NFPA No.

79

ELECTRICAL STANDARD FOR

METALWORKING MACHINE TOOLS 1969

$1.00

NATIONAL FIRE PROTECTION ASSOCIATION
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Official NFPA Definitions

Adopted Jan. 23, 1964. Where variances to these definitions are found, efforts to eliminate such conflicts are in process.

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Electrical Standard for

Metalworking Machine Tools

NFPA No. 79 — 1969

1969 Edition of No. 79

The 1969 edition of the Electrical Standard for Metalworking Machine Tools is a reconfirmation of the 1965 edition without substantive changes. The reconfirmation action was taken by the Committee in compliance with NFPA Regulations Governing Technical Committees. Editorial changes have been made to update reference material. The reconfirmation action was approved by the Correlating Committee of the National Electrical Code Committee and by the 1969 NFPA Annual Meeting.

Origin and Development of No. 79

This Standard was first submitted at the 1961 NFPA Annual Meeting under the title "Electrical Standard for Machine Tools" and was tentatively adopted subject to comments. It was extensively revised and resubmitted at the 1962 Annual Meeting when it was officially adopted. In 1965 a revised edition was adopted and this 1969 issue reconfirms the 1965 text.

To better coordinate its work, this Committee reports to the Association through the Correlating Committee of the National Electrical Code Committee. The primary reason is to correlate this Standard and the National Electrical Code, especially with respect to Article 670 thereof.

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SCOPE: Standards for the electrical features of metalworking machine tools not portable by hand. Reports to the Association through the Correlating Committee of the National Electrical Code Committee.

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Electrical Standard for

Metalworking Machine Tools

NFPA No. 79 — 1969

PREFACE

A Metalworking Machine Tool, as covered by this Standard, is defined herein as follows:

> A metal cutting machine tool is a power-driven machine, not portable by hand, used for the purpose of removing metal.
>
> A metal forming machine tool is a power-driven machine, not portable by hand, used to press, forge, emboss, hammer, blank, or shear metal.

Other types of electrically powered production and processing equipment are excluded, and their electrical equipment and installations should be judged under the general provisions of the National Electrical Code (NFPA No. 70 — 1969, USAS C1-1969), rather than this Standard.

In September 1941, the machine tool industry wrote its first Electrical Standard to make machine tools safer to operate, more productive, less costly to maintain and to improve the quality and performance of their electrical components. That particular standard served as an American "War Standard."

To study the special electrical problems involved with machine tools, the Electrical Section of the National Fire Protection Association in 1941 sanctioned a Special Subcommittee on Wiring, Overcurrent Protection and Control of Motor Operated Machine Tools. This Subcommittee, cooperating with machine tool builders, manufacturers of control equipment, and Underwriters' Laboratories, Inc., conducted tests and investigated the peculiar conditions involved with machine tools which might warrant exception to certain specific National Electrical Code requirements. This investigation resulted on August 4, 1942, in an Interim Amendment and first appeared in a 1943 Supplement to the 1940 Edition of the National Electrical Code as Article 670, Machine Tools. It remained essentially unchanged through the 1959 edition.

Meanwhile, manufacturers of other types of industrial equipment erroneously began to follow the specialized practices permitted by Article 670. Late in 1952 a Technical Subcommittee on Fundamentals of Electrically Operated Production Machinery and Material Handling and Processing Equipment for Fixed Locations was organized to attempt to group in one article the special requirements

of this broad field. The extremely broad scope introduced so many problems, that in December 1956, this Technical Subcommittee was reorganized into an NFPA Committee whose scope was limited to Machine Tools and whose objective was the preparation of this NFPA Standard with corresponding revisions in Article 670 in the National Electrical Code.

The electrical equipment of a modern industrial machine tool may vary from that found on a single motor machine such as a drill press which performs a simple, repetitive operation, to that of the very large, multimotored automatic machines which involve highly complex electrical control systems and equipment. Generally these machines are especially designed, factory wired and tested by the builder, and then erected in the plant in which they will be used. Because of their importance to the production of the plant, and their usual high cost, they are customarily provided with many safeguards and other devices, not often incorporated in the usual motor and control application as contemplated by the National Electrical Code.

Although these machines may be completely automatic, they are constantly attended, when operating, by a highly skilled operator. The machine tool usually incorporates many special devices to protect the operator, protect the machine and building against fires of electrical origin, protect the machine and work in process against damage due to electrical failures, and protect against loss of production due to failure of a machine component. To provide these safeguards, it may be preferable to sacrifice deliberately a motor or some other component, rather than to chance injury to the operator, the work, or the machine. It is because of such considerations that this standard varies from the basic concepts of motor protection as contained in the National Electrical Code.

It is the intent of this Standard to provide for the protection of both persons and property against injury or damage by fires or accidents of electrical origin. Because certain practices in this industry provide better than a bare minimum of safety, it was deemed advisable to include some of these desirable practices in this Standard as "Recommendations" rather than as minimum "Requirements."

CHAPTER 100. GENERAL

100-1. Purpose.

(a) The purpose of this Electrical Standard is to provide detailed information for the application to machine tools of electrical apparatus which will promote safety to life and property.

(b) This Standard is a minimum Standard and is not intended to limit or inhibit the advancement of the art of electrical or mechanical engineering.

100-3. Scope.

(a) The provisions of this Standard apply to all electrical equipment, apparatus, and wiring furnished as a part of an industrial machine tool, commencing at the place of connection of the supply to the machine tool electrical equipment.

(b) The provisions of this Standard apply to electrical equipment for use on circuits which operate from a supply voltage of 600 volts or less.

(c) This Standard shall not be considered adequate for machine tools intended for use in areas defined as hazardous locations by the National Electrical Code (NFPA No. 70—1968, USAS C1-1968).

(d) This Standard is not intended to apply to:

(1) Fixed or portable tools judged under the requirements of a testing laboratory acceptable to the authority having jurisdiction.

(2) Tools on which the electrical equipment consists only of a single motor, motor-controller, push button stations, and work lights.

(e) The installation of the machine tool is covered by Article 670 of the National Electrical Code (NFPA No. 70 — 1968, USAS C1-1968).

100-5. Definition of Metalworking Machine Tools. For the purpose of this Standard, machine tools are defined as follows:

(a) A metal cutting machine tool is a power-driven machine, not portable by hand, used for the purpose of removing metal.

(b) A metal forming machine tool is a power-driven machine, not portable by hand, used to press, forge, emboss, hammer, blank, or shear metal.

100-7. Mandatory and Advisory Rules. Mandatory rules of this Standard are characterized by the use of the word "shall." Advisory rules are characterized by the use of the word "should," or are stated as recommendations of that which is advised but not required.

CHAPTER 110. DIAGRAMS, INSTRUCTIONS, AND NAMEPLATES

110-1. Diagrams. Complete diagrams showing all of the electrical circuits on the machine tool shall be provided.

110-3. Instructions. Information referring to the installation, operation, and maintenance of the equipment shall be furnished.

110-5. Equipment Nameplates.

(a) A permanent nameplate listing supply voltage, phase, frequency, full-load current (see Note 1), ampere rating of largest motor, short circuit interrupting capacity of the machine overcurrent protective device if furnished, and diagram number shall be attached to the control equipment enclosure or machine where plainly visible after installation.

NOTE 1: The full load current shall be not less than the sum of the full load currents required for all motors and other equipment which may be in operation at the same time under normal conditions of use. Where unusual type loads, duty cycles, etc., require oversized conductors, the required capacity shall be included in the marked "full load current."

NOTE 2: Where more than one incoming supply circuit is to be provided, the nameplate shall state the above information for each circuit.

(b) Where overcurrent protection is provided in accordance with Section 130-3, the machine tool shall be permanently marked "Overcurrent protection provided at machine supply terminals."

110-7. Machine Marking. The machine tool shall be marked with the builder's name, trademark, or other identification symbol.

110-9. Component Marking.

(a) Where electrical equipment is removed from its original enclosure or where equipment is so placed that the manufacturer's identification plate is not readily visible, an additional identification plate shall be permanently attached to the machine tool or enclosure.

(b) Where the motor nameplate or the connection diagram plate is not visible, an additional plate shall be provided where it can be easily read.

(c) Nameplates or identification plates shall not be removed from electrical equipment.

110-11. Device Identification.

(a) All control panel devices shall be plainly and permanently identified with the same designation as shown on the diagrams.

Exception: Where the size or location of the devices make individual identification impractical, group identification shall be used.

(b) All devices external to the control panel shall be identified by a nameplate with the same designation as shown on the diagrams, and mounted adjacent to (not on) the device.

Exception: Devices covered by Section 110-13.

110-13. Function Identification. Each control station device (push button, indicating light, selector switch, etc.) shall be identified as to its function by a legend plate.

CHAPTER 120. SUPPLY CIRCUIT DISCONNECTING MEANS

120-1. Type. A manually operated disconnecting means shall be provided for each incoming supply circuit and shall be of the following types: A fusible or nonfusible motor circuit switch, or a circuit breaker, or a circuit interrupter (circuit breaker without trip elements).

120-3. Rating.

(a) The ampacity of the disconnecting means shall be not less than 115 per cent of the sum of the full load currents required for all equipment which may be in operation at the same time under normal conditions of use.

(b) The interrupting capacity of the disconnecting means shall be not less than the sum of the locked rotor current of the largest motor plus the full load current of all other connected operating equipment.

(c) Fusible motor circuit switches or circuit breakers shall be applied in accordance with Chapter 130.

120-5. Position Indication. The disconnecting means shall plainly indicate whether it is in the open or closed position.

120-7. Supply Conductors To Be Disconnected. Each disconnecting means shall disconnect all ungrounded conductors of a single supply circuit simultaneously. Where there is more than one source, additional individual disconnecting means shall be provided for each supply circuit, so that all supply to the machine may be interrupted.

120-9. Connections To Supply Lines. It is recommended that the incoming supply line conductors terminate at the disconnecting means with no connection to terminal blocks or other devices ahead of the disconnecting means.

120-11. Exposed Live Parts. With the disconnecting means open, there shall be no exposed live parts.

120-13. Mounting.

(a) The disconnecting means shall be mounted within the control enclosure, or adjacent thereto. It is recommended that it be mounted at the top of the control panel with no other equipment mounted directly above it.

(b) Where more than one disconnecting means is provided for multiple supply circuits, they shall be grouped in one location.

120-15. Interlocking. The disconnecting means shall be mechanically or electrically interlocked, or both, with the control enclosure doors.

120-17. Operating Handle.

(a) The operating handle of the disconnecting means shall be readily accessible.

(b) The center of the grip of the operating handle of the disconnecting means, when in its highest position, shall not be more than 6½ feet above the floor and it is recommended that it be at least 3 feet above the floor.

(c) The operating handle shall be so arranged that it may be locked in the "Off" position.

(d) When the control enclosure door is closed, the operating handle shall positively indicate whether the disconnecting means is in the open or closed position.

TYPICAL DIAGRAMS — PROTECTION OF MACHINE TOOL ELECTRICAL CIRCUITS

LINE	REFERENCE	SINGLE MTR.	MULTI MOTOR		
A	SUPPLY N. E. CODE, ARTICLE 670				
B	DISCONNECTING MEANS CHAPTER 120				
C	OVERCURRENT PROTECTION (WHEN SUPPLIED) SECTION 130-3				
D	ADDITIONAL OVERCURRENT PROTECTION (AS REQUIRED) SECTION 130-5				
E	CONTROL CIRCUITS CONDUCTORS SECT. 130-15 TRANSFORMER SECT. 130-19 UNDERVOLTAGE SECT. 130-21				
F	MOTOR CONTROLLERS SECTION 150-7				
G	MOTOR OVERLOAD SECTION 130-11				
H	MOTORS CHAPTER 230 SPECIAL MOTOR OVERLOAD SECTION 130-13				
	ALL CONDUCTORS CHAPTER 200	FIG I	FIG II	FIG III	FIG IV

CHAPTER 130. PROTECTION

130-1. Machine Tool Circuits. Figures I, II, III, and IV show typical circuits which are acceptable for protection of machine tool motors and controls. Protective interlocks are not shown. (See page 79-10.)

130-3. Supply Conductor and Machine Overcurrent Protection. The overcurrent protection as shown in line C of the Typical Diagrams, Figures I through IV inclusive, may or may not be furnished as part of the machine tool. Where furnished as a part of the machine tool it shall consist of a single circuit breaker or set of fuses and the machine shall bear the marking required in Section 110-5.

130-5. Additional Overcurrent Protection. The additional overcurrent protection shown in line D of the Typical Diagrams, Figures III and IV, shall be provided as part of the machine control. Such overcurrent protection (fuse or overcurrent trip unit of a circuit breaker) shall be placed in each ungrounded branch circuit conductor. A circuit breaker shall open all ungrounded conductors of the branch circuit.

130-7. Location of Protective Devices. Overcurrent protective devices shall be located at the point where the conductor to be protected receives its supply, except as follows:

Exception No. 1. Where all of the following conditions are complied with, (1) the conductor has an ampacity of at least one-third that of the conductor from which it is supplied, and (2) it is suitably protected from physical damage, and (3) is not over 25 feet long, and (4) terminates in a single circuit breaker or set of fuses.

Exception No. 2. Where all of the following conditions are complied with, (1) the conductor has an ampacity of not less than the sum of the maximum continuous load currents supplied, and (2) is not over 10 feet long, and (3) does not extend beyond the control panel enclosure.

130-9. Motor Branch Circuits.

(a) The overcurrent protective device for a branch circuit supplying a single motor shall be capable of carrying the starting current of the motor. Overcurrent protection shall be considered as being obtained when the overcurrent device has a rating or setting not exceeding the values given in Table 130-A. Where the overcurrent protection specified in the Table is not sufficient for the starting current of the motor, it may be increased to a maximum of 400 per cent of the motor full load current for thermal-magnetic

Table 130-A

Maximum Rating or Setting of Motor Branch Circuit Protective Devices for Various Types of Motors

TYPE OF MOTOR	Per Cent of Full-Load Current		
	Fuse Rating		Thermal-Magnetic Circuit Breaker Rating
	Time Delay or Dual Element	Nontime Delay	
MOTORS MARKED WITH CODE LETTER INDICATING LOCKED-ROTOR KVA			
All A.C. Single-Phase and Polyphase Squirrel-Cage and Synchronous Motors.			
Code Letter A	125	150	150
Code Letter B to E	125	250	200
Code Letter F to V	125	300	250
MOTORS NOT MARKED WITH CODE LETTER INDICATING LOCKED-ROTOR KVA			
Single-Phase, All Types	125	300	250
Squirrel-Cage and Synchronous	125	300	250
High Reactance Squirrel-Cage:			
Not more than 30 Amp. Full-Load Current	125	250	250
More than 30 Amp. Full-Load Current	125	200	200
Wound Rotor	125	150	150
Direct Current	125	150	150

trip circuit breakers and nontime delay fuses, and a maximum of 200 per cent for time delay or dual element fuses.

(b) Two or more motors and their control equipment may be connected to a single branch circuit provided all of the following conditions are complied with:

(1) The maximum size of a conductor (selected from Table 200-A) connected to a motor controller shall not exceed the values given in Table 130-B.

(2) The rating or setting of the overcurrent protective device shall be as low as practicable, and shall not exceed the values in Table 130-C for the smallest conductor in the circuit.

(3) The motor and controller circuits shall be so arranged that a minimum number of branch circuit overcurrent protective devices are used.

130-11. Motor Overload.

(a) Overload devices shall be provided to protect each motor, motor controller, and branch circuit conductors against excessive heating due to motor overloads or failure to start.

(b) Resetting of the overload device shall not restart the motor.

(c) The minimum number and location of overcurrent devices shall be determined from Table 130-D.

Table 130-B

Maximum Conductor Size for Given Motor Controller Size*

Motor Controller Size	Maximum Conductor Size, AWG or MCM
0	10
1	8
2	4
3	0
4	000
5	500

*See USAS-C 19.1—1959.

Table 130-C

Relationship Between Conductor Size and Overcurrent Protection Rating for Power Circuits

Conductor Size, AWG	Max. Rating of Overcurrent Protective Device, Amp.
14	60
12	80
10	100
8	150
6	200
4	250
3	300
2	350
1	400
0	500
00	600

Table 130-D

Number and Location of Overcurrent Devices

Kind of Motor	Supply System	Number and Location of Overcurrent Units (such as trip coils, relays, etc.)
1-phase A.C. or D.C.	2-wire, 1-phase A.C. or D.C. ungrounded	1 in either conductor
1-phase A.C. or D.C.	2-wire, 1-phase A.C. or D.C., one conductor grounded	1 in ungrounded conductor
1-phase A.C. or D.C.	3-wire, 1-phase A.C. or D.C., grounded-neutral	1 in either ungrounded conductor
3-phase A.C.	3-wire, 3-phase A.C., ungrounded	2 in any 2 conductors
3-phase A.C.	3-wire, 3-phase A.C., one conductor grounded	2 in ungrounded conductors
3-phase A.C.	3-wire, 3-phase A.C. grounded-neutral	2 in any 2 conductors
3-phase A.C.	4-wire, 3-phase A.C. grounded-neutral or ungrounded	2 in any 2 conductors except the neutral

NOTE: For 2-phase power supply systems refer to National Electrical Code, Section 430-37.

Table 130-E

Relationship Between Conductor Size and Overcurrent Protection Rating for Control Circuits

Conductor Size, AWG	Max. Rating of Overcurrent Protective Device, Amp.
22	6
20	10
18	15
16	30
14	45
12	60
10	70

130-13. Special Motor Overload. Short-time rated motors or high reversing duty motors which cannot be adequately protected by external overload devices shall be protected by a thermal device mounted in the motor and sensitive to the temperature of the motor, or to both motor temperature and current. In addition, such motors should be protected against stalled conditions.

130-15. Control Circuit Conductors.

(a) The conductors in the control transformer secondary circuit shall be protected against overloads and short circuits. A branch circuit overcurrent device (fuse or circuit breaker) shall be connected in series with each branch control circuit. Where the circuit is grounded, the protective device shall be located only in the ungrounded side.

(b) The rating or setting of the overcurrent protective device shall be as low as practicable, and shall not exceed the values in Table 130-E for the smallest conductor in the circuit.

130-17. Lighting Branch Circuits. Overcurrent protection for lighting branch circuits shall not exceed 15 amperes.

130-19. Control Circuit Transformer. The control circuit transformer shall be protected against secondary short circuits. Where the circuit is grounded, the protective device shall be located only in the ungrounded side [see 190-3(b)(2)].

NOTE: The same overcurrent device may be used to provide the protection called for in Sections 130-15, 130-17, and 130-19.

130-21. Undervoltage. Undervoltage protection shall be provided for all equipment which creates a hazardous condition should a motion be initiated upon the return of power after an undervoltage condition.

CHAPTER 140. CONTROL CIRCUITS

140-1. Source of Control Power. The source of supply for all control circuits shall be taken from the load side of the main disconnecting means.

140-3. Control Circuit Voltages.

(a) Alternating Current (AC) control voltage shall be 115 volts, single phase, obtained from a transformer with an isolated secondary winding, except as follows:

Exception No. 1. Other voltages may be used, where necessary, for the operation of electronic, precision, static, or similar devices used in the control circuit.

Exception No. 2. Exposed, grounded control circuits may be used when supplied by a transformer having a primary rating of not more than 115 volts, a secondary rating of not more than 25 volts and a capacity of not more than 50 volt-amperes. (See Section 240-1.)

Exception No. 3. Any electro-mechanical magnetic device having an inrush current exceeding 20 amperes at 115 volts may be energized at line voltage through relay contacts. The relay coil shall be connected to the control circuit.

(b) Direct Current (DC) control voltage shall not exceed 250 volts.

Exception. Other voltages may be used, where necessary, for the operation of electronic, precision, static, or similar devices used in the control circuit.

140-5. Connection of Control Devices. It is recommended that all operating coils of electro-mechanical magnetic devices be connected to the same side of the control circuit, and all contacts should be connected to the other side of the control circuit.

140-7. Interlocking. Where there is more than one electrically controlled or operated device on a machine tool, and where possible damage may be caused by the failure of any one device to function properly, the circuits shall be arranged with protective interlocks. Where practicable, these interlocks shall interrupt all operations, provided such interruption will not create a hazardous condition.

140-9. Sequencing. Where operation of control devices in improper sequence can create a hazardous condition, circuits shall be so interlocked as to insure proper sequence of operation.

CHAPTER 150. CONTROL COMPONENTS AND EQUIPMENT

150-1. Panel Mounted Devices. It is recommended that all panel mounted control devices be front connected and front wired.

150-3. Connections. It is recommended that convenient means for making conductor connections be provided on or adjacent to all control devices mounted in the control enclosure.

150-5. Subpanels. It is recommended that subpanels with concealed or inaccessible internal wiring or components be mounted and wired so as to be easily removable.

150-7. Manual and Electro-Mechanical Motor Controllers.

(a) Each controller shall be capable of starting and stopping the motor or motors which it controls, and for alternating current motors shall be capable of interrupting the stalled rotor current of the motor or motors.

(b) Alternating current motor controllers shall open all of the supply conductors leading to associated motors.

Table 150-A

Horsepower Ratings for Special Duty Motor Controller Applications*

Size of Motor Controller	Horsepower at	
	220 VOLTS	440/550 VOLTS
0	1	1
1	3	5
2	10	15
3	20	30
4	30	60
5	75	150
6	150	300

*See USAS-C19.1 — 1959.

(c) Where machine operation requires a motor controller to repeatedly open high motor current, such as in plug-stop, plug-

reverse, or jogging (inching) duty, requiring continuous operation with more than five openings per minute, the controller shall be derated in accordance with Table 150-A.

(d) Several motors may be operated from one motor controller if separate overload protection is provided for each motor, and the horsepower rating of the controller is not exceeded.

CHAPTER 160. CONTROL ENCLOSURES AND COMPARTMENTS

160-1. Type. Enclosures and compartments shall be nonventilated and constructed to exclude such materials as dust, flyings, oil and coolant.

Exception: Equipment normally requiring ventilation may be housed in ventilated enclosures or compartments provided they are so located that the enclosed equipment is capable of operating satisfactorily and without hazard.

160-3. Compartment Location. Compartments for built-in control shall be completely isolated from coolant and oil reservoirs. The compartment shall be readily accessible and completely enclosed; it shall not be considered enclosed where it is open to the floor, the foundation upon which the machine tool rests, or to other compartments of the machine tool which are not clean and dry.

160-5. Wall Thickness.

(a) The walls of compartments shall be not less than the following: No. 14 USS gage for sheet steel; ⅛ inch for cast metal; or 3/32 inch for malleable iron.

(b) Enclosures shall conform with the applicable requirements of Standards for Industrial Control Apparatus (USAS-C19.1 — 1959).

160-7. Dimensions. The depth of the enclosure or compartment including doors shall be not less than the maximum depth of the enclosed equipment plus the required electrical clearances.

160-9. Doors. All enclosures or compartments shall have hinged doors which swing about a vertical axis and shall be held closed with captive fasteners or vault-type hardware. The thickness of the door shall be not less than that indicated in Section 160-5 and it is recommended that the width not exceed 36 inches.

160-11. Gaskets. Where gaskets are used they shall be of an oil-resistant material and shall be securely attached to the door or enclosure.

CHAPTER 170. LOCATION AND MOUNTING OF CONTROL EQUIPMENT

170-1. General Requirements.

(a) Control equipment shall be so mounted and located that it will not interfere with machine adjustments or maintenance.

(b) It is recommended that control equipment and terminals be located above the operating floor line of the machine to provide safe and ready access.

(c) Pipe lines, tubing, or devices for handling air, gases, or liquids shall not be located in enclosures or compartments containing electrical control equipment.

170-3. Control Panels.

(a) It is recommended that all control devices normally panel mounted for any one machine be mounted in one enclosure or compartment and where more than one enclosure is required, that they be grouped together.

(b) All devices mounted on the control panel and connected to supply circuit voltage, or to both supply and control circuit voltages, shall be grouped above or to the side of devices connected only to control voltages.

Exception: Where supply circuit voltage is 150 volts or less.

(c) The panel shall not be set to such depth from door frame or other projecting portion of machine as to interfere with inspection and servicing.

170-5. Control Panel Enclosure.

(a) The enclosure shall be mounted in such a manner and position as to guard it against oil, dirt, coolant, and dust, and to minimize the possibility of damage from floor trucks or other moving equipment.

(b) It is recommended that no portion of the machine immediately above the door opening and less than 6 feet from the floor project more than 6 inches beyond the door frame.

170-7. Clearance in Enclosures.

(a) Enclosures or compartments for mounting control panels shall provide ample room between panel and case for proper wiring and maintenance.

(b) Exposed, nonarcing, bare, live parts within an enclosure or compartment shall have an air space between them and the uninsulated walls of the enclosure or compartment, including conduit

fittings, of not less than ½ inch. Where barriers between metal enclosures or compartments and arcing parts are required, they shall be of flame-retardant insulating materials which will not readily carbonize.

170-9. Machine Mounted Components.

(a) Control equipment such as limit switches, brakes, solenoids, position sensors, etc., shall be mounted rigidly in a readily accessible and reasonably dry and clean location, and shall be free from possibility of accidental operation by normal movement of machine components or operator. Such equipment shall be mounted with sufficient clearance from surrounding surfaces to make its removal and replacement easy.

(b) All limit switches or position sensors shall be so installed that accidental overtravel by the machine will not damage the limit switch or sensor.

(c) Solenoids shall be accessible and shall not be submerged in oil.

Exception: Where the solenoid is sealed in an individual oil-filled container.

CHAPTER 180. OPERATOR'S CONTROL STATIONS AND EQUIPMENT

180-1. Push Buttons, Selector Switches, Indicating Lights.

(a) All push button and selector switch operators and indicating lights shall be of the oiltight type.

Exception: Pendent stations, Paragraph 180-11(a).

(b) It is recommended that individually mounted drum type switches and toggle switches be oiltight.

(c) Emergency push-button operators shall be of the palm or mushroom type.

(d) "Stop" push-button operators shall be red in color, and the red color shall not be used to identify push-button operators having other functions.

180-3. Fixed Stations. Fixed control stations shall be dust-, moisture-, and oiltight.

180-5. Arrangement of Control Station Components. All start push buttons shall be mounted above or to the left of their associated stop buttons.

Exception: Start push buttons in series, such as operating buttons on punch presses.

180-7. Legend Plates. Legend plates shall be so located that they can be easily read by the machine operator.

180-9. Location of Control Stations.

(a) All stations shall be mounted in a reasonably clean and dry location.

(b) Controls shall be within easy reach of the machine operator, and shall be so placed that he does not have to reach past spindles or other moving parts which might cause injury.

(c) Controls shall be free from possibility of accidental operation by normal movement of the machine, operator or work.

180-11. Pendent Stations.

(a) It is recommended that oiltight controls and enclosures be used for pendent stations.

(b) A wobble stick or rod operator at the bottom of the station may be used for "Emergency Stop" controls.

(c) For grounding and bonding provisions, see Section 240-7, and Paragraph 240-9(c).

CHAPTER 190. ACCESSORIES AND LIGHTING

190-1. Attachment Plugs and Receptacles (External to Control Panel).

(a) Attachment plugs and receptacles shall be of a locking type to prevent accidental "disconnections," and approved for the voltage applied. Where used on 300 volts or over they shall be skirted and constructed to contain any arc generated when a connection is made or broken.

(b) The construction of attachment plugs and receptacles shall be such that if a grounding connection is provided, it will be automatically made before any live connections are made and will not be broken until all current-carrying parts of the attachment plug are dead. A grounding prong shall not be used as a current-carrying part.

(c) They shall be provided with gaskets to prevent entrance of oil or moisture when in operating position, and it is recommended that means be provided to seal effectively the receptacle when the plug is removed.

190-3. Control Panel and Machine Work Lights.

(a) The lighting circuit voltage shall not exceed 150 volts between conductors.

(b) Lights shall be supplied from one of the following sources:

(1) A separate isolating transformer connected to the load side of the machine tool disconnecting means.

(2) The 115-volt machine tool control circuit. (See 130-19.)

(3) The plant lighting circuit.

(c) The conductors to stationary or built-in lights shall be type MTW, and the conductors within the fixtures shall be not smaller than No. 18 AWG.

(d) Flexible cords shall be all thermoplastic Type STO.

(e) For grounding provisions, see Section 240-3.

(f) Incandescent lampholders shall be of the medium-base screwshell type and shall be switchless. The fixture shall not incorporate an attachment plug receptacle.

(g) Stroboscopic effects from lights shall be avoided.

CHAPTER 200. CONDUCTORS

200-1. Power and Control.

(a) Conductors (other than those in Section 200-3.) shall conform to one of the following:

(1) Machine tool wire shall be type MTW and the conductors shall be of annealed stranded copper, conforming to the requirements of ASTM designation B8, Class C, for nonflexing service and ASTM designation B174, Class K, for flexing service; and the insulation shall be flame retardant and suitable for use at maximum conductor temperature of 90° C in dry locations and 60° C where exposed to moisture, oil, or coolants.

(2) Multiconductor, all thermoplastic cord, Type STO.

(3) Special multiconductor control cables, having individual conductors of type MTW construction and a jacket suitable for the purpose.

(4) Mineral insulated metal sheathed cable, Type MI.

(b) Conductors shall be not smaller than:

	AWG
(1) Power Circuits	No. 14
(2) Lighting and control circuits on the machine and in raceways	No. 16

Exception: No. 18 AWG may be used in a jacketed, multiconductor cable assembly.

(3) Control circuits on panels	No. 18

(4) Electronic, precision, and static control. See Section 200-3.

(c) The current carried by conductors shall not exceed the values given in Table 200-A.

(d) Motor circuit conductors shall have an ampacity not less than 125 per cent of the full load current rating of the highest rated motor in the group, plus the sum of the full load current ratings of all other connected motors and apparatus in the group which may be in operation at the same time.

200-3. Electronic, Precision, and Static Control.

(a) Conductors used to connect electronic, precision, static, or similar devices or panels shall conform to the following:

Table 200-A

Conductor Ampacity

Conductor Size AWG	Ampere Rating In		Conductor Size AWG or MCM	Ampere Rating In	
	Conduit or Raceway	Control Enclosure		Conduit or Raceway	Control Enclosure
22	3	3	00	145	225
20	5	5	000	165	260
18	7	7	0000	195	300
16	10	10	250	215	340
14	15	20	300	240	375
12	20	25	350	260	420
10	30	40	400	280	455
8	40	55	500	320	515
6	55	80	600	355	575
4	70	105	700	385	630
3	80	120	750	400	655
2	95	140	800	410	680
1	110	165	900	435	730
0	125	195	1000	455	780

(1) Conductor insulation shall be suitable for the purpose and adequate for the voltage on that conductor. Where the conductors are run with, or adjacent to, other conductors, all conductors shall be insulated for the maximum voltage involved.

(2) It is recommended that stranded, tinned copper conductors be used.

(3) Printed circuit boards of flame-retardant material may be used in place of conventional conductor assemblies.

(b) Size of conductors:

(1) Conductors in raceways shall be not smaller than No. 18 AWG.

Exception. In a jacketed, multi-conductor cable assembly, No. 22 AWG or larger conductors may be used.

(2) Conductors not in raceways shall be not smaller than No. 22 AWG.

(c) The current carried by conductors shall not exceed the values given in Table 200-A.

CHAPTER 210. WIRING METHODS AND PRACTICES

210-1. General Requirements.

(a) Conductors shall be identified at each termination by marking with a number to correspond with the diagrams and shall be color coded as follows:

Black — Line, load and control circuits at line voltage.

Red — AC control circuits, at less than line voltage.

Blue — DC control circuits.

Green (with or without a yellow stripe) — Equipment grounding conductor where insulated or covered.

White — Grounded circuit conductor.

Exceptions to the above may be made only as follows:

Exception No. 1. Internal wiring on individual devices purchased completely wired.

Exception No. 2. Where insulation is used that is not available in the colors required.

Exception No. 3. Where multiconductor cable is used.

Exception No. 4. Conductors used to connect electronic, precision, static, or similar devices or panels.

(b) Conductors and cables shall be run without splices from terminal to terminal.

Exception: Splices may be made to leads attached to equipment, and shall be insulated with oil resistant electrical tape.

(c) Terminals on terminal blocks shall be plainly marked to correspond with the markings on the diagrams.

(d) It is recommended that electrical connections be made with pressure connectors (e.g., crimped lug or pin, etc.), or screw or bolt connections where the wire is retained (e.g., saddle, cup washer, etc.).

(e) Shielded conductors shall be carefully terminated to prevent fraying of strands and to permit easy disconnection.

210-3. Panel Wiring.

(a) Panel conductors shall be supported where necessary to keep them in place. Wiring channels may be used where made of a flame-retardant insulating material.

(b) It is recommended that control panels be front connected. Where back connected panels are used, access doors or swingout panels which swing about a vertical axis shall be provided.

(c) It is recommended that multiple-device control panels be equipped with terminal blocks or with attachment plugs and receptacles for all outgoing control conductors.

210-5. Machine Wiring.

(a) Conductors and their connections external to the control panel enclosure shall be totally enclosed in suitable raceways or enclosures as described in Chapter 220, unless otherwise permitted in this Section.

(b) Fittings used with raceways or multiconductor cable shall be liquidtight.

(c) Liquidtight flexible metal conduit or multiconductor cable shall be used where necessary to employ flexible connections to pendent push-button stations. The weight of pendent stations shall be supported by chains or wire rope external to the flexible conduit or multiconductor cable.

(d) Liquidtight flexible metal conduit and fittings shall be used for connections involving small or infrequent movements. They shall also be used to complete the connection to normally stationary motors, limit switches, and other externally mounted devices. The conduit length shall be no longer than necessary, but shall not exceed 5 feet.

(e) Connections to continuously moving parts shall be made with extra flexible conductors encased in liquidtight flexible metallic or nonmetallic conduit or with extra flexible multiconductor cable. Flexible cable and conduit shall have vertical connections and shall have sufficient slack to avoid sharp flexing and straining, except as follows:

Exception: Horizontal connections may be used if the flexible cable or conduit is adequately supported.

(f) Where flexible conduit or cable is adjacent to moving parts, the construction and the supporting means shall prevent damage to the flexible conduit or cable under all conditions of operation.

(g) All conductors of any circuit shall be contained in the same raceway, except as follows:

Exception: Where it is not practicable, all conductors of an individual control circuit need not be contained in the same raceway.

(h) Conductors connected in AC circuits and conductors connected in DC circuits may occupy the same raceway regardless of voltage, provided they are all insulated for the maximum voltage of any conductor in the raceway.

(i) Where electrical equipment is removable, it may be connected through a polarized, grounding type attachment plug and receptacle. The male plug shall be connected to the load circuit.

(j) Where construction is such that wiring must be disconnected for shipment, terminal blocks in an accessible enclosure or attachment plugs and receptacles shall be provided at the sectional points.

CHAPTER 220. RACEWAYS, JUNCTION AND PULL BOXES

NOTE: Raceways and junction boxes are provided for mechanical protection only. See Chapter 240 for acceptable means of equipment grounding.

220-1. General Requirements.

(a) All sharp edges, flash, burrs, rough surfaces or threads with which the insulation of the conductors may come in contact shall be removed from raceways and fittings. Where necessary, additional protection consisting of a flame-retardant, oil-resistant insulating material, shall be provided to protect conductor insulation.

(b) Raceways, junction and pull boxes shall be arranged to drain oil or moisture to convenient points where ¼-inch openings shall be provided.

(c) It is recommended that entrances for raceways and multiconductor cables be located in the sides, back or bottom of enclosures or compartments.

220-3. Per Cent Fill of Raceways. The combined cross-sectional area of all conductors and cables shall not exceed 50 per cent of the interior cross-sectional area of the raceway. The fill provisions shall be based on the actual dimensions of the conductors and/or cables used.

220-5. Rigid Metal Conduit and Fittings.

(a) Rigid metal conduit and fittings shall be of galvanized steel, meeting the requirements of USA Standards C80.1 — 1966 and C80.4 — 1963, or of a corrosion-resistant material suitable for the conditions. It is recommended that the use of dissimilar metals in contact anywhere in the system be avoided to eliminate the possibility of galvanic action.

(b) Conduit smaller than ½ inch, electrical trade size, shall not be used.

(c) Fittings shall be threaded unless structural difficulties prevent assembly.

(d) Running threads shall not be used.

(e) Conduit shall be securely held in place and supported at each end.

(f) Where conduit enters a sheet metal box or enclosure, a bushing providing a smoothly rounded insulating surface shall be installed to protect the conductors from abrasion, unless the design of the box or enclosure is such as to afford equivalent protection. Where conduit bushings are constructed wholly of insulating material, a locknut shall be provided both inside and outside the enclosure to which the conduit is attached.

(g) Bends of rigid conduit shall be so made that the conduit will not be injured, and that the internal diameter of the conduit will not be effectively reduced. The radius of the curve of the inner edge of any field bend shall not be less than shown in Table 220-A.

Table 220-A

Minimum Radii of Conduit Bends

Size of Conduit, Inches	Minimum Radius of Conduit Bends, Inches
½	4
¾	4½
1	5¾
1¼	7¼
1½	8¼
2	9½
2½	10½
3	13
3½	15
4	16
5	24
6	30

(h) A run of conduit shall not contain more than the equivalent of 4 quarter bends (360 degrees, total).

220-7. **Liquidtight Flexible Metal Conduit and Fittings.**

(a) Liquidtight flexible metal conduit shall consist of an oil-resistant, liquidtight jacket or lining in combination with flexible metal reinforcing tubing.

(b) Fittings shall be of metal and shall be designed for use with liquidtight flexible metal conduit.

(c) Liquidtight flexible metal conduit smaller than ½ inch, electrical trade size, shall not be used.

220-9. **Liquidtight Flexible Nonmetallic Conduit and Fittings.**

(a) Liquidtight flexible nonmetallic conduit shall consist of a

water- and oil-resistant and flame-retardant material. It shall be constructed of a seamless liner and cover, bonded together with one or more layers of flexible, braided, reinforcing cords.

(b) The conduit shall be resistant to kinking and shall have physical characteristics comparable to the jacket of multiconductor cable.

(c) The conduit shall be suitable for use at temperatures of 80° C in air, and 60° C in the presence of water, oil, or coolant.

(d) The conduit shall have a minimum wall thickness of 1/8 inch and diameters shall be as near as practicable to the limits given in Table 220-B.

Table 220-B

Liquidtight Flexible Nonmetallic Conduit Dimensions

Inside Diam. — Inches Minimum	Outside Diam. — Inches Maximum
1/2	27/32
3/4	1 3/16
1	1 15/32
1 1/4	1 25/32
1 1/2	2 1/32

(e) Fittings shall be of metal and shall be designed for use with liquidtight flexible, nonmetallic conduit.

(f) Liquidtight flexible nonmetallic conduit smaller than 1/2 inch inside diameter shall not be used.

220-11. Wireways.

(a) Exterior wireways may be used where rigidly supported above and clear of all moving or contaminating portions of the machine tool.

(b) Metal thickness shall be not less than No. 14 USS gage.

(c) Covers shall be gasketed and shaped to overlap sides. Covers shall be attached to wireway by hinges or chains and held closed by means of captive screws or other suitable fasteners. On horizontal wireways the cover shall be on the top.

(d) Where wireway is furnished in sections, the joints between sections shall fit tightly, but need not be gasketed.

(c) Only openings required for wiring or for drainage shall be provided. Wireways shall not have unused knockouts.

220-13. Machine Compartments and Raceways. Compartments or raceways within the column or base of a machine tool may be used to enclose conductors provided the compartment or raceway is isolated from coolant and oil reservoirs and is entirely enclosed. Conductors run in enclosed compartments and raceways shall be secured and so arranged that they will not be subject to physical damage.

220-15. Junction and Pull Boxes. Junction boxes shall not have unused knockouts and shall be provided with gasketed covers. It is recommended that external mounting means be provided.

220-17. Motor Terminal Boxes. Motor terminal boxes shall not be used as general purpose junction boxes for wiring to solenoid valves, limit switches, etc. Terminals for motor mounted devices such as brakes, thermostats, plugging switches, or tachometer generators, may be connected in the motor terminal box.