

SECTION 16402

INTERIOR WIRING SYSTEMS
02/83

PART 1 GENERAL

1.1 SUMMARY

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE, INC. (ANSI)
1430 BROADWAY
NEW YORK, NY 10018
(212) 354-3300

\-ANSI C80.1-\ 1977 Specification for Rigid Steel
Conduit, Zinc-Coated

\-ANSI C80.3-\ 1977 Specification for Electrical
Metallic Tubing, Zinc-Coated

\-ANSI C80.5-\ 1977 Specification for Rigid Aluminum
Conduit

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
1916 RACE STREET
PHILADELPHIA, PA 19103
(215) 299-5585

\-ASTM B1-\ 1970 (Rev. 1976) Hard-Drawn Copper Wire

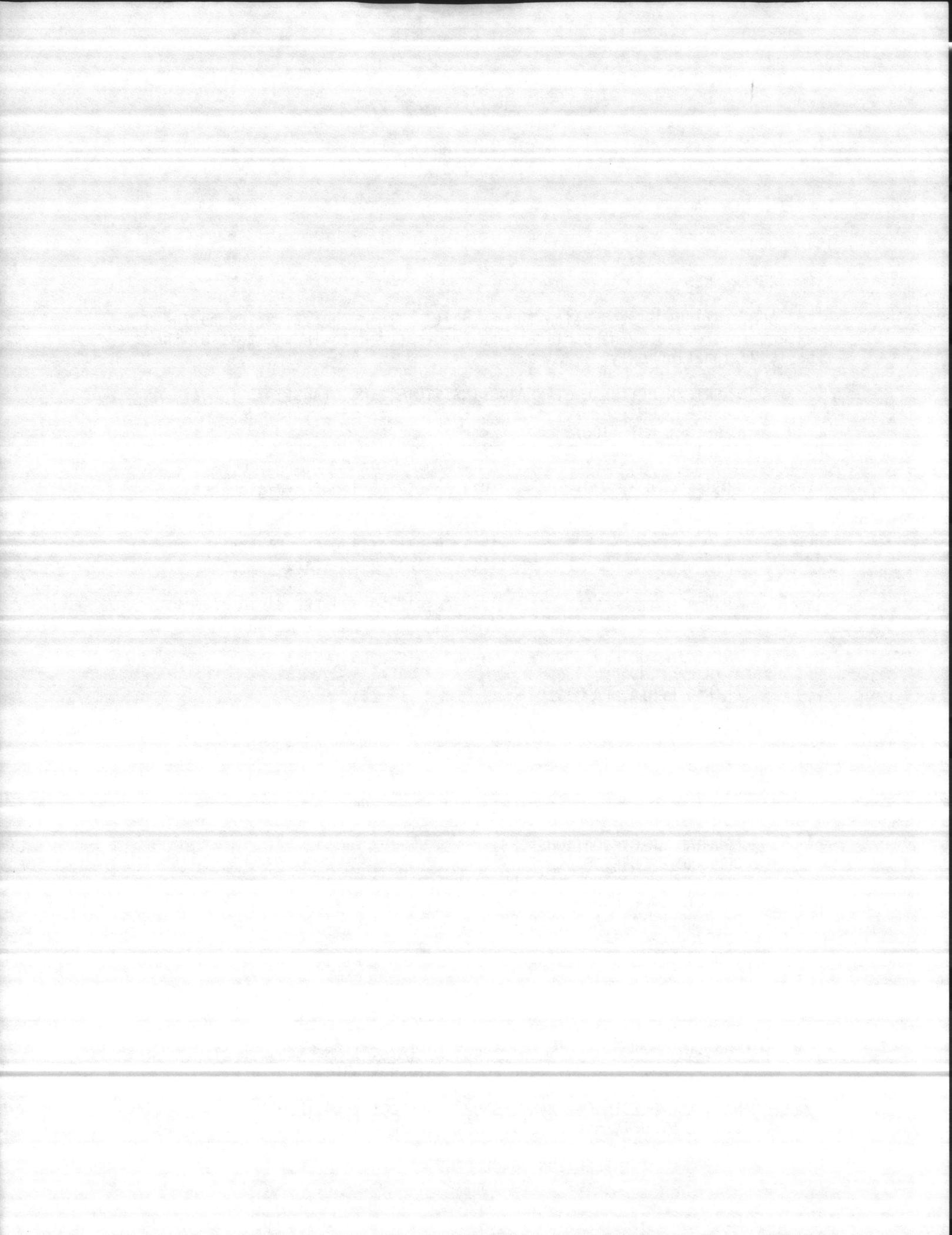
\-ASTM B8-\ 1981 Concentric-Lay-Stranded Copper
Conductors, Hard, Medium-Hard, or Soft

FEDERAL SPECIFICATIONS (FS)
COMMANDING OFFICER
NAVAL PUBLICATIONS AND FORMS CENTER
5801 TABOR AVENUE
PHILADELPHIA, PA 19120-5099
AUTOVON 422-2179
COMMERCIAL (215) 697-2179

\-FS W-C-375-\ (Rev. B) Circuit Breaker, Molded Case,
Branch Circuit and Service

\-FS W-S-896-\ (Rev. E) (Amd. 1) Switch, Toggle (Toggle
and Lock), Flush Mounted

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)
2101 L STREET, N.W., SUITE 300



SPECS-IN-TACT

WASHINGTON, DC 20037
(202) 457-8474

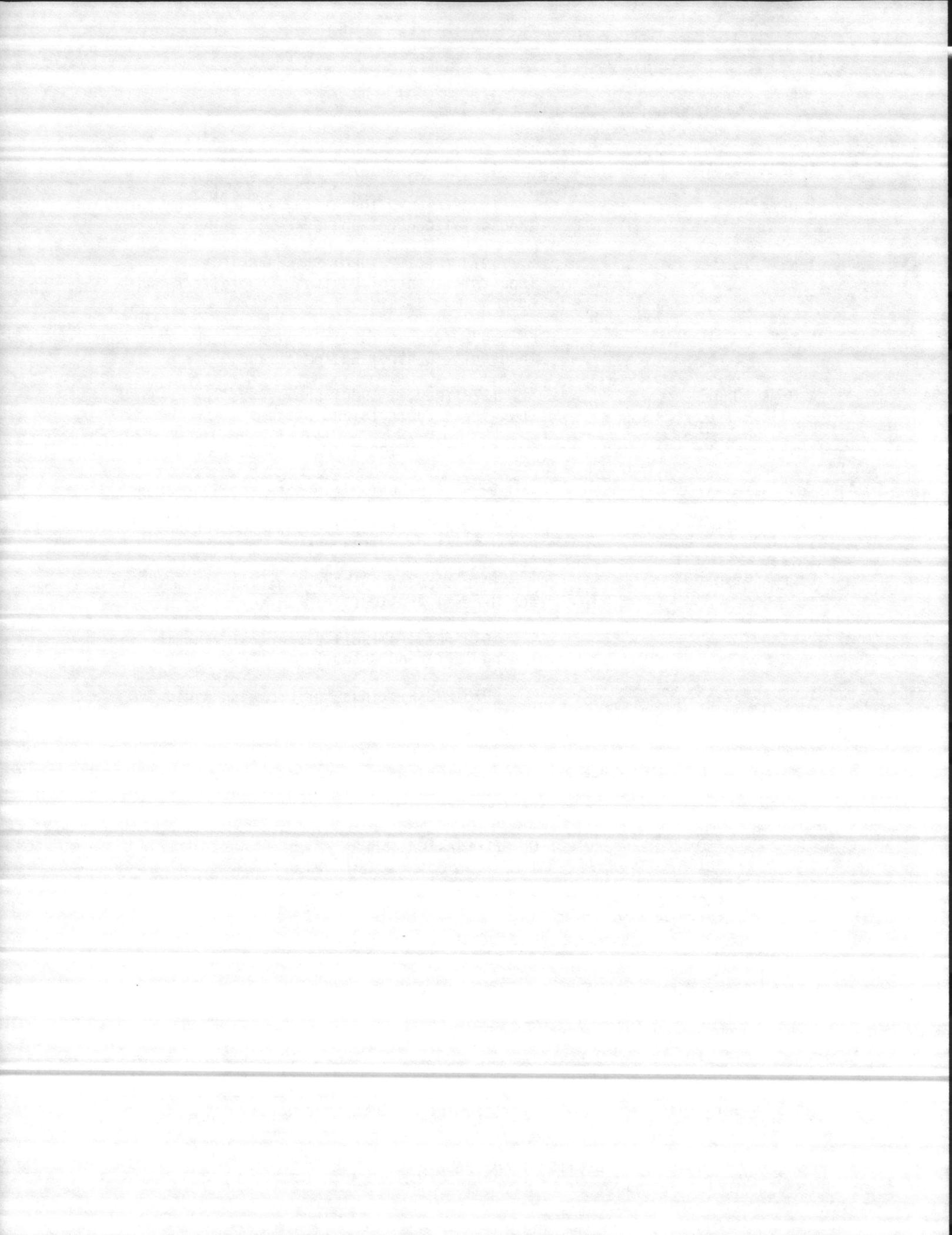
\-NEMA BU1-\	1978 (Rev. 1 1978) Busways
\-NEMA ICS1-\	1978 (Rev. 3 1980) General Standards for Industrial Control and Systems
\-NEMA ICS2-\	1978 (Rev. 2 1980) Standards for Industrial Control Devices, Controllers and Assemblies
\-NEMA ICS4-\	1977 (Rev. 1 1978) Terminal Blocks for Industrial Control Equipment and Systems
\-NEMA ICS6-\	1978 (Rev. 1 1980) Enclosures for Industrial Controls and Systems
\-NEMA KS1-\	1975 (Rev. 1981) Enclosed Switches
\-NEMA MG1-\	1978 (Rev. 6 1981) Motors and Generators
\-NEMA RN1-\	1980 PVC Externally Coated Galvanized Rigid Steel Conduit and EMT
\-NEMA ST20-\	1972 (Rev. 1978) Dry-Type Transformers for General Applications
\-NEMA TC2-\	1978 (Rev. 4 1981) Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)
\-NEMA TC3-\	1978 PVC Fittings for Use with Rigid PVC Conduit and Tubing
\-NEMA VE1-\	1979 Cable Tray Systems
\-NEMA WD1-\	1979 (Rev. 2 1981) General-Purpose Wiring Devices

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
PUBLICATIONS DEPARTMENT
BATTERYMARCH PARK
QUINCY, MA 02269
(617) 770-3000

\-NFPA 70-\	1984 National Electrical Code (NEC)
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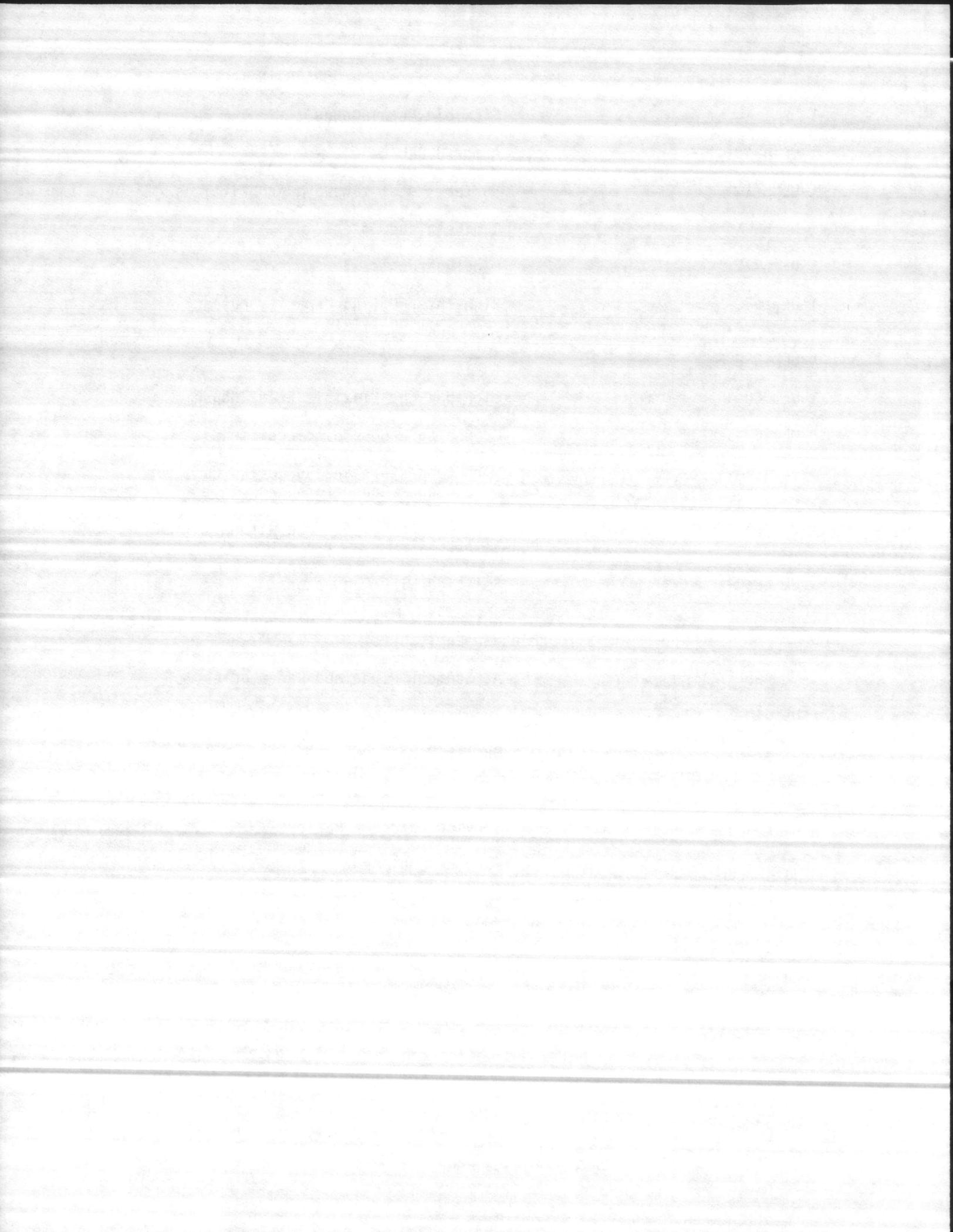
UNDERWRITERS LABORATORIES, INC. (UL)
333 PFINGSTEN ROAD
NORTHBROOK, IL 60062
(312) 272-8800

(All UL publications shall be current editions published and available in print on the date of advertisement of this contract.)



SPECS-IN-TACT

\-UL 1-\	Flexible Metal Conduit
\-UL 4-\	Armored Cable
\-UL 5-\	Surface Metal Raceways and Fittings
\-UL 50-\	Cabinets and Boxes
\-UL 67-\	Panelboards
\-UL 198C-\	High-Interrupting Capacity Fuses, Current-Limiting Types
\-UL 198E-\	Class R Fuses
\-UL 360-\	Liquid-Tight Flexible Steel Conduit
\-UL 467-\	Grounding and Bonding Equipment
\-UL 486A-\	Wire Connectors and Soldering Lugs for Use with Copper Conductors
\-UL 486B-\	Wire Connectors for Use with Aluminum Conductors
\-UL 486C-\	Splicing Wire Connectors
\-UL 489-\	Molded-Case Circuit Breakers and Circuit Breaker Enclosures
\-UL 498-\	Attachment Plugs and Receptacles
\-UL 510-\	Insulating Tape
\-UL 514-\	Outlet Boxes and Fittings
\-UL 719-\	Nonmetallic-Sheathed Cables
\-UL 854-\	Service-Entrance Cables
\-UL 869-\	Service Equipment
\-UL 886-\	Outlet Boxes and Fittings for Use in Hazardous Locations
\-UL 943-\	Ground-Fault Circuit Interrupters
\-UL 984-\	Hermetic Refrigerant Motor-Compressors
\-UL 1053-\	Ground-Fault Sensing and Relaying Equipment
\-UL 1242-\	Intermediate Metal Conduit
\-UL 1569-\	Metal-Clad Cables



1.3 GENERAL REQUIREMENTS

Section 16011, "Electrical General Requirements," applies to this section with additions and modifications specified herein. In each of the standards referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" had been substituted for "should" wherever it appears. Interpret reference in these standards to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer.

1.3.1 [Underground Service

Underground service conductors and associated conduit shall be continuous from the service entrance equipment to the outdoor power system connection.]

[Overhead Service

Overhead service conductors into buildings shall terminate at the service entrance fittings or weatherhead outside the building. The overhead service conductors and support bracket for the overhead conductors are included in Section 16302, "Overhead Electrical Work".]

1.4 SUBMITTALS

1.4.1 16SD-17, Manufacturer's Catalog Data

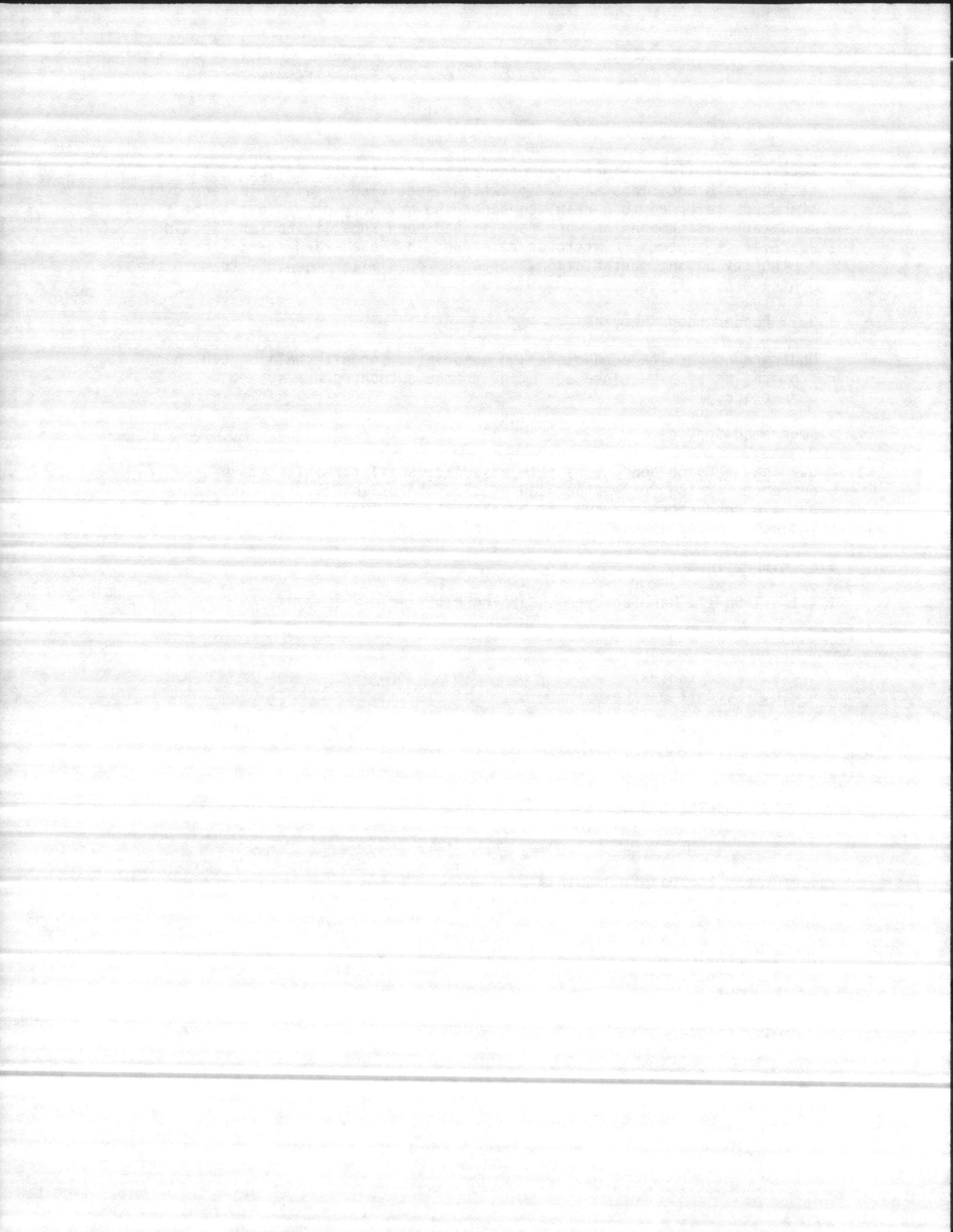
Manufacturer's Data:

- a. Receptacles
- b. Circuit breakers
- c. Switches
- d. Conduit and fittings (each type)
- e. Surface metal raceway
- f. Ground rods
- g. Device plates
- h. Insulated conductors
- i. Outlet and junction boxes
- j. _____*\

1.4.2 16SD-31, Detail Drawings

Shop Drawings:

- a. Panelboards
- b. Transformers
- c. Busway
- d. Wireway
- e. Cable trough
- f. Motor control center
- g. _____*\



1.4.3 *SD-70, Test Reports

Transformer Test and Test Reports: Perform tests classified as "routine" in accordance with \-NEMA ST20-\ on each transformer and submit the results for approval in report form. Submittal shall also contain the results of NEMA "design" and "prototype" tests that were made on transformers electrically and mechanically equal to those specified.*\

1.5 Government Approval

Government approval is required for the following:

- [a. _____]
- [b. _____]

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT, GENERAL

All materials, equipment, and devices shall, as a minimum, meet the requirements of UL where UL standards are established for those items, and the requirements of \-NFPA 70-\. All items shall be new unless specified or indicated otherwise.

2.2 CONDUIT AND FITTINGS

2.2.1 Rigid Steel Conduit (Zinc-Coated)

\-ANSI C80.1-\.

2.2.2 Rigid Aluminum Conduit

\-ANSI C80.5-\.

2.2.3 Rigid Nonmetallic Conduit

PVC Type EPC-40 in accordance with \-NEMA TC2-\, or UL approved fiberglass reinforced epoxy (FRE).

2.2.4 Intermediate Metal Conduit (IMC)

\-UL 1242-\, zinc-coated steel only.

2.2.5 Electrical Metallic Tubing (EMT)

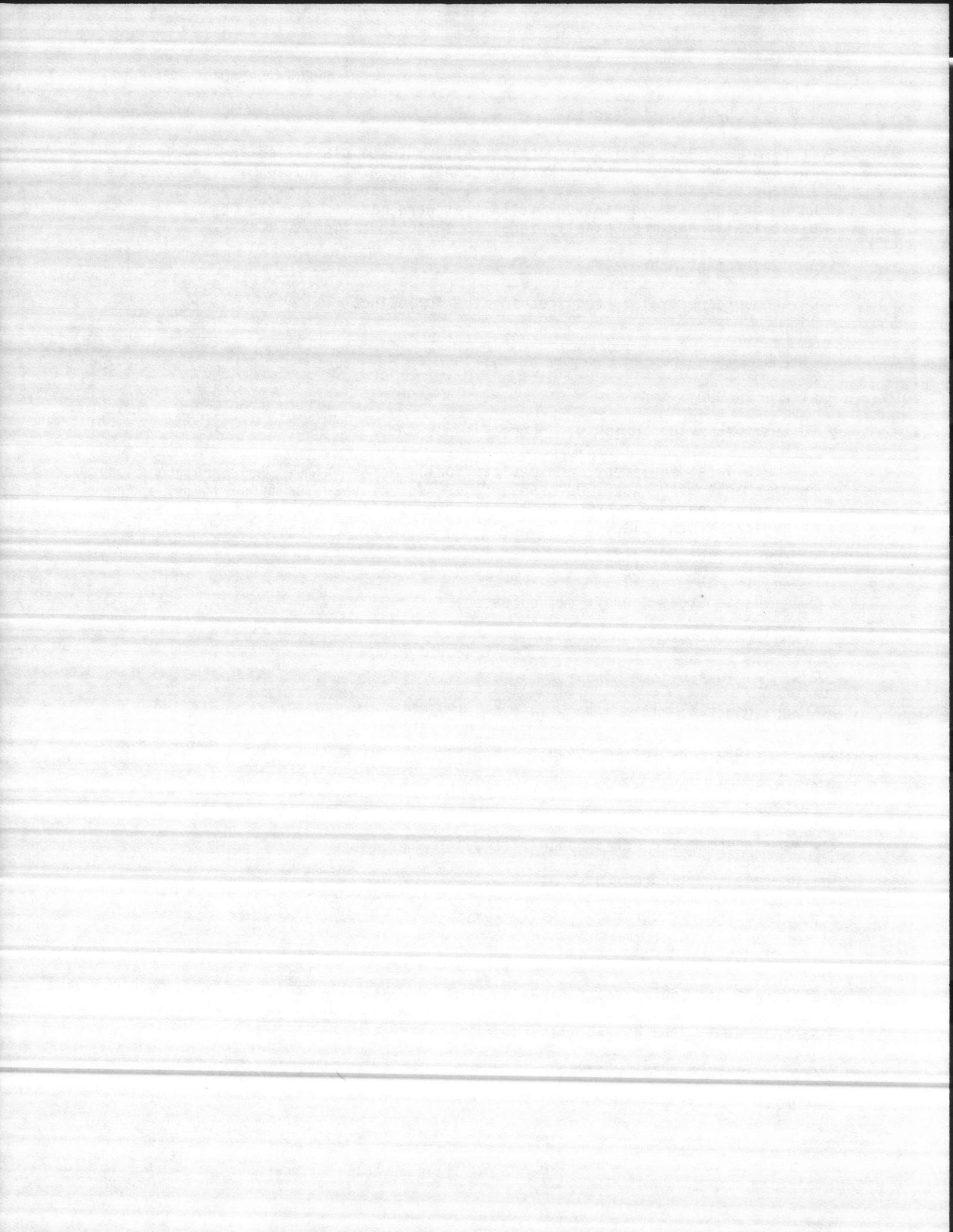
\-ANSI C80.3-\.

2.2.6 Plastic-Coated Rigid Steel and IMC Conduit

\-NEMA RN1-\, Type 40 (40 mils thick).

2.2.7 Flexible Metal Conduit

\-UL 1-\.



2.2.7.1 Liquid-Tight Flexible Metal Conduit (Steel)

\-UL 360-\.

2.2.8 Fittings

Fittings for Metal Conduit, Electrical Metallic Tubing, and Flexible Metal Conduit: \-UL 514-\. All ferrous fittings shall be cadmium-or zinc-coated in accordance with UL 514.

2.2.8.1 Fittings for Rigid Metal Conduit

Fittings for rigid metal conduit and IMC shall be threaded type. Split couplings are not acceptable.

2.2.8.2 Fittings for Electrical Metallic Tubing

Fittings for electrical metallic tubing (EMT) shall be the compression type.

2.2.8.3 Fittings for use in Hazardous Locations

\-UL 886-\.

2.2.9 Fittings for Rigid Nonmetallic Conduit

\-NEMA TC3-\.

2.2.10 Fittings for flexible metal conduit shall be the compression type.

2.3 SURFACE METAL RACEWAY AND FITTINGS

\-UL 5-\, two-piece painted-steel, totally-enclosed snap-cover type. [Provide multiple-outlet type raceway with grounding-type receptacle where indicated. Receptacles shall be as specified in this section of the specifications and shall be spaced a minimum of one every [18] [] inches.] [Alternate receptacles shall be wired on different circuits.]

2.4 BUSWAYS

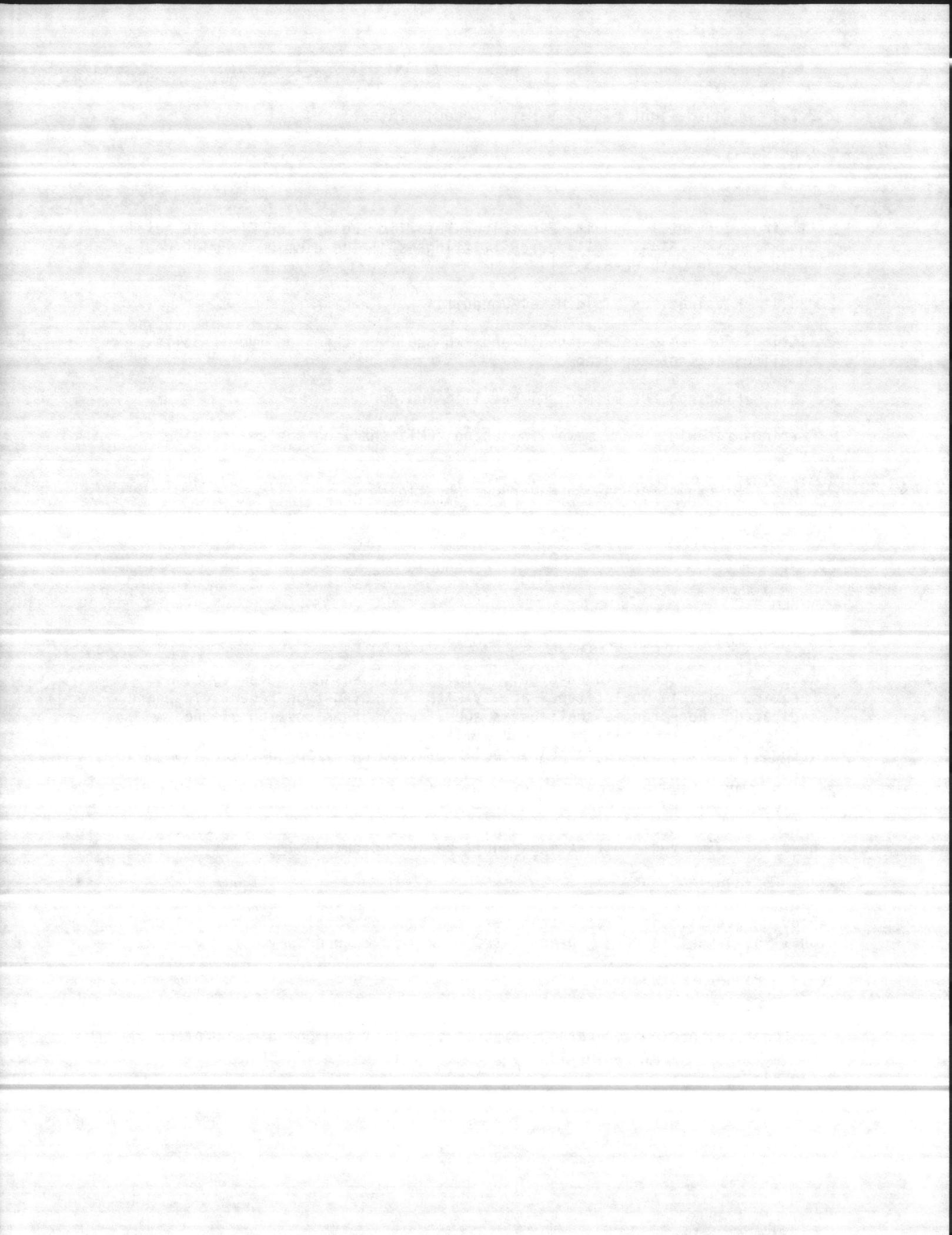
\-NEMA BU1-\. Buses shall be [copper] [or] [aluminum]. Enclosures shall be steel. Short-circuit ratings shall be as indicated.

2.4.1 Feeder Busways

Provide [ventilated, except that vertical busways within 6 feet of floors shall be unventilated,] [unventilated] low-impedance busway.

2.4.2 Plug-In Busways

Unventilated type. Plug-in units shall be the [fusible, handle-operated switch type, horsepower-rated] [circuit breaker type] [handle-operated switch type equipped with high-interrupting -capacity current-limiting fuses].



2.5 CABLE TRAYS

\-NEMA VE1-\. Material shall be of [steel] [or] [series 6000 aluminum alloy]. [Steel cable trays shall be hot-dip zinc coated after fabrication.] Fittings shall have not less than the load-carrying ability straight tray sections. Cable trays shall terminate 10 inches from both sides of smoke and fire partitions. Conductors run through smoke and fire partitions shall be installed in 4-inch rigid steel conduits with grounding bushings, extending 12 inches beyond each side of the partitions. The installation shall be sealed to preserve the smoke and fire ratings of the partitions.

2.5.1 Trough-Type Cable Trays

Trays shall be [sized as indicated] [of a nominal [6] [12] [18] [24] [30] [36]-inch width].

2.5.2 Ladder-Type Cable Trays

Trays shall be [sized as indicated] [of nominal [6] [12] [18] [24] [30] [36]-inch width with rung spacing of [6] [9] [12] [18] inches maximum].

2.5.3 Channel-Type Cable Trays

Trays shall be [sized as indicated] [[3] [4] inches in width].

2.5.4 Solid-Bottom Type Cable Trays

Trays shall be [sized as indicated] [of nominal [6] [12] [18] [24] [30] [36]-inch width].

2.6 OUTLET BOXES AND COVERS

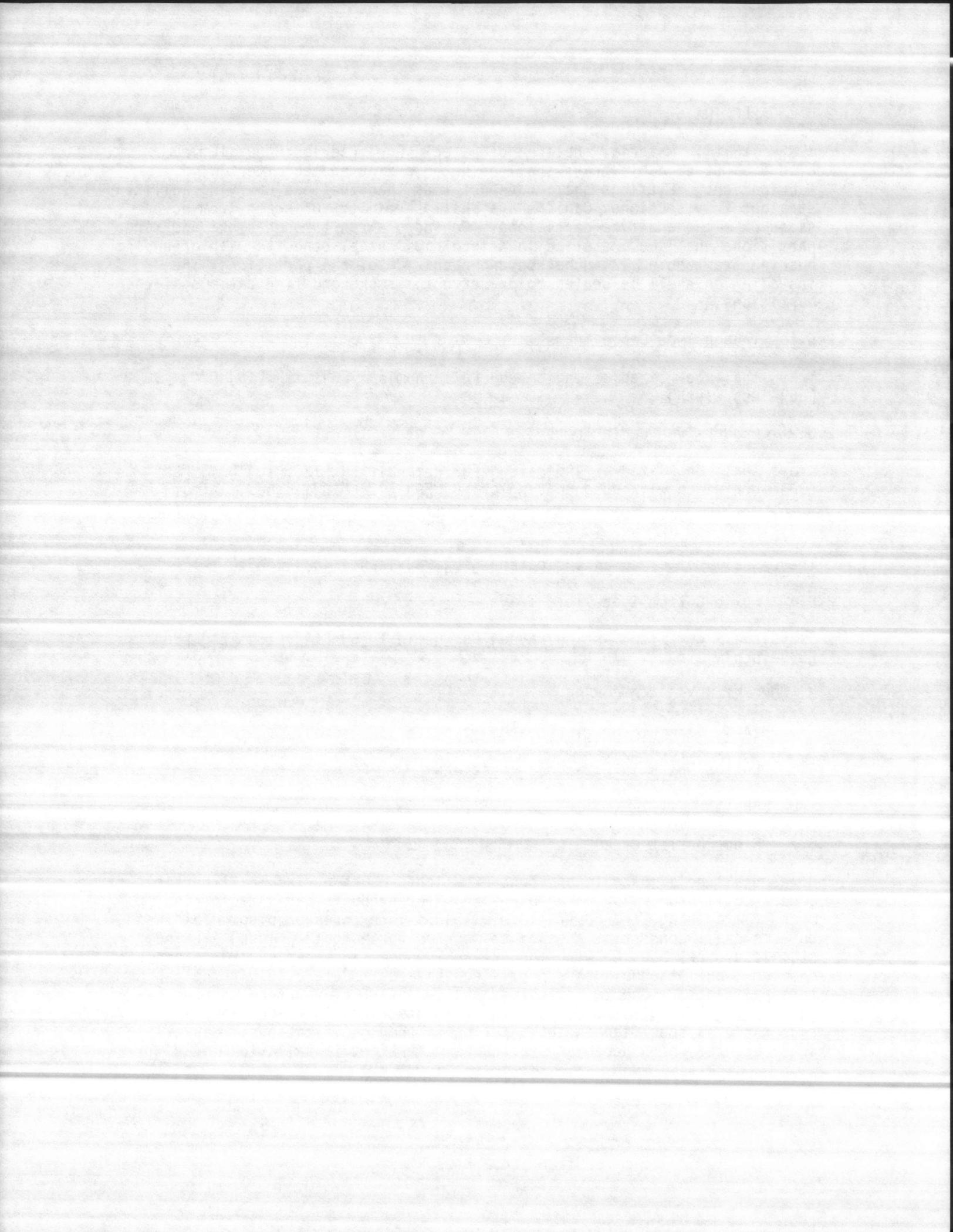
\-UL 514-\, cadmium- or zinc-coated if of ferrous metal.

2.6.1 Outlet Boxes in Hazardous Locations

\-UL 886-\.

2.6.2 Floor Outlet Boxes

Boxes shall be adjustable and concrete-tight. Each outlet shall consist of a cast-metal body with threaded openings for conduits, adjustable ring, brass flange ring, and cover plate with 3/4-inch threaded plug. Telephone outlets shall consist of a [surface-mounted horizontal] [flush] aluminum or stainless steel housing with a [one-inch bushed side opening] [3/4-inch top opening]; outlets shall have provisions to accommodate a 10-wire telephone terminal block. Receptacle outlets shall consist of [surface-mounted horizontal] [flush] aluminum or stainless steel housing with a duplex receptacle as specified in this section of the specifications. Gaskets shall be used where necessary to insure watertight installation.



2.6.3 Clock Outlet for Use in Other than a Wired Clock System

Provide an outlet box, a plaster cover where required, and a single receptacle with clock-outlet plate. The receptacle shall be recessed sufficiently within the box to allow the complete insertion of a standard cap, flush with the plate. A suitable clip or support for hanging the clock shall be secured to the top plate. Material and finish of the plate shall be as specified in paragraph, "Device Plates."

2.7 CABINETS, JUNCTION BOXES, AND PULL BOXES (LARGE THAN 100 CUBIC INCHES)

Cabinets, Junction Boxes, and Pull Boxes (With Volume Greater Than 100 Cubic Inches): (\-UL 50-\, hot-dip zinc-coated if of sheet steel.

2.8 WIRES AND CABLES

Wires and cables shall meet the applicable requirements of \-NFPA 70-\ and UL for the type of insulation, jacket, and conductor specified or indicated. Wires and cables manufactured more than 12 months prior to date of delivery to the site shall not be used.

2.8.1 Conductors

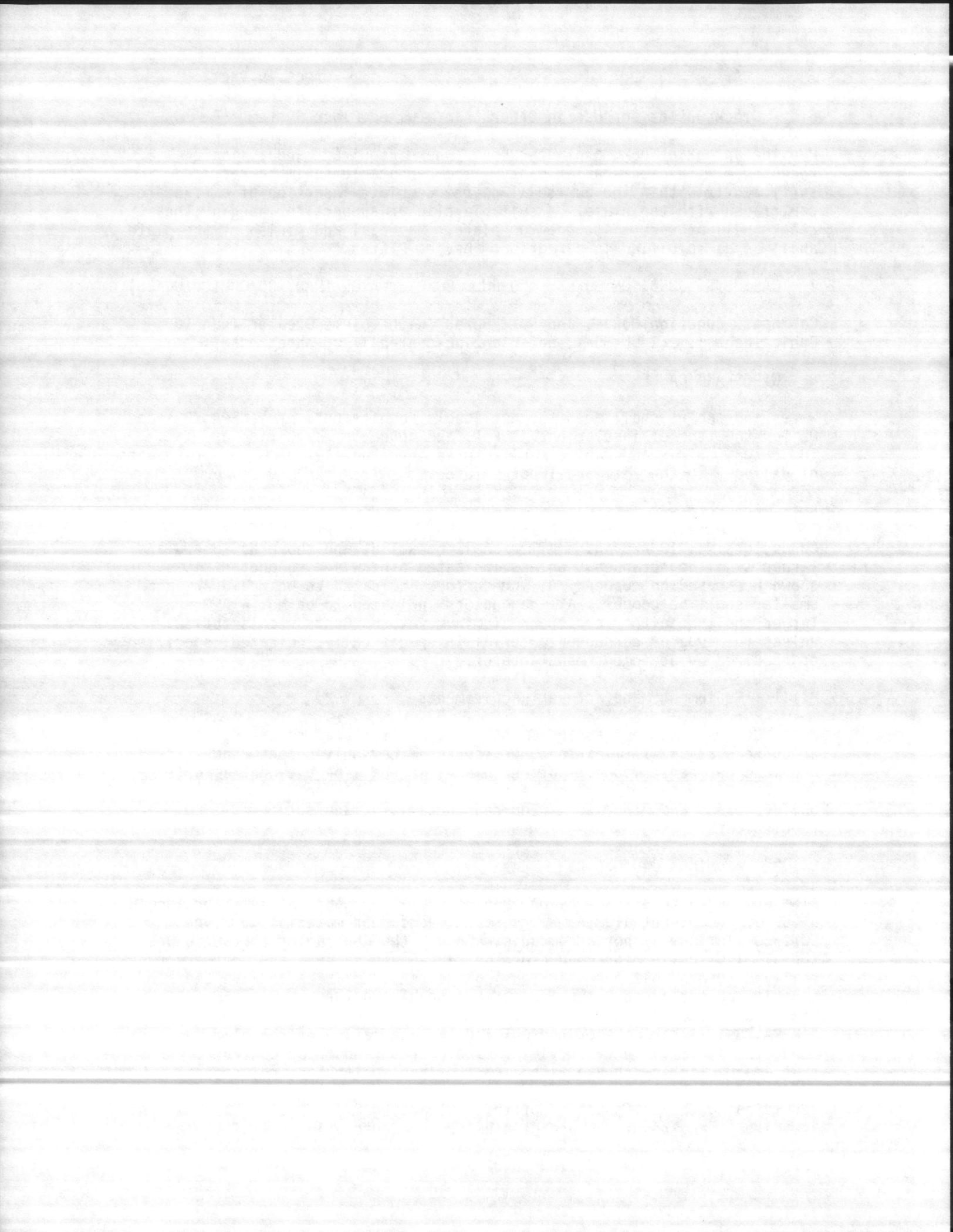
Conductors No. 10 AWG and smaller shall be solid, and those No. 8 AWG and larger shall be stranded. Unless indicated otherwise, conductor sizes shown are based on copper. All conductors indicated to be No. 6 AWG and smaller shall be copper. All conductors indicated to be No. 4 AWG and larger shall be either copper or aluminum, at the Contractor's option, unless the type of conductor material is specifically indicated, specified, or required by equipment manufacturer.

2.8.1.1 Equipment Manufacturer Requirements

Where Contractor provides equipment whose manufacturer requires copper conductors at the terminations, or requires that only copper conductors be provided between components of equipment, it shall be the Contractor's responsibility to provide copper conductors, or all necessary splices, splice boxes, and other work required to satisfy manufacturer's requirements.

2.8.1.2 Aluminum Conductors

Aluminum conductors shall be of an aluminum alloy that is listed or labeled by UL as "component aluminum-wire stock (conductor material)." Type EC/1350 aluminum is not acceptable. Should the Contractor choose to use the aluminum option for conductors No. 4 AWG and larger, the Contractor shall be responsible for: increasing the conductor size to have the same ampacity as the copper size indicated; increasing the conduit and pull box sizes to accommodate the larger size aluminum conductors in accordance with \-NFPA 70-\; insuring that the pulling tension rating of the aluminum conductor is sufficient; providing panelboards [and motor control centers] that are UL listed for use with aluminum, and so labeled; relocating equipment, modifying equipment terminations, resizing equipment, and resolving to the satisfaction of the Contracting Officer all problems that are direct results of the use of aluminum conductors in lieu of copper.



2.8.1.3 Minimum Conductor Sizes

Minimum size for branch circuits shall be No. 12 AWG; for Class 1 remote-control and signal circuits, No. 14 AWG; and for Class 2 low-energy remote-control and signal circuits, No. 16 AWG.

2.8.2 Color Coding

Provide for all service, feeder, branch, control, and signaling circuit conductors. Color shall be green for grounding conductors, and white for neutrals, except where neutrals of more than one system are installed in same raceway or box, the other neutral shall be white with a colored (not green) stripe. The color of the ungrounded conductors in different voltage systems shall be as follows:

- a. 120/208 volt, 3-phase: Phase A - black
Phase B - red
Phase C - blue
- b. 277/480 volt, 3-phase: Phase A - brown
Phase B - orange
Phase C - yellow
- c. 120/240 volt, single phase: red and black.
- [d. On a 3-phase, 4-wire delta system, the high leg shall be orange as required by \-NFPA 70-\.]

2.8.3 Insulation

Unless specified or indicated otherwise, or required to be otherwise by \-NFPA 70-\, all power and lighting wires shall be 600-volt, Type THW, THWN, XHHW, or RHW, except that grounding wire may be Type TW; remote-control and signal circuits shall be Type TW, THW or TF.

2.8.4 Bonding Conductors

\-ASTM B1-\, solid bare copper wire for sizes No. 8 AWG and smaller; \-ASTM B8-\, Class B, stranded bare copper wire for sizes No. 6 AWG and larger.

2.8.5 Service-entrance (SE) and Underground Service-Entrance (USE) Cables

\-UL 854-\.

2.8.6 Nonmetallic-Sheathed Cable

\-UL 719-\, Type NM (or NMC).

2.8.7 Wire and Cable for 400 Hertz Circuits

Insulated copper conductors only.



2.8.8 [Metal-Clad Cable

\-UL 1569-\, \-NFPA 70-\ Type MC cable.]

2.8.9 [Armored Cable

\-UL 4-\, \-NFPA 70-\ Type AC cable.]

2.8.10 [Mineral-Insulated, Metal Sheathed Cable

UL listed, \-NFPA 70-\ Type MI cable.]

2.8.11 Flat Conductor Cable

UL Listed, \-NFPA 70-\ Type FCC.]

2.9 SPLICES AND TERMINATION COMPONENTS

\-UL 486A-\ and \-UL 486B-\, as applicable for wire connectors, and \-UL 510-\ for insulating tapes. Connectors for wires No. 10 AWG and smaller shall be insulated pressure-type in accordance with \-UL 486A-\ or \-UL 486C-\ (twist-on splicing connector). Provide solderless terminal lugs on stranded conductors.

2.10 DEVICE PLATES

Provide UL listed, one-piece device plates for outlets and fittings to suit the devices installed. Plates on unfinished walls and on fittings shall be of zinc-coated sheet steel or cast metal having round or beveled edges. [Plates on finished walls shall be urea or phenolic, minimum 0.10-inch wall thickness. Plates shall be the same color as the receptacle or toggle switch with which it is mounted.] [Plates on finished walls shall be satin finish stainless steel or brushed-finish aluminum, minimum 0.03 inch thick.] Screws shall be machine type with countersunk heads in a color to match the finish of the plate. The use of sectional type device plates will not be permitted. Plates installed in wet locations shall be gasketed. Device plates for telephone and intercommunication outlets shall have a 3/8-inch bushed opening in center.

2.10 DEVICE PLATES: Plates on exposed raceways shall be cast metal or zinc-coated sheet steel having round or beveled edges. Provide UL listed, one-piece device plates for outlets and fittings to suit the devices installed. Plates on unfinished walls and on fittings shall be of zinc-coated sheet steel or cast metal having round or beveled edges. [Plates on finished walls shall be [urea or phenolic] [nylon or lexan], minimum 0.10-inch wall thickness. Plates shall be the same color as the receptacle or toggle switch with which it is mounted.] [Plates on finished walls shall be satin finish stainless steel or brushed-finish aluminum, minimum 0.03 inch thick.] Screws shall be machine type with countersunk heads in a color to match the finish of the plate. The use of sectional type device plates will not be permitted. Plates installed in wet locations shall be gasketed.

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with glass or plastic jewels. Provide a clear 5-watt lamp in each pilot switch. Jewels for use with switches controlling motors shall be green and jewels for other purposes shall be [white] [red] [amber].

have a 3/8-inch bushed opening in center.

2.11 SWITCHES

2.11.1 Toggle Switches

1/2 W-2-605-7, totally enclosed with bodies of thermosetting plastic and mounting screws. Handles shall be [Ivory]. Wiring terminals shall be of the screw type, side wired. Switches shall be rated duty-type ac only, 120/277 volts, with the current rating and number of poles indicated.

2.11.2 Pilot Lights

Single volt mounted panel type, rated 120 volts ac.

2.8.8 [Metal-Clad Cable

\-UL 1569-\, \-NFPA 70-\ Type MC cable.]

2.8.9 [Armored Cable

\-UL 4-\, \-NFPA 70-\ Type AC cable.]

2.8.10 [Mineral-Insulated, Metal Sheathed Cable

UL listed, \-NFPA 70-\ Type MI cable.]

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UL Listed, \-NFPA 70-\ Type FCC.]

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\-UL 486A-\ and \-UL 486B-\, as applicable for wire connectors, and \-UL 510-\ for insulating tapes. Connectors for wires No. 10 AWG and smaller shall be insulated pressure-type in accordance with \-UL 486A-\ or \-UL 486C-\ (twist-on splicing connector). Provide solderless terminal lugs on stranded conductors.

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2.11 SWITCHES

2.11.1 Toggle Switches

\-FS W-S-896-\, totally enclosed with bodies of thermosetting plastic and a mounting strap. Handles shall be [brown] [ivory]. Wiring terminals shall be of the screw type, side wired. Switches shall be rated quiet-type ac only, 120/277 volts, with the current rating and number of poles indicated.

2.11.2 Pilot Lights

Provide yoke-mounted candelabra-base sockets rated 125 volts and fitted with glass or plastic jewels. Provide a clear 6-watt lamp in each pilot switch. Jewels for use with switches controlling motors shall be green and jewels for other purposes shall be [white] [red] [amber].

2.8.8 [Metal-Clad Cable

\-UL 1569-\, \-NFPA 70-\ Type MC cable.]

2.8.9 [Armored Cable

\-UL 4-\, \-NFPA 70-\ Type AC cable.]

2.8.10 [Mineral-Insulated, Metal Sheathed Cable

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2.11 SWITCHES

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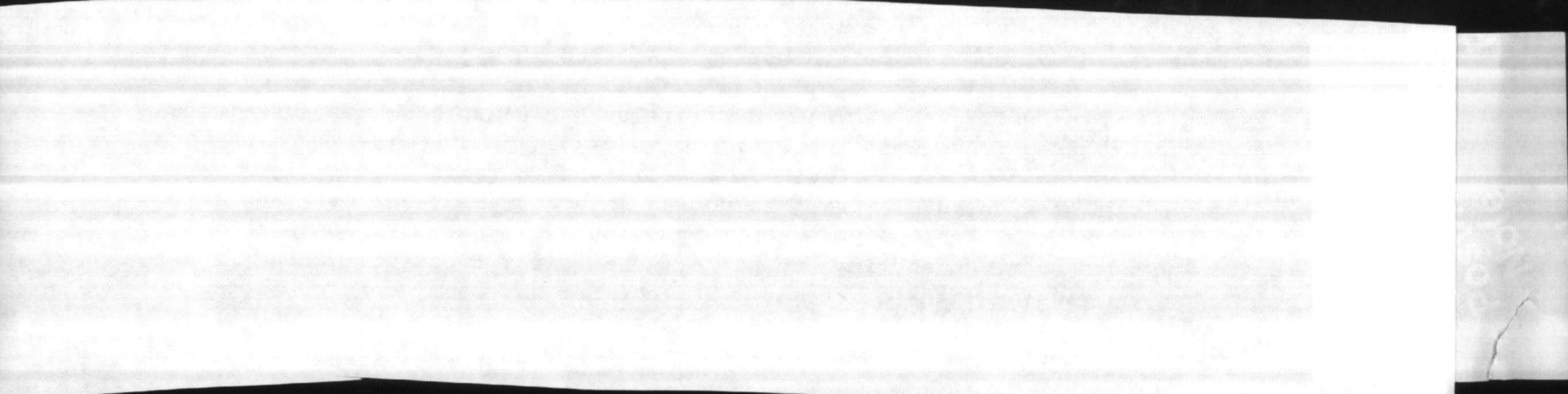
1-12 W-2-605-7, totally enclosed with bodies of thermosetting plastic and a mounting strap. Handles shall be [brown] [ivory]. Wiring terminals shall be of the screw type, side wired. Switches shall be rated outlet type ac only, 150V/27A volts, with the current rating and number of poles indicated.

2.11.2 Pilot Lights

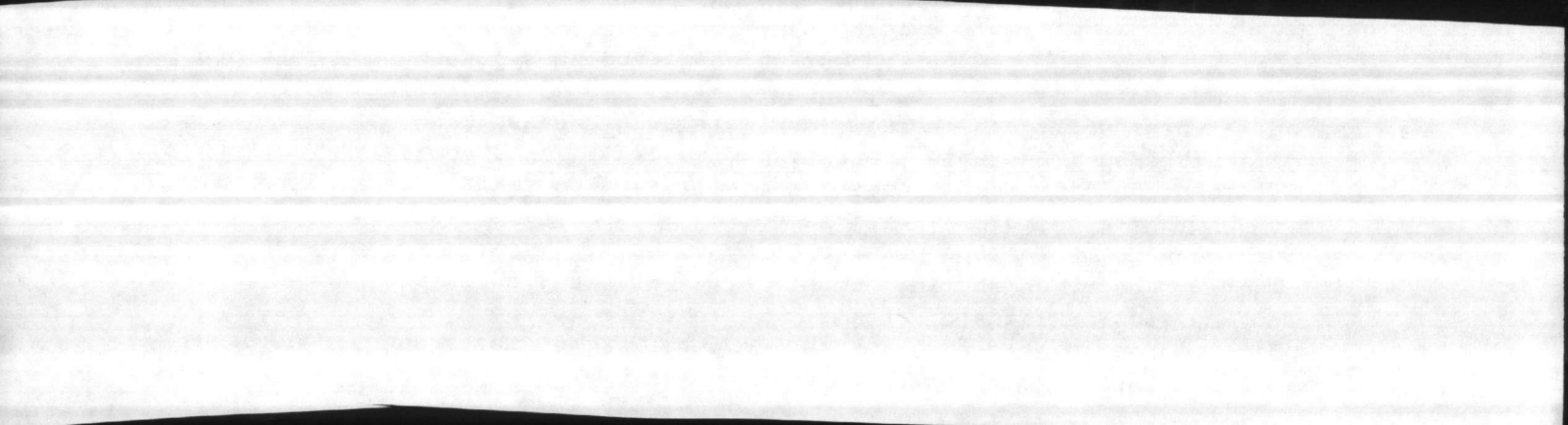
Provide yoke-mounted candlestick-base sockets rated 125 volts and fitted with glass or plastic lenses. Provide a clear 2-1/2" lens to be fitted.

2.10 DEVICE PLATES: Plates on exposed raceways shall be cast metal or zinc-coated sheet steel having round or beveled edges. Provide UL listed, one-piece device plates for outlets and fittings to suit the devices installed. Plates on unfinished walls and on fittings shall be of zinc-coated sheet steel or cast metal having round or beveled edges. [Plates on finished walls shall be [urea or phenolic] [nylon or lexan], minimum 0.10-inch wall thickness. Plates shall be the same color as the receptacle or toggle switch with which it is mounted.] [Plates on finished walls shall be satin finish stainless steel or brushed-finish aluminum, minimum 0.03 inch thick.] Screws shall be machine type with countersunk heads in a color to match the finish of the plate. The use of sectional type device plates will not be permitted. Plates installed in wet locations shall be gasketed.

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2.11.3 Disconnect Switches

\-NEMA KS1-\. Switches serving as motor disconnect means shall be horsepower rated. Provide heavy duty type switches where indicated, where switches are rated higher than 240 volts, and for double throw switches. Fused switches shall utilize Class R fuseholders and fuses, unless indicated otherwise.

2.11.4 Breakers Used as Switches for 120-Volt Fluorescent Fixtures

Breakers shall be marked "SWD" in accordance with \-UL 489-\.

2.12 RECEPTACLES

\-UL 498-\ and \-NEMA WD1-\, heavy-duty, hospital grade grounding type. Ratings and configurations shall be as indicated. Bodies shall be of [brown] [ivory] thermosetting plastic supported on a metal mounting strap. Wiring terminals shall be of the screw type, side wired. Connect grounding pole to the mounting strap.

2.12.1 Switched Duplex Receptacles

Provide separate terminals for each ungrounded pole. The top receptacle shall be switched when installed.

2.12.2 Weatherproof Receptacles

Provide in a cast metal box with a gasketed, weatherproof, cast-metal cover plate and a gasketed cap over each receptacle opening. The cap(s) shall be provided with a spring-hinged flap. Receptacle shall be UL approved for use in "wet locations."

2.12.3 Ground Fault Circuit Interrupter Receptacles

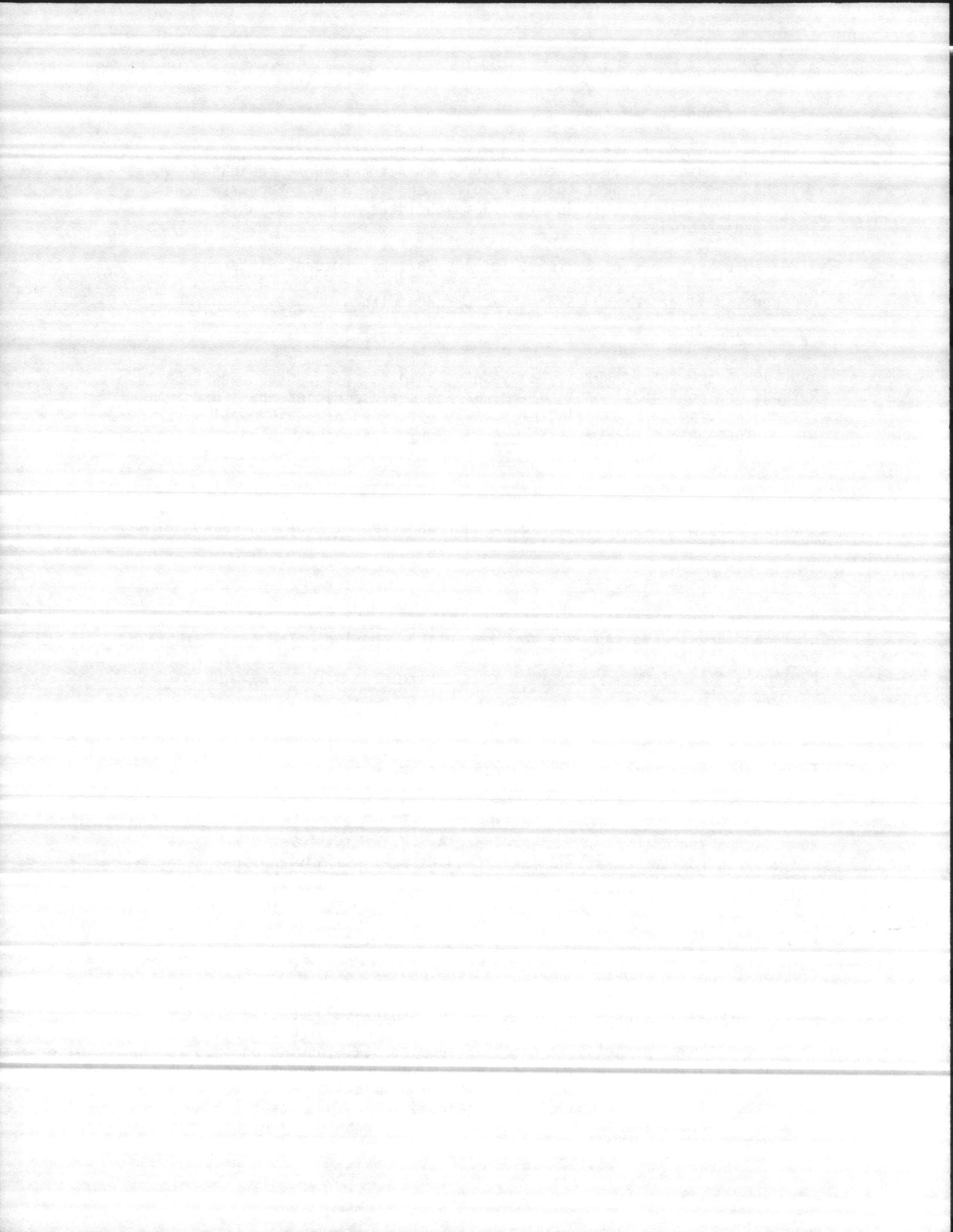
\-UL 943-\, and shall be duplex type for mounting in a standard outlet box. The device shall be capable of detecting a current leak of 5 milliamperes.

2.12.4 Special Purpose Receptacles

Receptacles serving _____ are considered special purpose for this project. [Provide in ratings indicated] [\-NEMA [____]-\ configuration, rated _____ ampere, _____ volts.] [Furnish one matching plug with each receptacle.]

2.13 PANELBOARDS

\-UL 67-\ and \-UL 50-\. Panelboards for use as service disconnecting means shall additionally conform to \-UL 869-\. Panelboards shall be circuit breaker equipped [unless indicated otherwise]. Design shall be such that any individual breaker can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as a means of obtaining clearances as required by UL. Where "space only" is indicated, make provisions for the future installation of a breaker sized as indicated. All panelboard locks included in the project shall be keyed alike. Directories shall be typed to indicate load served by each circuit



and mounted in a holder behind transparent protective covering.

2.13.1 Panelboard Buses

Support bus bars on bases independent of the circuit breakers. Main buses and back pans shall be designed so that breakers may be changed without machining, drilling, or tapping. Provide an isolated neutral bus in each panel for connection of circuit neutral conductors. Provide a separate ground bus marked with a green stripe along its front and bonded to the steel cabinet for connecting grounding conductors.

2.13.2 Circuit Breakers

\-FS W-C-375-\ [ambient-compensated] thermal magnetic type with interrupting capacity [as indicated] [of 10,000 amperes symmetrical minimum]. Breaker terminals shall be UL listed as suitable for the type of conductor provided. Plug-in circuit breakers are not acceptable.

2.13.2.1 Multipole Breakers

Provide common-trip type with a single operating handle. Breaker design shall be such that an overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent breaker poles are connected to Phases A, B, and C, respectively.

2.13.2.2 Circuit Breaker with Ground-Fault Circuit Interrupter

\-UL 1053-\ and \-NFPA 70-\. Provide with "push-to-test" button, visible indication of tripped condition, and ability to detect a current imbalance of approximately 5 milliamperes.

2.13.3 [Fusible Switches for Panelboards

\-NEMA KS1-\, hinged door type. Switches serving as motor disconnect means shall be horsepower rated.]

2.14 FUSES

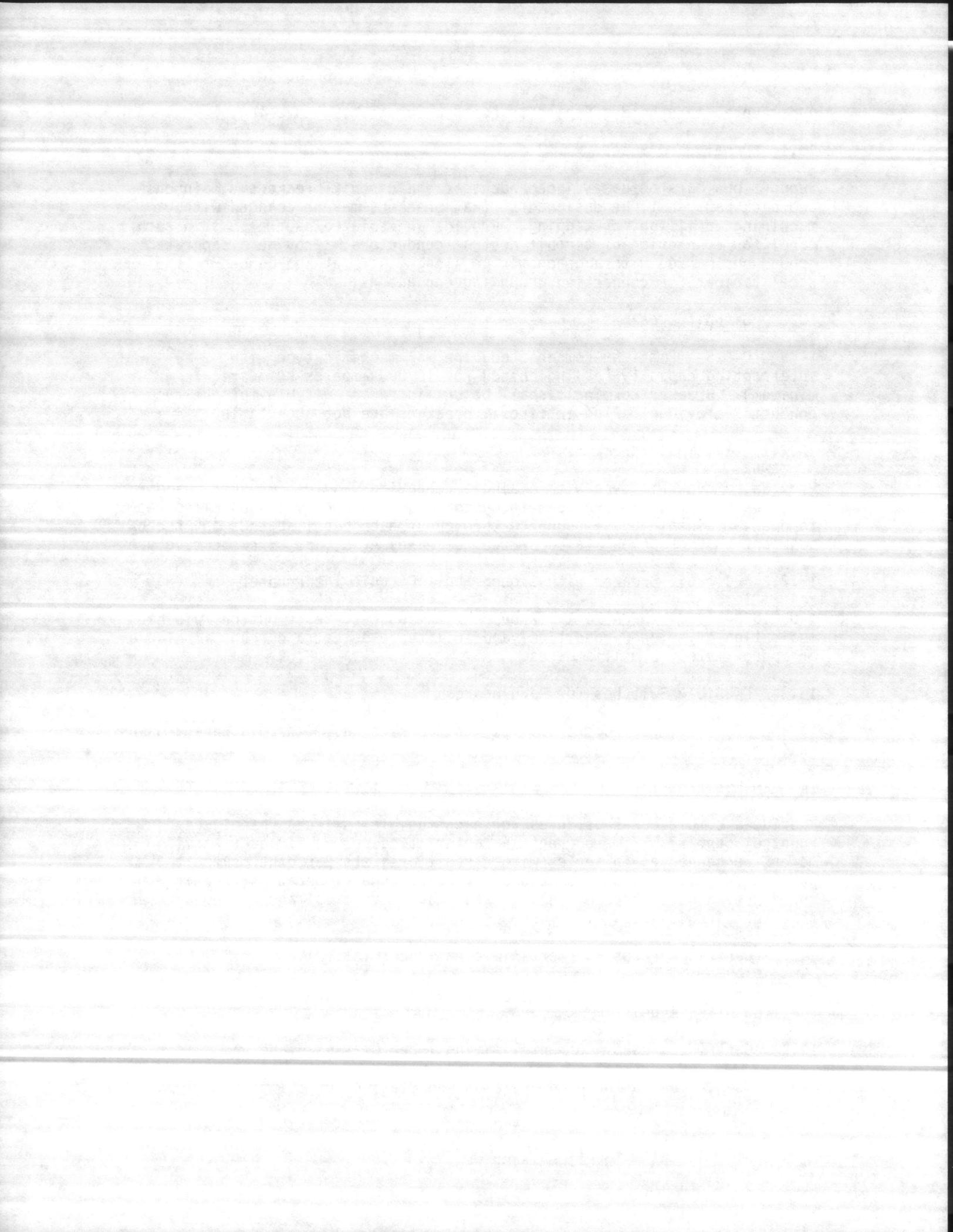
Provide a complete set of fuses for each fusible [switch] [panel] [and] [control center]. Time-current characteristics curves of fuses serving motors or connected in series with circuit breakers [or other circuit protective devices] shall be coordinated for proper operation; submit coordination data for approval. Fuses shall have a voltage rating not less than the circuit voltage.

2.14.1 Cartridge Fuses, Current-limiting Type (Class R)

\-UL 198E-\, Class [RK-1] [RK-5] [time-delay type]. Associated fuseholders shall be Class R only.

2.14.2 Cartridge Fuses, Current-limiting Type (Classes J and L)

\-UL 198C-\, Class J for 0 to 600 amps and Class L for 601 to 6000 amps.



2.15 TRANSFORMERS

\-NEMA ST20-\, general-purpose, dry-type, self cooled, [ventilated] [nonventilated] [sealed]. Provide transformers in a NEMA [1] [3R] [_____] enclosure. Transformer shall have 220 degrees C insulation system with a temperature rise not exceeding [150] [115] [80] degrees C under full rated load in a maximum ambient of 40 degrees C. Transformer shall be capable of carrying continuously 115 percent of the nameplate kVA without exceeding the insulation rating. [Transformers shall be the quiet type with an average sound level of at least 3 decibels lower than NEMA standard level for the transformer size indicated.]

2.16 MOTORS

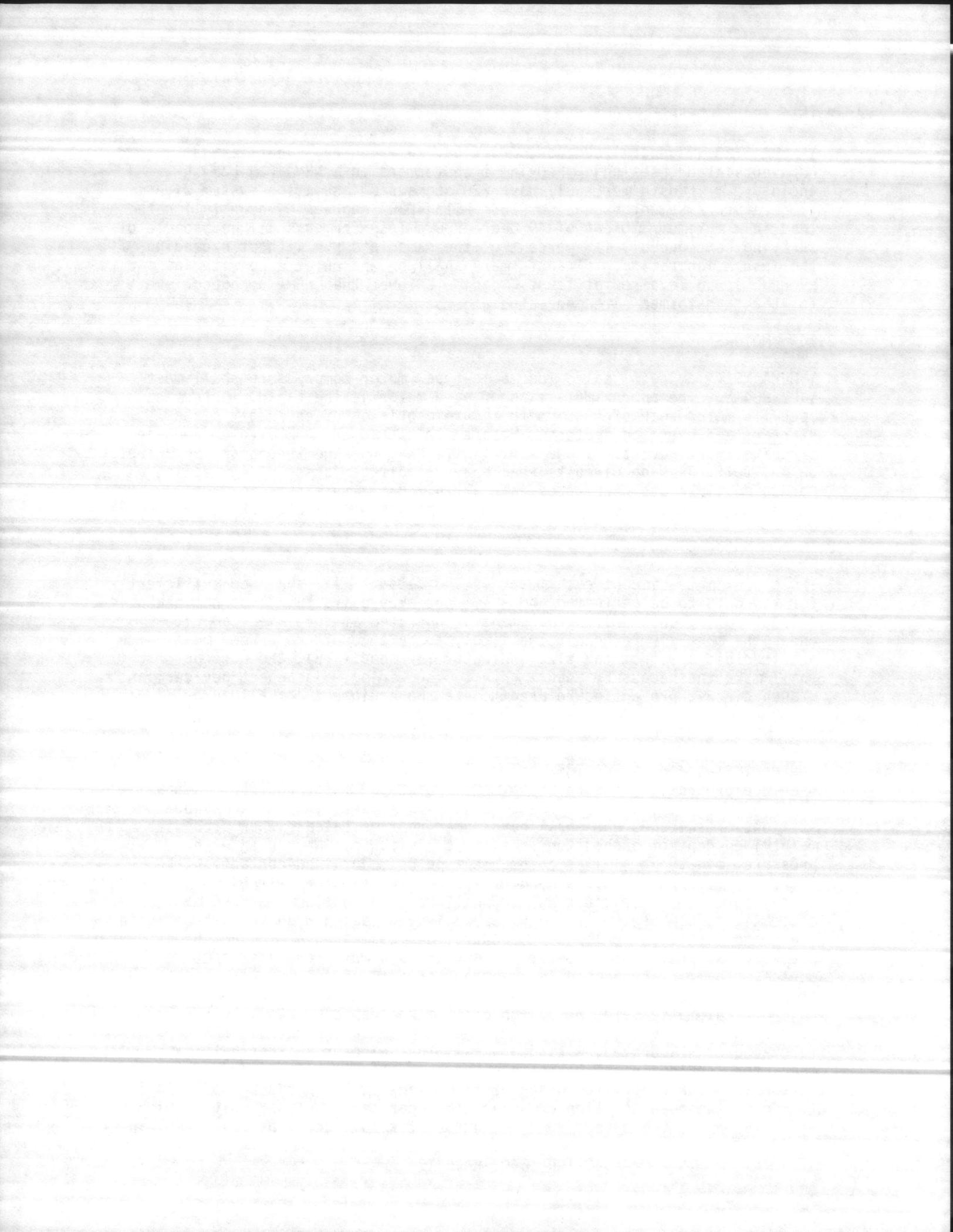
\-NEMA MG1-\, except sealed (hermetic-type) motor-compressors shall meet \-UL 984-\. The approximate size of each motor is indicated. Determine specific motor characteristics to insure provision of correctly sized starters and overload heaters. Motors for operation on 208-volt, 3-phase circuits shall have a voltage rating of 200 volts, and those for operation on 480-volt, 3-phase circuits shall have a voltage rating of 460 volts. Motors shall be designed to operate at full capacity with a voltage variation of plus or minus 10 percent of the motor voltage rating.

2.16.1 Motor Sizes

The approximate size of each motor is indicated. Size shall be sufficient for the duty to be performed and shall not exceed its full load nameplate current rating when driven equipment is operated at specified capacity under the most severe conditions likely to be encountered. When motor size provided differs from the size indicated (or specified), the Contractor shall make the necessary adjustments to the wiring, disconnect devices, and branch circuit protection to accommodate the equipment actually provided.

2.17 MOTOR CONTROLLERS

\-NEMA ICS1-\ and \-NEMA ICS2-\. All controllers shall have thermal overload protection in each phase. Magnetic-type motor controllers shall have under voltage protection when used with momentary-contact pushbutton stations or switches and shall have under voltage release when used with maintained-contact pushbutton stations or switches. When used with a pressure, float, or similar automatic-type or maintained-contact switch, the controller shall have a hand-off-automatic selector switch. Connections to the selector switch shall be such that only the normal automatic regulatory control devices will be bypassed when the switch is in the "hand" position. All safety control devices, such as low and high pressure cutouts, high temperature cutouts, and motor overload protective devices, shall be connected in the motor control circuit in both the "hand" and the "automatic positions. Control circuit connections to any hand-off-automatic selector switch or to more than one automatic regulatory control device shall be made in accordance with an indicated, or a manufacturer's approved, wiring diagram. The selector switch shall have means for locking in any position. For each motor not in sight of the controller, the controller disconnecting means shall be capable of being locked in the open position or a manually operated, nonfused switch which will disconnect the motor from the source of supply shall be placed within



sight of the motor location. Overload protective devices shall give adequate protection to the motor windings, be of the thermal inverse-time-limit type, and include a manual-reset type pushbutton on the outside of the motor controller case. The cover of a combination motor controller and manual switch or circuit breaker shall be interlocked with the operating handle of the switch or circuit breaker so that the cover cannot be opened unless the handle of the switch or circuit breaker is in the off position.

2.17.1 Enclosures for Starters and Controllers

\-NEMA ICS6-\.

2.17.2 Multiple-Speed Motor Controllers and Reversible-Motor Controllers

Across-the-line type, electrically and mechanically interlocked. Multiple-speed controllers shall have compelling relays and shall be the multiple-button station type with pilot lights for each speed.

2.17.3 Pushbutton Stations

Provide with "start-stop" momentary contacts having one normally open and one normally closed set of contacts, and ruby indicating lights to indicate when the motor is running. Stations shall be heavy-duty, oil-tight design.

2.17.4 Pilot and Indicating Lights

Provide transformer, resistor, or diode type.

2.17.5 Terminal Blocks

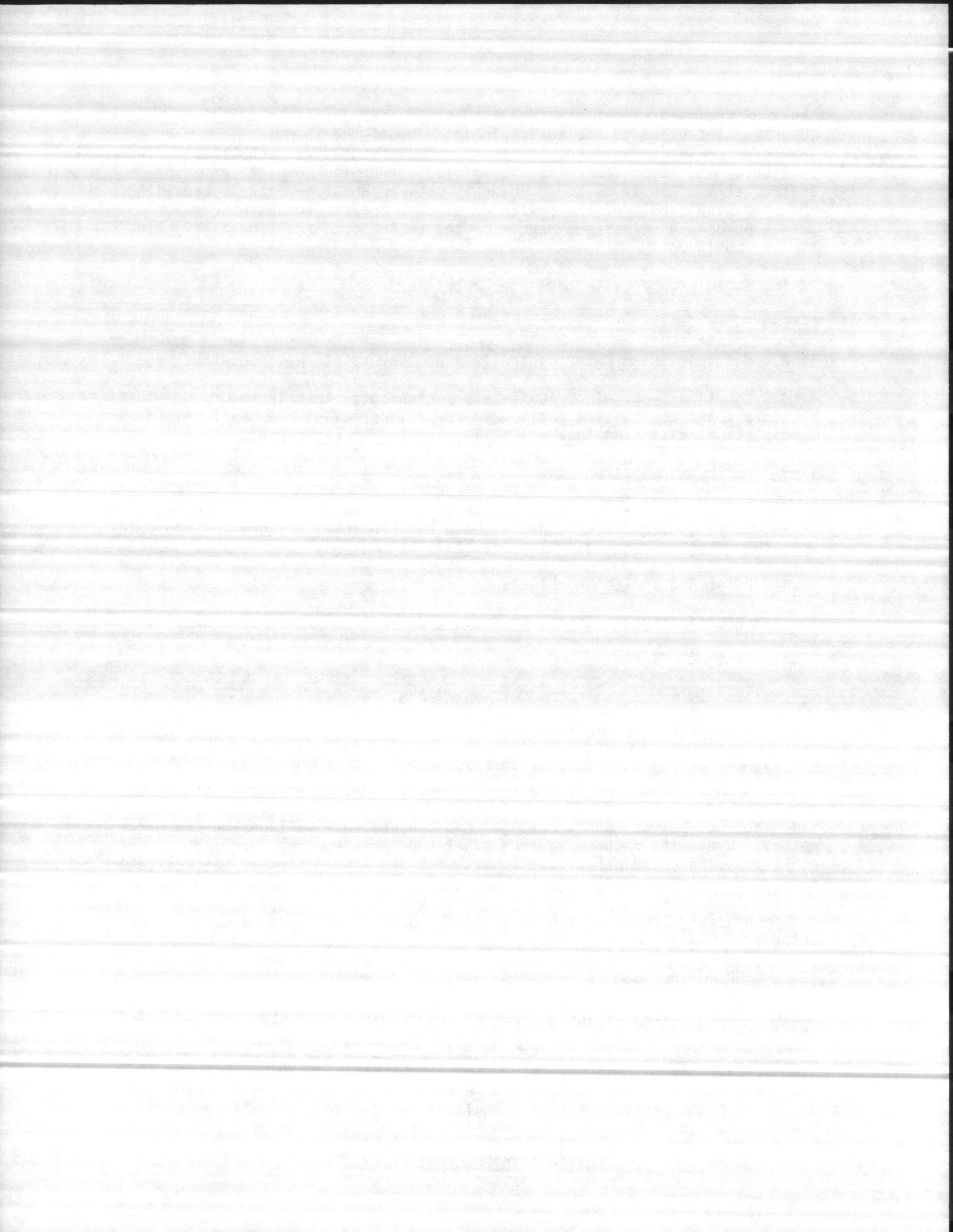
\-NEMA ICS4-\.

2.17.6 Reduced-Voltage Controllers

Provide for polyphase motors horsepower and larger. Reduced-voltage starters shall be of the single-step closed transition autotransformer, reactor, or resistor type, or as indicated, and shall have an adjustable time interval between application of reduced and full voltages to the motors. Wye-delta reduced voltage starter or part winding increment starter having an adjustable time delay between application of voltage to first and second winding of motor may be used in lieu of reduced voltage starters for starting of [motor-generator sets,] [centrifugally operated equipment] [or] [reciprocating compressors provided with automatic unloaders].

2.18 MOTOR CONTROL CENTERS

\-NEMA ICS2-\, Class [I] [II], Type [A] [B] [C], in NEMA Type [1] [3R] [12] enclosure. Control centers shall be rated at _____ volts, _____-phase, _____ hertz, _____-ampere bus braced for [42,000] [_____] amperes RMS symmetrical. Incoming power feeder shall be [busway] [cable] entering at [top] [bottom] of the enclosure and terminating on [lugs] [main protective device]. [Main protective device shall be [molded case circuit breaker] [low-voltage power circuit breaker] [fusible switch] rated at _____ amperes



RMS symmetrical interrupting capacity.] Arrange busing so that control center can be expanded from both ends. Bus shall be [tin-] [silver-] plated copper. Interconnecting wires shall be copper. Terminal blocks shall be plug-in type so that controllers may be removed without disconnecting individual control wiring.

2.19 TELEPHONE SYSTEM

Provide a system of conduits with pull wires, terminal boxes, outlet and junction boxes, and other accessories for telephone outlets. The complete system shall be ready for use by others who will install wire and equipment.

2.19.1 Outlet Boxes for Telephone System

Standard type, as specified hereinbefore. Mount flush in finished walls at the height [indicated] [specified for the outlet receptacles].

2.19.2 Cover Plates

Standard telephone type of the finish specified for receptacle and switch cover plates.

2.19.3 Conduit Sizing

Unless otherwise indicated, conduit for single outlets shall be a minimum of 3/4 inch and for multiple outlets a minimum of 1 inch. Size conduits for telephone risers to telephone cabinets, junction boxes, distribution centers, and telephone service as indicated.

2.19.4 Backboards

Interior grade plywood, 3/4 inch thick.

2.19.5 Terminal Cabinets

Construct of cold-rolled sheet steel. Match trim, hardware, doors, and finishes to lighting panelboards.

2.20 GROUNDING AND BONDING EQUIPMENT

\-UL 467-\). Ground rods shall be the sectional type, copper-encased steel, with minimum diameter of 3/4 inch and total length [as indicated] [of 20 feet].

2.21 HAZARDOUS LOCATIONS

Electrical materials, equipment, and devices for installation in hazardous locations, as defined by \-NFPA 70-\), shall be specifically approved by Underwriters' Laboratories, Inc., or Factory Mutual for the particular "Class," "Division," and "Group" of hazardous locations involved. The boundaries and classifications of hazardous locations shall be as indicated on the drawings.

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2.22 ADDITIONAL CRITERIA

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 General Requirements

Electrical installations shall conform to the requirements of \-NFPA 70-\ and to the requirements specified herein.

3.1.2 Hazardous Locations

3.1.1 General Requirements: Equipment that has been approved and listed by UL shall be installed as specified in the UL "Green Book", Electrical Materials Directory. Electrical installations shall conform to the requirements of NFPA 70 and to the requirements specified herein.

threads.

3.1.3 Wiring Methods

Wiring method shall be insulated conductors installed in conduit, except where specifically indicated or specified otherwise, or required by \-NFPA 70-\ to be installed otherwise. An [insulated] equipment grounding conductor shall be provided in all feeder and branch circuits, including lighting circuits. Provide insulated, green-colored conductor for grounding conductors installed in conduit or raceways.

3.1.3.1 Aluminum Conduit

Do not install underground or encase in concrete. Do not use brass or bronze fittings.

3.1.3.2 Electrical Metallic Tubing

Do Not:

1. Use in Feeder Circuits
2. Install underground
3. Encase in concrete
4. Use in areas where subject to severe physical damage
5. Use in hazardous areas
6. Use in outdoor work
7. Use in sizes larger than 2 inches.

3.1.3.3 Nonmetallic Conduit

Do not use above ground floor slab except where specifically indicated or specified for special situations or systems.

3.1.3.4 Service Entrance Conduit, Overhead

Rigid steel or IMC from the service equipment to the service entrance fitting or weatherhead outside the building.

Which one?

2.22 ADDITIONAL CRITERIA

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 General Requirements

Electrical installations shall conform to the requirements of \-NFPA 70-\ and to the requirements specified herein.

3.1.2 Hazardous Locations

Work in hazardous locations, as defined by \-NFPA 70-\, shall be performed in strict accordance with NFPA 70 for the particular "Class," "Division," and "Group" of hazardous locations involved. Provide conduit and cable seals where required by \-NFPA 70-\. All conduit shall have tapered threads.

3.1.3 Wiring Methods

Wiring method shall be insulated conductors installed in conduit, except where specifically indicated or specified otherwise, or required by \-NFPA 70-\ to be installed otherwise. An [insulated] equipment grounding conductor shall be provided in all feeder and branch circuits, including lighting circuits. Provide insulated, green-colored conductor for grounding conductors installed in conduit or raceways.

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Do Not:

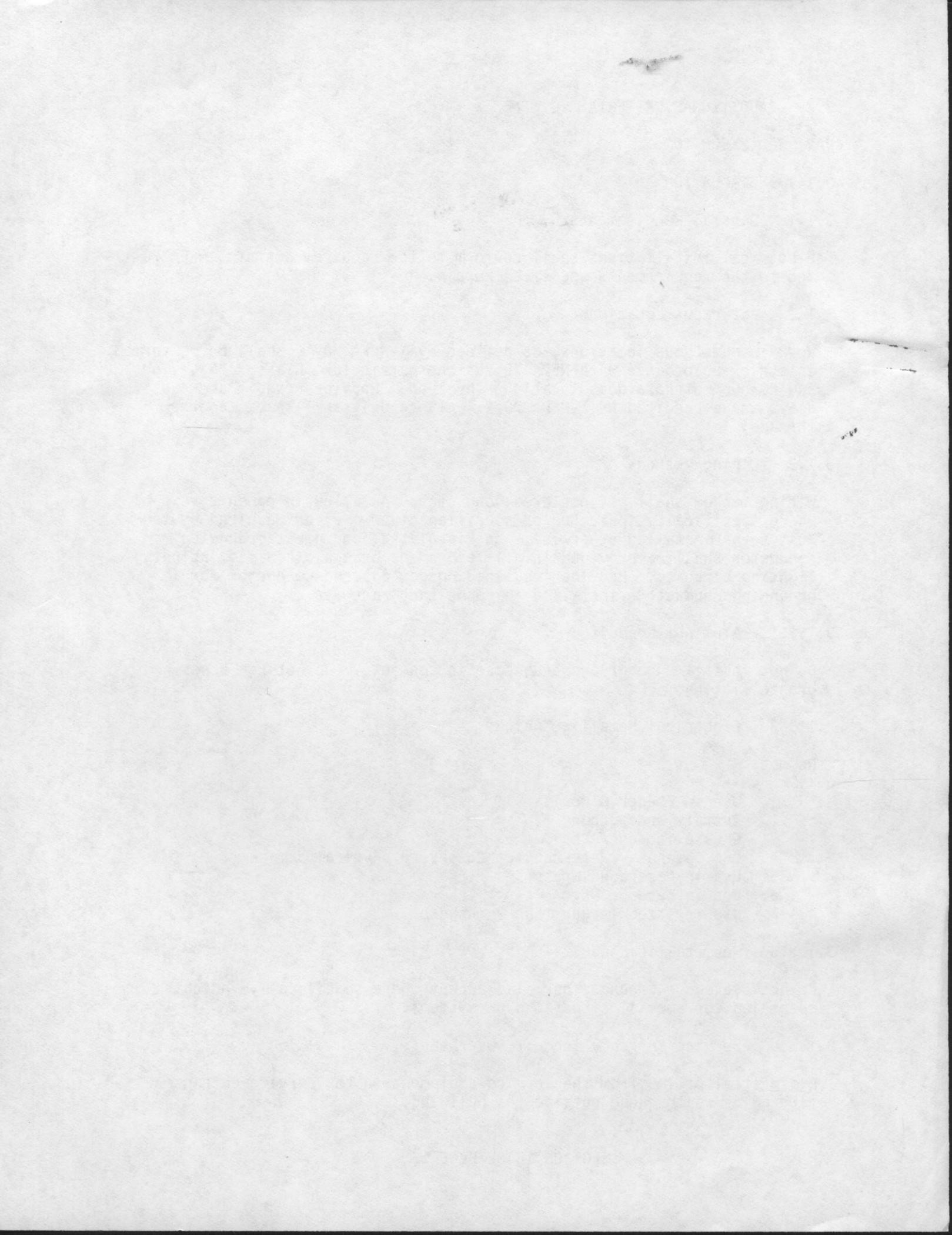
1. Use in Feeder Circuits
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Rigid steel or IMC from the service equipment to the service entrance fitting or weatherhead outside the building.



2.22 ADDITIONAL CRITERIA

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 General Requirements

Electrical installations shall conform to the requirements of \-NFPA 70-\ and to the requirements specified herein.

3.1.1 General Requirements: Equipment that has been approved and listed by UL shall be installed as specified in the UL "Green Book", Electrical Materials Directory. Electrical installations shall conform to the requirements of NFPA 70 and to the requirements specified herein.

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3.1.3.1 Aluminum Conduit

Do not install underground or encase in concrete. Do not use brass or bronze fittings.

3.1.3.2 Electrical Metallic Tubing

Do Not:

1. Use in Feeder Circuits
2. Install underground
3. Encase in concrete
4. Use in areas where subject to severe physical damage
5. Use in hazardous areas
6. Use in outdoor work
7. Use in sizes larger than 2 inches.

3.1.3.3 Nonmetallic Conduit

Do not use above ground floor slab except where specifically indicated or specified for special situations or systems.

3.1.3.4 Service Entrance Conduit, Overhead

Rigid steel or IMC from the service equipment to the service entrance fitting or weatherhead outside the building.

3.1.5. Hazardous Locations

Work in hazardous locations, as defined by NFPA 70-1, shall be performed in strict accordance with NFPA 70 for the particular "Class," "Division," and "Group" of hazardous locations involved. Provide conduit and cable as required by NFPA 70-1. All conduit shall have caps.

3.1.1 General Requirements: Equipment that has been approved and listed by UL shall be installed as specified in the UL "Green Book", Electrical Materials Directory. Electrical installations shall conform to the requirements of NFPA 70 and to the requirements specified herein.

Which one?

3.1.1 General Requirements: Equipment that has been approved and listed by UL shall be installed as specified in the UL "Green Book", Electrical Materials Directory. Electrical installations shall conform to the requirements of NFPA 70 and to the requirements specified herein.



3.1.3.5 Service Entrance Conduit, Underground

Rigid steel or steel IMC. The underground portion shall be encased in a minimum of 3 inches of concrete, and shall be installed at least 18 inches below slab, or grade.

3.1.3.6 Underground Conduit (Other Than Service Entrance)

Plastic-coated rigid steel; plastic-coated steel IMC; PVC, Type EPC-40; or FRE. Where non metallic conduit is used, it shall be converted to plastic-coated rigid (or IMC) steel conduit before rising through floor slab; plastic coating shall extend at least 6 inches above floor.

3.1.3.7 Conduit in Floor Slabs

Rigid steel; steel IMC; FRE; or PVC, Type EPC-40.

3.1.3.8 Conduit for 400-Hertz Circuits

Conduit for 400-Hertz circuits shall be aluminum. Where circuit runs through concrete, the aluminum conduit shall be installed in a nonmetallic conduit sleeve.

3.1.3.9 Conduit for Circuits Rated Above 600 Volts

Use rigid metal conduit or IMC only.

3.1.3.10 [Metal Clad Cable

Install in accordance with \-NFPA 70-\ Type MC cable.]

3.1.3.11 [Armored Cable

Install in accordance with \-NFPA 70-\ Type AC cable.]

3.1.3.12 [Flat Conductor Cable

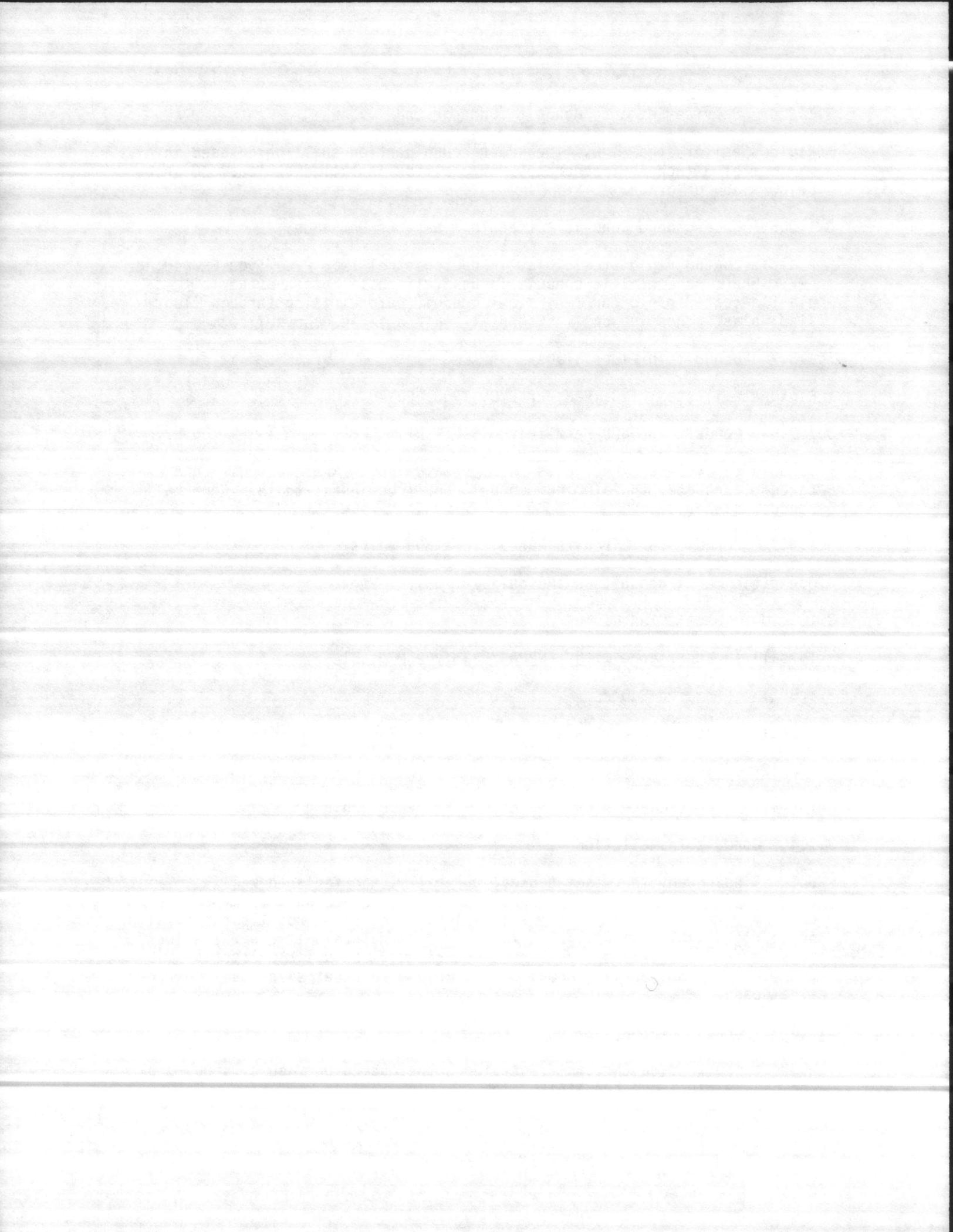
Install in accordance with \-NFPA 70-\ Type FCC cable.]

3.1.4 Conduit Installation

Unless indicated otherwise, conceal conduit within finished walls, ceilings, and floors. Keep conduit at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project. [Conduits in crawl space under slab shall be run as if exposed.]

3.1.4.1 Conduit Through Floor Slabs

Where conduits rise through floor slabs, the curved portion of bends shall not be visible above the finish slab.



3.1.4.2 Conduit Support

Support conduit by pipe straps, wall brackets, hangers, or ceiling trapeze. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. The load applied to fasteners shall not exceed one-fourth of the proof test load. Fasteners attached to concrete ceiling shall be vibration and shock resistant. Holes cut to a depth of more than 1-1/2 inches in reinforced concrete beams or to a depth of more than 3/4 inch in concrete joints shall not cut the main reinforcing bars. Fill holes that are not used. In partitions of light steel construction, use sheet-metal screws. In suspended-ceiling construction, run conduit above the ceiling and fasten only lighting system branch circuit conduits to the ceiling supports. Spring steel fasteners may be used for lighting branch circuit conduit supports in suspended ceiling in dry locations. [Support exposed risers in wire shafts of multistory buildings by U-clamp hangers at each floor level and at intervals not to exceed 10 feet.] Where conduit crosses building expansion joints provide a suitable [watertight] expansion fitting that maintains the conduit electrical continuity by bonding jumpers or other means.

3.1.4.3 Conduit Bends

Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with a hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits boxes, fittings, and equipment during construction. Free clogged conduits of all obstructions.

3.1.4.4 Use of Pull Wires

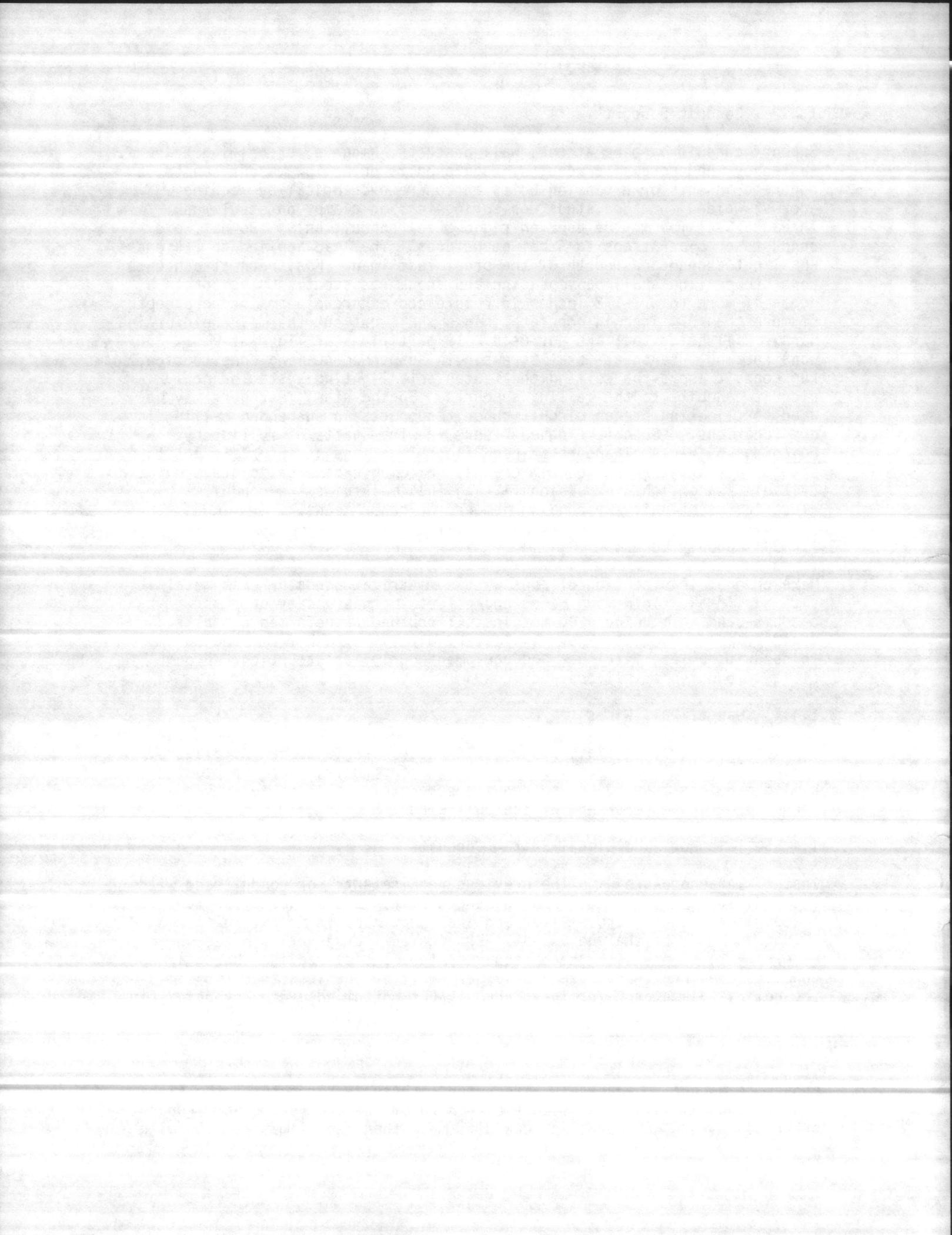
Install pull wires in empty conduits in which wire is to be installed by others. The pull wire shall be No. 14 AWG zinc-coated steel or plastic having not less than 200-pound tensile strength. Leave not less than 12 inches of slack at each end of the pull wire.

3.1.4.5 Telephone and Signal System Conduits

Install in accordance with the previous requirements for conduit and with the additional requirement that no length of run shall exceed 150 feet for trade sizes 2 inches and smaller and shall not contain more than two 90-degree bends or the equivalent. Provide pull or junction boxes where necessary to comply with these requirements. Inside radii of bends in conduits one-inch trade size and larger shall be not less than two times the nominal diameter. Terminate conduit [at bottom edge of backboard] [in terminal cabinet with two locknuts and a plastic bushing].

3.1.4.6 Conduit Installed in Concrete Floor Slabs

Locate so as not to adversely affect the structural strength of the slabs. Install conduit within the middle one-third of the concrete slab. [Do not stack conduits.] Do not stack conduits more than two diameters high with a



minimum vertical separation of _____ inches.] Space conduits horizontally not closer than three diameters except at cabinet locations. Curved portions of bends shall not be visible above the finish slab. Increase slab thickness as necessary to provide a minimum one-inch cover over conduit. Where embedded conduits cross expansion joints, provide suitable watertight expansion fittings and bonding jumpers. Conduit larger than one-inch trade size shall be parallel with or at right angles to the main reinforcement; when at right angles to the reinforcement, the conduit shall be close to one of the supports of the slab. Where nonmetallic conduit is used, raceway must be converted to rigid steel or steel IMC before rising above floor, unless specifically indicated otherwise.

3.1.4.7 Conduit Fastenings

Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by \-NFPA 70-\, where insulated bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, use at least a single locknut and bushing. Locknuts shall be the type with sharp edges for digging into the wall of metal enclosures. Install bushings on the ends of conduits and provide insulating type where required by \-NFPA 70-\.

3.1.4.8 Stub-Ups

Provide conduits stubbed up through concrete floor for connection to free-standing equipment with an adjustable top or coupling threaded inside for plugs, set flush with the finished floor. Extend conductors to equipment in rigid steel conduit, except that flexible metal conduit may be used 6 inches above the floor. Where no equipment connections are made, install screwdriver-operated threaded flush plugs in conduit end.

3.1.4.9 Recessed Lighting

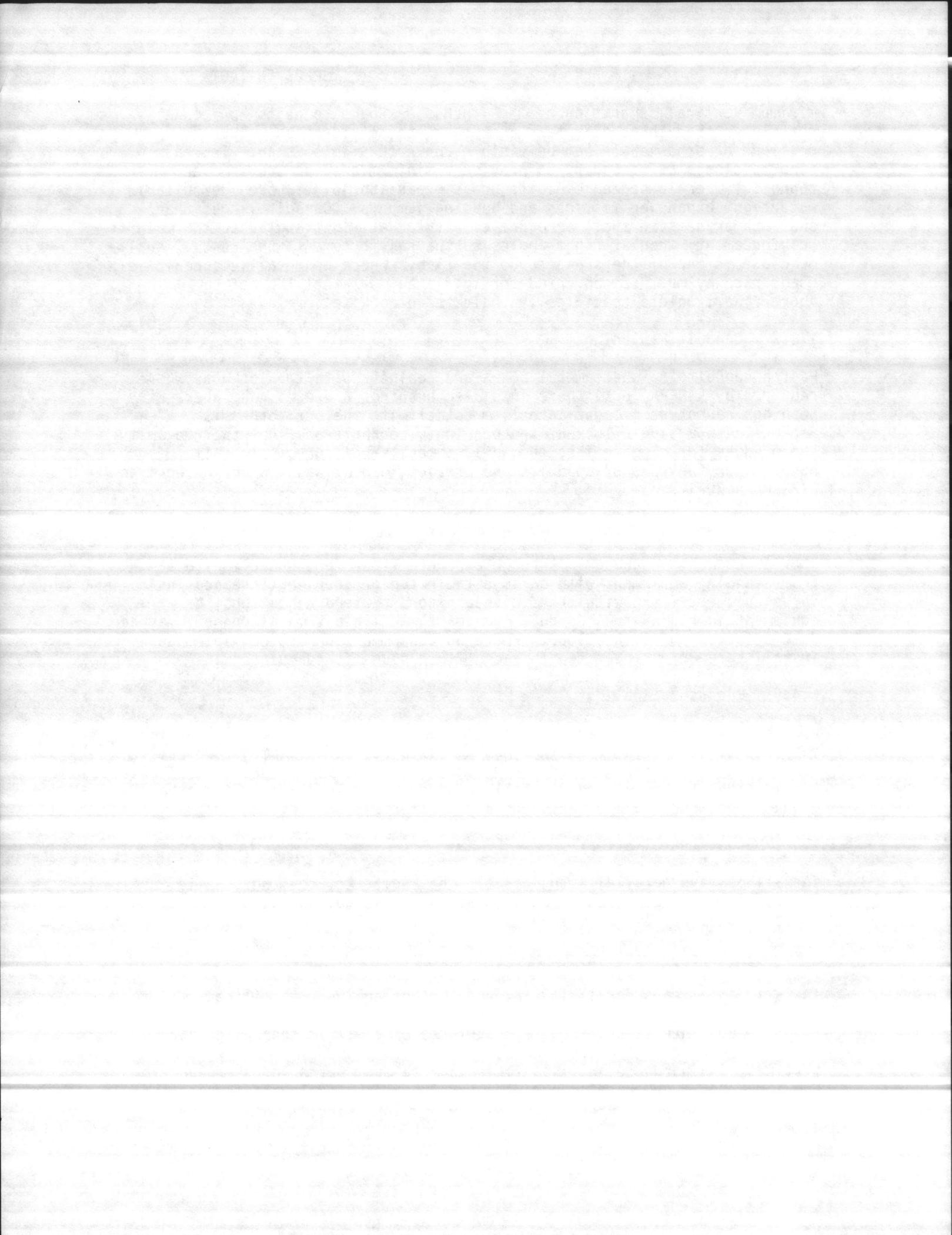
Flexible connections of short length (maximum of 6 feet) shall be provided for recessed and semi-recessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Liquid-tight flexible conduit shall be used in wet locations. A separate ground conductor shall be provided across flexible connections.

3.1.5 Busway Installation

Install busways parallel with, or at right angles to, ceilings, walls, and structural members. Support busways at intervals not exceeding 5 feet, and brace to prevent lateral movement.

3.1.6 Cable Tray Installation

Install cable trays parallel with, or at right angles to, ceilings, walls, and structural members. Support [as indicated] [at not more than [6] [_____] -foot intervals]. [Contact surfaces of aluminum connections shall be coated with an antioxidant compound prior to assembly.] All edges, fittings, and hardware shall be finished free from burrs and sharp edges. Provide a No. 2 AWG bare copper wire throughout the cable tray system and bond to each section, except use No. 1/0 aluminum wire if cable tray is aluminum.



3.1.7 Boxes, Outlets, and Supports

Provide boxes in the wiring or raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes for metallic raceways shall be of the cast-metal hub type when located in normally wet locations, when surface mounted on outside of exterior surfaces, when installed exposed up to 7 feet above interior floors and walkways, and when installed in hazardous areas. Boxes in other locations shall be sheet steel, except that aluminum boxes may be used with aluminum conduit [, and nonmetallic boxes may be used with nonmetallic [sheathed cable] [conduit] system]. Each box shall have the volume required by \-NFPA 70-\ for the number of conductors enclosed in the box. Boxes for mounting lighting fixtures shall be not less than 4 inches square (or octagonal), except that smaller boxes may be installed as required by fixture configurations, as approved. Boxes for use in masonry-block or tile walls shall be square-cornered tile-type, or standard boxes having square-cornered tile-type covers. Provide gaskets for cast-metal boxes installed in wet locations and boxes installed flush with the outside of exterior surfaces. Provide separate boxes for flush or recessed fixtures when required by the fixture terminal operating temperature; fixtures shall be readily removable for access to the boxes unless ceiling access panels are provided. Support boxes and pendants for surface-mounted fixtures on suspended ceilings independently of the ceiling supports or make adequate provisions for distributing the load over the ceiling support members in an approved manner. Fasten boxes and supports with wood screws on wood, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel work. [Threaded studs driven in by powder charge and provided with lockwashers and nuts [or nail-type nylon anchors] may be used in lieu of wood screws, expansion shields, or machine screws.] In open overhead spaces, cast boxes threaded to raceways need not be separately supported except where used for fixture support; support sheet metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved type fastener not more than 24 inches from the box. When penetrating reinforced-concrete members, avoid cutting any reinforcing steel.

3.1.7.1 Boxes with Raceway Systems

Boxes for use with raceway systems shall not be less than 1-1/2 inches deep, except where shallower boxes required by structural conditions are approved. Boxes for other than lighting-fixture outlets shall be not less than 4 inches square, except that 4 inch by 2 inch boxes may be used where only one raceway enters the outlet. Telephone outlets shall be a minimum of 4 inches square by 1-1/2 inches deep.

3.1.7.2 Pull Boxes

Construct of not less than the minimum size required by \-NFPA 70-\ of code-gage aluminum or galvanized sheet steel, except where cast-metal boxes are required in locations specified above. Furnish boxes with screw-fastened covers. Where several feeders pass through a common pull box, tag the feeders to indicate clearly the electrical characteristics,

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circuit number, and panel designation.

3.1.7.3 [Use of Extension Rings

Extension rings may be used only on existing boxes in concealed conduit systems where wall is furred out for new finish.]

3.1.8 Mounting Heights

Mount panelboards, circuit breakers, and disconnecting switches so the height of the operating handle at its highest position will not exceed 78 inches from the floor. Mount lighting switches [48 inches above finished floor], receptacles [18 inches above finished floor], [and other devices] [as indicated]. Measure mounting heights of wiring devices and outlets to the center of device or outlet.

3.1.9 [Nonmetallic Sheathed Cable Installation

Install cables concealed behind ceiling or wall finish where practicable. Thread cables through holes bored on the approximate centerline of wood members; notching of end surfaces will not be permitted. Provide sleeves through concrete or masonry for threading cables. Install exposed cables parallel or at right angles to walls or structural members. Protect exposed nonmetallic sheathed cables less than 4 feet above floors from mechanical injury by installation in conduit or tubing. When cable is used in metal stud construction, insert plastic stud grommets in the studs at each point through which the cable passes.]

3.1.10 [Mineral Insulated-Metal Sheathed (Type MI) Cable Installation

Cables shall be fastened within 12 inches of each turn or offset and at intervals of not more than 6 feet. Cable terminations shall be made in accordance with \-NFPA 70-\ and the cable manufacturer's recommendations.]

3.1.11 Conductor Identification

Provide conductor identification within each enclosure where a tap, splice, or termination is made. For conductors No. 6 and smaller, color coding shall be by factory-applied color-impregnated insulation. For conductors No. 4 and larger, color coding shall be by plastic-coated self-sticking markers, colored nylon cable ties and plates, or heat-shrink type sleeves. Identify control circuit terminations.

3.1.11 Conductor Identification: Provide numerical identification of each circuit conductor within each enclosure; identification shall denote panelboard and branch circuit number. Provide conductor identification within each enclosure where a tap, splice, or termination is made. For conductors No. 6 and smaller, color coding shall be by factory-applied color-impregnated insulation. For conductors No. 4 and larger, color coding shall be by plastic-coated self-sticking markers, colored nylon cable ties and plates, or heat-shrink type sleeves. Identify control circuit terminations.

which one?

conductors No. 2 AWG and larger with a solderless connector and cover with an insulation material equivalent to the conductor insulation. Make splices in

3.1.12.1 Splices Involving Aluminum Conductors

Make with solderless circumferential compression type, aluminum-bodied connectors as listed for AL/CU. Remove all surface oxides from aluminum conductors by wire brushing and immediately apply an oxide-inhibiting joint

circuit number, and panel designation.

3.1.7.3 [Use of Extension Rings

Extension rings may be used only on existing boxes in concealed conduit systems where wall is furred out for new finish.]

3.1.8 Mounting Heights

Mount panelboards, circuit breakers, and disconnecting switches so the height of the operating handle at its highest position will not exceed 78 inches from the floor. Mount lighting switches [48 inches above finished floor], receptacles [18 inches above finished floor], [and other devices] [as indicated]. Measure mounting heights of wiring devices and outlets to the center of device or outlet.

3.1.9 [Nonmetallic Sheathed Cable Installation

Install cables concealed behind ceiling or wall finish where practicable. Thread cables through holes bored on the approximate centerline of wood members; notching of end surfaces will not be permitted. Provide sleeves through concrete or masonry for threading cables. Install exposed cables parallel or at right angles to walls or structural members. Protect exposed nonmetallic sheathed cables less than 4 feet above floors from mechanical injury by installation in conduit or tubing. When cable is used in metal stud construction, insert plastic stud grommets in the studs at each point through which the cable passes.]

3.1.10 [Mineral Insulated-Metal Sheathed (Type MI) Cable Installation

Cables shall be fastened within 12 inches of each turn or offset and at intervals of not more than 6 feet. Cable terminations shall be made in accordance with \-NFPA 70-\ and the cable manufacturer's recommendations.]

3.1.11 Conductor Identification

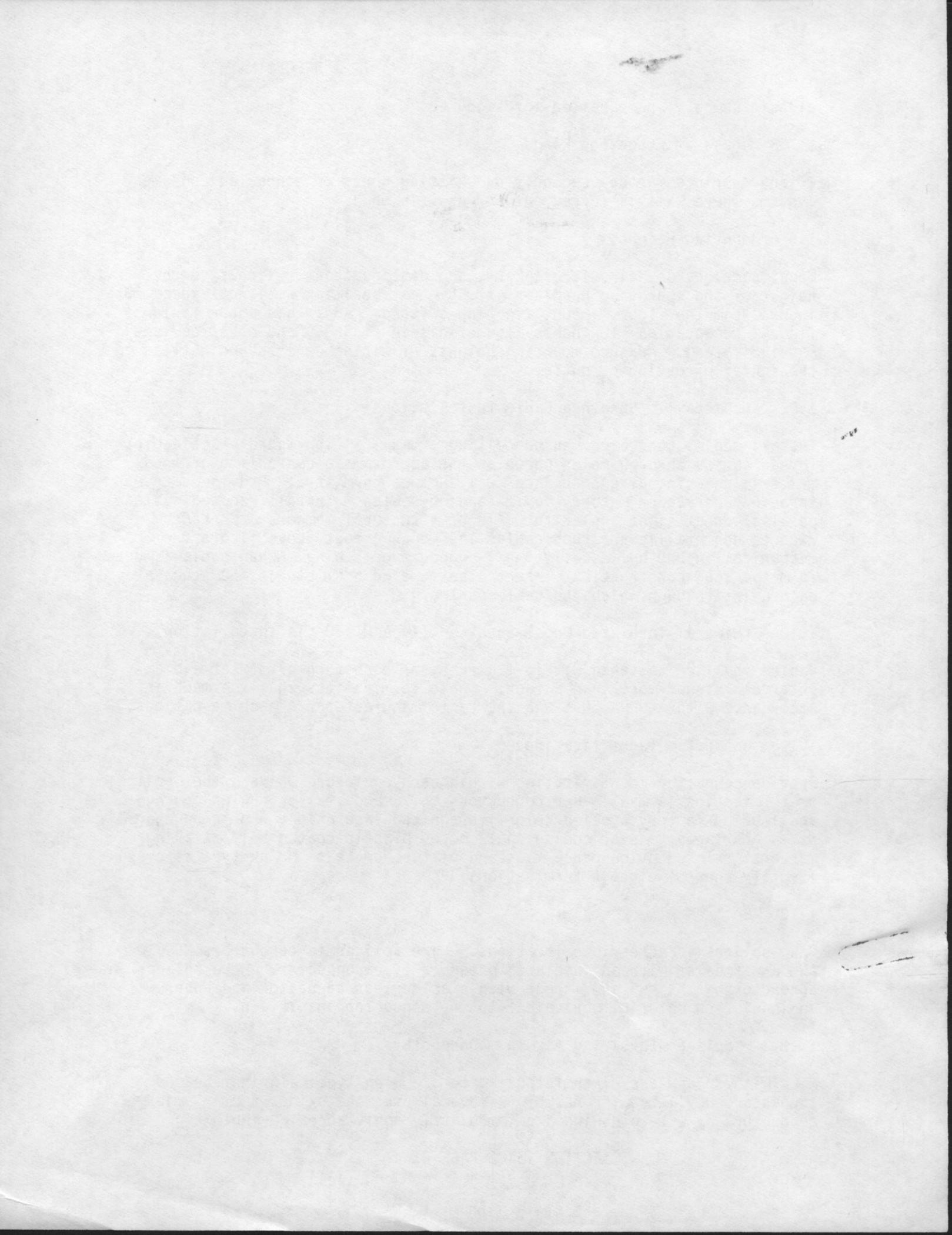
Provide conductor identification within each enclosure where a tap, splice, or termination is made. For conductors No. 6 and smaller, color coding shall be by factory-applied color-impregnated insulation. For conductors No. 4 and larger, color coding shall be by plastic-coated self-sticking markers, colored nylon cable ties and plates, or heat-shrink type sleeves. Identify control circuit terminations.

3.1.12 Splices

Make splices in accessible locations. Make splices in conductors No. 10 AWG and smaller with an insulated pressure type connector. Make splices in conductors No. 8 AWG and larger with a solderless connector and cover with an insulation material equivalent to the conductor insulation.

3.1.12.1 Splices Involving Aluminum Conductors

Make with solderless circumferential compression type, aluminum-bodied connectors UL listed for AL/CU. Remove all surface oxides from aluminum conductors by wire brushing and immediately apply an oxide-inhibiting joint



circuit number, and panel designation.

3.1.7.3 [Use of Extension Rings

Extension rings may be used only on existing boxes in concealed conduit systems where wall is furred out for new finish.]

3.1.8 Mounting Heights

Mount panelboards, circuit breakers, and disconnecting switches so the height of the operating handle at its highest position will not exceed 78 inches from the floor. Mount lighting switches [48 inches above finished floor], receptacles [18 inches above finished floor], [and other devices] [as indicated]. Measure mounting heights of wiring devices and outlets to the center of device or outlet.

3.1.9 [Nonmetallic Sheathed Cable Installation

Install cables concealed behind ceiling or wall finish where practicable. Thread cables through holes bored on the approximate centerline of wood members; notching of end surfaces will not be permitted. Provide sleeves through concrete or masonry for threading cables. Install exposed cables parallel or at right angles to walls or structural members. Protect exposed nonmetallic sheathed cables less than 4 feet above floors from mechanical injury by installation in conduit or tubing. When cable is used in metal stud construction, insert plastic stud grommets in the studs at each point through which the cable passes.]

3.1.10 [Mineral Insulated-Metal Sheathed (Type MI) Cable Installation

Cables shall be fastened within 12 inches of each turn or offset and at intervals of not more than 6 feet. Cable terminations shall be made in accordance with \-NFPA 70-\ and the cable manufacturer's recommendations.]

3.1.11 Conductor Identification

Provide conductor identification within each enclosure where a tap, splice, or termination is made. For conductors No. 6 and smaller, color coding shall be by factory-applied color-impregnated insulation. For conductors No. 4 and larger, color coding shall be by plastic-coated self-sticking markers, colored nylon cable ties and plates, or heat-shrink type sleeves. Identify control circuit terminations.

3.1.11 Conductor Identification: Provide numerical identification of each circuit conductor within each enclosure; identification shall denote panelboard and branch circuit number. Provide conductor identification within each enclosure where a tap, splice, or termination is made. For conductors No. 6 and smaller, color coding shall be by factory-applied color-impregnated insulation. For conductors No. 4 and larger, color coding shall be by plastic-coated self-sticking markers, colored nylon cable ties and plates, or heat-shrink type sleeves. Identify control circuit terminations.

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3.1.12 Splices

Make splices in accessible locations. Make splices in conductors No. 10 AWG and smaller with an insulated pressure type connector. Make splices in conductors No. 8 AWG and larger with a solderless connector and cover with an insulation material equivalent to the conductor insulation.

3.1.12.1 Splices Involving Aluminum Conductors

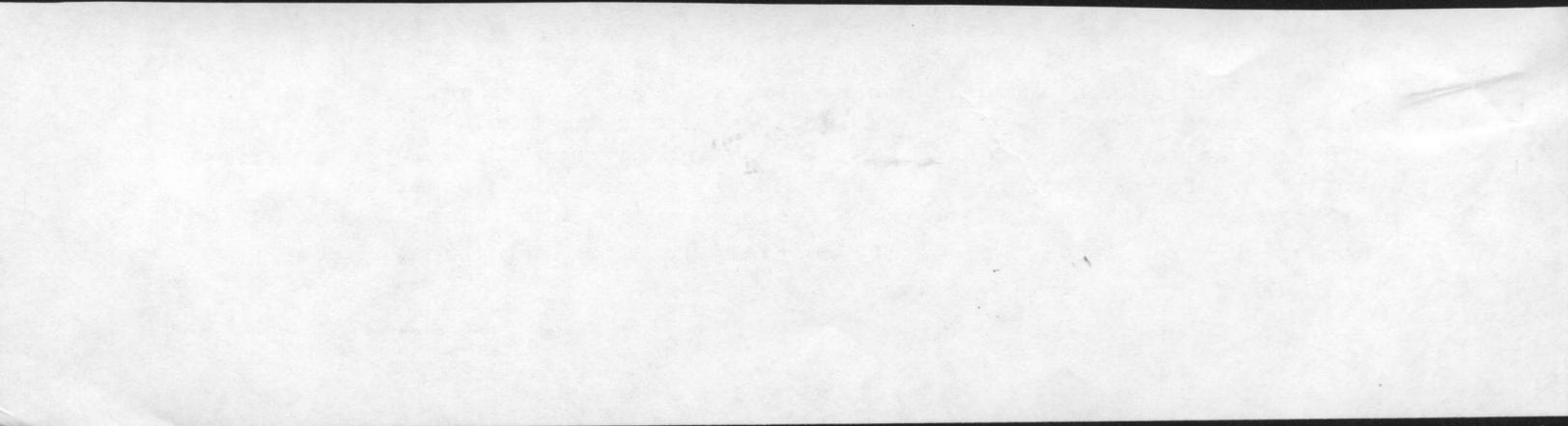
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NOTE

3.1.11 Conductor Identification: Provide numerical identification of each circuit conductor within each enclosure; identification shall denote panelboard and branch circuit number. Provide conductor identification within each enclosure where a tap, splice, or termination is made. For conductors No. 6 and smaller, color coding shall be by factory-applied color-impregnated insulation. For conductors No. 4 and larger, color coding shall be by plastic-coated self-sticking markers, colored nylon cable ties and plates, or heat-shrink type sleeves. Identify control circuit terminations.



compound and insert in connector. After joint is made, wipe away excess joint compound and insulate splice.

3.1.13 Terminating Aluminum Conductors

3.1.13.1 Aluminum-to-Copper

Terminate aluminum conductors to copper bus either by (a) inline splicing a copper pigtail to the aluminum conductor (copper pigtail shall have an ampacity at least that of the aluminum conductor), or (b) utilizing a circumferential compression type, aluminum-bodied terminal lug UL listed for AL/CU, and steel Belleville spring washers, flat washers, bolts, and nuts. Belleville spring washers shall be of cadmium-plated hardened steel. Take care to install the Belleville spring washers with the crown up toward the nut or bolt head, with the concave side of the Belleville bearing on a heavy-duty, wide series flat washer of larger diameter than the Belleville. Tighten nuts sufficiently to flatten Belleville and leave in that position. Lubricate all hardware with joint compound prior to making connection. Wire brush and apply joint compound to conductor prior to inserting in lug.

3.1.13.2 Aluminum-to-Aluminum

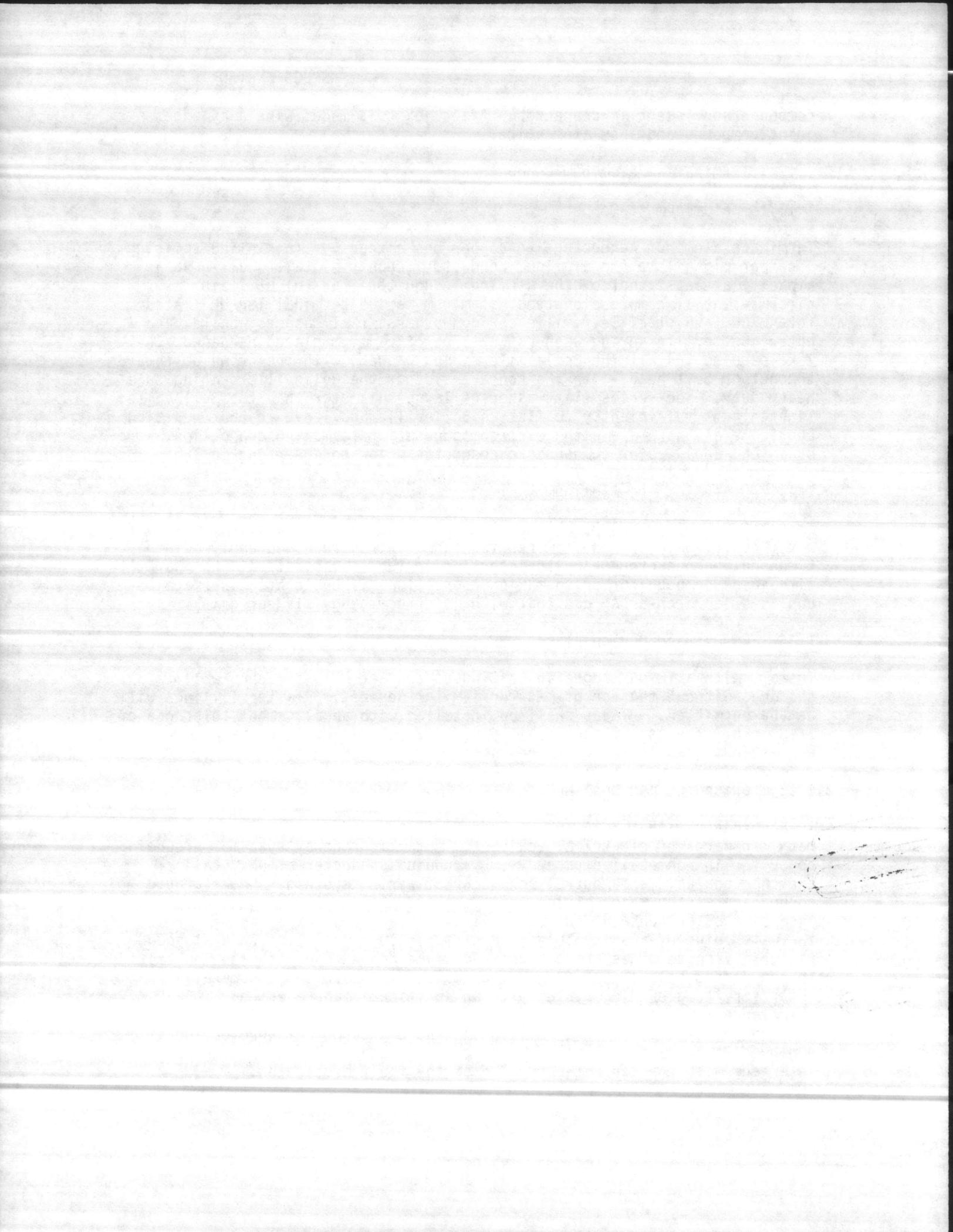
Terminate aluminum conductors to aluminum bus by utilizing all-aluminum nuts, bolts, washers, and compression lugs. Wire brush and apply joint compound to conductor prior to inserting in lug. Lubricate all hardware with joint compound prior to making connection; if bus contact surface is unplated, scratch-brush and coat with joint compound (without grit).

3.1.14 Covers and Device Plates

Install with all four edges in continuous contact with finished wall surfaces without the use of mats or similar devices. Plaster fillings will not be permitted. Plates shall be installed with an alignment tolerance of 1/16 inch. The use of sectional type device plates will not be permitted. Plates installed in wet locations shall be gasketed.

3.1.15 Grounding and Bonding

In accordance with \-NFPA 70-\. Ground all exposed non-current-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductor in nonmetallic raceways, [grounding conductor of nonmetallic sheathed cables,] and neutral conductor of wiring systems. [Make ground connection at the main service equipment and extend grounding conductor to the point of entrance of the metallic water service. Make connection to the water pipe by a suitable ground clamp or lug connection to a plugged tee. If flanged pipes are encountered, make connection with the lug bolted to the street side of the flanged connection. Supplement the metallic water service grounding system with an additional made electrode in compliance with \-NFPA 70-\.] [Make ground connection to driven ground rods on the exterior of the building.] Where ground fault protection is employed, take care that the connection of ground and neutral does not interfere with the correct operation of the fault protection.



3.1.15.1 Grounding Conductor

Provide an insulated, green-colored equipment grounding conductor in all feeder and branch circuits. This conductor shall be separate from the electrical system neutral conductor.

3.1.15.2 [Telephone Service

Provide a main telephone service equipment ground consisting of a separate No. 6 AWG ground wire in conduit between the equipment and a readily accessible grounding connection. The equipment end of the ground wire shall consist of a coiled length at least twice as long as the terminal cabinet or backboard height.]

3.1.15.3 Resistance

The maximum resistance to ground of the grounding system shall not exceed 25 ohms under normally dry conditions. Where the resistance obtained exceeds 25 ohms, contact the Contracting Officer for further instructions.

3.1.16 Government-Furnished Equipment

The Contractor [shall rough-in for this equipment] [shall make connections to this equipment] to make it operate as intended, including providing miscellaneous items such as plugs, receptacles, wire, cable, conduit, flexible conduit, and outlet boxes or fittings.

3.1.17 Repair of Existing Work

Lay out the work carefully in advance. Where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, or other surfaces is necessary for the proper installation, support, or anchorage of the conduit, raceways, or other electrical work, do this work carefully. Repair any damage to buildings, piping, or equipment using skilled mechanics of the trades involved.

3.1.17 Repair of Existing Work: Cut existing surfaces as required to install conduits, raceways, and other electrical work; repair damage caused by this work. Lay out the work carefully in advance. Where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, or other surfaces is necessary for the proper installation, support, or anchorage of the conduit, raceways, or other electrical work, do this work carefully. Repair any damage to buildings, piping, or equipment using skilled mechanics of the trades involved.

which one?

3.2.1 Devices Subject to Manual Operation

Each device subject to manual operation shall be operated at least five times, demonstrating satisfactory operation each time.

3.2.2 Test on 600-Volt Wiring

3.2.2.1 Test all 600-volt wiring to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on all wiring No. 6 AWG and larger using an instrument which applies a voltage of approximately 500 volts to provide a direct reading of resistance; minimum

5.2 FIELD TESTS

The Contractor shall provide all test equipment and personnel and submit written copies of all test results. As an exception to requirements that may be stated elsewhere in the contract, the Contracting Officer shall be given [] working days notice prior to each [] test[s].

3.1.15.1 Grounding Conductor

Provide an insulated, green-colored equipment grounding conductor in all feeder and branch circuits. This conductor shall be separate from the electrical system neutral conductor.

3.1.15.2 [Telephone Service

Provide a main telephone service equipment ground consisting of a separate No. 6 AWG ground wire in conduit between the equipment and a readily accessible grounding connection. The equipment end of the ground wire shall consist of a coiled length at least twice as long as the terminal cabinet or backboard height.]

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3.1.17 Repair of Existing Work

Lay out the work carefully in advance. Where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, or other surfaces is necessary for the proper installation, support, or anchorage of the conduit, raceways, or other electrical work, do this work carefully. Repair any damage to buildings, piping, or equipment using skilled mechanics of the trades involved.

3.2 FIELD TESTS

The Contractor shall provide all test equipment and personnel and submit written copies of all test results. As an exception to requirements that may be stated elsewhere in the contract, the Contracting Officer shall be given [5] [] working days notice prior to [each] [] test[s].

3.2.1 Devices Subject to Manual Operation

Each device subject to manual operation shall be operated at least five times, demonstrating satisfactory operation each time.

3.2.2 Test on 600-Volt Wiring

Test all 600-volt wiring to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on all wiring No. 6 AWG and larger using an instrument which applies a voltage of approximately 500 volts to provide a direct reading of resistance; minimum

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Provide an insulated, green-colored equipment grounding conductor in all feeder and branch circuits. This conductor shall be separate from the electrical system neutral conductor.

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resistance shall be 250,000 ohms*\.+\

3.2.3 Grounding System Test

Test the grounding system to assure continuity and that the resistance to ground is not excessive. Test each ground rod for resistance to ground before making any connections to the rod; then tie entire grounding system together and test for resistance to ground. Make resistance measurements in normally dry weather, not less than 48 hours after rainfall. Submit written results of each test to the Contracting Officer and indicate the location of the rods as well as the resistance and soil conditions at the time the measurements were made.

-- End of Section --

