

SECTION 16402

INTERIOR WIRING SYSTEMS

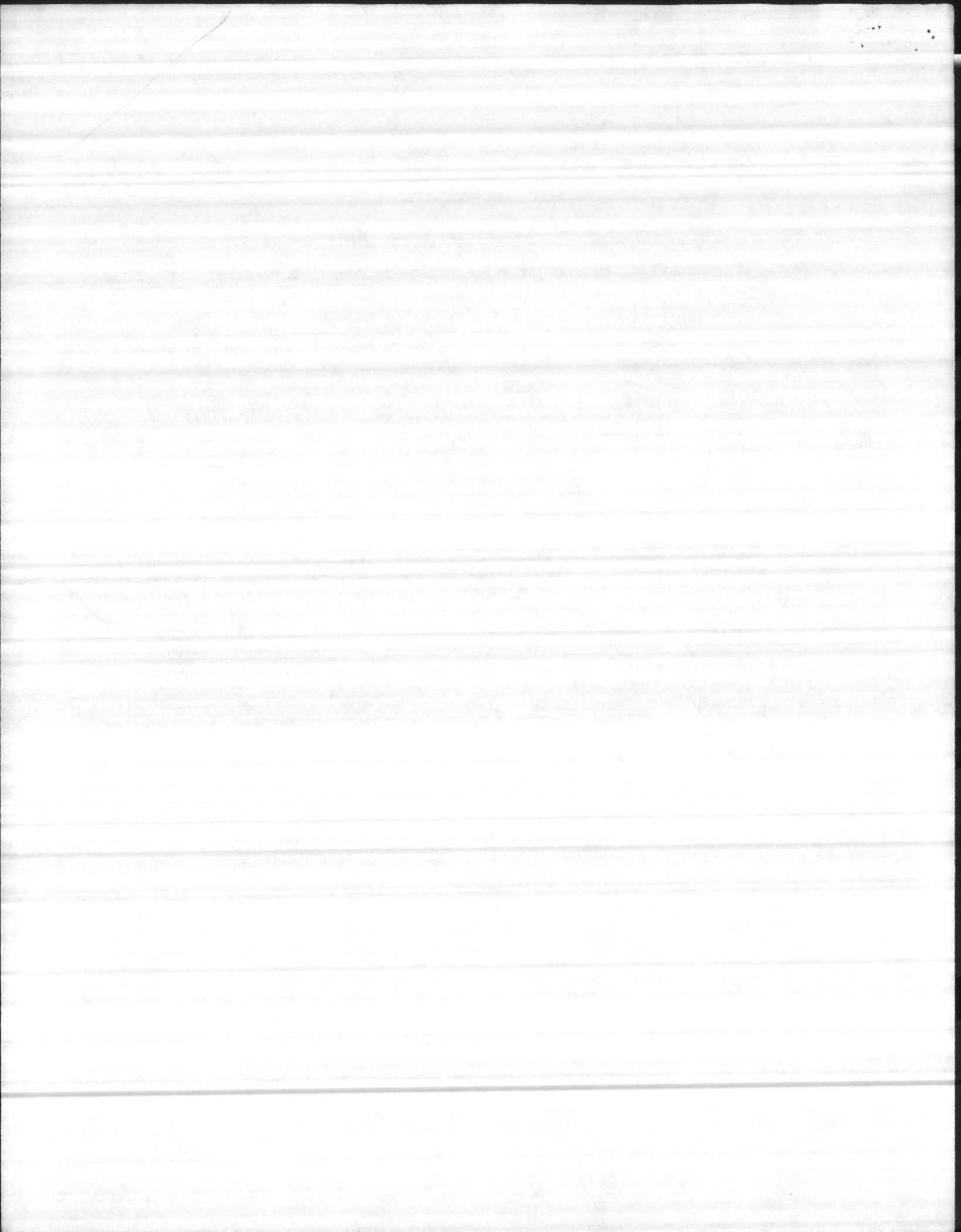
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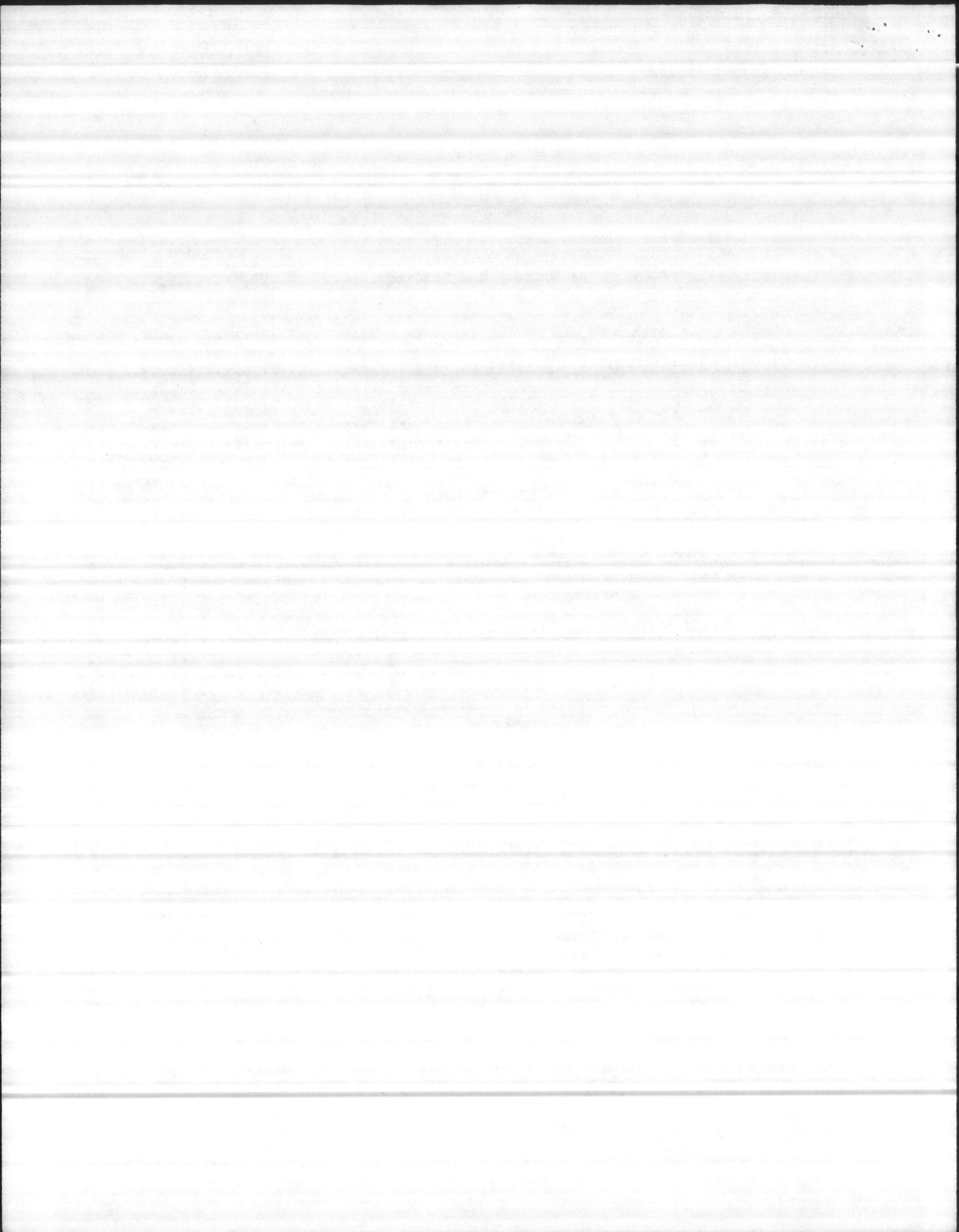
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This specification is not stocked at NPFC.



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SECTION 16402

INTERIOR WIRING SYSTEMS

PART 1 - GENERAL

1.1 APPLICABLE PUBLICATIONS: 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.

1.1.1 Federal Specifications (Fed. Spec.):

W-C-375B Circuit Breaker, Molded Case, Branch-Circuit and Service

W-S-896E(1) Switch, Toggle (Toggle and Lock), Flush Mounted

1.1.2 American National Standards Institute (ANSI) Publications:

C80.1-1977 Specification for Rigid Steel Conduit, Zinc-coated

C80.3-1977 Specification for Electrical Metallic Tubing, Zinc-coated

C80.5-1977 Specification for Rigid Aluminum Conduit

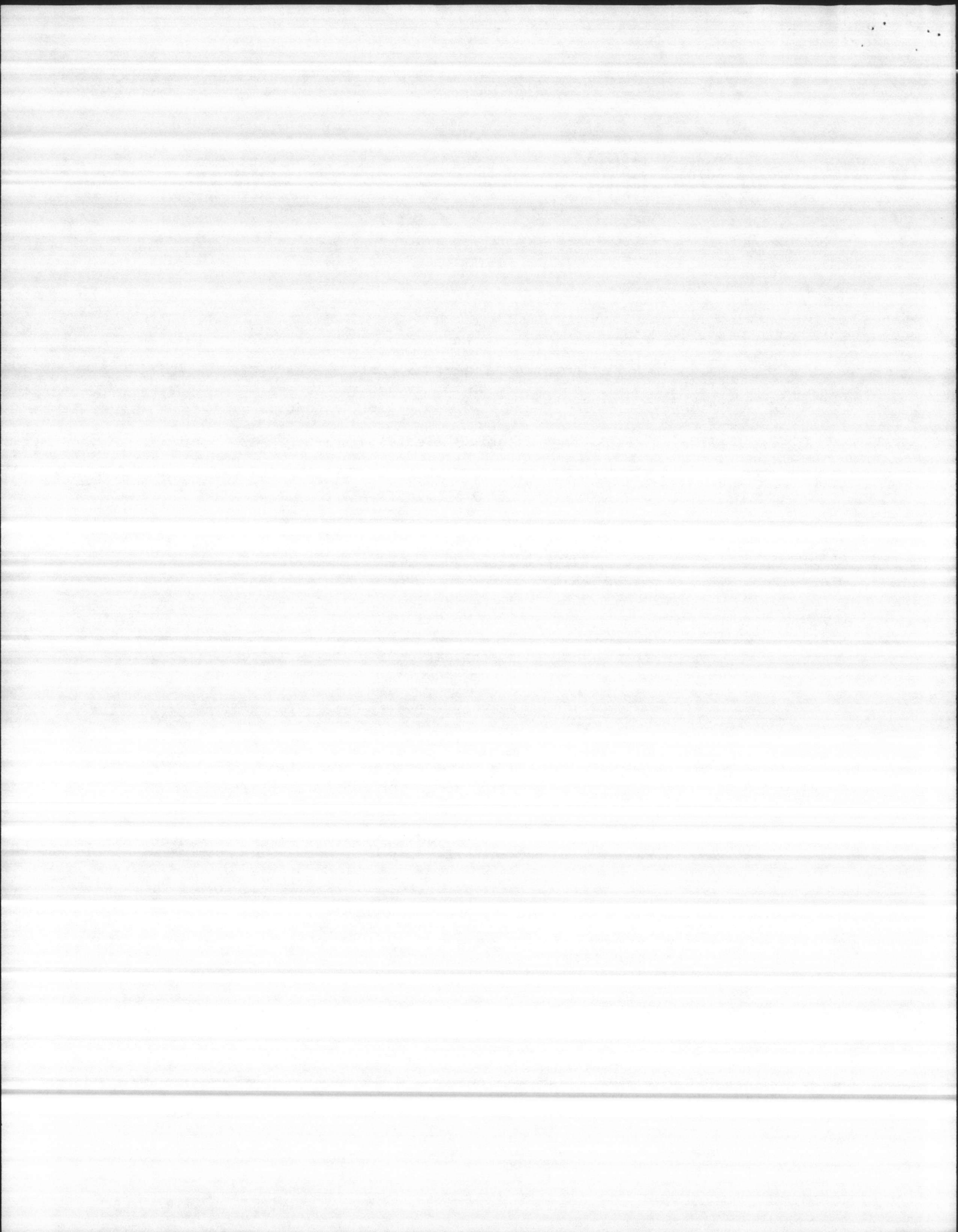
1.1.3 American Society for Testing and Materials (ASTM) Publications:

B 1-70 Hard-Drawn Copper Wire
(R 1976)

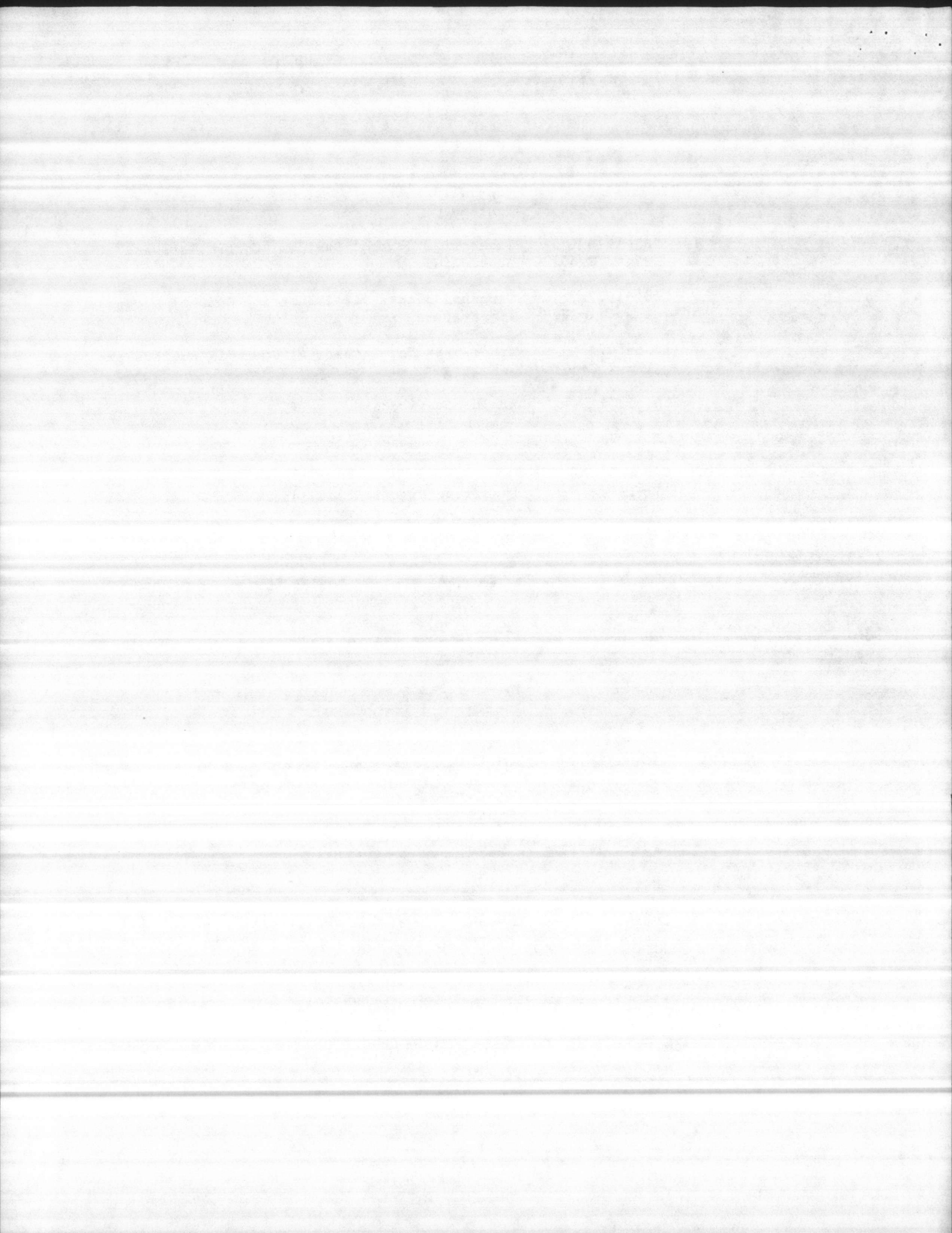
B 8-77 Concentric-Lay-Stranded Copper Conductor, Hard, Medium-Hard, or Soft

1.1.4 National Electrical Manufacturers Association (NEMA) Publications:

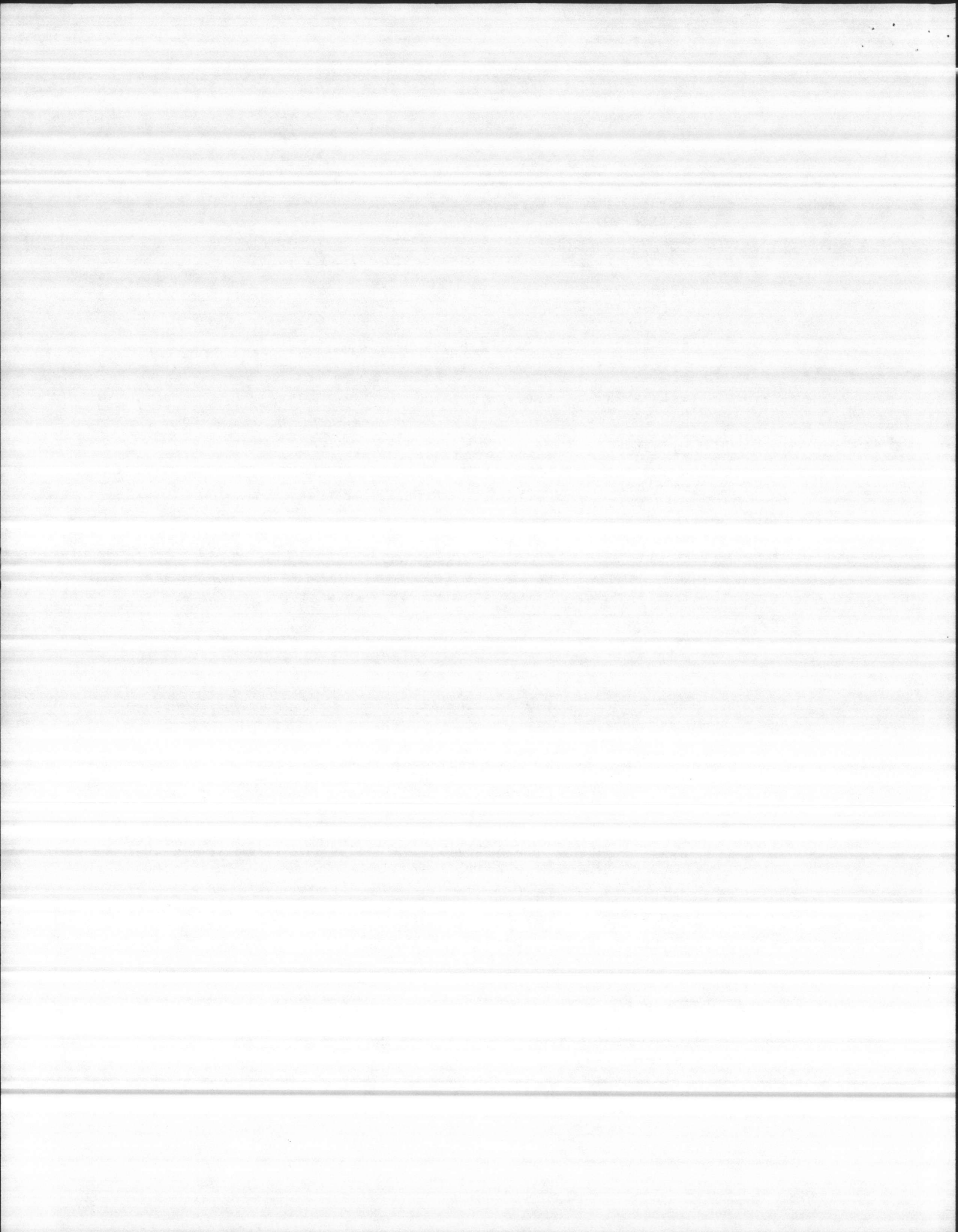
BUL-1978 Busways
(Rev. 1-78)



ICS1-1978 (Rev. 3-80)	General Standards for Industrial Control and Systems
ICS2-1978 (Rev. 2-80)	Industrial Control Devices, Controllers and Assemblies
ICS4-1977 (Rev. 1-78)	Terminal Blocks for Industrial Control Equipment and Systems
ICS6-1978 (Rev. 1-80)	Enclosures for Industrial Controls and Systems
ES1-1975	Enclosed Switches
MG1-1978 (Rev. 5-80)	Motors and Generators
FB2-1978	Deadfront Distribution Switchboards
ST20-1972 (R 1978)	Dry-Type Transformers for General Applications
TC2-1978 (Rev. 2-80)	Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)
TC3-1978	PVC Fittings for Use with Rigid PVC Conduit and Tubing
TC6-1978	PVC and ABS Plastic Utilities Duct for Underground Installation
TC9-1978 (Rev. 1-78)	Fittings for ABS or PVC Plastic Utilities Duct for Underground Installation
VE1-1979	Cable Tray Systems
WD1-1979 (Rev. 1-79)	General Purpose Wiring Devices
1.1.5 National Fire Protection Association (NFPA) Publication:	
70-1981	National Electrical Code (NEC)
1.1.6 Underwriters' Laboratories, Inc. (UL) Publications:	
1-1979 (Mar 80)	Flexible Metal Conduit
5-1979	Surface Metal Raceways and Fittings
50-1980	Cabinets and Boxes



67-1979 (Dec 80)	Panelboards
83-1980	Thermoplastic-Insulated Wires and Cables
198E-1975 (Aug 78)	Class H Fuses
198C-1981 (May 81)	High-Interrupting Capacity Fuses, Current-limiting Type
198D-1978 (May 79)	Class K Fuses
198E-1979	Class R Fuses
467-1972 (May 79)	Grounding and Bonding Equipment
486A-1980	Wire Connectors and Soldering Lugs for Use with Copper Conductors
486E-1978 (Feb 81)	Wire Connectors for Use with Aluminum Conductors
489-1980	Molded-Case Circuit Breakers and Circuit Breaker Enclosures
510-1976 (Jun 80)	Insulating Tape
514-1979 (Apr 80)	Outlet Boxes and Fittings
719-1979	Nonmetallic-Sheathed Cables
854-1979 (Nov 80)	Service-Entrance Cables
869-1977 (Nov 80)	Service Equipment
943-1972 (Jan 77)	Ground-Fault Circuit Interrupters
984-1979	Hermetic Refrigerant Motor-Compressors
1242-1977 (Draft)	Intermediate Metal Conduit



1.2 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. (D)

~~1.2.1 Underground Service: Underground service into buildings shall terminate at a point 5 feet outside the building and projections thereof, except that service conductors shall be continuous to the interior terminating point indicated. The underground portion of the conduit shall be encased in a concrete envelope having a wall thickness of not less than three inches and shall be buried not less than 24 inches. Where a conduit enters through a concrete floor, the curved portion shall not be visible above the finished floor and the entire conduit below the floor slab shall be encased in a concrete envelope having a wall thickness of not less than three inches. Ends of the underground conduit shall be protected by threaded metal caps until connections are made. Underground service from 5 feet outside the building to the connection to the existing power system shall be provided under Section 16301, "Underground Electrical Work."~~

~~** OR **~~

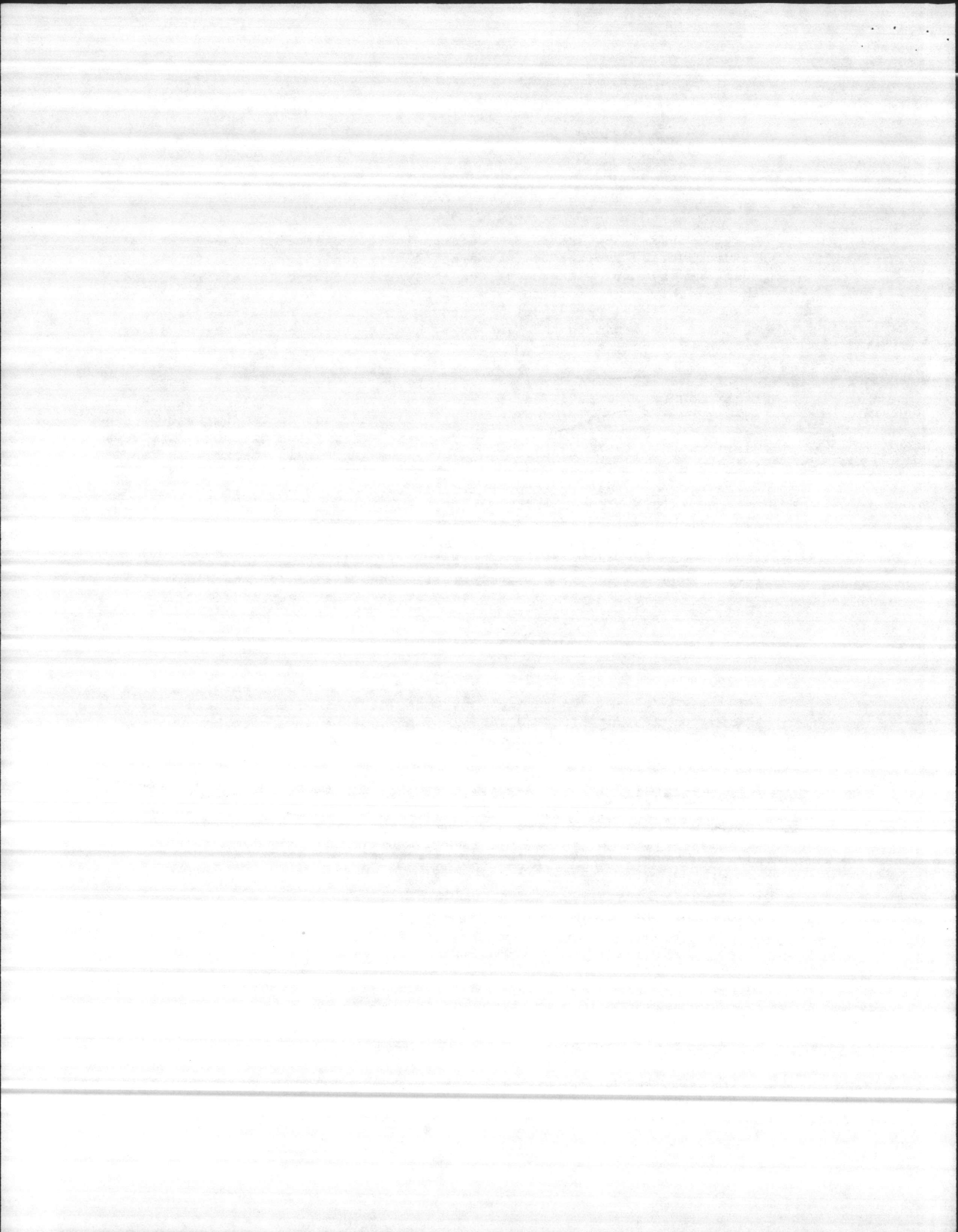
1.2.1 Overhead Service: Overhead service conductors into buildings shall terminate at the service entrance fittings or weatherhead outside the building. The overhead service conductors and support bracket for the overhead conductors are included in Section 16302, "Overhead Electrical Work."

~~1.2.2 Electrical Characteristics: Electrical characteristics for this project shall be [12.47] kV primary, [single] [three] phase, [three] [four] wire, [60] [60] hertz, [wye] [delta] connected and [208] [208] volts secondary, [single] [three] phase, [three] [four] wire, [wye] [delta] connected. Final connections to the power distribution system at the existing [substation] [manhole] [POLE] shall be made by the [Contractor as directed by the Contracting Officer] [Government using materials furnished by the Contractor].~~

1.3 SUBMITTALS:

1.3.1 Manufacturer's Data:

- a. Receptacles
- ~~b. Motor Controllers~~
- c. Circuit Breakers
- d. Switches



- ~~e. Surface Metal Raceway~~
- f. Intermediate Metal Conduit
- g. Conduit Supports
- ~~h. Fuses~~
- i. Plastic Conduit
- j. _____

1.3.2 Shop Drawings:

- a. Panelboards
- b. Transformers
- c. Busway
- d. Wireway
- ~~e. Cable Trough~~
- ~~f. Motor Control Center~~
- g. _____

1.3.3 Certificates of Conformance or Compliance:

- a. Conduit (except plastic and DMC)
- b. Ground Rods
- c. Outlet and Junction Boxes
- d. Insulating Tapes
- e. Conduit Fittings
- f. Device Plates
- g. Conductors
- h. _____

1.3.4 Samples:

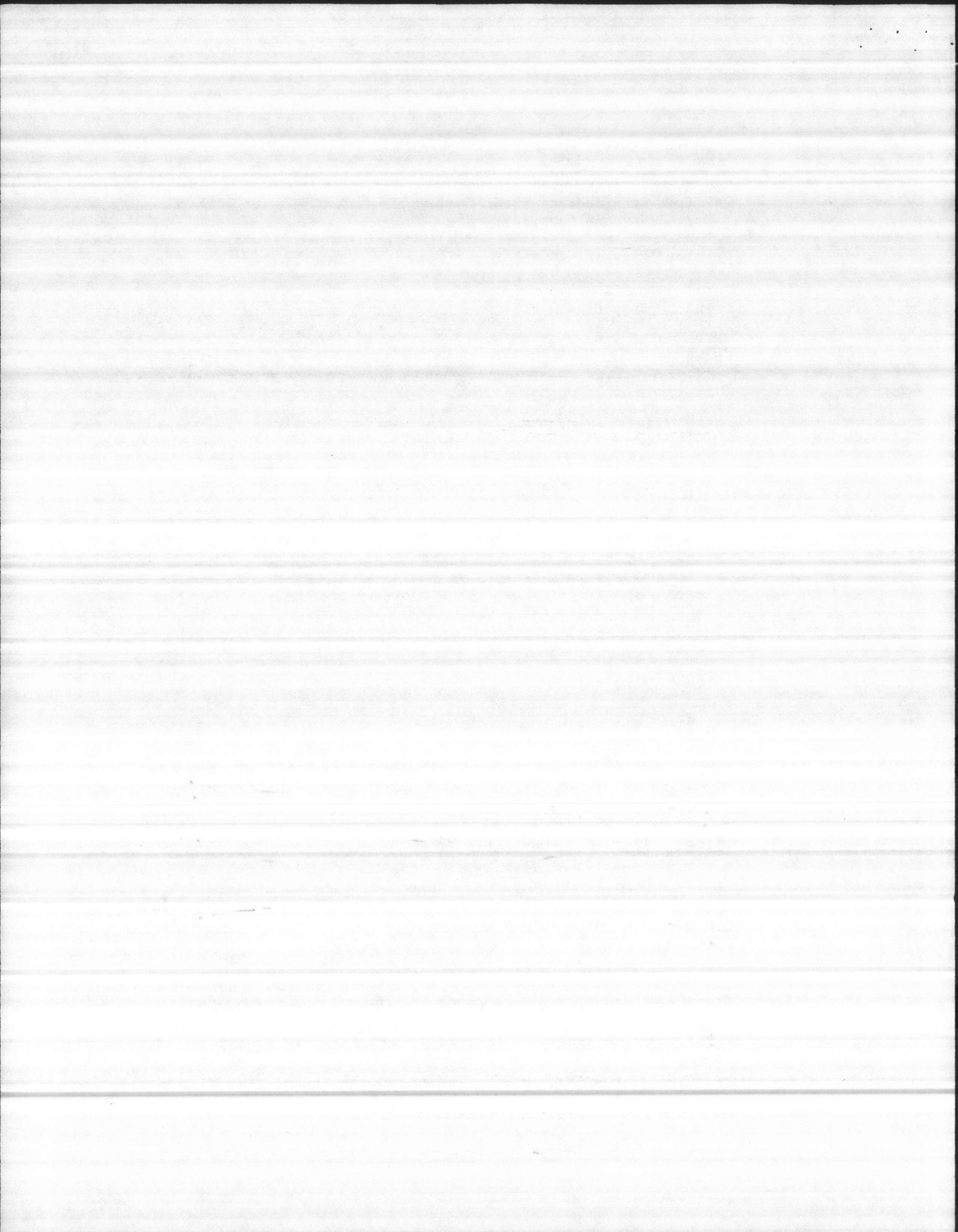
- a. _____
- b. _____

1.4 TRANSFORMER TESTS AND TEST REPORTS: Perform tests classified as "routine" per 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.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT: 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.

2.1.1 Coordination: Coordinate new equipment (fuses, circuit breakers, relays, and other equipment) with existing station equipment. The Contracting Officer will provide the necessary information on existing equipment when requested.



2.1.2 Conduit and Fittings:

2.1.2.1 Rigid Steel Conduit (Zinc-coated): ANSI C80.1

~~2.1.2.2 Rigid Aluminum Conduit: ANSI C80.5~~

2.1.2.3 Rigid Nonmetallic Conduit for Direct Burial: NEMA TC2, Type EPC-40, PVC only

2.1.2.4 Rigid Nonmetallic Conduit for Concrete Encased Burial: NEMA TC6, type EB, PVC only

2.1.2.5 Intermediate Metal Conduit (IMC): UL 1242, zinc-coated steel only

2.1.2.6 Electrical Metallic Tubing (EMT): ANSI C80.3

2.1.2.7 Flexible Metal Conduit: UL 1, zinc-coated steel only

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

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

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

2.1.2.9 Fittings for Rigid Nonmetallic Conduit: NEMA TC3 or NEMA TC9, as required.

~~2.1.3 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.]~~

~~2.1.4 Busways: NEMA BU1. Buses shall be [copper] [or] [aluminum]. Enclosures shall be [steel] [or] [aluminum]. Short-circuit ratings shall be [in accordance with NEMA BU1] [as indicated].~~

~~2.1.4.1 Feeder busways shall be [ventilated, except that vertical busways within 6 feet of floors shall be unventilated,] [unventilated] low-impedance busway.~~

~~2.1.4.2 Plug-in busways shall be unventilated. 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].~~



~~2.1.5 Cable Trays: NEMA VE 1. 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 of straight tray sections.~~

~~2.1.5.1 Trough-type cable trays shall be [sized as indicated] [of a nominal [6-] [12-] [18-] [24-] [30-] [36-] inch width].~~

~~2.1.5.2 Ladder-type cable 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].~~

~~2.1.5.3 Channel-type cable trays shall be [sized as indicated] [[3-] [4-] inches in width].~~

~~2.1.5.4 Solid bottom type cable trays shall be [sized as indicated] [of a nominal [6-] [12-] [18-] [24-] [30-] [36-] inch width].~~

2.1.6 Outlet Boxes and Covers: UL 514, cadmium or zinc-coated if of ferrous metal.

~~2.1.6.1 Floor outlet 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 ten-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.~~

~~2.1.6.2 Clock outlet for use in other than a wired clock system shall consist of 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."~~

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

2.1.8 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. Unless indicated or specified otherwise, conductor sizes are based on copper. Conductors No. 10 AWG and smaller shall be solid copper. Conductors No. 8 AWG and larger shall

be stranded copper. [Conductors No. 6 AWG and smaller shall be copper. Conductors No. 4 AWG and larger shall be ~~either copper or aluminum~~, at the Contractor's option. Should the Contractor opt to use aluminum, he shall be responsible for meeting the requirements of the following paragraph "Aluminum Conductors."] Wires and cables manufactured more than [six] [twelve] months prior to date of delivery to the site shall not be used.

~~2.1.8.1 Aluminum Conductors: Aluminum conductors shall be of an aluminum alloy that is acceptable to UL as "component aluminum wire stock (conductor material)." 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 the NEC; insuring that the pulling tension rating of the aluminum conductor is sufficient; relocating equipment, modifying equipment terminations, resizing equipment, and resolving to the satisfaction of the Contracting Officer all interference problems that are direct results of the use of aluminum conductors in lieu of copper.~~ (F)

2.1.8.2 Color coding is required for all service, feeder, branch, control, and signalling circuit conductors. Color shall be white for neutrals and green for grounding conductors. The color of the ungrounded conductors in different voltage systems shall be as follows:

- a. 120/208 volt, 3-phase: red, black, and blue
- b. 277/480 volt, 3-phase: yellow, brown, and orange
- c. 120/240 volt, single phase: red and black

All ungrounded conductors of the same color shall be connected to the same ungrounded feeder conductor.

~~2.1.8.3 Conductor sizes are expressed in American Wire Gage (AWG) or in circular mils. Minimum size for branch circuits shall be No. 12 AWG; for Class 1 remote control and signal circuits - No. 14 AWG; for Class 2 low energy remote control and signal circuits - No. 16 AWG.~~

2.1.8.4 Power and Lighting Conductors: UL 83, type THW or THWN (or XHHW) (G)

~~2.1.8.5 Service Entrance and Underground Secondary Conductors: UL 854 type USE, single conductor, rated 600 volts, except that type SE may be used from meter socket to service entrance panel. Cable shall be suitable for direct burial in earth or for installation in conduit.~~

~~2.1.8.6 Grounding and Bonding Conductors: ASTM B 1, solid bare copper wire for sizes No. 8 AWG and smaller; ASTM B 8, class B, stranded bare copper wire for sizes No. 6 AWG and larger. [Grounding and bonding conductors shall be insulated type where indicated or specified.]~~

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. (I)

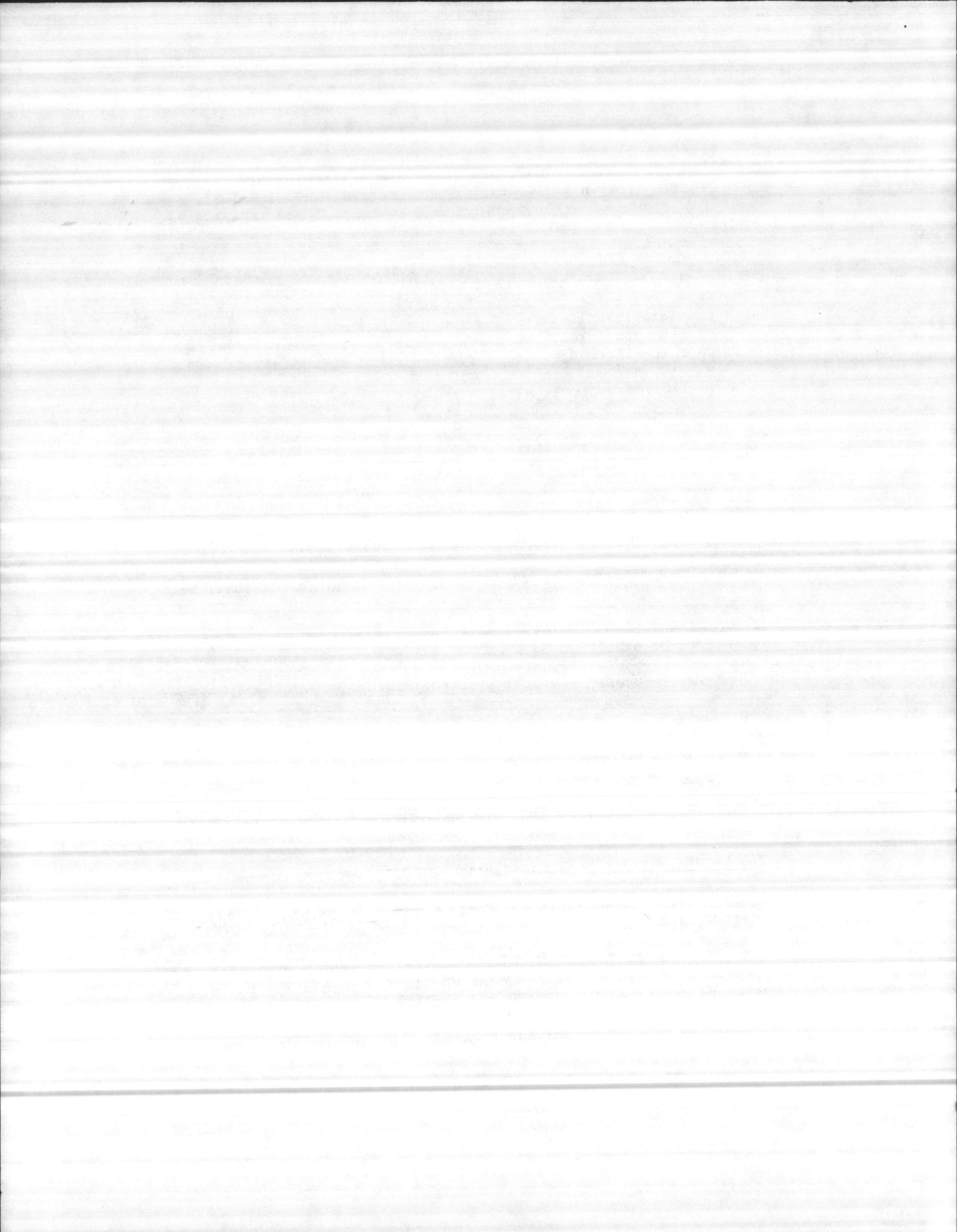
2.8.4 Bonding Conductors: ASTM B 1, solid bare copper wire for sizes No. 8 AWG and smaller; ASTM B 8, Class B, stranded bare copper wire for sizes No. 6 AWG and larger.

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.~~

2.9 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.



~~2.1.8.7 Nonmetallic-Sheathed Cable: UL 719, type NM (or NMC)~~

2.1.8.8 Flexible Connections: Connections to movable equipment shall be [flexible metal conduit with the number of conductors indicated] [heavy-duty type 90 cable having a green equipment ground conductor in addition to the current carrying conductors].

2.1.9 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 and smaller shall be insulated pressure-type or wirenut-type. Provide solderless terminal lugs on stranded conductors.

2.1.10 Device Plates: Provide 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 uraa or phenolic, minimum 0.10 inch wall thickness, and U.L. listed. 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.

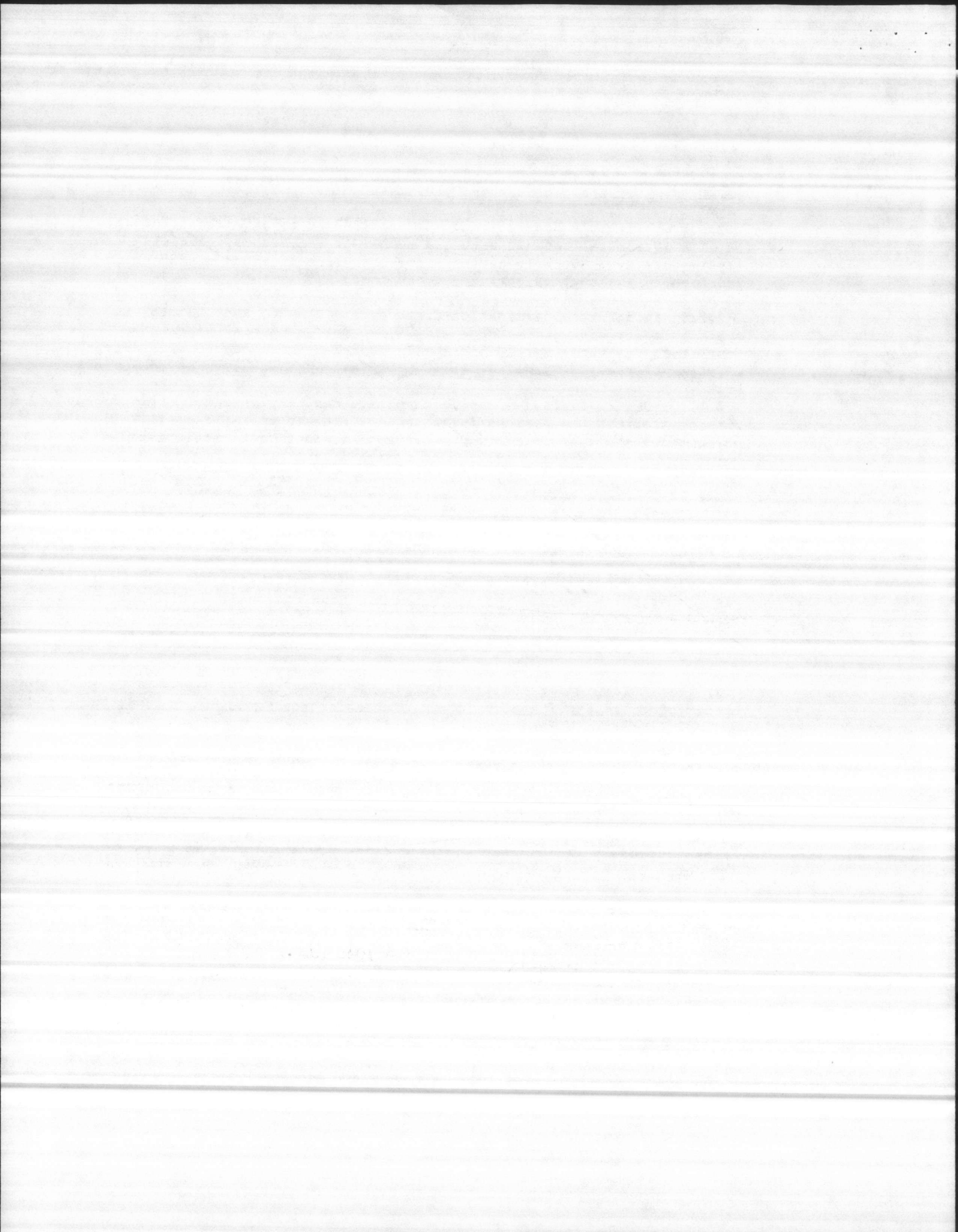
2.1.11 Switches:

2.1.11.1 Toggle Switches: Fed. Spec. W-5-896, totally enclosed with bodies of thermosetting plastic and a mounting strap. Handles shall be [brass] [ivory]. Wiring terminals shall be of the screw type, side wired. Switches shall be rated quiet-type AC only, 20 ampere, 120-277 volts, with the number of poles indicated.

~~2.1.11.2 Pilot lights shall consist of yoke-mounted candelabra-base sockets rated at 7.5 watts, 125 volts, and fitted with glass or plastic jewels. Furnish and install 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].~~

2.1.11.3 Disconnect Switches: NEMA[®] KS1, [general] [heavy] duty [fused] [nonfused], [single] [double] throw, quick-make quick-break, [240] [for] [300] volts, and the number of poles indicated. Provide switches in NEMA [] enclosure ^{as indicated} per NEMA ICS6. [Provide fused switches with fuse-holders to accept the specified fuse type.] [Switches serving as motor-disconnect means shall be horsepower rated.]

2.1.11.4 Mark circuit breakers used as switches for 120 volt fluorescent fixtures "SWD" per UL 489.



2.1.12 Receptacles: NEMA WD 1, heavy duty, grounding type. Ratings and configurations shall be as indicated. Bodies shall be of ~~metal~~ [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.

2.1.12.1 Duplex Receptacles: 20 amperes, 125 volts, No. 5342

~~2.1.12.2 Switched duplex receptacles shall have separate terminals for each ungrounded pole. The top receptacles shall be switched when installed.~~

2.1.12.3 Weatherproof Receptacles: Provide in a cast metal box with a gasketed, weatherproof, cast metal cover plate and a 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."

2.1.12.4 Ground Fault Circuit Interrupter Receptacles: UL 943, as applicable, and shall be duplex feedthrough-type for mounting in a standard outlet box. The device shall be capable of detecting a current leak of 5 milliamperes.

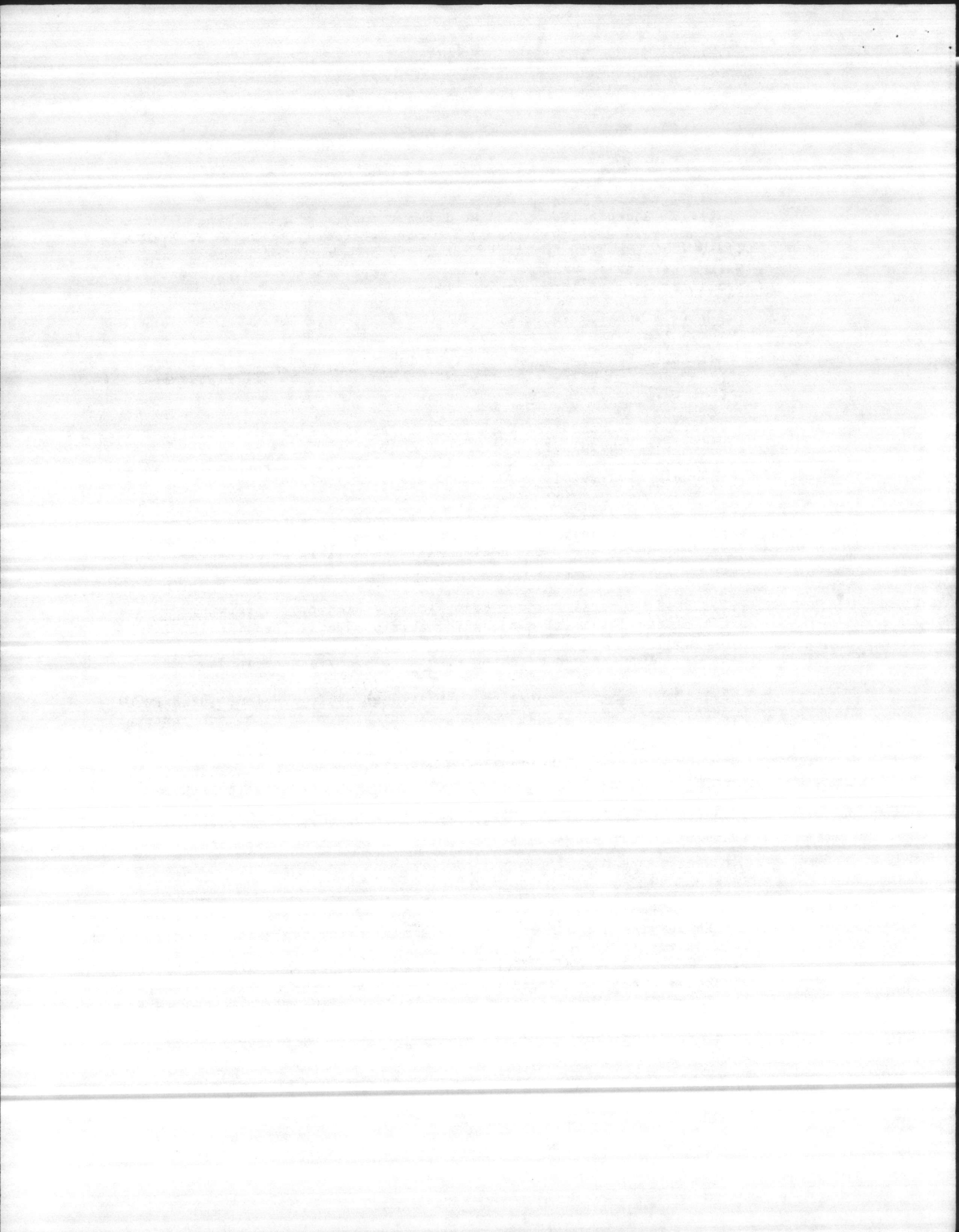
2.1.12.5 Special Purpose Receptacles: Receptacles serving _____ are considered special purpose for this project. [Provide in ratings indicated] [NEMA _____ configuration, rated _____ ampere, _____ volts.] [Furnish one matching plug with each receptacle.]

2.1.12.6 Range Receptacles: NEMA 14-~~30~~³⁰ configuration, rated ~~30~~³⁰ ampere, 125/250 volts. [Furnish one matching plug with each receptacle.] (I)

~~2.1.12.7 Dryer Receptacles: NEMA 14-30 configuration, rated 30 ampere, 125/250 volts. [Furnish one matching plug with each receptacle.] (J)~~

2.1.12.8 Plugs: Provide heavy-duty rubber-covered 3, 4, or 5 wire cord of the required size, install the plugs thereon, and attach to the equipment. The plugs shall be as listed with the receptacles, complete with grounding blades. Where equipment is not available, turn over the plugs and cord assemblies to the Government.

2.1.13 Panelboards: UL 67 and UL 50, as applicable. Panelboards for use as service disconnecting means shall additionally conform to UL 869. Panelboards shall be circuit breaker equipped [unless indicated otherwise]. Design complete panelboard assembly so 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.



2.1.13.1 Panelboard Buses: Provide {copper} ~~aluminum~~ bus bars supported on bases independent of the circuit breakers. Design main buses and back pans so that breakers may be changed without machining, drilling, or tapping. Provide an insulated 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.

2.1.13.2 Circuit Breakers: Fed. Spec. W-C-375 (ambient-compensated) thermal magnetic type with interrupting capacity [as indicated] [of 10,000 amperes symmetrical minimum]. Design breakers to accept copper, ~~copper-clad, and aluminum conductors~~. Plug-in circuit breakers are not acceptable.

2.1.13.2.1 Multipole Breakers: Provide common-trip type with a single operating handle. Design breakers so that an overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any {three} ~~two~~ adjacent breaker poles are connected to Phases {A, B, and C} ~~A and B~~ respectively.

~~2.1.13.2.2 Ground Fault Circuit Interruption Breaker: UL 943 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.~~

~~2.1.13.2.3 Fusible Switches for Panelboards: NEMA KSI, hinged door type. Switches serving as motor disconnect means shall be horsepower rated.~~

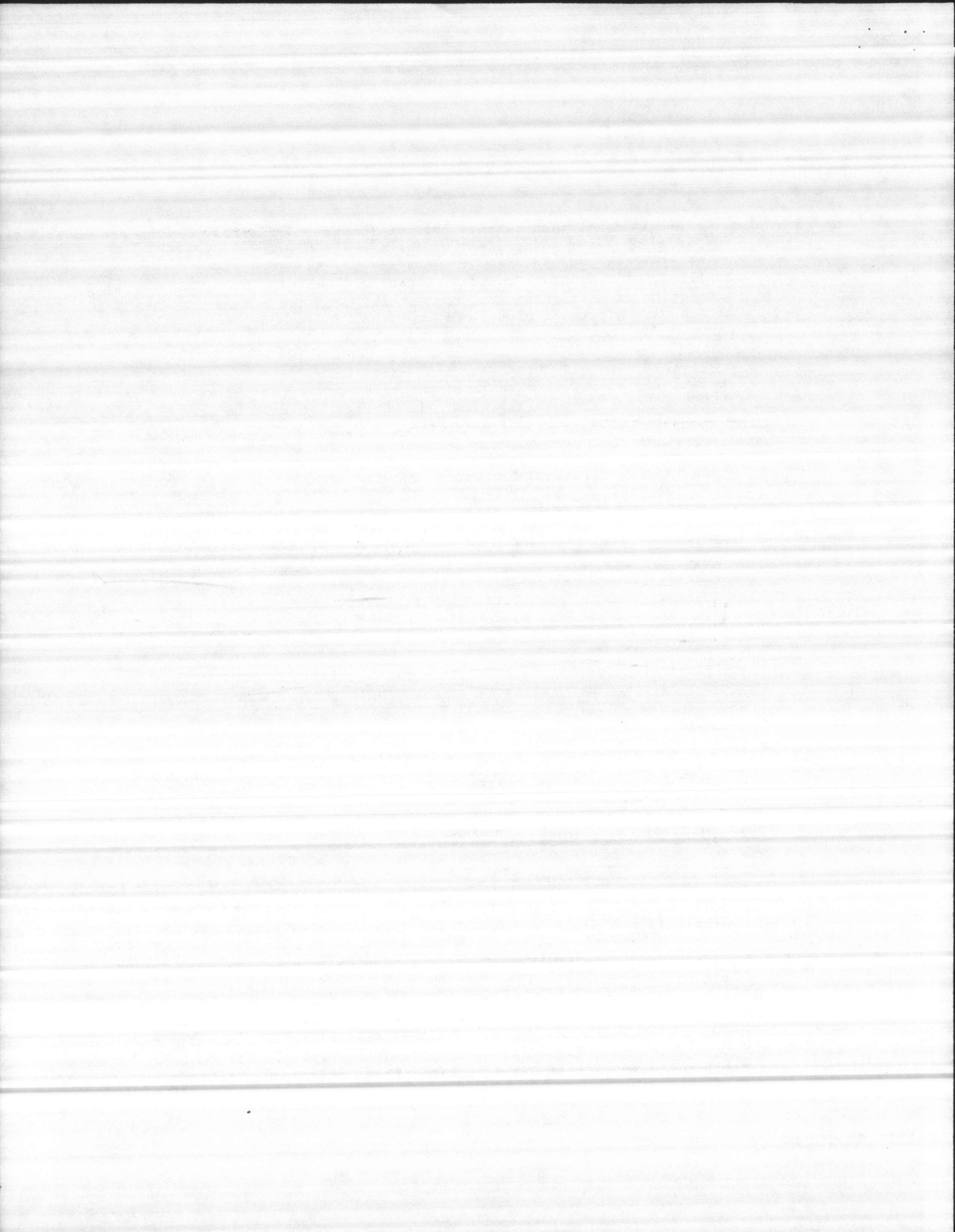
2.1.14 Fuses: Provide a complete set of fuses for each fusible [switch] [panel] [and] [control center]. Time-current characteristics curves of fuses serving motors or connected in series with circuit breakers [or other circuit protective devices] shall be coordinated for proper operation. Fuses shall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

2.1.14.1 Cartridge Fuses, Standard Type (Class H): UL 198B, non-renewable, rated [250] [600] volts. [Fuses shall be time-delay type.]

2.1.14.2 Cartridge Fuses, Current-limiting type (Class J): UL 198C

2.1.14.3 Cartridge Fuses, Current-limiting type (Class K): UL 198D, Class [K-1] [K-5] [K-9] [time-delay type]. Ratings shall be [250] [600] volts, and [50,000] [100,000] [200,000] amps rms symmetrical interrupting. [Peak let-through current shall not exceed [] amps.]

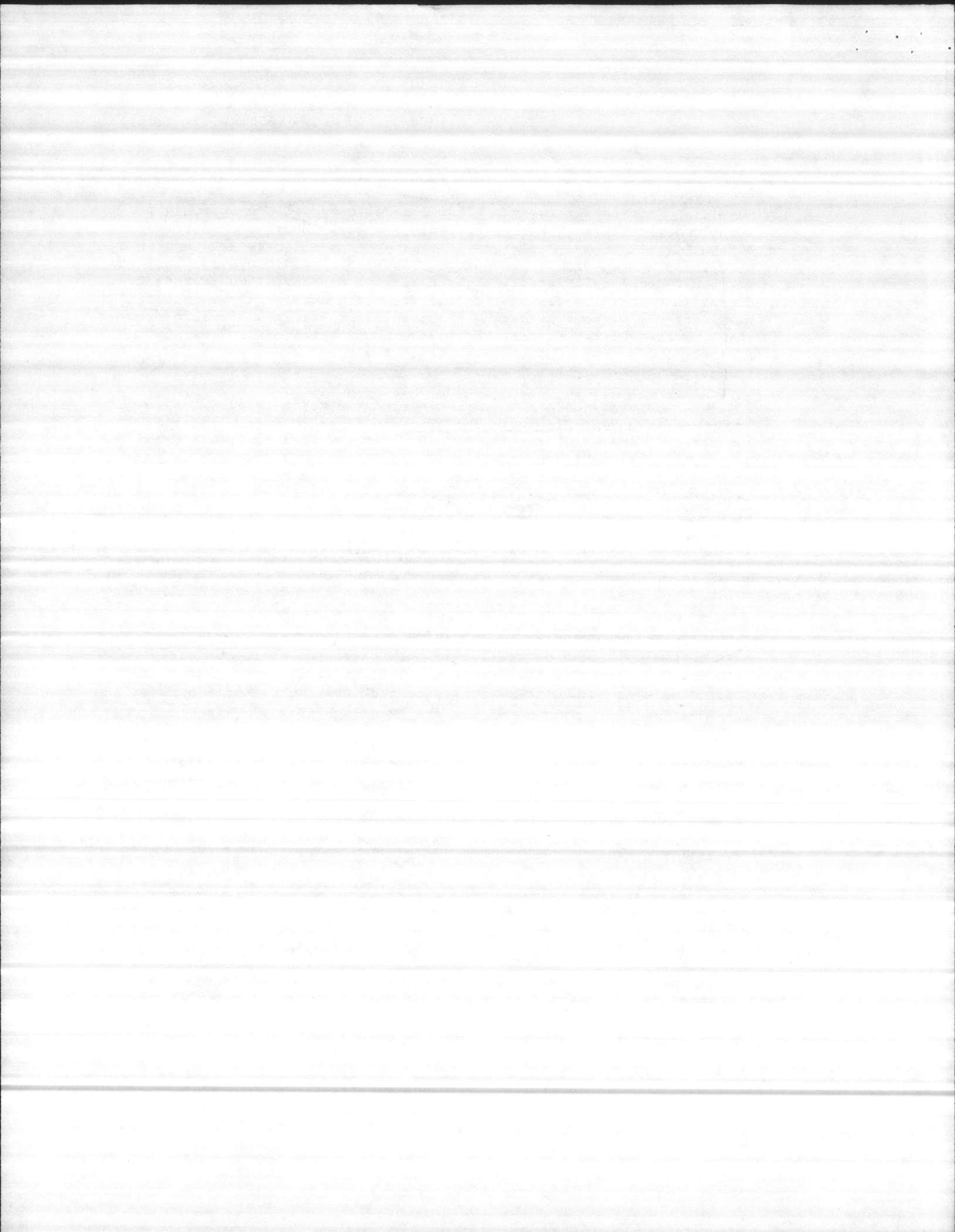
2.1.14.4 Cartridge Fuses, Current-limiting Type (Class RK): UL 198E, Class [RK1] [RK5] [time-delay type,] rated [250] [600] volts



~~2.1.15 Transformers: NEMA ST20, general purpose, dry-type, self cooled, [ventilated] [non-ventilated] [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.]~~ (L)

2.1.16 Motors: NEMA MG1 [except sealed (hermetic-type) motor-compressors: 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-volts, 3-phase shall have 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. Motors shall be of sufficient size for the duty to be performed and shall not exceed their full load nameplate current rating when driven equipment is operated at specified capacity under the most severe conditions likely to be encountered. (M)

~~2.1.17 Motor Controllers: NEMA ICS1 and ICS2. All controllers shall have thermal overload protection in each phase and short circuit protection. [Magnetic type motor controllers shall have under voltage protection when used with momentary-contact push-button 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 by-passed 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] [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, non-fused switch which will disconnect the motor 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 push button on the outside of the motor controller case. The cover of a combination motor controller and manual switch or circuit breaker shall~~ (M)



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.

2.1.17.1 Enclosures for Starters and Controllers: NEMA [1] [] per NEMA ICS6, unless indicated otherwise.

2.1.17.2 Manual Starters: [Single] [Double] [Three] pole designed for [flush] [surface] mounting.

2.1.17.3 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.

2.1.17.4 Combination Starters: Provide with integral [nonfusible disconnect switch] [circuit breaker].

2.1.17.5 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 designed for [flush] [surface] mounting.

2.1.17.6 Pilot and Indicating Lights: Provide transformer, resistor, or diode type.

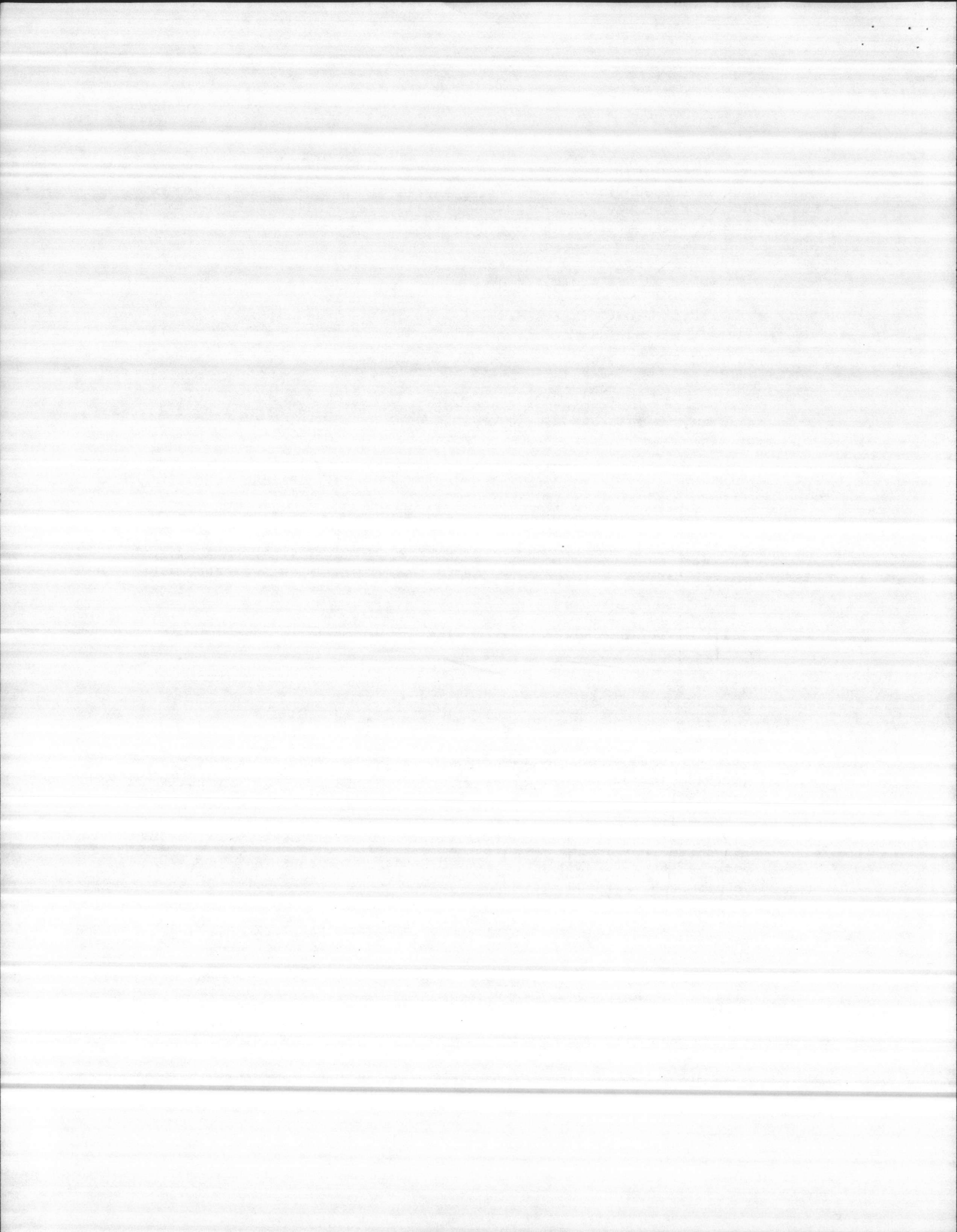
2.1.17.7 Terminal Blocks: NEMA ICS4.

2.1.17.8 Reduced-voltage controllers shall be provided for poly-phase motors [] horsepower and larger. Reduced-voltage starters shall be of the single-step 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].

(N)

2.1.18 Motor Control Centers: NEMA Standard No. 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 [4200] [] 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

(O, P)



protective device shall be [molded case circuit breaker] [low-voltage power circuit breaker] [fusible switch] rated at _____ ampere 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.

~~2.1.19 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.~~

~~2.1.19.1 Outlet Boxes for Telephone System: Standard type, as specified hereinbefore. Mount flush in finished walls at the height [indicated] [specified for the outlet receptacles].~~

~~2.1.19.2 Cover Plates: Standard telephone type of the finish specified for receptacle and switch cover plates.~~

~~2.1.19.3 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.~~

~~2.1.19.4 Backboards: 3/4 inch thick interior grade plywood.~~

~~2.1.19.5 Terminal Cabinets: Construct of cold-rolled sheet steel. Match trim, hardware, doors, and finishes to lighting panelboards.~~

2.1.20 Grounding and Bonding Equipment: UL 467

2.1.20.1 Equipment Grounds: Provide a green-colored equipment grounding conductor which shall be separate from the electrical system neutral conductor. Provide equipment ground conductors in branch circuits serving convenience outlets, receptacles, portable and permanently installed electrical appliances, equipment, apparatus, and other miscellaneous metal-enclosing bodies (including light switch boxes) normally within contact of personnel. ~~[Provide a main telephone service equipment ground consisting of a separate #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.]~~

2.1.20.2 Ground Rods: Copperweld type, 3/4 inch in diameter and 10 feet long unless otherwise indicated.



~~2.1.20.3 Hazardous Locations: Electrical materials, equipment, and devices for installation in hazardous locations as defined by NFPA 70 shall be specifically approved by Underwriters Laboratories or Factory Mutual for the particular "Class," "Division," and "Group" of hazardous location involved. The boundaries and classifications of hazardous locations shall be as [indicated on the drawings] [as specified herein].~~

2.1.21 - Smoke Detector

PART 3 - EXECUTION

3.1 INSTALLATION:

3.1.1 General Requirements: Electrical installations shall conform to the requirements of ANSI C2 and NFPA 70 and to the requirements specified herein. Measure mounting heights specified or indicated to the center of the device or outlet.

3.1.2 Hazardous Locations: Perform work in hazardous locations as defined by NFPA 70 in strict accordance with the NEC for the particular "Class," "Division," and "Group" of hazardous locations involved. Provide conduit and cable seals where required by NFPA 70.

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. Conduit shall be rigid metal conduit, intermediate metal conduit (IMC), or electrical metallic tubing (EMT) except where specified or indicated otherwise.

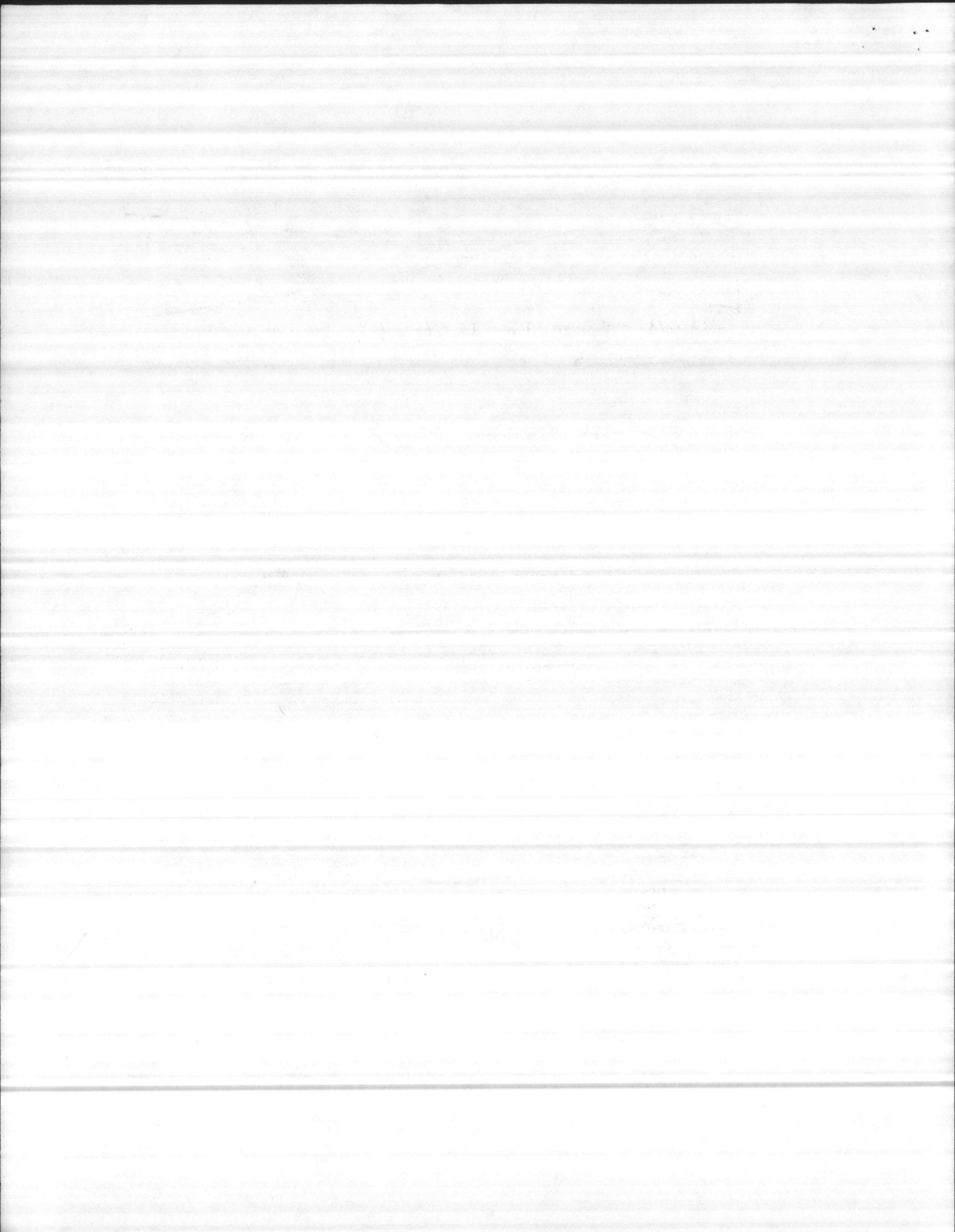
~~3.1.3.1 Aluminum Conduit: Do not install underground or encase in concrete.~~

3.1.3.2 Electrical Metallic Tubing: Do not install underground, encase in concrete, use in areas where subject to severe physical damage, or use in outdoor work.

3.1.3.3 Nonmetallic Conduit: Use only where specifically indicated or specified for special situations or systems.

3.1.3.4 Underground Conduit: [Rigid steel or steel IMC] [PVC, type EB] and encased in a minimum of 3 inches of concrete.

3.1.3.5 Conduit In or Under Floor Slabs: [Rigid steel or steel IMC] [or] [PVC, type EPC-40]



3.1.3.6 Service Entrance Conduit: [Rigid steel or IMC] [PVC, Type EB] from the service equipment [to the outdoor transformer or substation] [to a point at least 5-feet beyond the building or projection thereof and not less than 24-inches below grade] [to the service entrance fitting or weatherhead outside the building].

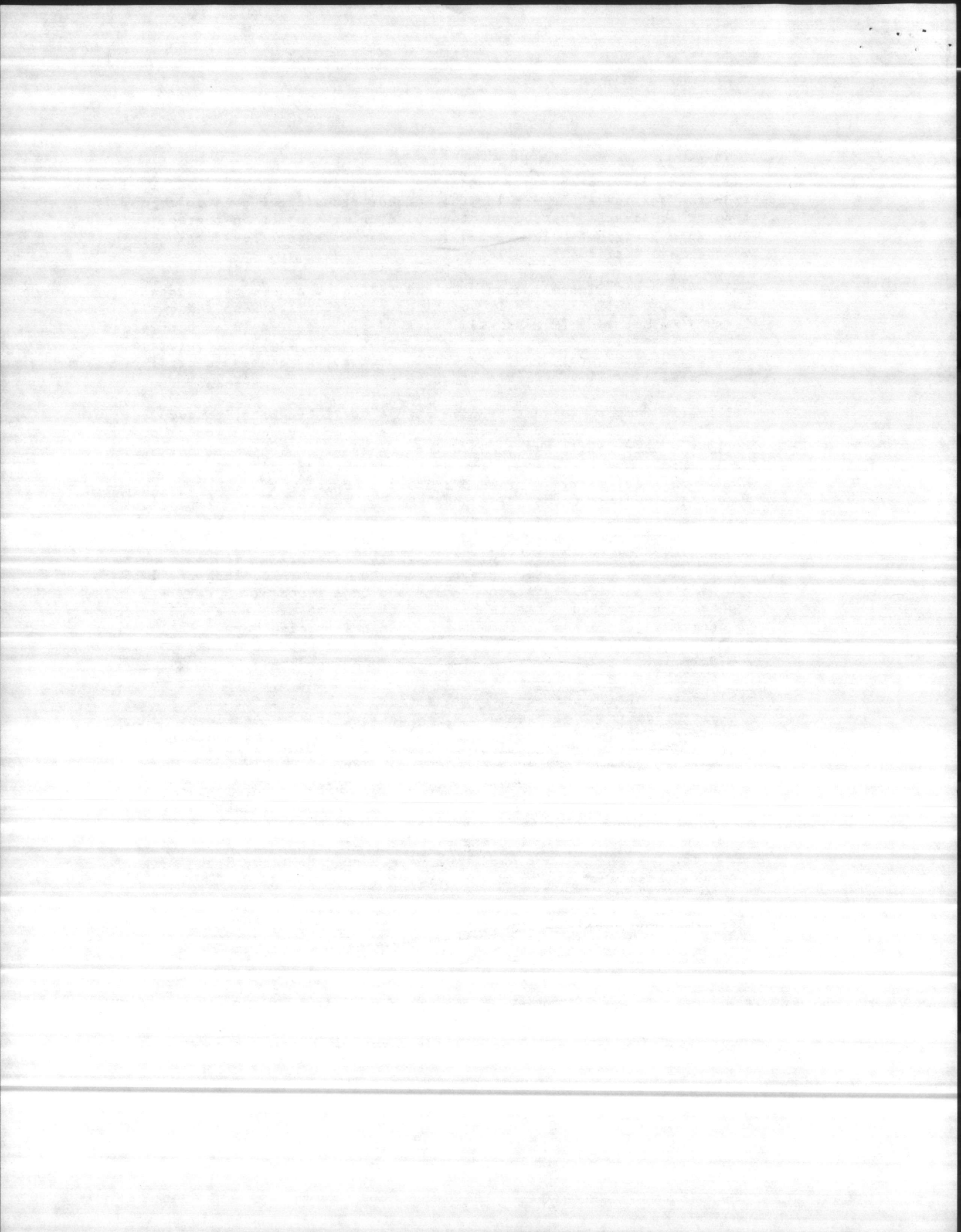
3.1.4 Conduit Installation: Unless indicated otherwise, conceal conduit within finished walls, ceilings, and floors. Keep conduit at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project.

3.1.4.1 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 studs driven in by a powder charge and provided with lock washers and nuts may be used in lieu of expansion bolts or machine or wood screws.] 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 multi-story buildings by U-clamp hangers at each floor level and at intervals not to exceed 10-feet.]~~

3.1.4.2 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.

~~3.1.4.3 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 pounds tensile strength. Leave not less than 12 inches of slack at each end of the pull wire.~~

~~3.1.4.4 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 inch and smaller and shall not contain more than two 90-degree bends or the equivalent. Install pull or junction boxes 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.~~

3.1.4.5 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. ~~(Encase conduit installed beneath floor slabs in a minimum of 3 inches of concrete.)~~

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3.1.4.6 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.

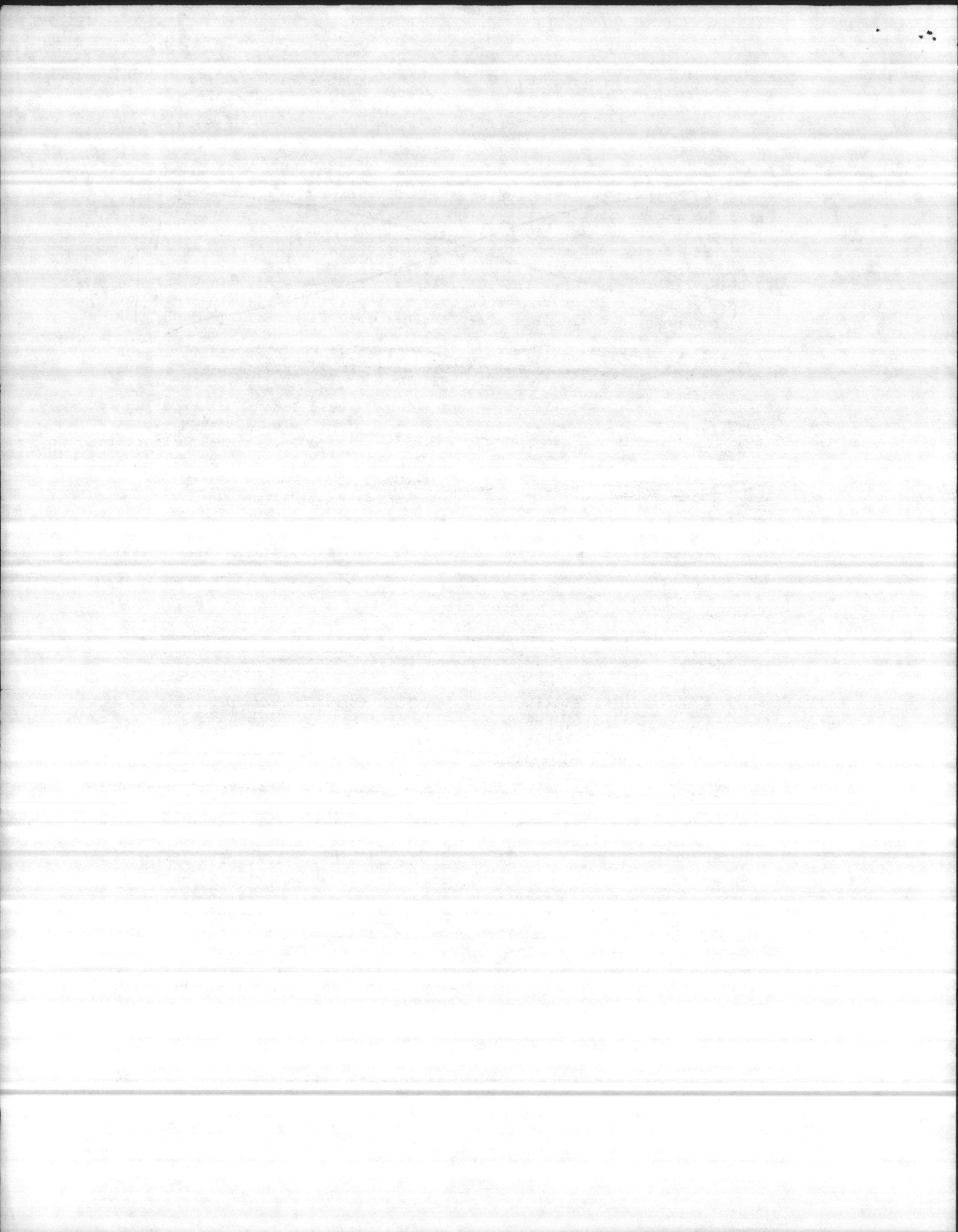
3.1.4.7 Stub-Ups: Provide conduits stubbed up through concrete floor for connection to free-standing equipment with an adjustable top or coupling threaded inside for plugs, set flush with the finished floor. Extend conductors to equipment in rigid steel conduit, except that flexible metal conduit may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

3.1.4.8 Flexible connections of short length shall be provided for recessed and semi-recessed lighting fixtures, 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, in hazardous areas, and when installed exposed up to 7 feet above interior floors and walkways. Boxes in other locations shall be sheet steel, ~~except that aluminum boxes may be used with aluminum conduit [, and non-metallic boxes may be used with non-metallic [wiring] [conduit] system].~~ Each box shall have the volume required by the NEC 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. Provide boxes installed for concealed wiring with suitable extension rings or plaster covers, as required. 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 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 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 the NEC of ~~code page 310.10~~ 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, circuit number, and panel designation.

3.1.8 Mounting Heights: Mount panelboards so the height of the top operating handle will not exceed 78 inches from the floor. Mount lighting switches {3 feet, 10 inches above finished floor}; receptacles, 18"; and other devices [as indicated].

~~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.~~

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3.1.10 Conductor Identification: Provide conductor identification within each enclosure where a tap, splice, or termination is made. Make identification with color-coded insulated conductors, plastic-coated self-sticking printed markers, colored nylon cable ties and plates, or heat-shrink type sleeves. Identify control circuit terminations.

3.1.11 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.

~~3.1.11.1 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 compound and insert in connector. After joint is made, wipe away excess joint compound and insulate splice.~~

