Preparing Activity: USACE Superseding
UFGS-35 20 20 (January 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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SECTION 35 20 20

ELECTRICAL EQUIPMENT FOR GATE HOIST

05/22

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USACE / NAVFAC / AFCEC / NASA **UFGS-35 20 20 (May 2022)**

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SECTION 35 20 20

ELECTRICAL EQUIPMENT FOR GATE HOIST
05/22

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NOTE: This guide specification covers the technical requirements for hoist applications using a squirrel-type induction motor commonly used for control gates for outlet works; penstock gates, crest gates, spillway tainter gates, and other similar applications. This section was originally developed for USACE Civil Works projects.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

****

PART 1 GENERAL

****

NOTE: This specification is to be used as a section of a supply specification for the procurement of hoisting equipment, or, with only minor modification, it may be used as a section in a general contract specification.

The specification is general and covers all types and ratings of hoist applications used by the Corps of Engineers on Civil Works structures where a squirrel cage induction-type hoist motor is used.

The specification must be accompanied by a drawing or drawings showing the schematic wiring diagram of the control system for the particular application, along with a description of the scheme of operation and illustrations showing the several items of electrical equipment.

In adapting this specification to any project, the form and phraseology will be changed as necessary to properly specify the work contemplated. When technical deviations from this specification are considered necessary and the specification is not submitted to Headquarters, US Army Corps of Engineers (HQUSACE), for review, prior approval of (HQUSACE) will be obtained. Instructions for the preparation and submission of specifications for approval are included in ER 1110-2-1200.

The electrical equipment requirements contained herein are based upon experience and information gained from similar equipment now in service and are considered the most suitable for use on hydraulic structures.

****

1.1 REFERENCES

****

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

****

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

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2023) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 112	(2017) Standard Test Procedure for Polyphase Induction Motors and Generators

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1	(2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA FB 1	(2014) Standard for Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 5	(2017) Industrial Control and Systems: Control Circuit and Pilot Devices
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2021) Motors and Generators

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-50553	(2015; Rev B; Notice 1) Fitting for Conduit, Metal, Rigid (Thick-Wall and Thin-Wall (EMT) Type)

UNDERWRITERS LABORATORIES (UL)

UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables

UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 546	(2008) UL Outline of Investigation for Conductor Termination Compounds

1.2 RELATED REQUIREMENTS

Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS and Section 26 08 00 APPARATUS INSPECTION AND TESTING apply.

1.3 SYSTEM DESCRIPTION

All equipment furnished under these specifications will be subjected to [severe moisture] [moderately moist] conditions, [that operate over a temperature range of [_____] to [_____] degrees C F,] and designed to render it resistant to corrosion. The general requirements to be followed are specified below; any additional special treatment or requirement considered necessary for any individual item is specified under the respective item.

1.3.1 Fastenings and Fittings

Where practicable, provide corrosion-resistant screws, bolts, nuts, pins, studs, springs, washers, and other miscellaneous fastenings and fittings or treat in an approved manner to render them resistant to corrosion.

1.3.2 Corrosion-Resisting Materials

Corrosion-resisting steel, copper, brass, bronze, copper-nickel, and nickel-copper alloys are acceptable corrosion-resisting materials. However, avoid contact between dissimilar metals as much as practicable, except where one of the dissimilar metals is steel or in the case of wiring and connections.

1.3.3 Corrosion-Resisting Treatments

Provide hot-dip galvanizing in accordance with ASTM A123/A123M or ASTM A153/A153M as applicable. Other corrosion-resisting treatments may be used if approved by the Contracting Officer.

1.3.4 Frames, Enclosing Cases, and Housings

Clean all surfaces of the enclosing cases or housings of controllers, brakes, limit switches, control stations, and other similar equipment, if other than plastic or stainless steel construction, of rust, grease, mill scale, and dirt and then treated with an approved iron and zinc phosphate solution followed by rinsing with a chromic acid solution, bonderizing, or equivalent process. Immediately after rinsing and drying, apply one coat of a zinc molybdate primer to the inside and outside surfaces and cure as required. For items of cast construction, the iron and zinc phosphate treatment may be omitted.

1.3.5 Finish Painting

****

NOTE: If severely moist conditions exist, a separate paint system should be specified using

Civil Works Guide Specification UFGS Section 09 97 02 PAINTING: HYDRAULIC STRUCTURES, system 21, epoxy finish or equivalent. When such painting is specified, care must be taken to specify a paint that will adhere to and not be injurious to the protective painting provided under these specifications.

****

Apply a minimum of two coats of paint to all equipment in accordance with the manufacturer's standard process for the conditions specified.

1.4 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Naming Convention; G[, [_____]]

SD-02 Shop Drawings

Controller; G[, [_____]]

Limit Switch; G[, [_____]]

Hoist Motor; G[, [_____]]

Control Station[s]; G[, [_____]]

Brake Enclosing Case

SD-03 Product Data

Hoist Motor; G[, [_____]]

Brake; G[, [_____]]

Programmable Limit Switch; G[, [_____]]

Overload Relays; G[, [_____]]

Controller; G[, [_____]]

Control Station[s]; G[, [_____]]

Wiring

Conductors

Terminal Leads

Terminal Blocks

Motor nameplates; G[, [_____]]

Equipment and Door Nameplates; G[, [_____]]

[Conductive Corrosion Inhibiting Compounds; G[, [_____]]]

Circuit Breakers; G[, [_____]]

SD-06 Test Reports

Factory Testing; G[, [_____]]

Acceptance Checks and Tests; G[, [_____]]

1.5 NAMING CONVENTION

Submit method of identifying conductors, terminal leads, and terminal blocks.

PART 2 PRODUCTS

2.1 HOIST MOTOR

****

NOTE: Coordinate with the respective electrical or mechanical designers to ensure motors are not being specified elsewhere in the contract documents and that all motor requirements are satisfied.

****

Submit motor characteristics, curves or tabulated data (tested or calculated), indicating the speed, power factor, efficiency, current and kilowatt input, all plotted or tabulated against torque or percent of rated motor load.

a. Submit calculations to determine the required horsepower rating of each motor.

b. Submit detailed descriptive specifications of the motor, with necessary cuts, photographs, and drawings to clearly indicate the construction of the machine. Place special emphasis on describing and illustrating features of "Insulated Windings," "Winding Heaters," "Bearings and Lubrication," and "Terminal Leads."

2.1.1 Motor Type

****

NOTE: When a single-speed motor or two single-speed motors in lieu of a two-speed motor is acceptable for the application, the designer will specify NEMA MG 1 standard design letter. The torque requirements listed in paragraph MOTOR LIMITS must be met, and the designer will verify that the design specified is sufficient. Design "C" and "B" have a 5 percent or less slip limit and are used where load inertia is lower. Design "D" has a 5 percent or greater slip and must be used where inertia is high. Designs "B," "C," and "D" provide progressively higher torques and get progressively more expensive. Design "B" will generally apply to motors from 745 to 2240 W 1 to 3 hp, design "C" to motors between 2.24 to 11 kW 3 and 15 hp, and design "D" for motors larger than 11 kW 15 hp. This a general guide according to NEMA minimum standards and may vary with manufacturer's specific equipment.

Totally-enclosed motors can be used in outdoor locations but are not suitable for submersion. At reduced cost, dripproof encapsulated construction may be used in protected locations. Consult manufacturer's data for information on application of this type motor to specific environmental conditions.

****

Provide a motor of the horizontal-shaft, squirrel-cage induction type [two-speed, two-winding, constant torque] [NEMA design [B] [C] [D]], designed for [full-voltage starting][adjustable speed drive operation],

[of water-proof, totally enclosed, fan-cooled or nonventilated frame construction],[dripproof, encapsulated frame construction]. The motor must conform to the applicable requirements of NEMA MG 1. Ensure the weep hole is at the lowest point of the motor for the intended installation.

2.1.2 Motor Rating

****
NOTE: For a two-speed motor, use single-voltage rating. Specify load conditions when Contractor designed. (Second Option) This specification covers three-phase motors which are suitable for most applications and must be used whenever possible. When utility three-phase power is unavailable and forces use of single-phase motors, this specification may be modified accordingly. Generally, single-phase motors used for this application should be below19 kW 25 horsepower. The torque limits should be carefully evaluated, and the testing requirements should be changed. Please consult Engineering Manual (EM) 1110-2-2610.
****

[The motor must be rated [_____] horsepower, [_____] rpm synchronous speed for the machinery design shown on the drawings or, if the design is changed as permitted by [_____], must have a horsepower rating as required by performance requirements specified to [_____].] [The motor must have a horsepower rating as required by the load conditions specified in [_____].] The motor must be rated for continuous full-load operation without exceeding the standard temperature rise for the class of insulation and frame construction used, and it must be wound for [_____] [230/460] [460] volts, three-phase, 60-Hz.

2.1.3 Motor Torque

****
NOTE: The torque values are those required by design guidance given in EM-1110-2-2610. The gate design must be coordinated with the requirements of this document to ensure that torque limits are met. Reducing the upper limit or raising the lower limit will result in significant cost increase and should be avoided where ever possible.
****

2.1.3.1 Motor Limits

The torque limits for each individual winding must be as follows:

a. Upper Limit: The upper limit of the torque between locked-rotor and breakdown must be not more than 280 percent of the rated full-load torque of the motor.

b. Lower Limit: The lower limit of the torque between locked-rotor and breakdown must be as high as possible consistent with good design but not less than 150 percent of the rated full-load torque of the motor.

c. When the characteristics of a motor or the winding of a motor results in a speed torque curve without a definite value of breakdown torque,

the limitations on the minimum value of torque must apply between locked-rotor and 75 percent of synchronous speed.

[2.1.3.2 Single-Speed Motor Limits

****

NOTE: Permit the use of two single-speed motors in lieu of a single two-speed motor where space is not a concern, and a two-speed motor cannot meet the specifications requirements.

****

Two single-speed motors may be used in lieu of a two-speed motor, providing the synchronous speed of the high-speed motor is not more than 1,800 rpm's and the low-speed motor will conform to the 50 percent over-speed requirements of the high-speed motor.

]2.1.4 Frames and Shafts

****

NOTE: Shafts of stainless steel may be specified in lieu of manufacturer's standard treatment where extremely corrosive atmospheres exist. The use of stainless steel will change the motor design and increase the shaft diameter at a significant cost. Manufacturer's should be consulted before specifying stainless steel in a given application.

****

Size and dimensions of frames must conform to NEMA MG 1. Provide eye bolts on all motors. Provide each motor with a drain-breather which must be located to prevent accumulation of water inside the motor. Frames must have corrosion prevention in accordance with the requirements of paragraph CORROSION PREVENTION AND FINISH PAINTING. Exposed portions of shafts must be treated with manufacturer's standard primer and two coats of moisture proof varnish in accordance with the manufacturer's recommendation.

2.1.5 Windings and Insulation

****

NOTE: Select insulation class based on NEMA temperature requirements as follows:

CLASS	LIMITING TEMPERATURE (in degrees Celsius)
B	130
F	155
H	180

Selection of insulation class should be left to the Contractor when he is also responsible for motor design, but in no case should it be less than Class B. Class F is typical.

Designer will provide ambient temperature values

where possible.
****

Insulation must be Class [B] [F] [H] [B or better as required for design conditions] with special moisture, [fungus], and oil proof treatment. Design and construct motors to withstand the environmental conditions specified. The following specifications describe the minimum requirements for acceptable insulation and are not intended to restrict or prohibit the use of materials or methods which will give equal or better performance. Temperature rise must be no greater than [80] [_____] degrees C [176] [_____] degrees F.

2.1.5.1 Insulated Windings

Unless otherwise approved, completely assemble insulated windings in the motor core before impregnating with the insulating compound. Insulating compound must be 100 percent solid. Use the vacuum impregnation method followed by baking to impregnate the windings with the insulating compound. Repeat the procedure as often as necessary to fill in and seal over the interstices of the winding, but in no case must the number of dips and bakes be less than two dips and bakes when the vacuum method of impregnation is used.

2.1.5.2 Magnet Wire

The magnet wire must have an insulation or combination of insulations with an insulation thickness not less than that required for the environment specified and the temperature rating as required by the hot-spot temperature of the motor.

2.1.6 Winding Heaters

****
NOTE: Delete this paragraph and the requirement for "Winding Heaters," if dripproof encapsulated motor is used. Additionally, the designer should consider elimination of winding heaters if possible in other situations, i.e. where the probability of condensation is low. In the past, heaters have been a maintenance problem and have been disconnected by project personnel.
****

A heater or heaters must be installed in the motor frame or end bells or wrapped around the winding end turns. Heaters must meet the requirements of paragraph HEATERS-GENERAL. Heaters installed around the winding end turns must consist of the required turns of heating cable wrapped around the end turns and secured in place before the motor windings are impregnated.

2.1.7 Bearings and Lubrication

****
NOTE: The use of sealed bearings should be limited to special applications. Sealed bearings do not require as much maintenance but reduce the overall life of the motor.
****

Provide the motors with antifriction bearings. The design of the housing and method of assembly must permit ready removal of the end brackets and prevent escape of lubricant and entrance of foreign materials. Bearings must be fitted with bronze or other approved bushings to prevent any binding of moving parts. Approved antifriction bearings of corrosion resisting construction may be used. Bearings [must be of an approved prelubricated type requiring no addition or change of lubrication for a period of at least 5 years] [must have fitted openings located on the top and bottom of the bearing housing. The openings must be readily accessible for applying and draining the lubricant]. Pressure lubrication fittings may be used provided the housings are properly vented to prevent damage to the seals. When the brake housing or other equipment is to be assembled adjacent to or bolted to the motor end bell, provide suitable filler and drain pipe extensions, with the ends properly fitted and easily accessible. For those applications where the brake wheel is mounted on a shaft extension on the front end of the motor, the bearing housing, or a suitable flange, must provide a suitable surface and connecting means to allow the fastening of the brake enclosure to the bearing housing (see paragraph BRAKE ENCLOSING CASE).

2.1.8 Terminal Leads

Terminals leads must extend outside the frame; must have insulation equivalent to that of the motor winding; must be terminated in a two-piece, watertight terminal box secured rigidly to the motor frame; and must be suitably identified. Position and seal leads where they pass through the frame with a water-resistant seal of a synthetic rubber material or a synthetic rubber gasket. Terminal box must have threaded conduit entrances on a minimum of four sides.

2.1.9 Machine Work

Machine work must be accurate, of high quality, and in conformity with approved standard practice. Threads must be in accordance with ASME B1.1. Thread fittings must be Class 2. Threads on all body-bound bolts must be chased a sufficient length so that when the nut is tightened there will be approximately one and one-half full threads under the nut. Provide all bolts and cap screws with lock washers.

2.1.10 Designation and Markings

Attach motor nameplates of a suitable corrosion-resisting material to the frame of each motor. Motor nameplates must indicate clearly the motor NEMA temperature and insulation class, continuous amperage rating, voltage rating, operating frequency, rated RPM, horsepower rating, nominal efficiency, NEMA locked rotor code letter and serial number. In addition, the nameplate must show a lead connection diagram. Identification or serial numbers must be die stamped on the frame.

2.1.11 Heaters

2.1.11.1 Heater Ratings

Heaters must be of such rating that, when energized, the temperature of the windings or enclosure will be held approximately 10C above ambient. They must be designed for 120 volts AC and for continuous operation under the conditions of installation. The rate of heat dissipation must be uniform throughout their effective length.

2.1.11.2 Insulation

Insulation for the heating cable (winding wrap around type) heaters must be suitable for a conductor temperature of 180C.

2.1.11.3 Heater Terminals

The terminals of the heater, including the leads, must be watertight. The leads must be terminated and sealed in a watertight terminal box located as selected by the motor manufacturer. The method of sealing must be as specified for the motor winding leads.

2.2 BRAKE

****
NOTE: Coordinate with the respective electrical or mechanical designers to ensure brakes are not being specified elsewhere in the contract documents and that all brake requirements are satisfied.
****

Submit detailed descriptive data covering the brake, with necessary cuts, photographs, and drawings to indicate clearly the construction of the brake and the materials used. Include releasing device specifications and characteristics, including input current minimum voltage required for brake release.

2.2.1 Brake Type

The brakes must be of the shoe type, spring set, type and must be completely enclosed in a watertight and dusttight enclosing case arranged for [floor mounting] [motor mounting].

2.2.2 Brake Rating

****
NOTE: Delete paragraph b. if constant torque two-speed motor or a single-speed motor is specified.
****

a. The brake must have a torque rating not less than 150 percent of the full load torque of the motor when referred to the shaft on which the brake wheel is mounted, efficiency of speed reducer not being considered. The torque rating must be based on open construction, [1-hour] [continuous] duty.

b. [The brake must have a torque rating of [_____] pound-feet as shown on the plans, or if the design is changed as permitted by [_____], the brake must have a torque rating not less than 150 percent of the full-load torque of the motor when referred to the shaft on which the brake wheel is mounted, efficiency of speed reducer not being considered.] [For a two-speed motor, computer the rating from the full-load torque of the low-speed winding of the motor.]

2.2.3 Adjustment

Provide means for varying torque required for holding. Additionally, the brake must have means of adjusting the position of the shoes to compensate for wear, unless the design is such that compensation for shoe wear is

automatic.

2.2.4 Release

2.2.4.1 Releasing Magnets and Rectifier

****
NOTE: Coordinate voltage requirements with paragraph MOTOR RATING.
****

The releasing magnets must be of the DC or AC shunt type and of standard stock design, suitable for operation on [_____] [230] [460]-volt, 60-Hz, AC electrical power. Supply direct current by means of a self-contained rectifier unit of proper rating. The complete unit must be suitable for connection to the control circuit or the power circuit of the motor with which the brake is used so that the brake will set or release when the motor is deenergized or energized, respectively. The brake releasing magnet must be rated in accordance with the brake rating requirements of paragraph MOTOR RATING. The brake releasing magnet must be sufficient to release and hold the brake in the released position with 85 percent of rated voltage impressed on the incoming terminals. When a rectifier is required, mount it in the motor controller enclosing case unless otherwise noted.

2.2.4.2 Hand Release

Provide hand release. Hand release must be operable only when the enclosing case cover is removed and must be self-resetting.

2.2.5 Terminal Leads

Connecting leads from the releasing magnet must be extended outside the enclosing case and must terminated on a terminal block located in a watertight terminal box. The terminal box must be rigidly bolted or equally secured to and on the outside of the lower or fixed half of the enclosing case. The terminal box must provide for conduit entrances on four sides. All conduit entrances to the brake terminal box must be threaded. The leads inside the brake enclosing case must be suitably protected. Terminate enclosing case space heater leads in the same manner in separate terminal boxes.

2.2.6 Brake Enclosing Case

****
NOTE: Manufacturers do not generally weld enclosures. Welding required only where conditions require substantial construction and costs may be justified.
****

Submit dimensioned outline drawings showing specific relationships and clearances between equipment and their component parts. The outdoor NEMA Type 4-watertight enclosing case must be [welded type] [in accordance with the manufacturer's standard practice for the conditions indicated]. In order that the brake mechanism will be accessible from above, when the upper half or cover of the enclosing case is removed, the enclosing case must be constructed to give equal accessibility to all portions of the brake. Make the joint between the two halves with a synthetic rubber

gasket, not less than 6 mm 1/4 inch in width, and held in place by embedding in a groove or by other equally effective means. For those applications where the brake wheel is mounted on a shaft extension on the front end of the motor, the enclosing case must be arranged to permit bolting to the bearing housing of the motor, the joint being made watertight with a gasket. For those applications where the brake wheel is mounted on a shaft of the operating machine or on a flange and shaft extension on the front end of the motor, suitable watertight seals must be provided on each part of the housing. The shaft seals must be arranged for pressure lubrication and must be adjustable for alignment relative to the shaft. An automatic drain breather, located in a protected location, must be provided in the lower part of the enclosing case. If the drain breather cannot be located in a protected location, the tapped hole must be plugged and the drain furnished separately for installation in the field. Provide enclosing case space heaters conforming to the applicable part of paragraph HEATERS-GENERAL. The enclosing case must be treated to render the steel resistant to corrosion as required by paragraph CORROSION PREVENTION AND FINISH PAINTING.

2.2.7 Mechanical Construction

Use no cast iron in brake construction, except for brake wheels, shoes, and electrical parts. All pins, fittings, and other miscellaneous small metal parts must be of approved corrosion-resisting metal or must be treated to render them corrosion-resistant as required by paragraph CORROSION PREVENTION AND FINISH PAINTING. Bearings must be fitted with bronze or other approved bushings to prevent any binding of moving parts. Approved antifriction bearings of corrosion-resisting construction may be used. Provide approved means for lubrication for all bearings, unless bearings are of an approved self- or prelubricated type. The machine work must conform to the requirements for the motor with which the brake is used.

2.2.8 Designation and Markings

Provide and attach a nameplate of suitable corrosion-resisting material to a part of the brake which ordinarily will not be renewed during its service life. The nameplate must conform to standard practice and clearly indicate the manufacturer's name, identification symbols, serial number, and salient design features such as type, frame, torque, rating, voltage, phase, and frequency. If adjustment is required, pertinent information for making the adjustments is necessary.

2.3 CONTROL SYSTEM

****

NOTE: The scheme of control shown on the applicable plate at the end of this document should be retained where possible.

The Plates listed below, containing the related control sequences, are attached at the end of this spec.

PLATE NO.	**SUBJECT**
1.	**Crest Gate, Electrical Control System (With Approximately 300 mm 1.0 Foot Increments)**

2. Crest Gate, Electrical Control System (With Approximately 150 mm 0.5 Foot Increments)

3. Crest Gate, Electrical Control System (With Remote Control and Approximately 300 mm 1.0 Foot Increments)

4. Crest Gate, Electrical Control System (With Remote Control and Approximately 150 mm 0.5 Foot Increments)

5. Outlet Control Gate, Electrical Control System (Single-Speed Motor)

6. Outlet Control Gate, Electrical Control System (Multispeed Motor)

7. Intake Gate, Electrical Control System.

In some instances, where control for a penstock intake gate hoist where the emergency lower control switch is to be located in the powerhouse, the length of the connecting circuit may be such that its mutual inductance may render the circuit susceptible to false operation. In such cases, it will be necessary to use direct current and interpose an additional control relay. The direct current can be provided from a rectifier located in the control cabinet or from a circuit on the power house control battery.

Use Section 40 60 00 or similar specification if PLC control is required.

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The scheme of operation of the [outlet control gate] [tainter gate] [intake gate] hoist motor control system must be as described and indicated. The control system must include the controller, limit switch[es], control station[s], and such other items as may be required to accomplish the operating features specified. Each item must be [installed and] tested as specified and must be complete and ready for operation [, when installed under another contract,] in accordance with the scheme of operation.

2.4 CONTROLLER

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NOTE: Separate mounting of the controller is usually the preferred practice. When mounting the controller on the hoist frame is desired, the Contractor will be required to submit a drawing showing the arrangement of the controller and other electrical equipment on the hoist frame. In this case, the electrical equipment should be wired in the shop complete and ready for operation upon bringing the power connection to the line side of the controller disconnect switch.

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Submit a description of the operation scheme, if other than herein specified or shown on the drawings; a dimensioned outline drawings showing specific relationships and clearances between equipment and their component parts, detailed panel layouts, schematic wiring diagrams, and a panel wiring diagram dimensioned outline drawings showing specific relationships and clearances between equipment and their component parts. Submit detailed descriptive data covering all component parts of the controller.

2.4.1 Controller Type

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NOTE: Adjustable speed drives (ASD) are appropriate for gates hoisted on each side and requiring skew control. Full-voltage magnetic starters are appropriate when using a torque shaft across the gate or when using wound-rotor motors to form a virtual shaft for skew control.

****

The hoist motor controller must be[an adjustable speed drive (ASD) in accordance with Section 26 29 23 ADJUSTABLE SPEED DRIVES (ASD) SYSTEMS UNDER 600 VOLTS. The controller must be][of the full-voltage magnetic type] initiated by the push-button control station and controlled automatically by a limit switch or limit switches. Limit switch[es] must be driven by the hoist mechanism or other auxiliary operating devices as indicated or required to provide the sequence of operation specified or indicated on the plans.

2.4.2 Protection

The controller must provide [under-voltage protection,] inverse-time-limit overload protection, or other protection as indicated or specified. [In addition, the controller must provide protection from single-phase faults.] Accomplish the protection by suitable relays conforming to the requirements of paragraph RELAYS. Overload relays must provide protection during both the starting and running condition, and provide means to manually reset the relays without opening the enclosing case of the controller. All forward and reversing contactors must be electrically interlocked. Controller disconnecting circuit breaker[s] must be interlocked with the controller enclosing case access door to permit opening or closing the access door only when the disconnect is in the "OPEN" position.

2.4.3 Enclosure

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NOTE: When controller is mounted in a dry room or gallery adjacent to the hoist equipment adjacent to the hoist equipment, a NEMA Type 12, industrial-use enclosure should be specified and the drawings and specifications revised accordingly. Hubs must be specified for all conduit entrances.

Wall mounting is generally the least costly alternative and should be used whenever practical.

Designer must coordinate padlock requirements with

local physical security standards.
****

Enclosing cabinet must be of the NEMA Type [3R [stainless steel]] [4 watertight [stainless steel] and moisture-resisting] [12 industrial use] construction with interior dead-front panel meeting the requirements of NEMA ICS 6. Design the enclosing cabinet for [floor mounting] [mounting on the hoist frame] [wall mounting]. Provide suitable padlock eyes to allow locking the exterior door in the closed position. Provide padlocks, conforming to [_____], with each controller and chained to the enclosing case. The chain must be of a nonferrous material resistant to corrosion. Use only front-connected devices, and clearances must be in accordance with NEMA ICS 1 requirements. Provide threaded hubs for conduit entrance of the welded-in type as indicated on the drawings or as required to make the wiring connections. Provide an automatic breather-drain, not less than 3/8-inch size and located in a protected location and at the lowest point of the enclosure.

2.4.4 Circuit Breakers

Provide and assemble circuit breakers as shown on the drawings or specified in the housing of each controller.

2.4.4.1 Circuit Breakers - General

Each circuit breaker must be listed for UL 489. The circuit breakers must be manually operated and must be of the instantaneous trip type, unless otherwise specified or indicated on the drawings. Circuit breakers for cabinet heaters, lights, and receptacles must be of the inverse-time trip type. All poles of each breaker must operated simultaneously by means of a common handle and must be enclosed in a common molded plastic case. The contacts of multipole breakers must open simultaneously when the breaker is tripped manually or automatically. The operating handles must clearly indicate whether the breakers are in "ON," "OFF," or "TRIPPED" position. Each circuit breaker must be externally operated [and interlocked] as specified in paragraph PROTECTION. Provide approved means for padlocking the breaker[s] operating handle in the "OFF" position. Provide a padlock of the same type as specified in paragraph ENCLOSURE for each breaker[and chained the padlock to the enclosing case]. The circuit breakers must be products of only one manufacturer and must be interchangeable when of the same frame size.

2.4.4.2 Trip Units

Except as otherwise indicated on the drawings, provide the circuit breakers with combination thermal and instantaneous magnetic trip units unless otherwise indicated. The minimum frame sizes and the trip unit ratings must also be as required for the equipment controlled. Nonadjustable instantaneous magnetic trip unit must be set as approximately 10 times the continuous current ratings of the circuit breakers.

2.4.4.3 480-Volt AC Circuits

Circuit breakers for 480-volt AC circuits must be rated 600 volts AC and must have a minimum NEMA interrupting capacity of 14,000 symmetrical amperes at 600 volts AC.

2.4.4.4 120-Volt AC Circuits

Circuit breakers for 120-volt AC circuits must be rated not less than 120/240 or 240 volts AC and must have a minimum NEMA interrupting capacity of 10,000 symmetrical amperes.

2.4.4.5 125-Volt DC Circuits

Circuit breakers for 125-volt DC circuits must be two-pole rated 125/250 or 250 volts DC and must have a minimum NEMA interrupting capacity of [5,000] [10,000] amperes DC.

2.4.5 Assembly of Controller

Furnish all necessary circuit breakers, contactors, relays, resistors, interlocks, master switches, limit switches, or other devices required by the scheme of operation. The panel for mounting the relays and contactors must be sheet steel of sufficient thickness to provide rigid support for the equipment mounted thereon. Give the steel panel a corrosion resisting treatment in accordance with the requirements of paragraph CORROSION PREVENTION AND FINISH PAINTING.

2.4.5.1 Wiring

Submit data sufficient to demonstrate that the proposed wire and cable conform to these specifications. Insulated wire must conform to the requirements of paragraph CONDUCTORS. Securely hold all wiring in place and arrange in a neat and orderly manner in horizontal and vertical runs. Protect with grommets all wiring passing through steel gutters, unless the openings in the steel gutter are formed to protect the wiring from damage. [All controllers must be wired in like manner as to location of parts and phase sequence.] Neatly and legibly identify the wire and terminal numbers in an approved manner. Use terminal blocks for making all external connections.

2.4.5.2 Terminal Blocks

Terminal blocks for control wiring must be molded type with barriers, rated not less than 600 volts. Provide terminal blocks with covers. The terminals must be removable, screw type, or of the stud type with contact and locking nuts. The terminals must not be less than No. 10 AWG in size and must have sufficient length and space for connecting at least two indented terminals on No. 10 AWG conductors to each terminal. The terminal arrangement must approved by the Contracting Officer.

a. Provide not less than 10 percent, but in no case less than 2, spare terminals on each block. Terminal blocks for conductors larger than No. 10 AWG or with a capacity of more than 30 amperes must be adequate for the purpose intended, having length and space for at least two indented terminals of the size required on the conductors to be terminated.

b. For conductors rated more than 50 amperes, all screws must have hexagonal heads. For conductors rated 50 to 99 amperes, the minimum screw size must be 8 mm 5/16 inch. Conducting parts between connected terminals must have adequate contact surface and cross section to operate without overheating.

c. Provide white or other light-colored marking strips, fastened by

screws to the molded sections at each block, for circuit designation. Each connected terminal of each block must have the circuit designation or wire number placed on the marking strip with permanent marking fluid. Furnish one reversible or one spare marking strip with each block.

2.4.6 Magnetic Contactors

2.4.6.1 Contactor Ratings

All heavy-duty magnetic contactors must be of the voltage rating indicated on the drawings or otherwise required. They must have a horsepower rating not less than the horsepower rating of the motor with which the controller is to be used, but the contactor used must not be smaller than NEMA, Size 1. The contactors must meet the requirements of NEMA ICS 2 and have continuous current ratings for the duty indicated. Contactors must be suitable for at least 200,000 complete operations under rated load without more than routine maintenance. They must operate successfully on 10 percent over-voltage and 15 percent under-voltage. The interrupting capacity must conform to NEMA standards. Provide mechanical interlocking between contactors as indicated or required and without any mechanical attachment between the interlocking mechanism and the moving parts of the contactor, unless otherwise approved by the Contracting Officer.

2.4.6.2 Arcing Protection

For each pole, the interruption arc and flame must be minimized by suitable arc chutes or other means so that no damage will be done to other portions of the device. The arc chutes, if provided, must be easily removable without removing or dismantling other parts.

2.4.6.3 Contactors

All current carrying surfaces must be of a silver alloy or of copper faced with a silver alloy and must be easily accessible and removable for replacement. Contactor must operate without chatter or perceptible noise while energized. Coils must be suitable for continuous operation on the voltage specified.

2.4.6.4 Construction

Provide each contactor with a minimum of three auxiliary contacts which may be easily changed from normally open to normally closed. Construct contactor to prevent corrosion in accordance with paragraph CORROSION PREVENTION AND FINISH PAINTING.

2.4.7 Relays

2.4.7.1 Control

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NOTE: The numerical portion of the contact rating indicates the maximum operating voltage (e.g. 600 for 600 volts). The letter portion indicates the maximum operating current and AC or DC. Over-sizing the current rating will increase the life of the contacts. See NEMA ICS 5. Choose A600 for the highest-rated contacts on AC control circuits. Choose N600 for the highest-rated contacts on DC

control circuits.
****

Control relay devices must meet applicable requirements of NEMA ICS 5 for Class [A600][N600] contacts. All contacts must be of a silver alloy or copper faced with a silver alloy.

2.4.7.2 Overload

Overload relays must meet the requirements of NEMA ICS 2 rated Class [20][_]. Relays must be the adjustable electronic type with normally closed control circuit contacts having a pilot and control circuit contact rating per paragraph CONTROL. Overload relays must have combination manual and automatic-type reset. They must have inverse-time tripping characteristics simulating the heating characteristics of the motor, must protect the motor against exceeding its specified temperature rise under any overload, stalled rotor, or single-phase condition, and must be self-protecting under all conditions, except short circuit. The relay must measure the current and electronically model the motor's thermal condition.

The means of adjusting the nominal rating must be sufficiently accurate to allow setting the relay at the full-load current value of the motor with which used. Reset mechanism must be trip free and arranged for manual reset in accordance with paragraph PROTECTION, unless automatic reset is indicated. Design the reset mechanism to permit changing from manual to automatic reset or vice versa without the use of special tools. Submit curves showing the overload relay tripping time versus current characteristics of the overload relays for the controller.

2.4.8 Control Transformer

The control transformer must be a standard, single-phase, 60-Hz, dry-type, [480][_]-120 volts, and with kVA rating sufficient to supply the control [and heater] circuits.

2.4.9 Control Voltage

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NOTE: Control circuits and pilot devices operating under 50 volts are safer for operating and maintenance personnel per NFPA 70E.
****

Provide a switched-mode power supply for control circuits and pilot devices unless otherwise indicated for specific devices. Feed the power supply from the control transformer. Output voltage must be [24 volts DC][_].

2.4.10 Control Circuit Breakers

The control circuit breakers must conform to the requirements of paragraph CIRCUIT BREAKERS, except that an external operating mechanism is not required.

2.4.11 Indicating Lights

Indicating lights must be complete with LED lamps, full-voltage with internal power supplies, [push-to-test,]and lens or color caps. Lens and lamp must be removable from the front. They must be suitable for flush or

semiflush mounting to the exterior cabinet door with [plastic][metallic] bevel and size [20 mm][30mm][_]. Exterior mounting of the indication lights must meet the requirement for the enclosure NEMA type. Use hinge wire for connections between the indicator lights and the terminal block.

2.4.12 [Plug Receptacle for Inching Pendant Control Switch

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NOTE: Inching pendant control switch in paragraph INCHING STATION, and receptacle is not required on crest gates. Omit requirement for receptacle on controller enclosure and mount receptacle on wall of gate inspection room if inspection room is above maximum flood.

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The receptacle body must be weather resistant with threaded cap and gasket complete with polarized female contact unit, four-wire, five-pole, grounded through shell and extra pole, and rated 30A, 460 volts.]

2.4.13 Equipment and Door Nameplates

Submit schedule of nameplates. Provide nameplates for the front of the cabinet door and for each item of equipment within the enclosure. Use anodized aluminum, stainless steel, or a laminated plastic sheet with black surface layer and a white bottom layer not less than 1/16 inch thick for the nameplate material. Identify equipment within the enclosure with nameplates or other suitable marking on the equipment unit base or on the panel.

2.4.14 Heater

[Where indicated,] [Each] control panel(s) must be provided with a thermostatically controlled electric heater capable of maintaining an enclosure temperature of [2] [_____] degrees C [35] [_____] degrees F when continuously exposed to an ambient temperature of [_____] degrees C degrees F.

2.4.15 Grounding

Make the ground connection for the controller enclosing cabinet by a threaded post fitting which extends through the enclosure wall and which is provided with fittings to connect No. 6 AWG stranded copper ground wire both inside and outside the enclosure. Inside the enclosure, the ground circuit must be extended with No. 6 AWG stranded copper wire from the connector to the panel.

2.5 CONTROL STATION[S]

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NOTE: If possible, select contact ratings greater than the load to increase the lifespan of the contacts.

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Control station[s] must be of the push-button type and must provide the number of indicating lights and individual switches of the type or types required by the scheme of operation. Enclosure must be NEMA 250 Type [3R] [4 watertight [stainless steel]] [12 industrial use] construction. All

contacts must be of the double-break bridging type and must have a pilot and control circuit rating designation of [A600][N600][_] in accordance with NEMA ICS 5. Provide switch cases with threaded bosses for conduit or cable connection and provide ample wiring space for conductors of the size and insulation specified. Submit detailed descriptive data covering the control station[s] for approval before fabrication. Data must include schematic diagrams, wiring diagrams, layout drawings, and parts lists.

2.5.1 Primary Station

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NOTE: Use padlocked stop switch on all hoists except intake gate hoists provided with remote lowering. Intake gate hoists may use either padlock or "substantial metal cover" alternate. If metal cover alternate is used, the emergency lower contact "ELS" in parallel with the stop switch contact should be deleted.

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NOTE: Use lamp colors in accordance with the "safety" scheme of NFPA 79-2015 Table 10.3.3.

COLOR	PURPOSE
Red	Danger
Yellow (Amber)	Warning/Caution
Green	Safe
Blue	Mandatory action
Clear, White, Gray, Black	Unspecified

****

Arange the primary station with the elements stacked vertically and with [_____]-inch conduit entrance from the bottom. The station must provide [a red indicating light and] [3] [4] operating rocker handle-type push buttons. Arrange the station starting at top with [a red light followed by] the "RAISE," ["CONDUIT OPEN,"] "LOWER," and "STOP" push buttons. The station switch elements must have nameplates with the above designations. [Provide the "STOP" switch with means of padlocking the switch in the stop or in the open position.] [Provide the station with a substantial removable or hinged metal cover which can be locked in the closed position to prevent operation of the switch elements.] The padlock must be chained to the enclosing case with a chain made of nonferrous material.

2.5.2 Inching Station

Arrange the inching station with the elements stacked vertically and with conduit entrance on the top for a cable clamp. The cable must be [_____] feet of five-conductor, No. 12 AWG portable cable with extra flexible conductors, heat and moisture resistant insulation, and outer Neoprene jacket. The station must have two rocker handle-type push buttons. The

switch elements must be designated "INCH UP" and "INCH DOWN" from top to bottom, respectively.

2.6 PROGRAMMABLE LIMIT SWITCH

Submit dimensioned outline drawing of the limit switch. Show on the Drawings specific relationships and clearances between equipment and their component parts.

a. Submit all limit switch computations used to determine the selection of gear ratios and calibration for gate travel.

b. Submit complete descriptive data covering the limit switch with necessary cuts, photographs, and drawings to indicate clearly the construction, materials used in the parts, rating, accuracy of tripping and reset, method of adjustment, and safeguards.

2.6.1 Normal Operation

The limit switch must be the programmable type with digital display and must operate on [24 volts DC][120 volts AC]. It must contain all the contacts required for making and breaking all control and interlocking circuits necessary for the proper control and operation in the manner specified or required.

2.6.2 Construction

The limit switch must be of compact and rugged construction, totally enclosed in a NEMA Type 12 case, and housed within the controller enclosure. The digital display must be visible without opening the enclosure door. This viewing port in the door must have a replaceable gasketed piece of clear plastic mounted to maintain the NEMA rating of the enclosure. Provide the cover with cap screws or other approved means for readily breaking the cover free for removal unless the gasket is so designed that it will not stick. All parts must be of corrosion-resisting metal or treated in an approved manner to render it resistant to corrosion. The switch must permit final adjustment in the field. Provide tapped bosses for making all conduit connections to the switch. Provide a clamp-type connector bolted to the outside of the case for making ground connections.

2.6.3 Switches

Switches must be solid state with current rating as required. Assemble or combine switches into operating units as indicated on the plans. Provide them with suitable terminals for connecting the external conductors. Switches must provide one remote digital readout. Each terminal must be suitably marked or tagged with the wire number shown on the contract drawings. Design the tripping mechanism for fail-safe operation and resetting the contacts when moving in the reverse direction. The switch must have an operator lockout feature which permits programming only by authorized personnel.

2.6.4 Transducer

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NOTE: Consider using a resolver if the point of measurement is exposed to significant heat, moisture, or vibration because resolvers do not

contain optics or electronics. However, encoder feedback systems are simpler.

****

The position sensor must be heavy-duty [resolver][encoder] enclosed in a outdoor NEMA 4 watertight enclosure. Provide a cable [chain] connector for the enclosure which is suitable for No. 16 AWG shield twisted pair.

2.6.5 Accuracy of Trip and Reset

****

NOTE: For installations where water control requires gate travel of over 9 m 30 feet, measurement of gate travel may become nonlinear. This is due to stretching of the wire rope. The attachment point for measurement of travel should be as near the switch as possible and need not be at the top of the gate. The designer must investigate possible options, including use of chain and additional limit switches.

****

Design the switch elements and operating mechanism of the limit switch to provide uniform and accurate setting. The switch must accurately transmit position within + 75 mm/- 3 inches and must reset gate for drift exceeding 150 mm 6 inches.

[2.7 OVERTRAVEL LIMIT SWITCHES

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NOTE: The requirements for positively-driven and force-guided limit switches imply a safety style.

****

Provide dry-contact limit switches for overtravel protection. [The limit switches must be positively-driven with the mechanical force of the hoisting system must be transmitted directly to the contacts to force them open. The limit switches must be force-guided with the contacts mechanically linked to ensure the normally-open and normally-closed contacts are not simultaneously closed.] Hardwire the normally-closed contacts of the switches to the motor starting circuit. Include provisions to backout of overtraveled positions using momentary pushbuttons to defeat the limit switch protection.

]2.8 WIRE AND CONDUIT

2.8.1 Conductors

Conductors must be of annealed copper wire. Insulate copper conductors with cross-linked thermosetting polyethylene (XLPE) of type XHHW-2. Conductors mjst be Class B or Class C stranding, except for hinge wire which must be Class D or K stranding. Unless otherwise specified, all wire and cable for power and control must be single conductor. Insulation thickness must be that required for a rated circuit voltage of 0 to 600 volts. Apply a moisture resisting thermoplastic jacket over the insulated conductor. The method of accomplishment must be in accordance with the current practice of the industry. Wire for power and motor circuits must have a current carrying capacity corresponding to the ampere rating of the circuit's circuit breaker and not less than No. 12 AWG and the full-load

current of the motor or the circuit. Wire for control circuits must not be smaller than No. 14 AWG.

2.8.2 Control Wire

All control wire entirely within an enclosure must be type SIS switchboard wire meeting the requirements of UL 44. All other control wire must be type XHHW-2 wire meeting the requirements of UL 44.

2.8.3 Conduit

Rigid steel conduit must conform to ANSI C80.1 and must be zinc-coated (galvanized) both inside and outside by the hot-dip method.

2.8.4 Fittings

Conduit fittings must conform to the requirements of NEMA FB 1 and CID A-A-50553.

[2.8.5 Conductive Corrosion Inhibiting Compounds

Provide conductive corrosion inhibiting compounds meeting the requirements of UL 546. Compounds must be compatible with aluminum and copper conductors, must inhibit oxidation at the conductor-to-connector interface, and must not damage the conductive or insulating materials.

Provide non-gritted conductive corrosion inhibiting compound that are non-petroleum based and non-toxic and contain no grit filler. Ensure non-gritted conductive corrosion inhibiting compound is specified by the manufacturer for application to the conductor-to-connector interface of mechanical connectors such as bolted joints, flat-to-flat contact surfaces, terminal and lug tongues, and grooves of bolted parallel connectors or clamps.

]2.8.6 Assembly

****

NOTE: For contracts where all conduit and wiring are furnished and installed by others, use paragraph 'a.'

For contracts where all conduit and wiring are on the hoist and are furnished and installed under this contract, use paragraph 'b.'

For contracts where the conduit and wiring on the hoist are furnished and installed under this contract and the connections to remotely located items are made under a subsequent contract, use paragraph 'c.'

****

Install the hoist motor, motor brake, controller, limit switch, and primary control station on the [hoist frame] [as shown on contract drawings].

[a. The conduit and wiring connections external to the items of electrical equipment previously mentioned will not be furnished or installed under this contract.]

[b. Furnish, install, completely connect, and make ready for operation the conduit and wiring connections external to these previously mentioned items of electrical equipment. The conduit, wiring, and connections for the incoming power will be made by others under a subsequent contract.]

[c. Furnish, install, completely connect, and make ready for opertation the conduit and wiring connections external to these previously mentioned items of electrical equipment which are installed on the hoist frame. The conduit and wiring connections to the remotely located control equipment and the incoming power connections will be made by others under a subsequent contract.]

d. Install all wiring in rigid hot-dip galvanized metal conduit with threaded-type fittings (Condulets) and zinc-coated watertight outlet and pull boxes. Securely mount and fasten the conduit to the hoist framework in a neat and workmanlike manner. Change direction of a conduit run by means of threaded-type fittings (Condulets) or factory fabricated bends. Install the conduit to fit close to the hoist framework. Use conduit unions whenever it is necessary to join conduits that are to be turned right and left. No running threads will be permitted. Carefully ream ends of conduits. All threaded connections must be made up with electrically conductive colloidal copper rust-inhibiting compound or other suitable compound. Provide separate conduit systems for power and control circuits. Ground the entire conduit system and instal so that any moisture will be drained away from terminal boxes and equipment. All conduit connections to equipment enclosures must be of the watertight threaded type. Provide suitable "drain-breather" devices at all low points of the conduit system to prevent an accumulation of water. Terminate all conductors in an approved manner. Use indented terminals on No. 12 AWG and larger conductors and terminate on screw or stud terminals. Use toothed lock washers on all screw terminals, and use locking nuts or lock washers on all stud terminals.

2.9 FACTORY TESTING

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NOTE: If designer elects to do operational tests of the gate hoist equipment, in conjunction with testing of the hoist itself, the hoist specification number must be included.

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Give a complete test of each item of equipment furnished, one of each rating and type and selected at random by the Contracting Officer. Give a routine test of the remaining items of equipment. All complete tests required herein will be witnessed by the Contracting Officer, unless waived in writing. Ship no equipment until it has been approved for shipment by the Contracting Officer. Notify the Contracting Officer sufficiently in advance of the date of the tests so that arrangements can be made for the Contracting Officer to be present at the tests. The test equipment and the test methods used must conform to the applicable requirements of ANSI, IEEE, and NEMA standards and will be subject to the approval of the Contracting Officer. Submit certified reports of all complete and routine tests, including complete test data. Certified copies of the results of a complete test for duplicate equipment will be accepted in lieu of the requirement of the complete test specified.

Include analysis and interpretation of test results in reports, and properly identify the test systems and materials. Provide test reports for "complete tests" on the motor, brake, and controller. Certified copies of "Complete Tests" on duplicate equipment may be accepted with the approval of the Contracting Officer. No substitute will be accepted for the routine test. The Contractor must bear the cost of performing all tests include the cost in the price bid. [Perform operational tests on the equipment in conjunction with the tests specified in [_____] for the assembled hoist.] [Perform operational tests on equipment after it is installed.] Performance curves indicating the results of the motor tests must be furnished as follows:

a. Excitation Tests. Volts or percent of rated voltage as abscissa vs. amperes and watts as ordinates.

b. Impedance Tests. Volts or percent of rated voltage as abscissa vs. amperes and watts as ordinates.

c. Performance Test. Torque or percent of rated horsepower output as abscissa vs. efficiency, power factor, amperes watts, and rpm or percent slip as ordinates.

d. Speed-Torque Test. Torque in foot-pounds as abscissa vs. speed in rpm or percent of synchronous speed as ordinates.

e. Temperature Test. Time in minutes as abscissa vs. temperature rise in degrees C as ordinate.

f. Insulation Resistance Test. Plot test result values on semilogarithmic graphs, the insulation resistance values as logarithmic ordinates, and the temperature values as uniform abscissa.

g. Include analysis and interpretation of test results in the routine test reports and properly identify the test systems and materials. No substitute will be accepted for the routine test. Provide test reports for "routine tests" on the motor, brake, controller, limit switch, [interrupter,] and wiring.

h. Submit description of "Interrupter" drive including copies of dimensioned outline drawing of the interrupter. Show on the Drawings specific relationships and clearances between equipment and their component parts.

2.9.1 Motor Tests

Perform all tests in accordance with the requirements of IEEE 112 for three-phase induction motors.

2.9.1.1 Complete Motor Tests

The complete tests must include the following:

a. Excitation test.

b. Impedance test.

c. Performance and speed-torque test (Prony brake or other approved method).

d. Temperature test.

e. Insulation resistance tests. Take measurements following temperature test with readings taken at approximately 10C intervals. Temperature must be determined by the resistance method.

f. Dielectric test.

g. Cold and hot resistance measurement.

h. Effectiveness of enclosure.

i. Motor winding heater test.

(1) Successful operation.

(2) Dielectric.

2.9.1.2 Routine Motor Tests

The routine tests must include the following:

a. Excitation test: (One point - no load, volts, amperes, and watts.)

b. Impedance test: (One point - half-voltage amperes and watts.)

c. General operation.

d. Insulation resistance - temperature test (one point).

e. Resistance measurements.

f. Dielectric.

g. Motor winding heater test.

(1) Successful operation.

(2) Dielectric.

[h. Interrupter.
]

2.9.2 Brake Tests

2.9.2.1 Complete Brake Tests

The complete tests must include the following:

a. Check operation of brake release at the specified rated brake torque for rated and 85 percent terminal voltage.

b. Heat run on release magnet at the specified rated brake torque and voltage.

c. Insulation resistance of release magnet including leads and terminal block.

d. Resistance measurements of release.

e. Dielectric test of release magnet including leads and terminal block.

f. Brake space heater test.

(1) Successful operation.

(2) Dielectric.

2.9.2.2 Routine Brake Tests

The routine tests of the brake must be the same as specified in paragraph COMPLETE BRAKE TESTS, except that the heat run tests must be omitted.

2.9.3 Controller Tests

2.9.3.1 Complete Controller Tests

The complete tests must include all tests listed in paragraph ROUTINE CONTROLLER TESTS, and the following:

a. Effect of voltage and frequency variation.

b. Temperature Test.

2.9.3.2 Routine Controller Tests

The routine tests must include the following:

a. Adjustment, fit, and material.

b. Successful operation.

c. Resistance.

d. Dielectric.

e. Insulation Resistance.

f. Enclosure space heater test.

(1) Successful operation.

(2) Dielectric.

2.9.4 Limit-Switch Tests

Test each limit switch in the manufacturer's shop by suitable means, simulating service conditions, to ascertain that it will transmit the correct information for the control sequence specified. In addition, the routine tests must include the following:

a. Adjustment, fit, and material.

b. Accuracy of trip and reset.

c. Successful operation.

2.9.5 Wiring Tests

Give all wiring outside an enclosure a dielectric test following installation by applying, for 1 minute, a voltage test of 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Apply voltage to each circuit and ground and between each conductor and all other conductors in the same conduit.

PART 3 EXECUTION

****
NOTE: Designer should add a reference to this Section in Part 3 of Section 26 08 00 APPARATUS TESTING AND INSPECTION.
****

3.1 FIELD QUALITY CONTROL

Perform acceptance checks and tests in accordance with NETA ATS and Section 26 08 00 APPARATUS INSPECTION AND TESTING.

3.1.1 Circuit Breakers

****
NOTE: See UFC 3-560-01 for requirements to perform acceptance testing of certain overcurrent protective devices in accordance with ANSI/NETA ATS. Field testing with actual settings will demonstrate proper trip timing and device operaton for arc flash protection.
****

Perform the following tests for [each main breaker and each breaker rated 225 amps or higher.][each three-phase, molded-case circuit breaker.]

A. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify the unit is clean.

5. Operate the circuit breaker to insure smooth operation.

6. Inspect bolted electrical connections for high resistance using a low-resistance ohmmeter.

7. Inspect operating mechanism, contacts, and arc chutes in unsealed units.

8. Perform adjustments for final protective device settings in accordance with the coordination study.

B. Electrical Tests

1. Perform insulation-resistance tests for one minute on each pole,

phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use 500 volts dc for 300-volt systems and 1000 volts for 600-volt systems and record the ambient temperature. Minimum insulation resistance must be 25 Megohms for 300-volt systems and 100 Megohms for 600-volt systems after correcting for temperature in accordance with NETA ATS Table 100.14.

2. Perform a contact/pole-resistance test.

3. Determine long-time pickup and delay by primary current injection.

4. Determine short-time pickup and delay by primary current injection.

5. Determine ground-fault pickup and time delay by primary current injection.

6. Determine instantaneous pickup by primary current injection.

7. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.

8. Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function, and trip unit battery condition. Reset all trip logs and indicators.

9. Verify operation of charging mechanism.

Plate No. 1

CREST GATE
ELECTRICAL CONTROL SYSTEM
(With Approximately 1.0 Foot Increments)
DESCRIPTION OF CONTROL SYSTEM

1. SCHEME OF OPERATION

a. General. The control system for the gate must be as indicated by the schematic control wiring diagram, and as specified below.

b. Control Points. The operation of the hoist motor must be controlled by:

(1) A push button station located on the gate hoist with momentary contacts designated "RAISE, "LOWER," and "STOP."

(2) A push button station located on the door of the controller cabinet with momentary contacts designated "BACKOUT FROM RAISE OVER TRAVEL" and "BACKOUT FROM LOWER OVER TRAVEL."

c. Operating Features

(1) Actuation of the "RAISE" and LOWER" contacts must provide seal-in operation.

(2) A limit switch geared or directly connected to the hoist machine, must control the incremental and stopping operations initiated manually from the control station as described under sequence of operation.

(3) Actuation of the "STOP" contact during any operation must stop the hoist motor and set the brake.

2. SEQUENCE OF OPERATION

a. Raising

(1) When the gate is between the closed and the intermediate position, each actuation of the "RAISE" contact will cause the gate to raise approximately 1 foot and stop.

(2) When the gate is at or above the intermediate position, actuation of the "RAISE" contact will cause the gate to raise continuously to the raised position.

b. Lowering

(1) When the gate is between the over travel raised position and the intermediate position, actuation of the "LOWER" contact will cause the gate to lower continuously to the intermediate position and stop.

(2) When the gate is at or below the intermediate position and is above the closed position, each actuation of the "LOWER" contact will cause the gate to lower approximately 1 foot and stop.

c. Over Travel. If during normal operation, the gate motor should fail to stop when the gate reaches the raised or closed positions, the over travel limit switch contacts must stop the hoist motor after over travel by de-energizing the "main" or "line" contactor of the controller. To operate the gate after an over travel, the appropriate backout must be held closed to permit operation of the gate only in the direction away from the over travel position after operation of either the "RAISE" or "LOWER" contact on the primary control station.

Plate No. 2

CREST GATE
ELECTRICAL CONTROL SYSTEM
(With Approximately 0.5 Foot Increments)
DESCRIPTION OF CONTROL SYSTEM

1. SCHEME OF OPERATION

a. General. The control system for the gate must be as indicated by the schematic control wiring diagram, and as specified below.

b. Control Points. The operation of the hoist motor must be controlled by:

(1) A push button station located on the gate hoist with momentary contacts designated "RAISE," "LOWER" and "STOP."

(2) A push button station located on the door of the controller cabinet with momentary contacts designated "BACKOUT FROM RAISE OVER TRAVEL" and "BACKOUT FROM LOWER OVER TRAVEL."

c. Operating Features

(1) Actuation of the "RAISE" and "LOWER" contacts must provide seal-in operation.

(2) A limit switch geared or directly connect to the hoist machine, must control the incremental and stopping operations initiated manually from the control station as described under sequence of operation.

(3) Actuation of the "STOP" contact during any operation must stop the hoist motor and set the brake.

2. SEQUENCE OF OPERATION

a. Raising

(1) When the gate is between the closed position and the first intermediate position, each actuation of the "RAISE" contact will cause the gate to raise approximately 0.5 foot and stop.

(2) When the gate is at or above the first intermediate position and is below the second intermediate position, each actuation of the "RAISE" contact will cause the gate to raise approximately 1 foot and stop.

(3) When the gate is at or above the second intermediate position, actuation of the "RAISE" contact will cause the gate to raise continuously to the raised position.

b. Lowering

(1) When the gate is between the over travel raised position and the second intermediate position, actuation of the "LOWER" contact will cause the gate to lower continuously to the second intermediate position and stop.

(2) When the gate is at or below the second intermediate position and above the first intermediate position, each actuation of the "LOWER" contact will cause the gate to lower approximately 1 foot and stop.

(3) When the gate is at or below the first intermediate position and is above the closed position, each actuation of the "LOWER" contact will cause the gate to lower approximately 0.5 foot and stop.

c. Over Travel. If during normal operation, the gate motor should fail to stop when the gate reaches the raised or closed positions, the over travel limit switch contacts must stop the hoist motor after over travel by de-energizing the "main" or "line" contactor of the controller. To operate gate after an over travel, the appropriate backout switch contact must be held closed to permit operation of the gate only in the direction away from the over travel position after operation of either the "RAISE" or "LOWER" contact on the primary control station.

Plate No. 3

CREST GATE
ELECTRICAL CONTROL SYSTEM
DESCRIPTION OF CONTROL SYSTEM
(With Remote Control and Approximately 1.0 Foot Increments)

1. SCHEME OF OPERATION

a. General. The control system for the gate must be as indicated by the schematic control wiring diagram, and as specified below.

b. Control Points. The operation of the hoist motor must be controlled by:

(1) A push button selector switch station located on the gate hoist with momentary push button contacts designated "RAISE", "LOWER", and "STOP" and selector switch contacts designated "LOCAL" and "REMOTE."

(2) A push button station located on the door of the controller cabinet with momentary contacts designated "BACKOUT FROM RAISE OVER TRAVEL" and "BACKOUT FROM LOWER OVER TRAVEL."

(3) A push button station, located on the spillway gate remote control board with momentary contacts designated "RAISE", "LOWER", and "STOP."

(4) A synchronous type indicator, located on the spillway gate remote control board to show the gate position.

c. Operating Features

(1) Actuation of the "RAISE" and "LOWER" contacts of the control station[s] must provide seal-in operation.

(2) The position of the "REMOTE-LOCAL" control switch will determine which station is operative.

(3) The remote control must utilize direct current interposing relays.

(4) A limit switch geared or directly connected to the hoist machine, must control the incremental and stopping operations initiated manually from the control station as described under sequence of operation.

(5) Actuation of the "STOP" contact during any operation must stop the hoist motor and set the brake.

2. SEQUENCE OF OPERATION

a. Raising

(1) When the gate is between the closed position and the intermediate position, each actuation of the "RAISE" contact will cause the gate to raise approximately 1 foot and stop.

(2) When the gate is at or above the intermediate position, actuation

of the "RAISE" contact will cause the gate to raise continuously to the raised position.

b. Lowering

(1) When the gate is between the over travel raised position and the intermediate position, actuation of the "LOWER" contact will cause the gate to lower continuously to the intermediate position and stop.

(2) When the gate is at or below the intermediate position and is above the closed position, each actuation of the "LOWER" contact will cause the gate to lower approximately 1 foot and stop.

c. Over Travel. If during normal operation, the gate motor should fail to stop when the gate reaches the raised or closed positions, the over travel limit switch contacts must stop the hoist motor after over travel by de-energizing the "main" or "line" contactor of the controller. To operate the gate after an over travel, the appropriate backout switch contact must be held closed to permit operation of the gate only in the direction away from the over travel position after operation of either the "RAISE" or "LOWER"contact on the primary control station.

Plate No. 4

CREST GATE
ELECTRICAL CONTROL SYSTEM
DESCRIPTION OF CONTROL SYSTEM
(With Remote Control and Approximately 0.5 Foot Increments)

1. SCHEME OF OPERATION

a. General. The control system for the gate must be as indicated by the schematic control wiring diagram, and as specified below.

b. Control Points. The operation of the hoist motor must be controlled by:

(1) A push button selector switch station located on the gate hoist with momentary push button contacts designated "RAISE", "LOWER", and "STOP" and selector switch contacts designated "LOCAL" and "REMOTE."

(2) A push button station located on the door of the controller cabinet with momentary contacts designated "BACKOUT FROM RAISE OVER TRAVEL" and "BACKOUT FROM LOWER OVER TRAVEL."

(3) A push button station, located on the spillway gate remote control board with momentary contacts designated "RAISE", "LOWER", and "STOP."

(4) A synchronous type indicator, located on the spillway gate remote control board to show the gate position.

c. Operating Features

(1) Actuation of the "RAISE" and "LOWER" contacts of the control station[s] must provide seal-in operation.

(2) The position of the "REMOTE-LOCAL" control switch will determine which station is operative.

(3) The remote control must utilize direct current interposing relays.

(4) A limit switch geared or directly connected to the hoist machine, must control the incremental and stopping operations initiated manually from the control station as described under sequence of operation.

(5) Actuation of the "STOP" contact during any operation must stop the hoist motor and set the brake.

2. SEQUENCE OF OPERATION

a. Raising

(1) When the gate is between the closed position and the first intermediate position, each actuation of the "RAISE " contact will cause the gate to raise approximately 0.5 foot and stop.

(2) When the gate is at or above the first intermediate position and

is below the second intermediate position, each actuation of the "RAISE" contact will cause the gate to raise approximately 1 foot and stop.

(3) When the gate is at or above the second intermediate position, actuation of the "RAISE" contact will cause the gate to raise continuously to the raised position.

b. Lowering

(1) When the gate is between the over travel raised position and the second intermediate position, actuation of the "LOWER" contact will cause the gate to lower continuously to the second intermediate position and stop.

(2) When the gate is at or below the second intermediate position and above the first intermediate position, each actuation of the "LOWER" contact will cause the gate to lower approximately 1 foot and stop.

(3) When the gate is at or below the first intermediate position and is above the closed position, each actuation of the "LOWER" contact will cause the gate to lower approximately 0.5 foot and stop.

c. Over Travel. If during normal operation, the gate motor should fail to stop when the gate reaches the raised or closed positions, the over travel limit switch contacts must stop the hoist motor after over travel by de-energizing the "main" or "line" contactor of the controller. To operate the gate after an over travel, the appropriate backout switch contact must be held closed to permit operation of the gate only in the direction away from the over travel position after operation of either the "RAISE" or "LOWER" contact on the primary control station.

Plate No. 5

OUTLET CONTROL DATE
ELECTRICAL CONTROL SYSTEM
DESCRIPTION OF CONTROL SYSTEM
(Single-speed Motor)

1. SCHEME OF OPERATION

a. General. The control system for the gate must be as indicated by schematic control wiring diagram, and as specified below.

b. Control Points. The operation of the hoist motor must be controlled by:

(1) A push button station located on the gate hoist with contacts designated "RAISE," "CONDUIT OPEN," "LOWER," and "STOP."

(2) A push button station located on the gate hoist with momentary contacts designated "BACKOUT FROM LOWER OVER TRAVEL" and "BACKOUT FROM RAISE OVER TRAVEL."

(3) A pendant push button station with momentary contacts designated "INCH UP" and "INCH DOWN," provided with a portable cable of suitable length to permit operation from the inspection room. The cable must terminate in a polarized plug matching receptacle located on motor controller cabinet or other suitable place.

c. Operating Features

(1) Actuation of the "RAISE", "CONDUIT OPEN", and "LOWER" contacts of the push button station must provide seal-in operation.

(2) Actuation of the "INCH UP" and "INCH DOWN" contacts of the pedant push button station must not provide seal-in operation.

(3) Actuation of the "STOP" contact during any operation must stop the hoist motor and set the brake.

(4) A limit switch geared to directly connected to the hoist machine must control the incremental and stopping operations initiated manually from the control station as described under sequence of operation.

2. SEQUENCE OF OPERATION

a. Raising

(1) When the gate is between the closed position and the raised position, actuation of the "RAISE" contact will cause the gate to open continuously to the raised position.

(2) When the gate is between the closed position and the conduit open position, actuation of the "CONDUIT OPEN" contact will cause the gate to open continuously to the conduit open position.

b. Lowering. When the gate is between the over travel raised position and the closed position, actuation of the "LOWER" contact will cause

the gate to lower continuously to the closed position.

c. Inching

(1) To raise the gate above the raised position the "INCH UP" contact must be held closed. The gate will be stopped at upper inch position by the limit switch.

(2) To lower the gate when it is above the raised position the "INCH DOWN" contact must be held closed. The gate will be stopped at the raised position by the limit switch.

d. Over Travel

(1) Over travel limit switches must stop the driving motor if it fails to stop at the raised or closed position on the gate.

(2) The "BACKOUT FROM LOWER OVER TRAVEL" or "BACKOUT FROM RAISE OVER TRAVEL" contact must be held closed to operate the gate from over travel closed and over travel raised, respectively.

Plate No. 6

OUTLET CONTROL GATE
ELECTRICAL CONTROL SYSTEM
DESCRIPTION OF CONTROL SYSTEM
(Multispeed Motor)

1. SCHEME OF OPERATION

a. General. The control system for the gate must be as indicated by the schematic control wiring diagram, and as specified below.

b. Control Points. The operation of the hoist motor must be controlled by:

(1) A push button station located on the gate hoist with momentary contacts designated "RAISE", "CONDUIT OPEN", "LOWER", and "STOP."

(2) A push button station located on the gate hoist with momentary contacts designated "BACKOUT FROM LOWER OVER TRAVEL" and "BACKOUT FROM RAISE OVER TRAVEL."

(3) A pendant push button station with momentary contacts designated "INCH UP" and "INCH DOWN", provided with a portable cable of suitable length to permit operation from the inspection room. The cable must terminate in a polarized plug matching receptacle located on motor controller cabinet or other suitable place.

c. Operating Features

(1) Actuation of the "RAISE", "CONDUIT OPEN", and "LOWER" contacts of the push button station must provide seal-in operation.

(2) Actuation of the "INCH UP" and "INCH DOWN" contacts of the pedant push button station must not provide seal-in operation.

(3) Actuation of the "STOP" contact during any operation must stop the hoist motor and set the brake.

(4) A limit switch geared to be directly connected to the hoist machine must control the incremental and stopping operations initiated manually from the control station as described under sequence of operation.

2. SEQUENCE OF OPERATION

a. Raising

(1) When the gate is between the closed position and the raised position, actuation of the "RAISE" contact will cause the gate to open continuously at low speed to the conduit open position.

(2) When the gate is between the closed position and the conduit open position, actuation of the "CONDUIT OPEN" contact will cause the gate to open continuously at low speed to the conduit open position where the limit switch must cause the gate to open continuously at high speed to the raised position. (3) When the gate is between the conduit open position and the raised position, actuation of the "RAISED" contact will cause the gate to open

continuously at high speed to the raised position.

b. Lowering

(1) When the gate is between the over travel raised position and conduit open position, actuation of the "LOWER" contact will cause the gate to lower continuously at high speed to the conduit open position where the limit switch must cause the gate to close continuously at low speed to the closed position.

(2) When the gate is between the conduit open position and the closed position, actuation of the "LOWER" contact will cause the gate to lower continuously at low speed to the closed position.

c. Inching

(1) To raise the gate above the raised position the "INCH UP" contact must be held closed. The gate will be stopped at upper inch position by the limit switch.

(2) To lower the gate when it is above the raised position the "INCH DOWN" contact must be held closed.

(3) The gate will be stopped at the raised position by the limit switch.

d. Over Travel

(1) Over travel limit switches must stop the driving motor if it fails to stop at the raised or closed position or the gate.

(2) The "BACKOUT FROM LOWER OVER TRAVEL" or "BACKOUT FROM RAISE OVER TRAVEL" contact must be held closed to operate the gate from over travel closed and over travel raised, respectively.

Plate No. 7

INTAKE GATE
ELECTRICAL CONTROL SYSTEM
DESCRIPTION OF CONTROL SYSTEM

1. SCHEME OF OPERATION

a. General. The control system for the gate must be as indicated by the schematic control wiring diagram, and as specified below.

b. Control Points. The operation of the hoist motor must be controlled by:

(1) A push button station located on the gate hoist with momentary contacts designated "RAISE," "LOWER," and "STOP."

(2) A push button station located on the door of the controller with momentary contacts designated "BACKOUT FROM LOWER OVER TRAVEL" and "BACKOUT FROM RAISE OVER TRAVEL."

(3) A pendant push button station with momentary contacts designate "INCH UP" and "INCH DOWN," provided with a portable cable of suitable length to permit operation from the inspection room. The cable must terminate in a polarized plug matching receptacle located on motor controller cabinet or other suitable place.

c. Operating Features

(1) Actuation of the "RAISE" and "LOWER" contacts of the push button station must provide seal-in operation.

(2) Actuation of the "INCH UP" and "INCH DOWN" contacts of the pendant push button station must not provide seal-in operation.

(3) Actuation of the "CLOSE" contact of the emergency lower switch must provide seal-in operation.

(4) Actuation of the "STOP" contact during any operation must stop the hoist motor and set the brake.

(5) A "balanced-pressure switch" with normally closed contact.

(6) A limit switch geared or directly connected to the hoist machine must control the incremental and stopping operations initiated manually from the control station as described under sequence of operation.

(7) Gate position indicating lights as follows:

(a) A red light on push button station and with emergency lower switch indicating gate is in normal operating position.

(b) A green and blue light with emergency lower switch indicating gate is in closed and raised position, respectively.

(c) Am amber light with emergency lower switch indicating gate is closing.

2. SEQUENCE OF OPERATION

a. Raising. When the gate is between the closed position and the raised position, actuation of the "RAISE" contact will cause the gate to open continuously to the raised position. If there is a pressure difference between the two sides of the gate, the gate will stop at the cracked position. After pressure is balanced actuation of the "RAISE" contact will cause the gate to open to the raised position.

b. Lowering. When the gate is between the over travel raised position and the closed position, actuation of the "LOWER" contact will cause the gate to lower continuously to the closed position.

c. Normal Operating Position

(1) The gate is placed in the normal operating position by either the raising or lowering operation described above.

(2) The red light indicates the gate is in normal position.

(3) Actuation of the "STOP" contact of the push button station stops the gate.

d. Emergency Closing. When the gate is between the normal position and the closed position, actuation of the "CLOSE" contact of the emergency lower switch will cause the gate to lower continuously to the closed position.

e. Inching

(1) To raise the gate above the raised position the "INCH UP" contact must be held closed. Gate will be stopped at upper inch position by the limit switch.

(2) To lower the gate when it is above the raised position the "INCH DOWN" contacts must be held closed. Gate will be stopped at the raised position by the limit switch.

f. Over Travel

(1) over travel limit switches must stop the driving motor if it fails to stop at the raised or closed position of the gate.

(2) The "BACKOUT FROM LOWER OVER TRAVEL" or "BACKOUT FROM RAISE OVER TRAVEL" contact must be held closed to operate the gate from over travel closed and over travel raised, respectively.

-- End of Section --