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Subject 469

1655 Scott Blvd.
Santa Clara, CA 95050
November 12, 1996

TO: Electrical Council of Underwriters Laboratories Inc.,
Subscribers to UL's Standards Service for Musical Instruments and Accessories

SUBJECT: Adopted Requirements for the Second Edition of the Standard for Musical
Instruments and Accessories, UL 469; ESTABLISHED EFFECTIVE DATE

UL has reviewed all comments received in response to the Subject 469 bulletin dated April 19, 1996, and has decided to adopt the requirements essentially as proposed. The text of the adopted requirements is shown in Appendix A.

Questions regarding interpretation of requirements should be directed to the responsible UL Staff. Please see Appendix B of this bulletin regarding designated responsibility for the subject product categories.

ESTABLISHED EFFECTIVE DATE

These new and revised requirements become effective December 1, 1998, as indicated in the small print notes following these requirements.

This bulletin should be kept with your copy of the standard until revision pages incorporating these requirements are issued. UL anticipates issuing revision pages by December 1996.

UNDERWRITERS LABORATORIES INC.

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A P P E N D I X A

ADOPTED REQUIREMENTS AND ESTABLISHED EFFECTIVE DATE FOR THE
SECOND EDITION OF THE STANDARD FOR
MUSICAL INSTRUMENTS AND ACCESSORIES,
UL 469

12.2.2 A power-supply cord shall be one of the types specified in Table 12.1. A cord of another type may be used if its properties are such that it will be equally serviceable for the application. For example, an appliance wiring material construction that has been determined to be equivalent to Non-Integral Type SPT-2 cord may be used in applications where Non-Integral Type SPT-2 cord is specified.

Revised 12.2.2 effective December 1, 1998

12.2.2.1 No. 20 AWG conductors may be employed in appliance wiring material constructions as referenced in 12.2.2 provided that:

- a) The appliance is rated 2.0 A or less,
- b) The appliance does not employ a convenience receptacle, and
- c) Overcurrent protection rated 2.0 A or less is provided in the attachment plug and connected so as to interrupt the ungrounded side of the supply circuit.

Added 12.2.2.1 effective December 1, 1998

Table 12.1
Cords for products

Products	Type of cord	Maximum length	
		feet	(m)
Commercial	SJ, SJT, SJE	25	(7.62)
Household	Non-Integral SPT-2, SV, SVT, SVE	10	(3.05)
	SJ, SJT, SJE	25	(7.62)

Revised Table 12.1 effective December 1, 1998

20 Remote-Control and Interconnecting Cables

20.1 A cable used as an interconnecting cable or for the connection of a remote control, or the like, shall be Type SJ, SJT, or SJE flexible cord or other cord that has been determined to be the equivalent.

Exception No. 1: A cable used solely for external interconnection between units of a system and not likely to be handled during normal operation may be of a type that is at least as serviceable as the supply cord.

Exception No. 2: Integral Type SPT-1 flexible-cord or a type that has been determined to be equivalent may be used for connection of a remote control, or the like, if:

- a) The remote-control circuit is supplied from a bell-ringing or Class 2 transformer; or*
- b) The following conditions are met:*
 - 1) The potential between the conductors of the cord, and between any conductor and earth or other accessible part is not more than 30 volts ac or 60 volts dc where wet contact is not likely to occur and 21.2 volts peak where wet contact is likely to occur if the current between these points is more than 0.5 milliamperes when tested in accordance with 36.1.2 – 36.1.8, and*
 - 2) The product does not involve a risk of fire or electric shock when it is subjected to the short-circuit test described in 50.1.1.*

Exception No. 3: A cord or cable other than Type SJ, SJT, SJE, Non-Integral Type SPT-2, an appliance wiring material construction that has been determined to be equivalent to Non-Integral Type SPT-2 cord, or the equivalent may be used for the connection of a remote control, or the like, under the conditions stated in Exception No. 2 (b) if the arcing test described in 50.2.1 and 50.2.2 does not result in a risk of fire.

Exception No. 4: A cord or cable other than Type SJ, SJT, SJE, Non-Integral Type SPT-2, an appliance wiring material construction that has been determined to be equivalent to Non-Integral Type SPT-2 cord, or the equivalent may be used for the connection of a remote control, or the like, if the cord or cable is located in a nonhazardous secondary circuit as described in 27.2.1 and 27.2.2.

Revised 20.1 effective December 1, 1998

A P P E N D I X B

DESIGNATED RESPONSIBILITY FOR UL
PRODUCT CATEGORIES
PWHZ, MUSICAL INSTRUMENTS
PWHZ2, MUSICAL INSTRUMENTS – COMPONENT

The individuals shown in the following tables are involved with the investigation of products covered under the subject categories. The Primary Designated Engineer (**shown in UPPERCASE letters**) coordinates the establishment and uniform interpretation of UL requirements applicable to the product categories. The Designated Engineers (**shown in lowercase letters**) work with the Primary Designated Engineer to interpret requirements and maintain standards.

Should you have questions regarding the interpretation of the requirements adopted in this bulletin or any adopted requirements that affect your product, you are encouraged to contact the individual at the office to which you normally submit your products.

The Industry Advisory Conference (IAC) Chairman for the subject categories is Doug Anderson at UL's Santa Clara office. The IAC Chairman oversees the significant interpretations made by the Primary Designated Engineer and arbitrates any differences regarding interpretation of UL requirements.

CCN	Office/Subsidiary	Responsible Engineer	Extension
PWHZ	Melville	Andy Nelson	22344
	Northbrook	BRAD ROWE	42888
	RTP	Mark Granata	11626
	Santa Clara	Craig Sato	32356
	Japan	Ariel Gruspe	23

CCN	Office/Subsidiary	Responsible Engineer	Extension
PWHZ2	Melville	Andy Nelson	22344
	Northbrook	BRAD ROWE	42888
	RTP	Mark Granata	11626
	Santa Clara	Alex Melton	32603
	Japan	Ariel Gruspe	23



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September 22, 1994

Revision pages for

Standard for

Musical Instruments and Accessories

UL 469, Second Edition

Attached to this transmittal notice is a revision of the second edition of UL 469.

A CHANGE ON A PAGE DATED SEPTEMBER 22, 1994 IS INDICATED BY A SMALL PRINT NOTE FOLLOWING THE AFFECTED ITEM, PRECEDED AND FOLLOWED BY AN ASTERISK.

THESE NEW AND REVISED REQUIREMENTS ARE NOW IN EFFECT EXCEPT FOR PARAGRAPHS 38.2, 38.3, 38.7, 38.8, 39.7, 39.7.1, 46.5.1, 46.5.2, 46.5.3, AND 46.5.4 WHICH BECOME EFFECTIVE OCTOBER 1, 1997 AS NOTED IN THE SMALL PRINT NOTE FOLLOWING THE AFFECTED ITEM. TO RETAIN THE REQUIREMENTS IN EFFECT UNTIL OCTOBER 1, 1997, DO NOT DISCARD THE PREVIOUS PAGES CONTAINING THE REQUIREMENTS SPECIFIED ABOVE UNTIL THIS FUTURE EFFECTIVE DATE.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this standard unless the applicant specifically requests that the product be judged under the current requirements. However, should the applicant elect this option, it should be noted that compliance with all the requirements in this standard will be required as a condition of continued Listing and Follow-Up Services after the effective date and understanding of this should be signified in writing.

The new and revised requirements are substantially in accordance with UL's bulletin on this subject dated August 30, 1993. The bulletin is now obsolete and may be discarded.

Attention is directed to the note on the title page of this standard outlining the procedure to be followed to retain the approved text of ANSI/UL 469-1994.

Revised and/or additional pages may be issued from time to time.

With the inclusion of the accompanying material, the standard consists of pages dated as shown in the following checklist:

Page	Date
1	April 14, 1993 (Reprinted September 22, 1994)
2, 3	September 22, 1994
4	April 14, 1993
5, 6, 6A	September 22, 1994
7 - 26	April 14, 1993
27 - 30, 30A	September 22, 1994
31, 32	April 14, 1993

(Continued)

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Page	Date
33, 34, 34A	September 22, 1994
35, 36, 37	April 14, 1993
38, 38A, 39	September 22, 1994
40	April 14, 1993
41	September 22, 1994
42 – 44	April 14, 1993
45, 46, 46A, 46B	September 22, 1994
47 – 52	April 14, 1993
53 – 56, 56A	September 22, 1994
57 – 59	April 14, 1993
60, 60A, 60B	September 22, 1994
61 – 76	April 14, 1993
77, 78, 78A	September 22, 1994
79 – 86, A1	April 14, 1993

APRIL 14, 1993

(Title Page Reprinted: September 22, 1994)



1

UL 469

Standard for

Musical Instruments and Accessories

First Edition – March, 1982

Second Edition

April 14, 1993

Approval as an American National Standard (ANSI) covers the numbered paragraphs on pages dated April 14, 1993. These pages should not be discarded when revised or additional pages are issued if it is desired to retain the ANSI approved text.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

Approved as ANSI 469-1986, January 3, 1986

Approved as ANSI 469-1994, January 31, 1994

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 published set of revision pages.

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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 differing from those detailed in the requirements of this Standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, 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.

INTRODUCTION

1 Scope

1.1 These requirements cover power-operated musical instruments and accessories rated 300 volts or less, intended for household and commercial use on supply circuits in accordance with the National Electrical Code, NFPA 70.

1.2 Musical instruments include organs, electronic pianos, music synthesizers, and other such products that produce music under the direct control of the player.

1.3 These requirements also cover accessories for use with musical instruments, such as rhythm generators and similar equipment having self-contained tone generators, tone cabinets, music tuners, and the like.

1.4 These requirements do not cover commercial audio equipment, such as amplifiers, mixers, and signal processors for general use; or special effects units, amplifier-speakers, and the like, that are intended for use by professional and semiprofessional musicians.

1.5 These requirements do not cover musical instruments that are categorized as electrically operated toys and are covered by the Standard for Electric Toys, UL 696.

1.6 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements as determined necessary to maintain the acceptable level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific provisions of this standard cannot be judged to comply with this standard. Where considered appropriate, revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

1.6 revised September 22, 1994

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

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

- a) Involves a feature or characteristic not needed in the application of the component in the product covered by this standard, or
- b) Is superseded by a requirement in this standard.

2.1.3 A component shall be used in accordance with its recognized rating established for the intended conditions of use.

2.1.4 Specific components are recognized as being incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions for which they have been recognized.

2.2 Units of measurement

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

2.2.2 All applicable alternating-current electrical measurements are in root-mean-square (rms) units unless otherwise stated.

2.3 Undated references

2.3.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

3 Glossary

3.1 For the purpose of this standard the following definitions apply.

3.2 FIBER — Where the term fiber is used, vulcanized fiber is meant.

3.3 HAZARDOUS CIRCUITRY — Circuitry involving a risk of electric shock as described in the Leakage-Current and Shock-Current Tests, Section 36, or a risk of fire as described in Risk of Fire, Section 26.

3.4 INSULATION, BASIC — The insulation necessary for the proper functioning of the product and for basic protection against electric shock.

3.5 INSULATION, REINFORCED — An improved basic insulation with such mechanical and electrical qualities that it, in itself, provides the same degree of protection against electric shock as an insulation system comprising both basic insulation and supplementary insulation.

3.6 INSULATION, SUPPLEMENTARY — An independent insulation provided in addition to the basic insulation to protect against electric shock in case of electrical breakdown of the basic insulation.

3.7 LOW-VOLTAGE CIRCUIT — A circuit involving a peak open-circuit potential of not more than:

- a) The applicable values specified in Table 36.1A, where wet contact is not likely to occur or
- b) 21.2 volts peak where wet contact is likely to occur.

3.7 revised September 22, 1994

3.8 ORDINARY TOOL — A flat-bladed or cross-recessed screwdriver or pliers.

3.9 PRODUCT, COMMERCIAL — A product intended for use in commercial establishments, hotels, motels, houses of worship, schools, studios, and businesses.

3.10 PRODUCT, HOUSEHOLD — A product intended for use in the home.

3.11 **PRODUCT, PORTABLE** – A product that is intended to be moved or that can easily be moved from one place to another in normal use.

3.12 **PRODUCT, STATIONARY** – A product for which there is a dedicated location or that is not easily moved from one place to another in normal use.

3.13 **UNRELIABLE COMPONENT** – The following are considered to be unreliable components: electrolytic capacitors, transistors, diodes, vacuum tubes, and the like.

19.5.2 A wire-wrapped connection is acceptable if it is not subject to movement or flexure on the wires during conditions of normal operation or user servicing.

19.5.3 Solid copper wire used for wire-wrapped connections shall be No. 24, 22, or 20 AWG (0.21, 0.32, or 0.52 mm²). Other sizes and types of wire may be used if investigated and found to be acceptable for the application.

19.5.4 A terminal shall be of copper or brass and have at least two sharp edges. A terminal of other materials may be used if investigated and found to be acceptable for the application.

19.5.5 A wrap shall have at least 20 points on the corners of the terminal in contact with the wire with at least 16 points closely wrapped with no overlapping. Closely wrapped means that there are no gaps between adjacent turns greater than one-half the diameter of the wire, not including gaps on the first and last turns. See Table 19.1 for typical number of wraps. A lesser number of wraps may be used if investigated and has been determined to be equivalent to one of the wraps covered in Table 19.1.

Table 19.1
Typical number of wraps

Number of sharp corners on the terminal	Number of closely wrapped turns	Total number of turns
4	4	5
2	8	10

19.6 Aluminum terminations

19.6.1 Aluminum conductors, insulated or uninsulated, used as internal wiring, such as for interconnection between current carrying parts or as motor windings, shall be terminated at each end by a method acceptable for the combination of metals involved at the connection point.

19.6.2 With reference to 19.6.1 a wire-binding screw or a pressure wire connector used as a terminating device shall be a type intended for use with aluminum under the conditions involved – for example, temperature, heat cycling, and vibration.

19.7 Quick-connect terminals

19.7.1 A nominal 0.110-, 0.125-, 0.187-, 0.205-, or 0.250-inch wide quick-connect terminal shall comply with the requirements for electrical quick-connect terminals, UL 310. Other sizes of quick-connect terminals shall be investigated with respect to crimp pull-out, engagement-disengagement forces of the connector and tab, and temperature rises; all tests are to be conducted in accordance with UL 310.

20 Remote-Control and Interconnecting Cables

20.1 A cable used as an interconnecting cable or for the connection of a remote control, or the like, shall be Type SJ flexible cord or has been determined to be the equivalent.

Exception No. 1: A cable used solely for external interconnection between units of a system and not likely to be handled during normal operation may be of a type that is at least as serviceable as the supply cord.

Exception No. 2: Type SPT-1 flexible-cord or a type that has been determined to be equivalent may be used for connection of a remote control, or the like, if:

- a) The remote-control circuit is supplied from a bell-ringing or Class 2 transformer; or*
- b) The following conditions are met:*
 - 1) The potential between the conductors of the cord, and between any conductor and earth or other accessible part is not more than 30 volts ac or 60 volts dc where wet contact is not likely to occur and 21.2 volts peak where wet contact is likely to occur if the current between these points is more than 0.5 milliamperes when tested in accordance with 36.1.2 – 36.1.8, and*
 - 2) The product does not involve a risk of fire or electric shock when it is subjected to the short-circuit test described in 50.1.1.*

Exception No. 3: A cord or cable other than Type SJ, SPT-1, or one that has been determined to be equivalent, may be used for the connection of a remote control, or the like, under the conditions stated in item (b) of Exception No. 2 if the arcing test described in 50.2.1 and 50.2.2 does not result in a risk of fire.

Exception No. 4: A cord or cable other than Type SJ, SPT-1, or one that has been determined to be equivalent, may be used for the connection of a remote control, or the like, if the cord or cable is located in a nonhazardous secondary circuit as described in 27.2.1 and 27.2.2.

20.1 revised September 22, 1994

20.2 A cable used as an interconnecting cable or for connection of a remote control shall have an ampacity not less than the current rating of the product, accessory, or product section it supplies. If the cable is permanently attached to the product, it shall be provided with a cord exit, strain relief, and push-back relief that comply with the requirements in 12.4.1 – 12.6.6.

20.3 Cord and wire used to interconnect units within the overall enclosure and involving a risk of fire or electric shock shall be provided with strain-relief means.

Exception: This requirement does not apply to cord or wire that is:

- a) Securely fastened to the enclosure walls by means of clamps, staples, or the like; or*
- b) Located so that it will not be subject to handling during user servicing.*

20.4 Interchassis cables and wiring within an overall enclosure shall be arranged and routed by means of clamps, string ties, or the determined equivalent, in spaces that afford protection against damage during user servicing.

21 Integrated Circuits

21.1 An integrated circuit involving hazardous energy shall be constructed of materials and subjected to the tests specified in Table 21.1.

Table 21.1
Requirements for integrated circuits

Alternative	Type of construction ^a	Minimum flammability classification ^b		External pin arcing test ^c	Other tests ^d
		Enclosure	Terminal support		
I	Hybrid	94HB	94V-1 ^e	Not required	1 and 2
II	Hybrid	94-5V (or metal)	94-5V	Not required	1
III	Hybrid	94-5V (or metal)	94V-1	Required on terminal material	1
IV	Hybrid	94V-2	94-5V	Required on enclosure material	1
V	Hybrid	94V-2	94V-1	Required on enclosure and terminal material	1
VI	Nonhybrid	94V-2	Not applicable	Not required	1

^a A hybrid construction typically consists of an aluminum or ceramic substrate printed-wiring board, with chips of discrete transistors and diodes, and discrete capacitors attached to the foils. Deposited carbon usually serves as resistive elements. Terminal pins are attached to the foils on the substrate and supported in a terminal block. The typical hybrid assembly usually has a thermoplastic enclosure covering the top and three sides, and the fourth side filled with the terminal block. A nonhybrid or true integrated circuit is generally smaller than the hybrid type, is completely encapsulated, and contains only layered elements. In such a case, the enclosure of the integrated circuit, which is generally also the encapsulant, is to have a minimum flammability classification of 94V-2.

^b See footnote a to Table 7.1.

^c Tests are to be conducted in accordance with 50.2.1 and 50.2.2, except arcing is to be across the terminal-support material rather than across cotton.

^d The numbers in this column refer to the following tests, the results of which are to be evaluated by the conditions described in 46.1.8.

- 1) Short-circuit tests at external IC pins, and unreliable component short-circuit tests at external IC pins.
- 2) Short-circuit tests at an IC assembly, and unreliable component short-circuit tests inside assembly.

^e Includes printed-wiring board.

Table 21.1 revised September 22, 1994

22 Motors, Coil Windings, and Transformers

22.1 A coil winding shall be impregnated or otherwise treated to resist the absorption of moisture.

22.2 With respect to the requirement in 22.1, film-coated wire is not required to be additionally treated to resist the absorption of moisture, but fiber, cloth, and similar moisture-absorptive materials shall be provided with impregnation or otherwise treated to resist the absorption of moisture.

22.3 A transformer or a motor transformer that is normally connected across the supply circuit shall comply with one of the following construction requirements for transformers or motor transformers as specified in:

- a) The Standard for Specialty Transformers, UL 506;
- b) The requirements for Class 2 power units, UL 1310;
- c) The requirements for transformers and motor transformers for use in audio-, radio-, and television-type appliances, UL 1411; or
- d) The Standard for Class 2 and 3 Transformers, UL 1585.

Exception: *This requirement does not apply to switching transformers.*

22.3 revised September 22, 1994

22.4 A motor provided as a part of a product shall be of a type that can handle the maximum normal load of the product without introducing a risk of fire, electric shock, or injury to persons.

22.5 A brush-holder assembly shall be constructed so that when a brush is worn out – no longer capable of performing its function – the brush, spring, and other parts of the assembly will be retained to the degree necessary to reduce the likelihood of:

- a) Accessible dead metal parts becoming energized and
- b) Live parts becoming accessible.

23 Field-Installed Accessories

23.1 For the purpose of these requirements, accessory equipment is defined as equipment that is:

- a) Intended to be attached or added to a product by the user and
- b) Of such size that it may be marked for identification by a catalog number or its equivalent.

Accessory equipment usually is dependent upon the basic product for mechanical or electrical support or input and may or may not, by itself, perform a complete function.

23.2 Accessory equipment shall be constructed so that it can be added to a product without introducing a risk of fire, electric shock, or injury to persons.

23.3 The installation of accessory equipment shall be restricted to an arrangement that can be accomplished mechanically by means of ordinary tools and electrically by means of a plug-in connection to a receptacle available on the product or as a part of the building wiring.

24 Switches and Interlocks

24.1 Switches

24.1.1 A switch connected to wiring involving a risk of fire or electric shock shall be of a type acceptable for the intended use and shall have an electrical rating not less than that of the load it controls.

24.1.2 With respect to the requirements in 24.1.1, the ampere rating of a supply circuit control switch shall be equal to or greater than the maximum steady state [root-mean-square (rms)] current it controls as determined during the input test. For a power amplifier supply circuit control switch, the ampere rating shall be equal to or greater than the maximum steady state (rms) current it controls as determined during the input test specified in 38.3, at one-eighth maximum undistorted power output or one-eighth of the manufacturer's rated output power, whichever is greater.

24.1.2 revised September 22, 1994

26 Risk of Fire

26.1 A risk of fire is considered to exist at any component connected to a source of power either under normal conditions or when all exposed parts and all user connections are grounded while the power-supply rectifier and any two elements of one other vacuum tube, transistor, or similar solid-state device are short circuited.

Exception: A risk of fire is not considered to exist if one or more of the following conditions exist:

- a) *There is additional series impedance of not less than 10,000 ohms in a circuit where the voltage is 125 volts or less.*
- b) *There is additional series impedance of not less than 20,000 ohms in a circuit where the voltage is more than 125 volts but not more than 250 volts.*
- c) *Material, such as cotton, is not ignited under any service conditions of breakdown or malfunction of the part itself. The arcing test for cables is described in 50.2.1 and 50.2.2.*
- d) *A component is connected in a low-voltage, limited-energy circuit as described in 27.1.2 and 27.1.3.*
- e) *A component is connected in a nonhazardous circuit as described in 27.2.1 and 27.2.2.*

27 Low-Energy Circuits

27.1 Low-voltage, limited-energy circuits

27.1.1 Spacings in a low-voltage, limited-energy circuit are not specified, other than as may be required to prevent contact with an uninsulated live part of another circuit.

27.1.2 A low-voltage, limited-energy circuit is a circuit that is supplied from an isolated secondary winding of a transformer and that complies with the applicable values specified in Table 27.1. Power limitations of a low-voltage, limited-energy circuit may be obtained by the use of any of the following configurations:

- a) An inherently-limited transformer;
- b) A non-inherently-limited transformer coupled with an overcurrent protective device in the output circuit;
- c) A combination transformer and fixed impedance; or
- d) An arrangement determined to be equivalent to (a), (b), or (c).

27.1.2 revised September 22, 1994

27.1.2.1 The secondary winding of the transformer and the fixed series impedance or regulator specified in 27.1.2 (b) and (c) are to be evaluated as part of the hazardous energy circuit.

27.1.2.1 added September 22, 1994

27.1.3 The overcurrent-protective device mentioned in 27.1.2 shall:

- a) Not be of an automatically reset type, and
- b) Be trip-free from the reclosing mechanism if of the manually reset type.

Table 27.1
Low voltage, limited energy circuits

Inherently limited transformer (overcurrent protection not required)				Not-inherently-limited transformer (overcurrent protection required)			
Circuit voltage (volts) ^a	0-20 volts ac or dc ^b	Over 20 volts but not more than 30 volts ac or dc ^b	Over 30 Volts but not more than 60 volts dc ^b	0 – 15 volts ac or dc ^b	Over 15 volts but not more than 20 volts ac or dc ^b	Over 20 volts but not more than 30 volts ac or dc ^b	Over 30 volts but not more than 60 volts dc ^b
Power limitation (volt-amperes) ^b	—	—	—	350	250	250	250
Current limitation (amperes) ^d	8	8	$150/\sqrt{a}$	$1000/\sqrt{a}$	$1000/\sqrt{a}$	$1000/\sqrt{a}$	$1000/\sqrt{a}$
Maximum overcurrent protection (amperes)	—	—	—	5	5	$100/\sqrt{a}$	$100/\sqrt{a}$

NOTE – In all cases the applied primary voltage shall be as indicated in Table 33.1.

^a Maximum output voltage, regardless of load, with applied voltage as specified in Table 33.1.

^b The waveform shall comply with the requirements in Table 36.1A.

^c Maximum volt-ampere output regardless of load, and overcurrent protection (if provided) bypassed.

^d Maximum output after 1 minute of operation under any noncapacitive load, including short circuit, and with overcurrent protection (if provided) bypassed.

Table 27.1 added September 22, 1994

27.2 Nonhazardous secondary circuits

27.2.1 A nonhazardous secondary circuit is considered to exist if the source of power to the circuit is not capable of:

- a) Producing an open-circuit voltage exceeding:
 - 1) 30 volts ac or 60 volts dc where wet contact is not likely to occur and
 - 2) 21.1 volts peak where wet contact is likely to occur (see 11.2); and
- b) Delivering a power of more than 15 watts into an external resistor connected singly between each of these points and any return to the power supply.

27.2.1 revised September 22, 1994

27.2.2 An overcurrent-protective device may be used to limit the available power in a circuit to 15 watts or less in order to comply with 27.2.1(b).

27.2.3 A printed-wiring board shall comply with the applicable requirements in Table 7.1 and wiring not segregated or routed away from wiring located in hazardous energy circuits or low-voltage, limited-energy circuits shall be rated VW-1.

27.2.4 There are no additional specifications for insulating material, spacings, and components in a nonhazardous secondary circuit other than as may be required to prevent contact with an uninsulated live part of another circuit.

PROTECTION AGAINST INJURY TO PERSONS

28 Scope

28.1 The requirements in Protection Against Injury to Persons, General, Section 29; Power-Operated Moving Parts, Section 30; Enclosures and Guards, Section 31; and Sharp Edges, Section 32; are applicable to products covered by this standard that may involve a risk of injury to persons in normal operation.

28.2 There are risks of injury to persons inherent in some products that, if completely eliminated, would defeat the utility of the product. The requirements in Sections 29 – 32 are intended to reduce such risks, while retaining the normal function of such a product.

29 General

29.1 If operation, maintenance, or reasonably foreseeable misuse of a product by the user involves a risk of injury to persons, protection shall be provided for the reduction of such risk.

29.2 Among the factors to be considered in judging the acceptability of an exposed moving part are:

- a) Degree of exposure necessary to perform its intended function,
- b) Sharpness of the moving part,
- c) Likelihood of unintentional contact therewith,
- d) Speed of the moving part, and

34 Normal-Operation Tests

34.1 General

34.1.1 Operation of a product as described in 34.1.2 shall not increase the risk of fire, electric shock, or injury to persons.

34.1.2 A sample of the product in the as-received condition is to be set up or installed and operated in accordance with the manufacturer's instructions with respect to the intended use of the product, including normal maintenance and cleaning, with all accessories supplied by the manufacturer for use with the product in place. The product is to be manipulated as it would be in actual use, including manipulation of all controls, and operated under the various loading conditions that can be expected. Operation is to be for a sufficient length of time or through a sufficient number of cycles that all reasonably foreseeable complications are revealed.

35 Connector- and Component-Displacement and -Substitution Tests

35.1 General

35.1.1 The disconnection and displacement of a part resulting from shipping or moving of the product shall not result in a risk of fire, electric shock, or injury to persons.

35.1.2 Any handling, disconnection, or displacement either intentional or unintentional, of a component of a printed-wiring assembly, a connector, lead, tube shield, cover, or other similar part that may occur during normal operation or user servicing shall not result in a risk of fire, electric shock, or injury to persons.

35.1.3 A barrier, mechanical restraint, and the effect of gravity are to be given consideration as means of fastening a connector, but a fastening means that relies solely on friction between parts is to be investigated with respect to its effectiveness. A fastening means is not to be removed if it cannot be removed unintentionally and need not be removed during user servicing. A flexible fastening means is to be constructed so that it returns to its original position and shape after flexing.

35.1.4 Inserting a male connector in a female connector other than the one intended to receive it, misalignment of male and female connectors, and other manipulations of parts that are accessible to the user shall not result in a risk of fire, electric shock, or injury to persons.

35.1.5 A disconnecting part, such as an electrical connector, secured by friction fit only, is to be investigated with respect to risks of fire or electric shock while in its most extreme disconnected position.

Exception: The part need not be so investigated if it complies with one or more of the following:

- a) The part withstands a separation force of 500 grams after five insertions and withdrawals;*
- b) The part is soldered together and need not be removed for user servicing;*
- c) The part is of such dimensions or is permanently routed or secured that no risk of fire, electric shock, or injury to persons can result if the part becomes disconnected; or*
- d) A 1/32-inch (0.8-mm) thick aluminum insulating sleeve having at least a 1/16-inch (1.6-mm) overlap is provided over the connector part.*

35.2 Vacuum-tube substitution

35.2.1 The insertion in any socket of any vacuum tube or its glass or metal equivalent of like designation used in the product shall not result in a risk of electric shock.

36 Leakage-Current and Shock-Current Tests

36.1 Leakage-current test

36.1.1 Leakage current refers to all currents, including capacitively coupled currents, that may be conveyed between exposed conductive surfaces of the equipment and ground, or other exposed conductive surfaces of the equipment.

36.1.2 If the open circuit potential between the accessible part and earth ground or any other accessible part is more than the applicable value specified in Table 36.1A, a product shall be tested for leakage current in accordance with 36.1.3 – 36.1.9. The leakage current at any accessible part shall not be more than:

- a) 0.5 milliamperes for ungrounded 2-wire portable, stationary, or fixed equipment;
- b) 0.5 milliamperes for grounded 3-wire portable equipment; and
- c) 0.75 milliamperes for grounded 3-wire stationary or fixed equipment.

36.1.2 revised September 22, 1994

36.1.3 All exposed conductive surfaces are to be tested for leakage currents. The leakage currents from these surfaces are to be measured to the grounded supply conductor individually as well as collectively where simultaneously accessible, and from one surface to another where simultaneously accessible. A part is considered to be an exposed surface unless guarded by an enclosure considered to reduce the risk of electric shock.

36.1.4 Parts are considered to be simultaneously accessible if they can be contacted by one or both hands of a person at the same time. For the purpose of this measurement, one hand is considered to be able to simultaneously contact parts that are within a 4 by 8 inch (100 by 200 mm) rectangle; and two hands of a person are considered to be able to simultaneously contact parts that are not more than 6 feet (1.8 m) apart.

36.1.5 If a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using a metal foil with an area of 10 by 20 centimeters in contact with the surface. If the surface is less than 10 by 20 centimeters, the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the equipment.

36.1.6 The measurement circuit for the leakage-current test is to be as illustrated in Figure 36.1. The measurement instrument is defined in 36.1.6 (a) – (c). The meter that is actually used for a measurement need only indicate the same numerical value for the particular measurement as would the defined instrument; it need not have all of the attributes of the defined instrument:

- a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 microfarad.
- b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor.

- c) Over a frequency range of 0 – 100 kilohertz, the measurement circuitry is to have a frequency response – ratio of indicated to actual value of current – that is equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.15-microfarad capacitor to 1500 ohms. At an indication of 0.5 milliampere, the measurement is to have an error of not more than 5 percent at 60 hertz.

Table 36.1
Current during user servicing

Table 36.1 relocated as Table 36.1B September 22, 1994

Table 36.1A
Maximum voltages

Wave form		Fundamental frequency, hz		Maximum volts peak ^a
Alternating current, direct current, and combinations of both	Polarity reversal	Greater than	But not greater than	Wet contact not likely to occur ^b
Where the change in instantaneous voltage for any duration equal to 5 percent of the period of the fundamental frequency of the wave form is not more than 20 volts. ^c	Where the instantaneous voltage does not reverse in polarity	Any		60
	Where the instantaneous voltage does reverse in polarity	Any		60 volts peak and 84.4 volts peak-to-peak ^d
Where the change in instantaneous voltage for any duration equal to 5 percent of the period of the fundamental frequency of the wave form is greater than 20 volts. ^c	Where the instantaneous voltage does not reverse in polarity	0	3	60
		3	4	55
		4	5	50
		5	6	45
		6	7	40
		7	8	35
		8	9	30
		9	10	25
		10	200	24.8
		200	300	26
		300	400	28
		400	500	31
		500	600	34
		600	700	37
		700	800	41
		800	900	46
		900	1000	51
		1000	1400	56
		1400		60
	Where the instantaneous voltage does reverse in polarity	Values to be determined by an investigation to determine equivalent protection level		

^a The maximum output voltage regardless of load shall be measured with the input voltage applied per Table 33.1.

^b "Wet contact not likely to occur" generally refers to indoor or sheltered locations that are not normally associated with water or other liquids.

^c The change in instantaneous voltage at any 5 percent of the period of the fundamental frequency of the wave form is to be determined by taking any 18-degree segment along with the wave form and determining the change in instantaneous voltage in that segment.

^d For a sinusoidal wave, 84.8 volts peak-to-peak equals 30 volts rms.

Table 36.1A added September 22, 1994

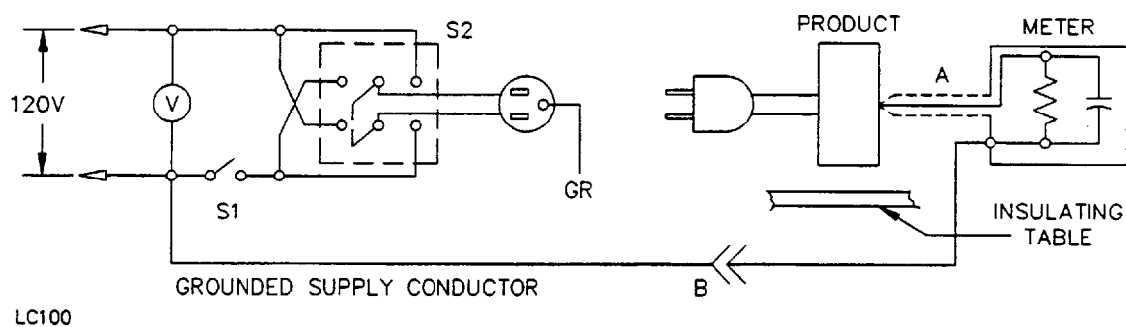
36.1.7 Unless the meter is being used to measure current from one part of a product to another, the meter is to be connected between the accessible parts and the grounded supply conductor.

36.1.8 A sample of the product is to be tested for leakage current starting with the as-received condition with all switches closed, but with its grounding conductor, if any, open at the attachment plug. A product that has not been energized for a minimum of 48 hours prior to the test and that is at room temperature is considered to be in the as-received condition. The supply voltage is to be the maximum voltage marked on the equipment, but not less than 120 or 240 volts. The test sequence, with reference to the measuring circuit — Figure 36.1 — is to be as follows:

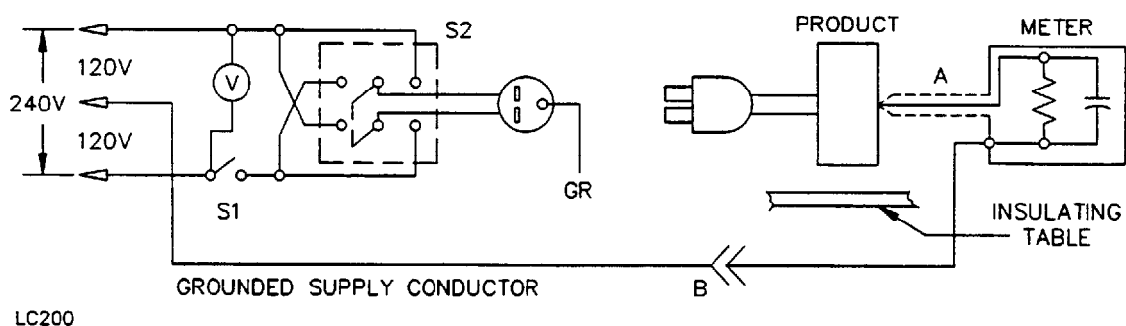
- a) With switch S1 open, the product is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2, and with the product switching devices in all of their normal-operating positions.
- b) Switch S1 is then to be closed, energizing the product, and within 5 seconds the leakage current is to be measured using both positions of switch S2, and with the product switching devices in all their normal-operating positions.
- c) Leakage current is to be monitored until thermal stabilization. Both positions of switch S2 are to be used in determining this measurement. Thermal stabilization is to be obtained by operation of the product as in the normal temperature test.

36.1.9 Normally, the complete leakage current test described in 36.1.8 is to be conducted without interruption for other tests. With the concurrence of those concerned, the leakage current test may be interrupted for the purpose of conducting other nondestructive tests.

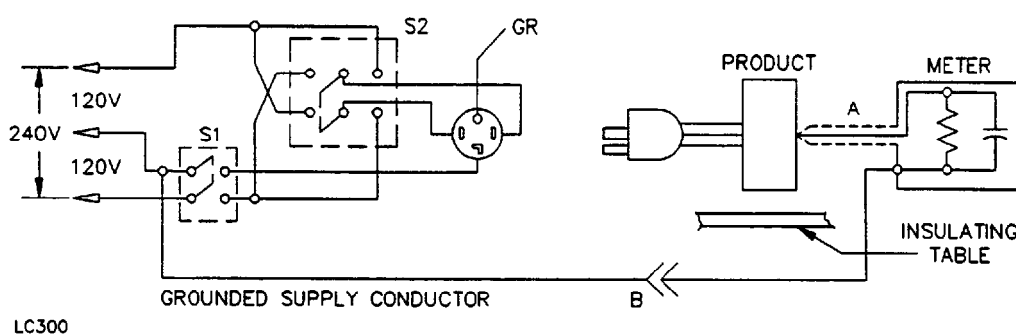
Figure 36.1
Leakage current measurement circuits



Product intended for connection to a 120-volt power supply.



Product intended for connection to a 3-wire, grounded neutral power supply, as illustrated above.



Product intended for connection to a 3-wire, grounded neutral power supply, as illustrated above.

A – Probe with shielded lead.

B – Separated and used as clip when measuring currents from one part of equipment to another.

36.2 Shock-current test

36.2.1 General

36.2.1.1 If the open-circuit potential between any part exposed only during user servicing and earth ground or any other simultaneously accessible part exceeds the values specified in Table 36.1A.

- a) The continuous current flow through a 500-ohm resistor shall not exceed the limits specified in Table 36.1B,
- b) The peak current shall not exceed 809 milliamperes regardless of duration,
- c) The combination of magnitude and duration of peak current flow shall not exceed the limits specified in 36.2.3.1, or
- d) The combination of capacitance and voltage shall not exceed the limits specified in 36.2.2.1.

36.2.1.1 revised September 22, 1994

Table 36.1B
Current during user servicing

Frequency, hertz ^a	Maximum current through a 500-ohm resistor, milliamperes peak
0 – 100	7.1
500	9.4
1,000	11.0
2,000	14.1
3,000	17.3
4,000	19.6
5,000	22.0
6,000	25.1
7,000 or more	27.5

^a Linear interpolation between adjacent values may be used to determine the maximum current corresponding to frequencies not shown. The table applies to repetitive nonsinusoidal or sinusoidal waveforms.

Table 36.1 relocated as Table 36.1B September 22, 1994

36.2.1.2 If the product has a direct-current rating, measurements are made with the product connected in turn to each side of a 3-wire, direct-current supply circuit.

36.2.1.3 Unreliable insulation, such as that usually used between the voice coil and the frame of a speaker, between live parts and the metal frame of a phonograph pickup cartridge, between the two channels of a stereophonic-phonographic pickup cartridge, and between the plates of an adjustable or variable air-dielectric capacitor, may be short-circuited during this test.

36.2.1.4 An unreliable component, such as a rectifier, vacuum tube, electrolytic capacitor, transistor, or other solid-state device that affects the shock current shall be open-circuited or short-circuited one at a time during the tests.

36.2.1.5 Current measurements are made:

- a) With any operating control, or adjustable control that is subject to user operation, in all operating positions; and

- b) Either with or without a tube, separable connector, or similar device in place.

36.2.2 Stored voltage

36.2.2.1 The maximum capacitance between capacitor terminals that are accessible during user servicing shall satisfy the following equations:

$$C = \frac{88,400}{E^{1.43} (L_n E^{-1.26})} \quad \text{for } 21.2 \leq E \leq 400$$

$$C = 35,288 E^{-1.5364} \quad \text{for } 400 \leq E \leq 1000$$

in which:

C is the maximum capacitance of the capacitor in microfarads,

L_n is the natural logarithm (base e), and

E is the potential in volts across the capacitor prior to discharge.

36.2.2.2 To determine whether a capacitor complies with the requirement in 36.2.2.1, the potential E is to be measured 5 seconds after the capacitor terminals are accessible by the removal or opening of an interlocked cover, or the like. Typical calculated values are given in Table 36.2.

36.2.3 Transient current

36.2.3.1 The duration of a transient current – direct or alternating – through a 500-ohm resistor connected between any part exposed only during servicing and earth ground or any other accessible part shall satisfy the following equation:

$$T \leq \left[\frac{20\sqrt{2}}{I} \right]^{1.43}$$

in which:

T is the duration, measured in seconds, from the time that the instantaneous value of the current first exceeds 7.1 milliamperes until the time that the current falls below 7.1 milliamperes for the last time; and

I is the peak current in milliamperes.

The interval between occurrences shall be equal to or greater than 60 seconds if the current is repetitive. The peak current shall not exceed 809 milliamperes regardless of duration. Typical calculated values are given in Table 36.3.

38 Power-Input Test

38.1 The current or wattage consumption of a product shall not exceed the marked input rating by more than 5 percent when the product is operated under normal conditions as specified in 38.2 – 38.10 while connected to a supply circuit of rated frequency and voltage as specified for normal operation in Table 33.1.

38.2 An organ or similar musical instrument having a tone generator shall be operated with any ten keys and two foot-pedals, if provided, depressed. Those stops and tabs causing the organ to operate under conditions of maximum load are to be activated. A matched resistive load is to be connected across the output of the product, and speakers, if provided, are to be disconnected and replaced by matched resistive loads. Input power (or current) is then to be determined according to the following equation:

$$P_{in} = P_o + \frac{1}{3} (P_{max} - P_o)$$

in which:

P_{in} is the calculated normal input power,

P_o is the measured input power under no signal conditions, and

P_{max} is the measured input power with the volume control adjusted to deliver maximum output and with ten keys and two foot-pedals depressed.

Exception: At the manufacturer's request, a 1-kHz or geometric mean frequency sine wave may be used as the input signal for a product employing a power amplifier. The input signal is to be applied to the first stage of the amplifier circuit. Input power or current is to be determined with the amplifier delivering one-eighth of the maximum undistorted output power into internal speakers or matched resistive loads when operated as specified in 38.5 – 38.9.

Revised 38.2 effective October 1, 1997

38.3 The input power or current of a product incorporating an amplifier and provided with auxiliary input jacks, with or without tone generators, is to be determined with the amplifier delivering one-eighth of the measured maximum undistorted output power or one-eighth of the manufacturer's marked output power, whichever is greater, into matched resistive loads when operated as specified in 38.5 – 38.9. The test is to be repeated for each audio-load-impedance tap provided, and in each test the resistive load is to closely match the rated-output load of the amplifier taps.

Revised 38.3 effective October 1, 1997

38.4 Each input and corresponding output of a biampifier, multichannel amplifier, or other product that has an effect on the total power consumption of the product is to be operated simultaneously under the conditions specified in 38.3.

38.5 The audio-input connections of the product to be tested are to be connected to a sinewave oscillator. The frequency of the oscillator is to be adjusted to 1000 hertz.

Exception: The geometric-mean-frequency of each channel is to be applied as the input signal for each channel of a product intended to cover only a limited portion of the audio-frequency range, such as a bass amplifier, biampifier, and the like.

38.6 The geometric-mean-frequency is equal to the square root of the product of the low-frequency limit and the high-frequency limit. The low-frequency limit is to be 20 hertz or the manufacturer's rated value, whichever is higher; the upper frequency limit is to be 20 kilohertz or the manufacturer's rated value, whichever is lower.

38.7 Tone controls, filters, and wave-shaping controls are to be set in the flat-response positions. The volume control is to be initially set in the middle of its range. The output connectors are to be connected to a resistive load matched to the manufacturer's output-load rating. Speakers provided with the product are to be electrically replaced with an equivalent resistive load unless the manufacturer requests that the speakers provided or sold with the product be used.

Revised 38.7 effective October 1, 1997

38.8 The sine wave oscillator output and amplifier volume control are to be adjusted to deliver maximum undistorted output power. The amplifier input used for the sine wave oscillator output is to be selected such that the sine wave is not distorted at a stage (for example, preamp) prior to amplification. Maximum undistorted output power is to be determined by visually examining the wave shape for clipping using an oscilloscope. If there is a question about clipping or flattening of the output sine wave, a distortion analyzer may be used to measure the total harmonic distortion (THD) present in the waveform. The THD is to be no greater than 1 percent. This is to be repeated for the range of audio load impedance taps and corresponding wattage ratings for the amplifier.

Revised 38.8 effective October 1, 1997

38.9 Each unused receptacle or connector, other than a conventional parallel-slot receptacle that is used to supply power to another product or accessory, is to be loaded to its maximum rating.

38.10 Other types of products not covered by 38.2 – 38.4 are to be tested under conditions closely approximating normal operating conditions.

39 Temperature Test

39.1 When a product is tested as specified in this section:

- a) The temperature at any part shall not be sufficiently high to constitute a risk of fire or to adversely affect any materials employed, and
- b) A thermal- or overcurrent-protective device shall not function.

39.2 The temperatures specified in Table 39.1 are based on an assumed ambient temperature of 25°C (77°F). A test may be conducted at an ambient temperature within the range of 10 – 40°C (50 – 104°F).

39.3 During a test conducted at an ambient temperature of 25°C (77°F), an observed temperature shall not exceed the values specified in Table 39.1.

39.4 If a test is conducted at an ambient temperature other than 25°C (77°F), an observed temperature shall be corrected as described in 39.5. A corrected temperature shall not exceed the values specified in Table 39.1.

39.5 An observed temperature is to be corrected by addition [if the ambient temperature is lower than 25°C (77°F)], or subtraction (if the ambient temperature is higher than 25°C) of the difference between 25°C and the ambient temperature.

39.6 If a corrected temperature exceeds the values specified in Table 39.1, at the request of the manufacturer, the test may be repeated at an ambient temperature closer to 25°C (77°F).

39.7 The product is to be operated until thermal equilibrium is reached:

- a) At the input measured in the Power-Input Test, Section 38;
- b) With all unused receptacles loaded to their maximum rating; and
- c) With the product mounted, positioned, closed, or enclosed to represent intended use when use conditions are not specified in this section.

Exception: A product incorporating an amplifier and provided with auxiliary input jacks with or without tone generators is to be tested as described in 39.7.1.

Revised 39.7 effective October 1, 1997

39.7.1 The equipment is to be operated with a pink noise audio input signal (band-limited at 12 decibels per octave, 20 hertz to 20 kilohertz, equal energy per octave) connected to each input affecting the power consumption of the unit, coupled through a filter circuit with a frequency roll-off of minimum 12 decibels per octave as follows. The amplitude-probability distribution shall be three standard deviations. The low and high frequency figures of the amplifier mentioned as follows are those given by the manufacturer:

- a) Low Frequency – Corner frequency (point where audio signal is down 3 decibels) of high pass filter set at 50 hertz or as close as practicable to twice the low frequency response figure, whichever is greater.
- b) High Frequency – Corner frequency of low pass filter set at 20 kilohertz or as close as practicable to one half the high frequency response limit figure, whichever is lower.

The signal amplitude is to be adjusted to cause the unit to deliver power equal to one-eighth of the measured maximum undistorted output power as described in the Power-Input Test, Section 38, or one-eighth of the manufacturer's rated output power, whichever is greater, into the matching load impedance that produced the maximum input power consumption. The output power is to be calculated using the relation:

$$P = \frac{E^2}{R}$$

in which:

E is the voltage measured by a true rms indicating voltmeter across the noninductive resistive output load R.

Exception: At the manufacturer's request, the temperature test may be conducted using a 1 kilohertz or geometric mean frequency sine wave input signal instead of the pink noise audio input signal. Pink noise shall be used where the construction of the amplifier is such that using a sine wave does not represent loading of the amplifier.

Added 39.7.1 effective October 1, 1997

39.7.2 Thermal equilibrium is considered attained when three successive readings taken at 15-minute intervals indicate that the temperature of the part has not changed by more than $\pm 1/2^{\circ}\text{C}$ over the 30 minute period.

39.7.2 added September 22, 1994

39.8 Ordinarily, the temperature of a coil or winding is to be measured by means of thermocouples mounted on the outside of the coil wrap. If the coil is inaccessible for mounting thermocouples – for instance, a coil immersed in sealing compound, or if the coil wrap includes thermal insulation or more than 1/32 inch (0.8 mm) of cotton, paper, rayon, or similar insulation – the resistance method is to be used. For the thermocouple-measured temperature of a coil of an alternating-current motor other than a universal motor having a frame diameter of 7 inches (178 mm) or less, as specified in item A of Table 39.1, the thermocouple is to be mounted on the integrally applied insulation of the conductor.

41.9.3 An automatic voltage-regulating device is to be rendered inoperative.

Exception: The device need not be rendered inoperative if, upon investigation, it is found that the device can be relied upon to prevent an increase in voltage. The investigation is to take into consideration any likely breakdown or malfunction in either the regulating device or the product, and the possibility of the device being disconnected, if it is not permanently connected in the circuit.

41.9.4 A connector or comparable part that is likely to be disconnected during normal operation or user servicing is to be both connected and disconnected during the test so that the maximum voltage may be obtained.

41.9.5 If a complex voltage is involved, the peak value of the voltage is to be measured.

42 Leakage Current After Humidity Conditioning Test

42.1 A portable product shall comply with the requirements for leakage current in 36.1.2, following exposure for 48 hours to air having a relative humidity of 88 ± 2 percent at a temperature of $32 \pm 2^\circ\text{C}$ ($90 \pm 4^\circ\text{F}$).

42.2 A sample of the product is to be heated to a temperature just above 34°C (93°F) to reduce the likelihood of moisture condensation during conditioning. The heated sample is then to be placed in a humidity chamber and is to remain for 48 hours under the conditions specified in 42.1. After the conditioning, the sample is to be tested unenergized as specified in 36.1.8(a). The sample is then to be energized and tested as specified in 36.1.8 (b) and (c). The test is to be discontinued when the leakage current stabilizes or decreases.

43 Capacitor Test

43.1 If the maximum voltage across an electrolytic capacitor is more than its marked operating-voltage rating when measured under the conditions specified in 41.9.2 – 41.9.5, the capacitor shall not short-circuit when subjected to the test specified in 43.2.

43.2 The product is to be operated until the capacitor reaches normal operating temperature after which all tubes are to be removed other than the power rectifier and any other tubes that are necessary to produce maximum direct-current voltages. The voltage is measured across the capacitor for 15 minutes. If there is any increase of the leakage current or a corresponding decrease in voltage, two additional samples are to be tested under the same conditions. The capacitor is acceptable if all three samples operate for 15 minutes without short-circuiting.

44 Low-Energy Circuit Tests for Low-Voltage, Limited Energy Circuits

44.1 General

44.1.1 A transformer, transformer-impedance combination, or a transformer and regulating circuit, intended to comply with 27.1.2 shall be tested for compliance as specified in this section.

44.1.1 revised September 22, 1994

44.2 Current capacity

44.2.1 In order to comply with the requirements specified in 27.1.2, under any noncapacitive condition of loading (including short circuit), the output current shall not be more than that specified in Table 27.1 at 1 minute after the primary is energized. If two or more secondary windings supply interconnected circuits, the sum of the outputs shall not exceed the values specified in Table 27.1.

44.2.1 revised September 22, 1994

44.2.2 If a fixed-series impedance or a regulator circuit is relied upon to limit the output, that impedance or regulator circuit is to be included in the circuit during the test. A multiple-winding transformer is to have one secondary winding tested with all the other secondary windings open-circuited, and is to be allowed to cool to room temperature again before another winding is tested. All overcurrent-protective devices that may terminate the test are to be rendered inoperative. If the transformer winding, other impedance, or transformer overtemperature protector opens the circuit in less than 1 minute after the primary is energized, the current shall not be more than the values specified in Table 27.1 just prior to opening of the circuit.

44.2.2 revised September 22, 1994

44.3 Volt-ampere capacity

44.3.1 In order to comply with 27.1.2, the maximum output shall not exceed the values specified in Table 27.1. If two or more secondary windings supply interconnected circuits, the sum of the outputs shall not exceed the values specified in Table 27.1.

44.3.1 revised September 22, 1994

44.3.2 The maximum volt-ampere output capacity is to be determined as follows. The primary winding of the transformer, at room temperature, is to be connected as intended in the product and the secondary winding in question is to be connected to a variable-resistance load. If a fixed-series impedance or a regulator circuit is relied upon to limit the output, that impedance or regulator circuit is to be included in the circuit during the test. A multiple-winding transformer is to have one secondary winding tested with all the other secondary windings open-circuited, and is to be allowed to cool to room temperature again before another winding is tested. All overcurrent-protective devices that may terminate the test are to be rendered inoperative. The primary winding is to be connected to a source of rated voltage. The load on the secondary is to be varied in approximately ten increments from open-circuit to short-circuit conditions in 2-1/2 minutes. For each step or increment in the resistance, the product of the output voltage and current is to be recorded, plotted, and drawn as a smooth curve.

44.4 Continuous operation

44.4.1 The secondary of a transformer, the output of a transformer-impedance combination or a transformer-regulating circuit that limits the current or the output as specified in 27.1.2 is to be subjected to continuous operation for not longer than 7 hours at short-circuit conditions and maximum power to the externally connected resistor without producing a risk of fire or electric shock. Protective devices may be left intact for the short-circuit and maximum-power tests. Following the test, the measurement specified in 44.2.1, 44.2.2, 44.3.1, and 44.3.2 are to be repeated. The open-circuit secondary voltage and either:

- a) The secondary current under any condition of noncapacitive loading (including short-circuit) after 1 minute or

- b) The volt-ampere output capacity of the secondary winding

shall still comply with Table 27.1.

Exception: If the short-circuit test continues for 7 hours, then the maximum-power test need not be conducted.

44.4.1 revised September 22, 1994

44.4.2 To determine compliance with the requirement in 44.4.1, the product is to be tested as specified in 46.1.1 – 46.1.9. Three complete tests are to be conducted, using new components when necessary.

44.5 Abnormal-operation

44.5.1 If a regulating or other type of circuit is located between the points being measured and the power supply, the opening or short-circuiting, singly, of any unreliable component in that circuit shall not cause the open-circuit secondary voltage to exceed 30 volts ac or 60 volts dc, and either:

- a) The secondary short-circuit current shall be 8 amperes or less after 1 minute, or
- b) The output capacity of the secondary winding shall be 250 volt-amperes or less.

44.5.1 revised September 22, 1994

45 Low-Energy Circuit Tests for Nonhazardous Secondary Circuits

45.1 Power and voltage determination

45.1.1 To determine compliance with 27.2.1, the source of supply for a nonhazardous secondary circuit shall be subject to the tests specified in 45.1.2 – 45.3.1.

45.1.2 A source of power for a component part or assembly is to be investigated to determine the points nearest the power supply not capable of:

- a) Producing an open-circuit voltage exceeding:
 - 1) 30 volts ac or 60 volts dc where wet contact is not likely to occur and
 - 2) 21.2 volts peak where wet contact is likely to occur, and
- b) Delivering a power of more than 15 watts into an external resistor connected singly between each of these points and any return to the power supply.

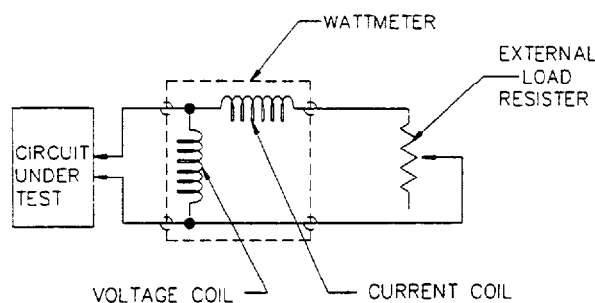
45.1.2 revised September 22, 1994

45.1.3 The measurements specified in 45.1.2 are to be made with the product operating normally – with no signal input for amplifier circuits – and with all components and circuits in place.

45.1.4 To locate the points not capable of delivering more than 15 watts of power that are mentioned in 45.1.2(b), an adjustable resistor is to be set for maximum resistance and then connected to a wattmeter and the circuit under investigation as illustrated in Figure 45.1. The external resistor is to be adjusted until it consumes the maximum power as indicated by a peak reading of the wattmeter. If the reading is more than 15 watts, the desired point has not been located and it is then necessary to move the input to the wattmeter

resistor to other points away from the supply side of the circuit. If an acceptable protective device is used in the product, a shorting switch is to be connected across the protective device in a closed position. The external resistor is to be adjusted for maximum resistance before being connected in the circuit. The resistor is then to be adjusted so the power it dissipates is exactly 15 watts as indicated by the wattmeter reading. The switch across the protective device is then to be opened and the time required for the protective device to open is to be recorded. If the protective device opens the circuit in 5 seconds or less, the desired point not capable of delivering more than 15 watts has been located.

Figure 45.1
Connection of wattmeter



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45.2 Abnormal operation

45.2.1 If a regulating or other type of circuit is located between the points being measured and the power supply, the opening or short-circuiting – singly – of any unreliable component in that circuit shall not cause the limits in 45.1.2 to be exceeded.

45.3 Continuous operation

45.3.1 The points determined by the measurements specified in 45.1.2 – 45.2.1 shall be investigated to determine that a risk of fire or electric shock is not produced under the conditions of separately short-circuiting them or loading them to maximum power.

45.3.2 As a result of the test specified in 45.3.1, no components located between the points being tested and the power supply shall be affected to such a degree – for example, by a change in value or characteristics – as to cause the limits in 45.1.2 to be exceeded.

45.3.3 To determine whether a product complies with the requirements in 45.3.1, it is to be tested as specified in 46.1.1 – 46.1.9.

45.3.4 If the short-circuit tests specified in 45.3.1 continue for 7 hours, it is not necessary that the maximum-power test be conducted.

46 Abnormal-Operation Tests

46.1 General

46.1.1 For abnormal-operation tests, the product is to be connected to a supply circuit fused at 30 amperes and placed on a white-tissue-paper-covered softwood surface. Exposed dead metal parts are to be connected to earth ground through a 1-ampere nontime-delay fuse. The supply-circuit connection is to be such that the maximum potential exists between the protective device of the product, if any, and the chassis.

46.1.2 A single layer of cheesecloth is to be draped loosely over the entire product.

- 5) Any two elements of the tube that are likely to short-circuit; for example, elements that are adjacent to each other. The short-circuit is to be simulated by shorting the elements at the tube-socket terminals.
- b) Solid-state rectifier – any two terminals.
- c) Electrolytic capacitor – any two terminals.
- d) Transistor – any two terminals.

46.3 Audio-output-fault conditions

46.3.1 In an amplifier audio-output circuit tested in accordance with 46.3.2 – 46.3.4, the voltage between any accessible parts of the audio-output circuit shall not exceed:

- a) 60 volts peak for voltages that do not reverse in polarity, or
- b) 60 volts peak and 84.8 volts peak-to-peak for voltages that reverse in polarity.

Exception: This requirement does not apply if the current through a 500-ohm noninductive resistor connected between the parts complies with the requirements in 36.2.1.1.

46.3.2 A variable resistor is to be connected between any two terminals of a discrete unreliable component – for example, a vacuum tube, diode, electrolytic capacitor, transistor, or integrated circuit – located in the audio-output circuit. The amplifier is to be operated under no-input signal conditions with no load connected to the audio output.

46.3.3 The variable resistor is to have a resistance value high enough so that when initially connected across the terminals of the component in the audio-output circuit being tested there is no effect on circuit operation. The variable resistor is also to be capable of being reduced to zero resistance and of conducting large amounts of current.

46.3.4 With the product connected to a supply circuit in accordance with 33.3.1 and Table 33.1 and operating normally under no-load conditions, the variable resistor is to be slowly reduced in value and the voltage at the audio output monitored. If the product ceases to function before the voltage at the audio output exceeds the values specified in 46.3.1, the cause of the malfunction is to be determined. If a component other than a fuse or overload protector or limiter has been damaged, it is to be replaced by either an open circuit or a short circuit, whichever produces the more unfavorable results. The test is to be continued until zero resistance of the variable resistor is reached, the maximum voltage reached, or until the voltage is reduced or interrupted by the opening of a fuse, overload protector, or limiter.

46.3.5 If the maximum value of output voltage measured according to 46.3.4 exceeds the values specified in 46.3.1, a 500-ohm noninductive resistor is to be connected between the parts. The test specified in 46.3.4 is to be repeated, however, the current through the 500-ohm resistor rather than the open-circuit voltage is to be monitored.

46.3.6 The current through the resistor shall satisfy the requirements for electric shock current specified in 36.2.1.1.

46.3.7 If a fuse or other replaceable circuit-protective element is relied upon to open the circuit, the product is to be marked in accordance with 64.8.1 and 64.8.2.

46.4 Endurance

46.4.1 If solid-state circuitry provides sensing, cut-off, limiting, or the like, to remove or prevent hazardous potentials appearing at the speaker terminals, the product with such circuitry shall complete 100,000 cycles of operation simulating each fault that is intended to interrupt, clear, or guard against.

46.4.2 Three samples of the product are to be subjected to the cycling test. Upon completion of the required number of cycles, the tests specified in 46.3.4 and 46.3.5 are to be repeated with acceptable results.

46.5 Abnormal temperature test

46.5.1 Each channel of equipment incorporating a power amplifier employing external speaker connections is to be loaded with a resistive value as specified in 38.3. Each channel is to be driven with a 1 kilohertz sine wave input or a sine wave at the geometric mean frequency of the specified frequency response limits of the channel. The output level of each channel is to be set at a voltage that will produce one-third maximum undistorted output power or one-third of the manufacturer's rated output power, whichever is greater. The determination of maximum undistorted output power is described in 38.8. The supply circuit voltage is to be the test voltage for intended operation as specified in Table 33.1. The amplifier is to operate under these conditions for a period of 7 hours, until thermal equilibrium as specified in 39.7.2 is established, or until a protective circuit or a protective device operates.

Added 46.5.1 effective October 1, 1997

46.5.2 If a protective circuit or a protective device operates before temperatures stabilize or before 7 hours have elapsed at the one-third level, the test described in 46.5.1 is to be repeated with the protective circuit or protective device repaired or replaced and the output level of the equipment set at one-fourth maximum undistorted output power or one-fourth the manufacturer's rated output power, whichever is greater, until stabilization occurs. If a protective circuit or a protective device operates at the one-fourth level, the equipment is to be repaired and the test repeated at the one-fifth and, if necessary, one-sixth levels until thermal stabilization occurs.

Added 46.5.2 effective October 1, 1997

46.5.3 The test specified in 46.5.1 is to be repeated at the one-third level only (set while the equipment is loaded with the resistive value specified in 38.3) with the resistive loads replaced with:

- a) A resistive load equal to one-half the value used in 38.3 and
- b) A short accomplished by an appropriate shorting device applied at the output terminals.

The amplifier is to operate under these conditions for a period of 7 hours, until thermal equilibrium as specified in 39.7.2 is established, or until a protective circuit or a protective device operates.

Exception: *The test described in 46.5.3 need not be performed on equipment with internal factory-wired speakers.*

Added 46.5.3 effective October 1, 1997

46.5.4 As a result of the test described in 46.5.1 – 46.5.3, there shall not be risk of fire or electric shock as described in 46.1.8. Transformers used in the equipment shall comply with the temperature limits specified in Table 46.1.

Exception: The temperature on the transformer need not be measured if the transformer complies with the construction and performance requirements for transformers and motor transformers for use in audio-, radio-, and television-type appliances, UL 1411, or with the construction and performance in the Standard for Class 2 and 3 Transformers, UL 1585.

Added 46.5.4 effective October 1, 1997

Table 46.1
Maximum temperature rises under abnormal temperature conditions

Condition	Type of protection	Maximum temperature rises									
		Class 105		Class 130		Class 155		Class 180		Class 120	
		°C	(°F)	°C	(°F)	°C	(°F)	°C	(°F)	°C	(°F)
1	Integral, non-replaceable, non-resettable protector, including open primary winding, resulting in the replacement of the transformer	130	234	155	279	180	324	205	369	245	441
2	None or any other form of protection	110	198	135	243	160	288	185	333	225	205

Table 46.1 added September 22, 1994

47 Switching-Device Test

47.1 Each switch and other current-interrupting device shall comply with the requirements for that component. The actual load controlled in the product may be used in place of the artificial load specified in the requirements applicable to the component.

Exception: Overload and endurance tests may be omitted for switching contacts in isolated secondary circuits if the controlled load is limited to 100 volt-amperes or less.

47.2 A switch or other device that controls a motor of a product is to be operated for 50 cycles making and breaking the locked-rotor current of the product. There shall be no electrical or mechanical malfunction of the device or undue pitting or burning of the contacts and the fuse in the grounding connection shall not open.

Exception: The test need not be conducted if the switch or other device is:

- Interlocked so that it will not have to break the locked-rotor-motor current or*
- Has been investigated and determined to be acceptable for the intended use.*

47.3 To determine if the switch or other control device is capable of performing acceptably in the overload test specified in 47.2, the product is to be connected to a grounded supply circuit with the rotor of the motor locked in position. During the test, exposed dead metal parts of the product are to be connected to ground through a 3-ampere plug fuse, and the connection is to be such that any single-pole, current-rupturing device is located in the ungrounded conductor of the supply circuit. If the product is intended for use on direct current, or on direct current as well as alternating current, the exposed dead metal parts of the product are to be connected so as to be positive with respect to a single-pole, current-rupturing, control device. The device is to be operated at a rate of not more than 10 cycles per minute, unless a faster rate of operation is agreeable to those concerned.

48 Solid-State Switch Test

48.1 Abnormal operation

48.1.1 A product containing a solid-state component or device that functions as a switch in a hazardous-energy circuit shall operate as intended when subjected to the following tests in the order in which they are presented:

- a) 50 cycles of operation consisting of making and breaking the actual or rated-output load.
- b) 50 cycles of overvoltage while connected to an input of 110 percent of rated-input voltage and to actual or rated-output load.
- c) 50 cycles of undervoltage, while connected to an input of 85 percent of rated-input voltage and to actual or rated-output load.

64.4.3 If a user-serviceable part can be made accessible by other than the intended method, and if the improper method results in a risk of fire, electric shock, or injury to persons, instructions for user servicing shall be provided to show the intended method. The instructions, when required, shall be located where readily visible from the approach likely to be used in making the improper method of user servicing.

Exception: Instructions are not required if the intended method is obvious.

64.5 Factory identification

64.5.1 If the same product is produced or assembled at more than one factory, each finished product shall have a distinctive marking to identify the factory of origin.

64.6 Interlock warning

64.6.1 In order to comply with 24.2.1(b), a product that incorporates an interlock device shall be marked, where readily visible during any approach to defeat the interlock, with the word "WARNING" and the following or the equivalent: "THIS COVER (OR BACK) IS PROVIDED WITH AN INTERLOCK TO REDUCE THE RISK OF ELECTRIC SHOCK. DO NOT DEFEAT ITS PURPOSE OR ATTEMPT TO SERVICE WITHOUT REMOVING COVER COMPLETELY."

64.7 Receptacles

64.7.1 A conventional parallel-slot receptacle that is not utilized for the connection of a part of the product shall be marked with the electrical rating in volts, frequency, and watts or amperes on or near the receptacle.

64.7.2 A receptacle or connector shall be marked where readily visible to indicate the specific acceptable accessory or the acceptable use for which it is intended if it:

- a) Is not of the conventional parallel-slot type, with or without a jumpered plug;
- b) Is intended for the connection of an accessory;
- c) Involves energy levels or an intended use that may produce a risk of fire or electric shock;
- d) Is readily perceptible by the user; and
- e) Is not utilized for the connection of a part of the product.

64.7.3 A receptacle or connector is considered readily perceptible by the user if it is recognizable during the normal procedure of operation or user servicing, visually or by casual touch, or if the presence of the receptacle is indicated by a marking on the product or by literature packed with it.

64.8 Fuse replacement

64.8.1 There shall be a replacement marking adjacent to a fuse or fuseholder if the fuse is used to reduce a risk of fire. The marking shall be located where readily visible during replacement of the fuse and shall consist of either:

- a) The word "CAUTION" and the following or the equivalent: "TO REDUCE THE RISK OF FIRE REPLACE ONLY WITH SAME TYPE ___A-___V FUSE" or
- b) The graphical symbol