

MEDIUM VOLTAGE MOTOR CONTROLLERS

(2,400, 4,160, AND 4,800 VOLTS)

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FOREWORD

The object of this publication is to provide a purchase specification to facilitate the manufacture and procurement of full voltage motor starters for the starting, control, and protection of squirrel cage induction motors for petroleum industry service. The specification is limited to motor starters rated for 2,400, 4,160, and 4,800 volts.

This specification requires the purchaser to specify certain details and features. Also it is recognized that the purchaser may desire to modify, delete, or simplify sections of the specification. It is strongly recommended that such modifications be made by supplementing this specification rather than by rewriting or by incorporating sections thereof into another complete specification.

Suggested revisions are invited and should be submitted to the director of the Refining Department, American Petroleum Institute, 2101 L Street, Northwest, Washington, D. C. 20037.

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MEDIUM VOLTAGE MOTOR CONTROLLERS (2,400, 4,160, AND 4,800 VOLTS)

SECTION 1—GENERAL

• 1.1 Scope

This specification (together with applicable data sheets and job specifications) covers the materials, design, and fabrication of full-voltage, indoor and outdoor motor starters protected with current limiting fuses for the supply, control, and protection of squirrel cage induction motors used in petroleum industry service. Any applicable state and local regulations and codes specified shall be considered a part of this standard. Should conflicts exist, job specifications shall govern.

1.2 Application

Motor starters supplied as part of this specification shall meet the requirements of the designated area classification in which they are installed. Refer to Appendix A for details and specific requirements.

• 1.3 Unusual Service Conditions

Motor starters designated as suitable for indoor operation shall be furnished with enclosures designed for both continuous operation and long periods of inactivity in atmospheres made corrosive by traces of chemicals that may be present in a petroleum processing plant and by such environmental conditions as high humidity, insects, rodents, and so forth that may exist at the plant site. The purchaser shall specify the chemicals involved and the environmental conditions that prevail.

Enclosures designated as suitable for outdoor operation shall afford adequate protection against storms (rain, snow, or dust), salt-laden air, and occasional hoseings (plus the requirements of indoor operation mentioned above), but shall not require additional protective shelters or coatings. The purchaser is to specify the NEMA* type enclosure (3, 3R, or 3S) required.

1.4 Operating Experience

Where a new design or material that has not been in proven service for at least two years is offered, pro-

posals shall indicate which parts of the starter (new insulating materials, contact design change, and so forth) are affected and the extent of experience with such parts.

1.5 Guarantee

Controllers shall be guaranteed by the vendor against defective material, poor workmanship, design deficiencies, and failure from normal usage for a minimum of one year after being placed in specified service but not exceeding 18 months after the date of shipment. The vendor shall repair or replace any defective controller parts or equipment and shall repair without expense to the purchaser any controller damage resulting from poor workmanship or faulty design found within this time period.

• 1.6 Drawings and Data

1.6.1 GENERAL

In addition to the information to be furnished by the manufacturer as a bidder (see Paragraphs 1.6.1.1 and 1.6.1.2), the manufacturer shall furnish the specified numbers of copies of pertinent information for design, installation, maintenance, and record purposes (see Paragraphs 1.6.2 and 1.6.3). All drawings and data shall be identified with the job number, purchaser's name, purchaser's complete requisition number, and item number.

1.6.1.1 The bidder shall furnish with his quotation the specified number of copies of each of the purchaser's data sheets after he has entered thereon the information to be supplied by him as bidder.

1.6.1.2 The bidder shall also provide with his quotation the specified number of copies of complete outline dimensional drawings for each starter or lineup. The drawings shall show the principal dimensions of the unit, horsepower, rating, type, and voltage rating.

1.6.2 PRELIMINARY DRAWINGS AND DATA

Within three weeks of receipt of a purchase order, the manufacturer shall supply the specified number of

NOTE: A bullet (•) in the margin indicates that a decision by the purchaser is required. When not covered by the data sheets provided herein (see Appendices A and B), decisions should be indicated on the checklist (see Appendix C).

*National Electrical Manufacturers Association, 155 East 44th Street, New York, N. Y. 10017.

copies of drawings covering dimensions, weights, mounting arrangements, and one-line, elementary, and wiring diagrams. (Dimensional drawings shall include all clearances required for door swings, equipment removal, and so forth.) These copies of the manufacturer's drawings shall be submitted for approval before fabrication is started. One copy bearing the purchaser's approval stamp and notations of any required corrections will be returned to the manufacturer.

1.6.3 FINAL DRAWINGS AND DATA

After approval of final drawings, the manufacturer shall supply the following data:

1. The specified number of copies or one reproducible copy of fully dimensional detail drawings including weights, mounting arrangements, and one-line, elementary, and wiring diagrams.
2. The specified number of copies of operating and maintenance instruction booklets.
3. The specified number of copies of the recommended spare parts list.
4. The specified number of copies of the bill of materials of electrical components.

SECTION 2—CONSTRUCTION

2.1 General

- 2.1.1 Motor data required for the selection of the controller and its components shall be supplied by the purchaser on the data forms.
- 2.1.2 The required interrupting capacity for a controller must be stated by the purchaser. Suggested ratings are:

200 MVA at 2,400 volts
350 MVA at 4,800 volts

- 2.1.3 The type of contactor and enclosure shall be specified by the purchaser. In general the enclosures should be as shown in Table 1. Contacts for control circuits in Division 2 areas must be housed in enclosures approved for Division 2 (explosionproof or pressurized), hermetically sealed, intrinsically safe, or approved oil immersed. Sealing fittings, where required, shall be the Type approved by NFPA's* National Electrical Code. The surface temperature of space heaters shall not exceed 80 percent of the ignition temperature of the gas or vapor in the area. The ignition point of the particular gas or vapor shall be specified.

2.1.4 Controllers shall be of the metal enclosed type consisting of a free-standing, full-height structure with a maximum of two high mountings per vertical section. Each controller will occupy a space approximately 45 inches high. Enclosures shall be rigidly constructed to allow mounting pad level variations of $\pm 1/8$ inch. Under these conditions, doors shall open and close smoothly and all mechanical interlocks shall function properly.

2.1.5 Air break or vacuum break starters shall have a drawout contactor. The fuses and contactor shall be separated from the control wiring and low voltage control devices (insofar as practicable and in accordance

with good engineering practices) by a substantial barrier such as sheet steel panels or a rigid insulating material within the enclosure. All parts shall be readily accessible for maintenance and inspection.

- 2.1.6 When specified on the data forms, cubicles shall be bused together. The entire length of the power bus shall be insulated for rated voltage. The power buses shall be individually insulated to minimize corrosion and to prevent contact by rodents, snakes, and the like. Where single units are required, they shall be equipped with power bus bars and a wiring trough extending the full cubicle width. All power, ground, and wiring facilities shall be arranged to facilitate future additions.
- 2.1.7 Space shall be provided for incoming power, control and ground wires, and conduits. The size and count of these wires and conduits will be specified on the data forms. Provisions for terminating all specified incoming conductors (power, control, and ground) shall be included.
- 2.1.8 Adequate space for incoming and outgoing cable connections shall be provided. A cable entrance compartment is required when the incoming cable exceeds one 500-MCM cable per phase. A cable entrance compartment is also required when cables with pot-heads or stress cones are specified for the incoming line.
- 2.1.9 All cubicles shall be grounded to a common ground bus running the full length of the assembly. When single units are required, they shall be equipped with a ground bus extending the full length of the cubicle for connecting future units.
- 2.1.10 A corrosion-resistant coating over a suitably prepared surface shall be applied to the inside and outside of the cubicle.

*National Fire Protection Association, 60 Batterymarch Street, Boston, Mass. 02110.

2.1.11 A no-load break disconnect switch or disconnection by separating bus stabs shall be provided in each fused controller and interlocked with the contactor to prevent the accidental opening or separating under load.

2.1.12 Feeder cables from one controller passing through another control compartment shall have suitable conduit or other isolating means so that the cables may be installed or removed without deenergizing the other controller. Removable panels suitable for conduit or cable cutout shall be provided above and below the wireway or conduit.

2.1.13 All lineups containing one or more two-high units will be furnished with the necessary contactor handling equipment whether built-in or portable.

2.2 Mechanical Design Features

• 2.2.1 INDOOR INSTALLATIONS

The cubicle design shall be NEMA Type 1 which assumes an environmentally controlled installation location or NEMA Type 12 (dusttight and driptight). In either type enclosure all ventilation openings shall be suitably filtered or screened with stainless steel hardware cloth arranged to prevent the entrance of snakes, rodents, and the like. All control devices shall be selected for proper operation in the designated atmosphere without further protection. Unless deleted on the data sheet, thermostatically controlled space heaters shall be provided to prevent condensation within the enclosure.

• 2.2.2 OUTDOOR INSTALLATIONS

The cubicle design shall be of the NEMA Type 3, 3R, or 3S (walk-in or conventional) with an outdoor weatherproof enclosure. The entire enclosure shall be sup-

ported on channels or other structural shapes that raise the enclosure a minimum of three inches above the foundation. The underside of the enclosure shall be protected by a liberal coat of mastic or another equally effective coating material to prevent rusting. Each vertical section shall have a one-piece steel, overhanging, sloping roof and shall conform to all of the requirements of the indoor enclosure mentioned above. When sections are combined, roof joints shall be between sections and suitably sealed or covered to prevent the entrance of moisture. All outside doors shall have holding devices that maintain the door in the open position. All exterior hardware (handles, hinges, nuts, bolts, and so forth) shall be of stainless steel unless otherwise noted on the data sheet.

2.2.3 GENERAL REQUIREMENTS FOR ALL CONTROLLERS

2.2.3.1 Either pilot lights or a mechanical indicator shall be provided to show the main contactor position (open or closed).

2.2.3.2 All contactors and enclosure assemblies shall have permanent, full-travel, alignment guides to position the contactor in the enclosure for insertion and withdrawal or for raising and lowering.

2.2.3.3 All special tools (nonstandard wrenches, sockets, and the like) required to latch, unlatch, bolt, unbolt, and so forth shall be provided with each controller assembly.

2.2.4 OIL-IMMERSED CONTROLLERS

2.2.4.1 Oil-immersed contactors shall be equipped with a permanent windless-type tank or a contactor-handling mechanism.

TABLE 1—ENCLOSURES AND TYPES OF CONTACTORS

Location	Classification	Enclosure	Contactor Type
Outdoor	Nonhazardous	NEMA Walk-in Type 3, 3R, or 3S or NEMA Conventional Type 3, 3R, or 3S	Air break Vacuum break Oil immersed
	Division 2 (Hazardous)	NEMA Walk-in Type 3, 3R, or 3S or NEMA Conventional Type 3, 3R, or 3S	Vacuum break Oil immersed
		NEMA Pressurized Type 5, 3R, or 3S	Air break Vacuum break Oil immersed
Indoor	Nonhazardous	NEMA Type 1 or 12	Air break Vacuum break Oil immersed
	Division 2 (Hazardous)	NEMA Type 1 or 12	Vacuum break Oil immersed
		NEMA Pressurized Type 12	Air break Vacuum break Oil immersed

2.2.4.2 The oil tank for the contactor shall be equipped with a 1/2-inch drain plug and a sight glass with a permanent mark indicating the proper oil level.

2.3 Electrical Design Features

2.3.1 CONTACTORS

2.3.1.1 Contactors shall be designed and rated in accordance with NEMA ICS-2-324 for alternating current, general-purpose, high-voltage, Class E2 controllers.

2.3.1.2 The contactor shall be a full-voltage, 3-pole,

electrically operated line contactor with necessary auxiliary switches and electrical interlocks.

2.3.2 FUSES

2.3.2.1 Fuses shall be self-contained, current-limiting power fuses. Fuses shall operate during the first half cycle on maximum fault conditions with no expulsion of gases or foreign matter from the tube.

- **2.3.2.2** Suitable storage (such as fiber tubes, bins, racks, and so forth) shall be provided for a set of spare fuses either within the controller enclosure or attached thereto.

SECTION 3—PROTECTION

3.1 Protective Devices

Control equipment shall have protective devices that adequately protect the motor for overload, locked rotor, and phase and ground fault conditions as specified below. Devices shall have time current characteristics that permit the motor to accelerate the driven machine to full-load speed under normal operating conditions.

1. Where relays are used for fault protection, they shall be arranged to lock out and shall be reset by hand.
2. There shall be overload protection in each phase. If current transformers are used, there shall be one per phase. Overload relays can be of either the hand- or automatic-reset type as specified.
3. Time-delay under voltage protection shall be supplied unless noted on the data form. It shall have continuous adjustability up to 4 seconds with provisions to bypass the time delay function.
4. Differential protective relaying shall be provided for motors above 1,000 horsepower when specified on the data sheet. The current transformers should be provided by the controller vendor and shipped to the motor vendor for mounting in the motor terminal cabinet in order to ensure proper coordination.
5. An instantaneous-type ground fault relay and a window-type current transformer or a residually-connected line current transformer shall be provided when specified on the data sheets.

6. Additional relaying, if required, will be shown on the appropriate one-line diagrams included with the data sheets.

• 3.2 Control Transformers

Each controller will have a fused control power transformer. The high voltage side of the control transformer shall have a fuse in each phase separate from the main power fuses. Secondary fuses shall be provided if specified. Control transformers should be sized to ensure proper operation on voltages 10 percent below nominal.

• 3.3 Space Heaters and Heater Bus

When specified, each controller or control center line-up will have an insulated motor space heater bus. The required voltage level will be specified on the data sheet. The power for this bus will be as specified on the data sheet. Each controller will have a motor space heater control circuit included that will provide power to the space heaters whenever the motor is not running regardless of the controller position (including removed). A space heater disconnect and visible indicator light showing "HEATER ON" shall be provided in each controller low voltage compartment. Mercury relays can be considered for the space heater control in Division 2 applications.

SECTION 4—INTERLOCKING AND SAFETY FEATURES

4.1 Interlocking

4.1.1 Mechanical and electrical interlocking shall be provided to prevent:

1. The high voltage door from opening if the isolating switch is closed or the drawout contactor is in the inserted position.
2. The isolating switch from being opened or closed or

the drawout contactor moved if the contactor is closed.

3. Access to the high voltage fuses or fuse compartment unless the isolating switch is open and the contactor is in the withdrawn position.

4. The isolating switch from being closed if any of the cubicle doors (except the low voltage door and excluding the outer door of an outdoor cubicle) are open.

4.2 Isolating Switch

4.2.1 The position of the isolating switch or drawout contactor shall be indicated without opening the high voltage compartment.

4.2.2 The center of the isolating switch handle shall not be more than 78 inches above the floor line of the cubicle.

4.2.3 Provisions shall be provided for the padlocking of all compartment doors and operating handles of the isolating switches and drawout contactors.

4.3 Protection During Maintenance

The spacing of all components mounted in the low voltage compartment or on the compartment door shall permit normal maintenance. All foreign circuits such as space heaters shall be marked and shall have their live parts located or guarded to eliminate the possibility of accidental contact during normal or permitted maintenance.

4.4 Nonpressurized Controllers

Nonpressurized controllers for Division 2 locations shall have all arc-producing devices hermetically sealed, intrinsically safe, or protected by oil or vacuum.

SECTION 5—CONTROL

5.1 Control Devices

Each controller will have both externally and internally operable control devices.

5.1.1 EXTERNALLY OPERABLE

Externally operable control devices shall be of the *hand-reset type for the overload relays* and shall have an alternating current control circuit power switch to be used as a control power disconnect and as a maintained stop.

5.1.2 INTERNALLY OPERABLE

Internally operable control devices shall include a readily accessible start/stop pushbutton to operate the

main contactor for maintenance testing. This device is to be inoperable except when the controller is in the test position.

• 5.2 Remote Operation

When specified, controllers for remote operation shall have an externally operable, two-position switch marked "REMOTE/OFF" with contacts arranged to perform the following:

1. REMOTE for control of the controller from the pushbutton at the motor.
2. OFF to open the controller and to isolate the pushbutton station at the motor from all control and alarm circuit voltage.

SECTION 6—ACCESSORIES AND OPTIONS

• 6.1 Switches and Indicating Lights

A single-phase ammeter (when specified, a three-phase ammeter) transfer switch and red and green "RUNNING" and "STOPPED" indicating lights shall be mounted clearly visibly on the outermost cubicle door. These devices may be mounted behind a window in the outermost door.

6.2 Storage

Space shall be provided to store within the enclosure (but readily accessible) drawings, instruction books, parts lists, and so forth.

6.3 Nameplates

6.3.1 Nameplates shall be attached to the controller group, individual doors, or contactor as appropriate and shall indicate:

1. Manufacturer's shop number, date, and catalog designation.
2. Horsepower rating of motor.
3. Interrupting rating of the controller.
4. Maximum continuous amperes.
5. Normal voltage rating.
6. Control circuit voltage.

6.3.2 Separate nameplates suitably located shall indicate:

1. Warning or operational instructions as required.
2. Identity of all relays, meters, and so forth.
3. Purchaser's assigned motor number if specified.
4. Foreign voltage when external sources are used.

• 6.4 Optional Features

The following additional features for grouped controllers and individual controllers are listed for the purchasers' consideration and may be included at extra cost:

1. In addition to the requirements of Paragraph 2.2.2, grouped controllers for outdoor application in a NEMA Type 3 walk-in enclosure that provides ample space for inspection, testing, and maintenance within the enclosure may be specified. A power ventilator or full air conditioning, as specified, would be included. These enclosures have doors equipped with antipanic hardware at both ends of the aisle. (One door has external locking provisions; the other is latched from the inside

only). The enclosures also have convenience outlets and overhead lights controlled with toggle switches at the normal entry door. All wiring for outlets, lights, space heaters, air conditioning, and so forth terminate on a readily convenient isolated terminal strip. All of these devices are protected with appropriately sized and identified circuit breakers or fuses housed in an internally mounted panel. The power source for these devices must be as specified on the data sheet.

2. Individual controllers may have (1) an elapsed time register, (2) an operational counter, (3) an indicating voltmeter, (4) an R.T.D. readout indicator, and/or (5) transducers for remote reading of volts, amperes, watts, and so forth.

SECTION 7—TESTS AND PERFORMANCE

7.1 Voltage Tests

Manufacturers supplying controllers to this specification shall have subjected the basic components and design to the interrupting, fault withstandability, and impulse voltage tests specified in NEMA ICS-2-324.40 for E2 controllers. The manufacturer shall also be able to substantiate that the controller's performance is equal to or better than these requirements.

7.2 Electrical and Mechanical Devices

After completion of the assembly and wiring of each controller, all of the electrical and mechanical interlocks, control devices, protective relays, indicator lights, meters, and any optional equipment provided shall be thoroughly tested to the extent required to assure a completely workable controller prior to shipping.

This will include a dielectric proof test per NEMA ICS-2-324.47. The test voltages shall be:

<i>Controller Rating Maximum Volts</i>	<i>Dielectric Withstand Test Voltage, Volts</i>
2,500	6,500
5,000	11,300

7.3 Independent Functions

When two or more controllers are designed with functions that depend on one another, these functions must also be thoroughly tested after final assembly and prior to shipping.

7.4 Enclosure Designs

Assembled enclosure designs (whether for single or multiple controllers) designated as walk-in or nonwalk-in NEMA Type 3, 3R, or 3S enclosures shall have been subjected to the appropriate design tests.

SECTION 8—SHIPPING

8.1 Assembly

Equipment shall be shipped completely assembled whenever possible. For large assemblies the lineup may be divided into reasonable sections to facilitate handling during transportation and installation.

• 8.2 Equipment Identification and Shipping Instructions

Equipment shall be identified with the purchaser's and the vendor's order numbers and any other designations requested on the purchaser's shipping instructions.

These shipping instructions shall also include any special protective shipping or storage packaging required because of long-term storage prior to installation or energization.

8.3 Temporary Materials

Foreign material to be removed prior to energization shall be clearly identified by distinctive colors and legends. Temporary warning signs stating "REMOVE TEMPORARY MATERIALS BEFORE ENERGIZATION" shall be posted on the exterior near the main power disconnect.

APPENDIX A
TYPICAL DATA SHEET FOR MEDIUM VOLTAGE SQUIRREL CAGE
INDUCTION MOTOR CONTROLLERS
(2,400, 4,160, AND 4,800 VOLTS)

INFORMATION TO BE SUPPLIED BY PURCHASER

Purchaser _____ Job Number _____
Destination _____ Item Number _____
Quotation Number _____ Requisition Number _____
Manufacturer _____

Motor Data

Rated _____ Horsepower _____ Volts _____ 60 Hertz
Enclosure _____ Speed _____ Full Load Amps _____
Service Factor _____ Temperature Rise _____ Locked Rotor Amps _____
Allowable Stall Time _____
Space Heaters: Watts _____ Voltage _____ Phase _____
Special Starting Conditions _____

Controller Data

Area Classification _____ Special Atmosphere _____
Enclosure Type _____ Contactor Type _____
Controller Rating _____ Contactor Rating _____
Configuration (See attached sketch) Straight Lineup _____
Single Units _____ Back-To-Back _____

Wiring Requirements

Incoming Power: Wire Size and Type _____ Conduit Size _____
Stress Cones Yes _____ No _____ Location _____
Incoming Auxiliary Power—Wire Size and Type _____ Conduit Size _____
Location _____
Outgoing Power: Wire Size and Type _____ Conduit Size _____
Stress Cones Yes _____ No _____ Location _____

Outgoing Control: Wire Size and Type _____ Conduit Size _____
Location _____

Outgoing Alarm: Wire Size and Type _____ Conduit Size _____
Location _____

Space Heater (Controller Enclosure) Power Source _____
Voltage _____ Thermostat _____

Grounding: Wire Size and Type _____ Conduit Size _____
Location _____

Relaying
Overload Relays Thermal _____ Hand Reset _____
Induction _____ Auto Reset _____

Time Delay Undervoltage Relay _____ Ground Fault Relay _____
Differential Relays _____ Additional Relays _____

Space Heater Bus (for Motors) Power Source _____
Voltage _____ Heater _____ Watts

Special Control: Local _____ Remote _____
Other _____

Drawings and Data (Required Numbers)

Data Sheets (Appendix B) _____

Outline Drawings _____ Preliminary Drawings _____

Final Drawings _____ Detailed Drawings _____

Operating and Maintenance Books _____ Spare Parts Books _____

Bill of Materials _____

Mandatory State and Local Regulations and Codes _____

Options (Describe) _____

INFORMATION TO BE SUPPLIED BY MANUFACTURER

Exceptions

APPENDIX C CHECKLIST

This appendix should be used to indicate specific requirements of the purchaser where the standard provides a choice or requires that a decision be made or additional information be provided. These items are indicated by a bullet (•) in this standard.

This checklist should be considered a part of this standard and should be completed by filling in all of the blanks. Also refer to Appendix A which covers information that should be supplied to the manufacturer for proposal or order purposes. Where the need for additional specification information is indicated, a supplement to the specification should be prepared.

Paragraph Reference	Item	Indicate Requirement	
		YES	NO
1.1	Does the job specification supersede the standard?	_____	_____
1.1	Do any specifications other than those referred to herein apply? If yes, specify.	_____	_____
1.3	Will any other ambient conditions be present? If yes, specify.	_____	_____
1.6	Have the number of copies of drawings, data books, and so forth been specified?	_____	_____
2.1.1	Has the motor data been specified?	_____	_____
2.1.2	Has the controller rating been specified?	_____	_____
2.1.3	Have the area classification, enclosure, contactor type, and the ignition point of the vapor or gas been specified?	_____	_____
2.1.6	Has the cubicle configuration been shown?	_____	_____
2.1.7	Have all incoming and outgoing wires and conduits been described?	_____	_____
2.1.8	Is a special cable compartment required?	_____	_____
2.2.1, 2.2.2	Has the enclosure type been specified?	_____	_____
3.1	Have the protective relays been specified?	_____	_____
3.2	Are secondary fuses on control power transformer required?	_____	_____

3.3	Is a motor space heater bus required? If so, is the voltage level indicated?	_____	_____
5.2	Are there special control requirements?	_____	_____
6.1	Are indicating lights required?	_____	_____
6.1	Is a three-phase ammeter transfer switch needed?	_____	_____
6.4	Are options required?	_____	_____
8.2	Are the shipping instructions specified?	_____	_____