CONSTRUCTION SPECIAL PROVISIONS

FOR

REPLACEMENT OF BRIDGE CONTROL SYSTEM
CAPE FEAR MEMORIAL LIFT BRIDGE OVER THE CAPE FEAR RIVER

WILMINGTON, NORTH CAROLINA

Prepared for:

State of North Carolina Department of Transportation

by

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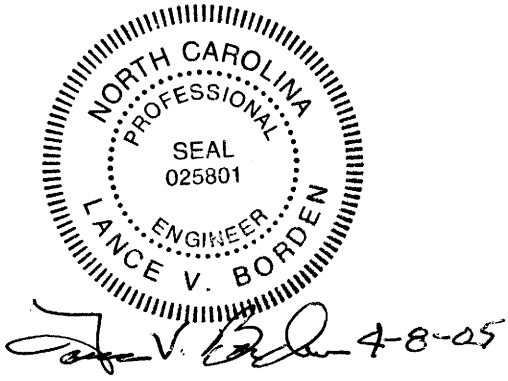

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SECTION 1

GENERAL REQUIREMENTS

1. **DESCRIPTION**

1.1 This work consists of furnishing all materials, equipment and labor, including additional detailing and coordination as may be required, for the furnishing and proper installation of the new bridge control system replacing the existing system to be removed. This work shall be performed in accordance with the Contract Plans and Specifications.

2. **REFERENCES**

2.1 All work and materials as described herein and shown on the Plans shall be in conformance with the applicable sections of the following references unless specified otherwise:

a) American Association of State Highway and Transportation officials:

AASHTO LRFD
MOVABLE HIGHWAY BRIDGE DESIGN SPECIFICATIONS
First Edition with interim revisions.

b) National Fire Protection Association:

NATIONAL ELECTRICAL CODE, 2005

c) National Electrical Contractors Association:

NECA 1-2000, STANDARD PRACTICES FOR GOOD WORKMANSHIP IN ELECTRICAL CONTRACTING

d) North Carolina Department of Transportation:

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
STANDARD SPECIFICATIONS FOR ROADS AND STRUCTURES

3. **SCOPE**

The work for this item includes, but is not necessarily limited to, the following general items of work:

3.1 Provide and install new 600A fused disconnect and metering cabinet at utility service drop and new conduit and cable from utility drop electrical room on the bridge.

3.2 Provide and install new 600 amp, 480/277 volt three-phase, 4-wire, incoming circuit breaker, new 480 volt transfer switch, 240 volt automatic transfer switch and metering equipment.

3.3 Provide and install motor control center, motor starters, equipment disconnect switches, and other distribution and motor control equipment as required.

3.4 Provide bridge control system with new automatic-sequence programmable logic controller based control logic, including necessary cabinets, portable programmer, bridge control console, and all other related devices and instrumentation as required.

3.5 Provide, and install flux vector variable speed drives and encoders for each drive motor.

3.6 Provide and install new aerial cable system, cable and supports across the lift span, replacing the existing submarine cables.

3.7 Provide and install armored riser cables and cable tray on east and west towers.

3.8 Removal of designated electrical equipment.

3.9 Provide structure grounding and electrical grounding systems in accordance with the plans and in compliance with the National Electrical Code.

3.10 Provide spare parts for new equipment, as listed herein, and as required by AASHTO for specific new, or replaced equipment.

3.11 Integrate and coordinate the work in accordance with sequence of construction as listed herein.

3.12 Provide on-site field installation and startup services, simultaneously, by control system vendor's and flux vector drive manufacturer's field service engineers.

3.13 Operate the bridge until such time as the control system is deemed satisfactory and the Department's operators have been trained.

3.14 Provide operation/maintenance manuals as required by AASHTO and further described elsewhere in these specifications.

4. ELECTRICAL CONTRACTOR AND CONTROL SYSTEM VENDOR QUALIFICATIONS

4.1 All bidders are hereby informed of qualifications requirements for the Electrical Contractor and the Control System Vendor. Documentation demonstrating that the Electrical Contractor and the Control System Vendor meet the requirements stated herein shall be submitted 2 weeks prior to the bid opening in a sealed envelope clearly indicating the contents to Mr. Randy Garris, State Contract Officer, Project Services Unit, Century Center Bldg. B., 1020 Birch Ridge Drive, Raleigh, NC 27610. Delivery shall be by Federal Express, UPS or in person. Bids submitted by bidders not meeting all the qualifications requirements of this section, will not be opened. These prequalification requirements are in addition to the requirement of being prequalified by the Contractual Services Unit.

4.1.2 All required previous project references, including names of bridge owners and contact persons with phone numbers, must be submitted with the qualification documents.

4.1.3 No substitution of Control System Vendor will be permitted after opening of bids. The Electrical Contractor will be notified of failure to meet any of these qualification requirements prior to the bid opening.

4.2 Electrical Contractor Qualifications

4.2.1 All bidders are herein informed that the Contractor performing the work on this project must be a licensed Electrical Contractor in the state of N.C., primarily and regularly engaged in the installation and servicing of industrial electrical distribution and controls systems.

4.2.2 All electrical work shall be performed by persons properly trained and qualified in the installation of industrial electrical and control systems. The Electrical Contractor shall provide on-site electrical supervisory personnel who are registered electricians experienced in 480-volt industrial distribution and control systems, and who have been employees of the Contractor for no less than six months prior to award of this Contract.

4.2.3 The Electrical Contractor shall employ a licensed Professional Electrical Engineer, experienced in the design, installation, and servicing of industrial electrical power and control systems, to oversee and coordinate all electrical work. The Electrical Contractor's engineer shall maintain intimate familiarity with the project throughout construction, and shall be on-site to directly supervise work during waterway disruptions, system final adjustments and start-ups, and similar critical tasks.

4.3 Control System Vendor Qualifications

4.3.1 Two (2) weeks prior to the bid opening, each bidder shall identify and submit (as stated in 4.1 above) the intended Control System Vendor (assembler/supplier of the integrated control system), and submit a sufficient previous experience log to verify that the Vendor meets the requirements listed herein. The equipment furnished by the Control System Vendor shall include, but not necessarily be limited to, the PLC, the PLC control logic, resolvers, encoders, all limit switches, flux vector drives, motor control center and the bridge control console.

4.3.2 The Control System Vendor must be able to demonstrate experience in movable bridge control systems by having completed five previous successful movable bridge control systems, at least three of which shall have incorporated a PLC system with flux vector variable speed drives.

4.3.3 The Control System Vendor shall employ a licensed Professional Electrical or Control Systems Engineer, regularly engaged in the design of industrial electrical control systems, who shall supervise all work related to integration, shop assembly, field installation, and start-up of the control system. The Control System Vendor's engineer must be a regular employee of the Control System Vendor or a subcontractor engaged by the Control System Vendor to dedicate not less than 20 hours per week to this project for its duration.

4.3.4 Control System Vendors unable to demonstrate compliance with the above requirements will not be accepted. The Electrical Contractor will be notified of failure to meet any of these requirements prior to the opening of bids.

4.4 **Start-Up Services**

4.4.1 The Control System Vendor shall provide a factory trained field engineer/technician to check out the control system installation on-site, including wiring interconnections as they relate to the control system, prior to the initial operation of the control system. The vendor's field engineer/technician(s) shall remain on-site during system startup for any required adjustments or modifications of the control logic and the flux vector drives.

4.4.2 The field engineer/technician will provide at least three days (eight hours per day) of operating and trouble shooting instructions to the operation and maintenance personnel. The overall project need not be accepted for the instruction period to commence, but the control system operation must be deemed satisfactory by the Engineer and in need of no further major adjustments or modifications. This approval to begin the instruction period does not imply final acceptance of the project or any part thereof.

4.4.3 The Control System Vendor shall also acquire the services of the flux vector drive manufacturer's field services engineer/technician to be on-site with and in addition to his own personnel during the startup and adjustment period. The drive manufacturer's field startup engineer/technician(s) shall be present at time of system startup and adjustment, and remain until the drives are confirmed to be fully operational and properly adjusted. Initial operation of the bridge will not be permitted in the absence of either of these two manufacturers' personnel.

5. SPECIAL SUBMISSIONS

5.1 The Electrical Contractor's electrical engineer shall coordinate and supervise the preparation of all electrical submittals, and fully review and check all submittal items, including those from subcontractors and vendors, prior to submission for compliance with the requirements of the contract documents, compatibility with all new and existing work, and coordination with other submittal items.

5.1.1 All submittals shall clearly and explicitly depict all information required to determine that the component(s) depicted satisfy the requirements of the Contract Documents, are appropriate for the intended use, and are compatible with all new work and existing systems and components. The Contractor is hereby notified that submittals which do not clearly and explicitly depict the required information will be returned for correction.

5.1.2 All submittal items must be approved by the Department prior to purchase, fabrication, or installation of the component(s) depicted. Submittals that have not been approved, or require correction, shall be resubmitted until such time as they are acceptable to the Department. This procedure shall not be considered a cause for delay. The Contractor shall bear all costs or damages that may result from the ordering or fabrication of any materials prior to the acceptance of the submittals, or from schedule slippage or delays due to incomplete or rejected submittals.

5.2 Contractor's Dimensions Coordination

5.2.1 Prior to performing any work on site, the Contractor shall perform the necessary dimensional coordination to determine, verify and/or confirm all relevant dimensions and obtain any other critical data needed to properly coordinate materials and equipment acquisitions, shop drawings, installation and layout drawings, wiring diagrams, etc.

5.2.2 Contractor shall coordinate size of the shipping splits of motor control centers, control console, and any other large components, and overall dimensions and lifting/handling provisions with the respective manufacturers as required for transport of the various system components into the electrical equipment room, the operator's room, tower top machinery rooms or any other locations established for the components. This coordination shall be performed prior to submitting shop drawings, and shall be so noted on the shop drawings.

5.2.3 It shall be further noted on such component shop drawings the timing or construction sequence involved in the components' on-site installation.

5.3 Shop Drawing Submittals

5.3.1 Shop Drawings and Catalog Cuts shall be submitted for all items and components that are proposed for installation, prior to purchase or delivery to site, or commitment to this project. Submittals shall clearly show dimensions and pertinent ratings, and shall be clearly marked or annotated so as to readily identify the intended use.

5.3.2 The Contractor is herewith informed that additional detail development will be necessary as part of the system integration and coordination. All such additional detail development required for proper shop drawing preparation, materials acquisition, and installation shall be included in the price bid for this item of work.

5.3.3 All references on the Contract Plans and in the Specifications to specific manufacturers' model/catalog numbers is for the purpose of describing minimum features and quality. Products of equivalent or better quality and features may be proposed for substitution. In

such cases, the contractor may be required, at no additional reimbursement, to submit a sample of the item for the Engineer's examination and evaluation. Such submitted samples will be returned to the Contractor following the evaluation.

5.4 **Installation Drawing Submittals**

5.4.1 Installation Drawings shall be submitted for approval prior to installation for all items and components where mounting provisions have not been detailed on the contract plans. Installation Drawings shall clearly show Contractor's proposed method of attachment, mounting details, specific hardware, any and all holes to be drilled or cut in existing steel or masonry, etc. These may be in the form of details on 8.5 x 11 inch sheets where appropriate, but must be clearly titled.

5.5 **Layout Drawing Submittals**

5.5.1 Layout Drawings shall be submitted for approval prior to installation of all cabinets, conduits, cables, cable trays, switches, and junction boxes. Layout drawings shall show proposed locations, dimensions, clearances to floors, walls, ceilings, structural members, other objects and equipment, etc.

5.6 **Wiring Diagrams**

5.6.1 Three-line and elementary Wiring Diagrams shall be submitted for approval prior to installation of conduit, cable and wiring. All conductors shall be identified by wire numbers that match the same wires or connections shown on other component shop drawings.

5.6.2 Wiring Diagrams are not intended to be to scale, but are schematic. They shall show all conductors with their associated wire numbers in identified raceways, cabinets, terminal strips within terminal cabinets and equipment enclosures, etc., and in their proper geographic orientation. Wire identification numbers in conduit runs, pull boxes, terminal blocks, etc., must be coordinated and clearly cross-referenced with wire numbers on Contractor's control logic diagrams.

5.6.3 Wiring diagrams for making the power and control circuit connections to each drive shall be provided at the time of control circuit shop drawing submittal. All wires and terminals shall be identified by wire numbers consistent with numbering on all other power and control wiring shop drawings.

5.6.4 Any proposed deviations from the above drawings, once the drawings have been approved, shall be approved in writing by the Engineer prior to performance of the work, and the affected drawings shall be revised by the Contractor to accurately reflect the as-built conditions.

5.7 **Miscellaneous Detail and Drawing Submittals**

5.7.1 In addition to or included in the above required drawing submittals listed above, the following installation details shall be submitted for review and approval prior to accomplishing the respective work:

a. Grounding arrangements for all equipment, explicitly showing grounding conductor size, routing, and connection device.

b. Complete schedule of all electrical equipment, in tabular format, listing each electrical device by its designation as shown on the submitted wiring diagrams, and cross-referenced to such drawings.

c. Wire tabulation in tabular or spread-sheet format, organized by each box or cabinet, for all wire numbers passing through each junction box and terminal cabinet. Tabulation shall also include device served or function of each conductor. Spare conductors shall also be assigned wire numbers, and shall be identified as such.

d. Conduit layout diagrams showing each conduit and raceway utilized, both new and existing, with all wire numbers installed therein, in table or spread-sheet format. Spare conductors shall also be assigned wire numbers.

5.8 **Updated As-Built Drawings On Site**

5.8.1 The Contractor shall maintain on site, a full-size set of working drawings, Installation Drawings, Layout Drawings, and Wiring Diagrams, as described above, as well as Contract Plans, marked up with changes/revisions in red to reflect the as-built or as-installed condition. Such plans and drawings shall be updated weekly, so that no changes or deviations are more than one week old without being recorded on the plans and drawings.

5.8.2 All such as-built or as-installed plans and drawings shall be continuously available for the Engineer's inspection in the Contractor's field office on site, and shall be turned over to the Engineer at the completion of the project.

5.9 **Operating and Maintenance Manuals**

5.9.1 Contractor shall assemble and deliver to the Department, five identical Operating and Maintenance Manuals.

5.9.2 Each manual may be multi-volume, in which case each volume shall be identical bindings (except for thickness), and shall include a volume number in the title (such as Vol.1 of 3, Vol.2 of 3, etc.).

5.9.3 The following features and provisions of the manuals shall be included:

a) Complete Table of Contents covering all volumes, included in each

volume.

b) Operating Instructions, control system description, and trouble shooting charts.

c) Preventative maintenance recommendations/instructions for all new equipment.

d) Manufacturers' literature, product specifications sheets, installation instructions, certified dimensions drawings, replacement parts lists, etc, for all new equipment and systems.

e) As-built drawings: electrical system drawings and wiring diagrams, and barrier gate drawings.

f) Bill of Materials and manufacturers' addresses for all new equipment.

5.9.4 Control system description shall include a detailed description of each device on the control console, one device per page (except indicator lights may be grouped), describing how and when the device is to be used, and what sequential actions are initiated or affected when it used. Also any cautions shall be stated where appropriate.

5.10 **Submittal Tracking**

5.10.1 For the purposes of tracking items throughout the entire submission process, each submittal (shop drawing, catalog cut, wiring diagram, layout diagram, installation detail, calculation set, etc.) shall be assigned a unique tracking number by the Contractor. Where a single catalog cut is comprised of several physical sheets, one tracking number shall be assigned for all sheets. Calculation sets and similar items containing multiple physical sheets shall be assigned one tracking number for each item. All other submittals, including shop drawing sets comprised of multiple physical sheets, shall have an individual tracking number assigned to each sheet. Once an item has been assigned a tracking number, it shall remain the same for all subsequent revisions and resubmissions of the item.

5.10.2 The Contractor shall clearly mark all submittal items with the following information: tracking number, title, contract plan equipment schedule item number (where applicable), and submission number. This information shall be typewritten, or legibly handwritten, on the front of each sheet of a submittal item. Additionally, submittal items which are comprised of multiple physical sheets which are all related to a common tracking number shall be marked with the page number and the total number of pages. Submittal items which are not prepared as required by this Paragraph will be returned unchecked.

5.10.3 Each submittal shall also be assigned a unique, descriptive title. Titles shall not be repeated, either within a single submission or between multiple submissions. Titles shall be descriptive of the function of the item(s) depicted and shall not, to the extent practicable, utilize a manufacturer's part, or model, name or number, or a trade name. (For example, use Liquidtight Flexible Metal Conduit, not Sealtite.) Once an item has been assigned a title, it shall remain the same for all subsequent revisions and resubmissions of the item.

5.10.4 Each catalog cut shall depict only one distinct item. Catalog cuts which cover multiple items will not be considered.

5.10.5 All submissions shall include a cover letter listing the tracking numbers and titles for each item included in the submission. The listing shall also indicate the submission number for each item, as well as the name of the party (contractor, subcontractor, vendor, manufacturer, system integrator, etc.) responsible for originating each item. The letter shall include the following statement: THESE ITEMS HAVE BEEN REVIEWED FOR ACCURACY, COMPLIANCE WITH THE REQUIREMENTS OF THE CONTRACT DOCUMENTS, COMPATIBILITY WITH ALL NEW AND EXISTING WORK OF ALL TRADES, AND COORDINATION WITH OTHER SUBMITTAL ITEMS, AND ARE HEREBY SUBMITTED FOR CONSIDERATION. The cover letter shall be written on the letterhead of the Contractor and signed by the Contractor's authorized representative. For all electrical submittals an additional cover letter, similar to that described above, shall be prepared by the electrical contractor/subcontractor, signed by the electrical contractor/subcontractor's electrical engineer, and included with the submission.

5.10.6 Each Request for Information (RFI), or similar correspondence, shall be clearly marked with a tracking number and title. Both tracking numbers and titles shall be similar to those required for submittal items. Each RFI shall cover only one distinct item.

5.11 Schedule of Submissions

5.11.1 Throughout the duration of the project the Contractor shall maintain a schedule of submissions covering all major submittal items. The submittal schedule shall clearly indicate the following information for each item listed:

Submission tracking number
Formal submission title
Current disposition (approved, returned for correction, not yet submitted, etc.)
Current submission number (first, second, etc.)
Current submission date
Anticipated next submission date

The schedule shall also clearly depict the proposed sequence of submittal items relative to one another. Submission tracking numbers and formal titles need not be shown on the schedule until they have actually been assigned. Anticipated submission dates need not be precise to the day, but should at least indicate the anticipated week of submission.

5.11.2 The initial proposed schedule of submittals shall be submitted within 30 days of contract award for review by the Engineer. This proposed schedule will not be explicitly approved or disapproved, but the Contractor shall make any adjustments deemed necessary by the Engineer. This review does not relieve the Contractor from full responsibility for providing and coordinating all required submittals. No other submittal items will be considered until the proposed submittal schedule has been submitted and reviewed, and the Engineer is satisfied that it is adequate to proceed with submissions.

5.11.3 The submittal schedule shall be updated as often as necessary, but no less than once a month, with updated copies provided to the Engineer. Items which are submitted out of the sequence shown on the submittal schedule, or are not listed on the current submittal schedule, may be returned unchecked. The Contractor shall bear all costs and damages resulting from any

delay due to the submittal schedule being incorrect, incomplete, or out of date.

6. MATERIALS

6.1 Corrosion Resistance

6.1.1 All enclosures, cabinets, and hardware shall be corrosion resistant as follows:

Operators House:	Cabinets and enclosures shall be factory painted with baked enamel finish; screws, bolts, and other hardware shall be plated.
All other locations:	Cabinets and enclosures shall be NEMA 4 stainless steel or cast aluminum; screws, bolts, and other hardware shall be stainless steel.

6.2 Vibration Isolation

6.2.1 The electrical equipment locations on this project are subject to significant vibration generated by roadway traffic.

6.2.2 The motor control center, flux vector drives, PLC and I/O cabinets shall be mounted on spring-type, vibration isolation bases, sized as required for the weight and size of the specific cabinets.

6.2.3 Installation of vibration isolation supports shall be in accordance with the manufacturers recommendations.

6.2.4 All miscellaneous hardware used on the project shall be vibration-proof.

6.3 Identification Labels

6.3.1 Identification labels for each contactor, circuit breaker, fuse, relay, transformer, or any other electrical device individually identified on the shop drawings, shall also be labeled with its own individual engraved nameplate according to its designation on the shop drawings, and located inside each cabinet adjacent to the respective device, and attached with screws.

6.3.2 All conductors, including those of power, control and communications circuits shall be identified at all terminations with machine printed labels. Terminal block connections shall likewise be labeled. Conductor labels shall be heat shrinkable type, permanently marked and resistant to oil and solvents.

6.4 Warning Labels

6.4.1 Switchboards, panelboards, MCC units, control equipment cabinets, terminal

cabinets, individual enclosed circuit breakers, individual enclosed starters, main and auxiliary drive cabinets, disconnect switches, transformers, and similar electrical power system equipment containing energized components which are not fully insulated or shielded when doors are opened or removed shall have warning labels attached to the outside and inside of all doors.

6.4.2 Warning labels shall be full color, UV and weather resistant, and permanently attached. Minimum overall dimensions of labels shall be 2 inches by 4 inches. Labels shall include the following features: red and white "DANGER" header, yellow ISO standard symbol for electrical shock, black legend text: "ARC FLASH AND SHOCK HAZARD, APPROPRIATE PPE REQUIRED." and "EQUIPMENT MAY BE POWERED FROM MULTIPLE SOURCES, LOCKOUT ALL SOURCES BEFORE SERVICING.". Warning labels shall conform to the requirements of NFPA 70E, ANSI Z535.4, and OSHA.

6.5 **Phase Monitor Relay**

6.5.1 True RMS phase sequence and voltage band monitor for use on a 480 volt, 3 phase, 4 wire, grounded system. Relay shall energize for no fault, and de-energize for undervoltage, overvoltage, phase loss, and phase reversal. Shall provide independently adjustable overvoltage (100% to 115%) and undervoltage (85% to 100%) ranges, adjustable time delay from 0.2 to 30 seconds and independent indicator lights for undervoltage, overvoltage, and phase sequence. Relay shall automatically reset after a fault normal power has been restored.

6.6 **Panelboards and Circuit Breakers**

6.6.1 All circuit breaker enclosures, disconnect switches, and panelboards shall be provided with laminated plastic nameplate identifying them according to their designation on the plans. Nameplates shall be attached with brass or stainless steel screws.

6.6.2 Molded case circuit breakers shall be 1-, 2-, or 3-pole as shown on plans, U.L. listed and shall meet NEMA Standard No. AB1 and Federal Specification No. W-C-375B/GEN, where applicable. Circuit breaker voltage and current ratings shall be as shown on plans. Where ratings are not shown, they shall be sized per National Electrical Code.

6.6.3 Molded case circuit breakers shall have over-center, trip-free, toggle-type operating mechanisms, with quick-make, quick-break action and positive handle indication. Two- and three-pole circuit breakers shall be common trip. Each circuit breaker shall have a permanent trip unit containing individual thermal and magnetic trip elements in each pole.

6.6.4 Circuit breaker operating handles shall assume a center position when tripped. All breakers shall be calibrated for operation in an ambient temperature of 40 degrees C. and shall be suitable for mounting and operating in any position.

6.6.5 Lugs shall be U.L. listed for copper conductors. Circuit breakers shall be U.L. listed for installation of mechanical screw-type lugs. All panelboards shall be U.L. listed and factory assembled with ratings as shown on plans.

7. SPARE PARTS

7.1 The following spare parts shall be provided.

Two complete lever arm limit switches of each type used.

Two snap action switches for the rotary cam limit switches.

One indicator light assembly of each color and type used.

Twenty-four indicator light lamps of each type and size used.

One pushbutton of each type used.

One selector switch of each type used.

One display and meter of each type used.

One complete drive motor encoder.

One resolver.

Six fuses of each type and size used.

Two control relays of each type used.

One timing relay of each type used.

Two complete set of replacement contacts for each type of relay with replaceable contacts.

Five surge suppressor replacement cartridges of each type used.

One complete set (movable and stationary) set of contacts and one coil for each type and size of contactor used.

One set of overload relay heater elements of each type and size used.

One complete set of replacement parts for the flux vector drives as recommended by the drive manufacturer.

One complete auxiliary drive gearmotor.

One complete barrier gate arm including warning lights.

One PLC I/O and specialty module of each type used.

7.2 All spare parts shall be boxed according to item in such a manner as to protected from damage and clearly labeled as to contents on the front and top of each box. Gate arm shall be placed in storage area as directed by the department.

8. CONTRACTOR RESPONSIBLE FOR COAST GUARD FINES

8.1 Any and all fines and penalties levied by the U.S. Coast Guard due to failures to open the bridge because of the Contractor's activities or lack thereof, shall be born by the Contractor. See detailed requirements in SECTION 9.

9. OPERATOR AND MAINTENANCE PERSONNEL TRAINING

9.1 Contractor shall provide a formal training program for bridge operators and maintenance personnel. The training program shall consist of two identical training sessions, offered at least one week apart. Specific schedules shall be approved by the Department.

9.2 Each session shall consist of 32 hours (8 hrs. per day, 4 consecutive days) of formal instruction: 16 hours of classroom, followed by 16 hours of hands-on operating and trouble shooting demonstration on the bridge.

9.3 Contractor shall prepare an instruction booklet for the training program. Materials for the instruction booklet shall be concise and brief, specifically designed for this booklet, such as charts focusing on bridge operation and basic trouble-shooting, with references to the appropriate sections of the Operating and Maintenance Manuals for more extensive explanations.

9.4 Contractor shall engage a training program coordinator and training instructor(s) experienced in such training programs, and familiar with electrical equipment such as is being provided on this project.

9.5 The training program layout and syllabus, and the training booklets, shall be submitted for approval prior to scheduling the training sessions.

10. GENERAL INSTALLATION

10.1 The contract plans and specifications depict the general intent of this contract. They are not intended to be of sufficient detail to be used in lieu of shop drawings, layout drawings, and wiring diagrams. Additional detail development is required of and shall be provided by the Contractor to provide and submit these drawings. It shall be the sole responsibility of the Contractor to provide the additional detailing and coordination as necessary to provide a complete, reliable, working system in conformance with the concepts and intent set forth on the plans and in the specifications. All such required additional detailing, coordination,

labor and incidental materials shall be furnished at no extra cost to the Department.

10.2 The work shall be performed in compliance with the National Electrical Code, 2005, and the AASHTO LRFD Movable Highway Bridge Design Specifications. Any discrepancies between the contract plans and specifications, and the two referenced publications shall be brought to the attention of the Engineer for resolution.

10.3 All workmanship shall be of the highest quality. Wiring and conduit, wherever practical, shall be bundled and run neatly, plumb or level, parallel to edges of cabinets, or at right angles. All conductors shall be permanently identified in accordance with the number system shown on the wiring diagrams and shop drawings. Terminal blocks shall likewise be permanently marked.

10.4 Panelboards, circuit breakers, transformers, and all other electrical equipment shall be installed in conformance to manufacturers' instructions.

10.5 All equipment and materials installed or located in areas exposed to weather shall be rated NEMA 4X.

10.6 Conduit and wiring entrances in outdoor cabinets and equipment shall be on sides or bottoms only. Top entrances will not be accepted

10.7 Resolvers, encoders and rotary limit switches shall be aligned by millwrights to the precision and accuracy recommended by the coupling manufacturer. Flexible helical stainless steel couplings shall be used.

10.8 All mechanical work shall be performed by trained machinists, mechanics, and millwrights who are thoroughly experienced and familiar with such work.

10.9 All structural steel work shall be performed by trained ironworkers who are thoroughly experienced and familiar with such work.

11. ASBESTOS

11.1 The Contractor is hereby notified that walls and floor tiles in the control house contain asbestos. The Contractor shall follow proper asbestos abatement, handling, and disposal procedures for any disturbance to the control house walls, and shall remove remaining tiles and adhesives.. The Contractor bears full and sole responsibility for compliance with all federal, state, and local laws, regulations, and rules pertaining to work involving asbestos and asbestos-bearing material. The Department assumes no liability for the Contractor's noncompliance with any such laws, regulations, or rules.

11.2 The Contractor shall submit detailed procedures for the handling, storage, transport, and disposal of all asbestos and asbestos-bearing materials, and for the protection of workers and Department personnel, for review and approval prior to starting work. Such procedures shall be prepared by personnel experienced in such work.

11.3 The Contractor shall provide the Department with record copies of all correspondence to and from, and submittals to, all federal, state, and local agencies regarding asbestos.

11.4 All personnel whose activities may result in exposure to asbestos shall be made fully aware of the hazards of asbestos exposure and have been trained in asbestos control procedures within the past 12 months. The Contractor shall submit proof of such training prior to starting work.

11.5 The Contractor shall provide and maintain all facilities and equipment necessary to protect all workers, including Department personnel, from asbestos hazards.

11.6 Asbestos removal procedures shall be such that Department personnel responsible for bridge operation may continue to occupy the control house to operate the bridge without the use of special equipment or formal training in asbestos hazards. However, the Contractor shall provide detailed briefings on asbestos exposure hazards and the asbestos control procedures and equipment used for this project to all Department personnel whose duties require them to work in or around the control house during periods when the Contractor's activities may result in the disturbance of asbestos or asbestos-bearing material.

11.7 The job site shall be completely decontaminated at the completion of work by an approved and industry standard method. Decontamination shall be confirmed by inspection and air sample analysis by a properly accredited laboratory experienced in such work.

11.8 The Contractor shall bear full responsibility for proper storage, transport, and disposal of all asbestos and asbestos-bearing material in accordance with all applicable federal, state, and local laws, regulations, and rules.

12. LEAD-BASED PAINT

12.1 The Contractor is hereby notified that the existing paint system on the structure includes lead-based primer. The Contractor shall follow proper containment, handling, and disposal procedures for any disturbance to lead-based paint. The Contractor bears full and sole responsibility for compliance with all federal, state, and local laws, regulations, and rules pertaining to work involving lead-based paint. The Department assumes no liability for the Contractor's noncompliance with any such laws, regulations, or rules.

12.2 The Contractor shall submit detailed procedures for the containment, handling, and disposal of all lead-based paint materials, and for the protection of workers and Department personnel, for review and approval prior to starting work. Such procedures shall be prepared by personnel experienced in such work.

12.3 The Contractor shall provide the Department with record copies of all correspondence to and from, and submittals to, all federal, state, and local agencies regarding lead-based paint.

12.4 All personnel whose activities may result in exposure to lead-based paint shall be made fully aware of the hazards of lead exposure and have been trained in lead-based paint control procedures within the past 12 months. The Contractor shall submit proof of such training prior to starting work.

12.5 The Contractor shall provide and maintain all facilities and equipment necessary to protect all workers, including Department personnel, from lead exposure hazards.

12.6 Lead-based paint control procedures shall be such that Department personnel responsible for bridge operation may continue to occupy the control house to operate the bridge without the use of special equipment or formal training in lead exposure hazards. However, the Contractor shall provide detailed briefings on lead exposure hazards and the lead-based paint control procedures and equipment used for this project to all Department personnel whose duties require them to work in or around areas where the Contractor's activities may result in the disturbance of lead-based paint.

13. PAINTING

13.1 All indoor electrical equipment supplied with manufacturer's factory applied enamel paint system need not be repainted, except where such paint has been scuffed, scraped, chipped, or otherwise damaged. Such paint damage shall be spot repaired with a paint of identical type and color to the satisfaction of the Engineer, or the entire component shall be properly cleaned and repainted with an epoxy enamel of similar approved color.

13.2 Paint system for new structural steel and touch-up of paint damaged by the Contractor on existing steel is outlined on the plans.

14. MEASUREMENT AND PAYMENT

14.1 Labor and materials in this section which are not specific to other sections of these Special Provisions, including indoor painting and spare parts, shall be paid for under the contract lump sum bid item Bridge Operating and Control System.

14.2 All labor, materials and other cost related to exposure, handling, storage and disposal of materials containing asbestos and lead shall be paid for under the contract lump sum bid item Control and Handling of Asbestos and Lead Materials

14.3 All labor, materials and other cost related to preparation, painting and touch-up of paint on structural steel shall be paid for under the contract lump sum price for Conduit and Wiring System.

SECTION 2

PROGRAMMABLE LOGIC CONTROLLER AND BRIDGE OPERATING SYSTEM

1. SCOPE

This Section covers the furnishing of all labor, material, equipment, devices and related appurtenances to install, test and put in permanent operation a complete programmable controller system, as shown on the contract plans and described below.

2. PROGRAMMABLE LOGIC CONTROLLER SYSTEM

2.1 Bridge control logic functions shall be performed by a programmable logic controller, such as a Model PLC-5/60, as manufactured by the Allen-Bradley Company, or equal accepted by the Engineer. The PLC processor shall utilize ladder-logic, SFC, and structured text programming, with an advanced instruction set including: file handling, sequencing, diagnostics, shift register(s), immediate I/O, program control instructions, timing, and mathematical functions. Processor memory shall be 64K or larger, battery backed static RAM with EEPROM program backup. Processor shall be capable of interfacing with up to 3072 I/O channels, with a scan time of 20 milliseconds or faster. Processor shall include built-in Remote I/O and 4 channel Data Highway Plus.

2.2 In general, except for specific exceptions, as may be granted by the Engineer, all control logic, timing, counting and other control functions shall be performed by the PLC. All necessary modules, interfaces internal and external to the controlled equipment, and other accessories shall be included to provide a complete working system. Interconnection between processors and I/O racks shall be via Remote I/O. The Remote I/O links to the console rack and the electrical room local racks shall utilize twin axial cable. The primary Remote I/O links to the tower racks shall utilize fiber optic cable, but twin axial cables shall be installed as unconnected backups.

2.3 Two identical PLCs shall be provided, each with its own dedicated power supply. Both PLCs shall be installed and wired in place. One shall be active, and the other shall be in totally de-energized reserve. The reserve PLC and its power supply shall be electrically-isolated from the power source and I/Os via a multipole transfer switch or relay(s). Transfer shall be performed via a maintained position selector switch mounted on the front of the PLC cabinet door. Upon transfer, the previously active PLC and its power supply shall be de-energized and electrically isolated.

2.4 **Uninterruptible Power Supply**

2.4.1 Uninterruptible power supplies (UPS) shall be provided in the PLC and I/O cabinets to provide short term (10 minutes) backup power to the PLC system. Only the PLC

processor and I/O circuits associated with bridge position sensing devices, limit switches, status and alarm circuits, and control console indicators and message display shall be powered via the UPS units. Contactor coil circuits and other power circuits shall not be powered via the UPS.

2.4.2 The UPS shall be a continuously on-line type, and include internal surge suppression and power conditioning.

2.5 **Surge Suppression**

2.5.1 General Control Circuit. The branch circuit supplying the bridge control system shall be provided with surge suppression protection, connected directly to the respective branch circuit conductors on the load side of the branch circuit breaker, at the panelboard supplying the bridge control circuit. Surge suppression device(s) shall be MAINS-MODUTRAB by Phoenix Contact, Inc., Harrisburg, Pennsylvania.

2.5.2 PLC I/O's. All PLC I/O module conductors from devices located outside the PLC cabinet shall be landed on surge suppression terminal blocks such as TERMITRAB-UK 5 or TERMITRAB-URTK/S by Phoenix Contact, Inc., mounted in the PLC cabinet. Suppressor voltage ratings shall be selected as close (low) as practicable to the particular I/O device voltage actually used in order to provide maximum protection.

2.6 **Fusing**

2.6.1 Control circuit conductors which extend between enclosures, such as between the PLC cabinet and MCC or control console, or to external devices, such as limit switches or sensors, shall be fused. Fusing shall be accomplished by landing each hot or supply conductor on fused terminal blocks at the originating enclosure (generally the PLC cabinet). Fused terminal blocks shall be rated 30 amperes at 600 volts AC and include LED or neon blown fuse indicators. Fuses shall be fast acting type, sized three amperes, or as required to prevent nuisance opening under normal operating conditions. Fuse blocks shall be Allen-Bradley 1492-WFB or equal.

2.7 **Input/Output Modules**

2.7.1 Input/output (I/O) modules shall be used which provide LED indicating lights for each input or output on the module as follows.

2.7.2 Input. Lights when field power is applied to input terminal.

2.7.3 Logic. Lights when input module has successfully responded to input; and when output modules have received an "ON" command from the processor.

2.7.4 Load. Lights when control power appears at output terminal.

2.7.5 Discrete I/O, analog I/O, and speciality modules shall be provided as necessary for a complete system. Discrete input modules shall be rated for use with 120Vac control power. Discrete output modules shall be relay type with contacts rated at least 2A at 120Vac. Analog input modules shall be selectable between +/-20Vdc and +/-20mA. Discrete output modules shall provide voltage or current outputs as required by the equipment served.

2.8 **Resolvers**

2.8.1 Resolvers and the associated decoder modules shall be electronically compatible, and shall be submitted together as a subsystem. The contractor shall submit written verification from the decoder manufacturer at the time of shop drawing/catalog submittal that the decoder submitted will perform as required with the submitted resolver. Decoders shall be PLC rack mounted. External power supplies (if used) and all other accessories shall also be included in the subsystem submittal.

2.8.2 Resolvers and decoder modules shall provide resolution as shown on the drawings. Span position indication on the control console shall be resolved to the nearest 0.1 foot. Skew indication on the control console shall be resolved to the nearest 0.1 inches.

2.8.3 Two sets of resolvers and decoder modules shall be provided in each tower: one primary and one backup. Selection of the active resolver shall be accomplished by selector switches on the console which will direct the PLC program which resolver to use.

2.8.4 The control system vendor shall verify the exact number of turns of the resolver drive shaft for full opening of the span and provide gear reduction as required .

2.8.5 Wiring from resolvers to the decoders in the I/O racks shall be selected and installed in strict compliance with the resolver manufacturers recommendations.

2.9 **Relays**

2.9.1 Control relays shall be UL listed NEMA type machine-tool relays. Relay contacts shall be field reversible cartridge type, number as required, plus one spare contact. Contacts shall be rated at least 10 amperes at 300 volts AC, 60 hertz. Relay coils shall be 120 volts AC, 60 hertz. Control relays shall be Allen-Bradley 700-N, or approved equal.

2.9.2 PLC isolation relays shall be provided for all motor starters and other large loads, and as shown on the plans. Relays shall be UL listed general purpose plug-in type relays with DPDT contacts rated 10 amperes at 300 volts AC, 60 hertz. Relay coils shall be 120 volts AC, 60 hertz. Relays shall include pilot light and manual operator. Sockets suitable for DIN rail or panel mounting, with retainer clips, shall be provided for each relay. Isolation relays shall be Allen-Bradley 700-HA, or approved equal.

2.10 **Alphanumeric Display**

2.10.1 Message display shall be a two line LED matrix display as indicated on the plans. Characters shall be 0.7 inch high, 20 characters per line.

2.10.2 The programmable controller shall be programmed to display variable messages on the control console message display for specified faults or conditions. When not providing specific status messages, the display shall show the current date and time of day.

2.10.3 Messages shall include, but not necessarily be limited to, specific information about all faults and warnings.

2.10.4 When a drive fault occurs, the PLC shall interrogate the faulted drive via the Data Highway Plus communication link and display specific information about the nature of the fault.

2.11 **Touchscreen Display**

2.11.1 A touchscreen display shall be mounted in the door of the PLC cabinet.

2.11.2 Touchscreen display shall have 15 inch, backlit, color active matrix display with analog resistive screen. Display shall support 1024x768, 18 bit color.

2.11.3 Touchscreen display shall be configured to provide a backup control point for the bridge. Multiple screens, organized by function, shall be used to prevent clutter and improve readability. A simple menu system shall be accessible from any screen to allow an operator to quickly switch to any other screen with minimal manipulation of menu options. Suggested groupings of screens are as follows:

a) Traffic signals, gates, and barriers.
b) Span locks.
c) Brakes.
d) Span control.
e) Operating mode controls.
f) Additional screens as required.

2.11.4 Displays for span height, span skew, span raise / lower, and status messages shall be visible on all bridge control screens.

2.11.5 Touchscreen display shall permit viewing of real-time and historical information from the datalogging system.

2.11.6 Touchscreen display shall permit adjustment of control system parameters such as timer delays, drive control parameters, span position setpoints, etc. Adjustment of such parameters shall password protected.

2.11.7 A keyed selector switch shall be installed in the PLC cabinet door adjacent to the touchscreen display to select between the following modes: "OFF", "MONITOR", and "CONTROL". In "OFF" mode, the touchscreen shall be powered off. In "MONITOR" mode, it shall be possible to monitor bridge control system operation, but not control any functions. In "CONTROL" mode, the normal control console shall be locked-out (status monitoring still possible) and control shall be from the touchscreen display. The selector switch shall be maintained in "OFF" and "MONITOR" positions, but spring return to "MONITOR" from "CONTROL". If the selector switch is released during operation, a normal stop shall be initiated. The touchscreen display keyed selector switch shall be keyed differently from the control console control power switch.

2.12 **Notebook Computer**

2.12.1 A notebook computer shall be included, with all necessary software, cables and interface module for programming the PLC. Programming capabilities shall include both on-line and off-line programming. The software and interface module shall be furnished by the PLC manufacturer, and shall include extensive documentation. The software shall have provisions for: programming in ladder logic-type graphics language, rung, address and instruction comments, program listings, cross-reference reports and contact histograms.

2.12.2 The notebook computer shall meet the following minimum requirements, unless specified otherwise by the PLC manufacturer: 1.3GHz (or higher) processor, 64Mb system RAM, 40Gb flash memory based hard disk drive, 3.5-inch floppy disk drive, 24X (or higher) CD-RW, 56Kbps internal modem, 13.3" 1024x768 (XGA) outdoor-readable TFT active matrix color LCD touchscreen display, and Windows XP Professional operating system. Shall provide RS-232 serial, parallel, USB 2.0, and 10/100 Ethernet ports. The notebook computer shall be moisture, dust, vibration, and drop-shock resistant, and designed using MIL-STD-810F test procedures. Shall include a 120-volt AC power supply. The notebook computer shall be mounted on a dedicated shelf inside the PLC cabinet. Notebook computer shall be Panasonic Toughbook, or approved equal.

2.13 **Modem**

2.13.1 A modem shall be provided and installed in the PLC cabinet. Modem shall provide for remote monitoring of PLC operation and data acquisition through normal telephone circuits

2.13.2 Provide surge suppressor in telephone line ahead of modem.

2.14 **Cabinets**

2.14.1 The electrical PLC cabinet shall be freestanding style, NEMA 12, constructed of 10 gauge steel. The machinery room I/O cabinets shall be freestanding, NEMA 4X, constructed of 10 gauge stainless steel, and include thermostatically controlled hearing and air conditioning. Cabinet doors shall incorporate suitable size plexiglass windows to provide clear observation of status indicator lights on all PLC's, I/O cards, and all other related peripherals.

2.15 **Miscellaneous**

2.15.1 Control system voltage, in general, shall be 120 volts..

2.15.2 EMI shielding and line filtering shall be included only to the extent required to ensure compatibility and trouble-free operation at this site. Specifically, the equipment shall not exhibit any malfunction, degradation of performance or deviation from specified requirements when subjected to radiated electromagnetic fields of intensities generated by typical marine and aviation radio, radar, or other communications equipment common to the area.

2.15.3 The Contractor shall submit a complete detailed interconnection diagram between all components and a list of equipment to be furnished for approval prior to starting his electrical work. Wire numbers shall be provided on the wiring diagrams. All electrical work shall be strictly in accordance with the requirements of the National Electrical Code.

2.15.4 The Contractor shall submit drawings for any proposed changes to the bridge control circuit for the engineer's approval, showing the ladder-diagram control logic on the left side of the sheet, with the corresponding PLC programming immediately to its right on the same sheet. A listing of the locations of all contacts for each relay or logic element shall be provided on the control circuit drawings. The control circuit drawings shall also illustrate, to scale, the layout of all the PLC system components within the PLC cabinet. These control drawings must be accepted by the Engineer prior to manufacturing of the control equipment. Control system shop drawings will not be accepted without the PLC program ladder-diagram

3. **PROGRAMMING**

3.1 This system is partially automated, such that once the operator performs a few preliminary operations (traffic signals, gates, and barriers) manually from the console, the lift span can be raised or lowered simply by operating the raise-lower selector lever on the console. Operation of span locks, brakes, driver motor speed control, and skew control are all accomplished in the proper sequence, automatically, by the PLC logic. PLC logic shall also assure correct sequence of manually initiated operations.

3.2 The ladder logic shown on the plans is conceptual only. Additional logic development and program writing by the control system vendor will be necessary to complete the program suitable for loading into the PLC.

3.3 The PLC program shall be written so as to accomplish the bridge operating sequence as described elsewhere herein.

3.4 Comments and cross-referencing of locations of all contacts and coils shall be provided as part of the required hard copy of the operating ladder-diagram program, included in the Operation and Maintenance Manual.

3.5 The documented ladder diagram shall be furnished with the shop drawing submittals for approval prior to the control system shop test. Control system shop drawings will not be approved without the ladder-diagram program.

3.6 Bypass Switches mounted on the control console serve to bypass conditions that would otherwise prevent operation from continuing using the PLC. The Bypass Switches always override the limit switches on the devices for which they are named. For example: Span Locks Pulled Bypass completes all lock pulled limit switch actions so that the PLC believes that the span locks have successfully pulled.

3.7 The program shall be written so that once a Bypass switch is activated, the bridge will complete only that one activity, after which the Raise and Lower circuits will both be locked out until the Bypass is restored to its normal non-bypassed position. Example: If a Bypass must be used to complete the Lower operation, it must be reset before the bridge can be raised. Stopping the Raise or Lower shall function as a completion in terms of the above described lock out feature.

3.8 **Fault Handling Procedure**

3.8.1 Fault message displays.

3.8.2 Bridge operating sequence will be interrupted if fault occurs or an interlock is not satisfied.

3.8.3 Operator investigates or calls for assistance. If condition is determined safe to be bypassed, operator will depress applicable pushbutton.

3.9 The PLC processor and most I/O modules are intended to be left continuously energized, regardless of the position of the Control Power switch. Control logic shall be so written that in the event the PLC processor is de-energized at any time during bridge operation, or inactivity, it shall automatically initialize itself and be ready to resume either raise or lower upon restoration of power without regard to the mode or position of operation immediately prior to the de-energizing.

3.10 Bridge Operating Sequence

3.10.1 The bridge control circuit logic shall be so interlocked within itself and with the various limit switches so as to assure that no step in the sequence listed below for opening or closing the bridge can proceed without the preceding step(s) having been properly executed. The interlocking is depicted, in a general sense, on the contract plans, but is not considered complete as for shop drawing use. Additional logic circuit and PLC program detail shall be developed by the Control System Vendor for suitable shop drawing development.

3.10.2 Normal Operation, Raise Span.

3.10.3 Operator turns the maintained contact keyed control power switch to "ON" position. Control power and console devices are energized.

3.10.4 Traffic Signals. The operator switches spring return traffic signal control switch from center position to red. The traffic signals turn yellow for a predetermined (adjustable) delay, then red. Console light indicates that red traffic signals are on. Red warning lights on the gate and barriers begin flashing.

3.10.5 Warning Gates. The operator holds either or both the spring return east and west gate switches in the "CLOSE" position. If the control circuit determines that the traffic signals are red, the gates lower to the closed position. Panel lights indicate that the "GATE LOWERED" limit switches have operated. Gate motors are de-energized.

3.10.6 Traffic Barriers. The operator holds either or both the east and west spring return barrier controls in the "LOWER" position. If the control circuit determines that both traffic gates are closed, the barriers move to the down position. Panel Lights indicate that the "BARRIER LOWERED" limit switches have operated. Barrier gate motors are de-energized. The gongs silence when all gates and barriers are lowered.

3.10.7 If required, the operator depresses the "Signal Horn" button sounding the appropriate signal with the signal horn.

3.10.8 The operator turns and releases the momentary "RAISE" selector. Bridge operation now proceeds automatically.

3.10.9 If the PLC determines that all gates and barriers are in the lowered position, the span lock contactors are closed and locks are pulled out. (Span lock control is in the "Auto" position). Console lights indicate when the "SPAN LOCK PULLED" limit switches have operated.

3.10.10 The PLC commands the drives to run in the raising direction. The brakes release and the motor smoothly accelerates up to Run Speed at a rate of approximately 10% per second.

3.10.11 At the Near Open 1 position the motor smoothly decelerates to Jog Speed at a rate of approximately 10% per second. The "NEAR OPEN" console light illuminates.

3.10.12 At the Near Open 2 position the motor smoothly decelerates to Seating Speed at a rate of approximately 10% per second.

3.10.13 At the Fully Open position the drive motor de-energizes and all brakes set. The rotary cam limit switch changes the span navigation lights from red to green.

3.10.14 The operator signals with the horns, as may be required, indicating that the bridge is open for marine traffic.

3.10.15 Normal Operation, Lower Span.

3.10.16 If "OFF", operator turns maintained contact key switch to "ON" position.

3.10.17 The operator turns and releases the momentary "LOWER" selector. Lowering the span now proceeds automatically.

3.10.18 The PLC commands the drives to run in the lowering direction. The brakes release and the motor smoothly accelerates up to Run Speed at a rate of approximately 10% per second.

3.10.19 The rotary cam limit switch changes the span navigation lights from green to red.

3.10.20 At the Near Closed 1 position the motor smoothly decelerates to Jog Speed at a rate of approximately 10% per second. The "NEAR CLOSED" console light illuminates.

3.10.20 At the Near Closed 2 position the motor smoothly decelerates to Seating Speed at a rate of approximately 10% per second.

3.10.21 At 6 inches above Fully Seated, the drives are switched to Reduced Torque mode and skew control is disabled to allow both ends of the span to seat independantly.

3.10.22 The PLC determines "SPAN SEATED" by indication from all four span seated proximity switches. The four span seating indicators are lighted as the corresponding span seated proximity switches are tripped.

3.10.23 Two seconds after "SPAN SEATED" has occurred the brakes are set.

3.10.24 Two seconds after all brakes are set the drive motors are de-energized and the span locks are driven. The console "LOCKS DRIVEN" indicator light illuminates when all span locks are driven.

3.10.25 The automatic lower sequence is completed. Permissive circuit will now allow manual operation of the traffic control devices by the operator.

3.10.26 Traffic Barriers. The operator holds east and west spring return barrier controls in the "RAISE" position. If the control circuit determines that the lift span is full closed with locks driven, the barriers move to the raised position. Panel lights indicate that the "BARRIER UP" limit switches have operated. The barrier gate motors are de-energized.

3.10.27 Warning Gates. The operator holds the spring return east and west gate switches in the "RAISE" position. If the control circuit determines that the traffic barriers are raised, the gates raise to the "RAISED" position. Panel lights indicate when the gate raised limit switches have operated. Gate motors are de-energized.

3.10.28 Traffic Signals. After performing a visual safety check, the operator moves the traffic signal selector from red to green. If the control circuit determines the traffic gates and barriers are raised, and the span is fully seated and locked, the traffic signals are changed from red to green.

3.10.29 The bridge is now open for vehicular traffic.

3.10.30 The operator switches control power to "OFF".

3.11 "STOP" Functions

3.11.1 The operator can stop span travel at any time, using the normal or emergency stop pushbuttons.

3.11.2 Depressing and releasing the "NORMAL STOP" pushbutton causes the main drive motors to be smoothly decelerated to zero speed at a rate of approximately 10% per second. The brakes are set when the motors are fully decelerated.

3.11.3 Depressing the maintained contact, mushroom head "EMERGENCY STOP" button opens all motor contactors by physically breaking the power supply to the output modules. Brakes are applied without the normal deceleration time. (Simultaneous application of motor and machinery brakes is prevented by preset hydraulic time delays.) This function is intended for emergency situations only. The emergency stop function shuts down the control bus and requires the emergency stop pushbutton manually returned to the "OUT" position before resuming any bridge control functions.

3.12 Skew Monitoring and Control

3.12.1 The PLC shall determine span skew by monitoring the differential position of the east and west ends of the span via the resolvers.

3.12.2 Span skew shall be displayed on the console using the two digital bargraph displays. Each display shall indicate the height of the corresponding side of the span relative to the opposite end of the span (i.e. if the east display shows +2 inches, and the west display shown -2 inches, the east end of the span is two inches above the west end).

3.12.3 The PLC shall directly control the speed of the east and west drives via independent analog speed reference signals to each drive. The magnitudes of the analog speed reference signals shall be based on the state of the control logic and the magnitude of span skew.

3.12.4 The east drives shall be the "master" drives. The analog speed reference signal sent to the active east drive shall be proportional to the speed commanded by the control logic (run, jog, or seating).

3.12.5 The west drive shall be the "follower" drives. The analog speed reference signal sent to the active west drive shall be adjusted by the PLC to minimize span skew by using the following functions:

For Raising the Span: $F = C + (Z * S)$
For Lowering the Span: $F = C - (Z * S)$
Where:
F = Follower Drive Analog Speed Reference
C = Nominal Speed Commanded by Control Logic
Z = Scaling Factor (Initially Set = 1)
S = Span Skew = East Height - West Height

3.12.6 The analog speed signals (in percent of motor base speed) issued to the drives shall be as follows:

		Follower Drive	
State	Master Drive	Nominal	Limits
Run Speed	90%	90%	80% - 100%
Jog Speed	30%	30%	25% - 35%
Seating Speed	5%	5%	3% - 7%

3.12.7 The analog speed reference signals sent to the inactive drives shall be equivalent to zero motor speed.

3.12.8 To facilitate control of span skew by the PLC, the inherit acceleration and deceleration times of each drive shall be set to the minimum possible value, and the PLC shall ramp the analog speed signals sent to the drives to achieve the desired acceleration and deceleration rates. Each drive's stop mode shall also be setup for free, uncontrolled stopping, and the PLC shall ramp the analog speed signals sent to the drives to achieve smooth, controlled deceleration of the motors to zero speed upon application of a "Normal Stop" command from the control logic. The initial acceleration and deceleration rates shall be 10% per second, and all acceleration and deceleration ramps shall be S-curve type.

3.12.9 All settings related to speed and skew control shall be adjusted in the field as directed by the Engineer.

3.12.10 All settings related to speed and skew control shall be adjustable via the PLC touchscreen display.

3.13 **Leveling**

3.13.1 PLC program shall provide that, when "excess skew" fault occurs, control must be resumed in "leveling" mode.

3.13.2 Selecting "east" or "west" in the leveling mode enables only the drive associated with that end of the lift span.

3.13.3 In leveling mode only "jog" speed will be available.

3.13.4 The operator shall have the option to raise or lower east or west end of the lift span, monitoring skew indicators, and correcting skew to within acceptable limits.

3.13.5 With skew within acceptable limits, leveling selector may be turned "off" and operation resumed in normal mode.

3.13.6 Leveling mode shall be available at any time, regardless of the magnitude of span skew.

3.14 **Traffic Signal Controls**

3.14.1 Traffic signal control is accomplished by the PLC. This requires that the PLC processor and certain I/O modules be left energized at all times. The Control Power switch, as shown, will not de-energize the PLC, but will only disable bridge operating logic. Traffic signal control logic shall remain operable with Control Power switch turned Off.

3.14.2 The traffic signal control logic shall be actuated by the respective bridge Control Console selector switches and/or traffic gate and barrier limit switches so that any time a gate or barrier arm is not fully raised, regardless of the position of the Control Console traffic signals selector switches, the respective traffic signals will turn red.

3.14.3 The normal position on the Control Console switch is assumed to be green, in which case the traffic signals shall be green. When the Control Console switch is turned to red, the signals shall turn from green to yellow, remain steady yellow for ten seconds, then turn red.

3.14.4 Gongs begin sounding when signals leave the green condition. The gongs are silenced when all gates and barriers are fully lowered.

3.14.5 Safety interlocking shall be provided in the bridge control circuit logic so that gates and barriers cannot be lowered unless their respective traffic signals are red.

3.14.6 Traffic signals for opposite directions of traffic shall be independently controllable.

4. DATA ACQUISITION SYSTEM

4.1 A data acquisition system shall be provided, installed, and demonstrated to include the features and capability as listed in this section.

4.2 The data acquisition system shall utilize the PLC system notebook computer running custom software.

4.3 The data acquisition system shall be capable of communicating and acquiring data for all of the analog and digital points in the system, plus all spare points. (A "point" references a single address in the PLC that corresponds directly to a memory location).

4.4 The data acquisition system software shall be compatible with the PLC programming software as to allow simultaneous operation of both software packages.

4.5 It shall be possible to select the rate at which data is sampled.

4.6 Software package requires a trending capability to allow trending either real-time or historical data in time-based or X-Y formats.

4.7 Software package must be capable of producing professionally-formatted reports on real-time information, as well as historical information contained in data logs, alarm logs and activity logs. It must be possible to print these reports to a disk or printer.

4.8 Specific data to be recorded includes the following:

a) Time and date at Traffic Signals Red.

b) Time and date at Control Power On.

c) All PLC digital I/O states at Control Power On.

d) All PLC digital I/O state transitions (with time/datestamp, and span height).

e) Bypass usage (with time/datestamp).

f) All alarms and faults (with time/datestamp).

g) Motor torques (via analog signal from the main drives to the PLC), span height, and span skew at 2-3 second intervals.

h) Time at Control Power Off.

i) Time at Traffic Signals Green.

j) Parameters for each operation:
1. Duration of roadway traffic disruption.
2. Raise time.
3. Lower time.
4. East drive motor maximum constant velocity torque.
5. West drive motor maximum constant velocity torque.
6. Maximum span skew and direction
7. Number of warnings and faults.

k) Cumulative parameters:
1. Total usage or each bypass switch.
2. Total span operations.

4.9 Data acquisition system software shall be designed to facilitate future expansion and modification.

4.10 Data acquisition system software shall permit remote access of real-time and historical data via modem connection and PLC touchscreen display.

4.11 Data acquisition system shall include all of the necessary software and hardware required to design, program, test and implement the system.

5. PRELIMINARY TESTING (FACTORY WITNESS TEST)

5.1 All PLC control logic, relays, and other internal control system components shall be assembled in the proper cabinet(s), ready for preparation for shipping (pending any corrections or adjustments necessitated by testing results) before performing this test.

5.2 The control console, the various motor contactors, and the flux-vector drives shall also be connected and utilized for this test. In general, the various motors need not be present, but temporary indicator lights shall be provided and energized through the power contacts of the motor contactors, and labeled according to the direction of motor rotation (i.e., raise, lower, etc) where applicable. Small motors shall be used with the flux-vector drives.

5.3 Toggle switches and/or selector switches, properly labeled and configured, may be substituted for limit switches for this test. All operations of the control sequence

must be demonstrated for this test. Any errors found in the system shall be corrected and the test rerun, to the satisfaction of the Engineer.

5.4 This test shall be conducted in the presence of the Department's representative. Accordingly, the Department shall be notified at least two weeks prior to the test date.

6. INSTALLATION

6.1 The PLC's, complete with required power supplies, input and output modules shall be installed in cabinets as described herein or as may be shown on the drawings, prior to shipment to the site.

6.2 All terminal blocks shall be clearly labeled to facilitate field connections. Labels shall be clearly readable and smudge-free.

6.3 The PLC and tower top I/O cabinets shall be sized as required, or break down as may be necessary, for transport and access into the control house and tower top machinery rooms. The tower top cabinets shall be climate controlled.

6.4 The PLC vendor shall alert the Contractor with respect to any special requirements for grounding of the system, shielding of conductors or other isolation of equipment or conductors. The PLC vendor shall provide instructions to accomplish special grounding or shielding requirements.

7. MEASUREMENT AND PAYMENT

The Programmable Logic Controller and all related Bridge Operating System components and appurtenances, including required tests, will be paid for at the contract lump sum bid item for Bridge Operating and Control System.

SECTION 3

MAIN DRIVES

1. SCOPE

This Section covers the furnishing of all labor, material, equipment, devices and related appurtenances to install, test and put in permanent operation a complete new flux-vector based variable speed main drive system as shown on the contract plans and described herein.

2. SUBMITTALS

2.1 Manufacturers catalog sheets shall be submitted for all main drive system components.

2.2 Complete shop drawings shall be submitted for the main drive system. Shop drawings shall include complete wiring diagrams showing internal and field interconnection of all drive system components, dimensioned cabinet layout drawings, and dimensioned dynamic braking resistor drawings.

2.3 Submit calculations verifying dynamic braking resistor sizing and selection.

2.4 Submit manufacturers installation and operation manuals for all components. Manuals shall be new, bound copies, and shall be edited to remove information not related to the actual model(s) and options provided.

2.5 Submit a complete listing of drive programmable parameters showing the proposed setting(s) for each. Where necessary, provide commentary to explain purpose of settings.

3. PRODUCTS

3.1 Flux-Vector Drive

3.1.1 Three phase AC drive providing true closed loop (encoder feedback) flux vector speed and torque control of an induction motor.

3.1.2 Drive shall be UL Listed.

3.1.3 Voltage and current ratings shall be as shown on drawings and as required for compatibility with the existing main drive motor. Drive continuous output current rating shall be at least 115% of motor rated full load current.

3.1.4 Drive shall utilize static (contactorless) reversing control.

3.1.5 Drive shall be capable of continuously providing 100% rated motor torque from zero to base speed, and 150% overload for one minute.

3.1.6 Speed regulation shall be 0.02% or better.

3.1.7 Nominal efficiency shall be 96% or better.

3.1.8 Displacement power factor shall be 0.95 or better.

3.1.9 Drive shall be operable from 0 to 40 Celsius without derating, and 5% to 95% relative humidity (non-condensing).

3.1.10 Drive shall utilize sinusoidal PWM output modulation using insulated gate bi-polar transistors. Carrier frequency adjustable from 1 to 6kHz.

3.1.11 Drive shall utilize microprocessor based control. Shall include an operator interface, with backlit LCD display and keypad, usable for drive status monitoring and adjustment of all parameters.

3.1.12 Operating modes fully programmable and selectable via external control inputs as required. Drive shall be configured for operation as depicted on the drawings.

3.1.13 Programmable parameters and at least the last four faults shall be stored in non-volatile memory.

3.1.14 Drive shall provide at least 8 programmable discrete inputs, 4 discrete outputs, 2 analog inputs, and 2 analog outputs.

3.1.15 Drive shall include built in communication capability including Data Highway Plus. Shall be capable of interfacing with PC based monitoring and programming software. Provide a copy of software along with all necessary cables, hardware, and manuals.

3.1.16 Drive shall provide for at least 4 preset speeds selectable via external discrete control input, as well as external analog speed reference. Shall provide for multiple independently adjustable acceleration and deceleration times selectable via external discrete control input. Drive shall provide for multiple independently adjustable driving and braking torque limits selectable via external discrete control input, or external analog torque limit reference.

3.1.17 Protective features shall include: overtemperature, overvoltage, undervoltage, ground fault, overcurrent, output short circuit, CPU error, electronic inverse time motor overload per UL standards, and motor stall protection (with adjustable time delay).

3.1.18 Manufacturer of drives shall be regularly engaged in the manufacture of flux-vector drives, and have produced such products for a period of at least 10 continuous years prior

to the project bid date. Manufacturer shall provide factory-trained field service personnel experienced in the installation and start-up of their products. Manufacturer shall be able to demonstrate experience in the application of flux-vector drives with wound-rotor motors by having successfully completed 3 such projects in the past 5 years. Documentation that the drive manufacturer satisfies these requirements shall be included with the drive system submittals.

3.2 Main Switch

3.2.1 UL Listed molded case or cabinet disconnect type with flange mounted operating handle. Operator mechanically interlocked with cabinet door and lockable in off position.

3.2.2 Three pole. Ratings as shown on drawings and as required for drive.

3.3 Input Fuses

3.3.1 UL Listed high speed, current limiting semiconductor protection fuses.

3.3.2 Sized by drive manufacturer.

3.4 Input Reactors

3.4.1 UL Recognized, three phase, 3% impedance input line reactor for use with inverter drive systems.

3.4.2 Specifically designed for use with AC adjustable speed drive systems.

3.4.3 Sized as required for drive.

3.5 Output Filter

3.5.1 UL Listed, three phase, output filter specifically designed for use with AC drives to limit voltage spike magnitude, voltage spike rise time, and reflected wave voltage.

3.5.2 Sized as required for motor and drive.

3.5.3 Shall not cause any degradation to speed and/or torque regulation performance of drive system.

3.6 Output Contactors

3.6.1 UL Listed, three pole, electrically held, magnetic contactor.

3.6.2 Field replaceable contacts.

3.6.3 Sized as required for drive.

3.6.4 120 volt AC coil.

3.6.5 Auxiliary contacts as required.

3.7 Dynamic Braking Resistors

3.7.1 Resistors and related hardware shall be sized by the drive manufacturer to provide braking torque of at least 100% rated motor torque at 100% duty cycle.

3.7.2 Resistors shall be edgewound stainless steel, mounted in stainless steel ventilated enclosures with rainhoods. All hardware shall be stainless steel or similarly corrosion resistant.

3.7.3 Braking transistor units and similar hardware shall be mounted in the cabinet of the drive served.

3.7.4 Resistor shall be protected from overload by an appropriately sized melting alloy thermal overload relay.

3.8 Drive Interface Relays

3.8.1 UL Recognized general purpose miniature relay for use in interfacing low voltage transistor outputs to 120 volt AC control circuits.

3.8.2 Shall be identical to PLC system interposing relays.

3.8.3 Number of relays as required, at least one per transistor output (used and unused). Additional relays as required to provide at least two sets of spare contacts per transistor output.

3.9 Control Transformers

3.9.1 UL Listed totally encapsulated industrial control transformer.

3.9.2 Copper windings.

3.9.3 Voltage regulation meeting or exceeding NEMA ST1.

3.9.4 Ratings as shown and as required for equipment served.

3.9.5 Primary and secondary fuses per NEC.

3.10 Cabinets

3.10.1 UL Listed heavy duty, free standing, disconnect type industrial control enclosure.

3.10.2 10 gauge or heavier steel with continuously welded seams. All welds ground

smooth.

3.10.3 Fully gasketed NEMA 12.

3.10.4 Heavy duty lifting eyes.

3.10.5 Stiffeners as required.

3.10.6 Three point latching mechanism with lockable handle. Mechanism interlocked with main switch.

3.10.7 10 gauge steel inner panel for equipment mounting.

3.10.8 Filtered louvers and fan.

3.10.9 Fluorescent light and receptacle.

3.10.10 Polyester power coat finish (inside and out).

3.10.11 Size and additional features as noted on the drawings and as required for enclosed components.

3.11 Main Drive Motor Encoders

3.11.1 Mill duty, bi-directional, quadrature, incremental encoder.

3.11.2 24 volt differential line driver output. Pulses per revolution as required by main drives.

3.11.3 NEMA 4, foot mounted, cast aluminum housing. Heavy duty ball bearings. 5/8 inch shaft.

3.11.4 Maximum 3600 RPM shaft speed. Operable from -40 to +80 Celsius. Rated for at least 50 G's shock for 11 milliseconds, and 5 to 2000 Hz vibration at 20 G's.

3.11.5 LED output indicators.

3.12 Encoder Splitter

3.12.1 Capable of splitting one encoder input into two independent and completely isolated outputs.

3.12.2 Line driver outputs. Independently adjustable output voltage levels.

3.12.3 Optically isolated inputs.

3.12.4 Compatible with quadrature or single channel inputs, with or without compliments. Capable of creating compliment outputs from an input without compliments.

3.12.5 Coordinate configuration with main drive motor encoder and main drives.

3.13 Additional Hardware

3.13.1 Provide all additional and miscellaneous hardware and components as may be necessary to make a complete system.

3.13.2 All point-to-point wiring internal to the drive cabinets shall be stranded copper with Type XHHW insulation. Control wire shall be minimum 14 AWG. Power wire shall be sized as required.

3.13.3 Terminate all field control wiring in the drive cabinet and at the encoder splitter on surge suppression terminal blocks. Coordinate ratings with circuits served.

3.13.4 Terminate incoming line side power conductors to the drives on surge suppression terminal blocks capable of discharging at least 20,000 amperes of surge current. Surge supressors shall include internal thermal disconnect devices and contacts for remote signaling of disconnect operation. Remote signaling contacts shall be connected to the drive external fault input. Surge supressors shall be as manufactured by Phoenix Contact, or approved equal.

4. EXECUTION

4.1 General

4.1.1 The contractor bears final and full responsibility for all coordination necessary to ensure compatibility of new and existing materials, equipment, and systems.

4.1.2 Exercise care in removal of old components and installation of new components to avoid damage to existing portions of the bridge drive machinery. Contractor bears full responsibility for any damage which may occur to existing portions of the bridge machinery during construction.

4.1.3 Install equipment in strict accordance with manufacturer's recommendations and the NEC.

4.2 Drives

4.2.1 Each flux vector drive shall be packaged together in its respective cabinet along with its main switch, input reactor, output contactor, and related hardware and components. Complete drive package shall be assembled and configured by the control system vendor.

4.2.2 All components housed within the drive cabinets shall be mounted on the inner

equipment mounting panel. Plastic wireways with removable covers shall be used for bundling conductors between components.

4.2.3 The control system vendor shall provide the drives, dynamic braking resistors, encoders, encoder splitter, and all related components as a complete and functional package.

4.2.4 Drive cabinets shall be installed level and plumb in final locations by bolting to the floor, and the wall near the top of the cabinet, with spring type vibration isolators.

4.3 Main Drive Motors Modifications

4.3.1 The nameplate data of the existing main drive motors is as follows:

Wound rotor
100 horsepower
460 volts
3 phase
60 hertz
590 RPM
1 ½ hour
151 amperes primary
221 volts, 208 amperes secondary
GE Model 5M828837A1
SN GD8367623
Frame 8288Z, Type M

4.3.2 All modifications to the existing main drive motors shall be performed by a reputable motor service shop with experience in the service, modification, and rewind of wound rotor motors. Documentation that the motor service shop satisfies these requirements shall be submitted for approval prior to modification of the existing main drive motors.

4.3.3 Prior to their use with the new flux-vector main drives, the secondaries of the existing wound rotor motors shall be shorted together, either by tying the secondary brushes together or by attaching shorting bars across the secondary slip rings. The method to be used shall be explicitly approved by the main drives manufacturer. Written proof of such approval shall be submitted to the Department along with the modification methods and procedures required below. If shorting bars are used the attachment method shall be as determined by the motor service shop, and they shall be installed symmetrically around the rotor such that they will not unbalance the rotor during operation. The proposed modification methods and procedures shall be submitted for approval prior to modification of the existing main drive motors.

4.3.4 Prior to the end of the project, the existing main drive motors shall be removed from the towers and transported to the motor service shop for rehabilitation. Motors shall be rewound as inverter duty, induction motors with Class H spike resistant winding insulation satisfying the requirements of NEMA MG1-31. The secondary brushes and slip rings shall be removed and the secondary windings tied directly together. Motor bearings shall be replaced with

stainless steel ball bearings. Motor frame and shafts shall be carefully inspected for damage, and any damage immediately reported to the Department for determination of additional repairs. Frames shall be repainted prior to reassembly of motor.

4.4 Commissioning and Start-Up

4.4.1 The contractor shall engage a factory-trained technician for commissioning and start-up of the drives.

4.4.2 The technician shall thoroughly evaluate all power and control wiring prior to the first application of power to the drives and correct any errors found.

4.4.3 The technician shall make any final adjustments as may be necessary for proper and reliable operation, and as may be directed by the Department.

4.4.4 The technician shall remain on-site until it is satisfactorily demonstrated to the Department that the drives are operating reliably and properly and that no further adjustment is necessary.

4.5 Training

4.5.1 Training on the main drives, including programming and troubleshooting, shall be provided as part of the control system training described elsewhere in these special provisions.

5. MEASUREMENT AND PAYMENT

The complete Main Drive System, installed and tested, and including all required components and appurtenances, will be paid for at the contract lump sum bid price for the Bridge Operating and Control System.

SECTION 4

MOTOR CONTROL CENTER

1. DESCRIPTION

This section covers the furnishing of all labor, material, equipment, and related appurtenances to install and put into permanent operation the new Motor Control Center as shown on the contract plans and described herein.

2. MATERIALS

2.1 Motor Control Cabinet (MCC) Assemblies shall be NEMA 12 construction. Panel mounted devices shall be corrosion resistant to the extent possible. Unit latches, door hardware, wireway barriers, unit support pans, and other implanted parts shall be suitably plated for resistance to corrosion in damp salt-laden atmosphere.

2.2 Motor Control Center shall be UL listed. Wiring shall be NEMA Class II, Type C, with master terminal boards. Each cabinet shall be dead front construction with vertical buses connected to horizontal bus when required.

2.3 The MCC Cabinets shall consist of vertical sections bolted together to form a rigid, freestanding assembly. Vertical sections shall be approximately 90" high, 20" deep. All weight bearing members and conduit entry roof plates shall be 12 gauge steel or heavier.

2.4 MCC Cabinets shall be suitable for operation with bus voltage of 480/277 volts, 3-phase. Control and coil voltage shall be 120 volts, 60 hertz.

2.5 The MCC shall be provided with a multi-function power monitor to include a front panel mounted digital display of system voltage, amperes, and power. Volts and amps display for each phase shall be selectable. Monitor shall have provisions for a remote display of all parameters.

2.6 Both the horizontal and vertical bus shall be supported and braced to withstand 65,000 RMS symmetrical amperes.

2.7 The main horizontal bus bars shall be tin-plated copper, electrolytically tin plated, and rated 600 amperes. The bus shall be one continuous piece and extend the full length of the assembly, except where split for shipment, in which case, the bus shall be continuous in each shipping block with a splice kit supplied as required to interconnect the buses in the field.

2.8 Vertical bus shall be copper, electrolytically tin plated, rated 300 amps minimum. The horizontal ground bus shall be tin-plated copper, rated 300 amps minium, and located in the horizontal wireway, top or bottom. Ground lugs shall be provided as standard.

2.9 Horizontal wireways shall be provided both top and bottom. The wireways shall be completely isolated from all buses. A full height vertical wireway shall be provided in each standard vertical section, and shall be completely isolated from the buses. A separately removable hinged door with 1/4 turn pawl-type latches shall cover the vertical wireway. Wire ties shall be furnished and utilized in the vertical wire trough to group and securely hold wires in place.

2.10 Each combination starter unit or other unit configuration shall have an individual door giving access only to that unit. Doors shall have concealed hinges and minimum of two 1/4 turn fasteners. Doors shall be interlocked to prevent opening when the device is in the "on" position. Removable blank doors shall cover all unused unit spaces and shall be provided 1/4 turn fasteners.

2.11 Operating handles on each unit shall be padlockable in the "off" position. Units shall have padlockable test/maintenance position providing positive removal from the power bus. It shall not be possible to close the door when the unit is in the de-energized test position.

2.12 Combination starter units shall connect to the vertical bus with a single stab block on the back of the unit. Stabs shall be hardened copper, tin plated and spring assisted.

2.13 Motor starter units shall be provided with thermal magnetic molded case circuit breakers, or instantaneous trip breakers (motor circuit protectors), sized in accordance with the National Electrical Code. Instantaneous trip breakers shall not be sized larger than or adjustable to more than 1300 percent of motor full load current. The circuit breaker shall have a clearly marked trip position.

2.14 Motor starter units for the span locks, warning and barrier gates, motor and machinery brakes shall have manual operating controls on the doors of the respective units.

2.15 Motor feeder circuits shall be rated not less than 140 percent of motor rated full load current.

2.16 Overload relays shall be ambient compensated Class 20 bimetallic, manual reset type, except main drive motor overloads shall be as specified with, and integral to the flux vector drives. Heater elements shall be removable. Overload relay shall provide single phase protection. Electrically isolated NO and NC contacts shall be provided on the relay. Integral adjustment shall provided.
A test trip feature shall be provided for trouble shooting.

2.17 Control transformers shall be utilized for motor starters when necessary to limit control circuit loading, and shall be totally encapsulated, 65VA minimum, with primary and secondary fuses.

2.18 Incoming line/disconnect section shall have an engraved nameplate with the MCC serial number, system electrical data, bus ampacity, and the bus short circuit rating.

2.19 Engraved plastic nameplates bearing the name of the equipment served shall be provided on each unit of each MCC cabinet. Nameplates shall be permanently attached to the front of each unit with small brass or stainless steel machine screws.

2.20 Each contactor, circuit breaker, relay, and transformer shall also be labeled with its own individual engraved nameplate according to its designation on the shop drawings, and located inside each MCC unit adjacent to the respective device.

2.21 Half-height units shall not be used.

3. INSTALLATION

3.1 Shipping splits shall consist of one, or two 20" wide sections. Each split shall have heavy-duty steel lifting eyes and shall be bolted to a wooden skid. Contractor shall coordinate size of the shipping splits and any additional lifting provisions with manufacturer as required for transport into the electrical equipment room. All splicing of bus bars and other reconnecting of MCC sections shall be detailed and included in the Contractor's shop drawings for MCC.

3.2 The motor control center shall be mounted on spring-type vibration isolators. Vibration isolation devices shall be sized and located in accordance with recommendations of the vibration isolation equipment manufacturer.

4. TESTING

4.1 The completed Motor Control Center shall be tested to the extent possible in conjunction with the PLC, flux vector drives and control console and witnessed by the engineer and NCDOT's representative before shipment to the project site. Tests shall be in accordance with the bridge control system testing procedure outlined elsewhere in these Special Provisions.

5. MEASUREMENT AND PAYMENT

The Motor Control Center will be paid for at the contract lump sum bid price for the Bridge Operating and Control System.

SECTION 5

SPAN BALANCING

1. GENERAL

This section includes adjusting lift span balance prior to commencing construction, maintaining the lift span within temporarily acceptable balance conditions throughout the construction period, and adjusting the lift span balance to the final balance requirements at the completion of construction.

1.1 Description of Work

Provide all apparatus, equipment, tools, devices, materials and labor to adjust and maintain the balance condition of the bridge in an approved manner as described herein.

The work includes maintaining the proper balance of the lift span during construction in accordance with the specifications and contract drawings or as directed by the Engineer. This shall include all adjustments as required to meet the specified span balance conditions for three distinct phases of the construction, as follows:

- Before commencing construction activities: The Contractor shall determine the span balance condition and bring it into a temporary imbalance condition within the limits stated for "Temporary Imbalance During Construction" in section 2.1.2 below. This work requires determining the balance condition by the strain gage method (paid for under separate item).
- During construction, and after all other construction activities are completed: This work includes development and continuous updating of a suitable span balance spreadsheet during all construction activities.
- Final balance after all other construction activities completed: The Contractor shall make all final balance adjustments as required elsewhere herein. This work requires confirming the balance condition by the strain gage method (paid for under separate item). If the strain gage balance testing results in this phase necessitate the transfer of more than 5,000 pounds of weight at either counterweight, the strain gage testing shall be repeated following the weight transfer.

In order to add the appropriate amount of weight to the existing counterweight pockets, approximately 120 existing concrete balance blocks shall be removed from each counterweight prior to placing the new higher density steel plate balance blocks shown on Drawing No. 45 of the plans.

Maintain the lift span balance throughout the construction duration by tracking all weight additions and removals and their span/counterweight location on a spreadsheet which is properly programmed to indicate span balance conditions at each corner of the lift span. Tracking and spreadsheet updating shall be performed daily, and adjustments made as required to maintain span balance within the stated allowable limits at all times.

1.2 **References and Standards**

1.2.1 The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only. The latest revisions only shall be used for all references.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A36/A36M Carbon Structural Steel

1.3 **Quality Assurance.**

1.3.1. Quality Control

The Engineer shall be notified immediately for clarification and resolution whenever any portion of work is not clearly or accurately defined or dimensioned.

1.4 **Submittals**

1.4.1. General

The Contractor's shop drawings shall clearly show the weights to the nearest pound of all components being mounted on or attached to the lift span or the counterweights. These component weights shall be included on the span balance spreadsheet and submitted on a weekly basis to the Engineer for approval. The Contractor shall submit complete details for approval, procedures and diagrams showing the sequence and details for erection/installation, including the proposed weight adjustments for each phase or step in the sequence.

1.4.2 Procedures

a. Approval of Procedures. Specific and detailed procedures for maintaining the lift span balance within the allowable limits at all times shall be developed and submitted to the Engineer for approval prior to commencing construction.

b. Span Balance Spreadsheet. A weight-based span balance spreadsheet shall be developed and submitted to the Engineer for approval prior to any activities that could affect span balance conditions. The spreadsheet shall be updated on a daily basis, or more frequently when necessitated by the Contractor's activities which involve adding to or subtracting weight from the lift span or the counterweights. The spreadsheet shall include specific details of all anticipated additions and removals of weight of any kind to the lift span and counterweights, and shall be utilized to determine the interim balance adjustments needed throughout the construction duration. During construction, the spreadsheet shall be maintained on a daily basis and shall be available for review by the Engineer at any time. The spreadsheet shall be submitted to the engineer prior to each installation or removal, either temporary or permanent, that would alter the lift span balance by 2,000 lbs or more. During the times when the bridge is movable, motor amperage

shall also be recorded at the following three points of travel (but shall not include acceleration and deceleration surges): within approximately five feet of seated, at mid height, and within approximately five feet of fully open.

2. EXECUTION

The span reaction at each corner, with the lift span in the seated position shall conform to the loading shown in the Balance Table herein. The removal of existing concrete balance blocks and/or the addition or removal of new steel plate balance blocks at each counterweight shall be used to correct the deviation from the desired balance condition at any given time.

The Contractor shall be responsible for all labor and materials required to provide an acceptable balance condition, as directed by the Engineer.

2.1 Lift Span Balancing

2.1.1 Maintaining Span Balancing

The Contractor shall determine, maintain and adjust the lift span balance in the acceptable limits stated in section 2.1.2 below, and in accordance with other specific requirements detailed elsewhere herein, throughout the following three general periods of this contract: 1) following the initial strain gage balance testing prior to commencement of any other construction activities on the site; 2) during construction as often as indicated by the span balance spreadsheet; and 3) for final balance adjustments as determined by the final strain gage balance testing following the completion of all other site activities.

a. Initial span balance prior to start of construction. Before commencing any construction activities on site, the Contractor shall determine the current span balance condition and bring it into a temporary imbalance condition within the limits stated for "Temporary Imbalance During Construction" in section 2.1.2 below. This requires determining the initial balance condition by the strain gage method (paid for under separate item), and making the necessary adjustments to the counterweights.

b. Weight distribution during construction. The Contractor's Spreadsheet described above shall track, throughout the duration of the construction phase, both the transverse and longitudinal center of gravity locations of all items added to or subtracted from the lift span, relative to the bridge centerline. The Spreadsheet shall reflect the actual work plan and sequence of construction. Temporary adjustments shall be made to maintain the balance condition within the stated limits at all times. The Contractor shall provide, install and remove balance blocks as needed to maintain the required lift span balance. Copies of the daily balance spreadsheet report shall be made available to a Structural Engineer registered in North Carolina for verification of stability and balance each day after any weight distribution has been affected. If at any point there is an imbalance exceeding acceptable limits specified in 2.1.2, the Engineer shall be immediately notified and bridge operators shall be advise not to operate the bridge until the Engineer determines that it is safe to do so.

c. Motor amperage. When the bridge span is movable, the change in the motor amperages recorded shall be noted on the weight spread sheet to correlate the calculations and changes in weight distribution with bridge operating system performance. Changes shall be tracked from initial pre-construction conditions throughout the entire duration of the project, when applicable. The motor amperage, upon final completion of the work and confirmation of final balance, shall be furnished to the Engineer prior to acceptance.

d. Transverse balance effects. The Contractor shall remove or add the counterweight adjustment weight in such a manner as to maintain lift span balance transversely at each end. The Contractor shall also adjust the flexible adjustable torque couplings in the drive train in each tower top, as required, to achieve transverse load sharing of the drive pinions in each tower top as part of these balance adjustments. Load sharing of the drive pinions shall be determined from the required strain gage balance testing data. See Section 2.1.2, Acceptable Balance.

e. Steel plate balance blocks. Steel plate balance blocks for balance adjustments shall be provided from ASTM A36 steel plate as shown on the plans for adjusting the span balance condition. Each individual steel balance block shall be painted with one coat of self-curing inorganic zinc primer in the shop prior to shipping to the site, in accordance with Standard Specifications Section 1080-7.

f. Removal of existing concrete balance blocks. The Contractor will be required to remove a portion of the existing concrete balance blocks from the counterweight pockets to make room for installing a sufficient number of higher density steel balance blocks.

2.1.2 Acceptable Balance

The Contractor shall maintain the lift span within acceptable balance limits according to the operating conditions. Acceptable balance shall be determined according to the reaction at each end of the lift span due solely to imbalance while fully seated (down), as shown in the Balance Table below.

Balance Table

Operating Condition	*Acceptable Imbalance Limits at each End of Lift Span*
Temporary Imbalance During Construction - Lift Span Operational	500 to 10,000 lbs span heavy
Lift Span Final Balance Condition	2,000 to 3,000 lbs span heavy

Note: Transverse balance difference between both corners of lift span at the same end shall not exceed 2,000 lbs at any time the bridge is operational.

2.2 **Pay Items**

2.2.1 Lift Span Balancing

This item includes the labor for the development and maintaining of the required balance spreadsheet, the maintenance of acceptable balance during construction, and the periodic shifting or transferring of weight for the adjustments of the span balance. These prices shall include all labor, equipment and incidentals necessary to satisfactorily complete the work in accordance with the plans and specifications, but not the furnishing and initial installation of the new steel balance blocks. The furnishing of the necessary amount of new steel balance blocks and the labor to install them one time shall be measured and paid for under separate bid item, Steel Balance Blocks, as described below.

2.2.2 Steel Balance Weights

This item consists of furnishing the materials and labor for installing the new steel balance weights, as detailed on the plans. Steel Balance Weights shall be measured per pound, for the net amount furnished, and for labor to be installed one time. The labor for periodic removal and re-installation of steel balance blocks for various balance adjustments throughout the construction period shall be paid for under a separate pay item, Lift Span Balancing.

2.2.3 Removal of Concrete Balance Blocks

This item consists of removing a portion of the existing concrete balance blocks from the counterweight pockets to make room for installing a sufficient number of higher density steel balance blocks. Removal of Concrete Balance Blocks shall be measured per pound of concrete balance blocks removed. Existing concrete balance blocks are anticipated to weigh approximately 95-100 pounds each.

3. BASIS OF PAYMENT

This work will be paid for at the contract bid prices for the following bid items, which shall include all labor, equipment and incidentals necessary to satisfactorily complete the work in accordance with the plans and specifications. For items measured in pounds, payment will be made only for the actual amount of weight measured. Whether the actual amount is greater than the bid basis, or less than the bid basis, payment will at the bid price per pound, regardless of the stated basis of the bid.

Bid Item	Unit
Lift Span Balancing	Lump Sum
Steel Balance Weights	Pound

(Note: All bids shall be based on a total of 40,000 lbs of new steel balance blocks. Payment will be based on the actual amount required to be installed.)

Removal of Concrete Balance Blocks	Pound

(Note: All bids shall be based on removal of a total of 23,000 lbs of existing concrete balance blocks. Payment will be made on the actual amount required to be removed.)

SECTION 6

TRAFFIC BARRIER GATES

1. DESCRIPTION

1.1 This section governs the replacement of the existing traffic barriers with new traffic barrier gates, including all materials, labor, and equipment. The furnishing and installing a traffic barrier gate anchorage in the median, structural steel supports for the new gate housing and removal of the existing barriers is also included with the work of this item.

2. DESIGN REQUIREMENTS

2.1 The barrier gate installations as shown on the plans are based on the model VT-6801 Vertical Automatic Barrier, by B & B Electromatic. Other models and manufacturers may be available. The model selected shall be designed and detailed to withstand load of a 5000 lb. vehicle at 50 MPH. The drawings shall be signed and sealed by a registered engineer qualified to perform this work. Drawings shall be submitted to the Engineer for review.

2.2 Gate operating mechanisms shall be sized such that the gate will remain operable with a wind load of 60 MPH against the arm from any direction. Operable is here defined as: (1) able to raise and lower the gate arm using the normal (electrical) operating mechanisms, and (2) the gate arm will not inadvertently raise or lower. A letter certifying compliance with this requirement shall be signed by a registered mechanical engineer and submitted with the shop drawings.

3. GATE ARMS

3.1 Barrier gate arms shall be aluminum tubular arm assemblies of tapered 6061-T6 aluminum tubes, with bracing as required. Each arm tube shall contain annealed stainless steel barrier cables, sized as necessary.

3.2 An arm end lock anchor shall be provided on the median barrier for the arm end to lock into at each location, as shown on the plans.

3.3 Gate arms shall be covered with alternating red and white reflectorized stripes.

3.4 Gate arm mounting channels shall be hot-dip galvanized carbon steel. Channels shall be offset to lace the gate arms at the proper elevation above the road surface, as shown on the plans.

3.5 Gate arm counterweights shall be hot-dip galvanized steel, sectional bolt-on type, sized and configured by the manufacturer so as to balance the arms throughout the entire range of gate arm movement.

3.6 Each gate arm shall be provided with two reflectorized delineators, fabricated

from 18 x 18 inch aluminum plate, painted yellow, with 9 3-inch amber reflectors in a 3 x 3 array. Delineators shall be mounted on the arms at the approximate centers of each lane, with their diagonal axis vertical.

4. HOUSINGS

4.1 Gate operating mechanism housing shall be fabricated from 0.375-inch steel plate, hot-dip galvanized after fabrication. Formed channel-shaped side plates shall be used for strength in lieu of welded corners. Housing shall have finish coat of aluminum paint.

4.2 Front and rear access doors shall be hung on bronze or stainless steel hinges. Hinge pins and all other hardware shall be stainless steel. Doors shall have neoprene gaskets and provisions for padlocking.

4.3 Door safety limit switches shall be provided for disabling the gate control circuit in the event a doors is opened.

5. TRANSMISSION

5.1 The transmission shall be an all gear, direct drive type, running in an oil bath. Use of belts and chains is not acceptable. The shafts and connecting rods shall be ASTM A311 Class B steel. Connecting rods shall be adjustable, and shall utilize self-aligning ball ends. Motor shall be sized by the manufacturer, rated to operate at 480 volts, three-phase. Specific motor data shall appear of shop drawings.

5.2 The transmission shall provide sinusoidal "S-curve" gate arm velocity for smooth acceleration and deceleration of the gate arms to prevent bounce or whip of the arm.

5.3 A hand crank shall be furnished for emergency operation in the event of electrical failure. A dedicated hand crank safety switch shall prevent motor operation during hand crank operation.

6. ELECTRICAL

6.1 Limit switches - Limit switches shall be provided in the housing for indication and control of full raised and full lowered. Multiple contacts, both normally open and normally closed, shall be provided for each end (limit) of travel. Switches shall be double-pole, double-throw (Form CC) snap-action type.

6.2 Warning Lights - Warning lights shall be two-way lights, with 4-inch diameter red acrylic lenses, beam spread of 30 degrees. Light housings shall be cast aluminum, designed for standard traffic signal lamps, and of weatherproof construction. Lights shall be B & B Electromatic type BM122 or equal.

6.2.1 Warning lights shall be mounted on gate arms at 5'-9" intervals. Lights shall be furnished with a 67 watt, 120 volt ac rough service lamp. Lights shall be circuited to alternately flash via the two circuits in the flasher with a steady burn light at the end of the arm.

6.3 Flasher - A heavy duty 2-circuit, motor driven, electro-mechanical flasher shall be supplied in the control house. The flasher shall provide two alternately flashing circuits and one steady burn circuit. As manufactured by Traffic Parts Inc., Spring, Texas, or accepted equal.

6.4 Disconnect Switch and Terminal Blocks - A motor disconnect switch shall be provided in each gate operator housing. Terminal blocks shall be provided for landing all external wiring coming into the gate operator. Terminal blocks shall be numbered in accordance with full wiring diagrams provided by the manufacturer as part of shop drawing submittal.

6.5 Maintenance Receptacles - Provide and install 120 volt, 15 amp GFCI receptacles in the gate housings.

7. ADDITIONAL MATERIAL

7.1 Structural Steel - A36, galvanized

7.2 Chemical Adhesive Anchor Bolts - stainless steel adhesive bolt system.

8. INSTALLATION

8.1 New barrier gates shall be installed as shown on the plans. Gates shall be shimmed level and closed under the base to completely seal the bottom of the housing.

8.2 Conduits shall be brought into the housing through the bottom.

8.3 Gates shall be adjusted so that gate arms in the fully lowered position are parallel with the roadway, and when in the fully raised position are vertical.

8.4 Gate arm warning lights shall be wired to begin flashing alternately when the traffic signals turn red, and shall remain flashing until gate arms are fully raised.

8.5 At the indicated locations in the existing median, holes shall be drilled for the chemical adhesive anchor bolts. Install the fabricated steel anchorage using the chemical adhesive anchor bolts. Ensure that the barrier gate end lock properly seats in the latching plate.

9. MEASUREMENT AND PAYMENT

Traffic Barriers, completely installed and fully operational, shall be measured as a unit each, which shall consist of a traffic barrier gate installation. The work of installing the anchorage for the traffic barrier gates in the existing median and the structural steel work for support of the gate housing is included in the item for traffic barrier gates.

Payment will be made under:

Bid Item	Unit
TRAFFIC BARRIER GATES	Each

SECTION 7

CONDUIT AND WIRING SYSTEM

1. DESCRIPTION

This work consists of furnishing and installing all materials necessary for both replacement and new installation of designated conduit, cable tray, general purpose wiring, and flexible and armored cable. Also included are junction boxes and terminal cabinets and the testing of new wiring.

2. MATERIALS

Material and installation requirements for all wiring and conduit shall be in accordance with AASHTO, applicable sections of the National Electrical Code, and NECA 1-2000.

3. CONDUIT

3.1 All exposed conduit shall be galvanized rigid steel per ANSI C80.1 with threaded couplings. Electrical metallic tubing (EMT) and intermediate electrical conduit (IMC) will not be allowed.

3.2 Sleeves for conduit holes through concrete walls and floors if required, shall be PVC pipe, epoxied in place.

3.3 Sizes shall be in accordance with the requirements of the National Electrical Code (NEC), and shall be sized to accommodate conductor pulling without damage to conductor insulation.

3.4 New conduit connecting to existing concealed conduit shall be no smaller than the existing conduit.

3.5 Conduits shall be provided with insulated throat grounding bushings with a bonding lug or screw, and shall be electrically bonded with a bonding jumper to all metal enclosures, boxes, wireways, and other equipment enclosures which they enter.

3.6 Couplings, connectors, and fittings shall be of a type specifically designed and manufactured for the application and for the conduit material. Conduit hubs shall be compatible with both the conduit and the enclosure material.

3.7 Where final connection to equipment with rigid conduit is not practicable, flexible, liquid-tight conduit shall be used, such as to equipment with adjustable mountings, to navigation lights, to limit switches, and to all machinery.

3.8 Flexible conduit shall be liquid-tight, UL listed. Flexible conduits shall be made liquid-tight by covering the steel core with a smooth, abrasion-resistant, liquid-tight polyvinyl chloride cover.

3.9 Conduit threads shall be standard American National Tapered Pipe Threads.

3.10 All threaded connections shall be coated with conduit thread sealant. Sealant shall be a waterproof conductive type, explicitly manufactured for the respective conduit material.

4. CABLE TRAY

4.1 Cable tray may be utilized to facilitate cable support from the aerial cable terminal cabinets on the tower platforms to the cable drops. Cable tray may be utilized to attach the armored riser cables on the tower structure.

4.2 Cable tray shall be heavy-duty aluminum, ladder type, extruded I-beam design and shall be UL listed. All cable tray hardware shall be corrosion-proof.

4.3 Aluminum barrier strips shall be used to separate power and control cables within cable trays.

5. WIRING AND CONDUCTORS

5.1 General Purpose Wiring

5.1.1 All conductors shall be copper, ASTM Class B stranding. Solid conductors shall not be used. Aluminum conductors shall not be used.

5.1.2 Wire and cable for general power and control circuits shall be rated 600 volts minimum.

5.1.3 Conductors shall be sized as shown on the plans. Conductor sizes, if not shown on the plans or otherwise specified, shall be minimum permitted by AASHTO for the application.

5.1.4 Conductors shall be UL listed type XHHW with cross-linked polyethylene insulation at least 30 mils thick. Conductors shall conform to the applicable requirements of UL Standard 44 and NEMA WC-70 / ICEA S-95-658.

5.1.5 Wiring, including shielded cable, shall be rated for wet locations. Wiring installed in exposed locations shall be sunlight and weather resistant.

5.2 High Temperature Wiring

All resistor connection wiring to, and within three feet of the braking resistor enclosures shall be motor lead and/or apparatus wiring, high temperature insulation, of one of the following types: type TFE, TGGT or PFAH Teflon rated 250 degrees C.; or type SRK, SRML, or SRGML silicon rubber rated 200 degrees C.

5.3 Aerial Cable

5.3.1 Conductor groupings shall be as shown on plans. Droop cable conductors shall be extra-flexible rope stranding (Class K), soft-drawn uncoated copper for high flexibility

applications.

5.3.2 Insulation shall be 600 volt, type W/SO ethylene-propylene rubber, for flexing, twisting applications.

5.3.3 Jacket shall be two layer, reinforced thermoset neoprene, weather and sunlight resistant.

5.3.3 Cable shall be UL listed and shall be rated for operation in ambient temperature range of -55 degrees to 105 degrees F.

5.3.4 Extra-flexible cable shall be as manufactured by BIW Cable Systems, Inc. "All-Temp Industrite", or equal, acceptable to the engineer.

5.4 **Armored Power and Control Cable.**

5.4.1 Armored cable shall be Type MC, C-L-X, 600 volt rated 90 degrees C.

5.4.2 Cable shall have close fitting, continuous, impervious aluminum C-L-X sheath with PVC jacket. Jacket shall be resistant to corrosive atmospheres, sunlight, and weather.

5.4.3 Cable shall be UL listed, and shall be required to comply with UL 1569, Section 14, "Test for Tightness of Armor on Conductors".

5.4.4 Armored cable shall be as manufactured by the Okonite Company, Type-MC, C-L-X or equal acceptable to the Engineer.

5.4.5 Cables which are to be supplied with a full size equipment grounding conductor (EGC) for NEC compliance may also, at the Contractor's option, be supplied with a smaller "standard" EGC. If a smaller EGC is supplied, it shall be spliced to the full size EGC, or terminated on the same ground bar as the full size EGC, at both ends.

5.5 **Armored Fiber Optic Cable**

5.5.1 Armored fiber optic cable shall consist of inner riser cable with eight 62.5/125um fibers with outer jacket enclosed in steel tape armor with overall polyethylene outer jacket. As manufactured by Optical Cable Corporation, Type DX, Armored, or accepted equal.

5.6 **Coaxial Cable**

5.6.1 Coaxial cable shall be RG-11U Type, 75 ohms impedance. Cable shall have stranded copper conductor and minimum 97% copper braid shield. Jacket shall be non-contaminating black PVC. As manufactured by Belden, No. 8261 of accepted equal.

6. **JUNCTION BOXES, PULL BOXES, TERMINAL CABINETS**

6.1 Unless specified otherwise, junction boxes, pull boxes, terminal cabinets, and other miscellaneous wiring device boxes outdoors on in the tower top machinery rooms shall be

NEMA 4X weatherproof, cast aluminum or stainless steel. Doors shall be gasketed to be weather-tight, per NEMA 4. Cabinets located in the operators house shall be NEMA 12 rated.

6.2 Hinges, bolts, screws, and other hardware shall be brass or stainless steel. All stainless steel cover fasteners shall be treated with anti-seize compound.

6.3 Terminal cabinets shall be provided with interior mounting panels for mounting of terminal strips. Cabinets that may house power and control conductors shall be sectionalized with divider between power and control sections.

6.4 Conduit hubs shall be gasketed and caulked with sealant, and shall be located on bottoms of boxes wherever practical. Top conduit entries shall not be permitted on NEMA 4 cabinets. NEMA 4 cabinets shall include breather and drain fittings similar to Crouse Hinds Series ECD.

7. INSTALLATION

7.1 All conduit, cable tray, wiring, junction boxes, and terminal cabinets, and support hardware shall be shown on the appropriate shop drawings, layout drawings, wiring diagrams, and other required submittal drawings and Approved by the engineer prior to installing.

7.2 Method of installation for all conduit and wiring shall be in accordance with contract plans, AASHTO, and the National Electrical Code (NEC). All conduits shall be supported in accordance with AASHTO requirements.

7.3 Replacement of conduit shall include replacement of associated, junction boxes, conduit clamps, U-bolts and associated hardware.

7.4 Exposed conduit shall be supported by hot-dip galvanized malleable iron conduit clamps with galvanized clamp backs and nest backs to support conduits at least ½-inch off of surfaces to which they are mounted.

7.5 Support all conduits at not more that 6-foot intervals, with at least one support between couplings.

7.6 Conduit bends shall be made with appropriate bending tools providing proper radius of bend without flattening or kinking the conduit. Flexible conduit shall not be accepted as a substitute for a bend in rigid conduit.

7.7 Conduit connections shall use threaded couplers and shall be sealed with a conductive waterproof sealant. Coupling new conduit to existing conduit shall be with three piece couplings.

7.8 Threads shall be clean cut, straight and true, and of sufficient length to permit full-depth coupling. Cut threads shall be coated with zinc-rich cold galvanizing compound. Excessive threads will not be permitted. Conduits shall be tightened until conduit ends are

together.

7.9 Provide supports on each side of conduit bends or elbows, and within 3 feet on each side of each pull box or other conduit termination. Conduits shall not be used to support pull boxes, terminal cabinets, etc; such items shall be supported independently of the conduits.

7.10 The Contractor shall cap open conduits until wiring is installed, and exercise the necessary precautions to prevent the lodgement of dirt or foreign materials in conduits, fittings and boxes during the course of installation. A run of conduit which has become clogged shall be entirely freed of these accumulations or shall be replaced.

7.11 Apply copper impregnated conductive paste to all conductors being terminated in terminal blocks. (Does not apply to crimp-on terminal lugs.)

7.12 Split-bolt connectors shall not be used on this project.

7.13 Conductors shall be pulled through conduits, enclosure and cabinet hubs, and conduit bodies in a manner that does not scrape or gouge the insulation. Nicks, gouges, and other damage to insulation will be considered sufficient basis for removal and replacement of conductors at Contractor's expense.

7.14 Power and control wiring shall not be combined in the same conduit.

7.15 No splices shall be permitted in aerial cable. Aerial cables shall be continuous from east tower to west tower.

7.16 Cast aluminum boxes, if used, shall be isolated from masonry with minimum 1/8 inch thick neoprene pads, neatly cut and trimmed to the outline of the box, extending beyond the edges of the box by approximately 1/8 inch.

7.17 All masonry anchors for boxes and conduit supports shall be stainless steel, drilled-in, capsule type chemical adhesive anchors.

7.18 Cable tray installation shall be in accordance with Article 318 of the National Electrical Code.

8. TESTING

8.1 Prior to installation of new wiring, all conduits shall be inspected for any deformations and thread damage. Any damaged conduit shall be replaced in kind for its entire length between connections.

8.2 All new conductors, including power, control, fiber optic, twin axial and coaxial shall be tested for continuity and conductor identification after placement. Continuity testing shall include all necessary tests to confirm that each conductor is continuous throughout its entire run.

8.3 All new conductor insulation shall be Megger tested prior to energizing. Contractor shall measure conductor insulation wire-to-wire and wire-to-ground using an approved ground reference. All devices and loads shall be disconnected prior to Megger testing. Testing shall be done according to IEEE Standard No.4, using an approved instrument. Minimum acceptable insulation value is 10 megohms.

8.4 Supply voltages shall be measured and verified correct for the actual installed devices or equipment being served. Only after these preliminary checks may the circuit be energized.

9. MEASUREMENT AND PAYMENT

Conduit, cable tray, wiring, and all related boxes, terminal cabinets, hardware, other miscellaneous components and appurtenances, and required tests will be measured as a unit installed for the entire project.

Bid Item	Unit
Conduit and Wiring System	Lump Sum

SECTION 8

AUXILIARY SPAN DRIVE

1. DESCRIPTION

This section covers the addition of a new auxiliary span drive assembly to the existing span drive in each tower, by making the necessary modifications to mount the new pinion, bearings, auxiliary gear-motor, auxiliary motor brake, and ancillary components. A new mechanical height indicator shall also be constructed and installed to monitor the span lift height, especially when operating on the new auxiliary gearmotor drive system.

2. SCOPE OF WORK.

The new auxiliary span drive shall consist of an auxiliary gear-motor, a new auxiliary motor brake, a manually operated clutch gear coupling, a new pinion shaft and supplied pinion, supporting bearings, pedestals, keys, anchor bolts, shims and other assembly hardware necessary to complete the installation, and properly align all components and the new auxiliary drive pinion to the existing main drive gear. The existing gear cover shall be modified to cover the new auxiliary drive pinion. A new inspection door shall be added to the modified cover. There shall be one new auxiliary span drive assembly and mechanical height indicator per tower, two total.

3. AUXILIARY DRIVE GEAR-MOTOR AND BRAKE.

3.1 The auxiliary drive shall consist of a 10 hp, 1750 rpm, 480V, 3- phase motor attached to an enclosed foot mounted reducer, with a 33.25:1 ratio, Model R97DV132M4 by SEW-Eurodrive or approved equal, and mounted to a welded pedestal which is anchored to the concrete floor and W14x38 floor support beam in each tower (two total). The gear-motor output shall be rated at 12,000 lb-in torque with an AGMA service factor of 2.0. The gear-motor shall have a rear extending shaft (1.5" diameter by 3.35" long with 3/8" by 3/32" keyslot) onto which is mounted the brake-wheel for the new auxiliary motor brake.

3.2 The new auxiliary motor brake shall be a 8" diameter drum brake with a maximum torque rating of 75 ft-lbs., adjusted to a initial braking torque setting of 55 ft-lbs. The brake shall be a MONDEL Model 8"MBE, or approved equal, spring applied, DC magnet released, with an 8" diameter offset hub brake-wheel, bored and keyed for installation on the auxiliary motor rear shaft extension. The brake shall have a low force manual release lever, latching type. The release lever shall be on the right side of the brake, when viewed from the magnet end. The brake shall also have corrosion protection for a salt water atmosphere.

3.3 The brake shall be supplied with an enclosed rectifier, Code number ABC-1x8"-3R-480/60, to operate the DC magnet from a 480 V, 3 Phase AC Power supply.

4. CLUTCH GEAR COUPLING.

4.1 The gear-motor output shaft shall be connected to a new auxiliary pinion input shaft via a clutched gear coupling, with manual lever actuation. The clutch gear coupling shall be a FALK 1020G72 disconnect coupling, or approved equal, with a FALK hand operated shifter mechanism, necessary to engage or disengage the coupling by shifting the outer sleeve. The long hub is mounted to the gear-motor output shaft. There is a 0.125" gap between the shaft ends in the coupling. The short hub is mounted to the new auxiliary pinion shaft.

4.2 The shifter mechanism shall be able to be locked in either the engaged or disengaged position. The standard Falk mechanism shall be modified as shown on the plans to operate a safety interlock switch so that the main drive motor control circuit is disabled when the clutch coupling is in the engaged position. The mechanism is modified by adding a T-shaped switch trip plate.

5. AUXILIARY PINION, SHAFT, AND BEARINGS.

5.1 The new auxiliary pinion shaft drives the main gear, G4, on the opposite side from the main pinion drive shaft. The new auxiliary pinion is separate from the pinion shaft. The pinion has an 8.117" pitch diameter, 17 teeth, 20 degree involute, 1.5" circular pitch (Diametral pitch = 2.094), 4.5" face width, 6.375" hub diameter by 6.5" wide, and a 3.5" diameter bore (FN2 fit with the shaft) with a key slot for a 3/4" square key. The teeth on the new auxiliary pinion shall have the same addendum and dedendum as the existing main pinion P4. The pinion shall be supplied by the NCDOT. The Contractor shall submit tooth thickness measurements of the existing gear G4 and the new auxiliary pinion P4 to the Engineer for review. These measurements will be used to determine the backlash setting. Verify all dimensions prior to fabrication of new support shaft.

5.2 The new pinion shaft is stepped with a maximum diameter of 3.5", a 3.000" diameter at the bearings, and 2.5" diameter at the clutch coupling. The shaft has an overall length of 48.25", including the 3/4" stub shaft end. It is made from forged alloy steel, ASTM A668, Class G, or AISI 4140 alloy steel bar, ASTM A29, with a minimum tensile strength of 80,000 psi.

5.3 One end of the new pinion shaft (opposite the auxiliary motor) shall have a 3/4" diameter by 2" long stub shaft with a #606 Woodruff key, used to drive the mechanical height indicator via a short floating shaft and worm gear reducer.

5.4 The new pinion shaft is supported by two spherical roller bearing pillow blocks with a 3.000" diameter bore, two hole mounting, and set screw locking collar. The pillow block bearing assembly shall be an SKF SYRS 3 (Cast Steel) with a 476215B-300 spherical roller bearing. After proper alignment of the new pinion with the existing gear G4, the pillow block bearings shall be bolted in place, and with the use of tapped chock blocks, secured in position to prevent future movement. If the cast steel pillow block bearings are available with blank bases, turned bolts shall be used in reamed holes after alignment to secure the position of the bearings.

6. MECHANICAL HEIGHT INDICATOR

6.1 The mechanical height indicator is used to mechanically determine the amount of lift of the span, especially when the span is being operated on the new auxiliary drive system. The indicator is driven by a stub shaft on the end of the new auxiliary pinion drive shaft, and is located on the opposite side from the new auxiliary gear-motor and brake.

6.2 The height indicator consists of two 24" diameter analog dials; one visually showing the span lift, from 0 ft. to 70 ft. in a 336 degree angle of rotation; the other dial shall rotate one revolution for every 10 ft. of span lift, and rotate exactly 7 revolutions for 70 feet lift.

6.3 The "10 ft." dial shaft also drives a mechanical digital counter that turns one revolution per one digit for 0.1 feet of lift. The counter is driven via a 1:1 timing belt drive, a 1:1 right angle box and a 1:100 speed increaser gear box.

6.4 The height indicator has an external 30:1 right angle worm gear input reducer and internal gearing of 3.2:1 ratio to drive the 10 feet dial, and additional 7.5:1 ratio to drive the main 70 feet dial, using all Delrin spur gears, with 12 diametral pitch, Style B with hubs. Refer to the plans for details on the gearing, shafts, bearings, and other components for the complete assembly of the mechanical height indicator.

6.5 All shafting shall be stainless steel, ASTM A276, Type 304/316, cold finished. Shaft spacers shall be nylon or Delrin tubing.

7. KEYS AND KEYWAYS,

7.1 Keys and keyways shall conform to the dimensions and tolerances for square and flat keys of the ANSI Standard B17.1, "Keys and Keyseats," unless otherwise specified. Keys shall be machined for an FN2 side fit and an LC6 top and bottom fit. Keyway corners shall be cut with a fillet radii as specified by ANSI Standard B17.1. All keys shall be effectively held in place, preferably by setting them into closed-end keyways milled into the shaft. The ends of all such keys shall be rounded to a half circle equal to the width of the key. Keyways shall not extend into any bearing.

7.2 Unless otherwise specified herein or on the drawings, keys shall be machined from equal or greater strength cold-finished carbon steel squares or flats that meet the requirements of ASTM A311, Class A, with a minimum tensile strength of 75,000 psi.

8. WELDED PEDESTALS AND BOLSTERS.

Steel for weldments shall be ASTM A572, Grade 50 unless otherwise specified, and always weldable grades as designated by applicable ASTM standards. Welding materials and methods shall conform to the AWS Structural Welding Code D1.1-2002. Where fillet weld size is not specified, use minimum size as given by AWS, based on plate thickness. All weldments shall be stress relieved with heat. Any machining shall be done after weldment is stress relieved.

9. MODIFICATIONS TO MACHINERY COVER.

Modification to the main pinion (P4) and gear (G4) equipment covers shall be necessitated by the addition of the new auxiliary drive brake-gearmotor and new pinion, shaft, and support bearings. Modify the cover as required to enclose the new auxiliary pinion and shaft. Provide a new hinged maintenance and inspection door for access to the auxiliary gear mesh. Use the same thickness steel for the modified addition of material, welding it to the existing material to give a seamless appearance. Repaint to the original color. The new pillow block bearings and supports should be outside the cover.

10. HIGH STRENGTH BOLTS, NUTS AND WASHERS.

Heavy hexagonal head structural bolts, heavy hexagonal nuts, and hardened washers complying with respectively ASTM A325, Type 1, A563, Grade C, and F436 shall be used for bolting components to their supports and the supports to structural steel or concrete floor. For anchor bolts that go through the concrete floor, but do not attach to structural steel, large ½" thick backing plates under the concrete floor shall be used.

11. HIGH STRENGTH TURNED BOLTS.

11.1 Turned bolts shall be made from a material and have a strength equal to ASTM A325, Type 1. Heavy hexagonal nuts, and hardened washers complying with A563,Grade C, and F436 respectively shall be used with the turned bolts. Locking shall preferably be by use of double nuts.

11.2 The body of the turned bolts shall be finished to 63 microinches or better. Threads for the turned bolts and nuts shall conform to the Unified Thread Standards, coarse thread series with a Class 2A tolerance for bolts and Class 2B tolerance for nuts, in accordance with ANSI B1.1, unless otherwise specified. Turned bolts are designated by their nominal thread size. The turned bolt body shall be 1/16th of an inch larger in diameter than the nominal size specified, and shall have an LC6 fit with reamed holes. Bolt head and nut bearing surfaces shall be flat and square with the axis of the bolt holes and shall be spot faced if necessary. Unless otherwise noted, bolt holes in machinery parts required for connecting to supporting steelwork may be sub-drilled (in the shop) smaller than the turned bolt diameter and shall be reamed together with supporting structural steel either during assembly or at erection, after the parts are correctly assembled and aligned. Positive type locking shall be provided. Double nuts are preferred. Where double nuts are used, heavy hex and jam nuts shall be used. Alternate locking methods shall be submitted to the Engineer for approval.

12. HUBS AND BORES.

The hubs of all gears and couplings shall be bored concentric with the pitch diameter of gears or with the outside of couplings. All hubs shall have an ANSI Class FN2 medium force fit on the shafts unless otherwise specified. Unless noted otherwise or otherwise recommended by

the manufacturer, all other hubs shall have a 63 microinch finish or better for a bore larger than 2 inches.

13. SHIMS.

Where shown on the drawings, all machinery shims required for leveling and alignment of equipment shall be stainless steel, ASTM A167, Type 302/304, neatly trimmed to the dimensions of the assembled parts and drilled for all bolts that pass through the shims. In general, total shim pack thickness shall be no less than twice the nominal thickness shown on the drawings, and of sufficient varying thicknesses shall be furnished to secure 0.003-inch variations of the shim allowance including one shim equal to the full allowance. Shims shall be placed to provide full contact between machinery and machinery supports. Shims shall be shown in detail on the shop drawings.

14. INSTALLATION.

14.1 The new auxiliary span drive arrangement and mechanical height indicator shall be installed as shown on the plans. All dimensions relating to existing equipment must be verified by the contractor on site. The Contractor shall supply all apparatus, tools, devices, materials and labor to manufacture, paint, ship, install, erect, align, adjust, lubricate, and test the auxiliary span drive machinery for the lift bridge in an approved manner. Any apparatus, tools, devices, materials and labor, not specifically stated or included, which may be necessary for the work, shall be furnished by the Contractor. The installation and adjustment of all new machinery shall be by millwrights experienced in this class of work. Painting specifications and color shall be as required by the NCDOT.

14.2 The new auxiliary span drive machinery, brake and motor, reducer, shafting, coupling, pinions, pinion bearings, bearing and gear-motor bolsters, and the like shall be erected and adjusted by competent mechanics and millwrights skilled in the type of work involved. They shall be provided with all necessary precision measuring and leveling instruments as may be required. The new machinery shall be erected with exactness so the various parts are truly aligned in their proper positions and, when entirely assembled, will operate smoothly without binding or undue looseness of the parts.

14.3 The new auxiliary pinion shall be aligned to the following criteria at the same time as the new pinion shaft bearings are being aligned, as they are an integral critical assembly. The new pinion is to be aligned relative to the existing gear G4 for proper backlash, and tooth mesh contact.

(1) G4 Gear/ New Pinion Backlash shall be determined from tooth thickness measurements taken by the Contractor.

(2) Tooth Contact area shall be a minimum of 70% of effective face width, centrally disposed; and 35% of tooth depth under a no load condition.

15. Measurement and Payment

The Auxiliary Span Drive including all necessary modifications components, hardware, and assembly shall be paid for at the contract lump sum bid price for the Auxiliary Span Drive and Mechanical Height Indicator.

SECTION 9

SEQUENCE OF CONSTRUCTION

1. SCOPE

1.1 This section is intended to present the requirements associated with construction sequencing, roadway disruptions, waterway disruptions, etc., and to demonstrate a recommended sequence of construction.

1.2 While certain work items are not explicitly considered by this section, all work shown on the plans and described elsewhere in these special provisions is required.

2. GENERAL REQUIREMENTS

2.1 The Contractor shall be responsible for developing the actual sequence of construction, which shall take into account all required work. The Contractor's actual sequence of construction shall provide sufficient detail to permit the Department to determine if the sequence complies with the requirements of the Contract Documents, and to ensure coordination between work items.

2.2 The Contractor is hereby notified that, while the requirements of this section related to allowed waterway disruptions and the recommended sequence of construction given in this section, have been informally coordinated with the United States Coast Guard, they have not been formally approved by the Coast Guard. Where such requirements are given, explicitly or implicitly, they are provided solely to illustrate anticipated Coast Guard requirements and to assist in bidding. The actual waterway disruptions allowed shall be fully at the discretion of the Coast Guard. The Department shall not be held responsible for any requirements, stipulations, limitations, etc. related to waterway disruptions as imposed by the Coast Guard which conflict with the requirements of the Contract Documents. Any such conflict shall not be considered cause for delay or additional payment.

2.3 The Contractor shall bear full responsibility for all required coordination with the Coast Guard, and shall secure approval from the Coast Guard for any disruptions to waterway traffic prior to commencing on-site activities. Such approval shall be initiated at least 6 months, and confirmed no less than 30 days but no more than 45 days, in advance of the first disruption.

2.4 The Contractor shall submit the actual sequence of construction to the Department, which shall take into account the actual waterway disruptions allowed by the Coast Guard. The actual sequence of construction must be approved by the Department prior to commencing on-site activities. However, such review and approval shall in no way relieve the Contractor of full responsibility for performing all work in accordance with the requirements of the Contract Documents. The Contractor shall bear full responsibility for the accuracy and practicality of the actual sequence of construction, and agrees to hold blameless the Department, and/or the Department's designated representative(s), for any mistakes, inconsistencies, etc. within the approved sequence. Any difficulties, damages, fines, etc. which may result from

usage of the approved sequence of construction shall be the sole responsibility of the Contractor, and shall not be considered cause for delay or additional payment.

2.5 The Contractor's actual sequence of construction shall comply with the requirements of the Contract Documents, all applicable state, federal, and local laws and regulations, and the following:

2.5.1 The Contractor shall operate the bridge from the time that the bridge is switched-over from the existing SCR main drives to the new flux-vector main drives until the project is accepted as complete by the Department.

2.5.2 The Contractor shall not operate the lift span prior to the switch-over to the main drives. Bridge operation during this time period will be by NCDOT personnel.

2.5.3 The Contractor's activities shall not disturb the current normal operation of the bridge (i.e. from the operator's point-of-view, the bridge must continue to operate in the same manner as it did prior to starting construction) while NCDOT personnel are operating the bridge.

2.5.4 Until the main drives switch-over, both existing modes of operation (SCR drives and switched resistance) must remain fully available.

2.5.5 The Contractor must keep a licensed electrician, plus at least one assistant or helper, on-site 24 hours per day any time significant (as determined by NCDOT) temporary wiring is being utilized, and/or while the Contractor is responsible for operation of the bridge.

2.5.6 During those periods when the Contractor is responsible for operating the bridge, a NCDOT representative will remain on-site to observe that all procedures and safety regulations are adhered to with respect to traffic control for bridge operations.

2.5.7 The new auxiliary drive motors, controllers, temporary generators, and related items must be fully operational prior to disturbing any bridge electrical system components.

2.5.8 The new auxiliary drive motors are to be used only as back-up in the event of a failure which takes the main drives out of service, except for pre-scheduled openings made at night such as are outlined in this section. Otherwise, either the existing drives (SCR and switched resistance) or new drives must remain in service any time the lift span is required to be operable.

2.5.9 The bridge must remain available to roadway traffic at all times. Any required test operations must be conducted at night or as otherwise directed by NCDOT.

2.5.10 Any waterway disruption longer than 24 hours must include one pre-scheduled nighttime opening to allow waterway traffic to pass. Such openings shall occur only between 8pm and 4am. (Note that this requirement has not been formally approved by the Coast Guard. Actual waterway disruptions allowed shall be coordinated with the Coast Guard as stated elsewhere herein.)

2.5.11 All waterway disruption periods must be separated by continuous periods of no disruption, the length of which shall be as directed by the Coast Guard. (Note that this requirement has not been formally approved by the Coast Guard. Actual waterway disruptions allowed shall be coordinated with the Coast Guard as stated elsewhere herein.)

2.5.12 The Contractor shall work continuously (around the clock in multiple shifts) during any waterway disruption and re-open the waterway as soon as the work necessitating the disruption is completed.

2.5.13 The Contractor shall maintain span balance, as required elsewhere in these Special Provisions, throughout the course of the project.

2.4 The Contractor shall bear full responsibility for all fines, fees, and damages resulting from non-compliance with the requirements of this section, United States Coast Guard regulations and requirements, and/or any other applicable local, state, or federal laws and regulations.

3. SEQUENCE OF CONSTRUCTION

3.1 The following recommended sequence of construction is provided solely to illustrate how to comply with the requirements of this section and to assist in bidding. The Contractor shall bear full responsibility for determining the actual sequence of construction in accordance with the requirements of this section, but is encouraged to use the recommended sequence given here as a guide in doing so. The Contractor's actual sequence of construction shall comply with the explicit and implicit requirements of this section, as well as the general intent of the sequence outlined here.

3.2 In the following sequence, the required ordering of tasks is designated by the task numbers enclosed in brackets.

3.3 PHASE I

3.3.1 The bridge remains fully operable on existing control and drive systems (SCR drives and switched resistance), and is operated by NCDOT. The roadway is available to traffic, and the lift span may be opened for waterway traffic upon request.

3.3.2 Tasks:

[1.1] Begin installation of new 10 horsepower auxiliary drive system. Install supports for new gearmotors and shafts, new gearmotors and shift couplings, new controllers, and new mechanical height indicator. Install temporary gas or diesel generators (sized to operate auxiliary drive motors) on each pier top and connect to the new auxiliary motor controllers using temporary wiring.

3.4 PHASE II

3.4.1 The lift span is placed in the fully seated position and cannot be opened for marine traffic (bridge machinery is inoperable). However, the waterway does remain available to

waterway vessels which do not require a lift span opening. The roadway remains available to traffic.

3.4.2 Maximum 8 hours (continuous).

3.4.3 Tasks:

[2.1] Install new auxiliary drive shafts and pinions. Temporarily align shafts and pinions using undersize bolts.

3.5 PHASE III

3.5.1 The bridge remains fully operable on existing control and drive systems (SCR drives and switched resistance), and is operated by NCDOT. The roadway is available to traffic, and the lift span may be opened for waterway traffic upon request.

3.5.2 Minimum 16 hours (continuous).

3.5.3 Tasks:

[3.1] Prepare for Phase IV.

3.6 PHASE IV

3.6.1 The lift span is placed in the fully seated position and cannot be opened for marine traffic (bridge machinery is inoperable). However, the waterway does remain available to waterway vessels which do not require a lift span opening. The roadway remains available to traffic.

3.6.2 Maximum 8 hours (continuous).

3.6.3 Tasks:

[4.1] Final align auxiliary drive shafts and pinions.

[4.2] Test lift span using auxiliary motors and generators.

3.7 PHASE V

3.7.1 Bridge remains fully operable on existing control and drive systems (SCR drives and switched resistance), and is operated by NCDOT. The roadway is available to traffic, and the lift span may be opened for waterway traffic upon request.

3.7.2 Minimum 168 hours (continuous).

3.7.3 Tasks:

[5.1] Relocate existing variable resistor banks to temporary locations in electrical room. Install any necessary temporary wiring such that any resistor bank is out of service for a maximum of two hours. Allow NCDOT to test lift span.

[5.2] Relocate existing field resistor banks to temporary location in electrical room. Install any necessary temporary wiring such that any resister bank is out of service for a maximum of two hours. Allow NCDOT to test lift span

[5.3] Install new MCC, main breaker, manual transfer switch and interconnecting power wiring. Install new fused service disconnect, new metering equipment, new bridge feeder conduit and wiring to new main breaker. Install new service conduit, wiring from existing service pole to new service disconnect and prepare for utility company hook-up. Test all new wiring.

Install new aerial cable brackets, cable, and terminal cabinets. Install new cable trays on towers. Relocate existing cables to one side of trays and temporarily install new cables in other side of trays. Interconnect with new aerial cables and test. Rebalance lift span as required throughout, and immediately after, installation of new aerial cables and related hardware as required to comply with the requirements for span balance outlined elsewhere in these Special Provisions.

Install new PLC cabinet in control house and remote racks in machinery rooms. Interconnect and test. Load the PLC with a temporary program to accomplish only main drive control (including skew control), brakes control, and span height and skew indication. While operating with this temporary program, the PLC will determine span position (fully seated, near closed, near open, fully open, etc.) using the new resolvers only. Raise and lower control will be via a temporary pendant station connected to the PLC with a cord long enough to reach the existing console.

Connect resolvers to remote racks with temporary wiring, test and prepare for installation. Install temporary digital span height and skew displays (fed from new PLC using new resolvers) at existing console and test.

Install temporary power and control wiring (suggest SO cord) from new MCC to span locks, traffic warning gates, traffic barrier gates, and brakes. Test and prepare for connection to motors during Phase II.

Install new drives for southeast and southwest main motors in temporary location in control house. Prepare encoders for installation and connection to drives. Install temporary power wiring from new MCC to new drives and test.

Install temporary control wiring from existing control cabinets and/or console to new MCC so that bridge will still be fully operable from existing console during Phase VII. Do not physically connect temporary control wiring to existing control circuits until Phase VI.

3.8 Phase VI

3.8.1 The lift span is placed in the fully seated position and cannot be opened for marine traffic (bridge machinery is inoperable). However, the waterway does remain available to waterway vessels which do not require a lift span opening. The roadway remains available to traffic.

3.8.2 Maximum 24 hours (continuous).

3.8.3 Tasks:

[6.1] Disconnect span locks, traffic gates, traffic barriers, and brakes from existing power wiring and connect to temporary power wiring to new MCC.

Finish connection to existing control circuits of temporary control wiring between existing control cabinets and/or console and new MCC (installed during Phase V) so that bridge will still be fully operable from existing console during Phase VII.

Install new wiring from existing 300kW generator to new transfer switch.

Install temporary power wiring from new MCC to existing switchgear.

Have utility remove existing service and install new grounded service connected to new service disconnect and bridge feeder. In the event that the utility change-over overruns the shutdown period, use the 300kW generator to operate the bridge until the new service is installed.

3.9 Phase VII

3.9.1 Bridge remains fully operational from existing console using existing SCR Drives (with switched resistance as back-up) and new MCC. NCDOT continues to operate bridge, but the Contractor must keep a licensed electrician and at least one assistant or helper on-site 24 hours per day from this point on to perform any required troubleshooting and/or modification to temporary wiring. The roadway is available to traffic, and the lift span may be opened for waterway traffic upon request.

3.9.2 Minimum 168 hours (continuous).

3.9.3 Tasks:

[7.1] Mechanically install encoders for southeast and southwest motors.

3.10 Phase VIII

3.10.1 From this point on, the Contractor is fully responsible for operating the bridge. One pre-scheduled opening will be made each night (between 8pm and 4am) using the new auxiliary drive to allow marine traffic to pass. During all other hours, the lift span is placed in the fully seated position and cannot be opened for marine traffic (bridge machinery is inoperable). However, the waterway always remains available to waterway vessels which do not require a lift span opening. The roadway remains available to traffic.

3.10.2 Maximum 96 hours (continuous).

3.10.3 Tasks:

[8.1] Disconnect southeast and southwest main drive motors from existing wiring and connect to new wiring. Remove secondary brushes and install shorting bars on secondary slip rings.

Remove existing span position selsyn transmitters and mechanically install new resolvers.

[8.2] Start-up southeast and southwest main drives and motors.

3.11 Phase IX

3.11.1 The bridge is operated by the Contractor using the new southeast and southwest main drives. The roadway is available to traffic, and the lift span may be opened for waterway traffic upon request.

3.11.2 Minimum 168 hours (continuous).

3.11.3 Tasks:

[9.1] Remove existing SCR drives, secondary resistors, and switchgear. Install new northeast and northwest main drives in permanent locations and connect to new wiring.

Remove existing tachometer/overspeed switch assemblies and prepare for installation of new encoders.

Remove existing barrier gates and install new (contracted to provide temporary traffic controls while barriers are out of service). Connect to temporary control and power wiring. Operate new barriers from local control switches on MCC bucket doors.

Disconnect locks and gates from existing control wiring and connect to temporary control wiring to new MCC. Disconnect temporary control wiring from existing control cabinets and/or console to new MCC. Operate locks and gates from local control switches on MCC bucket doors.

Install a temporary toggle switch for the roadway traffic signals (place switch at a convenient location in the control house) and extend temporary wiring (suggest SO cord) from the temporary switch to the roadway traffic signals. Disconnect the signals from their existing wiring and connect to the temporary wiring.

Remove northeast and northwest main drive motors and ship to motor shop for rewind.

[9.2] Remove existing power and control wiring to locks, gates, and brakes and replace with new. Remove existing wiring to roadway traffic signals and replace with new.

[9.3] Disconnect locks, gates, barriers, and brakes from temporary control and power wiring and connect new permanent wiring. Disconnect signals from the temporary wiring and connect to new wiring.

[9.4] Remove existing console and install new. Remove existing control cabinets. Install remaining new control wiring from PLC to new console and MCC.

3.12 Phase X

3.12.1 One pre-scheduled opening will be made each night (between 8pm and 4am) using the new auxiliary drive to allow marine traffic to pass. During all other hours, the lift span is placed in the fully seated position and cannot be opened for marine traffic (bridge machinery is inoperable). However, the waterway always remains available to waterway vessels which do not require a lift span opening. The roadway remains available to traffic.

3.12.2 Maximum 48 hours (continuous).

3.12.3 Tasks:

[10.1] Remove existing rotary cam limit switches and span skew selsyn transmitters. Install new rotary cam limit switches.

[10.2] Install normal PLC program and test.

3.13 Phase XI

3.13.1 The bridge is operated by the Contractor using the new southeast and southwest main drives and the normal PLC program and new console. The roadway is available to traffic, and the lift span may be opened for waterway traffic upon request.

3.13.2 Minimum 168 hours (continuous).

3.13.3 Tasks:

[11.1] Reinstall rewound northeast and northwest main drive motors. Install encoders. Start-up new northeast and northwest main drives and motors.

3.14 Phase XII

3.14.1 The lift span is placed in the fully seated position and cannot be opened for marine traffic (bridge machinery is inoperable). However, the waterway does remain available to waterway vessels which do not require a lift span opening. The roadway remains available to traffic.

3.14.2 Maximum 24 hours (continuous).

3.14.3 Tasks:

[12.1] Remove southeast and southwest main drive motors and ship to motor shop for rewind.

[12.2] Install temporary shafts with brakewheels and bearings between machinery brakes and motor brakes in place of removed motors.

3.15 Phase XIII

3.15.1 The bridge is operated by the Contractor using the new northeast and northwest main drives and the normal PLC program and new console. The roadway is available to traffic, and the lift span may be opened for waterway traffic upon request.

3.15.2 Minimum 48 hours (continuous).

3.15.3 Tasks:

[13.1] Move southeast and southwest main drives to permanent locations and connect to permanent wiring.

3.16 Phase XIV

3.16.1 The lift span is placed in the fully seated position and cannot be opened for marine traffic (bridge machinery is inoperable). However, the waterway does remain available to waterway vessels which do not require a lift span opening. The roadway remains available to traffic.

3.16.2 Maximum 24 hours (continuous).

3.16.3 Tasks:

[14.1] Remove temporary shafts and bearings. Re-install rewound southeast and southwest main drive motors.

3.17 Phase XV

3.17.1 The bridge is operated by the Contractor using the new main drives and the normal PLC program and new console until the project is complete and accepted by NCDOT. The roadway is available to traffic, and the lift span may be opened for waterway traffic upon request.

3.17.2 Tasks:

[15.1] Start-up new southeast and southwest main drives and motors.

[15.2] Remove existing cables from trays and reinstall new cables in permanent locations in trays.

[15.3] Remove temporary generators from machinery house and connect auxiliary drive controllers to new wiring to MCC.

4. MEASUREMENT AND PAYMENT

There will be no separate payment for costs associated with the sequence of construction provisions. The costs shall be included under the lump sum bid item Bridge Operating and Control System.

SECTION 10

TESTING AND ADJUSTMENT

1. SCOPE

1.1 This section covers the furnishing of all labor, material, equipment and related appurtenances as may be required for complete operational testing of the bridge electrical power and control system.

1.2 The Contractor shall be responsible for performing all testing, inspections, and any resulting corrective work required by these specifications.

1.3 All testing, inspections, and demonstrations, and any resulting remedial work, will be deemed solely the responsibility of the Contractor and will not be considered cause for delay or additional payment.

1.4 Wire and cable tests are outlined in the Conduit and Wiring System section of these Special Provisions.

2. PROCEDURES AND EQUIPMENT

2.1 Procedures and equipment used for the testing required by these Special Provisions shall be in accordance with manufacturer's recommendations, NETA Acceptance Testing Standards, any other applicable industry standards, and be appropriate for the specific test being performed.

2.2 Voltmeters, ammeters, etc. shall be true RMS type. Where recording instruments are required, they shall be three phase, strip chart type. All instruments shall be maintained in properly calibrated condition.

3. SUBMITTALS

3.1 Proposed testing procedures, including instruments and other equipment to be used, shall be submitted to the Engineer for approval at least 15 working days prior to testing.

3.2 The results of all tests shall be accurately recorded in a neat and orderly fashion along with time and date of test(s), environmental conditions (temperature, humidity, general weather conditions, etc.), the testing equipment used, conditions of test(s), and the name(s) of person(s) performing the test(s).

3.3 All test results shall be submitted, with all text in typewritten format, to the Engineer no later than 10 working days from date of test(s). The results of these tests must be deemed acceptable by the Engineer prior to acceptance of the work in question.

3.4 Submittals shall be required for, but not necessarily limited to, the following.

3.4.1 Insulation resistance testing

3.4.2 Ground resistance testing

3.4.3 Main drive chart recording

3.4.4 Operational testing of installed systems and sub-systems

3.4.5 Operational testing of the complete bridge electrical power and control system

4. GENERAL TESTS

4.1 Prior to energizing any circuit or connection of any piece of equipment to any circuit, the following tests shall be performed:

4.1.1 Measure the supply voltage and phase rotation and verify that both are correct for the equipment installed.

4.1.2 Verify that all conductors and current carrying parts of equipment are continuous, free of shorts, opens, or unintentional grounds, and that all conductors are properly terminated.

4.2 Physical Inspection

4.3 In addition to the required quantitative tests, the Contractor shall also be responsible for performing all qualitative inspections which may be required to ensure that all electrical system materials and components are properly installed. Such inspections shall include, but not be limited to:

4.3.1 Visual inspection of all electrical connections

4.3.2 Visual inspection of all raceway, conductor, device, and equipment installations

4.3.3 Verifying proper operation of all operating mechanisms and mechanical interlocks

4.3.4 Verifying proper tightening of mechanical lugs and terminals

4.3.5 Inspection of all hardware connections.

4.4 Operational Tests and Demonstrations

4.4.1 All portions of the electrical work, as well as the complete bridge electrical and control system, and including the barrier gates, shall be subjected to operational, as installed,

testing. Such testing shall be as required to establish that the item(s) under test meet all specified requirements and are operating in a reliable manner.

4.4.2 The Contractor shall also be prepared to conduct any additional miscellaneous operational demonstrations as may be requested by the Engineer to establish that a given product, system, or subsystem meets all specified requirements and is operating in a reliable manner.

4.5 **Adjustments**

4.5.1 After the bridge is fully operational, the variable parameters of the bridge operating and control system shall be tuned for the optimum smooth, automatic operation. This may include, but not be limited to, adjustment of motor drives, skew controls, limit switches, time delays and brakes. Adjustments shall be to the satisfaction of the Engineer.

4.6 **Corrective Actions**

4.6.1 For all test results which fall outside the stated acceptable values or conditions or the Engineer finds unacceptable, the Contractor shall investigate the cause of the failure, take appropriate corrective actions, and repeat the test(s). This procedure shall be repeated until such time as all test results are deemed acceptable by the Engineer.

5. **MEASUREMENT AND PAYMENT**

There will be no separate payment for testing and adjustment. The cost shall be included in the bid price for the Bridge Operating and Control System.

SECTION 11

SPAN BALANCE TESTING

1. GENERAL

This section includes the initial and final testing of the span balance condition, using strain gages.

1.1 Description of Work

Provide all apparatus, tools, devices, materials and labor to test the balance condition of the bridge in an approved manner as provided herein.

The work shall include furnishing, installing, and testing to determine the initial balance condition and final balancing of the span, all in accordance with the specifications and contract drawings or as directed by the Engineer.

Items include the following:

a. Perform initial span strain gage balancing (prior to construction) to obtain baseline imbalance, and repeat testing after each span balance adjustment which exceeds the transfer of 5,000 pounds or more, until the balance condition is within the required balance window.

b. Strain gage balancing shall also be performed at the completion of construction and repeated after each span balance adjustment which exceeds the transfer of 5,000 pounds or more until the span balance condition is within the required balance window..

1.2 Quality Assurance.

1.2.1. Quality Control

The Engineer shall be notified immediately for clarification whenever any portion of work is not clearly or accurately defined.

1.3 Submittals

1.3.1. Report

a. After each strain gage testing procedure is completed, test results shall be submitted to the Engineer within one week. After initial and final balance conditions are achieved, a report shall be submitted including values for imbalance at each corner, friction at each corner, end reaction vs. span height graphs with the theoretical balance curve included, and at least one annotated graph for each tower. The report shall also include a list of the equipment used with make and model numbers. In

addition, the report shall include analysis of the overall efficiency (friction) of each tower, peak loads, seating loads, motor overloads, and load sharing between corners.

1.3.2 Procedures

Specific and detailed procedures shall be submitted to the Engineer for approval prior to commencing construction for the following work items:

a. Strain gage balancing. Initial and final balancing using foil strain gages attached to span drive shafting (two shafts per tower) via spot welding. All procedures and results shall be documented and formally submitted.

2. EXECUTION

If significant weight changes to the span or counterweight are required after either the initial or final strain gage balance testing, as described above, a new series of tests shall be performed on the span and the above process repeated until the balance condition is acceptable. All testing and data analysis shall be carefully documented and formally submitted.

2.1. Acceptable Balance

Acceptable balance shall be defined as the reaction at each end of the lift span due only to imbalance while fully seated (down), and shall be as defined in the table in the Special Provisions section, Span Balancing.

2.2 **Pay Items**

2.2.1 Span Balance Testing

This includes the determination of the span balance by strain gage testing and the evaluation of the span balance both before and after construction execution. This price shall include all labor, equipment and incidentals necessary to satisfactorily complete the strain gage balance testing in accordance with the plans and specifications. New balance materials, balance spreadsheet maintenance, and adjusting of the counterweight blocks are not included in this pay item.

Span Balance Testing shall be measured on a lump sum basis.

3. BASIS OF PAYMENT

This work will be paid for at the contract bid price of lump sum for SPAN BALANCE TESTING. This price shall include all labor, equipment and incidentals necessary to satisfactorily complete the strain gage testing in accordance with the plans and specifications.

SECTION 12

STRUCTURAL STEEL

1. **DESCRIPTION**

1.1 Sections 440, 1072 and 1080 of the Standard Specifications are amended by the following.

1.1.1 This work refers to the addition of structural steel to the towers and lift span to support the new electrical aerial cables, as indicated on the drawings.

1.1.2 The material shall be as indicated on the plans.

1.1.3 High strength bolts, nuts and washers shall be galvanized.

1.1.4 Low modulus silicon sealant shall conform to Section 1028-4. Single component urethane caulk conforming to ASTM C920, grade NS may be substituted with the approval of the Engineer.

1.1.5 The paint shall be compatible with the existing paint system that is used on the steel towers and lift span as applicable. The color of the new top coat shall nearly match the color of the existing paint.

1.1.6 The new structural support components shall be shop assembled and three-coat painted, including the faying surfaces. The new faying surfaces of the existing steel tower shall be cleaned and prepared as indicated on the drawings.

1.1.7 The new structural steel supporting material shall be coated with an application of sealant or caulk that will spread out over the full size of the new attachment steel to fill any uneven areas between the two painted steel surfaces.

1.1.8 High strength bolts shall be tightened in accordance with the Turn-of-the Nut Method as stated in Section 440-10.

2. **MEASUREMENT**

There will be no Method of Measurement for this Support Structural Steel.

3. **PAYMENT**

This work will be paid for at the lump sum price bid for Conduit and Wiring System, which will include all preliminary work necessary to prepare the new structural steel and existing steel tower that is necessary to support the new aerial cables. This work will include all labor, materials, and equipment that is required to erect this support steel.