UL 2565

STANDARD FOR SAFETY

Industrial Metalworking and Woodworking Machine Tools

UL Standard for Safety for Industrial Metalworking and Woodworking Machine Tools, UL 2565

First Edition, Dated May 1, 2013

SUMMARY OF TOPICS

This revision of ANSI/UL 2565 dated October 24, 2019 Revisions To Expand The Scope To Cover Larger Industrial Metalworking And Woodworking Type Machines.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated May 3, 2019 and August 16, 2019.

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UL 2565

Standard for Industrial Metalworking and Woodworking Machine Tools

Prior to the first edition, the requirements for the products covered by this standard were included in the Outline of Investigation for Manual and Semiautomatic Metal Sawing Machines, UL 2565.

First Edition

May 1, 2013

This ANSI/UL Standard for Safety consists of the First Edition including revisions through October 24, 2019.

TThe most recent designation of ANSI/UL 2565 as an American National Standard (ANSI) occurred on October 24, 2019. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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INTRODUCTION

1 Scope

1.1 This standard covers industrial and commercial metalworking and woodworking machines, either manual or semiautomatic, that cut or change the shape of a work piece and machinery and accessory equipment, used in industrial and commercial applications, having a total connected power of 5 HP (3.7kw) or greater, or having 3-phase wiring.

1.2 This equipment is intended to be installed in accordance with the National Electrical Code, ANSI/NFPA 70 and the Electrical Standard for Industrial Machinery, NFPA 79 and provided with a means for grounding the machine on a branch circuit rated not more than 600 V.

1.3 Machines included in this category are not intended for the handling of hazardous material.

1.4 The use of some equipment involves certain inherent hazards related to the risk of injury that cannot be wholly eliminated by practical design features. These requirements are intended to reduce such hazards to an acceptable level.

1.5 This standard does not cover:

a) Robotics and associated control equipment. This equipment is covered by the Standard for Robots and Robotic Equipment, UL 1740.

b) Automated equipment designed to perform repetitive manufacturing related cutting or sawing tasks, is covered by the Outline of Investigation for Factory Automation Equipment, UL 2011.

c) Cord-connected or permanently-connected stationary and light industrial tools which are covered under Standard for Stationary and Fixed Electric Tools, UL 987.

d) Cord-connected transportable tools which are covered under UL 62841-1 and the applicable Part 3 series of standards.

e) Cord-connected metalworking and woodworking machines used in industrial and commercial applications either having a total connected power of less than 5 HP (3.7 KW) or not having 3-phase wiring.

1.6 Devices covered by this standard are not intended for the handling of hazardous materials in unattended applications.

1.7 In addition to complying with the requirements in this standard, machines covered under the scope shall also comply with:

a) Industrial metalworking machines shall comply with:

1) The applicable requirements in the Standard for Stationary and Fixed Electric Tools, UL 987.

b) Industrial woodworking machines shall comply with:

1) ANSI O1.1 Woodworking Machinery – Safety Requirements series of standards; and

2) The applicable requirements in the Standard for Stationary and Fixed Electric Tools, UL 987.

1.8 A control panel which forms a portion of the overall equipment, either alone or in conjunction with the machine, shall comply with the requirements in the Standard for Industrial Control Panels, UL 508A.

2 Components

2.1 Except as specified in 2.2 and 7.1, 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.

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

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

b) Is superseded by a requirement in this standard.

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

2.4 Specific components are 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.

3 Units of Measurement

3.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

4 Undated References

4.1 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.

5 Glossary

5.1 CLASS 2 CIRCUIT – An isolated secondary circuit involving a potential of not more than 30 V (42.4 V peak) supplied by:

a) An inherently-limited Class 2 transformer;

b) A combination of an isolated transformer secondary winding and a fixed impedance or regulating network that together comply with the performance requirements for an inherently limited Class 2 transformer;

c) A dry-cell battery having output characteristics not greater than those of an inherently-limited Class 2 transformer;

d) Any combination of (a), (b), and (c) above that together comply with the performance requirements for an inherently-limited Class 2 transformer; or

e) One or more combinations of a Class 2 transformer and an overcurrent protective device that together comply with the performance requirements for a noninherently-limited Class 2 transformer.

A line-connected circuit connected in series with an impedance as a means of limiting the voltage and current is not a Class 2 circuit.

5.2 CONTROLLED ENVIRONMENT– An environment relatively free of contaminants. A controlled environment may also be provided by means of a NEMA Type 4, 12 or 13 enclosure as specified in the Standard for Industrial Control Equipment, UL 508.

CONSTRUCTION

6 Spacings

6.1 The electrical spacings in a machine shall comply with the spacings requirements in the Standard for Industrial Control Equipment, UL 508.

6.2 The electrical spacings for a device or subassembly which is contained within the overall equipment shall comply with the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

7 Devices

7.1 As specified in 2.1, all devices employed in a metal sawing machine shall comply with the requirements for that component.

Exception No. 1: A non-electrical, non-hydraulic device such as one operating on air pressure is not required to be evaluated.

Exception No. 2: An electrical device operating entirely within a Class 2 Circuit is not required to be evaluated unless the device performs a safety function.

8 Strain Relief

8.1 A machine shall be provided with strain relief so that mechanical stress on a supply cord will not be transmitted to terminals, splices, or interior wiring.

8.2 A strain-relief device shall be subjected to the Strain Relief Test, Section 28.

8.3 Means shall be provided to prevent a flexible cord or interconnecting cable from being pushed into a machine through a cord-entry hole if such displacement results in:

a) Subjecting the supply cord or interconnecting cable to mechanical damage;

b) Exposing the supply cord or interconnecting cable to a temperature higher than that for which it is rated;

c) Reducing spacings; or

d) Damaging internal connections or components.

8.4 To determine compliance, the supply cord or interconnecting cable shall be tested in accordance with the Push-Back Strain Relief Test, Section 29.

9 Grounding

9.1 General

9.1.1 There shall be provision for grounding the machine and all dead metal parts that are exposed or that are likely to be touched by a person during normal operation or adjustment, and that are likely to become energized through electrical malfunction.

9.1.2 To determine whether a part is likely to become energized, such factors as construction, the proximity of wiring, and a dielectric voltage-withstand test conducted after appropriate overload, endurance, and burnout tests are to be evaluated.

9.1.3 A machine shall comply with the Grounding Resistance Test, Section 30.

9.2 Grounding means

9.2.1 An equipment-grounding terminal or lead-grounding point shall be connected to the frame or enclosure by a positive means, such as by a bolted or screwed connection.

9.2.2 Nonconductive coatings, such as paint, lacquer, and enamel shall be removed from the grounding surface area to assure electrical continuity, or the grounding connection shall reliably penetrate the nonconductive coating.

9.2.3 A grounding point shall be located so that it is unlikely that the grounding means will be removed during normal servicing.

9.2.4 The following are acceptable means for electrically grounding permanently connected equipment:

a) An equipment-grounding terminal or lead intended to be connected to a nonmetal-enclosed wiring system, for example, a nonmetallic-sheathed cable; and

b) A knockout or equivalent opening in a metal enclosure intended to be connected to a metal enclosed wiring system.

10 Printed-Wiring Boards

10.1 A printed-wiring board shall comply with the Standard for Printed Wiring Boards, UL 796.

10.2 A printed-wiring board containing circuits involving a risk of fire or electric shock shall be rated at least V-2 as specified in requirements for tests for flammability of plastic materials for parts in devices and appliances, Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. Printed-wiring boards not involving a risk of fire or electric shock may be rated HB.

10.3 The laminate material in a printed-wiring board used in a circuit that involves a risk of fire or electric shock shall comply with the direct support of current-carrying parts performance level requirements specified in the Standard for Printed Wiring Boards, UL 796, and be marked with:

a) "▲"; or

b) Have a unique type designation that is limited to such printed-wiring boards to indicate compliance with the direct support requirements of UL 796.

10.4 A conformal coating employed on the surface of a printed-wiring board intended to be used for the acceptance of reduced spacings may be acceptable if it complies with Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

11 Transformers

11.1 A Class 2 transformer used as a supply for a Class 2 circuit shall comply with the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

11.2 A power transformer shall comply with the Power Transformer Test, Section 18.3.

11.3 A transformer shall comply with the applicable performance requirements outlined in this standard, including the temperature and dielectric voltage-withstand tests.

12 Capacitors, Capristors and Varistors

12.1 General

12.1.1 A component such as a capacitor, a combination capacitor and resistor, varistor or a suppressor shall employ materials and shall be constructed so that a risk of fire is not introduced. The component shall not be adversely affected by the temperature it reaches under the most severe conditions of use.

12.1.2 Under both normal and abnormal conditions of use, a component as described in 12.1.1, employing a liquid dielectric medium more combustible than askarel shall not result in a risk of fire or electric shock, and shall be constructed to reduce the risk of expelling the dielectric medium.

12.1.3 A capacitor complying with the requirements for protected oil-filled capacitors in the Standard for Capacitors, UL 810, is considered to be protected against the expulsion of the dielectric medium.

12.2 Isolating components

12.2.1 A component, such as a capacitor, a combination capacitor and resistor, or a suppressor used for lineby- pass, or metal-cabinet isolation; or between supply-circuit (line) connected parts and exposed metal parts (where the component is continually stressed) shall comply with the requirements in the Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14.

12.3 Across-the-line components

12.3.1 A component such as a capacitor, a combination capacitor and resistor, a varistor, or a suppressor connected across the supply circuit shall comply with the Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14.

12.3.2 A component as described in 12.3.1 is considered to be across-the-line if it is used for line-by-pass isolation in a product provided with a terminal or connection intended to be grounded.

13 Parts Subject to Pressure

13.1 A pressure vessel having an inside diameter more than 6 in (152 mm), subjected to a pressure more than 15 psig (102 kPa), and eligible to be covered by the National Board of Boiler and Pressure Vessel Inspectors shall be marked in accordance with the appropriate boiler and pressure vessel code

symbol of the American Society of Mechanical Engineers (ASME) for a working pressure not less than the pressure determined in accordance with 13.3.

13.2 A pressure vessel, because of its application is not covered by the scope of the inspection procedure of the ASME code specified in 13.1, shall be constructed so that it complies with requirements in 13.3.

13.3 A part or an assembly that is subject to air or vapor pressure, including the vapor pressure in a vessel containing only a superheated fluid during normal or abnormal operation, shall be subjected to the Parts Subject to Pressure Tests, Section 34, as applicable.

14 Pressure-Relief Devices

14.1 A means for safely relieving pressure shall be provided for a part in which pressure might be generated by an external source of heat.

14.2 A pressure-relief device, a fusible plug, a soldered joint, nonmetallic tubing, or other equivalent pressure relief means may be employed to comply with the requirements in 14.1.

14.3 A pressure-relief device is considered to be a pressure-actuated valve or rupture member designed to relieve excessive pressure automatically.

14.4 There shall be no shut-off valve between the pressure-relief means and the parts that it is intended to protect.

14.5 A vessel having an inside diameter of more than 3 in (76 mm) and subject to air or steam pressure generated or stored within the metal sawing machine shall be protected by a pressure-relief device.

14.6 The start-to-discharge pressure setting of a pressure-relief device shall not be higher than the working pressure marked on the vessel. The discharge rate of the device shall be adequate to relieve the pressure.

14.7 A pressure relief device shall:

a) Be connected as close as possible to the pressure vessel or part of the system that it is intended to protect;

b) Be installed so that it is readily accessible for inspection and repair, and cannot be readily rendered inoperative so that it will not perform its intended function; and

c) Have its discharge opening located and directed so that:

1) Operation of the device will not deposit moisture on bare live parts or on insulation or components detrimentally affected by moisture; and

2) The likelihood of injury to persons by scalding is reduced.

14.8 A pressure-relief device having an adjustable setting is judged on the basis of the maximum setting unless the adjusting means is reliably sealed at a lower setting.

14.9 A control that limits the pressure in a vessel required to have a pressure-relief device shall be subjected to the Pressure-Relief Devices Test, Section 35.

PROTECTION AGAINST INJURY TO PERSONS

15 General

15.1 The performance of machines shall be investigated by subjecting the requisite number of representative samples to the tests described in Sections 16 – 39. Insofar as practicable, the tests shall be conducted in the order in which they are presented.

16 Power Input Test

16.1 The power input to the machine shall not exceed the marked rating by more than 10 percent when it is operated under the conditions of normal use while connected to a circuit of rated frequency and maximum rated voltage.

16.2 The machine is to be operated in its intended manner while cutting material specified by the manufacturer at the recommended tool speed and cutting depth.

17 Temperature Test

17.1 A machine shall be tested as specified in 17.2 – 17.6 and shall not attain a temperature at any point sufficiently high to:

a) Introduce a risk of fire;

b) Damage any materials employed in the equipment; or

c) Exceed the temperature rises specified in Table 17.1.

Table 17.1
Maximum acceptable temperature rises

Materials and Components	C°	(F°)
1. Varnished-cloth insulation	60	(108)
2. Fuses	65	(117)
3. Fiber employed as electrical insulation	65	(117)
4. Wood and other similar material	65	(117)
5. Any point on or within a terminal box of a permanently-connected tool	65	(117)
6. A surface upon which a permanently connected tool may be mounted in service, and surfaces that may be adjacent to the tool when so mounted	65	(117)
7. Insulation systems on stator windings of an a-c motor having a diameter of 7 in (178 mm) or less (not including a universal motor); and on a vibrator coil[a,b] :		
A. Class A insulation systems		
1. In an open motor and on a vibrator coil:		
Thermocouple or resistance method	75	(135)
2. In a totally enclosed motor:		
Thermocouple or resistance method	80	(144)
B. Class B insulation systems		

Table 17.1 Continued on Next Page

Table 17.1 Continued

Materials and Components	C°	(F°)
1. In an open motor and on a vibrator coil:	95	(171)
Thermocouple or resistance method		
2. In a totally enclosed motor:	100	(180)
Thermocouple or resistance method		
8. Insulation systems on stator windings of an a-c motor having a diameter of more than 7 in (178 mm), of a d-c motor, and of a universal motor[a,b]:		
A. Class A insulation systems		
1. In an open motor:		
Thermocouple method	65	(117)
Resistance method	75	(135)
2. In a totally enclosed motor:		
Thermocouple method	70	(126)
Resistance method	80	(144)
B. Class B insulation systems		
1. In an open motor:		
Thermocouple method	85	(153)
Resistance method	95	(171)
2. In a totally enclosed motor:		
Thermocouple method	90	(162)
Resistance method	100	(180)
9. Class E insulation systems on coil winding		
Thermocouple method	75	(135)
Resistance method	85	(153)
10. Class 105 insulation systems on windings of a relay, a solenoid, and the like:		
Thermocouple method	65	(117)
Resistance method	85	(153)
11. Phenolic composition employed as electrical insulation or as a part the deterioration of which could result in a risk of fire or electric shock[c]	125	(225)
12. Rubber- or thermoplastic-insulated wires and cords[c,d,e]	35	(63)
13. Capacitors:		
Electrolytic[f]	40	(72)
Other types[g]	65	(117)
14. Sealing compound	h	h
15. Class 130 insulation systems on windings of a relay, a sole-noid, and the like:		
Thermocouple method	85	(153)
Resistance method	105	(189)

[a] Temperature limits are based upon stator windings. The temperature of the armature is recorded by a convenient means as a reference temperature for establishing the armature oven conditioning temperature for the armature investigation test in double insulated equipment.

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

Table 17.1 Continued on Next Page

Table 17.1 Continued

Materials and Components	C°	(F°)
[c] Phenolic composition and rubber and thermoplastic insulation that has been investigated and found acceptable for use at higher temperatures may be used at those temperatures.		
[d] A rubber-insulated conductor within a motor employing Class A insulation systems, and a rubber-insulated motor lead may be subjected to a higher temperature rise if the conductor is provided with a braid that has been investigated and found acceptable for use at the higher temperature; and a rubber-insulated conductor of a flexible cord may be subjected to a higher temperature rise. This does not apply to thermoplastic-insulated wires or cords.		
[e]A short length of rubber- or thermoplastic-insulated flexible cord exposed to a temperature of more than 60°C (140°F), such as at terminals, is acceptable if: 1) Supplementary heat-resistant insulation having acceptable dielectric strength is employed on the individual conductors of the cord to prevent deterioration of the conductor insulation; and 2) The strain-relief means is not dependent on that portion of the insulation subjected to the excessive temperature.		
[f] For an electrolytic capacitor that is physically integral with or attached to a motor, the temperature rise on insulating material integral with the capacitor enclosure may not be more than 65°C (117°F).		
[g] A capacitor that operates at a temperature rise of more than 65°C (117°F) may be judged on the basis of its marked temperature limit.		
[h] The maximum acceptable sealing compound temperature, when corrected to a 25°C (77°F) ambient temperature, is 15°C (27°F) less than the softening point of the compound as determined in accordance with the Standard Test Methods for Softening Point of Resins Derived from Naval Stores by Ring-and-Ball Apparatus, ASTM E28.		

17.2 To determine if a machine complies with the temperature test requirements, the machine is to be operated continuously while loaded so that the current input equals the rated current input of the machine until temperatures are constant.

17.3 During the temperature test, the temperature of a surface that may be contacted by the user shall be no more than the value in Table 17.2.

Table 17.2
Maximum acceptable surface temperature

Location	Composition of surface			
	Metal		Nonmetallic	
	°C	°F	°C	°F
Handle, lever, or knob likely to be grasped	50	122	60	140
Accessible surface in a work area	60	140	85	185
Surface subject to casual contact	70	158	95	203

17.4 Permanently connected machines are to be tested with 4 ft (1.22 m) of wire attached to each field wiring terminal. The wire is to be of the smallest size having an ampacity of at least 125 percent of the test current for motor loads, continuous duty loads, and combination loads, and at least 100 percent for other loads. Wire size is to be determined in accordance with the National Electrical Code, ANSI/NFPA 70. The size is to be based upon wire that is acceptable for a temperature of 140°F (60°C) for a rating of 100 A or less, and upon wire that is acceptable for 167° F (75° C) for a rating greater than 100 A. The type of insulation is not specified.

17.5 *Deleted*

17.6 *Deleted*

18 Dielectric Voltage-Withstand Test

18.1 General

18.1.1 Immediately following the Temperature Test, Section 17 and while at its maximum normal operating temperature, a machine shall withstand for one minute without electrical breakdown an essentially sinusoidal potential of 1000 V plus twice maximum rated voltage applied between:

a) Line-voltage live parts and grounded or exposed metal parts of the enclosure with the contacts open and closed;

b) Line-voltage live parts of opposite polarity with the contacts closed;

c) Live parts of line- and low-voltage circuits, line-voltage and isolated-limited-energy secondary circuits, and different line-voltage circuits; and

d) Live parts of different secondary circuits.

18.1.2 A machine employing a low-voltage circuit shall withstand for one minute without electrical breakdown the application of an essentially sinusoidal potential of 500 V applied between:

a) Low-voltage live parts of opposite polarity with contacts, if any, closed; and

b) Low-voltage live parts and the enclosure and grounded dead metal parts.

18.1.3 The test requirement in 18.1.2 may be omitted for a portion of a low-voltage, nonsafety circuit that is beyond any fixed impedance.

18.1.4 To determine whether the machine complies with the requirements in 18.1.1 – 18.1.3, the machine is to be tested using a 500 VA or larger capacity transformer, the output voltage of which is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test level is reached, and is to be held at that level for one minute. The increase in the applied potential is to be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter.

18.1.5 If the charging current through a capacitor or capacitor-type filter connected across the line, or from line to earth ground, is large enough to make it impossible to maintain the required alternating-current test potential, the capacitors and capacitor-type filters may be tested as specified in 18.1.6.

18.1.6 The capacitors and capacitor-type filters described in 18.1.5 are to be subjected to a direct-current test potential of 1414 V for equipment rated 250 V or less or 1414 V plus 2.828 times the rated circuit voltage for equipment rated at more than 250 V. The direct-current test potential is to be maintained for one minute without breakdown.

18.1.7 The test potential may be obtained from any convenient source of sufficient capacity to maintain the required potential. The output voltage of the test apparatus is to be monitored. Starting at zero, the applied potential is to be increased at a rate of approximately 200 V/s until the required test value is reached and is to be held at that value for one minute. A direct-current source is to be used for testing a direct current circuit.

18.1.8 Printed-wiring assemblies and other electronic-circuit components that can be damaged by application of the test potential or that would short-circuit the test potential are to be removed, disconnected, or otherwise rendered inoperative before the dielectric voltage-withstand tests are conducted. A representative subassembly may be tested instead of an entire unit. Rectifier diodes in the

power supply may be individually shunted before the test is made to protect them in the case of a fault elsewhere in the secondary circuits.

18.2 Secondary circuits (controlled environment) test

18.2.1 A machine employing secondary circuits, other than those with a voltage of 42.4 V peak (30 V rms) or less, shall withstand for one minute without electrical breakdown an essentially sinusoidal potential as specified in Table 18.1 and 18.1.8 applied between:

a) The primary and secondary circuits; and

b) Secondary circuits and earth ground with all chassis-connected components (earth-grounded) disconnected at the chassis-to-earth-ground connection applied successively.

Table 18.1
Magnitude of test potential

Maximum voltage (rms) in the circuit[a]	Test potential
30 or less (42.4 peak)	No test
More than 30 (42.4 peak) but not more than 333.3 (471.3 peak)	Ten times maximum voltage in circuit (maximum of 1,000V rms)
More than 333.3 (471.3 peak) but not more than 1,000 (1,414 peak)	Three times maximum voltage in circuit
More than 1,000 (1,414 peak)	1,750 V plus 1.25 times voltage in circuit

[a] Where the peak voltage is greater than 120 percent of 1.414 times the rms voltage, the circuit shall be tested as if the voltage were peak voltage divided by 1.414.

18.3 Power transformer test

18.3.1 A power transformer of a machine that provides power at a higher potential than the primary windings shall withstand for one minute without breakdown an essentially sinusoidal potential as specified in Table 18.1. This requirements does not apply to windings of transformers that do not serve a prime power-supply function, such as the resonant winding of a constant-voltage transformer.

18.3.2 A power transformer of a machine shall withstand for one 1 minute without electrical breakdown the application of an of an essentially sinusoidal potential of 1000 V plus twice the maximum rated primary or secondary voltage, at rated frequency, between primary and secondary windings, and shall withstand under the same conditions the application of an essentially sinusoidal potential of 1000 V plus twice the rated voltage of each winding, at rated frequency, between each winding and the core or enclosure. The test between primary and secondary windings is omitted for an autotransformer. A dc potential of 1.4 times the rated voltage plus 1000 V may be employed instead of the ac potential.

18.3.3 Primary- and secondary-circuit wiring connected to a transformer is to be disconnected for the test specified in 18.3.1. An essentially sinusoidal source is to be used, and the frequency of the source may be in the range of 180 – 1000 Hz if necessary to prevent saturation of the core.

19 Overvoltage and Undervoltage Tests

19.1 An electromagnet used on a relay or solenoid shall operate as intended when tested as described in 19.2 and 19.3 at the test voltages specified in Table 19.1.

Exception: If limits of operating voltage that may be marked on the unit nameplate in addition to the rated voltage extend beyond the overvoltage and undervoltage values of Table 19.1, the test potential for the overvoltage and undervoltage test is to be the marked value.

19.2 Each relay and solenoid is to be connected to a supply source maintained at the overvoltage until the coils reach a constant temperature. The potential is then to be reduced to the normal test voltage. Each relay and solenoid is to operate as intended at this test voltage. The potential is to be maintained at the normal test voltage until the coils reach constant temperatures. The potential is then to be reduced to the undervoltage condition. Each relay and solenoid is to operate as intended under this test condition. A relay or solenoid that will not be subject to continuous operation is to be energized at the overvoltage and at the normal test voltage for the maximum time permitted by its duty cycle, or until it reaches constant temperature, whichever occurs first.

Table 19.1
Values of voltage for tests

Test	Voltage rating of equipment and corresponding test potential, volts[a]				
	110 – 120	220 – 240	254 – 277	440 – 480	550 – 600
Overvoltage, AC or DC	132	264	305	528	660
Undervoltage, AC	102	204	235	408	510
Undervoltage, DC	96	192	222	384	480

[a] If the rating of the equipment does not fall within any of the indicated voltage ranges, the equipment is to be tested at 110 percent of rated voltage during the overvoltage test, 85 percent of rated AC voltage, and 80 percent of rated DC voltage during the undervoltage test.

19.3 If a relay and a solenoid are energized through a transformer, the voltage adjustments described are to be made at the transformer primary.

20 Use With Water Test

20.1 A cord-and-plug connected machine rated for a nominal 120, 208, or 240 V supply shall comply with the requirements for Leakage Current Test in Standard for Stationary and Fixed Electric Tools, UL 987 after a hose, fitting, or vessel is ruptured one at a time such that the entry of liquid into the machine is at its worst. The machine is then to be operated as in normal use and in any position recommended in the instruction manual for one minute.

20.2 Immediately following the Leakage Current Test specified in 20.1, the machine is to be visually inspected to determine if water entering the enclosure results in a risk of fire, electric shock, or injury to persons.

20.3 A permanently connected machine shall be operated as in normal use and in any position recommended in the instruction manual for one minute, after a hose, fitting, or vessel is ruptured one at a time such that the entry of liquid into the machine is at its worst.

20.4 Immediately following the test specified in 20.3, the machine is to be visually inspected to determine if water entering the enclosure results in a risk of fire, electric shock, or injury to persons.

21 Single Phasing Test

21.1 A machine shall be tested as specified in 21.2. As a result of the test, the machine shall:

a) Not introduce a risk of fire or electric shock; and

b) Be electrically and mechanically operable.

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

22 Fan Locked Rotor Test

22.1 A machine shall be tested as specified in 22.2 and 22.3. As a result of the test, the machine shall not introduce a risk of fire or electric shock.

22.2 The machine is to be operated at rated supply voltage. The fan blades of the cooling fan are to be prevented from rotating. The equipment is to be operated in a normal operating mode in this condition until ultimate results occur. Only one fan is to be locked at a time.

22.3 The test is to continue until the test is terminated by a protective device or until the temperatures remain constant.

23 Blocked Filter Test

23.1 A machine having filtered ventilation openings shall be tested as specified in 23.2. As a result of the test, a machine shall:

a) Not introduce a risk of fire or electric shock; and

b) Be electrically and mechanically operable.

23.2 The machine specified in 23.1 is to be operated at rated supply voltage with the openings blocked to represent clogged filters. The test is to be conducted initially with the ventilation openings blocked approximately 50 percent. The test is then to be repeated under a full blocked condition until terminated by a protective device or until the temperatures remain constant.

24 Drive Motor Locked Rotor Test

24.1 A machine provided with motor speed drive controls shall be tested as specified in 24.2 and 24.3. As a result of the test, the machine shall not introduce a risk of fire or electric shock. Opening of the line fuse is an acceptable result of this test. See also 24.3.

24.2 The drive motor rotor is to be locked in place to prevent rotation. The equipment is then to be operated at rated voltage until ultimate results occur.

24.3 Unless it has been shown to be acceptable for the purpose, motor protection is to be disabled for this test.

25 Emergency Stop Operation Test

25.1 An emergency stop or a safety door interlock of a machine shall shall perform its intended function to either preclude an action from being initiated in an unintended manner or stop an action, or both, when the equipment is tested in accordance with 25.2.

25.2 The machine is to be operated at rated supply voltage until maximum speed is reached. Each emergency stop button or safety door interlock as described in 25.1 is to be actuated separately. The equipment shall stop operating within 5 s of depressing the stop button or actuating the safety door interlock.

25.3 With respect to the door interlock specified in 25.1, with the machine off, interlocks intended to preclude an action from being initiated in an unintended manner shall be actuated separately and machine operation initiated. Each such safety door interlock shall prevent initiating of the action it is intended to preclude.

26 Breakdown of Components Test

26.1 A capacitor, diode, or other solid-state component whose failure may result in a risk of fire or electric shock is to be subjected to the Breakdown of Components Test in the Standard for Industrial Control Equipment, UL 508.

27 Power Loss and Power Restoration Test

27.1 A machine integrally equipped with a no/low voltage control shall be tested as specified in 27.2. As a result of the test, the machine shall not introduce a risk of injury to persons that may be caused by inadvertent operation or uncontrolled movement.

27.2 The machine shall be operated at rated supply voltage. The power is then to be shut off while the machine is operating and then restored to determine the effect of the power loss and restoration on the machine. The test is to be repeated while the machine is operating in each mode (such as auto and teach).

28 Strain Relief Test

28.1 When tested as specified in 28.2, a strain-relief device shall withstand without damage to the cord or conductors and without displacement a direct pull of 35 lb (156 N) applied to the cord for one minute. Supply connections within the equipment are to be disconnected from terminals or splices during the test.

28.2 A 35-lb (15.9-kg) weight is to be suspended on the cord and supported by the machine so that the strain-relief means will be stressed from any angle that the construction of the machine permits. The strain relief is not acceptable if, at the point of disconnection of the conductors, there is such movement of the cord as to indicate that stress would have resulted on the connections.

28.3 A pigtail lead intended for field-wiring connection shall withstand without damage or displacement a direct pull of:

a) 20 lb-f (89 N) for one minute applied to a lead extending from the enclosure such as through a hub or nipple; and

b) 10 lb-f (44.5 N) for one minute applied to a lead within a wiring compartment.

29 Push-Back Strain Relief Test

29.1 To determine compliance with 8.3, a machine shall be tested as specified in 29.2 without occurrence any of the conditions specified in 8.3 (a) – (d).

29.2 The supply cord or lead is to be held 1 in (25.4 mm) from the point where the cord or lead emerges from the machine and is then to be pushed back into the machine. When a removable bushing which extends further than 1 in is present, it is to be removed prior to the test. When the bushing is an integral part of the cord, then the test is to be carried out by holding the bushing. The cord or lead is to be pushed back into the machine in one inch increments until the cord buckles or the force to push the cord into the product exceeds 6 lb-f (26.7 N). The supply cord or lead within the machine is to be manipulated to determine compliance with 8.3.

30 Resistance of Grounding Path Test

30.1 The resistance of the grounding path between a dead metal part and the equipment-grounding terminal or lead or the point of attachment of the wiring system shall not be more than 0.1 Ω.

30.2 With reference to the requirements in 30.1, the resistance may be determined by any convenient method. If unacceptable results are recorded, either a direct or alternating current at a potential of not more than 12 V, and equal to the current rating of the largest branch-circuit overcurrent-protective device that may be employed with the machine is to be passed from the equipment-grounding terminal or from the point of attachment of the wiring system to the dead metal part, and the resulting drop in potential is to be measured between those two points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes passing between the two points.

31 Flexing Test

31.1 Wiring of a machine that is subjected to movement at times other than during installation and servicing shall be tested as specified in 31.2. Following the test, all safety-related functions, including emergency stop, slow speed in teach mode, single point of control, and the like shall operate normally.

31.2 The wiring harness is to be tested by cycling the mechanism in such a way to flex the wiring harness through its maximum length of travel permitted by the design. The duration of the test is to be 100,000 cycles. The machine shall then be subjected to the dielectric voltage withstand test requirements in 18.1. The potential is to be applied between each motor power conductor in the cable assembly and all other motor power conductors, all other conductors, and to accessible metal parts of the manipulator arm. The wiring is to be examined for damage and to determine if any conductors are broken or if individual strands have penetrated the insulation.

32 Physical Stability Test

32.0 A machine installed in accordance with the manufacturer's instructions shall not overturn when any doors, empty drawers, movable tables, or other appurtenances are placed in any position to which they are capable of being moved without the use of a hand tool. The machine need not be capable of normal operation when components are positioned for this test.

32.1 All machines shall be provided with bolt holes or other means for securing to the floor or supporting structure.

Exception: A machine that is provided with instructions to the user to fasten the machine to the bench top or floor prior to installation is not required to comply with this requirement. See 40.4.

32.2 A machine intended to be used without being fixed to the floor shall not tip over when tilted 10 degrees from its intended, upright position. The test is to be conducted under the most unfavorable conditions. The combination machine and attachment is to be placed on the inclined plane with all doors, drawers, and other movable or adjustable parts in the position tending to decrease the stability of the machine. The combination is to be tested in all possible positions that may typically be encountered while the attachment is:

a) In a position of being assembled or prepared prior to operation – for example, positioning parts of the attachment prior to adding functional parts;

b) In a position as if being used to perform one of its intended functions; and

c) In a position of being disassembled or cleaned after operation – for example, with applicable functional parts removed.

32.3 The requirements in 32.2 apply to all free standing machines. A free standing machine is defined as floor standing and not intended to be secured to other units or to the floor or other parts of the building.

33 Lifting/Transportation Means Loading Test

33.1 The lifting or transportation eyebolts or similar means when provided on a controller and machine shall be tested as specified in 33.2. As a result of the test, there shall be no deformation or damage of the lifting or securing means or enclosure to which these are attached.

33.2 The lifting or transportation means specified in 33.1 are to be subjected to 2 times their maximum load for 5 minutes.

34 Parts Subject to Pressure Tests

34.1 A part or an assembly that is subject to air or vapor pressure, including the vapor pressure in a vessel containing only a superheated fluid, during normal or abnormal operation shall withstand a pressure equal to the highest of the following that is applicable.

a) Five times the pressure corresponding to the maximum setting of a pressure-reducing valve provided as part of the assembly, but not more than five times the marked maximum supply pressure from an external source and not more than five times the pressure setting of a pressure-relief device provided as a part of the assembly.

b) Five times the marked maximum supply pressure from an external source, unless the pressure is limited by a pressure-relief device in accordance with item (a).

c) Five times the pressure setting of a required pressure-relief device.

d) Five times the maximum pressure that can be developed by an air compressor that is part of the assembly unless the pressure is limited by a pressure-relief device in accordance with (a).

e) Five times the working pressure marked on the part.

Exception No. 1: A section of a pressure system constructed of continuous tubing or of lengths of tubing connected by hard-soldered, brazed, or welded joints provided the wall thickness of tubing is not less than the value specified in Table 34.1 is not required to be tested.

Exception No. 2: A pressure vessel bearing the ASME code inspection symbol, other than the UM symbol, is not required to be tested provided the vessel is marked with a value of working pressure not less than that to which it is subjected during normal or abnormal operation.

Exception No. 3: A part or assembly that is subject to air pressure, such as an air hose, contained entirely within an enclosure is not required to be tested if it can be determined that leakage or rupture does not result in a risk of electric shock or injury to persons.