

UL 1244

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Electrical and Electronic Measuring and Testing Equipment

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Announcement Bulletin(s): This Standard contains the announcement bulletin(s) dated June 5, 1996 and March 6, 1998. The announcement bulletin is located at the end of the Standard (after the adoption bulletin(s)).

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The Department of Defense (DoD) has adopted UL 1244 on July 4, 1994. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. 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 this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

1 General

1.1 Scope

1.1.1 Electrical or electronic measuring or testing equipment

This standard applies to electrical, electronic, or electromechanical measuring or testing equipment designed:

- | | | |
|----|------------------------------------|---------------------|
| a) | to | |
| | –measure, or | |
| | –observe, and | |
| | indicate quantities of | |
| | –electrical, or | Measuring Equipment |
| | –electronic | |
| | phenomena, or | |
| b) | to supply | |
| | –electrical, or | Testing Equipment |
| | –electronic | |
| | quantities for measuring purposes. | |

(Inclusion of equipment that measures or indicates electrical analogs of other phenomena is under consideration.)

1.1.2 Auxiliary or accessory equipment

This standard also applies to auxiliary equipment and accessories rated for use with electrical, electronic, or electromechanical measuring and testing equipment wherein auxiliary and accessory equipment is separate and does not itself perform the desired function but is used in addition to or as a supplement to equipment according to 1.1.1.

1.1.3 Equipment covered

Electrical, electronic, and electromechanical measuring and testing equipment includes, but is not necessarily restricted to:

- a) indicating and recording measuring equipment,
- b) electrical and recording measuring equipment,
- c) signal generators and other equipment supplying electrical quantities (voltage, current, and/or waveforms) for measuring or testing purposes,
- d) measurement standards, potentiometers, and measuring bridges,
- e) substitute power supplies used in addition to or as a supplement to equipment according to this Sub-clause.

1.1.4 Constraints

This standard applies to equipment that:

- a) is rated for connection to an unlimited voltage or power-supply source, according to Clause 16, (ac or dc or both), but does not exceed
 - i) 480 V rms (root-mean-square) between phases for 3-phase supply circuits,
 - ii) 250 V rms for single-phase supply circuits;
- b) is rated for connection to a voltage-limited or power-limited supply source and internally derives from that source either unlimited voltage or unlimited power according to Clause 16;
- c) is rated for measuring, testing, or other connection to an unlimited-voltage or unlimited-power circuit.

1.1.5 Environmental conditions

Equipment according to this standard is intended for use in enclosed locations where air temperature is controlled and normally only nonconductive pollution occurs.

The basic climatic conditions for heated or cooled enclosed locations are:

- | | | |
|----|-----------------------------|---|
| a) | temperature | from 5°C (41°F) to 40°C (104°F)
Equipment may occasionally be used temporarily or for short time periods at -10°C (14°F) to +5°C (41°F). |
| b) | altitude | up to 2,200 m (7,218 ft) |
| c) | relative humidity | up to 80 percent with wet bulb temperature not to exceed 27°C (81°F). |

1.1.6 Equipment not covered

This standard does not apply to equipment:

a) intended primarily for identifying, examining, and investigating materials and making measurements and tests such as might be associated with manufacturing processes and quality-control procedures.

Note: This type of equipment is categorized as "Inspection and Measuring Equipment".

b) intended primarily for technological activities including the measurement of physical or chemical properties of materials, functional performance (nonelectrical or nonelectronic) of equipment, qualitative or quantitative constituent analysis of substances, and the preparation of materials.

Note: This type of equipment is categorized as "Laboratory Equipment".

c) intended primarily for use in medical diagnostic and therapeutic applications.

Note: This type of equipment is categorized as "Medical and Dental Equipment".

d) watt-hour meters and similar revenue-related equipment for use and installation by electric utility companies for measuring electric energy and related quantities.

Note: This type of equipment may be categorized as "Energy Usage Monitoring Systems".

e) intended primarily for use as a general-use battery charger, auxiliary supply source, substitute power, or general-use power supply not specifically intended for use with measuring or testing equipment.

Note: This type of equipment is categorized as "Battery Chargers and Power Supplies".

Specifically intended is defined as being:

- 1) packaged with the equipment, or
- 2) referenced in an equipment marking, or
- 3) referenced in the operating instructions packed with the equipment.

f) intended primarily for use of its measuring or testing functions exclusively for control purposes.

Note: This type of equipment is categorized as "Process-Control equipment".

2 Definitions

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

2.1 ACCESSIBLE PART – A part that can be touched during normal use or operator servicing. See 10.1.

2.2 ATTACHMENT PLUG – A connecting device for a flexible cord that, by insertion into a receptacle, establishes supply-circuit connections between the flexible cord and the receptacle.

2.3 BENCH-TOP EQUIPMENT – Equipment intended to be used on and supported by a bench, table, stand, or similar surface, but is neither fixed nor hand-carried as determined by the following:

- a) It has at least one handle and exceeds 20 kg mass (44 lb mass).
- b) It has no handle and exceeds 5 kg mass (11 lb mass).
- c) It is not mobile (does not have casters, wheels, rollers, and the like nor is it provided with a cart).

2.4 CIRCUIT-TO-GROUND VOLTAGE – The rated value of voltage with respect to earth ground.

2.5 CLEARANCE DISTANCE – The shortest distance measured in air between conductive parts.

2.6 CREEPAGE DISTANCE – The shortest distance measured over the surface of insulation between conductive parts. Air gaps shorter than 1.0 mm (0.04 inch) are not considered to interrupt the surface path.

2.7 CONDUCTIVELY CONNECTED – A part is conductively connected to another part if the current between the parts, with the equipment at reference test conditions, exceeds the limit for leakage current.

2.8 CORD-CONNECTED EQUIPMENT – Equipment that connects to a supply circuit by means of a permanently attached flexible power-supply cord and attachment plug or by means of a detachable power-supply cord.

2.9 ELECTRONIC DEVICE – A part or an assembly of parts that employs electron or hole conduction in a semiconductor or electron conduction in a vacuum or gas.

2.10 EQUIPMENT –

- a) Hand-Held – Any piece of equipment either intended to be or indicated by the manufacturer that it can be (that is, in advertising literature or in the operating instructions) held in one hand during any phase of normal operation, regardless of its weight.
- b) Permanently connected – Equipment that is fastened or otherwise secured to the building at a specific location.
- c) Portable – Cord and plug connected equipment that:
 - i) has no provision for permanent mounting, and
 - ii) can be moved from one place to another for use.

d) Stationary – Cord and plug connected equipment that is intended to be fastened in place or located in a dedicated space.

e) Hand-Carried – Note: This is different from "Hand-Held Equipment" which is intended to be used and carried in one hand rather than carried by hand from one location to another. Equipment specifically intended to be easily carried by hand from one location to another as determined by the following:

i) It is provided with at least one handle and is not greater than 20 kg mass (44 lb mass).

ii) It has no handle and is not greater than 5 kg mass (11 lb mass).

2.11 FIELD-WIRING TERMINAL – Any terminal to which a supply wire can be connected by an installer in the field is a field-wiring terminal unless the wire is provided as part of the equipment and a connector, soldering lug, soldered loop, crimped eyelet, pressure terminal, or other means for making the connection is factory-assembled to the wire.

2.12 GAUGES – Wherever it appears in this Standard, the abbreviation AWG means American Wire Gauge.

2.13 GROUND – A conducting connection, whether international or otherwise, between an electrical circuit or electrical equipment and either the earth or some conducting body that serves in place of the earth.

2.14 GROUNDING – The act of establishing a conductive connection, whether intentional or otherwise, between an electrical circuit or electrical equipment and the earth or some conducting body that serves in place of the earth.

2.15 INSULATION –

a) Double – A system of insulation comprising both basic and supplementary insulation

b) Functional/Basic – Insulation necessary for the proper functioning of equipment and for basic protection against electric shock.

c) Reinforced – Improved basic insulation with mechanical and electrical qualities providing the same degree of protection against electric shock as double insulation.

d) Supplementary – Independent insulation provided in addition to the basic insulation to protect in the case of physical or electrical breakdown of the basic insulation (see item b).

2.16 ISOLATED CIRCUIT – A circuit in which the current, with the equipment at reference test conditions, to any other circuit or conductive part does not exceed the limit for leakage current.

2.17 MEASURING OR TESTING TERMINAL – The external terminal or connector of the equipment to which connection is made to serve the equipment function.

2.18 OPERATOR – The person using or operating the equipment.

2.19 OPERATOR CONTROL – An operator-accessible control-usually operated by a knob, pushbutton, lever, or the like – provided to enable the operator to cause the equipment to perform its intended function.

2.20 POWER-SUPPLY CORD – The cord provided to connect the equipment to the branch circuit.

2.21 PROBE ASSEMBLY, MEASURING OR TESTING – An assembly consisting of a probe(s), a remote terminal(s), and a connecting lead(s) or shielded cable for conveniently extending the equipment input or output circuits to the external circuit in which measurement or testing is desired. Refer to Figure 2.1 for a typical example.

The leads may be permanently connected to the equipment or may be terminated with a connector(s) to mate with the equipment measuring or testing terminals.

The probe assembly may contain components or circuits that modify the characteristics of the voltage or current passing through the probe assembly or the input or output characteristics of the equipment.

2.22 RATED SUPPLY VOLTAGE – The supply voltage, or range of voltages, for which the manufacturer has constructed the equipment.

2.23 RATED VALUE – The value, or one of the values, assigned by the equipment manufacturer.

2.24 RECEPTACLE – A connector device permanently connected to the supply circuit (usually a branch circuit) into which an attachment plug is inserted.

2.25 REMOTE-CONTROL DEVICE – A device for controlling equipment from a distance.

2.26 SAFETY SWITCH – A switch employed for the purpose of providing protection according to this standard.

2.27 SUBSTITUTE POWER SUPPLY – Supply equipment that may be used instead of a battery supply for the equipment.

2.28 SUPPLY CIRCUIT – The circuit supplying electrical energy to the equipment from a branch circuit.

2.29 SUPPLY EQUIPMENT – Equipment that takes energy from an electrical supply, generally a branch circuit, and supplies it in a modified form to energize other equipment.

2.30 TERMINAL DEVICE – A part used to facilitate the making of one or more electrical connections.

It may contain several terminal contacts (a connector).

2.31 TESTS –

a) Routine Test – A test that is carried out on each piece of equipment during the production process.

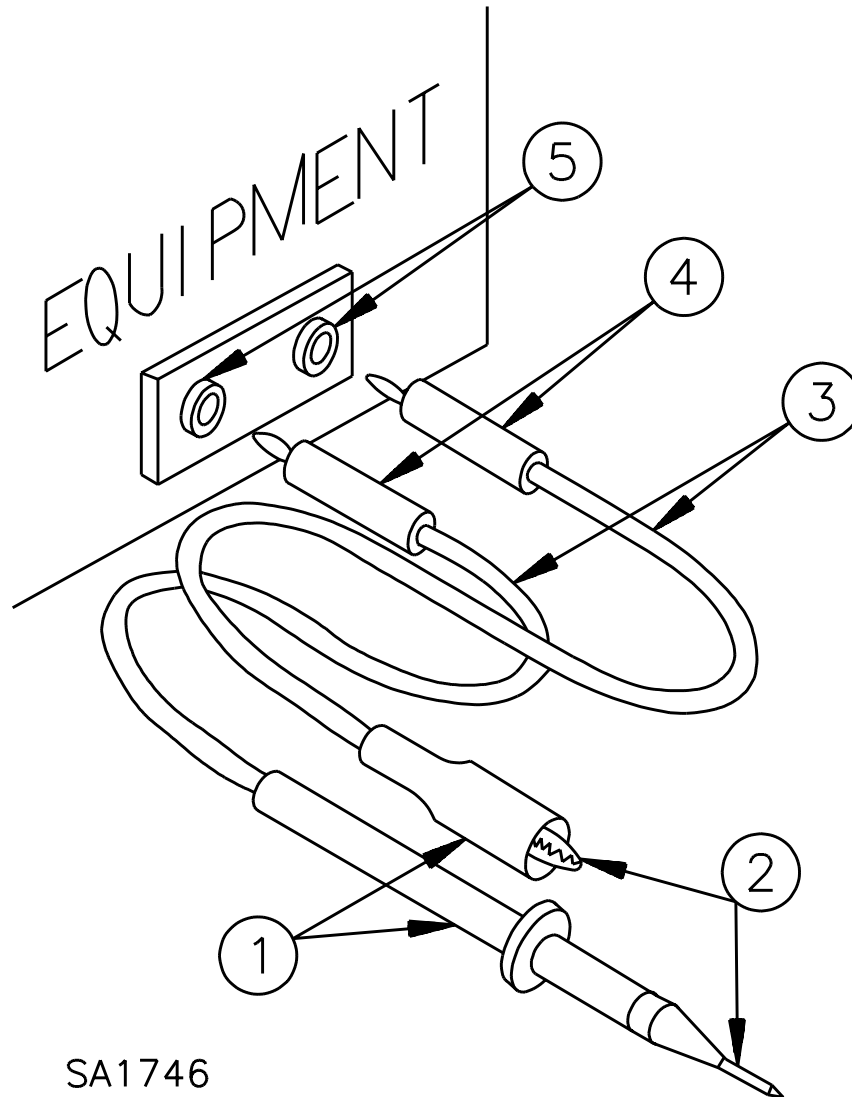
–Continuity of grounding connection test (see 10.5.1)

–Polarization test (see 10.8.6).

–Production-line dielectric voltage-withstand test (see 10.11.1 b).

b) Type Test – A test that is carried out on one or more pieces of equipment, representative of a type, to determine whether the construction and manufacturing methods comply with the requirements according to this standard.

Figure 2.1
Typical probe assembly (illustration only for defining generic parts)



1 PROBE – The handle, body, boot, etc. used to support and insulate the remote terminal and to facilitate its application to the circuit in which measurement or testing is desired.

2 REMOTE TERMINAL – The clip, pin, grip, or other connecting or contacting device that makes the electromechanical connection to the external circuit in which measurement or testing is desired.

3 LEADS – The insulated leads or shielded cable interconnecting the remote terminal(s) with the equipment input or output circuit.

4 CONNECTOR – The connector device, if any, that terminates the leads or cable with a means to make the electromechanical connection to the equipment input or output terminals or connector.

5 MEASURING OR TESTING TERMINALS – See 2.18.

3 General Information

3.1 Purposes of this standard

The purposes of this standard are to establish minimum requirements for protection and to specify means of measurement for determining compliance.

Note: These requirements include specific protections identified in the various Clauses.

These requirements do not, in general, concern other properties of the equipment such as effectiveness, accuracy, or reliability.

Equipment depended upon for indication of acceptable performance of other equipment – for example, a leakage-current meter – shall also be evaluated for effectiveness, accuracy, and ability to perform the intended function according to the manufacturer's ratings.

Should it be technically impractical to determine the effectiveness of such equipment, markings pertaining to the characteristic(s) in question shall be prominently displayed on the equipment.

3.2 Compliance

Compliance with the requirements is determined by performing inspections and tests according to the Clauses applicable to the particular equipment.

3.3 Components

Where component or material ratings are required in this standard, such ratings shall be according to applicable component or material requirements.

Exception: Component and material requirements may be modified.

3.4 Units of measurement

If a value for measurement as given in this standard is followed by a value in parentheses in other units, the second value may be only approximate. The first-stated value is the requirement.

Example:



4 General Requirements

4.1 The equipment construction shall be such that:

- a) Fire, electric shock, or injury to persons is not likely to occur during normal use or operator servicing; and
- b) the components and materials are used within their rated value(s), such as electrical, mechanical, and temperature limits, and other limitations of use; and

(Note: Also see 3.3.)

- c) the components, wiring, and other internal parts are protected from being displaced or damaged.

4.2 The components, parts, and materials to which reference is made in 4.1 and elsewhere in this Standard are those involving or associated with

- the risk of fire; or
- the risk of electric shock; or
- the risk of injury to persons.

Exception: Where indicated otherwise.

5 General Type-Test Requirements

5.1 Conduct of tests

5.1.1 Tests specified in this standard are type tests.

Exception: Where indicated otherwise.

If in this standard it is required that tests on components or parts of equipment are to be made in accordance with their individual relevant specifications, such tests need not necessarily be performed during the type test specified in this standard.

5.1.2 Type tests shall be carried out on one and the same piece of equipment or on identical multiple samples.

Type tests specified in this standard shall be carried out on equipment in the condition as shipped from the factory or as repaired to the same condition.

Note: Where it is necessary to perform destructive tests, additional samples of identical components or equipment may be used.

5.1.3 For voltage measurements, the voltmeter sensitivity shall not be less than 20,000 ohms per volt dc or 5,000 ohms per volt ac for potentials of 500 V or less and the resistance shall not be less than 10 megohms for a-c or d-c potentials of more than 500 V. Voltmeters having a higher input resistance shall be used wherever it is warranted by the resistance of the circuit under test.

Exception: Where indicated otherwise.

5.1.4 Cheesecloth specified in this standard shall be untreated cotton cloth running 26 – 28 m²/kg (14 – 15 yd²/lb) and having what is known to the trade as a count of 13 by 11 – that is, (for any square centimeter, 13 threads in one direction and 11 threads in the other direction (for any square inch, 32 threads in one direction and 28 threads in the other direction).

Test involving cheesecloth shall be made in a room free of drafts.

5.1.5 The terms "voltage" and "current" indicate rms or d-c values.

Exception: Where specified otherwise.

5.2 Reference test conditions (reference conditions for test purposes)

The following conditions shall prevail in the location in which the equipment is being tested:

- Temperature within the range of 15 – 35°C (59 – 95°F).
- Relative humidity of less than 80 percent,
- Atmospheric air pressure (absolute) within the range of 86– 106 kPa (12.5 – 15.4 psi),
- Environment free of hoarfrost, dew, percolating water, rain, solar radiation, and the like.

Exception: Where specified otherwise.

5.2.1 Each test shall be carried out under the most unfavorable combination of:

a) Position

The equipment shall be in any position of normal use and mounted according to the instructions. Normal ventilation shall not be impeded by artificial means.

b) Applied supply-circuit voltage

The applied supply-circuit voltage shall be the maximum "utilization" voltage of the intended "nominal" supply circuit voltage.

Note: The maximum "utilization" voltage for various "nominal" supply circuits are shown in Table 5.1.

If the equipment supply rating exceeds the maximum "utilization" voltage of intended "nominal" supply circuit, the applied supply-circuit voltage shall be the maximum supply-voltage rating of the equipment.

The applied supply-circuit frequency shall be any rated supply frequency of the equipment.

The applied supply voltage for a-c and d-c rated equipment shall be ac or dc.

Note: Equipment that may be operated either from an a-c or d-c supply, may be connected to the worst-case d-c input specified if such operation imposes more severe conditions than if operated from the a-c supply.

The applied supply voltage for single-phase a-c rated equipment may be polarized as intended or reversed.

c) Measuring circuits

Measuring circuits shall be energized by any value between zero and the rated input.

Isolated measuring circuits shall be connected to any Potential between zero and the rated circuit-to-ground voltage.

d) Ground terminals

Protective-grounding terminals shall be connected to ground.

Exception: Where specified otherwise in the test clauses.

Measuring-circuit ground terminals shall be connected to ground when specified by the manufacturer.

Exception: Where specified otherwise in the test clauses.

e) Operating controls

Accessible controls shall be set to any position.

Exception: Supply-circuit voltage-setting devices shall be set according to the manufacturer's instructions.

Remote-control (operating) devices shall either be connected or not.

Note: This condition should not cause the operating device to be set to cause abnormal operation of the equipment.

f) Normal use

The equipment shall be used for its intended purpose, or not connected for any use whatsoever.

g) Motors and motor-driven parts

Motors and motor-driven parts of the equipment shall be loaded according to the intended purpose.

Note: When testing motor-driven parts, other parts of the equipment that are intended to operate at the same time should remain connected.

h) Testing (output) circuits

Equipment supplying electrical quantities (voltage, current, and/or waveshapes) shall:

- i) Be operated in such a way as to provide the maximum rated output; and
- ii) If isolated, be connected to any potential between zero and the rated circuit-to-ground voltage.

i) Substitute power supplies

Substitute power supplies shall be tested in or with the equipment for which they are intended, and according to the manufacturer's instructions.

j) Accessories

Noninterchangeable accessories shall be connected according to the manufacturer's instructions, or not connected.

Interchangeable accessories and accessories of limited interchangeability shall be subjected to separate tests relating to their own characteristics.

5.3 Fault conditions

Note: Testing under fault conditions denotes that, in addition to the reference test conditions mentioned in 5.2, the breakdown of particular components is simulated one after the other. Testing under fault conditions is according to Clause 11.

When performing tests under simulated fault conditions, multiple concurrent faults are not initially induced but are considered if they result from the initial induced fault.

Table 5.1
Minimum and maximum "utilization" voltages for "nominal" supply circuits^a

Supply-circuit system and "nominal" voltage	Minimum "utilization" voltage	Maximum "utilization" voltage applied supply-circuit voltage: 5.2.1(b)
X-wire, E-volts	0.9E V	1.05E V
2-wire, 100 V	90 V	105 V
2-wire, 115 V	103.5 V	120.75 V
2-wire, 120 V	108 V	126 V
2-wire, 127 V	114.3 V	133.35 V
3-wire, 100/200 V	90/180 V	105/210 V
3-wire, 120/208 V	108/187.2 V	126/218.4 V
3-wire, 120/220 V	108/198 V	126/231 V
3-wire, 115/230 V	103.5/207 V	120.75/241.5 V
3-wire, 120/240 V	108/216 V	126/252 V
^a "Utilization" voltage is the voltage at the line terminals of the equipment. The "nominal" voltage of a supply circuit is a value assigned to the circuit (or system) for the purpose of conveniently designating its voltage class.		

6 Marking

The equipment shall be marked according to this Clause.

6.1 General requirements

The marking required in this Clause shall:

- a) resist the deleterious effects of handling, cleaning agents as specified by the manufacturer, and the like expected in normal use; and,
- b) make the information clear and legible under conditions of normal use.

Compliance is checked by inspection.

6.2 Equipment-identification markings

Equipment shall bear identification markings on the exterior, excluding the bottom, according to this Sub-clause.

Exception No. 1: For handed-held equipment, such identification markings may be on the bottom.

Exception No. 2: The markings may be located where it is visible upon removing a cover or opening a door that is intended to be removed or opened by an operator without the use of tools.

Compliance is checked by inspection.

6.2.1 Manufacturer's identification

The equipment shall bear the name, trade name, or trademark of the manufacturer or private labeler, or other distinctive marking by means of which the organization responsible for the equipment can be readily identified.

Compliance is checked by inspection.

6.2.2 Model identification

The equipment shall bear a distinctive designation, such as a model number, that distinguishes it from other equipment made by the same organization.

Compliance is checked by inspection.

6.2.3 Factory identification

If equipment bearing the same distinctive designation (model number) is manufactured at more than one location, equipment from each manufacturing location shall bear in identification on such location.

Note: Such identification may be in code and need not be on the equipment exterior.

Compliance is checked by inspection.

6.2.4 Accessory, plug-in module, and auxiliary-equipment identification

Equipment intended to work with a specific accessory, plug-in module, or auxiliary equipment shall bear markings or be provided with a means for identifying each such accessory, plug-in module, or auxiliary equipment.

Accessory, plug-in module, and auxiliary equipment intended to work with specific equipment shall bear marking or be provided with a means for identifying each such equipment.

The identification markings may be located on the equipment, on the accessory, plug-in module, or auxiliary equipment, or in the literature packed with either.

Compliance is checked by inspection.

6.2.5 Separate Grounding Conductor

Equipment that requires a separate grounding conductor (see 19.3) as part of the (wiring) installation, shall provide a marking on the unit. The marking shall indicate the need for such grounding and shall make reference to the installation instruction.

Exception: The marking need not reference the installation instructions when complete instructions are provided on the equipment.

Compliance is checked by inspection.

6.3 Equipment-rating markings

Equipment shall bear rating marking visible from the exterior, excluding the bottom, according to this Sub-clause (see 2.23).

Note: A rating is a value assigned to the equipment by the manufacturer.

Note: For hand-held equipment, such rating markings may be on the bottom.

Note: The markings may be located where they are visible upon removing a cover or opening a door that is intended to be removed or opened by an operator without the use of tools.

Compliance is checked by inspection.

6.3.1 Supply-circuit type and frequency rating

- a) Equipment intended to operate from a direct-current supply shall bear markings indicating that the supply shall be direct current.

Note: The symbol  (IEC Publication 60417, Symbol no. 5031; see Appendix) may be used for this marking.

- b) Equipment intended to operate from an alternating-current supply shall bear markings indicating that the supply shall be alternating current.

Note: The symbol  (IEC Publication 60417, Symbol no. 5032; see Appendix) may be used for this marking.

The markings shall include the equipment supply-circuit frequency or supply-circuit frequency-range rating (cycles per second, cycles/second, hertz, c/s, cps, or Hz).

- c) Equipment intended to operate from either direct-or alternating-current supplies shall bear markings indicating that the supply may be either direct current or alternating current.

Note: The symbol $\sim$ (IEC Publication 60417, Symbol no. 5033; see Appendix) may be used for this marking.

The markings shall include the equipment supply-circuit frequency or supply-circuit frequency-range rating (cycles per second, cycles/second, hertz, c/s, cps, or Hz).

Compliance is checked by inspection.

6.3.2 Polyphase supply-circuit rating

Equipment intended for operation on a polyphase supply circuit shall bear markings designating the number of phases and number of wires, including the grounded conductor and excepting the protective ground conductor, if any.

Compliance is checked by inspection.

6.3.3 Supply-circuit voltage rating

Equipment shall bear markings designating the supply-circuit voltage(s) or voltage-range(s) rating(s) of the equipment that can be applied without the adjustment of a voltage-setting device.

Multiple-voltage equipment shall bear markings indicating the supply-circuit voltage or voltage range for which the equipment is set.

If the equipment is constructed so that the supply-circuit voltage-selector setting can be changed by the operator, the action of changing the voltage-selector setting shall also change the supply-circuit voltage indication.

Compliance is checked by inspection.

6.3.4 Supply-circuit current or power rating

Equipment shall bear markings designating the equipment supply-circuit current or power rating in amperes, volt-amperes, or watts (A, VA, or W). Such rating shall include the maximum current or power of any accessory or auxiliary equipment that is supplied through and operated simultaneously with the equipment.

The measured supply-circuit current or power shall not exceed 110 percent of the marked supply-circuit current or power rating.

Compliance is checked by inspection and by measuring the equipment supply-circuit current or power consumption under reference test conditions.

6.3.5 Supply-circuit receptacle rating

Equipment incorporating operator-accessible supply-circuit receptacles for supplying operating energy to other equipment shall bear markings adjacent to such receptacles indicating the available voltage, frequency, and either current or power.

Compliance is checked by inspection.

6.3.6 Fuse ratings

Equipment incorporating fuses providing protection against the likelihood of fire shall bear markings adjacent to the fuse or fuseholder designating the fuse current and voltage ratings.

Note: The fuse ratings may be incorporated into a fuse-replacement caution marking (see 6.4.1).

Compliance is checked by inspection.

6.3.7 Equipment duty-cycle rating

Equipment intended for short-term or intermittent use, and, if operated continuously, would exceed the temperature rises according to Clause 7 shall bear a duty-cycle rating.

Such duty-cycle rating shall be visible from the operating position and, if applicable, shall be adjacent to or otherwise related to the duty-cycle controls.

Compliance is checked by inspection.

6.4 Warning and caution markings

Equipment shall bear warning and caution markings according to this Sub-clause.

A warning or caution marking required in this Sub-clause shall

- i) be permanently attached; and
- ii) not be attached to parts likely to be replaced during maintenance or servicing;

Exception: If the marking is integral with the replacement part, part ii) is not applicable.

- iii) have lettering in which

- the precautionary signal word shall be at least 2.75 mm or 7/64 inch high;

- the text shall be at least 1.5 mm or 1/16 inch high and contrasting in color to the background; and

- if molded or stamped in a material, the text shall be at least 2.0 mm or 5/64 inch high and, if not contrasting in color, a depth or raised height of at least 0.5 mm or 0.02 inch.

Note: Warning and caution markings may be combined under the signal word "WARNING".

Compliance is checked by inspection.

6.4.1 Operator-replaceable fuse-replacement caution marking

Equipment incorporating an operator-replaceable fuse providing protection against the likelihood of fire shall bear a replacement caution marking.

The marking shall be prefaced by the signal word "CAUTION" and

- a) state that the fuse provides protection against fire, and
- b) instruct that replacement shall be only with a fuse of the specified voltage and current ratings.

Note: For example:

"CAUTION-FOR CONTINUED PROTECTION AGAINST FIRE, REPLACE ONLY WITH FUSE OF THE SPECIFIED VOLTAGE AND CURRENT RATINGS."

The marking shall:

- i) be located on the equipment so that it is visible during fuse replacement.

Note: A fuse-rating marking (6.3.6) may be incorporated into the fuse-replacement caution marking provided that the replacement marking is adjacent to the fuse or fuseholder, or

- ii) be prominently displayed in the operating instruction manual; provided the symbol for a fuse (IEC Publication 60417, symbol no. 5016a. See Appendix) and its electrical rating enclosed in an equilateral triangle (as shown) is located adjacent to the fuse. The fuse rating may be adjacent to the fuse – in place of it appearing within the triangle.

The overall symbol shall be at least 3.2 mm (1/8 inch) high. The electrical rating of the fuse shall be in letters not less than 1.6 mm (1/16 inch) high.

Compliance is checked by inspection.

6.4.2 Operator-servicing warning marking

Equipment in which parts conductively connected to the measuring circuit are accessible under conditions of operator servicing, such as replacing batteries and fuses or any other part intended for operator replacement, shall bear a service warning marking.

The marking shall be prefaced by the signal word "WARNING" and

- i) state that parts could render an electric shock, and
- ii) instruct that the measuring terminals are to be disconnected from external circuits prior to operator servicing.

Such marking shall be located where visible prior to operator access to such parts.

Note: For example:

"WARNING-TO AVOID ELECTRIC SHOCK, DISCONNECT MEASURING TERMINALS BEFORE REMOVING (OR REPLACING, OR OPENING, OR THE LIKE.) _____."

Compliance is checked by inspection.

6.4.3 Implosion-protection warning marking

Equipment incorporating an operator-replaceable vacuum device with a face plate exceeding 160 mm (6-5/16 inches) in diameter, or equivalent face area, (over 20,000 mm² or 31 inches²), shall bear a warning marking.

The marking shall be prefaced by the signal word "WARNING" and

- i) state that the device is dangerous to handle, and
- ii) instruct that servicing should be performed by qualified personnel.

Such marking shall be visible during operator servicing of the device.

Note 1: For example:

"WARNING – CATHODE-RAY TUBE DANGEROUS TO HANDLE REFER SERVICING TO QUALIFIED PERSONNEL."

Note 2: An implosion-protection warning marking may be incorporated into the cathode-ray-tube-replacement warning marking 6.4.4).

Compliance is checked by inspection.

6.4.4 Cathode-ray-tube-replacement warning marking

Equipment incorporating a cathode-ray tube having integral implosion protection and that can be replaced with a cathode-ray tube without integral implosion protection shall bear a replacement warning marking.

The marking shall be prefaced by the signal word "WARNING" and

- i) state that the cathode-ray tube incorporates integral implosion protection, and
- ii) instruct that the tube shall be replaced only with a tube having integral implosion protection.

Such marking shall be visible during replacement of the cathode-ray tube.

Note: For example:

"WARNING – CATHODE-RAY TUBE EMPLOYS INTEGRAL IMPLOSION PROTECTION. REPLACE WITH SAME TYPE NUMBER FOR CONTINUED PROTECTION."

Note: A cathode-ray-tube-replacement warning marking may be incorporated with the implosion-protection warning marking (6.4.3).

Compliance is checked by inspection.

6.4.5 X-radiation warning marking

Parts of equipment producing X-radiation exceeding the limits specified in 7.1.1 and employing supplemental protective covers or shields shall bear a warning marking.

The marking shall

- i) state that such covers or shields provide protection from X-radiation, and
- ii) instruct that personnel shall wear protective clothing when operating equipment with such covers or shields removed.

Such marking shall be located on the cover or shield, or where visible during servicing of parts behind such cover or shield.

Compliance is checked by inspection.

6.4.6 High-leakage-current warning marking cord-connected equipment incorporating an electro-magnetic-radiation-suppression filter and having a leakage current (see 10.5.8 and 10.10.1) exceeding 0.5 mA shall bear a warning marking.

The marking shall be prefaced by the signal word "WARNING" and shall

- i) state that the protective earth-grounding conductor provides protection from electric shock, and

- ii) instruct that the equipment must be earth-grounded.

Such marking shall be located either adjacent to the attachment-plug grounding terminal or on the equipment.

Compliance is checked by inspection.

6.5 Operator-control and terminal markings

Operator controls and terminals shall be identified such that the equipment may be connected and operated as intended by the manufacturer, so that electric shock, fire, or injury to persons are not likely.

6.5.1 Terminal and control identification

If the equipment controls or terminals are not expressly identified on the equipment, the controls and terminals shall be identified in the operator instructions or literature packaged with the equipment.

Compliance is checked by inspection.

6.5.2 Terminal markings and ratings requiring explanations

If, to preserve the protection afforded by the equipment, further explanations beyond the terminal identification and ratings marked on the equipment are necessary, the marking shall include a reference to the operating instructions.

The symbol **⚠** may be used for this purpose.

The reference shall be adjacent to or related to the marking or rating requiring explanation.

Compliance is checked by inspection.

6.5.3 Terminal function, use, or ratings

If the equipment terminals are not expressly marked with function, use, or ratings; the terminal function, use or ratings, whichever is appropriate to the intent of the terminals, shall be in the operator instructions or literature packaged with the equipment. A terminal or terminal set used for more than one function shall be marked to identify the function use or rating appropriate for each function.

Note: Abbreviations and symbols may be incorporated in such markings.

Note: Such markings may include other function, use, or ratings pertinent to equipment operation.

Note: Terminal function, use, or ratings may be incorporated into operator-control markings.

Compliance is checked by inspection.

6.5.4 Isolated terminal ratings

An isolated terminal or terminal set that is intended to be connected to an energized external source shall be marked with an isolated rating.

Compliance is checked by inspection.

6.5.5 Unlimited voltage terminal identification

A terminal or terminal set rated for unlimited voltage shall be identified by a marking on the equipment, adjacent to or otherwise related to the terminal or terminal set. Alternatively, control or terminal markings, indicators, equipment configuration or name, or other identifiers shall imply the terminal functional identification.

Compliance is checked by inspection.

6.5.6 Voltage terminal ratings

A terminal or terminal set intended for connection to an external voltage source or that supplies unlimited voltage shall bear a rating marking adjacent or otherwise related to the terminal or terminal set. Alternatively, the related controls, indicators, or other identifiers shall specify the terminal rating or use, whichever is appropriate to the intent of the terminal.

Compliance is checked by inspection.

6.5.7 High-voltage-terminal marking

A measuring or testing terminal to which or from which a voltage equal to or exceeding 1000 V may be applied or supplied shall be marked with the flash symbol ⚡ in red (IEC Publication 60417, Symbol No. 5036; see Appendix).

Note 1: For example:

- The flash symbol pointing to individual terminal(s) intended to be marked.
- The flash symbol located equidistant from two or more terminals intended to be marked.
- The flash symbol located in the terminal area but not adjacent to any particular terminal or terminals in such a manner that it applies to all the terminals.

Note 2: The markings (symbol) may be incorporated into a rating marking.

Compliance is checked by inspection.

6.5.8 Current terminal rating

A terminal or terminal set intended for connection to an external current source or that supplies current shall bear a rating marking adjacent to or otherwise related to the terminal or terminal set. Alternatively, the related controls, indicators, or other identifiers shall specify the terminal rating or use, whichever is applicable to the intent of the terminal.

Compliance is checked by inspection.

6.5.9 Protective-grounding terminal

A protective-grounding terminal for equipment not having supply-circuit connections shall be identified.

Note: The symbol $\oplus$ (IEC Publication 60417, Symbol No. 5019a; see Appendix) may also be marked adjacent to any protective-grounding terminal. When used, the symbol shall be defined in the operating instructions provided with the equipment.

The marking shall be adjacent to the terminal.

Compliance is checked by inspection.

6.6 On/off switch

The off position, or the on position, or both, of the principal supply-circuit switch controlling equipment operating energy shall be identified. (See 14.2.1 and 14.2.2.)

The symbols **O** and **I** (IEC publication 60417, symbol Nos. 5008 and 5007; see Appendix) may be used for this purpose.

Identification by illumination alone is not acceptable.

Switches that appear to be in the same position when on or off shall not be used for the principal supply-circuit switch.

Compliance is checked by inspection.

6.7 Field wiring connection temperature markings

Equipment having wires or terminals within a terminal box or compartment, intended for branch circuit supply connections, that attain a temperature higher than 60°C (140°F) when tested in accordance with Clause 7, shall be marked with a field wiring temperature marking. The marking shall include the following statement: "For supply connections, use wires rated for at least ____" (see Table 6.1 for values).

Compliance is checked by inspection.

Table 6.1
Temperature for marking

Temperature attained in terminal box or compartment	Temperature marking
61 – 75°C (142 – 167°F)	75°C (167°F)
76 – 90°C (168 – 194°F)	90°C (194°F)

6.8 Double insulation marking

Equipment employing double insulation according to Clause 20 shall bear an identification of such a construction.

The symbol  (IEC Publication 60417, symbol no. 5172; see Appendix) shall be used for this identification.

6.8.1 Double insulation servicing marking

Equipment or the servicing instructions for equipment employing double insulation shall bear a servicing marking. The marking shall:

- i) include a reference to the operating instructions, and
- ii) indicated the equipment employs double insulation, and
- iii) indicated only specified replacement parts are to be employed

Such marking shall be located where visible when servicing the equipment or prominently in the servicing instructions.

The symbols  , along with the wording "When Servicing, Use Only Specified Replacement Parts" or the equivalent, shall be used for this purpose.

7 Equipment Emanations

The equipment shall be constructed to limit the levels of ionizing radiation.

Exception: This requirement does not apply to equipment containing radioactive substances. Such equipment is covered under separate standards.

Compliance is checked according to 7.1.

7.1 Ionizing radiation

7.1.1 X-radiation measurement

The exposure-rate limit averaged over an area of 10 square centimeters (1.55 inches²) shall not exceed 0.5 mR/h, 36 pA/kg or 129 nC per kg/h 5 cm (2 inches) from the surface of the equipment or surface of the part of the equipment being measured. The method of determining the amount of radiation shall be effective over the range of possible radiation energies.

The equipment shall be prepared and adjusted such that:

- a) The equipment under test shall be complete.

Covers or doors that are intended to be removed or opened by the operator shall be removed or opened.

- b) The supply-circuit voltage to the equipment under test shall be

- i) adjusted to be within the rated range(s) according to 5.2.1(b), or

- ii) 130 V if the supply-circuit voltage rating is within the range of 105 – 130 V, and 260 V if the supply-circuit voltage rating is within the range of 210 – 260 V.

whichever produces the maximum X-radiation.

- c) Measurements on multifunction equipment shall be made with the equipment in any and all modes of normal operation, and with applicable signals applied to all input terminals in whatever manner produces the maximum X-radiation.

- d) Cathode-ray-tube equipment shall display a pattern from each beam not exceeding 30 by 30 mm (1-3/16 by 1-3/16 inches) or the smallest possible display, whichever is larger. The display(s) shall be positioned to maximize X-radiation.

Note: For example: Not necessarily centered or multiple beams overlapping.

- e) To simulate conditions that may occur during repair of the equipment, the equipment under test shall be adjusted to produce maximum X-radiation, and all parts whose opening or removal is normal during service or repair shall be opened or removed during the test.

Note: For example: Covers, cathode-ray tube bezels, panels, windows, shields, barriers, or chassis.

Compliance is checked by measuring the X-radiation under the conditions of this Sub-clause in a direction normal to the surface of the equipment or surface of the part of the equipment being measured.

7.1.2 Enclosure or shield construction requirements

Parts of equipment that produce X-radiation exceeding the limits in 7.1.1 shall be additionally enclosed or shielded. The enclosures or shields:

- a) shall not be removable by hand, and
- b) shall be captive, and
- c) shall provide shielding during normal use, operator servicing according to 10.1 (a) and (b), and repair by service personnel (except servicing of the enclosed or shielded parts), and
- d) shall be marked according to 6.4.5 (X-radiation warning marking).

Compliance is checked by inspection.

8 Heating

8.1 General

When equipment is operated under reference test conditions 5.2, the temperature rises in Table 8.1 shall not be exceeded.

Note: For equipment having special operating conditions, such as short-term or intermittent use, this Clause applies as far as compatible with such special operating conditions.

Compliance is checked by performing the tests according to this Sub-clause.

8.2 Temperature limits

Compliance with the temperature-rise limits is checked by measuring the temperature rise under reference test conditions after thermal equilibrium has been attained.

Thermal equilibrium

Note: Thermal equilibrium is considered attained when three successive readings taken at equal intervals of

- i) five minutes, or
- ii) ten percent of the total test time elapsed previous to the start of the first interval,

whichever is longer, indicates that there is no temperature change of the part.

8.2.1 Thermocouples

Thermocouples, if used, shall:

- a) be No. 28-32 AWG iron and constantan, or
- b) conform with the requirements specified in the Initial Calibration Tolerances for Thermocouples table in Temperature Measurement Thermocouples, ANSI/ISA MC96.1

A thermocouple junction and lead wire shall be held in thermal contact with the material being measured. A temperature is determined to be constant when three successive readings, taken at intervals of 10 percent of the previously elapsed test duration, but not less than 5-minute intervals, show no change.

Note: Taping or cementing the thermocouple in place is acceptable; however, if a metal surface is involved, brazing or soldering may be necessary.

8.2.2 Test conditions

Each heating test shall be carried out under the most unfavorable combination of the conditions described in this Sub-clause.

a) Position – general

The equipment shall be in any position of normal use or positioned and mounted according to the manufacturer's instructions. Normal ventilation shall not be impeded by artificial means.

All doors and covers that may be closed during operation of the equipment shall be closed.

Exception: Consideration may be given to the actual conditions of normal operation wherein doors and covers must be opened after each cycle of operation.

b) Portable and bench-top equipment

Rubber and other materials subject to deterioration shall be removed from feet and other supports of the equipment if deterioration of the material might result in the equipment or the supporting surface attaining higher temperatures.

Exception: If the arrangement of ventilation or other cooling means is such that the temperature rise is not affected by such placement or if the equipment construction is such that a greater spacing has to be provided.

If the equipment lends itself to such placement, the heating test shall be conducted with the equipment against a wall, in a right-angle corner, or in an alcove, even though such placement results in restricted ventilation. If the manufacturer's instructions specify minimum ventilation spacings, those spacings shall be provided between the equipment and the test surfaces. Walls shall be formed by black-painted vertical sheets of plywood not less than 9.5 mm (3/8 inch) thick and having such width and height that they extend not less than 0.6 m (2 ft) beyond the physical limits of the equipment.

c) Rack-mounted and incomplete equipment

Equipment intended for rack mounting or that is provided without a complete enclosure and is intended for a protected installation shall be tested for temperature rise in

- i) an enclosure according to the manufacturer's instructions, or
- ii) a built-up enclosure constructed of wood not less than 9.5 mm (3/8 inch) thick and of dimensions that provide 50 mm (2 inches) clearance from the top, sides, bottom, and back of the equipment with openings in surfaces such as the front and back to expose operator controls, cables, jacks, connections, leads and the like.

d) Fixed equipment

Fixed equipment shall be installed according to the manufacturer's instructions, or as close to the wall or corner as the construction makes possible.

8.3 Polymeric-enclosure and insulating-material thermal conditioning

The equipment shall withstand thermal conditioning.

8.3.1 Thermal conditioning shall be conducted in either of two ways:

- a) One sample of the complete equipment or that part of the equipment being evaluated is to be placed in a full-draft circulating-air oven for at least 7 hours and maintained at a uniform temperature not less than 10°C (18°F) higher than the maximum operating temperature of the material, measured during the heating test (8.1), but not less than 70°C (158°F) in any case. The equipment shall not be operated during this thermal conditioning; or
- b) One sample of the complete equipment is to be placed in a test chamber for at least 7 hours. The circulation of air within the chamber is to simulate normal room conditions. The air temperature within the chamber, as measured at the supporting surface of the equipment, is to be maintained at 60.0 ±2.0°C (140.0 ±3.6°F). The equipment shall be operated in the same way as for the heating test (8.1).

8.3.2 Compliance is checked after the thermal conditioning of 8.3.1 to determine that:

- a) *There is no interference with operator servicing of the equipment.*
- b) *The equipment complies with the requirements in 10.1.*
- c) *The equipment spacings according to 10.7 have been retained.*
- d) *The equipment dielectric voltage-withstand capabilities according to 10.11 have been retained.*
- e) *The equipment complies with the power-supply cord strain-relief requirements.*
- f) *The integrity of the enclosure provides the same mechanical protection to internal parts of the equipment as prior to the conditioning.*

Table 8.1
Maximum temperature rise^a under reference test conditions

Parts of the equipment	Temperature rise °Celsius (°Fahrenheit)	
Accessible parts:		
A. surfaces of enclosures		35 (63)
B. small areas and easily discernible heat sinks (not likely to be touched in normal use)		65 (117)
Operating devices and handles:		
A. metallic		20 (36)
B. insulating material		30 (54)
Enclosure interior surfaces:		
A. wood		65 (117)
B. insulating material		b
Insulating materials:		
A. polymeric		b
B. varnished cloth		60 (108)
C. fiber		65 (117)
D. wood and similar material		65 (117)
Insulating systems:		Method
	Resistance	Thermocouple
Class 105 windings of:		
A. transformers	75 (135)	65 (117)
B. relays, electromagnets, solenoids, and the like	85 (153)	65 (117)
C. motors: d-c, universal, and a-c motors with frame diameter larger than 178 mm (7 inches) ^c		
i. open motors	75 (135)	65 (117)
ii. enclosed motors	80 (144)	70 (126)
D. a-c motors with frame diameter of 178 mm (7 inches) or less ^c		
i. open motors	75 (135)	75 (135)
ii. enclosed motors	80 (144)	80 (144)
E. Vibrator coils	75 (135)	75 (135)
Class 130 windings of:		
A. transformers	95 (171)	85 (153)
B. relays, electromagnets, solenoids, and the like	105 (189)	85 (153)
C. motors: d-c, universal, and a-c motors with frame diameter larger than 178 mm (7 inches) ^c		
i. open motors	95 (171)	85 (153)
ii. enclosed motors	100 (180)	90 (162)
D. a-c motors with frame diameter of 178 mm (7 inches) or less ^c		
i. open motors	95 (171)	95 (171)
ii. enclosed motors	100 (180)	100 (180)
E. Vibrator coil	95 (171)	95 (171)
Capacitors ^d :		
A. electrolytic		40 (72)
B. other types		65 (117)
Fuses		65 (117)

Table 8.1 Continued on Next Page

Table 8.1 Continued

Parts of the equipment	Temperature rise °Celsius (°Fahrenheit)
Semiconductor devices ^d	75 (135)
Sealing compound	40 (72) (Less than melting point)
Selenium rectifiers ^d	50 (90)
Terminal box	65 (117)
Surface on which equipment might be mounted in service, and surfaces that might be adjacent to the unit when it is so mounted	65 (117)
Wires and cords ^d	35 (63)
^a The heating test can be conducted at any room temperature between 15°C and 35°C (59°F and 95°F) and the observed temperatures corrected to a room temperature of 25°C (77°F). ^b Polymeric material shall be acceptable for the application when evaluated with respect to temperature. ^c The diameter, measured in the plane of the laminations, of the circle circumscribing the stator frame, excluding lugs, boxes and the like, used solely for motor-mounting assembly or connection. ^d Does not apply if investigated and accepted for a higher temperature.	

9 Protection From Effects of Implosion and Explosion

9.1 Implosion protection

The equipment enclosure, or any direct-view high-vacuum device such as a cathode-ray tube, shall provide protection with respect to the effects of implosion.

Implosion protection shall be provided for direct-view high-vacuum devices with a face plate exceeding 160 mm (6-19/64 inches) in diameter, or with a face-plate area exceeding 20,000 mm² (31 inches²), whichever is greater.

Implosion protection shall be provided for both collapse of the vacuum-device structure and mechanical impact.

The integrity of the enclosure and any protective means shall not be impaired by an implosion.

Compliance is checked after implosion according to

- i) 9.1.1(a) (Thermal-shock method) or*
 - ii) 9.1.1(b) (High-energy-impact method), and*
 - iii) 9.1.2 (Mechanical impact) by:*
 - a) measuring the mass of expelled particles and their distance from the equipment, and*
- Exception: Shale, slivers, and glass dust are not considered glass particles.*
- b) inspecting the equipment enclosure for mechanical integrity.*

The equipment shall be complete, with all covers and other normally openable or removable parts in place. A window that is not intended for implosion protection shall be removed. The equipment shall be in a normal operating position on a support with a height of 75 ± 5 cm ($29\text{-}1/2 \pm 2$ inches) and horizontal dimensions not larger than those of the equipment. Equipment that normally stands on the floor shall be tested standing on the floor.

The floor shall be covered with a nonskid or nonbounce material. Two barriers each 13 mm ($1/2$ inch) thick, 250 mm ($9\text{-}1/2$ inches) high, and at least 2 m (72 inches) long shall be placed on the floor located 0.5 m ($1\text{-}1/2$ ft) and 2.0 m (6 ft) from the projection of the front of the equipment enclosure.

After implosion is induced:

- a) a glass particle with a mass greater than 2 g (0.07 oz) shall not pass the 0.5 m ($1\text{-}1/2$ ft) barrier;*
- b) the total mass of all of the glass particles between the two barriers shall not be more than 42.5 g ($1\text{-}1/2$ oz);*
- c) a glass particle of any mass shall not pass the 2.0 m (6 ft) barrier;*
- d) a glass particle of any mass shall not be expelled from the sides, top, or rear of the enclosure.*

Note: Two implosion methods are described in 9.1.1. The thermal-shock method is preferable; however, if an implosion cannot be induced by the thermal-shock method, the high-energy-impact method shall be used.

Two implosion tests shall be conducted on each protection system.

9.1.1 Implosion by collapse of the structure

An implosion that simulates collapse of the structure shall be induced in the vacuum device.

Note: Any of several methods may be employed for inducing such an implosion provided that the method does not affect the measurement.

a) Thermal-shock method

An area shall be scratched with a glass cutter or diamond stylus in one of the patterns, according to Figure 9.1, on the funnel as near as possible to the juncture of the funnel and face-plate rim. Implosion shall be induced by repeated applications of the end of a 9.5 mm ($3/8$ -inch) diameter glass rod, heated until nearly fluid, to the scratch pattern. Alternatively, implosion shall be induced by repeated applications of liquid nitrogen, or the like, to the scratch pattern.

b) High-energy-impact method

A 25 mm (1-inch) diameter pin shall be inserted through a hole in the equipment enclosure and rested on the funnel, as near as possible to the juncture of the funnel and face-plate rim. A means shall be provided to limit the maximum displacement of the pin to 15 mm ($19/32$ inch). The pin shall receive the impact energy of a 5 kg (11 lb) mass falling from a height of 1500 mm (5 ft) (See Figure 9.2). The mass or height shall be increased, as necessary, to induce implosion.

9.1.2 Implosion by mechanical impact

The display surface shall be subjected to the impact according to Table 9.1. The impact shall be produced by the specified spherical steel mass falling through the required distance as a pendulum.

Note: The penetration of the sphere may be restricted after impact provided that the impact energy is not reduced.

9.2 Explosion protection

The equipment enclosure or configuration shall provide protection with respect to explosion of a component within the enclosure. The equipment enclosure or configuration shall also provide protection with respect to a discharge.

Note: For example: A discharge may occur from an electrolytic-capacitor pressure-relief device or from a battery-electrolyte leak.

Compliance is checked by inspection following the tests according to Clause 10 and according to 9.2.1.

9.2.1 Battery-Protection Test

Equipment incorporating circuitry or devices intended to provide battery protection shall be subjected to short- or open-circuiting of any one component or device in the protection circuit.

Exception: The battery-protection test is not required if it can be demonstrated that an explosion or fire will not result under the conditions mentioned.

Figure 9.1
Scratch patterns for implosion by the thermal-shock method
Dimensions are in mm (inch)

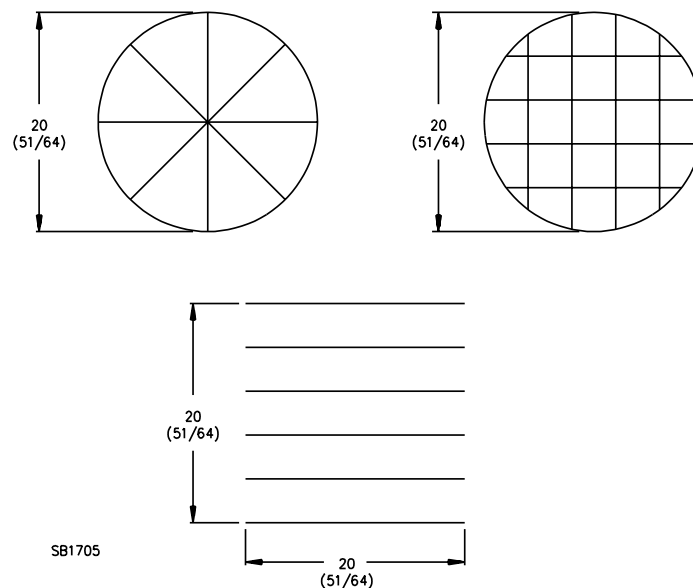


Figure 9.2
International electrotechnical commission (IEC) test apparatus for implosion by the high-energy-
impact method
 Dimensions are in mm (inch)

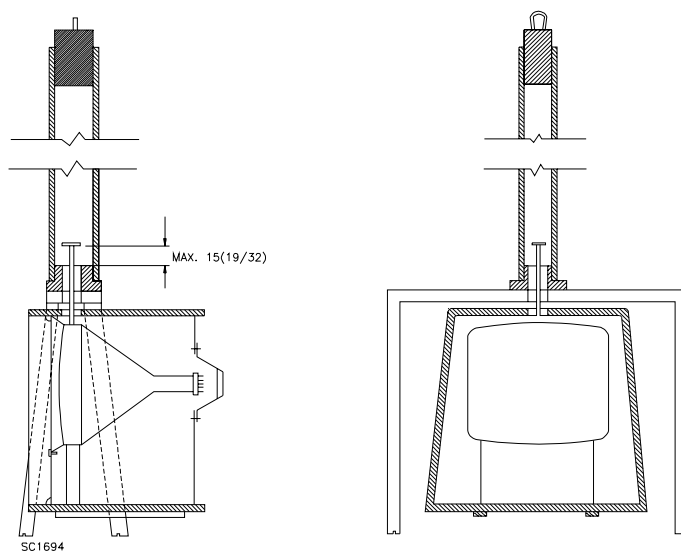


Table 9.1
Impact levels for implosion by mechanical impact

Display surface dimension in mm (inches)	Steel ball diameter ^a in mm (inches)	Impact level in N-m (ft.lbf)
exceeding 160 (6-19/64) and less than 400 (15-3/4)	50.8 (2) or 40 (1-1/2)	4.0 (3)
equal to and exceeding 400 (15-3/4)	50.8 (2) or 40 (1-1/2)	5.5 (4)

^a Either diameter of steel ball may be used as it is not expected that the difference in diameter can affect the results.

10 Protection From Electric Shock

10.1 Accessible parts

Accessible parts shall not render an electric shock.

Note: For measuring or testing terminals (see definition in 2.17), refer to 10.3.4.

Accessible parts of equipment include those that

- a) become accessible upon, for example,
 - removing a cover,
 - opening a door,
 - adjusting a control,
 - setting a supply-circuit voltage mechanism,
 - replacing a fuse,
 - attaching and detaching an interconnecting cable assembly, and the like, and
- b) are intended for access by the operator during normal use or operator servicing.

Note: Equipment parts that are intended for access by the operator are determined according to those parts that are historically operator serviceable or according to the operator and operator-servicing instructions. See Clause 19.

Compliance is checked by inspection according to 10.1.3 and by performing the tests according to 10.2.

10.1.1 Accessible insulation

Because the insulation may be readily damaged, insulation consisting only of enamel, lacquer, oxides, anodic films, nonimpregnated paper, fiber and fibrous materials, wood, and the like shall not be regarded as providing protection from electric shock. Such insulation that is accessible shall be short-circuited during the tests according to 10.1.3 and 10.2.