed control-circuit load, such as a pilot lamp) are within the same enclosure.

B. The fuse protects a component (such as pilot light, a relay-operating coil, a valve, or the like) whose load characteristics as shown by an appropriate endurance test are not likely to increase.

C. The fuse can be ruptured only by incorrect wiring; i.e. excess voltage, incorrect frequency, etc.

91. A protective device shall be wholly inaccessible from outside the apparatus without opening a door or cover, except that the operating handle of a circuit breaker, the operating button of a manually-operable motor protector, and similar parts may project outside the enclosure.

92. Except as noted in paragraph 93, the door or cover of an enclosure shall be hinged and shall be provided with a catch or spring latch if it gives access to any overload-protective device, the normal functioning of which requires renewal, or if it is necessary to open the cover in connection with the normal operation of the protective device.

93. A hinged cover is not required for a device in which the only fuses enclosed are control-circuit fuses, the fuses and control-circuit loads (other than a fixed control-circuit load, such as pilot lamp) are within the same enclosure.

94. Means shall be provided for holding the door or cover over a fuseholder in a closed position; and the door or cover shall be tight-fitting. The holding means shall not depend solely upon screws or other similar means requiring the use of a tool or manipulation of a handle to retain the cover in a closed position.

95. A switch, a lampholder, an attachment-plug receptacle, a motor attachment plug, or similar component shall be mounted securely and, except as noted in paragraphs 96 and 97, shall be prevented from turning. See paragraph 98.

96. The requirement that a switch be prevented from turning may be waived if all four of the following conditions are met:

A. The switch is to be of a plunger or other type that does not tend to rotate when operated. (A toggle switch is considered to be subject to forces that tend to turn the switch during the normal operation of the switch).

B. Means for mounting the switch make it unlikely that operation of the switch will loosen it.

C. The spacings are not to be reduced below the minimum acceptable values if the switch rotates.

D. Normal operation of the switch is to be by mechanical means rather than by direct contact by persons.

97. A lampholder of a type in which the lamp cannot be replaced (such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel) need not be prevented from turning if rotation cannot reduce spacings below the minimums required.

98. The means for preventing the turning mentioned in paragraph 95 is to consist of more than friction between surfaces, e.g., a suitable lock washer, properly applied is acceptable as means for preventing a small stem-mounted switch or other device having a single-hole mounting means from turning.

Protection Against Corrosion

99. Except as noted in paragraph 100, all surfaces of iron or steel parts shall be suitably protected against corrosion by enameling, galvanizing, plating, or other suitable means.

100. The requirement in paragraph 99 does not apply to:

A. Bearings, balance weights, laminations, or minor parts of iron or steel (such as washers, screws, etc.);

B. Other parts of iron or steel, if failure of such parts would not be liable to result in hazardous conditions; and

C. The interior surface of a vessel that contains or conducts liquid solvent.
Field Wiring Connections

General

101. Except as indicated in paragraph 102, an apparatus intended to be permanently wired shall be provided with field-wiring terminals or leads for the connection of the power supply or other conductors, and with means for the connection of a wiring system as required by the American National Standard National Electrical Code C1-1971 for the locations involved.

102. For the purpose of these requirements, a field-wiring terminal is considered to be a terminal to which a power supply or control connection will be made in the field when the apparatus is installed.

103. Field-wiring terminals or leads that are supplied from circuits which are judged to be low-voltage circuits, as defined in paragraph 19, are not required to be further enclosed. These circuits may be intrinsically safe. See paragraphs 104-106.

104. Except as noted in paragraph 105, if provided, an opening or a knockout not having rounded edges and intended to be used for the entry of field installed conductors of a circuit as described in paragraph 103 shall be provided with a suitable insulating bushing. The bushing may be mounted in place in the opening or may be within the enclosure so that it may be properly mounted when the device is installed. Only the number of bushings necessary to properly wire the device need be provided.

105. If the opening mentioned in paragraph 104 is suitable for accommodating an NEC Class I wiring system and the installation instructions specify such a wiring system, bushings need not be provided.

106. A bushing of rubber or rubber-like material provided in accordance with paragraph 104 shall be 1/8-inch or more thick, except that it may not be less than 1/16-inch thick (with a minus tolerance of 1/64 inch) if the metal around the hole is eyeletted or similarly treated to ensure smooth edges. A bushing shall be located so that it will not be exposed to oil, grease, oily vapors, or other substances having a deleterious effect on the material of the bushing. A hole in which a bushing is mounted shall be free from sharp edges, burrs, projections, etc., which might damage the bushing.

107. The space within the enclosure shall provide ample room for the distribution of wires and cables required for the proper wiring of the device.

Terminal Compartments

108. A terminal compartment, that is intended for connection of a supply raceway and can be positioned to suit a particular installation, shall be provided with a means for attachment to the apparatus to prevent turning both during and after installation.

109. An outlet or terminal box in which connections to the power supply circuit will be made shall be located so that, after the apparatus has been installed as intended, the connections will be readily accessible for inspection.

110. The compartment mentioned in paragraph 109 shall be located so that during conduit connections thereto, internal wiring and electrical components shall not be exposed to physical abuse or strain.

Wiring Terminals and Leads

111. The wiring terminals or leads mentioned in paragraph 101 shall be suitable for the connection of field-installed conductors having an ampacity, as required for the device, in accordance with the American National Standard National Electrical Code, C1-1971.

112. If the apparatus is intended to be adapted upon installation for either of two different supply voltages (e.g., 120 volts, two wire or 120/240 volts, three wire), it shall be provided with means by which the appropriate connections may be made during field installation, without the necessity of changing or disrupting internal wiring or connections other than at the point of field connection. This requirement does not apply to apparatus which is factory wired internally for a specific voltage and so marked on the name plate.

113. A wiring terminal shall have a suitable pressure wire connector, firmly bolted or held by a screw; except that a wire-binding screw may be employed at a wiring terminal intended to accommodate a No. 8 AWG or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in position.

114. A wiring terminal shall be prevented from turning.

115 A wire-binding screw shall thread into metal.

116. Except as noted in paragraphs 117 and 118, a wire-binding screw at a wiring terminal shall be no smaller than No. 8.
117. A No. 6 screw may be used for a terminal to which a No. 14 AWG wire or smaller would normally be connected.

118. A wire-binding screw at a wiring terminal supplied from circuits which are judged to be low-voltage, as described in paragraph 19, shall be no smaller than a No. 5 machine screw. These low-voltage circuits may be intrinsically safe.

119. A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050-inch thick except that a plate not less than 0.030-inch thick is acceptable if the tapped threads have adequate strength. There shall be two or more full threads in the metal, which may be extruded, if necessary, to provide the threads.

120. Upturned lugs, a cupped washer, or equivalent shall retain a conductor of the size indicated in paragraph 111 under the head of the screw or the washer.

121. A terminal for connection of a grounded power supply conductor shall be of, or plated with, a metal substantially white in color and shall be readily distinguishable from the other terminals; or proper identification of the terminal for the connection of the grounded conductor shall be clearly shown in some other manner, such as on a wiring diagram adjacent to the terminals.

122. A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green colored head that is hexagonal-shaped, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified, such as by being marked, G, GR, GROUND, GROUNDING, or the like, or by a suitable marking on a wiring diagram provided on the equipment. The wire-binding screw or pressure wire connector shall be located so that it is unlikely to be removed during normal servicing of the unit.

123. A terminal for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size suitable for the particular application in accordance with the American National Standard National Electrical Code, C1-1971.

124. A soldering lug, a push-in (screwless) connector, or a quick-connect or similar friction-fit connector, shall not be used for the grounding terminal.


125. The surface of a lead intended for connection of a grounded-power-supply conductor shall be white or natural grey, and shall be readily distinguishable from the other leads.

126. The surface of an insulated lead intended for connection of an equipment-grounding conductor shall be green or green with one or more yellow stripes, and no other lead shall be so identified.

127. The requirements in paragraphs 125 and 126 relating to color coding for identification do not apply to internal wiring that is not visible in a wiring compartment in which field connections are to be made.

128. The free length of a lead inside an outlet box or wiring compartment shall be 6 inches or more if the lead is intended for field connection to an external circuit.

129. A lead intended for field connection and exiting from the apparatus through a conduit hub shall be at least 18 inches in length measured from the point of exit of the apparatus to the connection end of the lead.

130. A lead intended to be connected to field-installed wiring shall be no smaller than No. 18 AWG.

Cord Connected Devices

Cords And Plugs

131. Portable equipment and fixed or stationary equipment requiring cord connection to facilitate removal or disconnection for maintenance and repair may be provided with a flexible cord and an attachment plug for connection to the supply source.

132. The type of cord shall be suitable for the particular application in accordance with Table 5. The rating of the plug and the current-carrying capacity of the cord, as given in the American National Standard National Electrical Code C1-1971, shall be not less than the marked rating of the device.

133. Equipment for use in ordinary locations shall be provided with an attachment plug of other than the hazardous location type.

134. Except as noted in paragraphs 135 and 139, equipment for use in hazardous locations shall be provided with an attachment plug suitable for use in the hazardous location class and group for which the equipment is intended.

135. Process control instruments intended for use in Class I, Division 2 locations may be connected through flexible cord, attachment plug and receptacle, provided:

A. The input current does not exceed 3 amperes at 120 volts;
B. The power-supply cord does not exceed three feet, is of a type approved for extra-hard usage or for hard usage if protected by location, and is supplied through a plug and receptacle of the locking and grounding type;

C. Except as noted in paragraph 136, a suitable switch or equal, is provided so that the plug is not depended on to interrupt current;

D. Only necessary receptacles are provided; and

E. The receptacle carries a marking warning against unplugging under load if the receptacle is in a circuit which is capable of releasing sufficient energy to ignite a specific hazardous-atmospheric mixture under normal conditions. See paragraph 138.

Paragraph 135 effective March 30, 1973

136. The switch referred to in Item C of paragraph 135 need not be provided as part of the instrument if instructions in accordance with paragraph 364 are provided indicating that such a switch is necessary.

Paragraph 136 effective March 30, 1973

137. If provided as a part of the instrument, the switch required by item C of paragraph 135 shall have an enclosure approved for Class I locations unless an ordinary location enclosure is provided and current-interrupting contacts are (1) immersed in oil, (2) enclosed within a chamber hermetically sealed against the entrance of gases or vapors, or (3) in circuits which under normal conditions do not release sufficient energy to ignite the specific hazardous-atmospheric mixture for which the instrument is intended.

138. If the receptacles referred to in item E of paragraph 135 are not provided, instructions in accordance with paragraph 366 shall be provided indicating that the marking indicated in item E is necessary.


139. Equipment produced without the attachment plug attached shall be provided with suitable instructions regarding the installation of this component in accordance with paragraph 363.


Strain Relief

140. Strain relief shall be provided so that a mechanical stress on a flexible cord will not be transmitted to terminals, splices, or interior wiring.

Table 5

<table>
<thead>
<tr>
<th>Area Classification</th>
<th>Cord Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinary Locations</td>
<td>SJ, SJO, SJT, SJTO, S, SO, ST, STO</td>
</tr>
<tr>
<td>Class I, Division 2</td>
<td>S, SO, ST, STO, SJ, SJO, SJT, SJTO</td>
</tr>
<tr>
<td>Class II, Division 2</td>
<td>S, SO, ST, STO</td>
</tr>
</tbody>
</table>

* Permissible only where mechanically protected in process control instruments in accordance with paragraph 135.

141. If a knot in a flexible cord serves as strain relief, the surface against which the knot may bear or with which it may come in contact shall be free from projections, sharp edges, burrs, fins, etc., which may cause abrasion of the insulation on the conductors.

Bushings

142. At a point where a flexible cord passes or is intended to pass through an opening in a wall, barrier, or enclosing case, there shall be a suitable bushing or the equivalent which shall (1) be substantial, (2) be reliably secured in place, and (3) have a smoothly-rounded surface against which the cord may bear.

143. If the cord opening is in wood, porcelain, phenolic composition or other suitable nonconducting material, a smoothly-rounded surface is considered to be the equivalent of a bushing.

144. Ceramic materials and some molded compositions are acceptable generally for insulating bushings; but separate bushings of wood or so-called hot-molded shellac and tar compositions are not acceptable.

145. A fiber bushing shall (1) not be less than 1/16-inch thick (with a minus tolerance of 1/64 inch for manufacturing variations), (2) be so formed and secured in place that it will not be affected adversely by conditions of ordinary moisture, and (3) not be employed where it will be subjected to a temperature higher than 90°C under normal operating conditions.

Internal Wiring

146. The internal wiring and connections between parts of the apparatus shall be enclosed except that a suitable length of flexible cord may be employed for external connections if flexibility is essential.

147. For the purpose of these requirements, the internal wiring of an apparatus is considered to be all the wiring within the apparatus or forming an integral part thereof.
148. Unless it is to be judged as an uninsulated-live or grounded part, insulated-internal wiring (including an equipment-grounding conductor) shall consist of wire of a type or types suitable for the particular application, when considered with respect to:

A. The temperature and voltage to which the wiring is liable to be subjected;

B. Exposure to oil, grease, cleaning fluid, or other substances liable to have a deleterious effect on the insulation;

C. Exposure to moisture; and

D. Other conditions of service to which it is liable to be subjected.

149. Except as indicated in paragraphs 150, 151, and 152, insulated wire employed for internal wiring shall (1) be standard building, or fixture wire or appliance-wiring material recognized as being suitable for the purpose and (2) have an insulation thickness of 1/32 inch or more.

150. Appliance-wiring material having 1/64-inch thick insulation and provided with a suitable outer braid or jacket is acceptable.

151. Recognized appliance-wiring material having thermoplastic insulation, or equivalent, no less than 1/64-inch thick and without an outer braid or jacket is acceptable in the secondary circuit of an isolated-power supply rated 100 volt-amperes or less and 600 volts or less.

152. Appliance-wiring material having a heat-resistant rubber insulation, of other than a silicone type, 3/64-inch or more thick and without an outer a braid is acceptable.

153. Unless the apparatus includes a heating element and unless the wire is subjected to a temperature of more than 80°C (176°F), asbestos-insulated wire shall not be employed if the wire is liable to be exposed to moisture, including any condensation resulting from operation of the apparatus.

154. If the wiring inside an apparatus may be subjected to physical injury, it shall be in armored cable, conduit, or electrical metallic tubing or shall be otherwise suitably protected.

155. Wiring shall be protected from sharp edges (including male screw threads), burrs, fins, moving parts, etc., that might cause abrasion of the insulation on conductors.

156. A hole for insulated wires to pass through a sheet metal wall within the overall enclosure shall be provided with a smoothly rounded bushing or the surfaces upon which the wires may bear shall be smooth and free of burrs, fins, sharp edges, etc. which might abrade the insulation.

157. Insulated wires may be bunched and passed through a single opening in a metal wall within the enclosure of the apparatus.

158. No wires, other than those leading to a part mounted on the door or cover, shall be brought out through the door or cover of an enclosure.

159. All splices and connections shall be mechanically secured and shall provide adequate and reliable electrical contact.

160. Except as indicated in paragraph 161, a soldered connection shall be mechanically secured before being soldered.

161. The requirement in paragraph 160 is not applicable to components mounted to a printed wiring board where dip or wave soldering is used.

162. A splice shall be provided with insulation equivalent to that of the wires involved if permanence of spacing between the splice and other metal parts is not ensured.

163. Insulation consisting of two layers of friction tape, of two layers of recognized thermoplastic tape, or of one layer of friction tape on top of one layer of rubber tape is acceptable on a splice if the voltage involved is less than 250 volts. In determining whether or not splice insulation consisting of coated fabric, thermoplastic, or other type of tubing is acceptable, consideration is given to such factors as its dielectric properties, heat resistant and moisture-resistant characteristics, etc. Thermoplastic tape wrapped over a sharp edge is not acceptable.

164. The connection of stranded internal wiring to a wire-binding screw shall be such that the loose strands of each wire are prevented from contacting other live parts not always of the same polarity as the wire and from contacting dead-metal parts. This may be accomplished by the use of a pressure terminal connector, a soldering lug, a crimped eyelet, soldering all strands of the wire together, or other suitable reliable means.

165. An open-end spade lug shall not be used unless suitable means are provided to hold the lug in place if the wire-binding screw or nut becomes slightly loosened. Upturned ends on the tang of the lug or a retaining barrier are considered acceptable to hold the lug in place.

Printed Wiring

166. A printed-wiring board, a printed-wiring assembly, and a printed cable shall be recognized as being suitable for the use.
Live Parts

167. A current-carrying part in a circuit, other than one classified as low-voltage, shall be of silver, copper, or copper alloy, or other material suitable for the purpose.

168. Suitably plated iron or steel may be used for a current-carrying part (1) whose temperature during normal operation is more than 100°C (212°F), (2) within a motor or associated governor, or (3) if permitted in accordance with paragraph 27. Plain (unplated) iron or steel is not acceptable. These restrictions do not apply to stainless steel and other corrosion-resistant alloys.

169. An uninsulated live part shall be secured to the base or mounting surface so that it will be prevented from turning or shifting in position if such motion may result in a reduction of spacings below the minimum acceptable values.

170. Friction between surfaces is not acceptable as the sole means to prevent the turning of a live part; but a suitable lock washer properly applied is acceptable for this purpose.

Electrical Insulation

171. Insulating washers, bushings, etc., and bases or supports for the mounting of live parts shall be of a material that (1) is moisture resistant (such as porcelain or phenolic composition, or other material recognized as being suitable for the particular application), (2) is not affected injuriously by the temperatures to which the part will be subjected under conditions of actual use, and (3) has the strength and rigidity necessary to withstand the stresses of actual service.

172. Insulating material employed in an apparatus is judged with respect to its suitability for the particular application. Materials such as mica, some molded compounds, and certain refractory materials are usually acceptable for use as the sole support of live parts. Other materials that are not suitable for general use, such as asbestos and magnesium oxide, may be accepted if used in conjunction with other more suitable insulating materials and located and protected so that physical injury and the absorption of moisture are prevented. If an investigation is necessary in order to determine whether or not a material is acceptable, consideration is given to its physical strength, dielectric strength, insulation resistance, heat resistant qualities, the degree to which it is enclosed or protected, and any other features that have a bearing on the fire and accident hazards involved, in conjunction with the conditions of actual service. All of these properties mentioned here are to be considered with respect to the effects of thermal aging.

173. Ordinary vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated current-carrying parts except as indicated in paragraph 174.

Paragraph 173 effective March 30, 1973

174. In low-voltage circuits, vulcanized fiber may be used for sole support of current-carrying parts if failure of the insulation does not result in an increase in the energy output to an intrinsically safe circuit.

Paragraph 174 effective March 30, 1973

Transformer

175. A transformer shall be housed within its own enclosure, or within the main enclosure of the apparatus, or within a combination thereof.

176. The transformer shall be suitable for the particular application and shall operate under normal conditions without introducing hazardous conditions as described in paragraph 226.

177. The transformer winding shall resist the absorption of moisture and shall be formed and assembled in a workmanlike manner.

Overcurrent Protection

178. A fuseholder or circuit breaker shall be recognized as suitable for the particular application.

179. A plug fuseholder intended for the fuse mentioned in paragraph 178 shall be Type S or shall be Edison-base with a factory-installed, non-removable adapter of Type S construction.

180. An overload- or overcurrent-protective device shall not open the circuit during normal operation of the apparatus.

Lampholders

181. If the apparatus is intended to be connected to the identified (grounded) conductor of the power-supply circuit, the screw shell of any Edison-base lampholder in the appliance shall be connected to that conductor.

182. If more than one Edison-base lampholder is provided, the screwshells of all such lampholders shall be connected to the same conductor unless there is no shock hazard present when replacing the lamps.
183. A lampholder shall be designed or installed so that uninsulated live parts other than a screw shell will not be exposed to contact by persons removing or replacing lamps in normal service.

Receptacles

184. An attachment-plug receptacle intended for general use shall be of the grounding type.

Switches

185. A switch shall be located or protected so that it will not be exposed to physical injury during normal use.

186. A switch shall be suitable for the particular application, and shall have a current and voltage rating no less than that of the circuit (load) which it controls when the apparatus is operated normally.

187. A switch or other device that controls a motor shall have voltage and horsepower ratings no less than the corresponding ratings of the motor it controls.

188. A switch or other device that controls a contactor, a relay coil, or other electromagnetic device shall have voltage and volt-ampere ratings no less than the corresponding ratings of the load it controls.

189. The current-carrying capacity of a switch that controls an inductive load, such as a transformer or an electric-discharge-lamp ballast, shall be no less than twice the rated full load current of the transformer or ballast unless the switch has been recognized as being suitable for the particular application.

190. A switch that controls a medium-base lampholder of other than a pilot or indicating light shall be suitable for use with tungsten-filament lamps.

191. In an apparatus intended for connection to a grounded power supply conductor, a switch with a marked “off” position shall disconnect all ungrounded conductors of the supply circuit.

Capacitors

192. The voltage rating of a capacitor shall be no less than the maximum steady state potential to which the capacitor is subjected during operation of the apparatus.

Grounding

193. Cord-connected equipment designed for use on circuits involving a potential of more than 150 volts to ground, permanently-connected equipment, and equipment for use in hazardous locations shall have provision for grounding all dead-metal parts which are exposed or which are liable to be touched by a person during normal operation or adjustment of the device, and which are liable to become energized.

194. In a permanently-connected device, the provision of a knockout or other suitable opening in the enclosure for the connection of conduit, other metal raceway, or armored cable is acceptable as a means for grounding.

Spacings

195. Except as noted in paragraphs 198 to 200, the spacings in the apparatus shall be no less than those indicated in Tables 6 and 7.

Paragraph 195 effective March 30, 1973

196. 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.

197. All uninsulated live parts connected to different circuits shall be spaced from one another as though they were parts of opposite polarity, and shall be judged on the basis of the highest voltage involved.

198. The spacing between uninsulated live parts of opposite polarity and between such parts and dead metal which may be grounded in service is not specified for parts of a circuit which is classified as low-voltage under paragraph 19.

199. As indicated in footnote 9 of Table 7, the spacing between uninsulated live parts of opposite polarity and between such parts and dead metal which may be grounded in service is not specified for parts of circuits which are classified as isolated limited secondary circuits under paragraph 21. The spacing is based on acceptable performance of applicable dielectric withstand and abnormal operation tests.

200. The spacings in a component device (such as a snap switch, lampholder, etc.) supplied as part of the equipment shall be no less than the minimum spacings required for the component device or the spacings indicated in Tables 6 and 7, whichever are smaller.
TABLE 6
MINIMUM SPACINGS IN INCHES

<table>
<thead>
<tr>
<th>Maximum Rating 600 Volts</th>
<th>Unlimited Volt-Amperes</th>
<th>2000 Volt-Amperes, Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential Involved In Volts</td>
<td>0-50</td>
<td>51-150</td>
</tr>
<tr>
<td>Between any uninsulated live part and an uninsulated live part of opposite polarity, uninsulated grounded part other than the enclosure, or exposed-metal part</td>
<td>Through Air</td>
<td>1/16&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Over Surface</td>
<td>1/16&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Between any uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable</td>
<td>Shortest Distance</td>
<td>1/16&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>The spacing between field wiring terminals of opposite polarity and the spacing between a wiring terminal and a grounded dead-metal part shall be no less than 1/4 inch if short-circuiting or grounding of such terminals may result from projecting strands of wire.

<sup>b</sup>These spacings may be 3/64 inch between opposite polarity conductors on printed wiring boards of recognized construction.

<sup>c</sup>For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is liable to reduce spacings between the metal piece and uninsulated live parts. If an integral projection or a metal piece attached to the enclosure is fixed in relation to the live parts so that deformation of the enclosure does not affect spacings, the integral projection or metal piece is not considered part of the enclosure.

Table 6 Effective March 30, 1973.

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

202. Enamel-insulated and similar film-insulated wire is considered to be the same as an uninsulated live part in determining compliance of a device with the spacing requirements in this Standard.

203. If an isolated dead-metal part is interposed between or is in close proximity (1) to live parts of opposite polarity, (2) to a live part and an exposed dead-metal part, or (3) to a live part and a dead-metal part that may be grounded, the spacing may be not less than 3/64 inch between the isolated dead-metal part and any one of the other parts previously mentioned, provided the sum of the spacings between the isolated dead-metal part and the two other parts is not less than the value indicated in Table 7.

204. The spacing at a field-wiring terminal is to be measured with a wire of the appropriate size (for the rating) connected to the terminal as in actual service.

TABLE 7
MINIMUM SPACINGS IN ISOLATED SECONDARY OF A TRANSFORMER IN INCHES

<table>
<thead>
<tr>
<th>Maximum Rating 600 Volts 100 Volt-Amperes Or Less</th>
<th>0-50</th>
<th>51-600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential Involved In Volts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between any uninsulated live part and an uninsulated live part of opposite polarity, an uninsulated grounded dead-metal part other than the enclosure, or exposed-metal part</td>
<td>Through Air or Oil</td>
<td>1/16&lt;sup&gt;a, b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Over Surface</td>
<td>1/16&lt;sup&gt;a, b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Between any uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable</td>
<td>Shortest Distance</td>
<td>1/16&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>These spacings do not apply to components or parts where the short-circuiting or grounding of the parts will not result in manifestation of a shock or fire hazard in the equipment nor increase the energy output of the intrinsically safe circuit.

<sup>b</sup>These spacings may be 3/64 inch between opposite polarity conductors on printed wiring boards of recognized construction.

<sup>c</sup>These spacings may be 3/64 inch between opposite polarity conductors on printed wiring boards of recognized construction used in circuits of 150 volts or less.

Table 7 effective March 30, 1973.
Insulating Barrier or Liners

205. Except as noted in paragraphs 206, 207, and 208, an insulating barrier or liner that is used to provide spacings shall be of material suitable for the particular application and shall be a nominal 1/32 inch (minimum 0.028 inch) thick.

206. A barrier or liner that is used in conjunction with not less than one-half the required spacing may be less than 1/32 inch but shall be a nominal 1/64-inch (minimum 0.013 inch) thick, provided the barrier or liner is (1) of a good quality of suitable insulating material, (2) resistant to moisture, (3) of adequate mechanical strength if exposed or otherwise liable to be subjected to mechanical injury, (4) reliably held in place, and (5) located so that it will not be affected adversely by operation of the equipment in service — particularly arcing.

207. An insulating barrier or liner used as the sole separation between live parts and grounded parts or between live parts of opposite polarity, shall be of material of a type that is suitable for the mounting of uninsulated live parts and is a nominal 1/32-inch (minimum 0.028 inch) thick. Otherwise, a barrier shall be used in conjunction with at least a 1/32-inch air spacing.

Paragraph 207 effective March 30, 1973

208. Insulating material having a thickness less than that specified in the preceding paragraphs may be used if, upon investigation, it is found to be suitable for the particular application, and is equivalent to materials of the thicknesses contemplated.

Separation of Circuits

209. Unless provided with insulation suitable for the highest voltage involved, insulated conductors of different circuits (internal wiring) shall be separated by barriers or segregated; and shall, in any case, be separated or segregated from uninsulated live parts connected to different circuits.

210. Segregation of insulated conductors may be accomplished by clamping, routing, or equivalent means which ensures permanent separation from insulated or uninsulated live parts of a different circuit.

211. If a barrier is used to provide separation between the wiring of different circuits, it shall be (1) of grounded metal or of suitable insulating material, (2) of adequate mechanical strength if exposed or otherwise liable to be subjected to mechanical injury, and (3) reliably held in place. Unclosed openings in a barrier for the passage of conductors shall not be larger than 1/4 inch in diameter and shall not exceed in number, on the basis of one opening per conductor, the number of wires which will need to pass through the barrier. The closure for any other opening shall present a smooth surface wherever an insulated wire may be in contact with it; and the area of any such opening, with the closure removed, shall not be larger than required for the passage of the necessary wires. Also see paragraph 156.

Paragraph 211 effective March 30, 1973

212. Field-installed conductors of any circuit shall be segregated or separated by barriers from:

A. Field-installed and factory-installed conductors connected to any other circuit, unless the conductors of both circuits are or will be insulated for the maximum voltage of either circuit. Also see paragraph 215.

B. Uninsulated live parts of any other circuit of the device, and from any uninsulated live parts whose short-circuiting would result in unsafe operation of the controlled device, except that (1) a construction in which field-installed conductors may make contact with wiring terminals is acceptable, provided that Type RH, T, RF-2, or equivalent conductors are or will be installed, and (2) a construction in which field-installed conductors which do or may have insulation less than those types of wire mentioned in item (1) may make contact with low-voltage wiring terminals (see paragraph 19) is acceptable, provided that the short-circuiting of such terminals would not result in unsafe operation of the controlled device.

213. A barrier used to provide separation between the field wiring of one circuit and the wiring or uninsulated live parts of another shall be spaced not more than 1/16 inch from the enclosure walls and from interior mechanisms and component-mounting panels, etc., which serve to provide segregated compartments.
214. A metal barrier used to provide segregation shall be (1) grounded, (2) of adequate strength and rigidity, and (3) at least the thickness specified under the “With Supporting Frame” column of Table 2 for the dimensions of the barrier. A barrier of insulating material shall be of such thickness and be so supported that its deformation cannot be readily accomplished so as to defeat its purpose, but in any case, the nominal thickness shall be 1/32 inch (minimum 0.028 inch). A barrier between uninsulated live parts connected to different circuits, and a barrier between uninsulated live parts of one circuit and the wiring of another circuit shall also comply with the requirement of paragraphs 206 and 207.

Paragraph 214 effective March 30, 1973

215. With respect to item A of paragraph 212, if the intended uses of the device are such that in some applications a barrier is required while in some other applications a barrier is not required, a removable barrier or one having openings for the passage of conductors may be employed, provided adequate instructions for the use of the barrier are a permanent part of the device. Complete instructions in conjunction with a wiring diagram may be acceptable in lieu of a barrier if, upon investigation, the combination is found to be adequate.

216. Segregation of field-installed conductors from other field-installed conductors and from uninsulated live-metal parts of the device connected to different circuits may be accomplished by arranging the location of the openings in the enclosure for the various conductors (with respect to the terminals or other uninsulated live-metal parts) so that the intermingling of the conductors or parts of different circuits is unlikely.

217. If the number of openings in the enclosure does not exceed the minimum required for the proper wiring of the device, and if each opening is located opposite a set of terminals, it is to be assumed, for the purpose of determining compliance with paragraph 212, that the conductors entering each opening will be connected to the terminals opposite the opening. If more than the minimum number of openings are provided, the possibility of conductors entering at points other than opposite the terminals to which they are intended to be connected and contacting insulated conductors or uninsulated current-carrying parts connected to a different circuit is to be investigated.

218. To determine if a device complies with the requirement of paragraph 212, it is to be wired as it would be in service; and in doing so, a reasonable amount of slack is to be left in each conductor, within the enclosure, and no more than average care is to be exercised in stowing this slack into the wiring compartment.

PERFORMANCE

General

219. Unless otherwise indicated, a representative sample of the product shall be subjected to the tests described. The order of tests, as far as applicable, shall be as presented here.

220. Unless otherwise indicated, the tests shall be conducted at rated frequency and at the voltage indicated in Table 8.

TABLE 8

<table>
<thead>
<tr>
<th>Voltage Rating of Device</th>
<th>Test Potential In Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>110-120 a-c</td>
<td>120 a-c</td>
</tr>
<tr>
<td>110-125 d-c</td>
<td>125 d-c</td>
</tr>
<tr>
<td>208 a-c</td>
<td>208 a-c</td>
</tr>
<tr>
<td>220-240 a-c</td>
<td>240 a-c</td>
</tr>
<tr>
<td>220-250 d-c</td>
<td>250 d-c</td>
</tr>
<tr>
<td>265-277 a-c</td>
<td>277 a-c</td>
</tr>
<tr>
<td>440-480 a-c</td>
<td>480 a-c</td>
</tr>
<tr>
<td>550-600 a-c</td>
<td>600 a-c</td>
</tr>
</tbody>
</table>

If the rating of the equipment does not fall within any of the indicated voltages ranges, it is to be tested at its rated voltage.

221. Apparatus having a dual rating may be tested at either or both ratings to ensure that tests are conducted under the most adverse conditions.

Product Tests

Power Input

222. Except as indicated in paragraph 223, the power input shall not exceed the marked rating of the device by more than 10 percent when it is operated under the conditions of normal use and with the device connected to a supply circuit as indicated in Table 8.

223. A device rated 20 watts or less may have an input of not more than 25 percent above its marked rating.
Power Output

224. The open-circuit voltage and short-circuit current shall be measured at the output terminals, if provided. These values will be used as the basis for establishing the connection and marking requirements as indicated elsewhere in this Standard. In the power circuits, the output may be measured with assumed failures of electronic components. However, only one failure is to be introduced at a time.

Maximum Voltage Output

225. Unless evident from the other tests conducted, measurements will be made at various points to determine the maximum voltage within the device. These voltage measurements will be used as a basis for determining the voltages employed in the dielectric withstand test.

Normal Temperature

226. When tested under the conditions described in paragraphs 227-235, the apparatus shall not attain a temperature at any point sufficiently high to constitute a fire hazard or to affect injuriously any materials employed in the device, nor show temperature rises at specific points greater than those indicated in Table 9.

227. With reference to Items 12 and 13 in Table 9, the temperature rise observed by means of a thermocouple on the surface of a coil, where Class A or B insulation is involved and where the temperature at that point is affected by an external source of heat, may be 15°C (27°F) higher than that indicated in the table, provided that the temperature rise by the resistance method for the item in question is not more than that specified in the table.

228. All values for temperature rises in the table are based on an assumed ambient (room) temperature of 25°C (77°F); however tests may be conducted at any ambient temperature within the range of 10-40°C (50-104°F). If the equipment is intended for use in an ambient temperature higher than 25°C (77°F), the test is to be conducted at the higher ambient temperature and the allowable temperature rises specified in Table 9 are to be reduced by the difference between the higher ambient and 25°C (77°F).

229. A low potential source of supply may be utilized for conducting temperature tests on parts other than coils or transformer windings. Unless otherwise noted, the tests on all parts are to be made simultaneously, as the heating of one part may affect the heating of another part.

---

**TABLE 9**

<table>
<thead>
<tr>
<th>Materials and Components</th>
<th>Degrees Celsius</th>
<th>Degrees Fahrenheit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Knife-switch blades and contact jaws</td>
<td>30</td>
<td>54</td>
</tr>
<tr>
<td>2. Laminated contacts</td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>3. At any point within a terminal box or wiring compartment of permanently-connected apparatus in which power-supply conductors are to be connected, including such conductors themselves, unless the apparatus is marked in accordance with paragraph 372.</td>
<td>35</td>
<td>63</td>
</tr>
<tr>
<td>4. Class 90 (Class 0) insulation</td>
<td>B. Resistance method</td>
<td>60</td>
</tr>
<tr>
<td>5. Class 2 transformer enclosure</td>
<td>60</td>
<td>108</td>
</tr>
<tr>
<td>6. Varnished cloth insulation</td>
<td>60</td>
<td>108</td>
</tr>
<tr>
<td>7. Solid contacts, buses and connecting bars</td>
<td>65</td>
<td>117</td>
</tr>
<tr>
<td>8. Fuses</td>
<td>65</td>
<td>117</td>
</tr>
<tr>
<td>9. Fiber employed as electrical insulation</td>
<td>65</td>
<td>117</td>
</tr>
<tr>
<td>10. Wood and other combustibles</td>
<td>65</td>
<td>117</td>
</tr>
<tr>
<td>11. Power transformer enclosure</td>
<td>65</td>
<td>117</td>
</tr>
<tr>
<td>12. Class 105 (Class A) insulation on coil windings</td>
<td>A. In open motors:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thermocouple method</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Resistance method</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>B. In totally enclosed motors:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thermocouple method</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Resistance method</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>C. Other coils:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thermocouple method</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Resistance method</td>
<td>85</td>
</tr>
<tr>
<td>13. Class 130 (Class B) insulation</td>
<td>A. Thermocouple method</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>B. Resistance method</td>
<td>95</td>
</tr>
<tr>
<td>14. Phenolic composition employed as electrical insulation or as a part where failure would result in a hazardous condition</td>
<td>125</td>
<td>225</td>
</tr>
<tr>
<td>15. All rubber- or thermoplastic-insulated wire and cords except those mentioned in item 16</td>
<td>35</td>
<td>63</td>
</tr>
<tr>
<td>16. Types RFH, FFH, AND RH wire</td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>17. Other types of insulated wire</td>
<td>e</td>
<td>e</td>
</tr>
<tr>
<td>18. Sealing compounds</td>
<td>45°C less than melting point</td>
<td>72°C less than melting point</td>
</tr>
<tr>
<td>19. Capacitors</td>
<td>d</td>
<td>d</td>
</tr>
</tbody>
</table>

*a* See paragraph 227

*b* The limitation on phenolic composition and on rubber and thermoplastic insulation does not apply to compounds which have been investigated and recognized as having special heat resistant properties.

*c* For standard insulated conductors other than those mentioned in items 15 and 16, reference should be made to the American National Standard National Electrical Code, CI-1971 and the maximum allowable temperature rise in any case is 25°C (45°F) less than the recognized temperature limit of the wire in question, except as noted in paragraph 228.

*d* For a capacitor, the maximum allowable temperature rise is 20°C (45°F) less than the recognized temperature limit of the capacitor, except as noted in paragraph 228.
230. Ordinarily, coil or winding temperatures are to be measured by thermocouples mounted on the outside of the coil wrap. If the coil is inaccessible for mounting thermocouples (e.g., a coil immersed in sealing compound) or if the coil wrap includes thermal insulation, such as asbestos or more than 1/32 inch of cotton, paper, rayon, or the like, the change-of-resistance method is to be used. For a thermocouple-measured temperature of a coil of a motor (items 12 and 13 of Table 9), the thermocouple is to be mounted on the integrally-applied insulation of the conductor.

231. The resistance method consists of the determination of the temperature of a copper winding by comparing the resistance of the winding at the temperature to be determined with the resistance of the winding at a known temperature, according to the formula:

\[ T = \frac{R}{r} (234.5 + t) - 234.5 \]

in which \( t \) is the known temperature in degrees celsius, \( r \) is the resistance in ohms at the known temperature, \( R \) is the resistance in ohms at the temperature to be determined, and \( T \) is the temperature in degrees celsius to be determined.

232. Temperatures are to be measured by thermocouples consisting of wires no larger than No. 24 AWG and no smaller than No. 30 AWG, except that a coil temperature is to be determined by the change-of-resistance method if the coil is inaccessible for mounting thermocouples — see paragraph 230. When thermocouples are used in determining temperatures in electrical equipment, it is standard practice to employ thermocouples consisting of No. 30 AWG iron and constantan wire and a potentiometer-type instrument; and such equipment will be used whenever referee temperature measurements by thermocouples are necessary. The thermocouples and related instruments are to be accurate and calibrated in accordance with good laboratory practice. The thermocouple wire is to conform with the requirements for "special" thermocouples as listed in the table of limits of error of thermocouples in the American National Standard, C96.1-1964 "Temperature Measurement Thermocouples." A temperature is considered to be constant when three successive readings, taken at intervals of ten percent of the previously-elapsed duration of the test (but no less than five minute intervals) indicate no change.

233. A thermocouple junction and the adjacent thermocouple lead wire are to be securely held in good thermal contact with the surface of the material whose temperature is being measured. In most cases, adequate thermal contact will result from securely taping or cementing the thermocouple in place but, if a metal surface is involved, brazing or soldering the thermocouple to the metal may be necessary.

234. The temperature rise attained by the motor of a timing device, when stalled and while connected to a supply circuits as indicated in Table 8, shall not exceed the limits given in Table 9, if stalling the motor is part of the normal operation.

235. To determine if the equipment complies with the requirements of paragraphs 226 through 234, the device is to be operated under normal conditions, unless otherwise indicated. The potential of the supply circuit is to be in accordance with Table 8.

Exposed Surface Temperature

236. When tested under the conditions described in paragraphs 227-235, apparatus intended for use in a Division 2 location shall not attain a temperature on any exposed surface greater than that indicated in Table 10.

Paragraph 236 effective March 30, 1973

237. All values for temperatures in Table 10 are based on an assumed ambient (room) temperature of 40°C (104°F), however, tests may be conducted at any ambient temperature within the range of 10-40°C (50-104°F). If the equipment is intended for use in an ambient temperature higher than 40°C (104°F), the test is to be conducted at the higher ambient.

238. Equipment for Class II, Division 2, Group G is to be blanketed with grain dust during the test.

<table>
<thead>
<tr>
<th>TABLE 10</th>
<th>EXPOSED SURFACE TEMPERATURE DIVISION 2 LOCATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Degrees Celsius</td>
</tr>
<tr>
<td>Class I, Groups A and B</td>
<td>224</td>
</tr>
<tr>
<td>Class I, Group D</td>
<td>172</td>
</tr>
<tr>
<td>Class I, Group C</td>
<td>128</td>
</tr>
<tr>
<td>Class II, Group G</td>
<td>120</td>
</tr>
</tbody>
</table>

a For equipment not employing explosion-proof enclosures and intended for use in Class I, Division 2, location, these temperatures will also apply to internal parts of the device under normal operation of the equipment only.

b If the apparatus is marked to indicate the maximum exposed surface temperature or temperature range attained during the tests in accordance with paragraphs 361 and 362, the temperature may exceed 172°C (342°F) but it is not to exceed 224°C (435°F).

c If the apparatus is marked to indicate the maximum exposed surface temperature or temperature range attained during the tests in accordance with paragraphs 361 and 362, the temperature may exceed 128°C (262°F) but it is not to exceed 144°C (291°F).

d For equipment intended for use in Class II, Division 2 locations which neither employs dust-ignition-proof enclosures nor is designed to exclude the entrance of dust as described in paragraph 70, these maximum temperatures will also apply to internal parts of the device under normal operation of the equipment only.

Table 10 effective March 30, 1973
239. If used, the ignition temperature or ignition temperature range, referred to in footnotes \( b \) and \( c \) of Table 10, shall be based on operation in a 40°C ambient, or at a higher ambient temperature if the equipment is intended for use in an ambient higher than 40°C (104°F): see paragraph 237. The temperature range, if provided, shall be indicated in code numbers in accordance with Table 11. The code number, if employed shall be in an individual block on the name plate, properly designated, i.e., “temperature range___.”


**Operation**

240. An electromagnet (e.g., relay, solenoid) provided on apparatus intended for use on direct-current shall be able to withstand 10 percent above the test voltage for the apparatus (in accordance with Table 8) continuously without injury to the operating coil and to operate successfully at 20 percent less than the rated voltage. This does not apply to a force coil intended to produce a modulated force as a function of current.


### TABLE 11

<table>
<thead>
<tr>
<th>Maximum Temperature Deg C</th>
<th>Code Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deg F</td>
<td></td>
</tr>
<tr>
<td>450</td>
<td>842</td>
</tr>
<tr>
<td>300</td>
<td>572</td>
</tr>
<tr>
<td>280</td>
<td>536</td>
</tr>
<tr>
<td>260</td>
<td>500</td>
</tr>
<tr>
<td>230</td>
<td>446</td>
</tr>
<tr>
<td>215</td>
<td>419</td>
</tr>
<tr>
<td>200</td>
<td>392</td>
</tr>
<tr>
<td>180</td>
<td>356</td>
</tr>
<tr>
<td>165</td>
<td>329</td>
</tr>
<tr>
<td>160</td>
<td>320</td>
</tr>
<tr>
<td>135</td>
<td>275</td>
</tr>
<tr>
<td>120</td>
<td>248</td>
</tr>
<tr>
<td>100</td>
<td>212</td>
</tr>
<tr>
<td>85</td>
<td>185</td>
</tr>
</tbody>
</table>

Table 11 effective March 30, 1973.

241. An electromagnet provided on apparatus intended for use on alternating-current shall be able to withstand 10 percent above the test voltage for the apparatus (in accordance with Table 8) continuously without injury to the operating coil and to operate successfully at 15 percent less than the test voltage. This does not apply to a force coil intended to produce a modulated force as a function of current.


242. For the operation at minimum voltage, the apparatus is to be subjected to the normal test voltage per Table 8 until constant temperature is reached, and the electromagnet is then tested immediately for closing at the minimum voltage.

**Dielectric Withstand**

243. A device shall be capable of withstanding for 1 minute without breakdown the application of a 60 hertz potential of 1000 volts plus twice maximum test voltage in accordance with Table 8:

A. Between line-voltage live parts and grounded or exposed-metal parts or the enclosure with the contacts open and closed;

B. Between line-voltage live parts of opposite polarity with the contacts closed;

C. Between live-metal parts of line and low-voltage circuits; and

D. Between live-metal parts of different line-voltage circuits.

244. Low-voltage circuits (paragraph 19) shall be capable of withstanding the application of a 60 hertz potential of 500 volts for 1 minute without breakdown. The potential shall be applied between live parts and the enclosure, grounded dead-metal parts, or exposed, isolated (insulated) parts.

245. Isolated limited-energy circuits shall be capable of withstanding the application of 60 hertz root mean square potential equal to three times the maximum peak voltage of the circuit, but not less than 500 volt root mean square for 1 minute without breakdown. The potential shall be applied between live parts of different circuits and between live parts and grounded dead-metal parts, or exposed, isolated (insulated) parts.

246. If the isolated limited-energy circuit has no alternating-current potential, the test may be performed using a direct-current potential of three times the maximum direct current voltage of the circuit but not less than 500 volts.

247. If the low-voltage or isolated limited-energy secondary circuit is grounded at one or more points, the grounding points shall be removed for the tests covered in paragraphs 244-246.

**Dust-Air Atmospheres**

248. Enclosures of equipment for Class II, Group G, Division 2, locations intended to exclude the entrance of dust shall be subjected to the following tests.
249. The electrical enclosures shall be exposed to the circulating dust-air atmospheres to determine that the device is dust-tight. During this test there shall be no entrance of the dust into the device, as determined by visual examination following the test described in paragraph 250.

250. For the test, the device is to be installed in a test chamber to permit free circulation of dust-air mixtures around the device. The test chamber is to be provided with a cover and with dust-air inlet and outlet connections. The device is to be exposed to the dust-air atmosphere which is to be produced by auxiliary apparatus and introduced into the test chamber. The test is to be continued for at least two heating and cooling cycles and for at least 10 hours while the device is continuously exposed to the circulating dust-air atmosphere.

251. Grain dust that has passed through a 100 mesh screen is to be used in the dust-air atmosphere test.

Conduit Hub Secureness

252. A conduit hub that is not integrally cast with the enclosure for equipment for use in Division 2 locations shall be capable of withstanding a torque of (1) 800 pound-inches for 3/4 inch trade size and smaller, (2) 1000 pound-inches for 1, 1-1/4, and 1-1/2 inch trade sizes, and (3) 1600 pound-inches for 2 inch trade size and larger. There shall be no stripping of any threads or turning of the hub in the enclosure.

253. The torque is to be applied to a short length of rigid conduit threaded into the hub in the intended manner with the enclosure securely (rigidly) mounted or supported.

Limited Energy Transformers

General

254. Three representative samples of the transformer shall be subjected to tests in the following order: open-circuit secondary voltage, current output, volt-ampere capacity (optional), burnout, and dielectric withstand. Depending on the test results the transformer may be classified as indicated in Table 12.

Open-Circuit Secondary Voltage

255. With the primary of a Class 2 or energy-limiting transformer connected to a supply circuit as indicated in Table 8 at rated frequency, the open-circuit secondary voltages shall not exceed the values indicated in Table 12.

Current Output

256. Under any noncapacitive condition of loading (including short-circuit) the secondary current of a Class 2 energy-limiting transformer shall not be more than 8 amperes one minute after the primary is energized from a supply circuit as indicated in Table 8 at rated frequency.

Volt-Ampere Capacity

257. The capacity of a Class 2 nonenergy-limiting or a 600 volt, 100 volt-ampere energy-limiting transformer shall not be more than 100 volt-ampere.

258. To determine if the capacity of a single secondary winding of a Class 2 nonenergy-limiting or an energy-limiting transformer is not more than 100 volt-ampere, the transformer is to be tested as follows or as indicated in Paragraph 259. With a suitable rheostat, voltmeter, and ammeter connected to the secondary, the primary is to be connected to a supply circuit as indicated in Table 8 at rated frequency. The rheostat is to be adjusted until the volt-ampere output of the transformer is the maximum obtainable or 100 volt-ampere, whichever is less; and the rheostat is to be readjusted 5 minutes after the primary is energized if necessary to maintain constant output. The temperature rise on the enclosure of the transformer is to be measured by means of a thermocouple, and the transformer is to be considered to comply with the requirement in paragraph 257 if the temperature rise is not less than 50°C (90°F). The test is to be continued until thermal equilibrium is attained, except that the test may be discontinued as soon as the above mentioned temperature rise is observed. If an overcurrent-protective device is provided, it may be shunted out during the test, if necessary.
259. To determine if a multiple secondary winding-transformer capacity is not more than 100 volt-amperes, the transformer is to be tested as follows. The primary is to be connected to a supply circuit as indicated in Table 8 at rated frequency. A suitable rheostat, voltmeter, and ammeter is to be, in turn, connected to each secondary winding with all remaining secondary windings open-circuited. The load in the winding under test is to be varied from open-circuit to short-circuit in such a manner that the elapsed time is between 1½ and 2½ minutes. The output voltage and current are to be recorded at frequent intervals. If an overcurrent-protective device is provided, it may be shunted out during the test, if necessary. The calculated maximum volt-amperes shall not exceed the following values:

<table>
<thead>
<tr>
<th>Secondary, Volts</th>
<th>Volt-Ampere Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-15</td>
<td>350</td>
</tr>
<tr>
<td>16-30</td>
<td>250</td>
</tr>
<tr>
<td>31-600</td>
<td>200</td>
</tr>
</tbody>
</table>

Burnout

260. There shall be no injury to the enclosure nor emission of flame or molten metal when an energy-limiting transformer is operated with any or all secondary windings short circuited. The sample shall be operated continuously at a voltage in accordance with Table 8 at rated frequency for 7 hours or until burnout, whichever occurs first.

261. Except as indicated in paragraph 262, the core temperature during the test described in paragraph 260 shall not exceed (1) a 60°C (108°F) rise, or (2) a 125°C (225°F) rise if the transformer burns out within 1 hour.

262. Core temperatures higher than those specified in paragraph 261 may be acceptable if a hazard is not introduced by the higher temperature.

Dielectric Withstand

263. While hot from the burnout test, an energy-limiting transformer shall be capable of withstanding without breakdown for a period of 1 minute the application of a 60 hertz potential as follows:

A. 1000 volts plus twice the test voltage per Table 8 applied between the primary and secondary windings; and

B. 1000 volts plus twice the test voltage per Table 8 applied between the primary winding and the core and shield, if any.

Normal Switching – Division 2

264. No product will be considered as meeting the test requirements if the switch or equivalent arc-interrupting mechanism in an apparatus intended for use in a Division 2 location ignites the specified surrounding flammable gas — or vapor-air atmosphere when the switch is subjected to normal operation tests consisting of at least 10 cycles of “on” and “off” operation for each explosive mixture. A test mechanism may be used in place of the switch as indicated in paragraph 267. The electrical input to the device is to be adjusted to at least 110 percent of the test voltage per Table 8 and probable nonobvious faults may be introduced in the device. A series of tests shall be conducted over the flammable range of the gas- or vapor-air mixtures. For battery-operated devices, each test of the series is to be conducted with a fully-charged battery.

265. For the switch operation tests, the switching mechanism is to be installed in a test chamber provided with inlet and outlet connections to the pipeline carrying the explosive mixture. The explosive mixture is to be caused to flow readily around the contacts of the switching mechanism. To insure that the explosive mixture flows around the switch contacts, slight revisions may be made to the switch enclosure and/or the switch may be installed in a chamber from which the original air can be evacuated before the explosive mixture is introduced. The explosive mixtures are to be prepared by auxiliary equipment capable of maintaining predetermined concentrations of the mixtures.

266. The explosive mixture is to be allowed to flow into the test chamber until the original air has been displaced. Samples are then to be taken for analyses from (1) the test chamber and (2) the line carrying the explosive mixture. The switch is then to be operated at least ten times in the presence of the specified flammable gas- or vapor-air atmosphere.

267. If agreeable to all concerned, one of the test mechanisms described in paragraph 348 may be substituted for the switch contacts in the test described in paragraphs 264-266.
Rainproof

268. The complete device is to be mounted with conduit connections as in actual service. The tightening torque for rigid conduit threaded into the opening in the enclosure is to be (1) 800 pound-inches for \( \frac{3}{4} \) inch and smaller trade sizes, (2) 1000 pound-inches for 1, 1\( \frac{1}{4} \), and 1\( \frac{1}{2} \) inch trade sizes and (3) 1600 pound-inches for 2 inch and larger trade sizes. A water spray, approximately equivalent to a beating rain, is then to be applied to the enclosure from the top and sides for 1 hour. Water shall not enter the enclosure above the lowest part within the enclosure.

Aging

269. A gasket employed to make an enclosure rainproof shall be subjected to one of the accelerated aging tests described in either paragraph 270 or 271, depending upon the gasket composition.

270. A gasket of rubber or neoprene or a composition thereof intended for use at 60°C (140°F) or less is to be exposed for 96 hours to oxygen at a pressure of 300 ± 10 pounds per square inch and a temperature of 70 ± 1°C (158 ± 1.8°F). Gaskets for use at over 60°C (140°F) are to be subjected to other appropriate aging tests. The gasket is considered adequately resistant to aging if there is no visible evidence of deterioration such as softening, hardening, or cracking after flexing.

271. A gasket of thermoplastic material, or a combination thereof, may be accepted after consideration of the effects of heat aging, distortion under condition of use, and the means of securing the gasket to the cover or enclosure.

MARKING

272. The marking shall comply with paragraphs 358-381.

PART II
REQUIREMENTS RELATING TO INTRINSICALLY SAFE EQUIPMENT AND WIRING

GENERAL

273. Intrinsically safe equipment and wiring in other than explosion-proof or dust-ignition-proof enclosure intended for use in Division 1 hazardous location areas shall comply with the applicable requirements of Part I of this Standard and in addition shall comply with the applicable requirements specified in Part II of this Standard.

274. The equipment covered in this part of the Standard includes:

1. Complete intrinsically safe equipment powered by:
   A. A battery supply, or
   B. Other supplies of low energy.

2. Intrinsically safe circuits connected through an isolating-type transformer to electrical line powered apparatus and having current-limiting features.

275. Electrical circuits and wiring of apparatus which is not intrinsically safe shall be provided with explosion-proof and/or dust-ignition-proof enclosures depending upon the hazardous location groups for which it is designed, or the nonintrinsically safe wiring parts shall be mounted outside of the Division 1 area.

276. Faults in the nonintrinsically safe circuits and parts shall not result in electric currents, above minimum ignition-capable-energy levels, passing to the intrinsically safe circuit intended for use in a hazardous area.

CONSTRUCTION
Protective Components

277. Intrinsically safe circuits may depend only on the use of protective components. If this approach is taken, the other components may be omitted from or left in the circuit, depending upon which condition produces the most unfavorable effect.

Paragraph 277 effective March 30, 1973
278. Protective components shall consist of one or a combination of the following:

1. A transformer with a construction such that the primary and secondary windings are physically separated in order to prevent the primary circuit potential from being impressed on the secondary circuits. Physical separation may be accomplished in one of the following manners (also see paragraph 280).
   A. The primary windings and secondary windings shall be wound on separate legs of the grounded core of the transformer.
   B. A grounded-copper shield at least 0.005-inch thick, or equivalent, shall be provided between the primary and secondary windings. The conductor between the shield and the grounded core shall be at least equal in size to the primary leads but not less than No. 24 AWG (404 circular mils). The shield shall completely separate the primary and secondary windings including splices and crossover leads if present. The transformer core shall be grounded.
   C. The primary and secondary windings may be wound on one length of core (both coils coaxial but not concentric on core) if the two windings are separated end-to-end on the grounded core by a phenolic- or melamine-resin barrier or barrier of equivalent characteristics. The barrier shall be at least 1/32-inch thick.
   D. The transformer core shall be grounded. The primary and secondary windings including splices and crossover leads shall be insulated by noncombustible thermal insulation such as mica no less than 0.007-inch thick, except that a lesser thickness may be considered in accordance with paragraph 208.

2. A wire-wound resistor on a ceramic core with ceramic or equal covering. A wire-wound current-limiting resistor shall be subjected to the test specified in paragraphs 339-341. In intrinsically safe circuit tests, the limiting resistor shall be shunted with a resistor of double its value.

3. Two or more resistors of the carbon type, wire-wound or metal film, connected in series. In the intrinsically safe circuit tests, the largest ohmic value resistor shall be short-circuited and the others paralleled by a resistor of the same value.

4. Two capacitors in series. Capacitors employed for this application shall be subjected to the dielectric withstand test indicated in paragraph 243 between the terminals. In the intrinsically safe circuit tests, one of the capacitors shall be short-circuited.

5. Avalanche (zener) diodes, when two are provided in parallel across intrinsically safe circuit output. The avalanche diode shall not open when subjected to abnormal conditions within the circuit under consideration. Abnormal conditions shall include steady-state, transient conditions, and those considered under the intrinsically safe circuit tests.

6. A resistor consisting of a deposited-metal film on a nonconducting, noncombustible core. This type of resistor shall be subjected to the tests specified in paragraph 342.

Paragraph 278 effective March 30, 1973

279. All of the components indicated in paragraph 278 shall be coated to resist absorption of moisture, and in production be subjected to functional operational tests in subassemblies or final assemblies. The components indicated in items 3-6 of paragraph 278 shall be operated at not over 50 percent of their ratings.

Paragraph 279 effective March 30, 1973

280. For a multiple-winding transformer where one or more secondary windings are connected in the intrinsically safe circuit(s) and where one or more secondary windings are also connected in a nonintrinsically safe circuit(s), the construction described in Item 1 of Paragraph 278 may be used to separate the intrinsically safe and nonintrinsically safe secondary windings. If such separation is not provided, shorting of the secondary windings will be considered in the fault analysis.

Paragraph 280 effective March 30, 1973

Circuit Fault Analysis

281. As an alternative or supplementary to protective components, analysis can be made of the circuits with the faults described in paragraphs 283-285. From this analysis, circuits, which represent the worst fault conditions, are selected for tests.

Paragraph 281 effective March 30, 1973
282. In the circuit tests, referred to in paragraph 281 the sources of possible ignition shall include:
1. Discharge of capacitive circuits.
2. Interruption of inductive circuits.
3. Intermittent make-break (arching in resistance circuits).
4. High surface temperature conditions on both the enclosure as well as individual components.
5. Hot wiring fusing.
6. Operation of battery supplies while short-circuited.

Paragraph 282 effective March 30, 1973

283. In applying the fault analysis considerations to a fixed or stationary product that is user supervised, the number of initial electrical faults shall be
A. Any three nonobvious faults;
B. Any two nonobvious faults and one obvious fault; and
C. Any two obvious faults and one nonobvious fault.

Paragraph 283 effective March 30, 1973

284. In applying the fault analysis considerations to a stationary or fixed product that is not user supervised, the number of initial faults shall be any or all electrical faults, except as noted in paragraph 286.

Paragraph 284 effective March 30, 1973

285. In applying the fault analysis considerations to a portable product, the number of initial faults shall be any or all electrical faults, except as noted in paragraph 286.

Paragraph 285 effective March 30, 1973

286. If an investigation indicates that the construction of apparatus as described in paragraphs 284 and 285 is such as to reduce the probability of specific faults to a negligible value, it may not be necessary to introduce all such faults into the circuit simultaneously.

Paragraph 286 effective March 30, 1973

287. Subsequent electrical failures of other components resulting from the initial faults are considered to be part of that initiating fault.

Paragraph 287 effective March 30, 1973

288. For a device for use in Division 1 hazardous locations having a force-moving component in the intrinsically safe circuit, opening or shorting of the intrinsically safe circuit would be considered as one of the obvious faults unless normally-operating contacts are provided in the circuit.

Paragraph 288 effective March 30, 1973

289. In the application of the fault analysis of the circuit, a short spacing permitted by a footnote \( a \) of Table 7 is to be judged under the most unfavorable condition that might result because of that short spacing. The failure of the spacing will be considered as one fault. If multiple-capacitive and-inductive components are involved, and if failure of the spacings could result in those components becoming additive, they will be so considered.

Paragraph 289 effective March 30, 1973

Overcurrent Protection

290. Fuses may be used for circuit protection in intrinsically safe apparatus or systems, but are not considered as protective components and are shorted out in tests in hazardous atmospheres.

291. Except as noted in paragraph 292, fuses shall not be used in apparatus intended for use in Division 1 locations unless in appropriate explosion-proof and/or dust-ignition-proof enclosures.

292. A fuse in an intrinsically safe circuit intended for use in a Division 1 location need not be enclosed in an explosion-proof and/or dust-ignition-proof enclosure if tests show that the circuit and the fuse will not ignite the hazardous atmospheres under consideration.

293. In apparatus intended for use as part of an intrinsically safe system loop and intended for use in Division 2 locations, fuses for overcurrent protection of the instrument circuits may be mounted in general purpose enclosures if:
A. The fuses do not exceed 3 ampere rating,
B. The circuit is not rated over 120 volts,
C. A switching means is provided which can open the circuit containing the fuse before removal and replacement of the fuse. This switch may be part of a specific apparatus or may be external and may be arranged to de-energize a group of related devices, and
D. The switching means is suitable for operation in a Division 2 location.

Paragraph 293 effective March 30, 1973

Spacing

294. The spacings in the apparatus shall be no less than those indicated in Tables 13 and 14 and paragraph 298.

Paragraph 294 effective March 30, 1973

295. 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.
296. A ceramic, vitreous-enamel, or similar coating is not acceptable as insulation in place of spacers unless, upon investigation, the coating is found to be uniform, of adequate minimum thickness, reliable, and otherwise suitable for the purpose.

297. Enamel-insulated and similar film-insulated wire is considered to be an uninsulated live part in determining compliance of a device with the spacing requirements in this Standard.

298. Except as noted in paragraph 299, the spacing between and the arrangement of field wiring terminals of different intrinsically safe circuits shall be such that short circuiting of the circuits at the terminals is unlikely.

299. No spacings are required between field wiring terminals of different intrinsically safe circuits, if a short circuit between the terminals will not increase the energy output of either intrinsically safe circuit.

Barriers

300. Barriers shall comply with the requirements given in paragraphs 205-208.

Separation of Circuits

301. Conductors of intrinsically safe circuits (internal wiring) shall be separated by barriers or shall be segregated from insulated conductors of line-voltage circuits or uninsulated live parts connected to different circuits.

Paragraph 301 effective March 30, 1973

| TABLE 13 | MINIMUM SPACINGS BETWEEN INTRINSICALLY SAFE CIRCUITS AND LINE CONNECTED CIRCUITS IN INCHES |
|------------------|------------------|------------------|------------------|------------------|
| Potential Involved | 0-50 | 51-150 | 151-300 | 301-600 |
| Between any uninsulated live part of an intrinsically safe circuit and an uninsulated live part of a line-connected circuit | Through air | 1/4 | 1/4 | 1/4 | 3/8 |
| Over Surface | | 1/4 | 1/4 | 3/8 | 1/2 |

*a For the purpose of these requirements, the intrinsically safe circuit includes the entire protective component. In circuits where more than one protective component is employed, these requirements apply to the minimum number of protective components necessary to maintain the integrity of the intrinsically safe circuits.

Table 13 effective March 30, 1973

302. Unless provided with insulation suitable for the highest voltage involved, insulated conductors of intrinsically safe circuits (internal wiring) shall be separated by barriers or shall be segregated from low-voltage and isolated limited-energy circuits; and shall, in any case, be so separated or segregated from uninsulated live parts connected to different circuits.

| TABLE 14 | MINIMUM SPACINGS FOR PROTECTIVE COMPONENTS IN INTRINSICALLY SAFE EQUIPMENT IN INCHES |
|------------------|------------------|------------------|------------------|------------------|
| Potential Involved | 0-50 | 51-600 |
| Between any uninsulated live part of a protective component and an uninsulated live part of opposite polarity or other circuits, or an uninsulated grounded dead-metal part other than the enclosure | Through Air Or Oil | 1/16 | 1/8 |
| Over Surface | | 1/16 | 1/8 |
| Between any uninsulated live part of a protective component and the walls of a metal enclosure, including fittings for conduit or armored cable | Shortest Distance | 1/8 | 1/4 |

*a These spacings do not apply to components or parts where the short-circuiting or grounding of the parts will not result in manifestation of a shock or fire hazard in the equipment nor increase the energy output of the intrinsically safe circuit.

*b These spacings may be 3/64 inch between opposite polarity conductors on printed wiring boards of recognized construction.

c These spacings may be 1/16 inch for all components that are securely and reliably held in position and used in isolated limited-energy secondary circuits of 150 volts or less.

d These spacings may be 3/64 inch between opposite polarity conductors on printed wiring boards of recognized construction used in isolated limited-energy secondary circuits of 150 volts or less.

*e For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is liable to reduce spacings between the metal piece and uninsulated live parts. If an integral projection or a metal piece attached to the enclosure is fixed in relation to the live parts so that deformation of the enclosure does not affect spacings, the integral projection or metal piece is not considered part of the enclosure.

Table 14 effective March 30, 1973

303. Segregation of insulated conductors may be accomplished by clamping, routing, or equivalent means which insures permanent separation from insulated or uninsulated live parts of a different circuit.

304. If a barrier is used to provide separation between the wiring of different circuits, it shall be (1) of grounded metal or of suitable insulating material (2) of adequate mechanical strength if exposed or otherwise liable to be subjected to mechanical injury, and (3) reliably held in place. Unclosed openings in a barrier for the passage of conductors shall be not larger than 1/4 inch in diameter and shall not exceed in number, on the basis of one opening per conductor, the number of wires which will need to pass through the barrier. The closure for any other opening shall have a smooth surface wherever an insulated wire may be in contact with it; and the area of any such opening, with the closure removed, shall not be larger than required for the passage of the necessary wires. Also see paragraph 156.
305. Field-installed conductors of an intrinsically safe circuit shall be segregated or separated by barriers from:
   A. Field-installed and factory-installed conductors connected to any other circuit, i.e., line-voltage or low-voltage,
   B. Uninsulated live parts of any other circuit of the device, and from any uninsulated live parts whose short circuiting would result in unsafe operation of the controlled device.

306. A barrier used to provide separation between the field wiring of one circuit and the wiring or uninsulated live parts of another circuit shall be spaced not more than 1/16 inch from the enclosure walls and from interior mechanisms and component-mounting panels, etc., which serve to provide segregated compartments.

307. A metal barrier used to provide segregation shall be (1) grounded, (2) of adequate strength and rigidity, and (3) at least the thickness specified under the “With Supporting Frame” column of Table 2 for the dimensions of the barrier. A barrier of insulating material shall be of such thickness and be so supported that its deformation cannot be readily accomplished so as to defeat its purpose, but in any case, the thickness shall be 1/32 inch nominal (minimum 0.028 inch). A barrier between uninsulated live parts connected to different circuits, and a barrier between uninsulated live parts of one circuit and the wiring of another circuit shall also comply with the requirement of paragraphs 202 and 203.

Paragraph 307 effective March 30, 1973

308. With respect to item A of paragraph 305, if the intended uses of the device are such that in some applications a barrier is required while in some other applications a barrier is not required, a removable barrier or one having openings for the passage of conductors may be employed, provided adequate instructions for the use of the barrier are a permanent part of the device. Complete instructions in conjunction with a wiring diagram may be acceptable in lieu of a barrier if, upon investigation, the combination is found to be adequate.

309. Segregation of field-installed conductors from other field-installed conductors and from uninsulated live-metal parts of the device connected to different circuits may be accomplished by arranging the location of the openings in the enclosure for the various conductors (with respect to the terminals or other uninsulated live-metal parts) so that the intermingling of the conductors or parts of different circuits is unlikely.

310. If the number of openings in the enclosure does not exceed the minimum required for the proper wiring of the device, and if each opening is located opposite a set of terminals it is to be assumed, for the purpose of determining compliance with paragraph 305, that the conductors entering each opening will be connected to the terminals opposite the opening. If more than the minimum number of openings are provided, the possibility of conductors entering at points other than opposite the terminals to which they are intended to be connected and contacting insulated conductors or uninsulated current-carrying parts connected to a different circuit is to be investigated.

311. To determine if a device complies with the requirement of paragraph 305, it is to be wired as it would be in service; and in doing so, a reasonable amount of slack is to be left in each conductor, within the enclosure, and no more than average care is to be exercised in stowing this slack into the wiring compartment.

312. Inherent resistance devices may be provided in batteries to limit the short circuit currents below a value which will ignite the specified explosive atmospheres. Except as indicated in paragraph 313, if the resistance devices are not an integral part of the battery, the battery and the resistance devices shall be provided with an explosion-proof and/or dust-ignition-proof enclosure.

313. Battery-operated equipment where the resistance devices are not an integral part of the battery and where the enclosure is not of the explosion-proof or dust-ignition-proof type may be accepted under the following conditions:

1. The battery housing is arranged and constructed so that the batteries can be installed and/or replaced without subjecting the battery output to short-circuiting and without applying the battery output to the load side of the current-limiting (protective) resistors.
2. The current-limiting (protective) resistors are encapsulated with an acceptable potting material. The potting material should be resistant to the solvent action of the chemicals covered by the hazardous atmospheres in which the device is intended to be used. The potting material shall be of a type that cannot be removed without destruction of the device.

Portable Battery-Operated Equipment
3. The battery supply is incapable of causing ignition under conditions of double voltage or double current availability. See paragraph 316.

4. The device is safe under the applicable fault conditions as indicated in paragraph 283 or 284, and the arcing test described in paragraph 334.

5. The construction of the battery compartment will prevent the ejection of batteries when subjected to the drop test described in paragraph 346.

6. The apparatus is marked as indicated in paragraph 368.

**Lamp-Ejection Mechanism — Division 1 Hazardous Locations**

314. The lamp compartment in other than an explosion-proof enclosure may be provided with a lamp-disconnect mechanism to prevent the ignition of specified surrounding flammable gas- or vapor-air atmospheres when the glass bulb of the lamp is broken. The mechanism, if provided, shall disconnect the broken lamp bulb immediately from the circuit. The lamp-filament-disconnect mechanism shall be actuated by reliable means, such as by compression spring action. Where it is necessary to use nonmetallic components in the lamp-disconnect mechanism, they shall be made of phenolic material or shall be investigated for stability with respect to the operating temperatures and the hazardous atmospheres in which the device is to be used.

315. The disconnect mechanism discussed applies equally to tungsten-filament-lamps and to gaseous-discharge-lamps.

**PERFORMANCE**

316. Except for the test described in paragraph 324, battery-operated devices shall be tested both under conditions of double-voltage and double-current availability.

317. Double-voltage and double-current conditions are not to be applied simultaneously to a circuit during tests.

318. A line-powered device in which no protective components are provided in the intrinsically safe circuit, other than a transformer as described in item 1 of paragraph 278, shall be tested with the input voltage increased to 137.5 percent of the test voltage per Table 8.

319. A device provided with protective components, other than a transformer as described in item 1 of paragraph 278, shall be tested with 110 percent of the test voltage per Table 8.

320. In conducting the tests each of the following conditions shall be considered:

A. Fuses, circuit breakers, etc., are not considered as current-limiting components and shall be shorted out in the tests in hazardous atmospheres.

B. All user adjustments shall be placed in their most unfavorable setting.

C. The most unfavorable combination of component failures and circuit faults, including field-wiring faults, shall have occurred as indicated in paragraphs 281-289.

321. The gas- or vapor-air atmospheres for tests of intrinsically safe circuits for Class I locations shall be in accordance with Table 15.

**TABLE 15**

<table>
<thead>
<tr>
<th>Group</th>
<th>Gas Or Vapor In Mixture With Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Acetylene</td>
</tr>
<tr>
<td>B</td>
<td>Hydrogen</td>
</tr>
<tr>
<td>C</td>
<td>Ethyl ether or ethylene</td>
</tr>
<tr>
<td>D</td>
<td>Propane, pentane and/or gasoline</td>
</tr>
</tbody>
</table>

a For tests involving energy due to arcing, Group C equipment is normally tested using ethylene and Group D equipment is normally tested using propane. For tests involving high temperature parts such as glowing filaments, Group C equipment is normally tested using ethyl ether and Group D equipment is normally tested using gasoline, however pentane may also be used.

b A straight run distillation non leaded gasoline, having a specific gravity of 60 to 70 and an octane rating of 56 to 60.

322. For tests, the mixtures (percent by volume) of gas or vapor with air shall be the concentrations most easily ignitable.

323. The acetylene, hydrogen, ethylene, pentane and propane shall be obtained from commercial cylinders with purity of at least 99 percent. The ethyl ether shall be chemically pure (99 percent minimum).
Component Overload

324. Any component, such as a relay coil, resistor, potentiometer, capacitor, transistor, etc., of intrinsically safe equipment and/or systems not provided with explosion-proof and/or dust-ignition-proof enclosures and intended to be used in a Division 1 location shall be judged under the most unfavorable condition as determined by fault analysis. In the tests, the exposed surface temperature of a component shall not exceed those indicated in Table 16. Also see paragraphs 326-329. Where the power supply is a battery, each test shall be conducted with a fully-charged battery.

Paragraph 324 effective March 30, 1973

325. With regard to paragraph 324, thermal runaway conditions are to be considered for a semiconductor device, such as a transistor.

Paragraph 325 effective March 30, 1973

Exposed Surface Temperature

326. Except as noted in paragraph 327, the apparatus shall not attain a temperature on any exposed surface greater than that indicated in Table 16 when tested under the fault conditions described in paragraphs 324, 325, 336, and 344.

Paragraph 326 effective March 30, 1973

327. The surface temperature of small component parts, such as transistors, diodes, resistors, etc., may exceed the temperature indicated in Table 16 under abnormal conditions if tests indicate that the parts will not ignite the specified explosive atmosphere.

328. All values for temperature in Table 16 are based on an assumed ambient (room) temperature of 40°C (104°F), however, tests may be conducted at any ambient temperature within the range of 10-40°C (50-104°F). If the equipment is intended for use in an ambient temperature higher than 40°C (104°F), the test is to be conducted at the higher ambient.

329. If used, the ignition temperature or temperature range referred to in footnotes a and c of Table 16 shall be based on operation in a 40°C (104°F) ambient or at a higher ambient temperature if the equipment is intended for use in an ambient higher than 40°C (104°F); see paragraph 328. The temperature range if provided, shall be indicated in code numbers in accordance with Table 11. The code number, if employed shall be in an individual block on the name plate, properly designated, I.E., “Temperature range.”

Paragraph 329 effective March 30, 1973

TABLE 16

<table>
<thead>
<tr>
<th>Enclosure of intrinsically safe equipment for use in:</th>
<th>Degrees Fahrenheit</th>
<th>Degrees Celsius</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I, Groups A and B</td>
<td>536</td>
<td>280</td>
</tr>
<tr>
<td>Class I, Group D</td>
<td>419</td>
<td>215</td>
</tr>
<tr>
<td>Class I, Group C</td>
<td>320</td>
<td>160</td>
</tr>
<tr>
<td>Class III, Group G</td>
<td>329</td>
<td>165</td>
</tr>
</tbody>
</table>


Burnout

330. There shall be no injury to the enclosure nor emission of flame or molten metal when a transformer as described in item 1 of paragraph 278 is operated with any or all secondary windings short circuited. The sample shall be operated continuously at a voltage in accordance with Table 8 at rated frequency for 7 hours or until burnout, whichever occurs first.

Paragraph 330 effective March 30, 1973

Dielectric Withstand

331. While hot from the burnout test indicated in paragraph 330 a transformer, as described in item 1 of paragraph 278 and employed in an intrinsically safe circuit, shall withstand without breakdown for a period of 1 minute the application of a 60 hertz potential as follows:

A. 1000 volts plus twice the test voltage per Table 8 applied between the primary and secondary windings,

B. 1000 volts plus twice the maximum rated secondary voltage applied between the secondary windings and the core and shield, if any, and

C. 1000 volts plus twice the test voltage per Table 8 applied between the primary winding and the core and shield, if any.

Paragraph 331 effective March 30, 1973
332. Test B in paragraph 331 may be waived in circuits which have one side of the secondary grounded.

333. Test C in paragraph 331 may be waived for a transformer which is not intended to be Class 2.

Arcing

334. A battery-operated device employing batteries which are not provided with inherent-resistance devices as an integral part of the battery, encapsulated, or located within an enclosure that is explosion-proof and/or dust-ignition-proof shall be subjected to arcing tests consisting of at least 10 cycles of operation. The making and breaking tests on the circuit are to be conducted in specific explosive mixtures representative of the hazardous atmospheres in which the intrinsically safe equipment is intended to be used. The tests shall be conducted under conditions of double-voltage and double-current availability for the battery supply. See paragraph 317.

Battery Rupture

335. A rechargeable battery shall not rupture when subjected to a temperature of 90°C (194°F) for a period of 7 hours.

Paragraph 335 effective March 30, 1973

Transistor Thermal Runaway

336. Three samples of each transistor shall be subjected to this test. The transistor collector and emitter shall be connected in series with the power source. The polarity shall be such that the emitter junction shall be forward biased. A suitable variable resistor shall be connected between the transistor base and collector. The resistance shall be slowly decreased until thermal-runaway condition occurs, or until the resistance is reduced to zero. The test is to be continued under these conditions until maximum temperatures are attained. Also see paragraph 325.

337. The test described in paragraph 336 is to be conducted with the transistor heat sink in place if the transistor and heat sink are securely assembled together. However, if agreeable to all concerned, the test may be conducted without the heat sink.

338. The temperature of the exposed surfaces of the transistor and its heat sink, if used in the test, shall not exceed those specified in Table 16.

Paragraph 338 effective March 30, 1973

Abnormal Operation—Resistors: Employed as Protective Components

Wire-Wound Resistors

339. Wire-Wound resistors shall be subjected to abnormal operation tests to determine that their calibration is adequate for the intended application.

340. Three samples of each resistor shall be subjected to the tests described in paragraph 341.

341. The resistance of each resistor is to be measured by a wheatstone bridge. Each resistor, in turn, is to be connected to a variable alternating-current source of supply. The supply voltage is to be gradually increased until the outside middle surface of the resistor attains a temperature of 600 ± 15°C (1112 ± 59°F). After the resistor has operated at this voltage for a period of 3 hours the supply circuit is to be disconnected, the resistor cooled to room temperature, and the resistance measured. The resistance shall not decrease more than 50 percent during the tests, and not more than 25 percent at the completion of the tests when the resistor has cooled to room temperature.

Deposited-Metal-Film Resistors

342. Except as noted in paragraph 343, a deposited-metal-film resistor shall withstand five times the applicable fault power for three hours. After cooling to room temperature there shall not be more than a 10 per cent decrease in resistance.

343. If the resistor opens during the test specified in paragraph 342, the resistor shall be caused to carry the maximum current that it is capable of conducting continuously, without opening, for three hours. The resistor shall be considered acceptable if there is not more than a 10 percent decrease in resistance after cooling to room temperature.

Battery Supply Abnormal Operation Tests

344. In a battery-operated device, it shall be determined that strands of wire provided in the device shall be of a diameter which will not ignite the specified explosive atmosphere when a single strand of each diameter of wire employed is shorted across the battery supply. For this test, the length of wire employed shall not exceed the minimum length required to bridge the battery-supply terminals by more than 1/2 inch. If in the device, coiled wire is employed, it shall be used in lengths as specified above.

345. The battery supply mentioned in paragraph 344 includes the resistors described in Item 2 of paragraph 313, if provided.
Drop Test on Battery-Operated Equipment

346. A drop test shall be conducted on battery-operated apparatus where the current-limiting devices are not an integral part of the battery. When the device is dropped to a concrete floor ten times from a height of 3 feet, there shall be no ejection of the battery or batteries nor other manifestation of a hazard.

347. For the first five drops, the device is to be allowed to fall freely in a manner that would normally be the case if the device were to fall from a horizontal surface to the floor. In the remainder of the test, the device is to be held at various angles 3 feet above the concrete surface and then dropped to the floor.

Intrinsically Safe Operation in Class I Atmospheres

348. Intrinsically safe equipment and wiring shall be subjected to tests consisting of making and breaking the intrinsically safe circuit in specific explosive mixtures representative of the hazardous atmospheres in which the intrinsically safe equipment and wiring is intended to be used. The tests shall be conducted under normal and abnormal (electrical fault) conditions using any of the following mechanisms and/or their equivalent for making and breaking the circuits in explosive atmospheres. The tests shall be conducted using the power supplies specified in paragraphs 316 through 320.

A. Test Mechanism 1 — The circuit-interrupting mechanism consists of a copper wire passing across a steel screen in the presence of explosive gas — or vapor-air mixtures. The copper wire has a diameter of 0.010 inch. The screen is made of steel wire, 0.022 inch in diameter with openings of 3/32 by 3/32 inch. The 0.010-inch diameter copper wire is held at the end of an arm 7-1/2 inches from the pivot. In operation, the end of the wire strand is swept back and forth over the steel screen through an arc of about 40 degrees. By means of a cord and a spring on the arm, the wire is moved across the steel screen by remote operation. For each concentration of mixture in the flammable range, the wire is to be swept back and forth 60 times in contact with the steel screen.

B. Test Mechanism 2 — The apparatus consists of a 30 degree pointed copper electrode arranged to contact the end of 30 degree pointed steel electrode. By remote operational means, the ends of the electrodes can be manually contacted. A compression spring separates the electrodes. The assembly has a micrometer for adjusting the break gap.

C. Test Mechanism 3 — The device consists of an explosion chamber of about 15-1/4 cubic inches volume, in which circuit-making and-breaking sparks are produced in the presence of explosive gas — or vapor-air mixtures. Components of the contact arrangement are a brass disc with two slots and four tungsten wires of 0.008 inches diameter which slide over the disc. The free length of the tungsten wires is 0.433 inches. The driving spindle, to which the tungsten wires are attached, makes 80 revolutions per minute. The spindle on which the brass disc is mounted revolves in the opposite direction. The ratio of the speeds of the driving spindle to the other spindle is 50 to 12. The spindles are insulated from one another and from the housing. The explosion chamber is designed to withstand pressures up to 213 psig. Because the test apparatus uses fine tungsten wires it is considered suitable for testing currents up to 3 amperes. The apparatus is suitable for testing circuits up to 300 volts. For circuits exceeding these parameters, a different type of apparatus may be needed. For tests of capacitive circuits, modified apparatus may be needed to allow adequate charging time.

349. The above methods of test cover, in general, equipment and wiring consisting of copper wire and a steel case or parts. If the current-carrying parts should consist of other materials, further tests may be conducted using the other materials for making and breaking the circuits.

Intrinsically Safe Operation in Class II Atmospheres

350. Intrinsically safe circuits for use in explosive dust-air atmospheres shall be tested by:

A. Making and breaking the test circuit on a dust mound or layer to determine whether the repeated arcing of at least 50,000 cycles will cause ignition of the dust or charring of organic dusts considered to be representative of the classification covered; and
B. Making and breaking the test circuit in a dust cloud considered to be representative of the classification covered. A modified Clement-Frazer apparatus is to be used in this test. It consists essentially of a spherical glass vessel of 0.0665 cubic foot capacity in which the dust is dispersed in the presence of sparking steel electrodes. An indicator for measuring and recording explosion pressure shall be connected to this vessel. Dust shall be disseminated within the explosion vessel by discharging a stream of air downward onto a weighed sample of the dust contained in a polished hemispherical cup at the base of the apparatus, the air for this purpose being stored under a pressure of 40 PSIG in an external cylinder of 4.88 cubic inch capacity connected to the vessel by a normally-closed solenoid valve.

Lamp Bulb Breakage
Division 1 Hazardous Locations

With Lamp Disconnect Mechanism

351. The heated filament of a tungsten-filament lamp or the arc of a gaseous-discharge lamp shall not ignite the surrounding flammable gas- or vapor-air atmosphere during the lamp bulb breakage tests. A series of at least twenty tests shall be conducted over the flammable range of the specified gas- or vapor-air atmosphere.

352. For the lamp bulb breakage tests, the lamp having normal power is to be installed in a test chamber provided with inlet and outlet connections to the pipelines carrying the explosive mixture. The explosive mixture is to be caused to flow readily around the lamp bulb and the disconnect mechanism. The explosive mixtures are to be prepared by auxiliary equipment capable of maintaining predetermined concentrations of the mixtures.

353. A mechanism is to be provided in the test chamber for breaking the glass envelope of the lamp bulb either by a sharp blow or by pinching or squeezing the sides of the glass envelope. The mechanism is to be of a construction that does not damage the lamp bulb filament or electrodes while breaking the surrounding glass bulb. The lens of the apparatus may be omitted or may be cut away to accommodate the breaking means.

354. The explosive mixture is to be allowed to flow through the casing of the device and into the test chamber until the original air has been displaced. Samples are then to be taken for analysis from (1) the test chamber and (2) the line carrying the explosive mixture. The lamp is then to be lighted by the normal power supply provided for the device and the glass envelope of the lamp bulb is to be broken by operating the lamp bulb breakage mechanism.

Without Lamp Disconnect Mechanism

355. The heated filament of a tungsten-filament lamp or the arc of a gaseous-discharge lamp shall not ignite the surrounding flammable gas- or vapor-air atmosphere during the lamp bulb breakage tests. A series of at least twenty tests shall be conducted over the flammable range of the specified gas- or vapor-air atmosphere.

356. For the lamp bulb breakage tests, the device having normal power is to be installed in a test chamber provided with inlet and outlet connections to the pipelines carrying the explosive mixture. The explosive mixture is to be caused to flow readily around the lamp bulb. The explosive mixtures are to be prepared by auxiliary equipment capable of maintaining predetermined concentrations of the mixtures.

357. The explosive mixture is to be allowed to flow into the test chamber until the original air has been displaced. Samples are then to be taken for analysis from (1) the test chamber and (2) the line carrying the explosive mixture. The lamp is then to be lighted by the normal power supply provided for the device with the glass envelope of the lamp bulb broken.

MARKING

358. These marking requirements apply to devices covered in both Parts I and II of this Standard.

359. Each device shall be permanently marked with the following:
   A. The manufacturer's name or trade name.
   B. A distinctive catalog designation, or equivalent, to specifically identify the device.
   C. The electrical rating or ratings (see paragraphs 381-382).
   D. The maximum working pressure, if applicable.
   E. Ambient temperature rating, if over 40°C (104°F).
   F. Designation of the hazardous location in which the device is intended to be used: i.e., "Class ___, Group ___." In addition, a product for Division 2 only, shall bear the wording Division 2 following the hazardous location class designation, i.e., "Class ___, Division 2, Group ___."
   G. If intrinsically safe, the equipment shall also be marked "Intrinsically Safe."

Paragraph 359 effective March 30, 1973
360. Intrinsically safe equipment and other equipment which may affect intrinsic safety shall be provided with a permanent warning marking; "Caution: Any substitution of components may impair intrinsic safety," or equivalent.

Paragraph 360 effective March 30, 1973

361. If the exposed surface temperature exceeds the limits indicated in Tables 10 or 16, the equipment shall be permanently marked with the maximum surface temperature or the temperature range indicating code number as indicated in Table 11. This marking is to be based on the maximum temperature attained in the temperature tests based on the ambient temperature specified in paragraph 237. See paragraphs 239 and 329. The maximum surface temperature, if used, may be combined with the cautionary statement given in paragraph 362.

Paragraph 361 effective March 30, 1973

362. If the equipment is marked with a maximum surface temperature or a temperature range indicating code number, the equipment shall also be permanently marked with the following: "Caution: To prevent ignition of hazardous atmospheres, this apparatus should not be installed in an area where vapors or gases having an ignition temperature less than ___°C (or ___°F) are present."

Paragraph 362 effective March 30, 1973

363. Apparatus which is produced without the attachment plug cap attached shall be provided with suitable instructions regarding the installation of this component. The instructions shall include all required information regarding the attachment plug cap that must be provided. The instructions shall be either provided as a permanent part of the equipment or shall be contained on a removable tag secured to each piece of equipment.

Paragraph 363 effective March 30, 1973

364. Process control instruments connected through flexible cord but not provided with an integral switch so that the plug is not depended upon to interrupt current shall be provided with instructions indicating that such a switch is necessary. See item C of paragraph 135 and paragraph 136.

Paragraph 364 effective March 30, 1973

365. The receptacle of process control instruments connected through flexible cord shall carry a permanent marking warning against unplugging under load if the receptacle is in a circuit capable of releasing sufficient energy to ignite a specific hazardous atmospheric mixture under normal conditions. See item E of paragraph 135.

Paragraph 365 effective March 30, 1973

366. If the receptacle referred to in item E, paragraph 135, is not provided as part of the instrument, instructions shall be provided indicating that the marking in paragraph 365 is necessary.

367. Battery-operated devices shall be permanently marked with the identification (manufacturer's name and designation or equivalent), and voltage of the battery to be employed: i.e., "Use___, No.____, ____V Battery, only."

Paragraph 367 effective March 30, 1973

368. Battery-operated devices employing batteries which are not intrinsically safe as shown by tests both under conditions of double-voltage and double-current availability shall be permanently marked: "Caution: To prevent ignition of hazardous atmospheres, batteries must be replaced in a nonhazardous location only."

Paragraph 368 effective March 30, 1973

369. An apparatus having provision for permanent connection to multiple power supplies shall bear a permanent cautionary marking to indicate that fact. The marking shall be on the outside of the device, where readily visible after installation. The marking shall be made at each point at which a power supply connection is to be made, and shall state the following or the equivalent: "Caution: This has more than one power supply connection point. Disconnect all power supplies before servicing."

Paragraph 369 effective March 30, 1973

370. An apparatus which is intended for Division 2 locations and has a supplementary fuse, shall bear a permanent cautionary marking to indicate that the fuse shall not be replaced unless the apparatus is disconnected from the supply circuit. The marking shall be located adjacent to the fuseholder and shall state the following or the equivalent: "Caution: De-energize the apparatus before replacing fuse."

Paragraph 370 effective March 30, 1973

371. If any point within a terminal box or wiring compartment of a permanently connected appliance in which the power supply conductors are intended to be connected (including such conductors themselves) attains a temperature rise of more than 35°C (65°F) during the normal temperature test, the appliance shall be permanently marked "For supply connection, use wires suitable for at least ___°C (___°F)", or with an equivalent statement: and the temperatures value shall be in accordance with Table 17. This statement shall be located at or near the point where the supply connections are to be made, and shall be clearly visible both during and after installation of the appliance.
372. If connections are to be made in the field to subassemblies or components, suitable instructions shall be provided to direct attention to the necessity for making such connections and other pertinent information concerning them.

373. Each individual apparatus of a system shall be permanently marked with its distinctive catalog number or equivalent to identify it as a part of the system.

Paragraph 373 effective March 30, 1973

374. Unless proper field-wiring connections are evident, a wiring diagram shall be attached to the device. For apparatus intended to be interconnected to companion equipment, such as in a process control loop, the wiring connections may be provided in an installation or instruction manual.

375. A proper sticker glued and/or shellacked to an accessible cover is considered to be adequately attached to the machine in accordance with the requirements in paragraph 375.

376. If necessary for proper operation of the equipment, the polarity of the output leads or terminals of a D-C circuit shall be permanently marked.

377. All permanent markings shall be legible and prominent and, except as noted in paragraphs 378 and 379, shall be so located that they will be visible after installation of the equipment.

378. Permanent markings which are required to be on a device need not be located on the outside of the enclosure of a device which is intended for use in an ordinary location, or in a Class I, Division 2 location or Class I, Division 2 location provided it is readily visible by opening a door or removing a cover after installation.

379. Permanent markings which are required to be on a device need not be located on the outside of the enclosure of small portable battery operated apparatus if the marking, except that required by paragraph 368, is located so that it is readily visible when replacing batteries.

380. A marking that is required to be permanent shall be molded, die-stamped, paint-stenciled, stamped or etched metal that is permanently secured, or indelibly-stamped lettering or pressure-sensitive labels secured by adhesive, that, upon investigation, is found to be adequate and suitable for the application. Ordinary usage, handling, etc. of the apparatus and the atmosphere in which used, is considered in the determination of the permanency of the marking.

RATING

381. An apparatus shall be rated in amperes, volt-amperes, horsepower, or watts, and also in volts, and may be rated for alternating-current only. The rating shall include the number of phases if the device is designed for use on a polyphase circuit, and shall include the frequency if necessary because of motors, relay coils, or other control devices. The voltage rating shall be in accordance with any appropriate single voltage or voltage range.

382. An apparatus having provision for permanent connection to the electrical supply and incorporating a motor load of more than 1/8 horsepower shall also be marked with the motor load in amperes and volts.
HOW STANDARDS ARE DEVELOPED
BY UNDERWRITERS' LABORATORIES

UL Standards for Safety are developed under a procedure which provides for participation and comment from the affected public as well as industry. The procedure takes into consideration a survey of known existing standards, and the needs and opinions of a wide variety of interests concerned with the subject matter of the Standard. Thus manufacturers, consumers, individuals associated with consumer-oriented organizations, academicians, government officials, industrial and commercial users, inspection authorities, insurance interests and others provide input to UL in the formulating of UL Standards for Safety, and keeping them consonant with social and technological advances.