

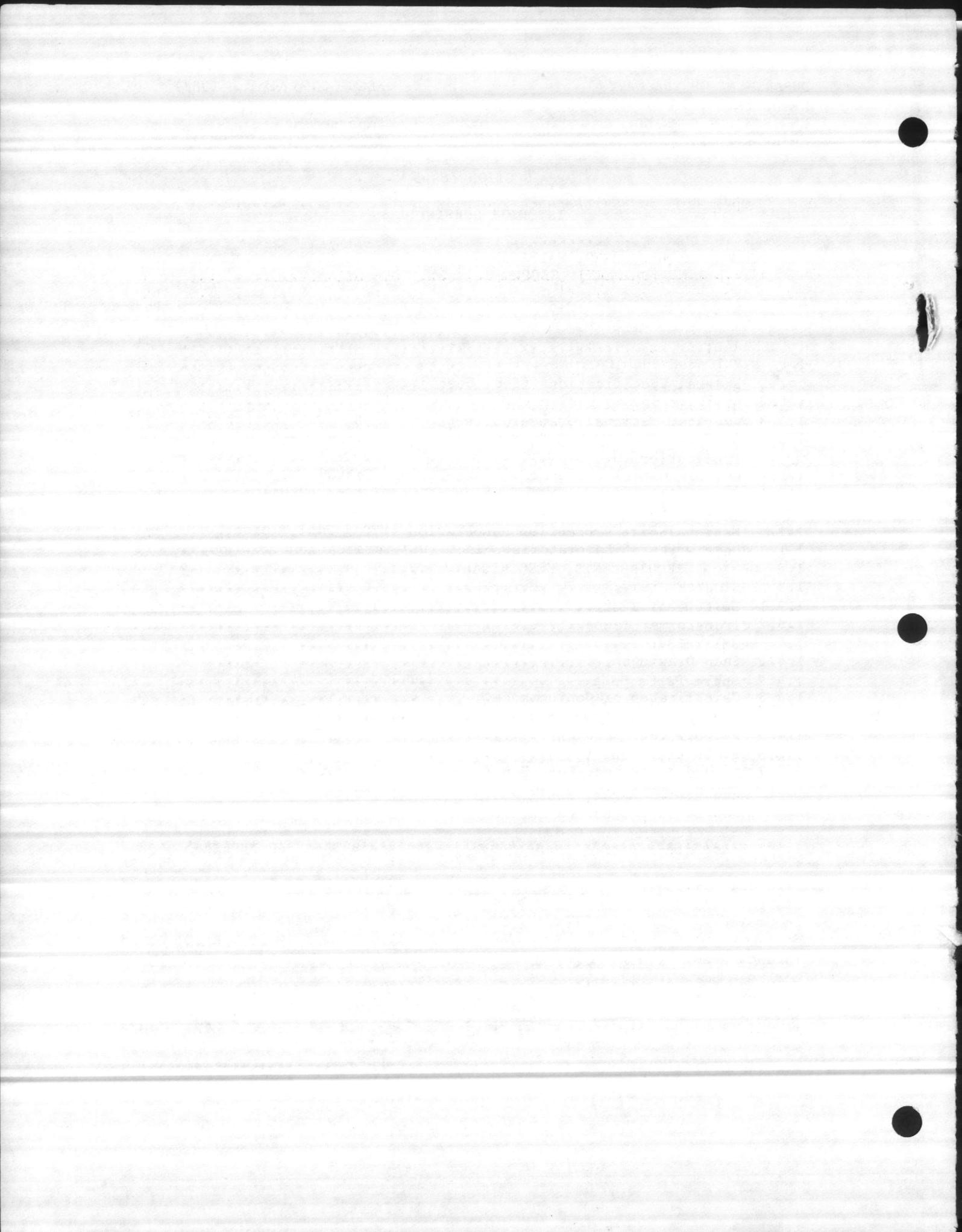
SECTION 16465

INTERIOR SUBSTATIONS

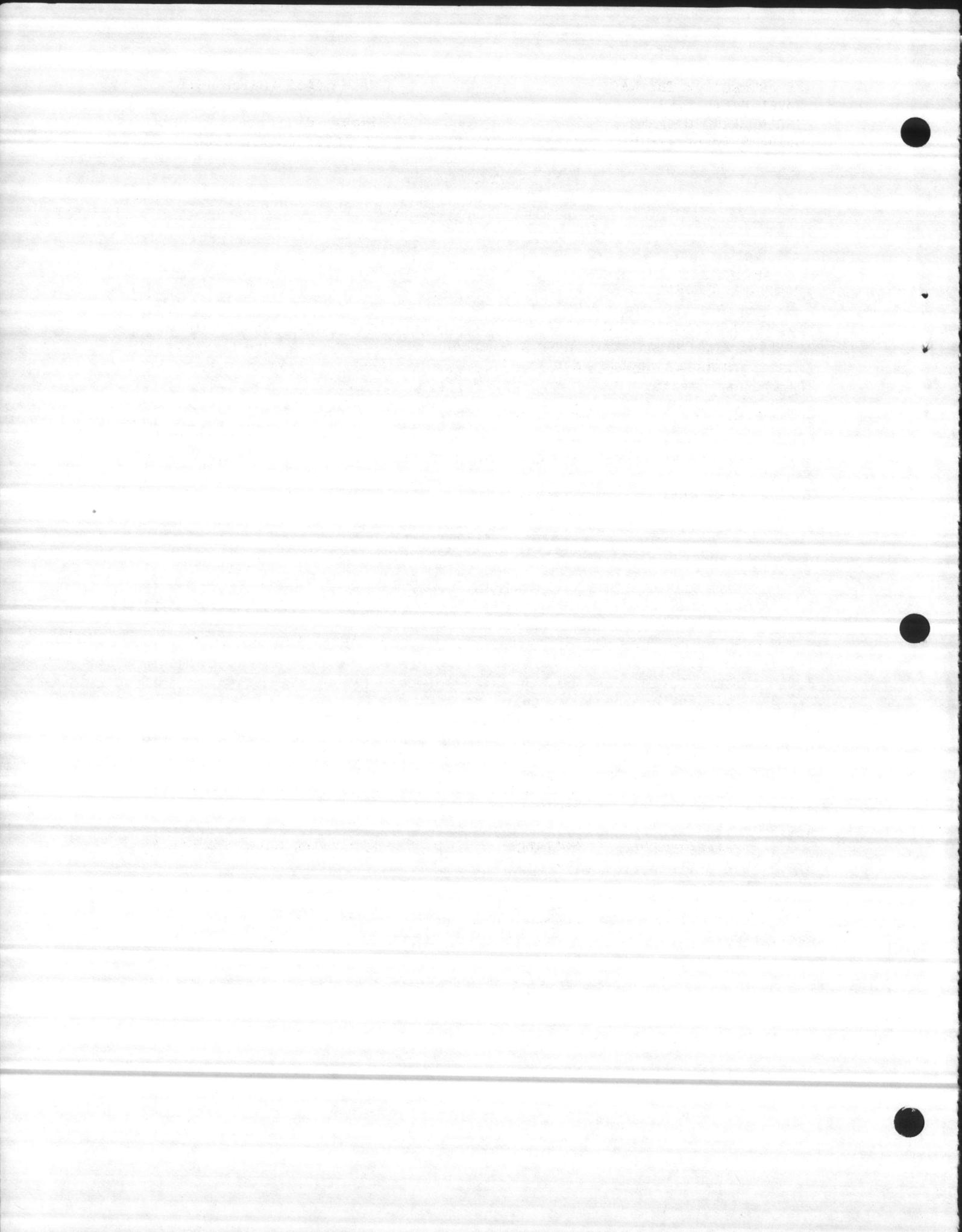
TABLE OF CONTENTS

| | Page |
|---|------|
| 1 GENERAL..... | 1 |
| 1.1 APPLICABLE PUBLICATIONS..... | 1 |
| 1.1.1 Federal Specifications (Fed. Spec.)..... | 1 |
| 1.1.2 Military Specification (Mil. Spec.)..... | 1 |
| 1.1.3 American National Standards Institute (ANSI) Publications.... | 1 |
| 1.1.4 American Society for Testing and Materials (ASTM) Publications..... | 2 |
| 1.1.5 Factory Mutual Engineering Corporation (Factory Mutual)..... | 2 |
| 1.1.6 National Electrical Manufacturers Association (NEMA) Publications..... | 2 |
| 1.1.7 National Fire Protection Association (NFPA) Publication..... | 2 |
| 1.1.8 Underwriters' Laboratories, Inc. (UL) Publication..... | 3 |
| 1.2 GENERAL REQUIREMENTS, ELECTRICAL..... | 3 |
| 1.3 FACTORY TESTS..... | 3 |
| 1.3.1 Switchgear Tests..... | 3 |
| 1.3.2 Transformer Tests..... | 3 |
| 1.4 SUBMITTALS..... | 3 |
| 1.4.1 Shop Drawings..... | 3 |
| 1.4.2 Spare Parts Data..... | 4 |
| 1.4.3 Certificates of Conformance..... | 4 |
| 1.4.4 Laboratory Test Reports..... | 4 |
| 1.4.5 Factory Test Reports..... | 4 |
| 1.4.6 Field Test Reports..... | 4 |
| 1.4.7 Ground Resistance Test Reports..... | 5 |

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| | Page |
|--|------|
| 1.4.8 Operating and Maintenance Instructions..... | 5 |
| 2 PRODUCTS..... | 5 |
| 2.1 GENERAL REQUIREMENTS, MATERIAL..... | 5 |
| 2.2 ARTICULATED [PRIMARY] [SECONDARY] UNIT SUBSTATION..... | 5 |
| 2.2.1 Incoming Section[s]..... | 5 |
| 2.2.2 Transition Section[s]..... | 6 |
| 2.2.3 Transformer Section[s]..... | 7 |
| 2.2.4 Auxiliary Section[s]..... | 7 |
| 2.2.5 Outgoing Section[s]..... | 7 |
| 2.2.6 Instruments..... | 11 |
| 2.2.7 Watthour Meters..... | 12 |
| 2.2.8 Relays..... | 12 |
| 2.2.9 Instrument and Control Transformers..... | 13 |
| 2.2.10 Ground Fault Protection..... | 13 |
| 2.2.11 Heaters..... | 14 |
| 2.2.12 Insulated Phase Barriers..... | 14 |
| 2.2.13 Nameplates..... | 14 |
| 2.2.14 Miscellaneous Switchgear Devices..... | 14 |
| 3 EXECUTION..... | 15 |
| 3.1 GENERAL REQUIREMENTS, ELECTRICAL..... | 15 |
| 3.2 GROUNDING..... | 15 |
| 3.2.1 Grounding Electrodes..... | 15 |
| 3.2.2 Substation Grounding..... | 16 |
| 3.2.3 Connections..... | 16 |
| 3.2.4 Ground Cable Crossing Expansion Joints..... | 16 |
| 3.2.5 Grounding and Bonding Equipment..... | 16 |
| 3.3 METERS AND INSTRUMENT TRANSFORMERS..... | 16 |
| 3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES..... | 16 |
| 3.5 TOUCH-UP PAINTING..... | 16 |
| 3.6 FIELD TESTS AND INSPECTIONS..... | 16 |
| 3.6.1 Acceptance Checks, Settings, and Tests..... | 16 |
| 3.6.2 Acceptance Checks and Tests..... | 17 |
| 3.6.3 Relay Setting and Coordination Tests..... | 18 |
| 3.6.4 Transformer Test..... | 19 |
| 3.6.5 Field Dielectric Tests..... | 19 |
| 3.6.6 Follow-Up Verification..... | 19 |
| 3.6.7 Ground Resistance Tests..... | 19 |
| GENERAL NOTES..... | 20 |
| TECHNICAL NOTES..... | 21 |



SECTION 16465

(B)

INTERIOR SUBSTATIONS

(A)

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.

(C)

1.1.1 Federal Specifications (Fed. Spec.):

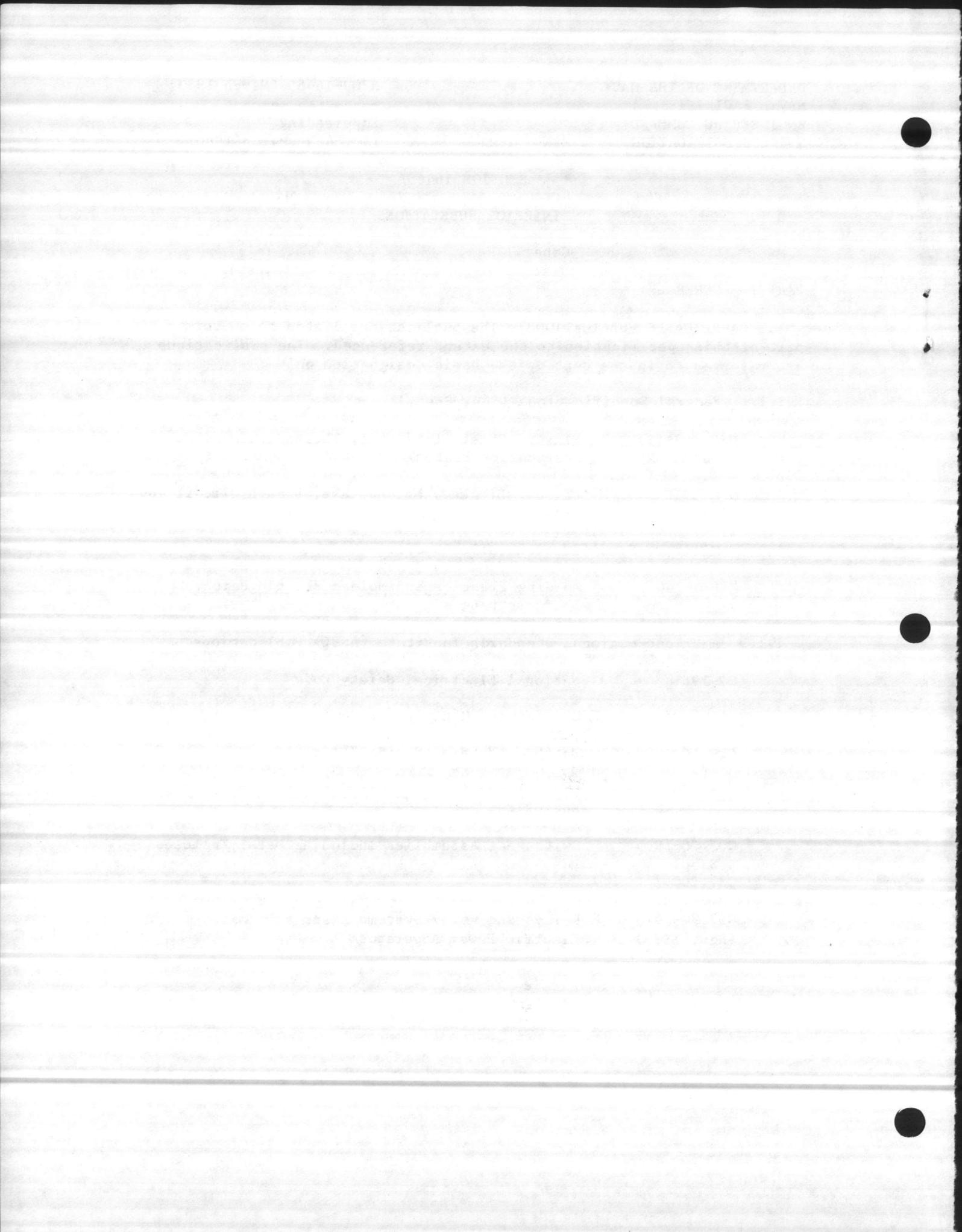
| | |
|-------------------------|--|
| L-P-387A(1) Int Am 2 | Plastic Sheet, Laminated, Thermosetting (For Designation Plates) |
| W-C-375B | Circuit Breaker, Molded Case, Branch Circuit and Service |

1.1.2 Military Specification (Mil. Spec.):

| | |
|-----------|--|
| MIL-M-14G | Molding Plastics and Molded Plastic Parts, Thermosetting |
|-----------|--|

1.1.3 American National Standards Institute (ANSI) Publications:

| | |
|------------------------------------|---|
| C2-1981 | National Electrical Safety Code |
| C12-1975 | Electricity Metering, Code for |
| C12.10-1978 | Watt-hour Meters, Standard for |
| C37.13-1981 | Low-Voltage AC Power Circuit Breakers Used in Enclosures |
| C37.20-1974 & Suppl. C37.20D | Switchgear Assemblies Including Metal-Enclosed Bus |
| C37.90-1978 (Rev. 1979) | Relays and Relay Systems Associated With Electric Power Apparatus |



| | |
|---------------------------|--|
| C39.1-1981 | Requirements for Electrical Analog Indicating Instruments |
| C39.2-1964 (Rev. 1969) | Direct-Acting Electrical Recording Instruments (Switchboard and Portable Types) |
| C57.12.00-1980 | General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers |
| C57.12.01-1979 | General Requirements for Dry-Type Distribution and Power Transformers |
| C57.12.90-1980 | Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers |
| C57.12.91-1979 | Test Code for Dry-Type Distribution and Power Transformers |
| C57.13-1978 | Requirements for Instrument Transformers |

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

| | |
|------------|--|
| D 92-1978 | Flash and Fire Points by Cleveland Open Cup, Test Method for |
| D 877-1980 | Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes, Test Method for |

1.1.5 Factory Mutual Engineering Corporation (Factory Mutual):

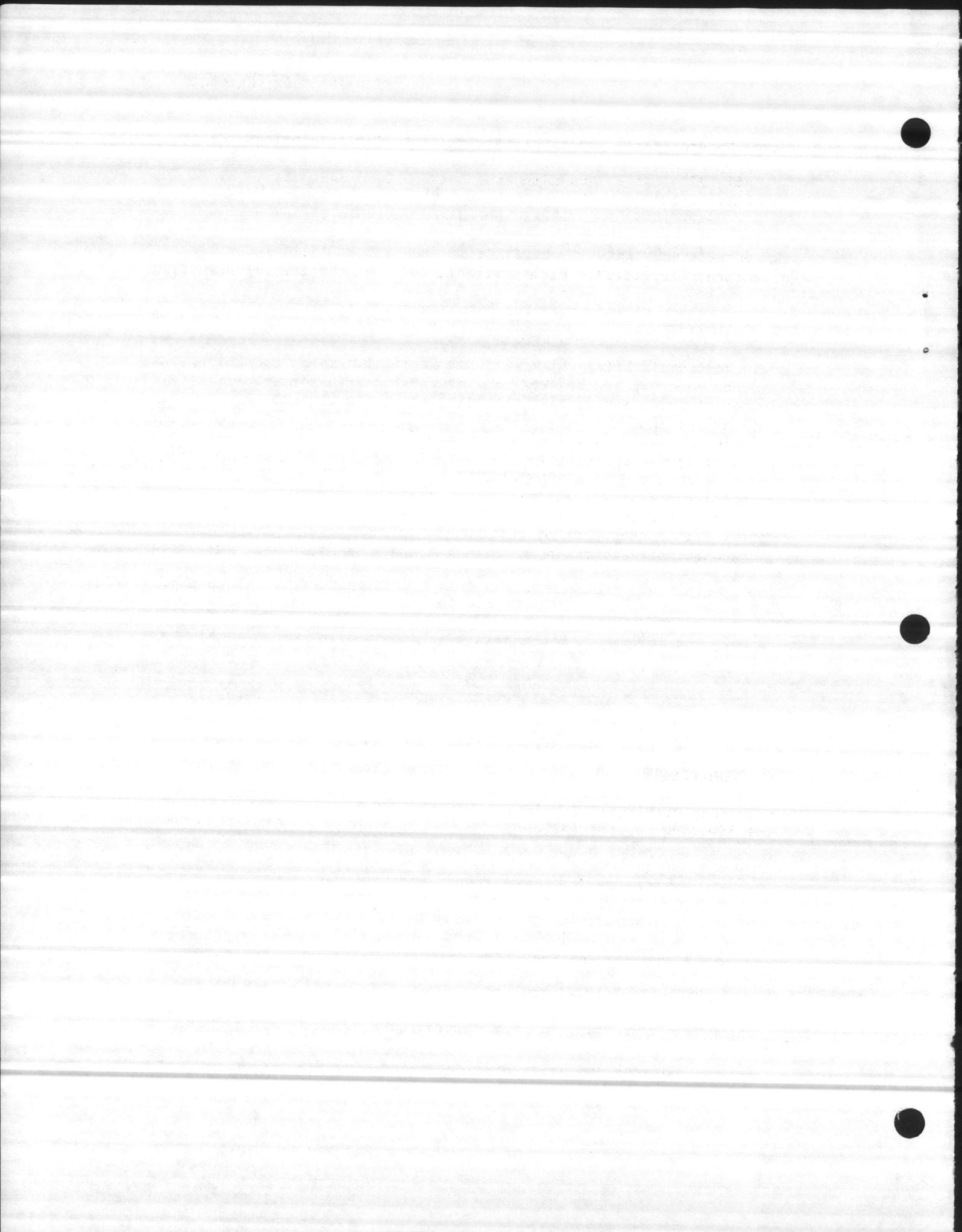
1980 Approval Guide

1.1.6 National Electrical Manufacturers Association (NEMA)
Publications:

| | |
|---------------------------|--|
| 201-1970 (Rev. 1976) | Primary Unit Substations |
| 210-1970 (Rev. 1976) | Secondary Unit Substations |
| ST 20-1972 (Rev. 1978) | Dry-Type Transformers for General Applications |

1.1.7 National Fire Protection Association (NFPA) Publication:

70-1981 National Electrical Code



1.1.8 Underwriters' Laboratories, Inc. (UL) Publication:

467-1972 Grounding and Bonding Equipment
(Rev. 3/82)

1.2 GENERAL REQUIREMENTS, ELECTRICAL: Section 16011, "General Requirements, Electrical," with additions and modifications as specified herein applies.

1.3 FACTORY TESTS:

1.3.1 Switchgear Tests: ANSI C37.20. Perform design, production, and conformance tests of the switchgear. For power circuit breakers, after completion of interrupting test at full rating, there shall be no evidence of any damage to any part except for minor burning of the arcing contact tips. Breaker shall be satisfactory for immediate return to service at full rating without repairs or maintenance of any kind. One breaker of each rating shall be given impulse, momentary, and interrupting tests at its full rating [; these tests shall be witnessed by the representative of the Contracting Officer]. [In lieu of the above testing, a certified report of these tests previously performed on identical units of each rating will be acceptable.]

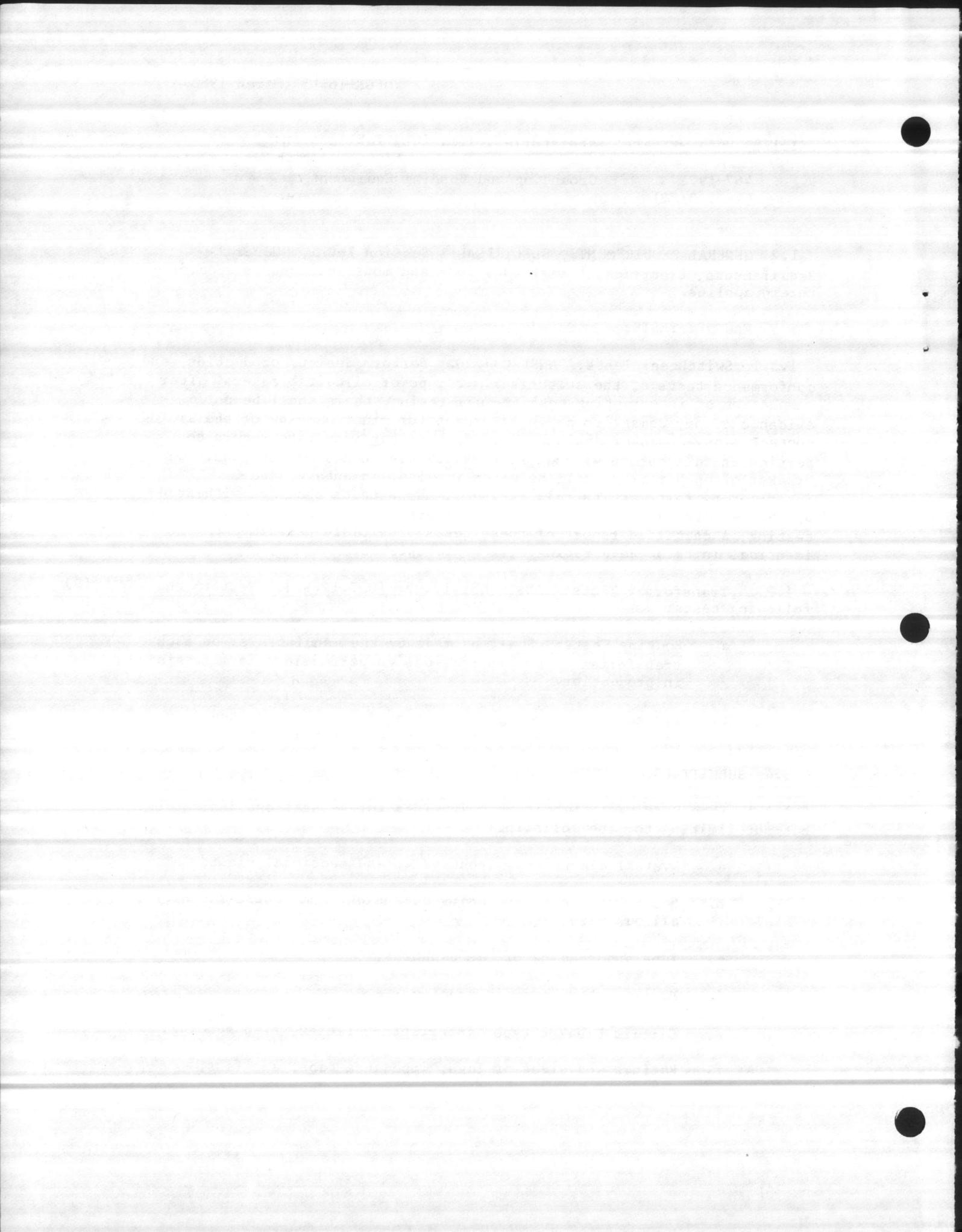
1.3.2 Transformer Tests: ANSI [C57.12.90] [C57.12.91]. Perform the following tests: (D)

- a. Routine Tests: Shall be made by the manufacturer on each transformer to ensure that design performance is maintained in production.
- b. Design Tests: Design test reports will be accepted as proof of compliance with design test requirements.

1.4 SUBMITTALS:

1.4.1 Shop Drawings: Submit shop drawings for substations indicating, but not limiting to, the following:

- a. Overall dimensions, front view, and sectional views;
- b. Bus arrangements including dimensions and ampere ratings of all bus bars;
- c. Type and spacing of bus supports;
- d. Maximum short circuit bracing;
- e. Circuit breaker type, interrupting rating, trip setting;
- f. Ratings and sizes of lugs, impedance taps, and fans;



- g. Elementary diagrams and wiring diagrams with terminals identified and indicating the internal wiring for each item of equipment and the interconnection between the items;
- h. Manufacturer's data for all components and accessories including switches, fuses, meters, and test instruments; and
- [i. Provision for future extension.]

In addition, the Contractor shall submit the manufacturer's published time-current curves (on full-size logarithmic paper) of the transformer [high-side fuse,] [high-voltage weak-link fuse,] [main secondary breaker,] [internal low-voltage secondary circuit breaker,] and largest feeder device [breaker and current-limiting fuse] at each [substation] [transformer] to allow designer to verify that proper protection and coordination has been achieved.

1.4.2 Spare Parts Data: As soon as practicable after approval of materials and equipment, furnish spare parts data for each different item of equipment listed. Data shall include a complete list of parts and supplies with current unit prices and source of supply. The foregoing shall not relieve the Contractor of any responsibilities under the guaranty. (E)

1.4.3 Certificates of Conformance: Submit certificates, in [triplicate] [_____], for the following:

- a. Provide certification for relay technician indicating the technician is skilled and actively engaged in the business of testing and calibrating power relays. Provide this certification of experience in writing 10 days before the actual testing is proposed.

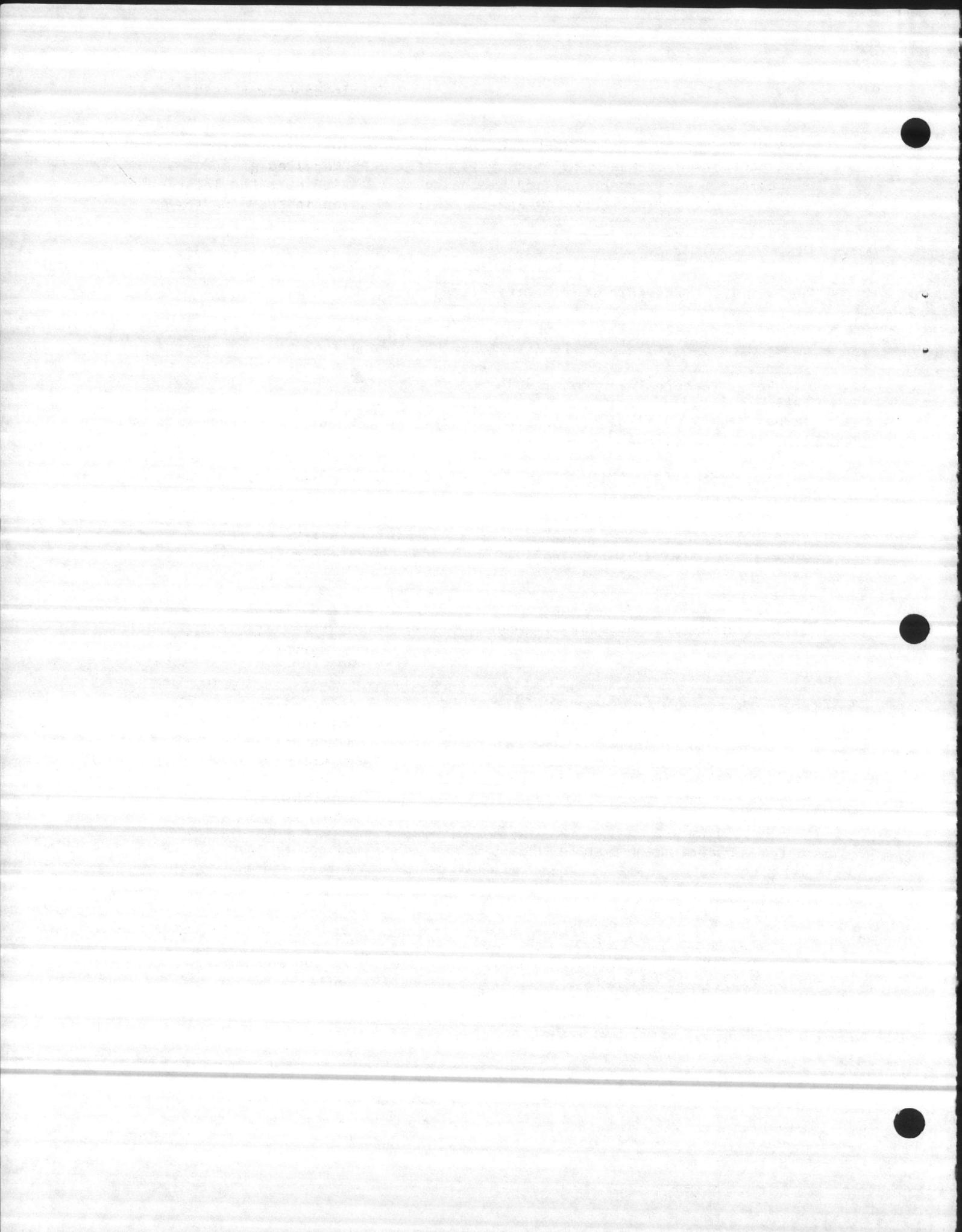
[b. _____.]

[c. _____.]

1.4.4 Laboratory Test Reports: Submit certified copies, in [triplicate] [_____], of all test reports required in referenced publications for the following: _____.

1.4.5 Factory Test Reports: Submit certified copies, in [triplicate] [_____], of factory test reports as required herein and await approval before delivering equipment to the project site.

1.4.6 Field Test Reports: Submit certified copies in, [triplicate] [_____], of all field tests required herein.



1.4.7 Ground Resistance Test Reports: Upon completion and before final acceptance of the work, submit in writing the measured ground resistance of each ground rod and grounding system; indicate the location of the rod and grounding system and the soil condition at the time the measurements were taken.

1.4.8 Operating and Maintenance Instructions:

a. Substations

[b. _____.]

[c. _____.]

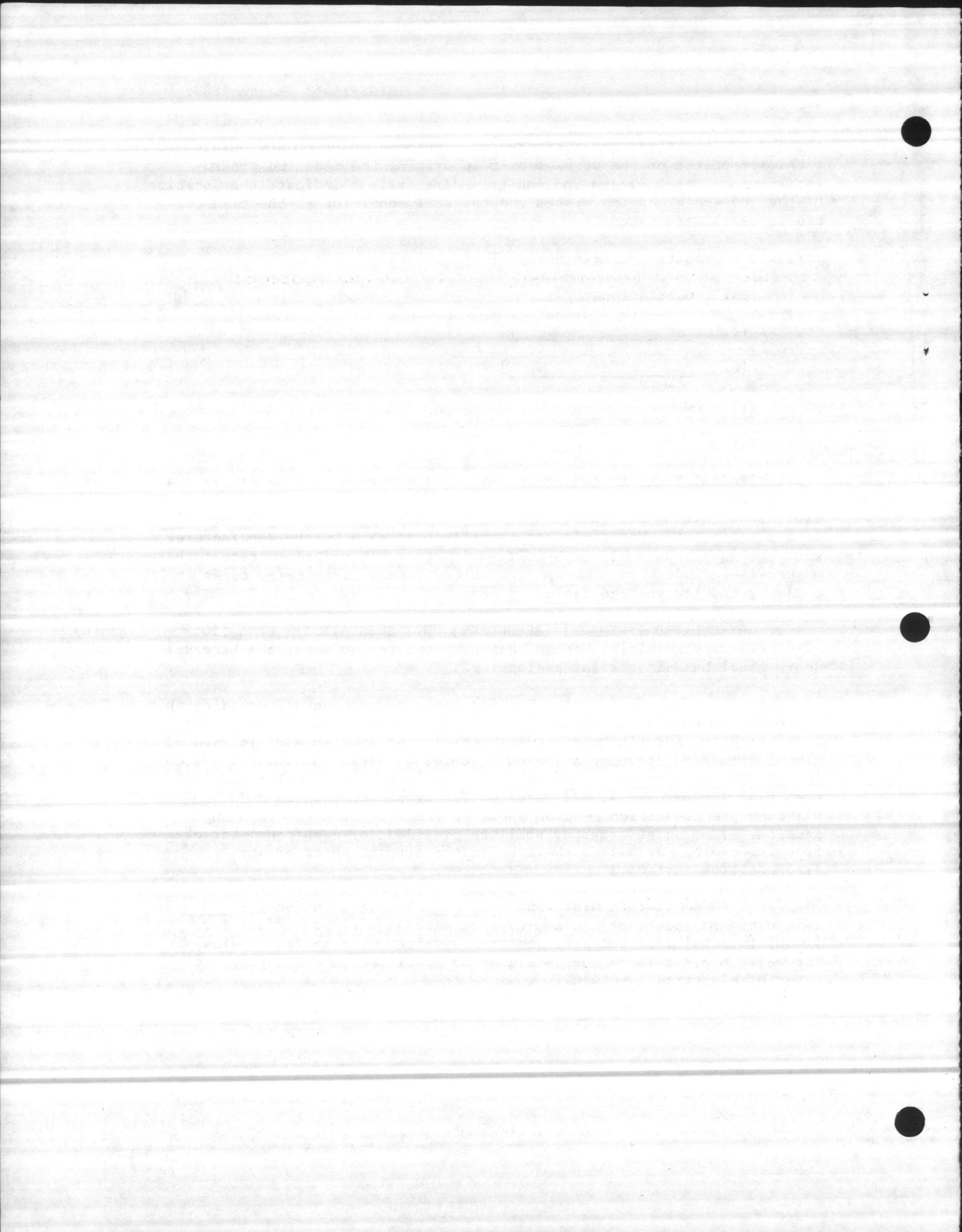
PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS, MATERIAL: All equipment and materials shall be new unless indicated or specified otherwise. Askarel and insulating liquids containing polychlorinated biphenyls (PCB) shall not be provided in any equipment. Materials not normally furnished by the manufacturer with the equipment shall be specified in other electrical sections; these materials include terminators, high-voltage cable, arresters, tapes, conduit, and low-voltage cable. (F)

2.2 ARTICULATED [PRIMARY] [SECONDARY] UNIT SUBSTATION: NEMA [201] [210] [,as applicable]. Design equipment for indoor service. External doors shall be suitable for padlocking. (A) (G)

2.2.1 Incoming Section[s]: Provide incoming section[s] including an [incoming switchgear section] [air-filled terminal chamber] for connecting the incoming circuit [directly] [through [an air] [a vacuum] circuit breaker] [through a [fused] [nonfused] [load interrupter switch] [air interrupter switch]] [through a [fused] [nonfused] oil-cutout] to the [bus] [transformer]. If required for proper connection and alignment, a transition section shall be included with the incoming section. [One surge arrester shall be provided for each conductor of incoming cable. Arresters shall be in the circuit ahead of any disconnecting devices.]

2.2.1.1 Conductor Terminations: [_____ 1/c terminations] [_____ 3/c terminations] [bushings] [clamp-type terminals] with provisions for [loop] [single] feed and arranged for conduits entering from [below] [above]. Cable terminations shall be as specified in the appropriate exterior electrical section.

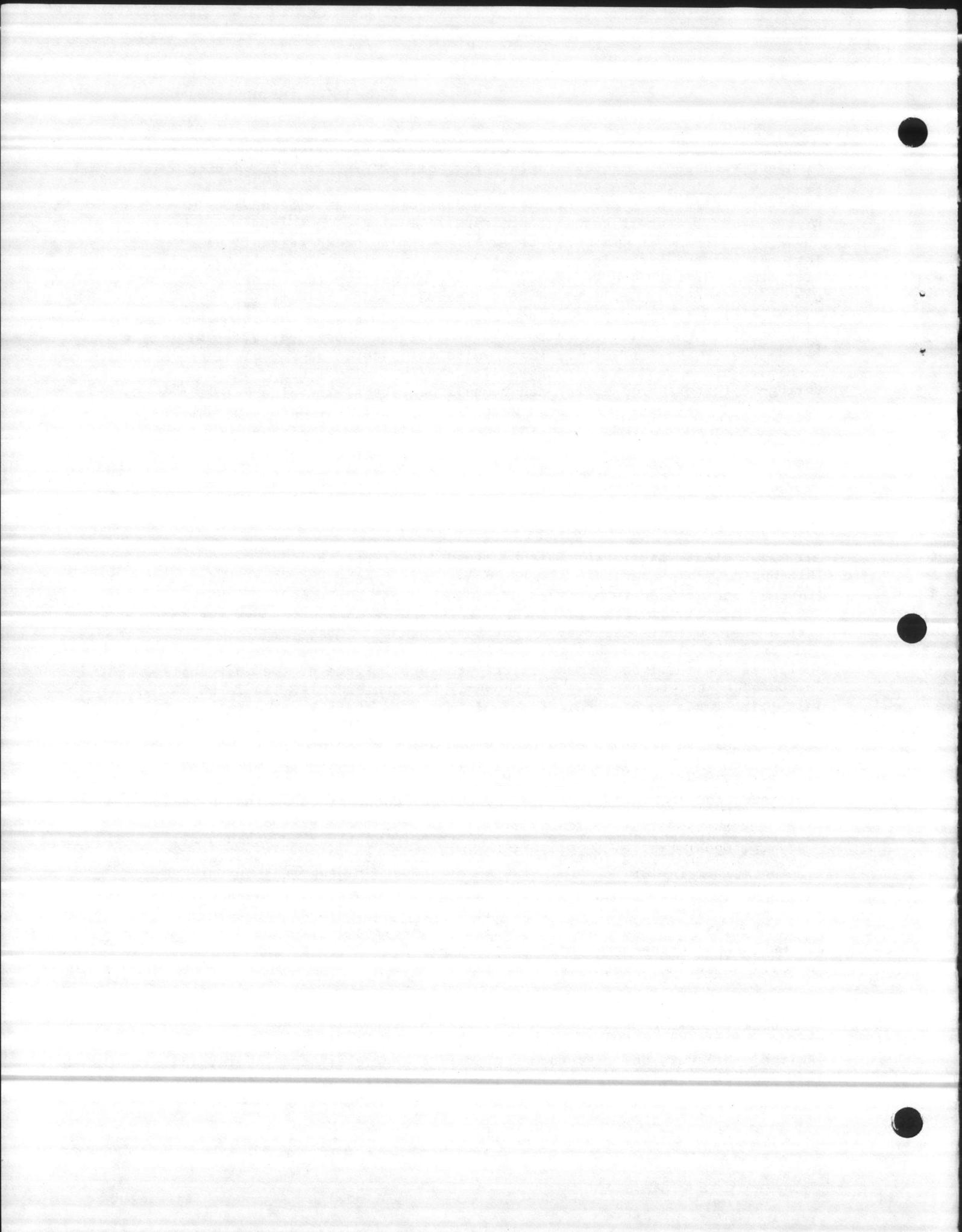


2.2.1.2 [Air] [or] [Vacuum] Circuit Breaker: Electrically group-operated, three-pole, single-throw, circuit interrupting device rated for _____ amperes continuous at _____ kV and _____ kV basic impulse level (BIL). Breaker shall be designed for service on a _____-kV system with a short circuit interrupting rating of not less than _____ [amperes symmetrical] [mVA]. Circuit breakers shall be [drawout-mounted] [stationary-mounted] and mechanically and electrically trip free. Circuit breakers shall include a position indicator, operation counter, auxiliary switches, primary and secondary disconnection devices [, and a mechanical interlock with the primary disconnects]. Circuit breakers shall be designed and rated for [[48] [125] [250] volts dc]] [[115] [230] volts ac]] stored energy closing mechanism and a [48] [125] [250] -volt dc trip coil. [The spring-charging stored energy motor shall be rated [125 volts dc] [115 volts ac].] [Breaker shall be arranged with a safety shutter that covers all primary connections. This shutter automatically closes as the circuit breaker is withdrawn from the connected position and remains closed until the breaker is inserted and racked in.]

** OR **

2.2.1.2 [Air Interrupter Switch] [Load Interrupter Switch]: Three-pole, group-operated, single-throw, dead-front metal-enclosed, [fused] [nonfused] with manual-stored energy operator rated _____ kV and _____ kV basic impulse level (BIL) for service on a _____-kV system with a short circuit capacity of not less than _____ [mVA] [amperes symmetrical]. A ground bus shall extend the width of the switch enclosure and shall be bolted directly thereto. Frame of the unit shall be connected to ground bus. Switch shall be a three-pole, single-throw unit [with fuses mounted on a single frame]. Unit shall be designed for easy inspection [and fuse replacement]. Switch shall be operated by a manually charged spring-stored energy mechanism which shall simultaneously disconnect or connect all ungrounded poles. [Fuses and] movable blade of the switch shall be deenergized when in the "open" position. The mechanism shall enable the switch to close against a fault equal to the momentary rating of the switch without affecting its continuous current-carrying or load-interrupting ability. Switch shall be capable of carrying continuously [and interrupting] _____ amperes with a momentary rating of _____ amperes at _____ kV. Switch shall have provision for padlocking in the open and closed positions. Fuses shall be [power] [current limiting] type rated [_____ amperes continuous, _____ kV and _____ amperes interrupting capacity] [approximately _____ percent of the transformer full-load rating] [as indicated and coordinated to the transformer provided].

2.2.2 Transition Section[s]: Provide transition section[s] for [cable] [bus-bar] connections to the transformer primary [and secondary]. Support [bus] [cable] connections between high-voltage [switch] [breaker] and transformer primary by porcelain insulators, and size and brace [bus] [cable] to withstand the available fault current.



2.2.3 Transformer Section[s]: Provide [one] [two] transformer section[s]. Transformer shall be [ventilated] [sealed] [dry-type] [vacuum-cast coil-type] [high-fire-point-liquid-insulated] [nonflammable fluid-insulated] rated _____ kVA, [self-cooled] [forced-air-cooled], [55/65] [65] [80] [115] [150] -degrees C temperature rise, 60 hertz, 3-phase, _____ kV, _____ kV BIL primary connected [delta] [wye] to _____ volts secondary connected [delta] [wye]. [Forced-air-cooling fans shall have [automatic temperature control relay] [winding temperature indicator with sequence contacts]]. Minimum transformer impedance shall be _____ percent. Provide low voltage neutral bushings on units having wye-connected low-voltage windings. Transformer shall have stainless steel or corrosion-resistant aluminum diagrammatic nameplate. In addition to the requirements of NEMA [201] [210], transformer shall be designed according to ANSI [C57.12.00] [C57.12.01]. [Provisions shall be made for future addition of automatically controlled fans.] [Sound level shall not exceed _____ dB, as determined in accordance with NEMA standards.]

(H)

2.2.3.1 Taps (Deenergized Operation): Provide externally operated taps. Transformer shall deliver rated kVA at any tap setting. [_____ taps shall be 2-1/2 percent full capacity above rated voltage] [and] [_____ taps shall be 2-1/2 percent full capacity below rated voltage].

2.2.3.2 Windings: Transformer shall have two separate windings. Windings shall have basic impulse level of _____ kV.

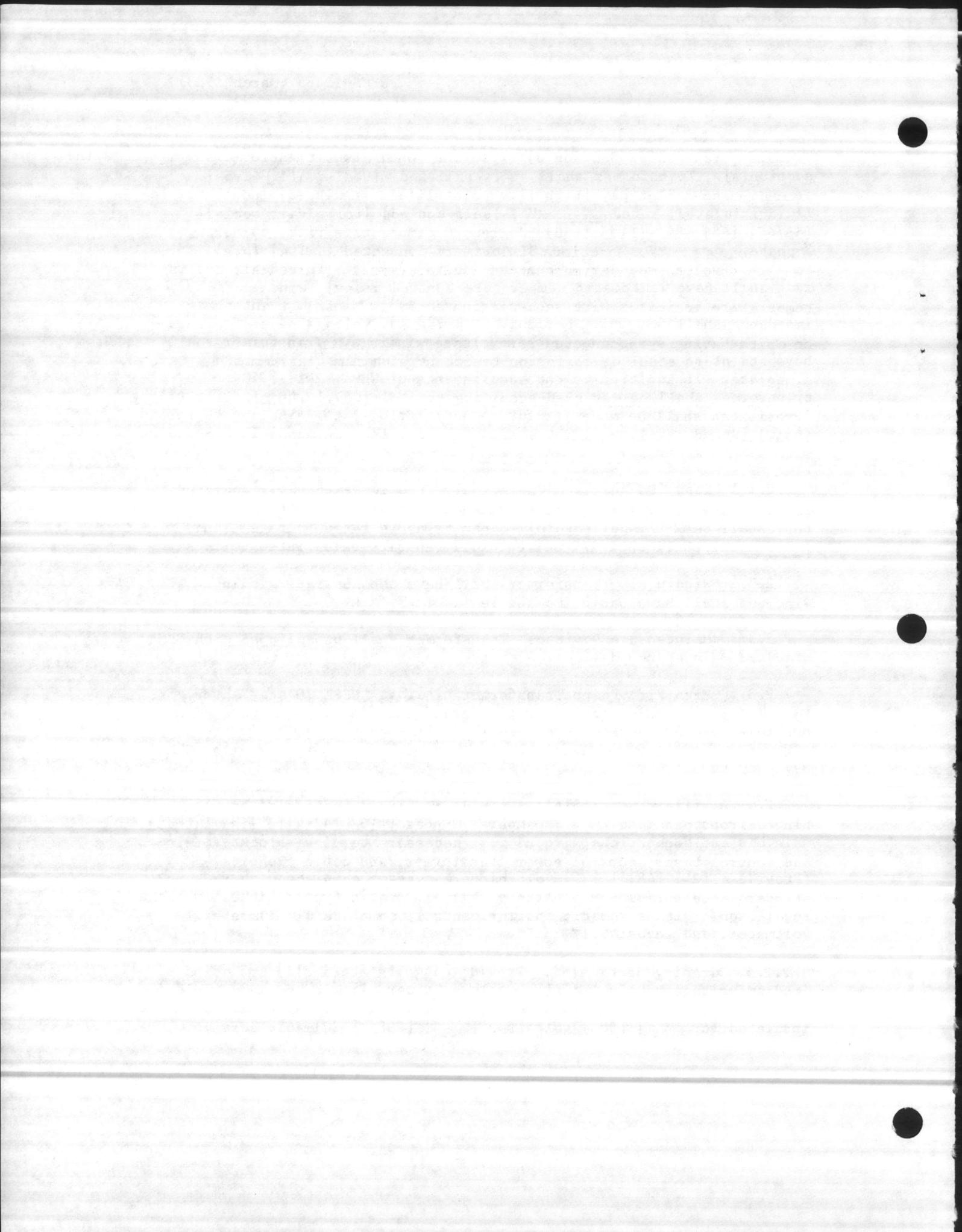
2.2.3.3 Maintenance Devices: Transformer shall be equipped with NEMA standard maintenance devices.

2.2.3.4 High Fire Point Transformer Liquids: NFPA 70 and Factory Mutual Approval Guide for "less-flammable" liquids having a fire point not less than 300 degrees C tested in accordance with ASTM D 92 and a dielectric strength not less than 33 kV tested in accordance with ASTM D 877.

2.2.4 Auxiliary Section[s]: Provide auxiliary section[s] having hinged front panel; a _____-ampere, 3-phase, [3] [4]-wire [insulated] main bus and connections; ground bus; necessary terminal blocks; wiring and control buses; control power transformer; and cable supports. [Provide a [24] [48] [_____] -volt battery system, complete with rack and standard accessories and a battery charger, static type, [without voltage regulation] [with automatic charger control] complete with ammeter, voltmeter, and rheostat.]

2.2.5 Outgoing Section[s]: Provide outgoing section[s] including [medium-voltage metal-clad] [low-voltage power circuit breaker] [molded case circuit breaker] [insulated-case circuit breaker] switchgear insulated for [_____] [600] volts for [_____] [208] [120]-volt service.

(I) (J)

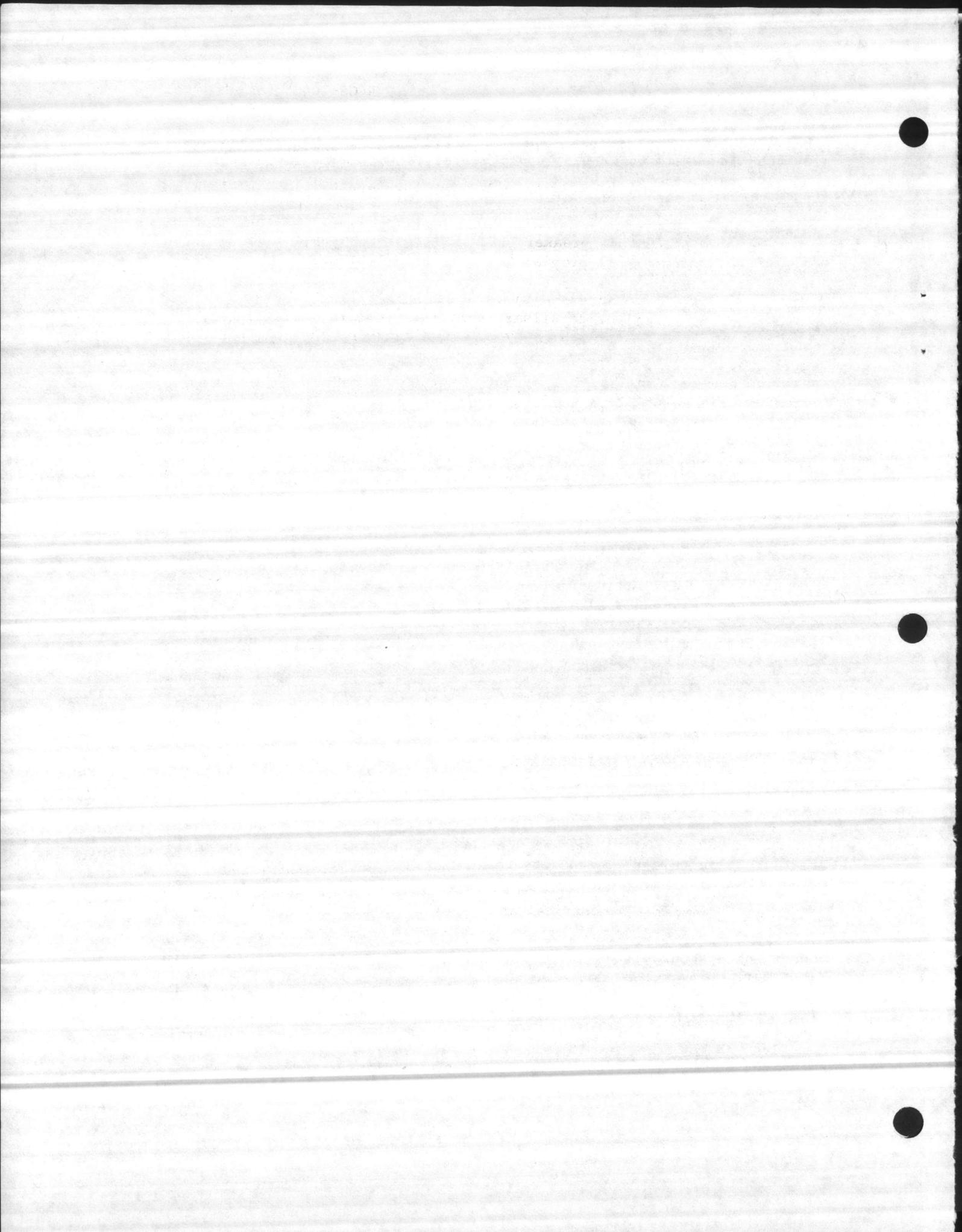


[Main secondary breaker shall be key-interlocked with the primary [switch] [breaker] to prevent operation of the primary [switch] [breaker] with the main secondary breaker closed.] Each steel unit forming part of the switchgear structure shall be a self-contained housing having individual breaker or instrument compartments, and a full height rear compartment for the [insulated] [bare] buses, instrument transformers, and outgoing cable connections. Individual circuit-breaker compartments shall be equipped with primary and secondary contacts, rails, disconnecting mechanism parts, and a cell interlock that will prevent moving the removable element into or out of the "connected" position while the circuit breaker is closed. A steel door shall be provided for each individual breaker compartment. Top, sides, and rear of indoor structures shall be enclosed with removable steel sheets. [The structure shall be designed so that future additions may be made.] An engraved circuit designation plate shall be provided on each individual circuit breaker compartment door. [A monorail with hoist shall be provided to facilitate removal and installation of breakers.] [All circuit breakers shall be of the same manufacturer, the same type, and shall be interchangeable.] [A portable test set shall be provided [, in each substation,] that is designed to field test and calibrate all the functions of the circuit breakers provided.]

2.2.5.1 Phase Buses and Connections: Mount bus structure on insulated supports of high-impact, nontracking, high-quality insulating material and brace to withstand the mechanical forces exerted during short circuit conditions when connected directly to a source having maximum of _____ amperes RMS symmetrical available. Bus bars shall be [high conductivity copper having silver-plated joints] [welded aluminum] [aluminum having tin-plated joints]. Bus bar connections shall be made from main buses to the incoming circuit breaker studs. Outgoing circuit breaker studs shall be equipped with mechanical clamp-type cable connectors for the size of cables shown. Cable supports for outgoing cables shall be provided. [Cable compartment shall be isolated from bus compartment]. Secondary circuits including heater circuits shall be wired to terminal blocks. Terminal blocks shall be readily accessible for making external connections as required. Neutral bus shall be sized _____ percent of full load amperes.

2.2.5.2 Ground Bus: Provide a copper ground bus secured to each vertical structure and extending the entire length of the switchgear. Ground bus size shall be [_____] [as indicated]. Include provisions for making the station ground connections.

2.2.5.3 Main Circuit Breaker: ANSI C37.13. [Manually] [Electrically] operated [drawout] [stationary] low-voltage power circuit breaker having an interrupting rating not less than _____ amperes symmetrical at _____ volts. Breaker shall be equipped with magnetic or solid-state long time trip device with adjustable [short time] [ground fault] tripping characteristics so that branch breakers normally will trip first on overload and at lower fault-current levels. Breaker also shall be equipped with a [motor-charged] stored-energy closing mechanism that



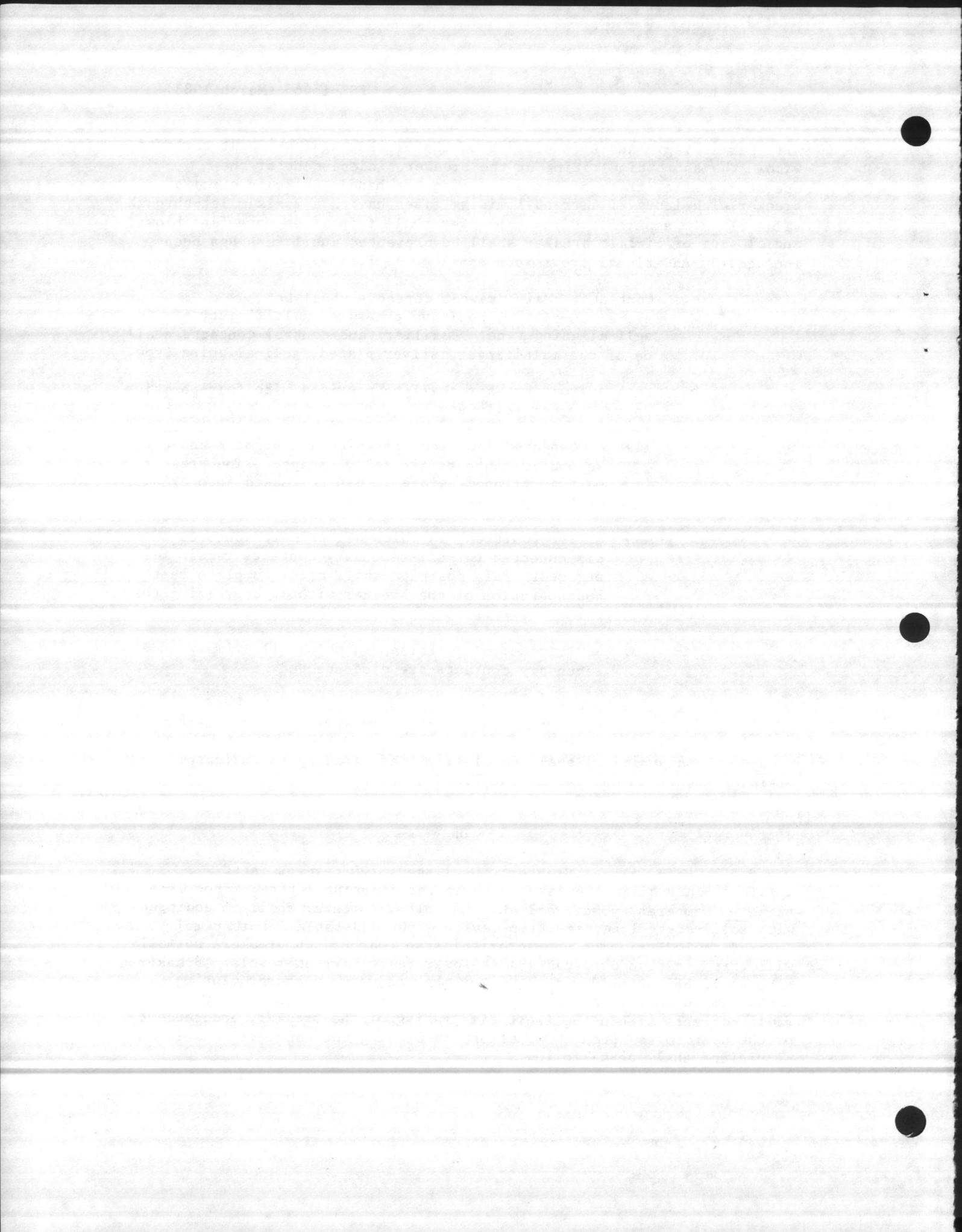
will permit rapid and safe closing of the breaker against fault currents within the short time rating of the breaker, independent of the operator's strength or effort in closing the handle. [Equip circuit breaker with integral current limiting fuses having a maximum let-through value of _____ amperes. Circuit breaker shall trip if any one fuse blows, and closing of circuit breaker shall be prevented until fuse has been replaced.] Additional provisions shall be as follow:

- a. Contacts: Main drawout contacts shall be silver-to-silver, positive pressure, multifinger, self-aligning type. Auxiliary and control contacts shall be of the multifinger, silver plated, self-aligning type.
- b. Each drawout breaker shall be provided with four-position operation, as follows:
 - (1) A Connected Position, in which all primary and secondary contacts are fully engaged. The breaker must be tripped before it can be racked into or out of this position.
 - (2) A Test Position, in which all primary contacts are disconnected but all secondary contacts remain fully engaged. This position shall allow complete test and operation of the breaker without energizing the primary circuit.
 - (3) A Disconnected Position, in which all primary and secondary contacts are disconnected.
 - (4) A Withdrawn Position, which places the breaker completely out of its compartment ready for removal.

Each of these positions shall be clearly identified by an indicator visible through an opening in the housing door.

** OR **

2.2.5.3 Main Circuit Breaker: UL listed, 100 percent rated insulated-case circuit breaker with an interrupting rating of not less than _____ amperes symmetrical at _____ volts. Breaker shall be equipped with solid-state long time trip device with adjustable [short time] [ground fault] tripping characteristics so that branch breakers normally will trip first on overload and at lower fault-current levels. Breaker also shall be equipped with a [motor-charged] stored-energy closing mechanism that will permit rapid and safe closing of the breaker against fault currents within the short time rating of the breaker, independent of the operator's strength or effort in closing the handle. Additional provisions shall be as follow:



- a. Operating Mechanism: Provide breaker with true two-step stored energy mechanism which allows closing in a maximum of 5 cycles.
- b. Each drawout breaker shall be provided with four-position operation, as follows:
 - (1) A Connected Position, in which all primary and secondary contacts are fully engaged. The breaker must be tripped before it can be racked into or out of this position.
 - (2) A Test Position, in which all primary contacts are disconnected but all secondary contacts remain fully engaged. This position shall allow complete test and operation of the breaker without energizing the primary circuit.
 - (3) A Disconnected Position, in which all primary and secondary contacts are disconnected.
 - (4) A Withdrawn Position, which places the breaker completely out of its compartment ready for removal.

Each of these positions shall be clearly identified by an indicator visible through an opening in the housing door.

2.2.5.4 Setting for Main Breaker:

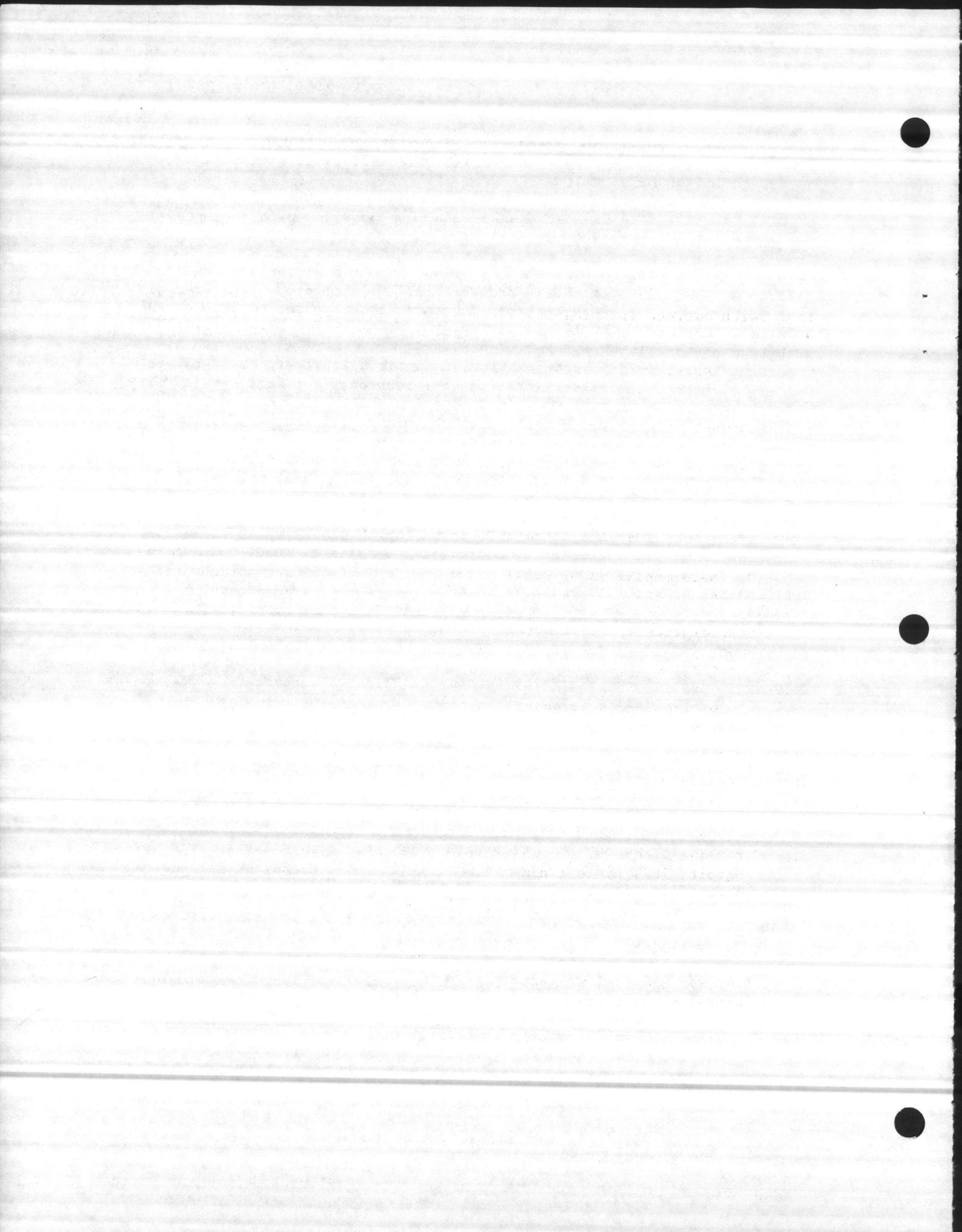
(K)

- a. Long time delay setting shall be ___ percent of coil rating.
- b. Short time pickup settings shall be adjustable with calibrated marks set at ___ percent of trip unit rating.
- c. Trips shall be set at ___ amperes.
- [d. Ground fault trip with adjustable time delay and pickup.]

2.2.5.5 Secondary Feeder Breakers: Provide as specified for main breaker, except that they shall have an interrupting rating not less than ___ amperes symmetrical at ___ volts. Delay and trip settings shall be as follow:

(K)

- a. Long time delay setting: ___ percent of coil rating.
- b. [Instantaneous] [Short time] pickup settings: ___ percent of trip unit rating.



- c. Trips: _____ amperes.
- [d. Ground fault trip with adjustable time delay and pickup.]

** OR **

2.2.5.5 Secondary Feeder Breakers: Fed. Spec. W-C-375. Molded-case type [with current limiting fuses] [having an interrupting rating of _____ amperes]. Breakers shall have a quick-make, quick-break operating mechanism and shall be equipped with [ambient-compensated thermal magnetic] [solid-state] trip device having long time delay, [short time delay,] [instantaneous pickup,] [ground fault pickup,] [shunt trip]. Circuit breaker shall trip free of handle; and handle position shall indicate whether breaker is "on", "off", or "tripped". Circuit breaker shall be mounted so that when removed, the busing will not be disturbed. An overload in one phase shall cause all three phases to trip.

2.2.5.6 Space Only Compartments: Provide fully equipped with busing, drawout breaker mounting and connecting straps to accommodate future breakers. These compartments shall have blank cover plates or doors.

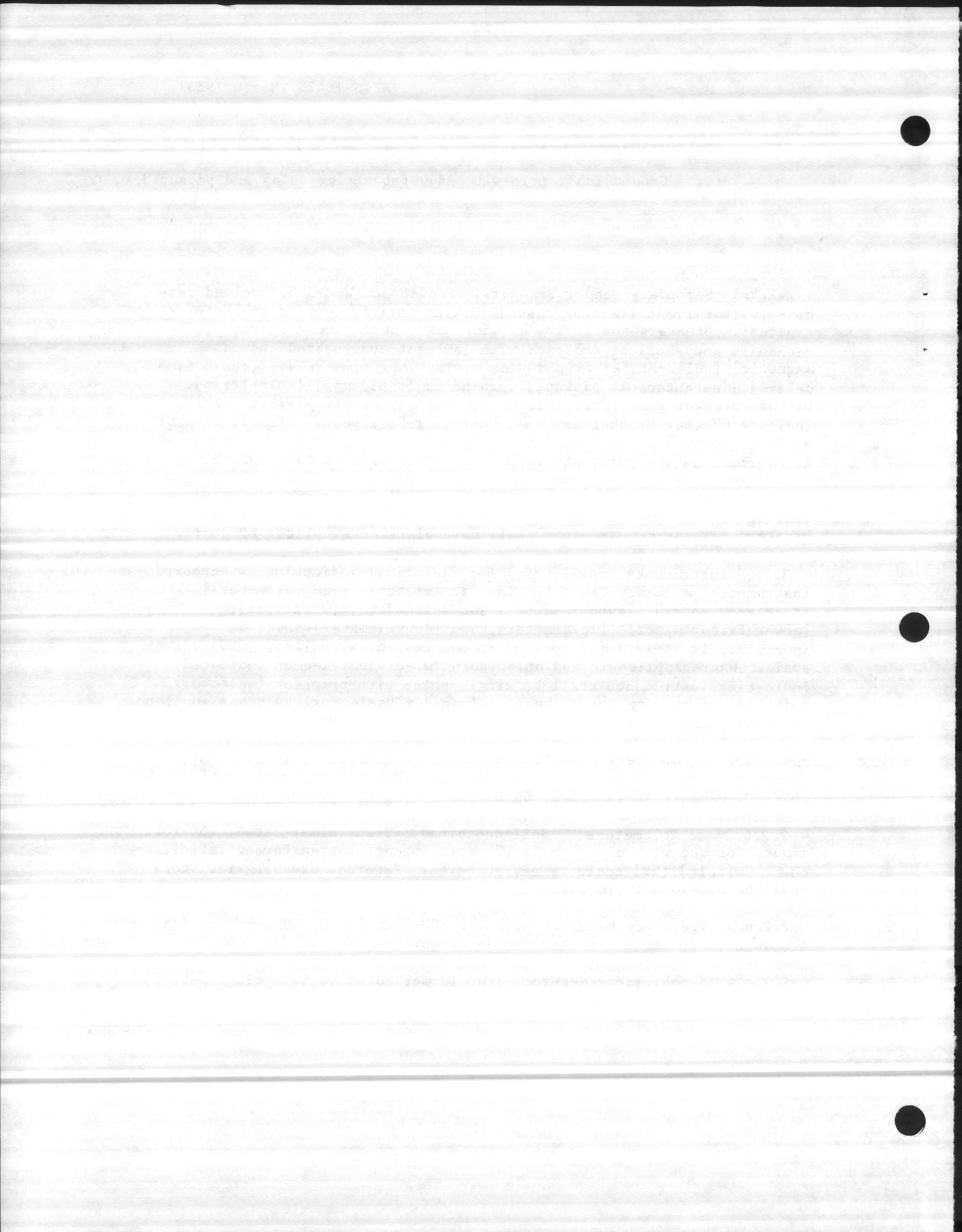
2.2.6 Instruments: ANSI C39.1 for electrical-indicating switchboard instruments, accuracy Class 1. The [ac ammeters], [ac voltmeters], [frequency meter], [synchroscope], [ac wattmeter], [varmeters], [power-factor meter], [dc ammeter], and [dc voltmeter] shall be approximately [4-1/2] [6] [8-1/2] inches square, with [180] [250] degree scale. Where applicable and unless otherwise specified or indicated, indicating instruments shall be single-phase with transfer (selector) switches for reading three phases. Transfer (selector) switches shall be flush-mounting type. (L)

2.2.6.1 Ac Ammeters: [Self-contained] [Transformer rated, 5-ampere input, for use with a _____ - to 5-ampere current transformer ratio], 0- to _____ -ampere scale range, 60 hertz.

2.2.6.2 Ac Voltmeters: [Self-contained] [Transformer rated, 150-volt input, for use with a _____ - to 120-volt potential transformer ratio], 0- to _____ -[volt] [kV] scale range, 60 hertz. External dropping resistors shall be provided if required.

2.2.6.3 Frequency Meters: Rate for 120-volt input, 60 hertz nominal frequency, _____ - to _____ - hertz scale range.

2.2.6.4 Synchroscope Meters: Transformer rated at 120-volt input, 60 hertz, with slow-fast scale.



2.2.6.5 Ac Wattmeters: Transformer rated for 120-volt input, 60 hertz, 3-phase, [3] [4]-wire, 0- to ___-[watt] [kW] scale range for use with ___- to 5-ampere current transformer ratio and ___- to 120-volt potential transformer ratio. Furnish resistors, if required.

2.2.6.6 Varmeters: Transformer rated, 5-ampere [3-wire, 120-volt] [4-wire, [120] [208]-volt] input, 60 hertz, 3-phase, ___-0- ___ scale range for use with ___- to 5-ampere current transformer ratio and ___- to 120-volt potential transformer ratio. Varmeters shall be complete with phase-shifting transformer.

2.2.6.7 Power-Factor Meters: Transformer rated, 5-ampere, [120-] [208-] volt input, ___ scale range for use on [3] [4]-wire, 3-phase circuits. Accuracy shall be plus or minus 0.01.

2.2.6.8 Dc Ammeters: [Self-contained] [Shunt-rated], [0- to ___ -ampere] [___-0-___ ampere] scale range.

2.2.6.9 Dc Voltmeters: Self-contained, [0- to ___-volt] [___-0-___ volt] scale range. Furnish resistors, if required, with the voltmeter.

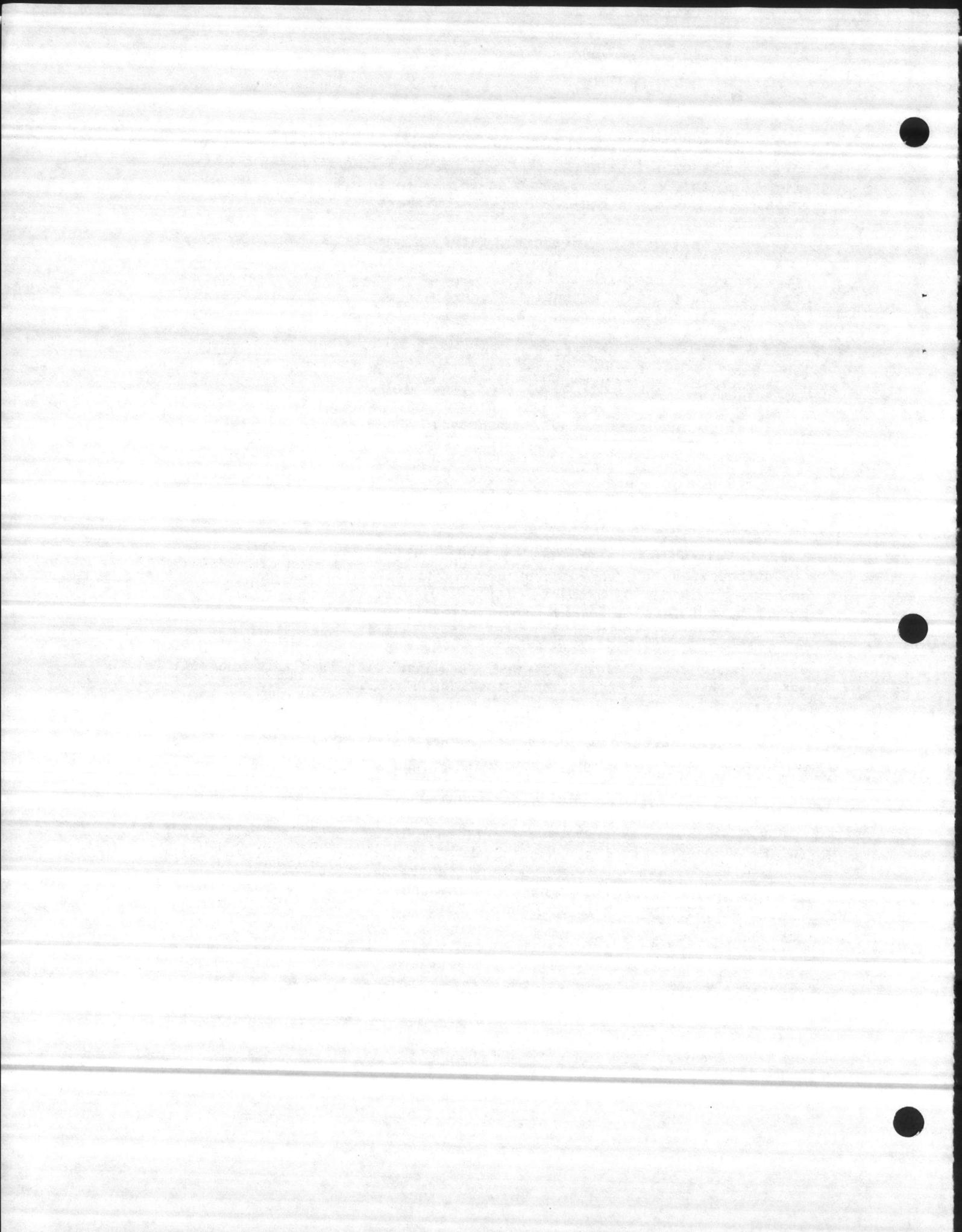
2.2.7 Watthour Meters: ANSI C12.10 unless specified otherwise. Class 20, 60-hertz, semiflush-mounted, drawout-type switchboard meter with test switches, [2] [3] [] elements, [69] [120] volts rating for each potential coil, and a 5-dial [cyclometer] [pointer-type] register. Provide register with secondary reading. Indicate meter multiplier (potential transformer ratio multiplied by the current transformer ratio) on the meter face. Provide demand attachment with 15-minute interval and maximum indicating hand. [Meter shall have provisions for future pulse initiation.] (M)

2.2.7.1 Electric Strip-Chart Recording Instruments: ANSI C39.2 for semiflush mounting. Chart speed shall be ___ inches [per hour] [per minute] and chart drive motor shall be rated 120 volts, 60 hertz. The instrument shall have a full scale accuracy of 1 percent.

2.2.8 Relays: ANSI C37.90, semiflush mounted, drawout type, with built-in test facilities. A means shall be provided to automatically short-circuit the associated current transformer secondaries when removing the relay from its case. Relays shall be for operation on a [___-volt dc] [___-volt ac] control bus. (L)

2.2.8.1 Provide [___] [very] [extremely] [inverse] induction time phase overcurrent relays (Device 50-51) with time delay range of ___ amperes and instantaneous range of ___ amperes.

2.2.8.2 Provide [___] [very] [extremely] [inverse] induction time ground overcurrent relay[s] (Device 50-51N) with time delay range of ___ amperes and instantaneous range of ___ amperes.



2.2.8.3 Provide [] high-speed directional relay[s] with watt characteristic to detect reverse power flow (Device 32).

2.2.9 Instrument and Control Transformers: ANSI C57.13, as applicable.

2.2.9.1 Current Transformers: Provide with ratio and accuracy indicated. Voltage rating shall be [] volts.

** OR **

2.2.9.1 Current Transformers: [Single] [Multi-ratio] transformers, [] to 5-ampere ratio []/ [] to 5-ampere ratio], insulation class _____ volts, 60 hertz, and shall have an accuracy classification of [0.3] [0.6] [1.2] for a burden of B- [0.1] [0.2] [1.0] [2.0] [4.0] [8.0].

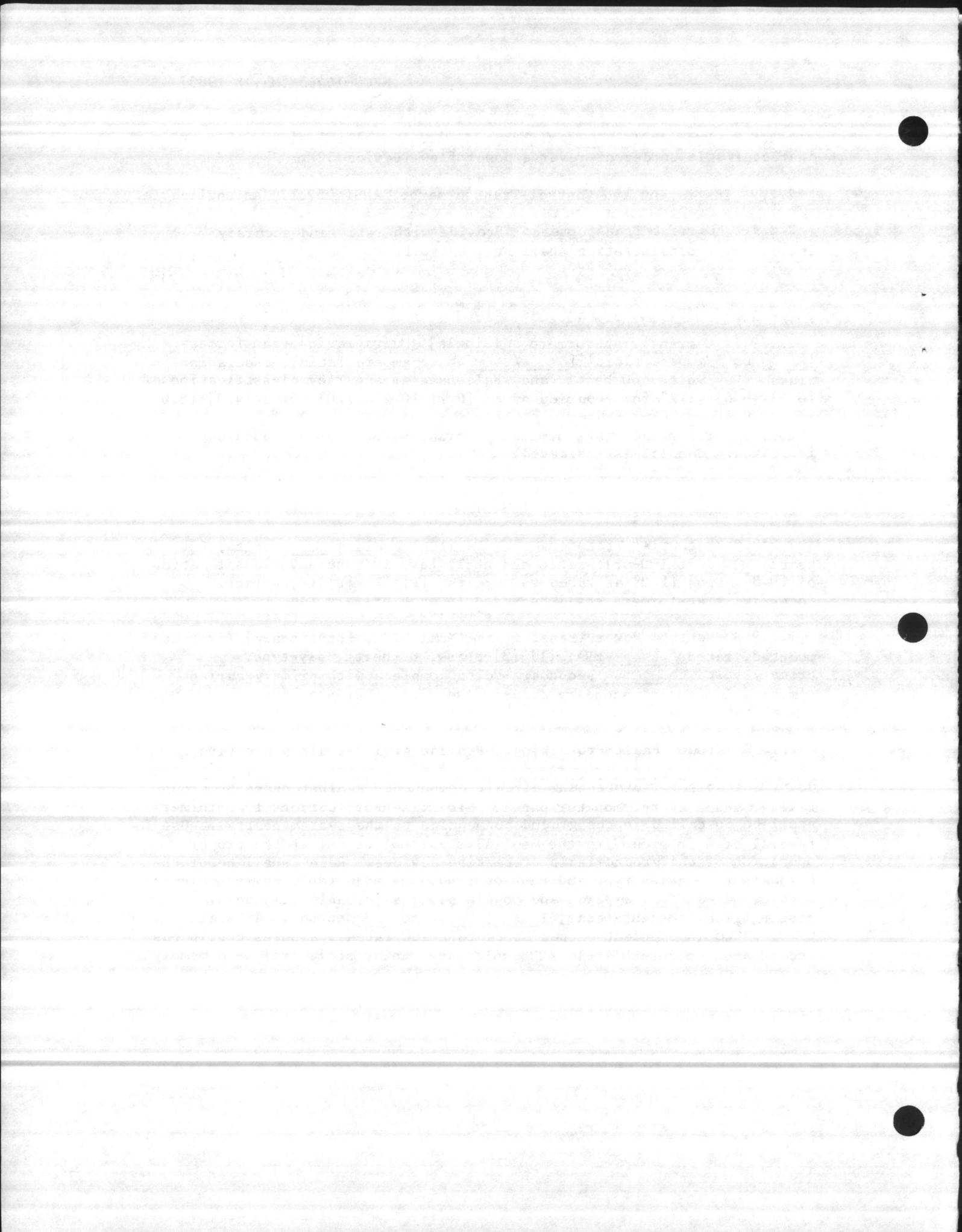
2.2.9.2 Potential Transformers: Provide with ratio and accuracy indicated. Connect as indicated.

** OR **

2.2.9.2 Potential Transformers: Insulation class _____ volts, 60 hertz, _____ to 120-volt ratio and shall have an accuracy classification of [0.3] [0.6] [1.2] at rated voltage for [W] [X] [Y] [Z] burden. Potential transformers shall be fused in each primary leg.

2.2.9.3 Control Power Transformer: NEMA ST20, [stationary] [drawout] mounted, rated _____ kVA, [1] [3]-phase, 60-hertz, dry-type, _____ primary volts to _____ secondary volts complete with primary current limiting fuses and secondary molded case circuit breaker interlocked with the primary fuses.

2.2.10 Ground Fault Protection: Provide ground fault protective devices including current transformers, fault protection relays with time delay suitable for protecting circuit components against phase to ground faults, and a system monitor panel. Ground sensor (current transformer) shall be installed in the ground connection to the system neutral. Use special care in grounding the neutral so as not to defeat the proper operation of the ground fault protective devices. Relay shall be of the standard time delay type and have continuously adjustable current pickup settings of _____ amperes and continuously adjustable time delay setting from [instantaneous] [] to _____ seconds. It shall provide two independent output contacts, each rated 5 amperes continuous and 30 amperes inrush at 120/208 volts ac. Relay shall include a memory



function to recognize and initiate tripping on intermittent ground faults. Monitor panel shall indicate relay operation, shall provide means for testing the system with or without interruption of service, shall not permit the ground fault system to be inadvertently left in an inactive or "OFF" state, and shall have selectable "alarm and trip" and "alarm only" settings.

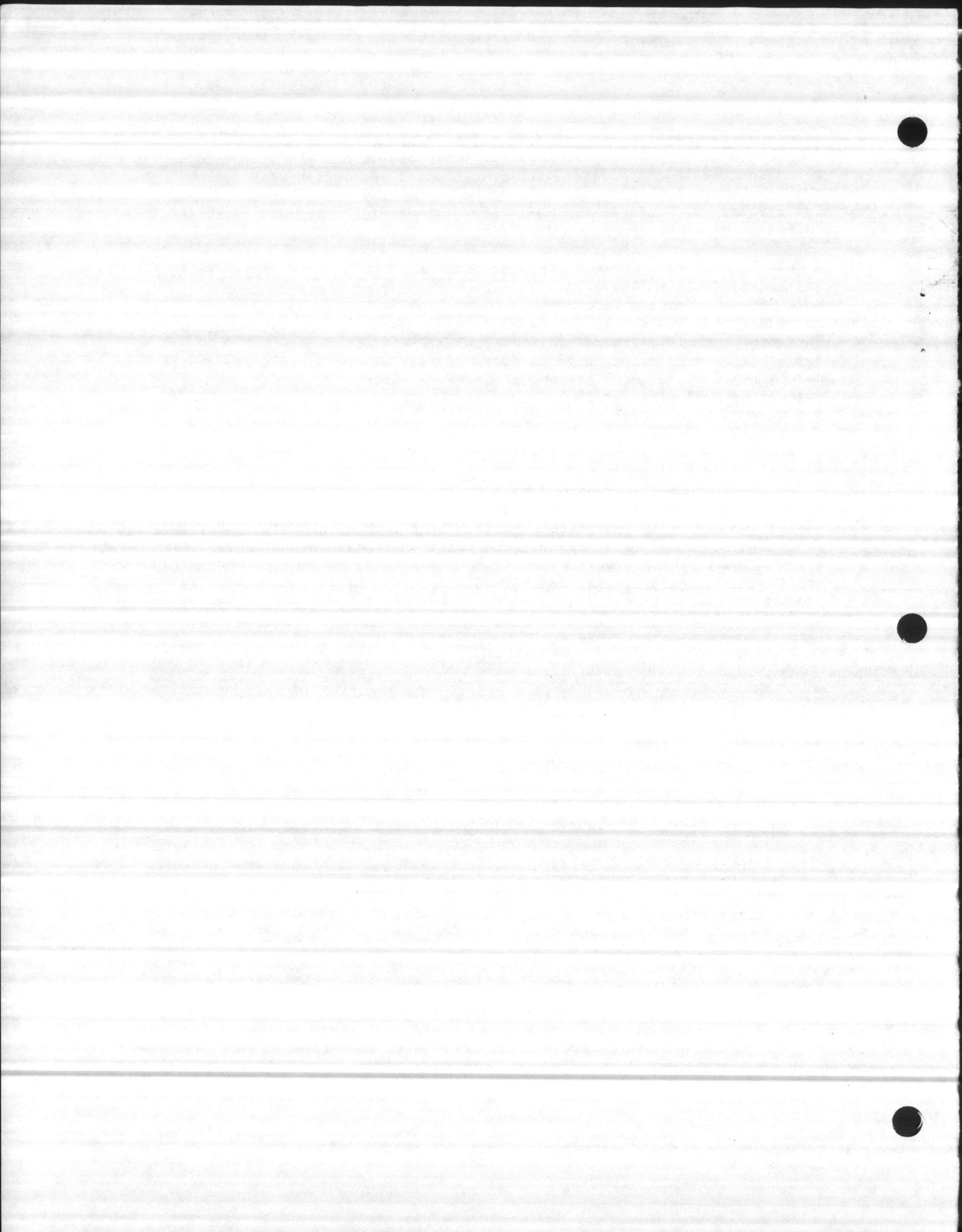
2.2.11 Heaters: Provide strip heater, rated [120] [___] volts in each switchgear section. Heaters shall be of sufficient capacity to control moisture condensation in the compartments and be controlled by a thermostat and humidistat located inside secondary switchgear section. Thermostats shall be industrial type, high limit, to maintain compartments within the range of 60 to 90 degrees F. Humidistats shall have a range of 30 to 60 percent relative humidity. [Electric heaters in switchgear assemblies shall be energized while equipment is stored or in place prior to being placed in service.]

2.2.12 Insulated Phase Barriers: Mil. Spec. MIL-M-14, Type MAT-30.

2.2.13 Nameplates: Provide laminated plastic nameplates for each relay, switch, and device to identify its function, and where applicable, its position. Laminated plastic shall be 1/8-inch thick Melamine plastic conforming to Fed. Spec. L-P-387, and white with black center core. Surface shall be a matte finish. All corners shall be square. Lettering shall be accurately aligned and engraved into the black core. Size of nameplates shall be one inch by 2-1/2 inches minimum. Lettering shall be minimum 1/4-inch high normal block lettering. Number, location, and letter designation of nameplates shall be as indicated. Nameplates shall be fastened to the device with a minimum of two sheet-metal screws or two rivets.

2.2.14 Miscellaneous Switchgear Devices:

- a. Control and transfer (selector) switches shall be of the rotary, multiposition, cam-operated, multistage type with dust cover and silver-to-silver contacts rated 600 volts, 20 amperes, and adequate for the duty performed in excess of 20 amperes. Each circuit breaker control switch shall have red and green target and indicating lamps to indicate breaker position. Equip each switch with engraved plastic escutcheon or nameplate identifying its function and position.
- b. Provide identified terminal boards with engraved plastic terminal strips for external wiring between components and for internal wiring between removable assemblies. Terminal board identification shall be identical in all similar units. Color code external wiring consistently for all similar terminal boards. Control wiring shall terminate at terminal boards with ring-tongue terminals.



PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS, ELECTRICAL: ANSI C2, NFPA 70, and the requirements specified herein. Work includes the [provision of a new] [and] [the modification of existing] substation[s] for indoor use. Install and connect substation[s] as indicated on project drawings, the approved shop drawings, and as specified herein.

(N)

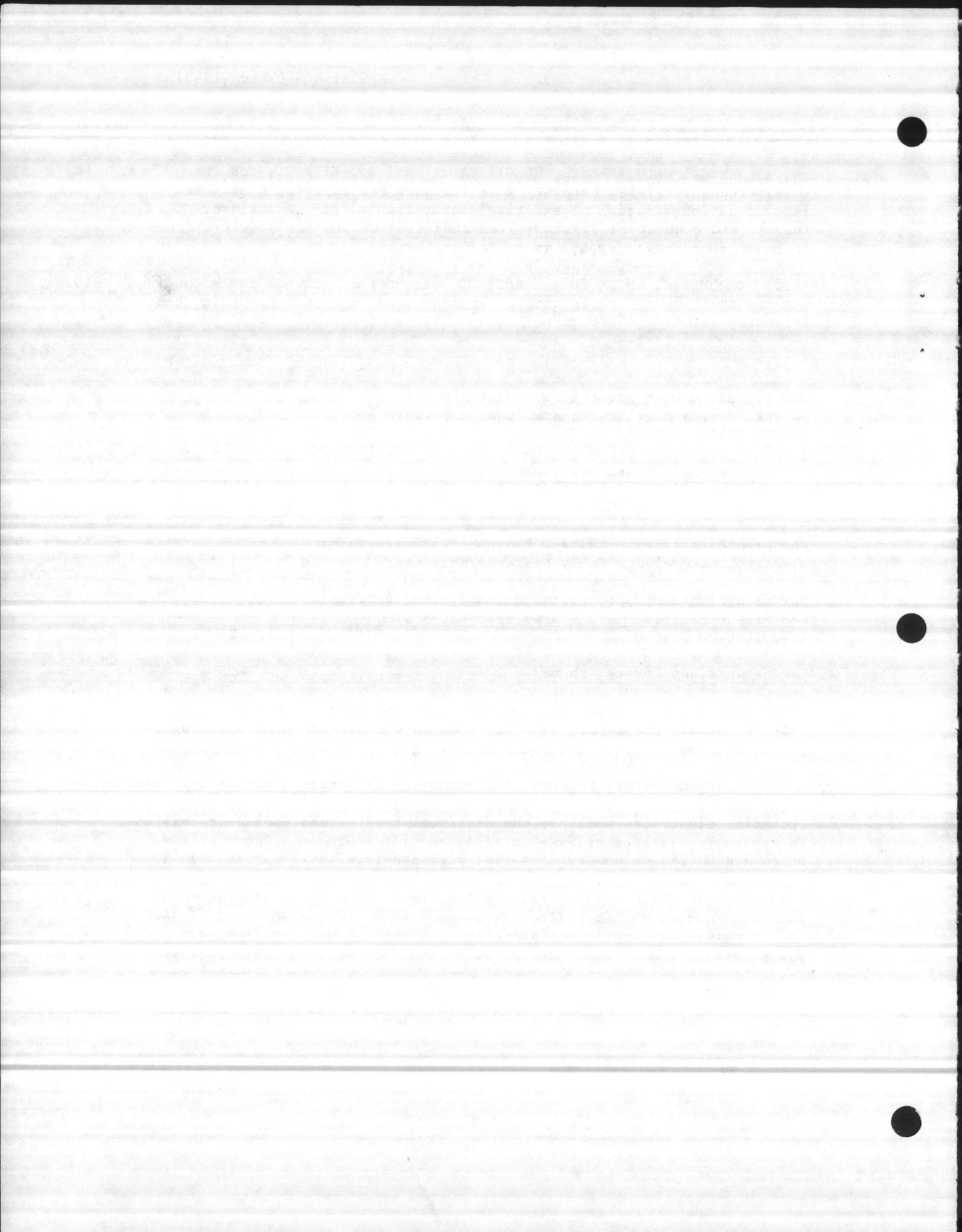
3.2 GROUNDING: NFPA 70 and ANSI C2, except that grounds and grounding systems shall have a resistance to solid earth ground not exceeding the following values:

(O)

| | <u>Ohms</u> |
|---|-------------|
| For grounding main substations, distribution substations, and switching stations on primary distribution systems | |
| a. 5000 kVA and above | 3 |
| b. 1000 to 5000 kVA | 5 |
| c. Below 1000 kVA | 10 |
| For grounding other metal enclosures of primary voltage electrical and electrically operated equipment | 10 |
| For grounding secondary distribution systems (neutral) noncurrent carrying metal parts associated with distribution systems | 25 |
| For grounds not covered above | 25 |

When work in addition to that indicated and specified is directed in order to obtain the specified resistance to ground, the provisions of the contract respecting an adjustment for changed conditions shall apply.

3.2.1 Grounding Electrodes: The grounding electrode system shall include ground rods driven exterior to the building. Artificial grounding electrodes shall be the sectional type ground rods as specified in the appropriate exterior electrical section. Grounding connections which are buried or otherwise normally inaccessible shall be made by exothermic weld or by using a compatible mechanical connection and brazing over. Exothermic welds shall be made strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces, indicating improper cleaning, are not acceptable. No mechanical connector is required at exothermic weldments.



3.2.2 Substation Grounding: Provide a bare copper cable not smaller than No. 4/0 AWG not less than 24 inches below grade connecting to the indicated ground rods. Transformer neutral connections shall not be smaller than No. 1/0 AWG. Where rated secondary current exceeds 400 amperes, size of transformer neutral ground connection shall be increased in size to not less than one-half the cross-section area of the secondary-phase conductors. Where the measured ground resistance exceeds _____ ohms, the Contracting Officer shall be notified.

3.2.3 Connections: Weld joints in grounding conductors and mats. The welding process shall not in any way cause the parts joined to be damaged or weakened and shall join all strands. The welding process shall be an exothermic type, and the completed connection or joint shall be equal to or larger in size than the conductors joined.

3.2.4 Ground Cable Crossing Expansion Joints: Protect ground cables crossing expansion joints or similar separations in structures and pavements from damage by means of suitable approved devices or methods of installation which will provide the necessary slack in the cable across the joint to permit movement. Stranded or other approved flexible copper cable run or jumper shall be used across such separations.

3.2.5 Grounding and Bonding Equipment: UL 467, except as indicated or specified otherwise.

3.3 METERS AND INSTRUMENT TRANSFORMERS: ANSI C12.

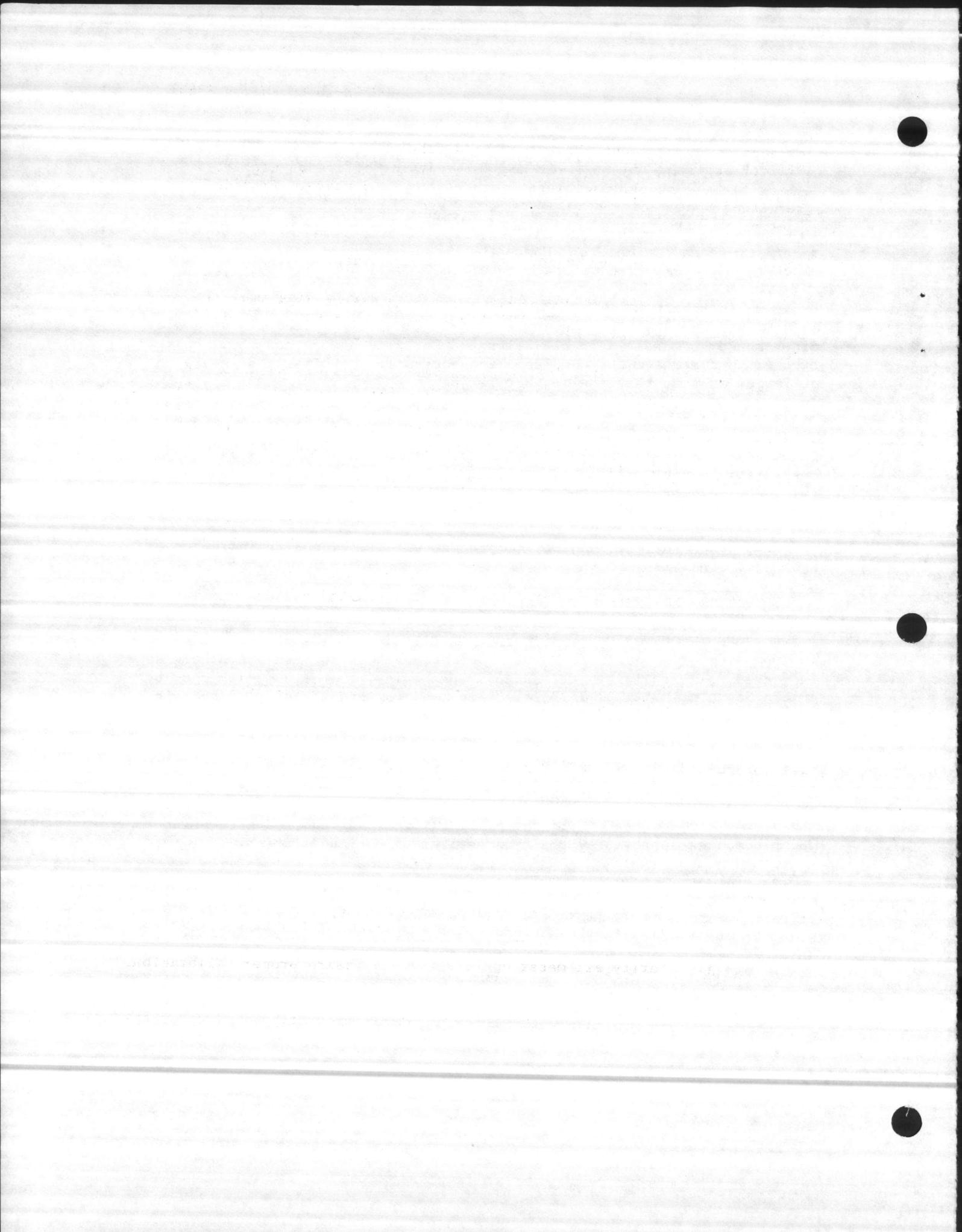
3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES: Provide concrete slab for mounting of substations. Bolt substations to slab. Unless otherwise indicated, slab shall be at least 8 inches thick, reinforced with a 6- by 6-inch No. 6 mesh placed uniformly 4 inches from the top of slab and with a 6-inch thick, well-compacted gravel subbase. The top of the concrete slab shall be approximately 4 inches above the finished floor. Edges above floor shall have 1/2-inch chamfer. The slab shall be of adequate size to project at least 8 inches beyond the equipment. Concrete work shall be as specified in Section 03300, "Cast-In-Place Concrete."

(P)

3.5 TOUCH-UP PAINTING: Touch-up all surfaces as required with paint and procedures approved by the manufacturer of each substation.

3.6 FIELD TESTS AND INSPECTIONS:

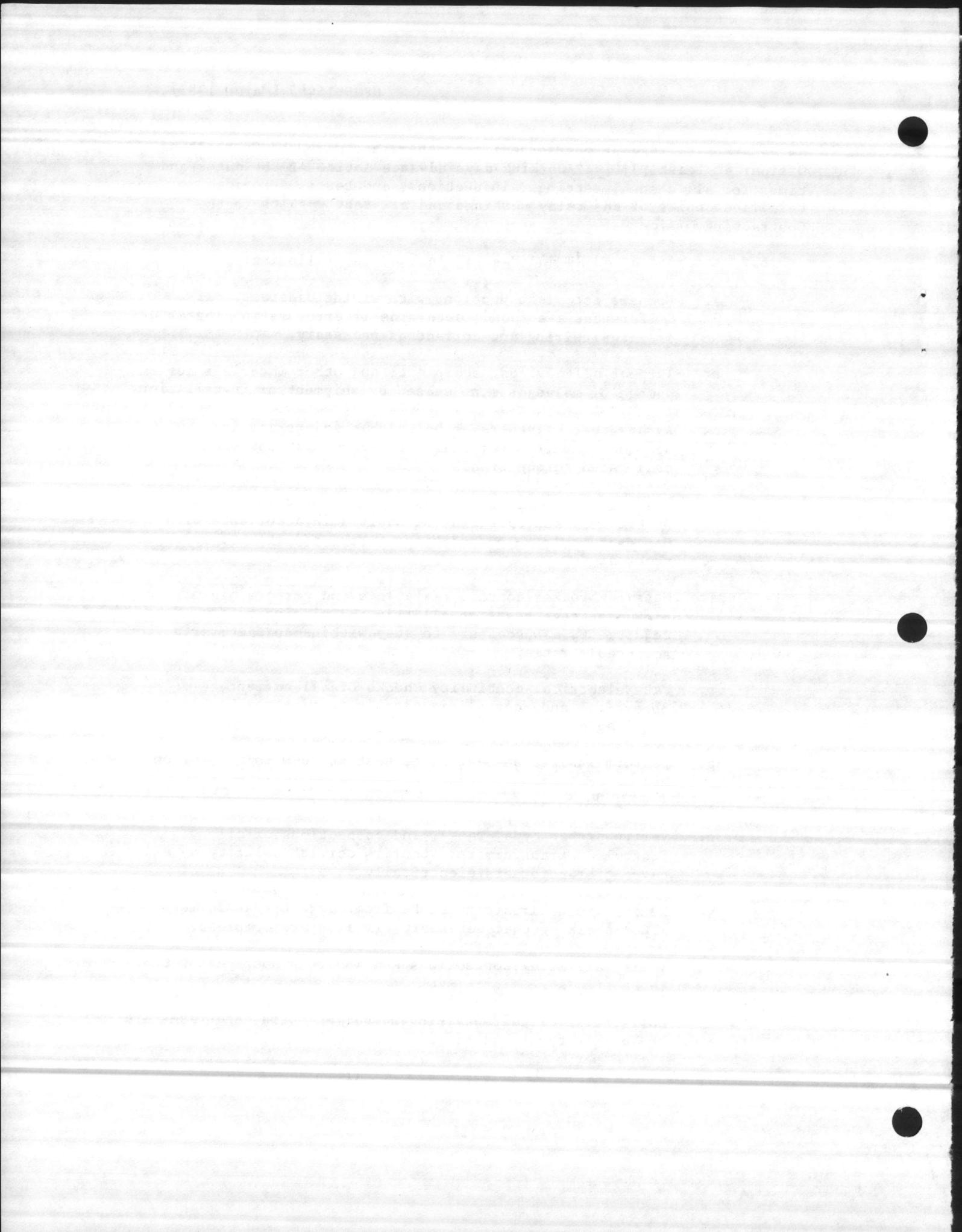
3.6.1 Acceptance Checks, Settings, and Tests: Perform in accordance with the manufacturer's recommendations and the latest IEEE standards unless specified otherwise. Perform work in a careful and safe manner so as not to endanger personnel or equipment. Perform tests in such a way as to obtain information about the performance of the breakers, relays, meters, wiring, and instrument transformers together as a unit, as well



as separately. Except where specified otherwise, give the Contracting Officer at least [5] [] working days advance notice of the dates and times for all checks, settings, inspections, and tests. Provide certified copies of the relay settings and all test results to the Contracting Officer.

3.6.2 Acceptance Checks and Tests: Include the following:

- a. Compare actual connections with wiring diagrams. If differences are found, determine if error is in diagram or in actual wiring and correct as necessary.
- b. Inspect all devices, equipment, and other materials for damage or maladjustment caused by shipment or installation.
- c. Assure that tightness of bolted bus joints are in accordance with manufacturer's recommendations (use calibrated torque wrench).
- d. Perform all mechanical operator and contact alignment tests on breakers and operating mechanisms in accordance with manufacturer's recommendations. Make adjustments as necessary.
- e. Measure breaker contact resistance and perform minimum pickup voltage tests on all trip and closing coils. Make adjustments as necessary to stay within manufacturer's acceptable range.
- f. Make electrical continuity checks of all current, potential, and control circuits, referring constantly to the diagrams.
- g. Perform insulation resistance test at 1000 volts D.C. on all control wiring. Minimum insulation resistance shall be 1,000,000 ohms.
- h. Verify proper type, range, and connections of all instrument transformers. Confirm correct polarity of all current transformers electrically.
- i. Remove short-circuiting links from current transformers after checking that secondary circuits are complete.
- j. Verify all meter connections and insure proper calibration.
- k. Verify that all protective relays, auxiliary relays, trip coils, trip circuit seal-in and target coils, and fuses are the proper types and range.



- l. Remove wedges, ties, and blocks installed by the manufacturer to prevent damage during shipment.
- m. Check all circuit breakers in accordance with manufacturer's instruction.
- n. Verify minimum resistance to ground of all grounding systems.
- o. Measure battery system charging voltage and each individual cell voltage assuring that measured values are within manufacturer's specified tolerances. Measure electrolyte specific gravity and level.
- p. Perform relay setting and coordination tests and dielectric tests.

CAUTION: All changes of connection, insertion, and removal of meters, relays, etc., shall be made in such a manner that the secondary circuits of energized current transformers are not opened, even momentarily.

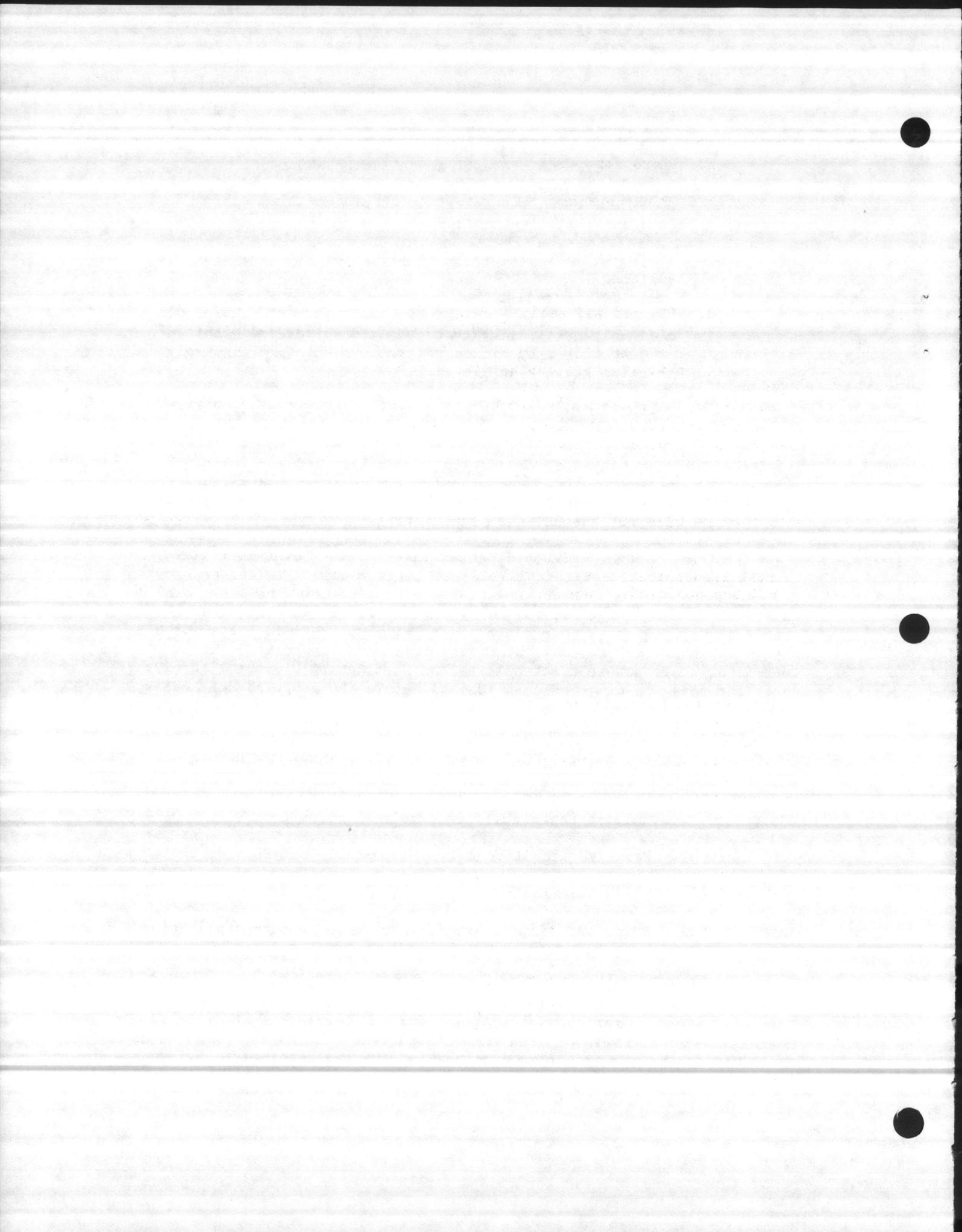
3.6.3 Relay Setting and Coordination Tests: [The Government will furnish the Contractor with the relay settings required to set the new relays to coordinate with the existing system protective devices. This data will be made available to the Contractor within 30 days after the Contractor furnishes the nameplate and relay response curve data for the new relays which he proposes to provide under this contract.] The Contractor shall submit a schedule to the Contracting Officer listing the dates for relay testing at least 10 days before the proposed test dates, to permit observation of the tests by the Government. (Q)

3.6.3.1 The Contractor shall provide a skilled relay technician actively engaged in the business of testing and calibrating power relays. The Contractor shall furnish all special equipment required.

3.6.3.2 Relay wiring tests shall include the following:

- a. Primary circuit polarity test shall include a dc test from the current transformer to each terminal block and relay terminal.
- b. Relay and circuit breaker operation test by application of power from a portable relay test set.

3.6.3.3 Relay testing shall be accomplished after completion of the switchgear installation, using standard portable test set equipment and the relay manufacturer's testing directions and parameters to determine conformance of the relay to the time-overcurrent information given in the relay manufacturer's performance curves and the tap settings [provided by the Government]. Overcurrent relay testing shall include the following:



- a. Zero set test
- b. Pick-up test
- c. Time-current characteristics (operation at currents 3 and 4 times the directed tap settings and instantaneous at the directed tap setting)
- d. Target and seal-in operation

3.6.3.4 The Contractor shall provide the Contracting Officer with three copies of an attested certificate stating that the relays have been set, tested, and adjusted in accordance with the data [provided by the Government] [specified] and indicating the relay settings as finally made for all new circuit breaker relays and shall further test the wiring and relay operation of all circuit breakers whose control circuits may have been disturbed in any way during construction and testing. Field test information shall be reported on an approved form. Test data and technician's initials shall be placed on a card in the relay window. Certification and test information shall be submitted to the Contracting Officer within 10 days after completion of the testing.

3.6.4 Transformer Test: Perform a turns ratio test between windings for all tap positions. Results shall not deviate more than one half of one percent (0.5%) from calculated ratio. Set tap at desired ratio.

(R)

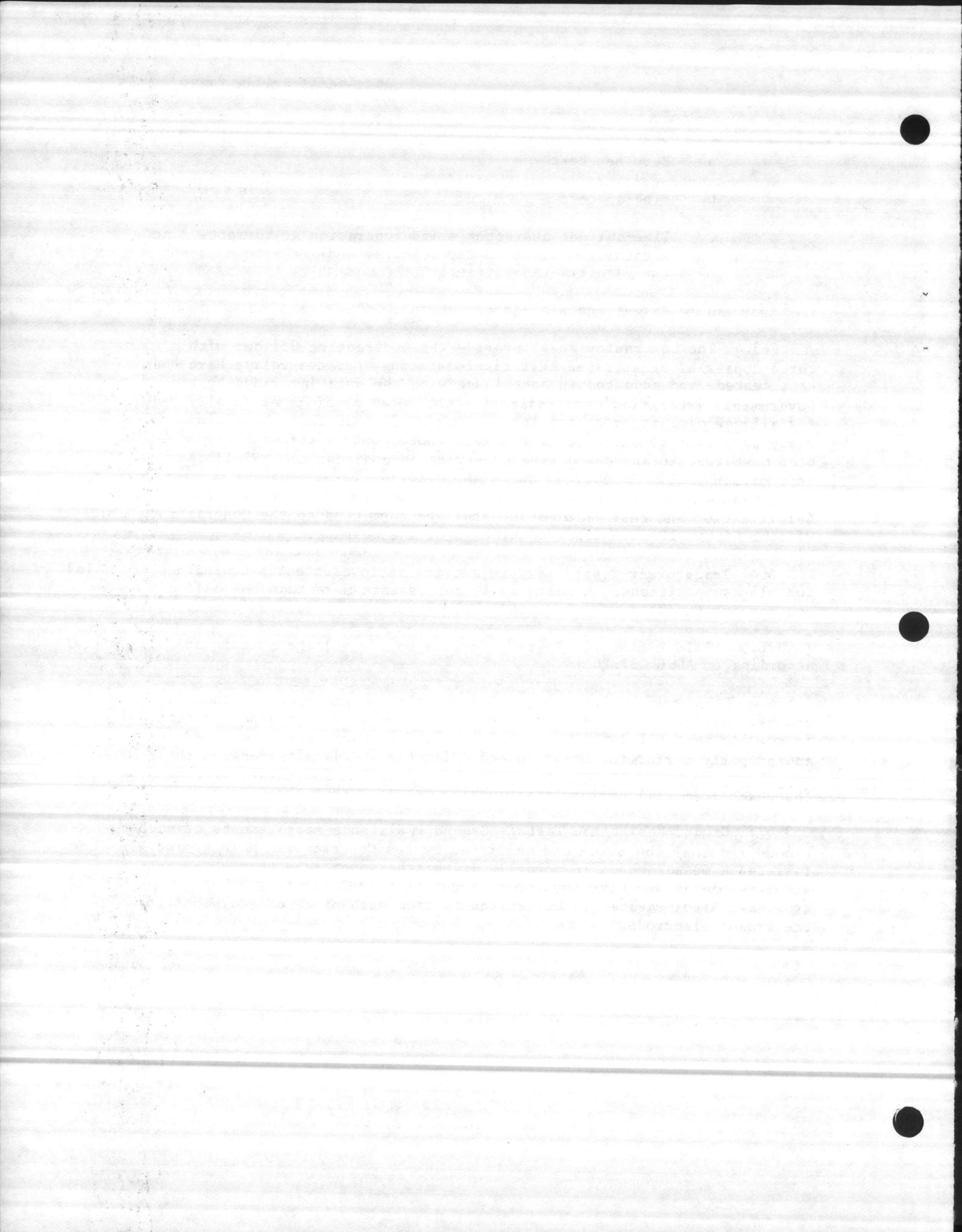
[3.6.5 Field Dielectric Tests: Perform on low voltage switchgear according to ANSI C37.20.]

(S)

3.6.6 Follow-Up Verification: Upon completion of all acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that all circuits and devices are in good operating condition and properly performing their intended function. Circuit breakers shall be tripped by operation of each protective device. Test shall be such that each item will perform its function not less than three times.

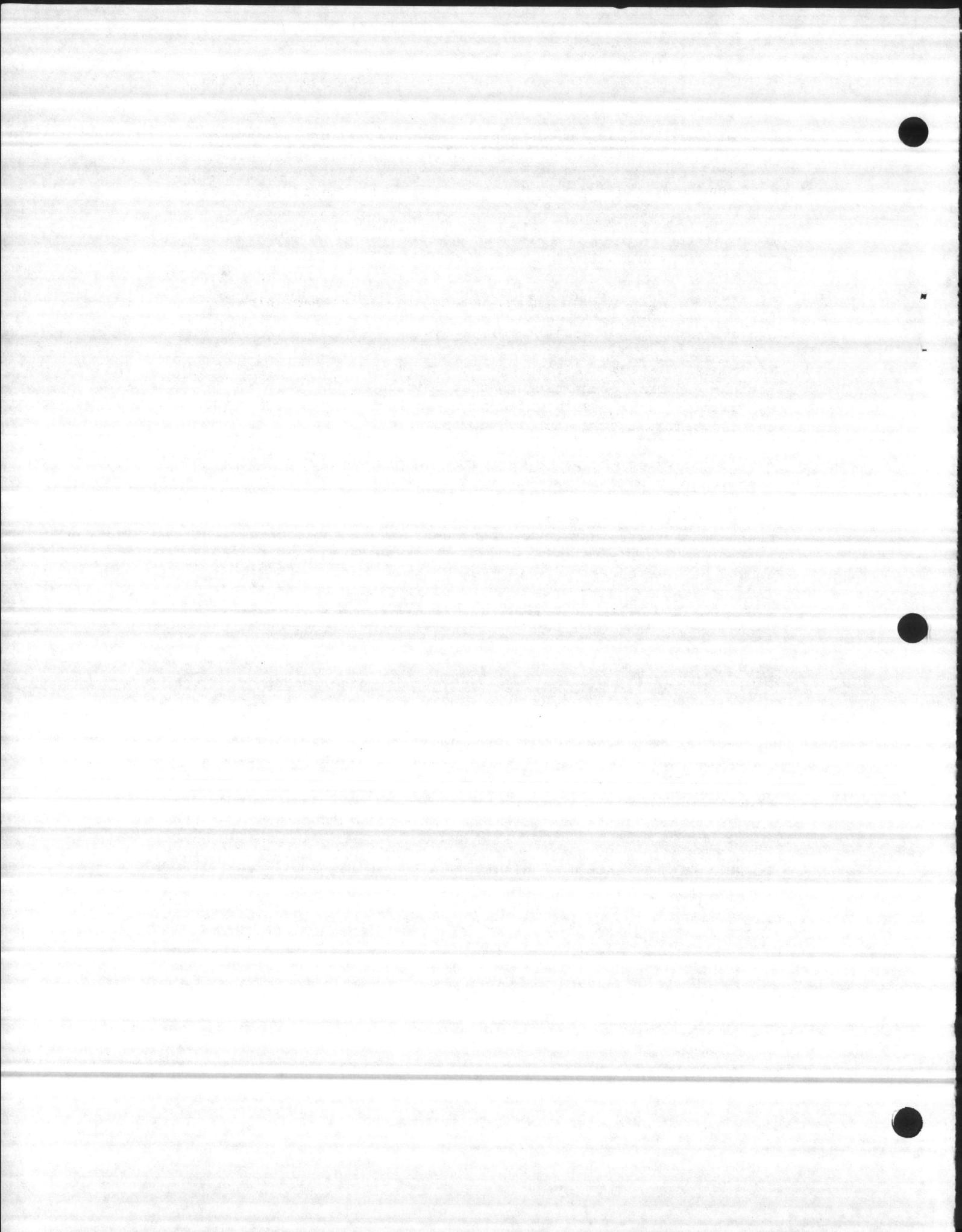
3.6.7 Ground Resistance Tests: Ground resistance measurements of each ground rod shall be taken and certified by the Contractor. Make ground resistance measurements in normally dry weather, not less than 48 hours after rainfall, and with the ground under test isolated from other grounds. Also measure ground resistance from each piece of equipment to the ground electrode.

*** END OF SECTION ***



GENERAL NOTES

1. This guide specification supersedes NAVFAC TS-16465 of March 1980.
2. This guide specification shall not be referenced but is to be used as a manuscript in preparing project specifications. APPROPRIATE CHANGES AND ADDITIONS AS MAY BE NECESSARY AND AS REQUIRED BY THE NOTES MUST BE MADE. Where the phrase "unless indicated or specified otherwise", "as indicated", or words of similar import are used, appropriate requirements, as necessary, shall be included in the project drawings or specifications.
3. The capital letters in the right hand margins indicate that there is a technical note pertaining to that portion of the guide specification. It is intended that the letters in the margins be deleted before typing the project specification.
4. Where numbers, symbols, words, phrases, clauses, or sentences in this specification are enclosed in brackets [], a choice or modification must be made; delete inapplicable portion(s) carefully. Where blank spaces occur in sentences, insert the appropriate data. Where more than one paragraph has the same number, delete those paragraphs that are not applicable. Where entire paragraphs are not applicable, they should be deleted completely. The designer must check with industry/matrix catalogs and current data to use standard available choices when tailoring this guide specification for a specific application to avoid unnecessary additional costs to the Government.
5. CAUTION: Coordination of this section with other sections of the specification and with the drawings is mandatory. If materials or equipment are to be furnished under this section, but installed, connected, or placed in operation under other sections of the specification and/or the drawings, then state that fact clearly and concisely in this section and in all other sections involved. EACH DISCIPLINE SHALL REVIEW THE ENTIRE SPECIFICATION TO INSURE THAT LANGUAGE IS INCLUDED TO PROVIDE COMPLETE AND OPERABLE SYSTEMS AND EQUIPMENT.
6. DO NOT INCLUDE TABLE OF CONTENTS, GENERAL NOTES, AND TECHNICAL NOTES IN THIS SECTION IN FINAL MANUSCRIPT.
7. The following information should be indicated on the project drawings or specified in the project specifications:

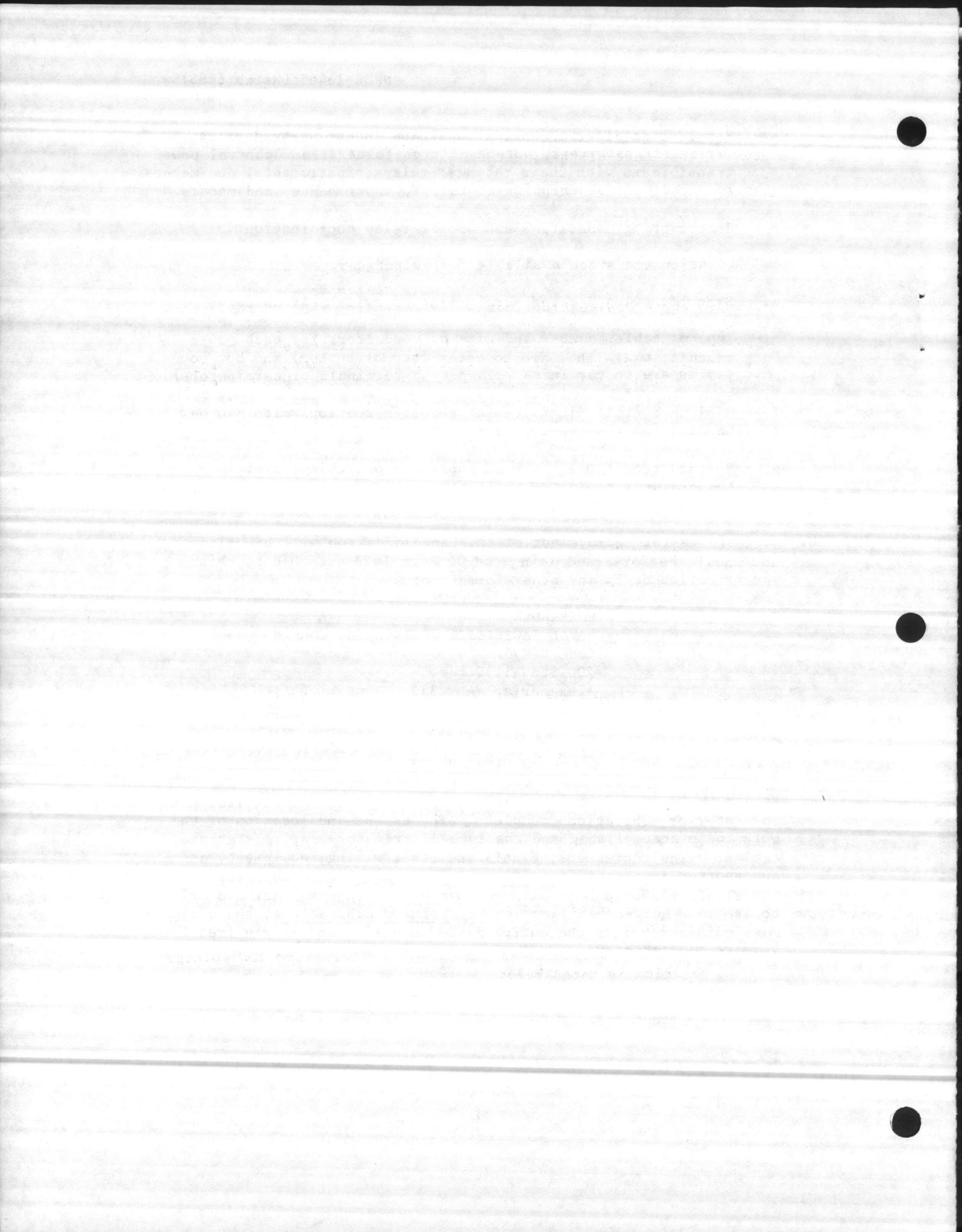


- a. Single-line diagram showing buses and interrupting devices; current transformers, potential transformers, and control power transformers with their ratings; relays, instruments, and meters required; and description of relays, instruments, and meters.
 - b. Interrupting capacities and proper relay coordination.
 - c. Location and space available for switchgear.
 - d. Sketch showing desired arrangement of switchgear units.
 - e. Type of cable, number and size of conductors for each power circuit, where they are to enter (top or bottom) and how power cables are to terminate (clamp-type terminals or terminators).
 - f. Minimum overall dimensions of shipping section which can be handled and installed at destination.
 - g. Special conditions, such as capacitor switching, altitude, temperature, humidity, and exposure to fumes, vapors, dust, and gases.
8. Suggestions for improvement of this specification will be welcomed and should be forwarded using the DD Form 1426 attached to this specification or in any other format to:

COMMANDER
NAVAL FACILITIES ENGINEERING COMMAND
Code 04M2D
200 Stovall Street
Alexandria, VA 22332

TECHNICAL NOTES

- A. Paragraph 2.2: This guide specification includes the requirements for interior substations complete. The extent and location of the work to be accomplished and the type of transformers, substations, cables, circuit breakers, panels and other wiring, equipment, and accessories indicated, specified, or necessary for a complete installation should be indicated on the project drawings. In order to use this guide specification for primary substations, the designer must edit and tailor the entire guide specification as required for primary substations.

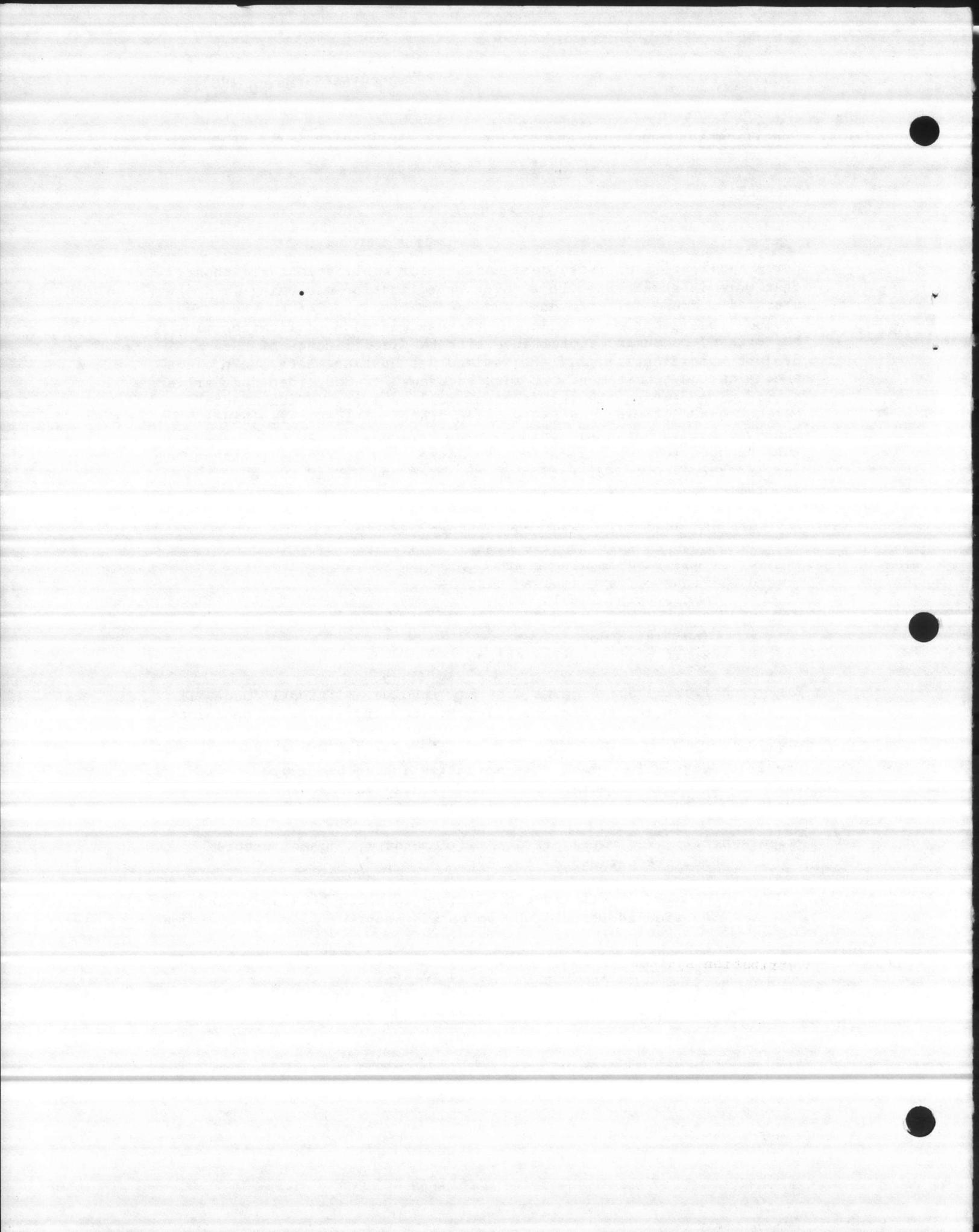


- B. Specification, section, and page numbers shall be centered at the bottom of each page of this section.

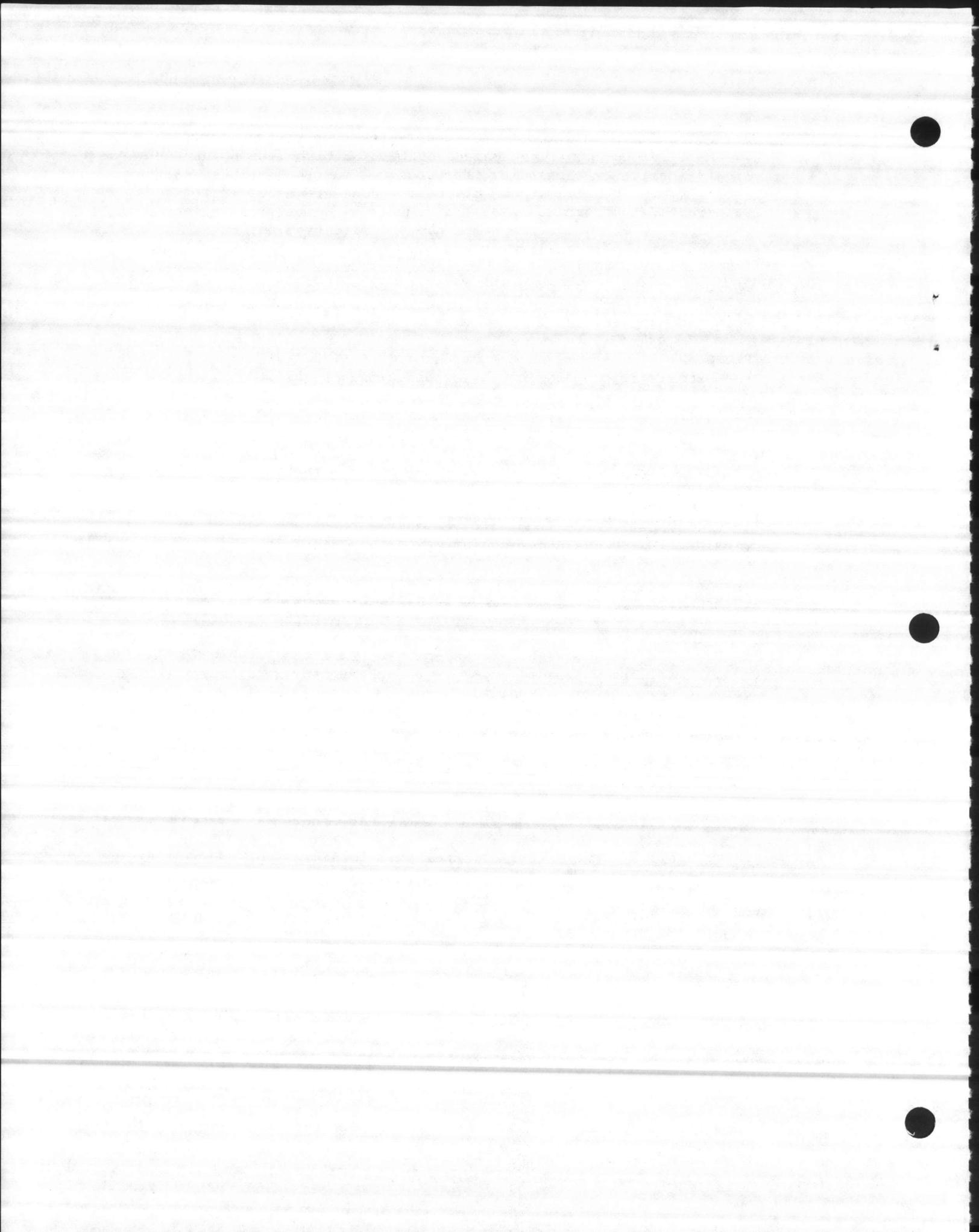
EXAMPLE:

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16465-1

- C. Paragraph 1.1: The listed designations for publications are those that were in effect when this guide specification was being prepared. Where designations have been revised, prior to the date a project specification is written, the designated specification must be reviewed to ensure conformance with the requirements of the project specification. If the revised designation meets the project specification requirement, it must be used. If not, then the earlier designation meeting the requirements will be used, adding a note in parentheses following the designation "(not the latest revision)." Whenever the latest designation cannot be used, NAVFAC Code 04M2D must be notified so that corrective action can be started, either to rescind the latest designation or to amend the NAVFAC Guide Specification.
- a. Reduced full wave impulse test
 - b. Chopped wave impulse test
 - c. Full wave impulse test
 - d. Front of wave impulse test
 - e. Audio sound level
 - f. Zero sequence impedance
 - g. Insulation power factor
 - h. Short circuit calculations
- E. Paragraph 1.4.2: Spare parts data may involve additional cost. If it is not essential to the specific application, it should be deleted.
- F. Paragraph 2.1: Designer may insert additional details describing the specific project for which this specification is being used. If there is no exterior work, items such as high-voltage cable and arresters must be specified in this section.
- G. Paragraph 2.2: The words primary and secondary as used in this specification are defined as follows:
- a. Primary Substation—a substation in which the low-voltage section is rated 1,000 volts and above.
 - b. Secondary Substation—a substation in which the low-voltage section is rated below 1,000 volts.

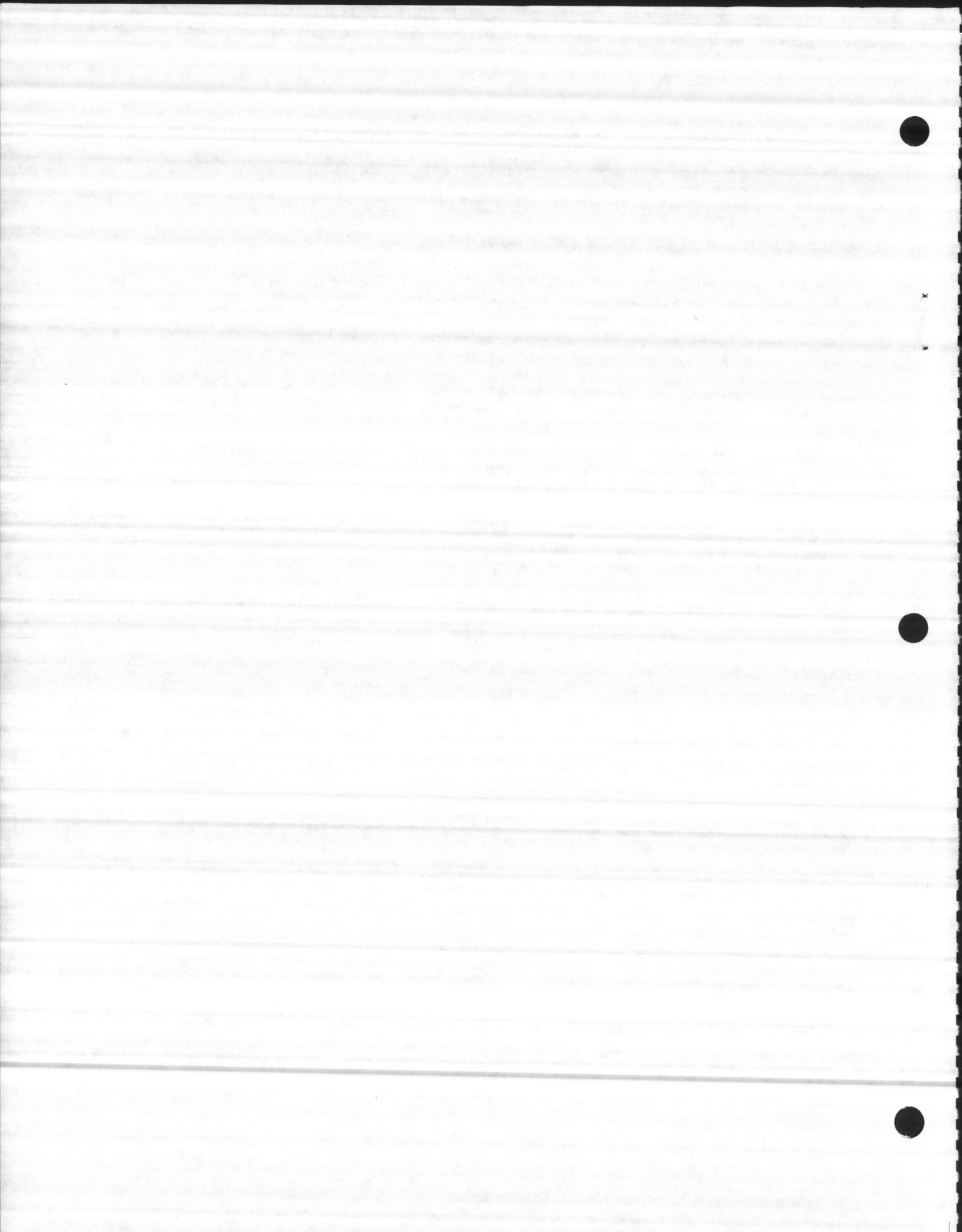


- H. Paragraph 2.2.3: Indicate and specify the type of transformers required for the project. When specifying a high-fire-point-liquid-insulated transformer, the designer must ensure that all the requirements of the National Electrical Code are met. If it is anticipated that future load requirements will necessitate increasing the capacity of the transformer, the specification for the transformer should require that provision be made for this by the inclusion of components and brackets for future forced air cooling and/or mechanical circulation for the coolant fluid. Specify sound level requirements if noise is expected to be a problem for a specific project.
- I. Paragraph 2.2.5: Key interlock feature shall be specified only when the primary switch does not have load-break capability.
- J. Paragraph 2.2.5: If future expansion is anticipated, the designer should consider open-ended switchgear lineups.
- K. Paragraphs 2.2.5.4 and 2.2.5.5: The settings in these paragraphs may be deleted in specifications for installations having adjustable settings and where the Government (or the Base Utilities Department) is to furnish to the Contractor coordination data based on breakers provided and the existing equipment. Also, see Technical Note Q.
- L. Paragraphs 2.2.6 and 2.2.8: Select the essential instruments, relays, and meters. Add to the specification any special metering or relays not listed which are required for a specific project.
- M. Paragraph 2.2.7: Designer may specify 2-1/2 elements when installing a wattmeter for measuring power in a 3-phase, 4-wire circuit in an existing switchboard with limited space. A 2-1/2 element-meter uses 2 potential coils and is commonly called a 2-1/2-element instrument although only using 2 elements.
- N. Paragraph 3.1: Space should be provided on all sides of equipment to permit passage to personnel, equipment, maintenance, and ventilation. The architectural and electrical designers must coordinate the space requirements with each other.
- O. Paragraph 3.2: Where rock or other soil conditions prevent obtaining a suitable ground, other methods of grounding should be specified. Where it is impractical to obtain the indicated ground resistance values, the designer should make every effort within reason to obtain ground resistance values as near as possible to the indicated values. The designer may refer to the IEEE green book for grounding standards.

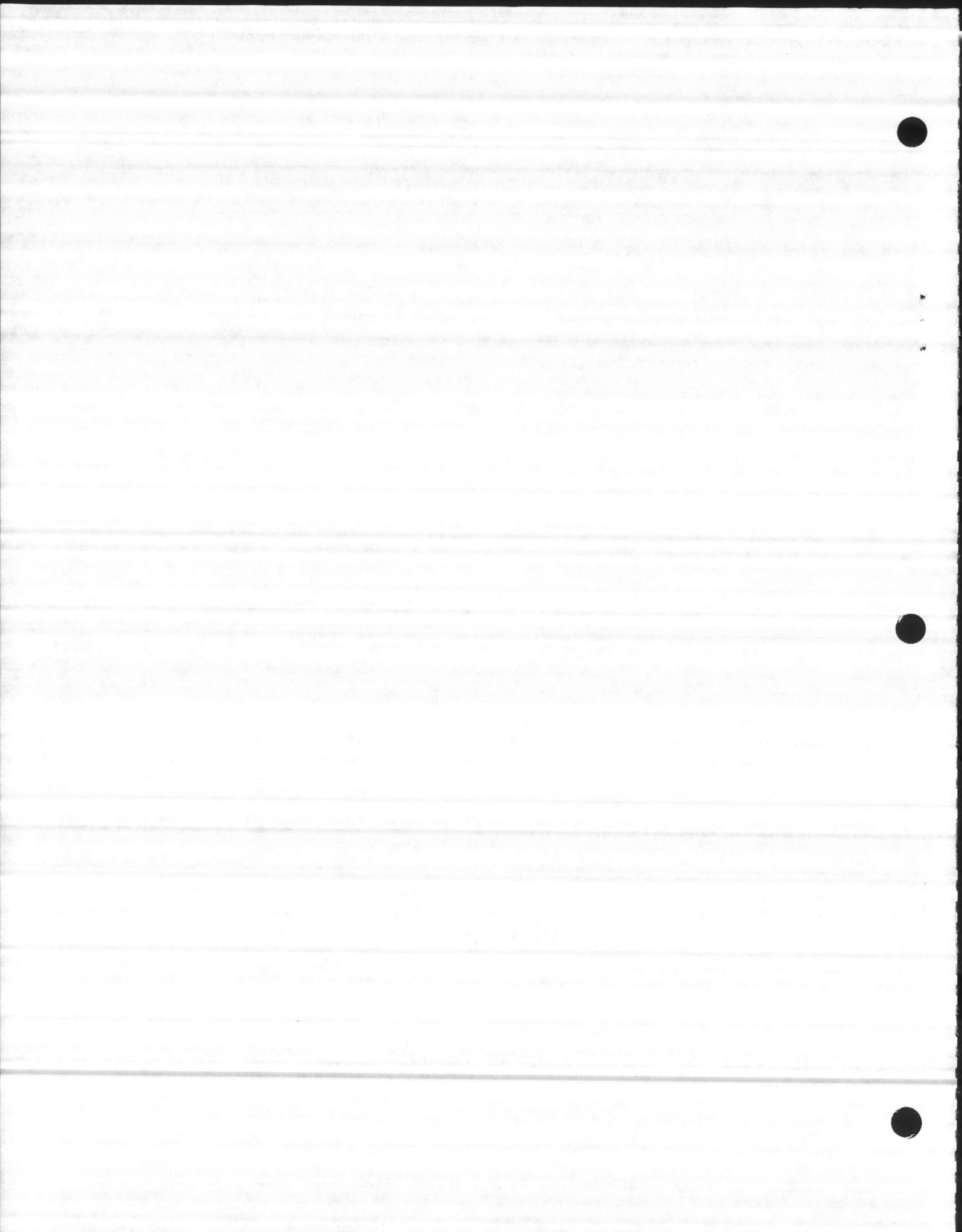


- P. Paragraph 3.4: Substation mounting slab connections may have to be given in detail, depending on the requirements for the seismic zone in which the substation is located. A sole plate embedded in the concrete slab may be provided to allow for proper leveling of equipment.
- Q. Paragraph 3.6.3: Determine if the Government is to furnish relay settings and coordination data to the Contractor or whether these settings and data will be completely designed into the contract specifications and drawings. Edit this paragraph as required. Also, see Technical Note K.
- R. Paragraph 3.6.4: For projects involving numerous or large substations, the designer may desire to specify more extensive field testing for transformers (dielectric absorption tests, etc.).
- S. Paragraph 3.6.5: Field dielectric tests are recommended when new units are added to an existing installation or after major field modifications. The equipment should be verified as being in good condition prior to the field test.

*** E N D ***







INSTRUCTIONS: In a continuing effort to make our standardization documents better, the DoD provides this form for use in submitting comments and suggestions for improvements. All users of military standardization documents are invited to provide suggestions. This form may be detached, folded along the lines indicated, taped along the loose edge (*DO NOT STAPLE*), and mailed. In block 5, be as specific as possible about particular problem areas such as wording which required interpretation, was too rigid, restrictive, loose, ambiguous, or was incompatible, and give proposed wording changes which would alleviate the problems. Enter in block 6 any remarks not related to a specific paragraph of the document. If block 7 is filled out, an acknowledgement will be mailed to you within 30 days to let you know that your comments were received and are being considered.

NOTE: This form may not be used to request copies of documents, nor to request waivers, deviations, or clarification of specification requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

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